The encyclopaedia of photography : containing over one thousand references and illustrated with above 200 explanatory sketches and diagrams by the author / Walter E. Woodbury.

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THE

ENCYCLOPÆDIA

OF

PHOTOGRAPHY

By WALTER E. WOODBURY.

CONTAINING

OVER ONE THOUSAND REFERENCES

AND ILLUSTRATED WITH

ABOVE 200 EXPLANATORY SKETCHES

AND DIAGRAMS

BY THE AUTHOR.

LONDON

ILIFFE & SON, 3, ST. BRIDE STREET, E.C.

1890.

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PREFACE.

IN presenting to the public a new Encyclopædia of Photography, no apology, I imagine, will be required for the undertaking. The Author has long felt that there was need of such a work, which should present the features of a dictionary of photographic processes, optical and chemical terms, &c., and at the same time treat certain subjects with which it is desirable that the student should be better acquainted with something of the exhaustiveness adopted in an encyclopædia. The result is the present work, to be published in about twelve monthly parts until complete, and the object of which is to place in the hands of all who practise photography, whether for pleasure or profit, a book which shall assist them to better understand the optical and chemical principles of the art, and spare them the time, trouble, and expense of referring to the large number of bulky and costly works which I have myself been obliged to consult.

Photography is essentially the child of optics and chemistry, and it is indeed lamentable to find how little the majority of photographers of the present date know about either. The Author sincerely hopes that his endeavours will be instrumental in changing this state of things for the better, and for this reason has given much attention to the sciences of optics and chemistry. Under the various headings connected with the former, he has endeavoured to explain as clearly as possible, in readable language, the theories of light and the image, the construction of lenses, and the defects of chromatic, spherical, and other aberrations. Under chemistry as much as possible is given of the outlines of chemistry, the theory of atoms and molecules, and a clear explanation of the different signs and symbols that the photographer is likely to meet with. And under the chemical headings it has been thought

necessary to give, not only the chemical composition, but also to explain the nature of the substance, the manner in which it is obtained or prepared, and its various properties, so that the worker shall be better acquainted with the article he is handling.

A work in some ways similar to this was published a little over thirty years ago under the title of "Sutton's Dictionary of Photography." But although this work is of still great value to the student, and I have myself derived much benefit from it, yet since its publication many important changes have taken place. Much more is known with regard to optics, and great changes have consequently taken place in the construction of lenses. Many new discoveries in chemistry, and important alterations in the nomenclature and atomic weights, have been made. Again, too, the collodion process has to a great extent been supplanted in this country by the modern dry-plate one, although it has not been thought advisable to omit mention of the former process in this work, it being still worked to a very large extent for special purposes.

A clear description is given of all the various photographic processes now in use, and reference made of many that have been discarded. The study of the latter is likely to be very useful to the experimentalist.

A word or two with regard to the subsequent numbers of this work. My chief aim will be the accurate character of the information, therefore many of the articles will be supported by other testimony than my own. In such cases the evidence of the authorities upon which I rely will be such as to convince me that it is trustworthy.

As this work is written for beginners, as well as those more advanced in the art, I have endeavoured to make the language as simple and clear as possible, avoiding all complicated terms likely to lead to confusion. The technical terms which it has been necessary to make use of, however, are all clearly explained in their places.

The illustrations to this work are all very carefully prepared by the Author, and are intended not so much for the purpose of embellishment as to show what is meant in a clear manner where verbal definition alone is insufficient. I have also been anxious to arrange the matter in as methodical a manner as possible, so as to make the task of finding the desired information on any particular subject as little laborious as possible, and for this purpose cross references are freely given.

In an undertaking of this kind it is not to be wondered at if faults are found. The defects, however, I hope and trust, will be few in number, and not of any importance in comparison at least with the general utility of the work. The writer hopes that should the reader find any errors he will communicate with him through the publishers, so that the necessary corrections may be made in the subsequent editions. Besides this, I shall be glad of any information and advice.

With these few words the first portion of "The Encyclopædia of Photography" is launched out into the world to a wait the verdict of the public.

WALTER E. WOODBURY.

The Athenæum, Manchester.

EXPLANATIONS OF ABBREVIATIONS, ETC.

Arab.—Arabic.
Eng.—English.
Fr.—French.
Ger.—German.
Gr.—Greek.
Lat.—Latin.
e.g.—*exempli gratiâ*—for example.
fr.—from.
i.e.—*id est*—that is.
lit.—literally.
mod.—modern.
viz.—namely.
q.v.—*quod vide*—which see.
v.—*vide*—see.
At. w.—atomic weight.
C.—Centigrade.
Cel.—Celsius.
Fahr.—Fahrenheit.
Mol. w.—molecular weight.
Re.—Reamur.
Sp. gr.—specific gravity.

A, *a*, or *a a*, is sometimes used in formulæ for *ana*—in equal parts.

AAA in old chemistry means an amalgam.

Aberration (Lat. *aberratio*—a wandering from).—A term used in optics when the rays of light deviate from their normal path, or when the refraction of the lenses of the several elementary colours is unequal. There are various forms of aberration. Those with which we have to deal are known as "Spherical aberration," "Chromatic aberration," "Curvature of the field," "Aberration of thickness," and "Astigmatism."

Spherical aberration is caused by the rays refracted by the margin of the lens meeting at a different point in the axis than

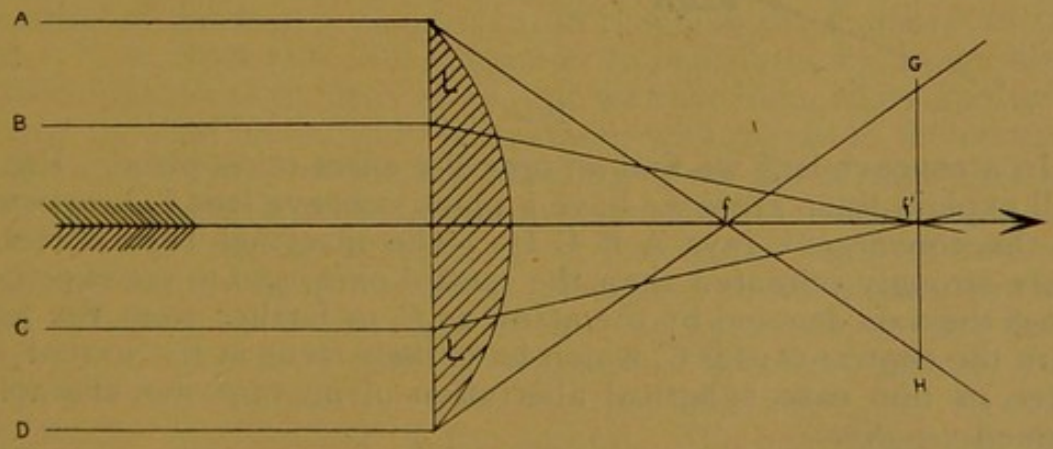


FIG. 1.

those rays which are refracted from the centre. As it proceeds from the sphericity of the surface of the lens it is termed "spherical aberration." The accompanying diagram, Fig. 1, is intended to show the aberration produced by a lens having a spherical surface. L L is a section of a plano-convex lens, the arrow indicating the line of axis. Now, if the plane side be exposed to the parallel rays A B C D, the extreme rays A D being perpendicular to the plane surface will pass

directly through to the convex side, where, upon leaving, they will be refracted to *f*, crossing the axis at that point, and forming an image there. But an image of the object will also be formed at *f'* by the central rays B C, while from *f* to *f'*, the distance of the difference of the central and marginal rays which is termed the longitudinal aberration, images of the same object will be formed by the intermediate portions of the lens. Now, the image formed at *f'* by the central rays is consequently the sharpest, but if we focus on to the screen, the image is surrounded by a halo G H caused by the marginal rays A D diverging after crossing the axis at *f* falling on to the screen placed to receive the image of the central rays at *f'*. This halo is termed the lateral spherical aberration, or circle of aberration, and the diameter constitutes the measure or *expression* of the lateral spherical aberration. The aberration produced by a lens of this kind in the manner shown is termed *positive*.

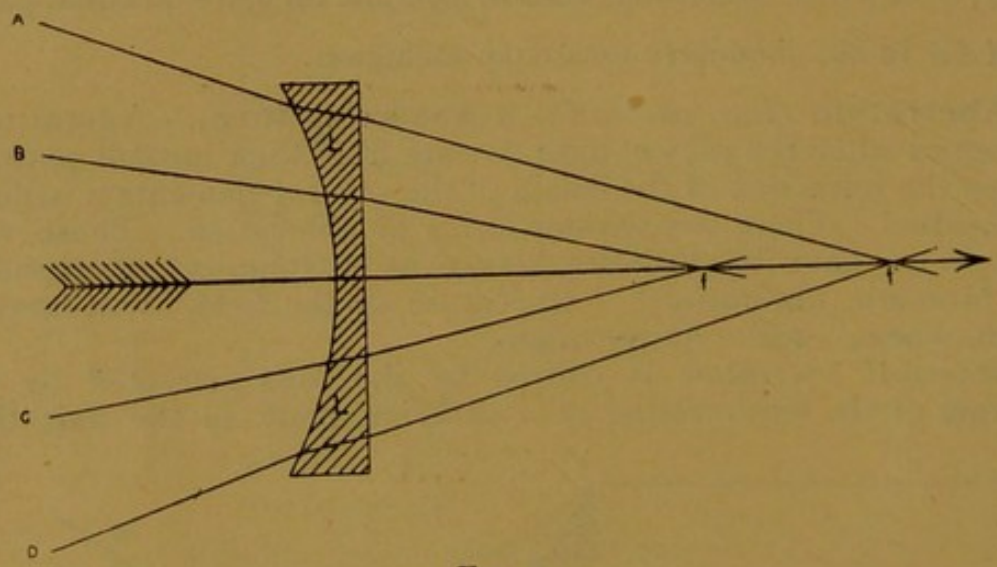


FIG. 2.

In a concave lens we find an opposite effect takes place. Fig. 2 will explain this. Here we have a plano-concave lens L L exposed to the convergent rays A B C D. The marginal rays A D are more strongly refracted than the central ones, and in consequence cross the axis denoted by the arrow at *f'*, or farther from the lens than the central rays B C, which have their focus at *f*. So that we have in this case spherical aberration of an opposite character termed *negative*.

It will not be difficult to understand that these different images, and the various rays that form them, interfering with and crossing each other instead of meeting at one focus, cause no little confusion and indistinctness of the image, and the larger the aperture of the lens in proportion to its focal length, the greater the defect of spherical aberration, or, in other words, the longitudinal spherical aberration increases as the square of the diameter of the aperture, and inversely as its focal length, while the lateral aberration increases as the cube of its aperture, and inversely as the square of

its focal length. It will be seen, then, that if we take two lenses of equal curvature made of the same material, or possessing the same refractive index, the one having an aperture twice the diameter of the other, the longitudinal aberration of the larger one is four times as great, and the lateral aberration is eight times as great as that of the smaller one of half the aperture. Take two lenses with the same aperture, but let one possess a focal length equal to twice that of the other, the longest one has but one-half the longitudinal, and one-fourth the lateral aberration.

We have now to consider the means of correcting this spherical aberration, and the first point that attention must be called to is the curvature of the lens, for the reason that spherical aberration depends upon the sphericity of the surfaces of the lens. It is clear, therefore, that the more convex the surfaces are, the shorter the radii of curvature relative to the diameter of the lens, and the greater the spherical aberration. Thus it is found in its worst form in a bi-convex lens. In plano-convex and meniscus lenses, the defect is not so great, and it is quite possible with the use of a diaphragm to make good landscape pictures with the latter. The

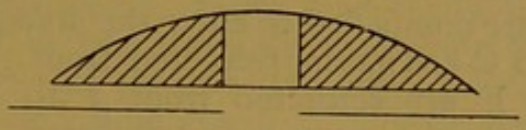


Fig. 3.

diaphragm will reduce the defect of spherical aberration very considerably, but never completely destroys it. Fig 3. illustrates the effect of the stop or diaphragm in reducing the diameter of the lens. Now, if we reduce the diameter to one-sixth, we do not alter the focal length of the lens at all, but we have reduced its aperture, so that by what has already been stated with regard to the relation of the aperture to this kind of aberration, we see at once that we have reduced the lateral aberration to one-thirty-sixth.

But in reducing the aperture of our lens in this manner we have also reduced the light, and consequently the rapidity also, so that it is necessary that the lens should be aplanatic, or free from aberration, when used with full aperture. We have already seen what is meant by positive and negative aberration, fig. 1 representing the first and fig. 2 the second. We have also seen that these two aberrations are of an entirely opposite character, the rays refracted near the centre of the lens in the one being refracted farthest from it in the other, so that it will be at once apparent that by combining two lenses of opposite character the defects of one may be counteracted by those of the other. Let us see how this is in practice. In fig. 4 we have a convergent lens L L, the aberration of sphericity of which we are anxious to destroy. To it we attach a lens D D of an opposite kind, called a divergent lens, and it will be clear that, provided its radii of curva-

ture are suitable, it will scarcely change the central rays, while it will greatly change the directions of the marginal so as to bring them also to a point farther away from the centre of the

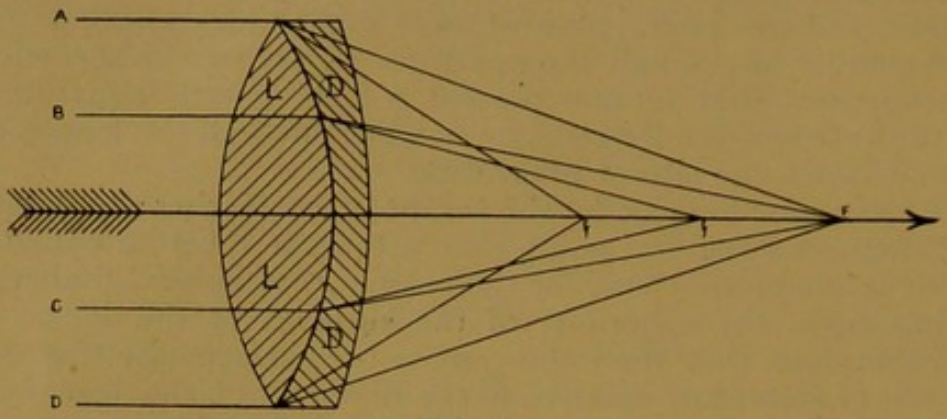


FIG. 4.

lens. In other words, the parallel rays A B C E enter into the lens L L, and on emerging would (were the divergent lens removed) find their focus the marginal rays A E at *f*, and the central rays B C at *f'*. But, as shown in fig. 4, these rays, on leaving the convergent lens, are compelled to enter the divergent one, by which the central rays B C are again refracted from *f'* to F, while the marginal rays A E are refracted from *f* to F. So that the effect of the divergent lens, properly calculated, is to bring all the rays at one focus (F), for the reason that its prismatic form is greater at the margin than at the centre. And if this lens be made of different kind of glass to the convergent, we shall at the same time be able to correct another form of aberration hereafter explained. These two lenses cemented together form a single convergent lens free from spherical aberration, which is termed aplanatic. It is, however, almost a matter of impossibility to so calculate the radii of curvature of the divergent lens as to *entirely* correct spherical aberration; at least, it has never been accomplished as yet.

As it is often necessary to test a lens for spherical aberration, the following instructions are given. Cut two small circular pieces of paper and fasten to the window pane so that they just touch each other, measure the aperture of the lens, and find a stop that will reduce it to one half. Focus the image of the papers, and carefully examine it by the aid of a focussing glass. Now place the diaphragm into position, and if it is found that when the stop is inserted the image of the paper dots becomes sharper, it is a sign that the aberration has not been completely corrected. It is, of course, necessary that this test should be made along the axis of the lens. If it is necessary to draw back the ground glass of the camera in order to preserve the image as it was before placing in the diaphragm, the lens possesses what is termed *positive* aberration, and if, on the contrary, we have to advance the screen, *negative* aberration.

Chromatic Aberration.—If a ray of light passes through a prism it is split up into its constituent coloured rays, and a spectrum is formed. (See fig. 5.) Now, these coloured rays emerging

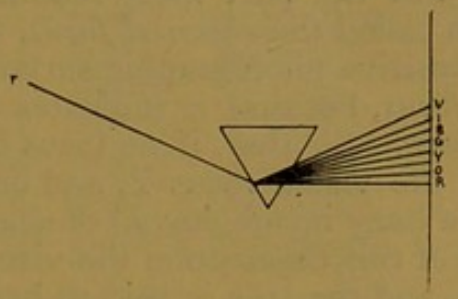


FIG. 5.

from the prism are unequally refrangible—that is to say, if they fall at the same angle of incidence on the surface of a refracting medium, they will each pursue, in this medium, a different path. The indigo and violet rays are more refracted than the yellow and red, and, in consequence, they are separated from them, occupying a higher position in the solar spectrum. Now, if the prism refracts the blue rays more than the red, and as the outside of a bi-convex lens resembles a prism, it is easily seen that a lens of this description will do the same, and will bring the blue rays to a focus at a point nearer than the red rays, giving what is termed chromatic aberration. The result of this is that we get on the screen a luminous image bounded by coloured fringes.

If we take a cheap non-achromatic magnifying glass, and look through it, we shall perceive the same effect. The object is surrounded by all the colours of the spectrum—very pretty to look at, but disastrous to photography.

Now, the causes which produce chromatic aberration tend also to divide the chemical and visual focus. If we take a photographic lens LL (fig. 6), and stop it down to reduce the spherical aberration to as small a quantity as possible, the image A of a white spot emits rays of different refrangibility; the violet rays

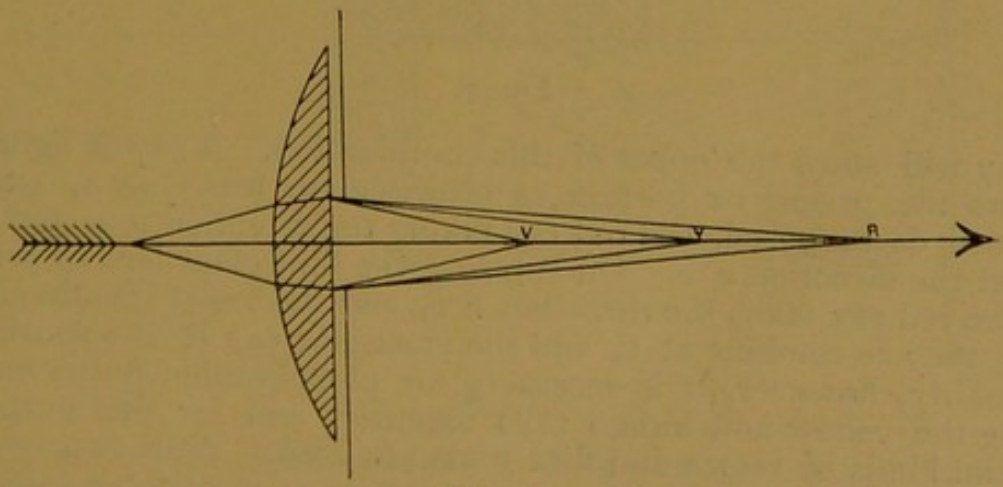


FIG. 6.

have their focus at V, the yellow at Y, and the red at R. Now, let us see the result. The chemical action corresponds more towards the violet, but the part most luminous to the eye is the yellow. The first is called the *chemical focus*, to indicate its focus as determined by sensitive photographic surfaces, and the latter is termed the *visual focus*, because it indicates the focus of the lens as apparent to the eye. So that, if we focus on the ground glass, we should do so at the visual focus Y, and on exposing the plate we should get only a hazy image devoid of sharpness. Therefore, we see that in a lens of this description the visual and the chemical foci do not coincide, and the lens is said to have a chemical focus. It was at one time necessary to focus at the visual point, and then, previous to exposing the plate, to push it forward to obtain the greatest amount of distinct outline in the image impressed by chemical action. But few lenses are now sold that are not achromatised, that is to say, so arranged that the visual and the chemical foci meet at the same point.

We have shown that a ray of white light entering a dense medium obliquely becomes decomposed at once, and we get a number of coloured rays; but if the surfaces of this medium be parallel to each other the effect is not seen, as the one counteracts the other, and the rays dispersed by the one are re-combined by the other. Or, if we combine two lenses made from different varieties of glass, and possessing different powers of separating the coloured rays, we obtain the same effect. The two kinds of glass used for this purpose are *flint glass*, containing oxide of lead, and a light *crown glass*. The former is usually made into divergent and the latter into convergent lenses. A glance at

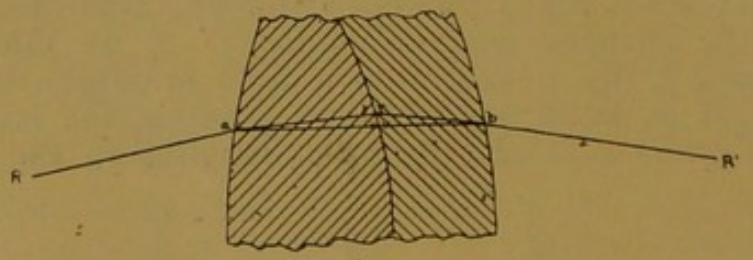


Fig. 7.

fig. 7 will show the effect of this combination. A ray of light R enters the prism, or portion of crown glass lens C at *a*, and is at once decomposed, the red ray taking the direction *a r* and the violet the direction *a v*. On entering the flint glass lens or prism F, the red ray takes the direction *r b*, and the violet the direction *v b*; they re-combine at *b*, and the emergent ray R′ is colourless. In reality, however, it is necessary for photographic purposes to bring the yellow and indigo rays together, and for this purpose special kinds of crown and flint glass are used. With two lenses or prisms it is only possible to achromatise at most three colours, but if chosen with a suitable angle and material it is sufficient

for all practical purposes. Figs. 8 to 13 show how these lenses are combined in different manners.

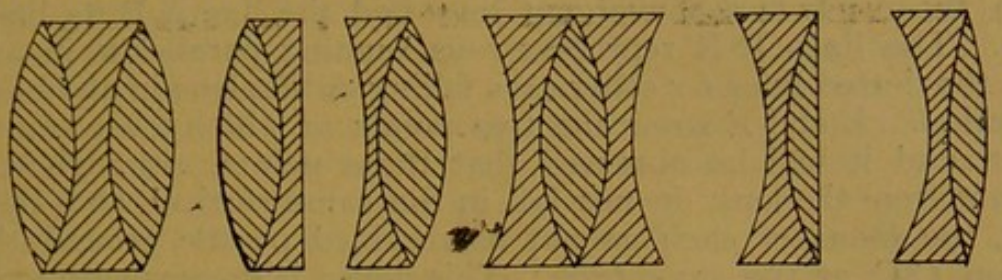


FIG. 13 FIG. 12 FIG. 11 FIG. 10 FIG. 9 FIG. 8

The first is a divergent meniscus, the second a plano-convex, the third a biconcave, the fourth a convergent-meniscus, the fifth a plano-convex, and the sixth a double-convex lens. The first three are divergent and the others convergent lenses. They are each composed of the two kinds of glass, crown and flint (the convergent lens in each case being of crown and the divergent of flint glass), cemented together.

Curvature of the Field.—In a photographic camera the image is thrown upon a plane screen; but, as will be seen by fig. 14, the screen, in order to receive the image, should be of a concave form. The retina of the eye, upon which the image is thrown, is of a concave form, and for this reason we see all things straight. The effect of placing a plane screen is at once apparent. When we focus this image on the ground glass in the centre the

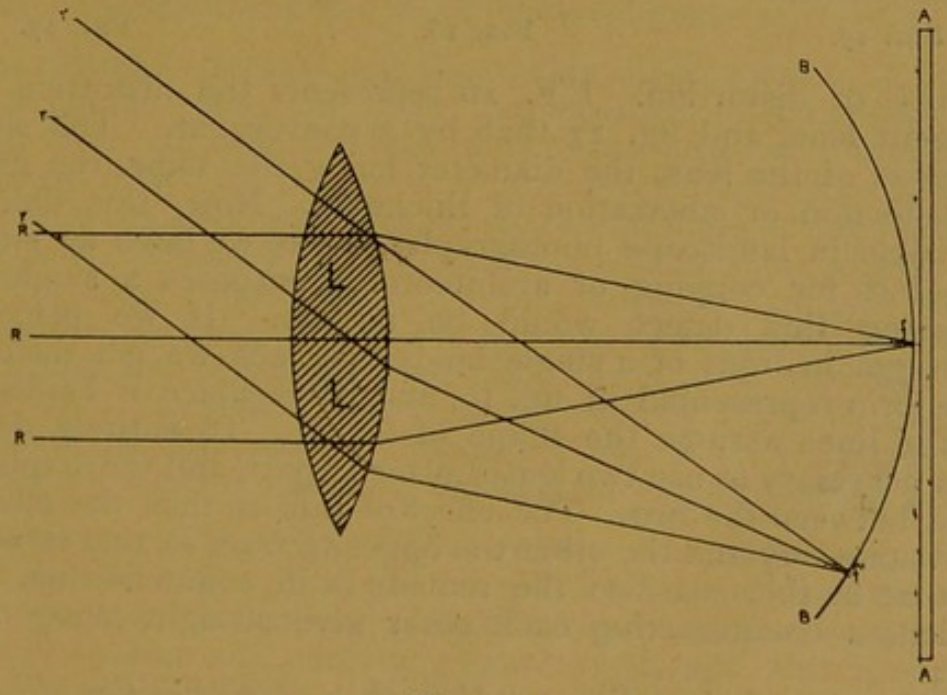


FIG. 14.

sharpness of the outer portions is destroyed, and if we bring the screen in a little these outer portions become sharp, but the centre loses its distinctness. This aberration is termed the *curvature of*

the field of the image, and is often mistaken for spherical aberration. It should not be, however, because unsharpness from that cause would be spread over the whole field.

In fig. 14, L is a convergent lens, and the line A B its line of axis. The lines R R represent rays running parallel to its axis, and the dotted lines *r r* other rays falling on the lens in an oblique direction. B and E show the two points at which these two foci meet, and it will be observed that these points, although equidistant from the lens, do not fall in the same vertical, and, therefore, the focus of each cannot be received on the ground glass screen C C at the same time. This defect is greater with lenses of short focus than with lenses of long focus, and it is remedied to a very great extent by the use of the diaphragm. This subject is also dealt with under the headings **Diaphragm** and **Focus**, *q.v.*

Aberration of Thickness, or distortion of the image.—This defect is at once apparent by drawing with a piece of black chalk on a white sheet of cardboard a series of black lines as in fig. 15, and focussing the same on the ground glass screen of the camera. If they possess the appearance of fig. 16 or 17 the lens

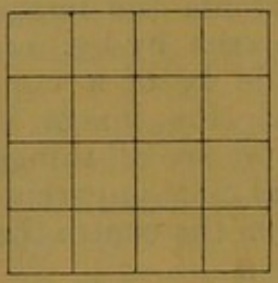


Fig. 15.

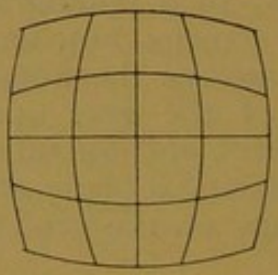


Fig. 16.

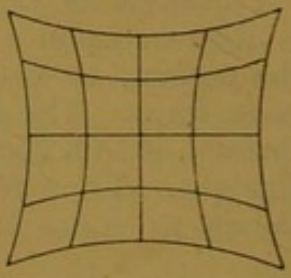


Fig. 17.

is guilty of distortion. Fig. 16 represents the distortion of a divergent lens, and fig. 17 that by a convergent. The shorter the focus of the lens, the diameter being the same, the greater the distortion or aberration of thickness. Now, this defect is not visible in landscape photography, where we have no straight lines, but for copying or architectural purposes a single lens possessing this defect would be useless. If we place the diaphragm in front of a single landscape lens we get distortion in the form represented in fig. 16, and if we place it behind the lens the lines assume the shape of fig. 17. To entirely destroy it it is necessary to use two lenses placed apart, and the diaphragm placed between the two. The effect of this is that the one lens distorts one way and the other the opposite way, so that it will be seen that in this case also the remedy is in counteraction. The two lenses counteracting each other give straight lenses as in fig. 15.

Astigmation, Astigmatism, or Aberration of the Position of Lenses, is a defect in a lens or combination of lenses, the result of which is a difficulty to obtain the same degree of sharpness round the margin as in the centre of the image. To test a lens for astigma-

tion cut out a circular disc of white paper, or take a white wafer and attach it to a black ground. Focus on the centre of the screen. Now turn the camera until the image of the disc is seen at the margin, but indistinctly, and upon endeavouring to focus it it spreads out vertically or horizontally, and takes the form of an oval. The reason of this is that for rays falling parallel to each other but oblique to the axis of the lens there are two focal lengths. One in the plane passing through the radiating point and the optical centre, and the other passing through the principal axis of the lens and the radiating point, but perpendicular to the first. This difference between the primary and the secondary focus is termed astigmatism or astigmation, the defect being also found in the eyes of a great number of people. It may be reduced to a minimum by the use of a diaphragm. It will be seen that the diaphragm plays several important parts, which are more clearly explained under that heading.

Absolute Alcohol.—See **Alcohol.**

Absolute Temperature (*Absolutus* — perfect).—Temperatures taken from the absolute zero of temperature are termed absolute temperatures, and are obtained by adding 458 to the temperature on the Fahrenheit scale, and 273 to the temperature on the Centigrade scale.

Absorbent (Lat. *imbibing*).—A term used in chemistry to denote any substance possessing the power of absorbing gases or vapours into its pores, such as charcoal made from dense wood, which thus takes up 90 times its volume of ammoniacal gas.

Absorption.—*In chemistry*, the taking up of a gas by a liquid, or by a porous solid. *In optics*, the retention of some rays, and the reflection of others when they pass into an imperfectly transparent body. In the study of the proper light for the dark room which shall not affect the sensitive materials during manipulation, it is necessary to obtain media which shall absorb the actinic rays and allow the non-actinic to pass through. Ruby glass was at one time supposed to be superior to anything else for this purpose, but unless of a very dark tint a little blue will also pass through. A yellow light is supposed to be super to a red, as it gives greater illumination, although a care must be taken that this does not allow too much green light to pass through it also.

Accelerator (Lat. *acceleratio*).—A term used in photography to certain agents which tend to hasten the action of the light upon the dry plate, or the working of the developer on the latent image. Heat will shorten the necessary exposure, as will also electricity under certain conditions. If the exposed dry plate previous to developing with ferrous oxalate be laid for a few minutes in a solution of hyposulphite of soda made in the proportion of one drachm of hypo to 150 ounces of water, the effect will be to con-

siderably hasten the action of the developer. This method is largely adopted in Germany for the development of instantaneous or under-exposed negatives. Common salt, perchloride of mercury, and nitrate of chrysaniline also act as accelerating agents with the oxalate developer. With alkaline development, the alkali is the accelerator. Common salt will also act as an accelerator in developing bromide papers, bringing up the detail gradually and evenly before the shadows get too dense.

Accessories.—See **Portraiture and Studio.**

Acetate of Amyl.—See **Amyl Acetate.**

Acetate of Copper.—See **Copper Acetate.**

Acetate of Lead.—See **Lead Acetate.**

Acetate of Silver.—See **Silver Acetate.**

Acetate of Soda.—See **Sodium Acetate.**

Acetates.—The acetates used in photography are given in their various places, as referred to above. To test for acetates, mix with sulphuric acid and heat gently, when the smell of vinegar can be detected. A neutral solution of an acetate gives with ferric chloride a red liquid, which becomes turbid and deposits a brown precipitate on boiling.

Acetic Acid (Lat. *acetum*—vinegar. (Formula, $C_2H_3O(OH)$, or $\left.\begin{matrix} C_2H_3O \\ H \end{matrix}\right\}O$ Molecular weight, 60. Synonyms, *Purified pyroligneous acid. Methane carboxylic acid*).—Methyl formic acid formed by the acetous fermentation of alcohol. Acetic acid is a monotomic monobasic acid, and its salts are called acetates.

Alcohol when quite pure is not affected by exposure to the air, but as soon as it is diluted, and a portion of yeast added to it, the yeast soon acts as a ferment, and causes the spirit to unite with the oxygen of the atmosphere, and become sour from the formation of acetic acid. A tray of finely-divided spongy platinum is placed on a triangle over a porcelain dish containing a little alcohol, gently warmed, and the whole covered with a bell glass, standing on a wedge, and opened at the top to allow a gentle current of atmosphere to pass through the apparatus. The oxidation of the alcohol proceeds very rapidly, and acetic acid condenses in abundance on the inside of the jar. In this method of production, however, aldehyde is developed as an intermediate product. The addition of ferments greatly assists the oxidation of the alcohol. In France and Germany wine is usually used; in England malt. Malt vinegar is obtained in this manner, it being nothing more than acetic acid diluted, and a little colouring matter and other impurities added. Concentrated acetic acid may be obtained by neutralising common vinegar with carbonate of soda, and crystallising out the acetate

of soda thus formed. This acetate is then deprived of its water of crystallisation, and fused at a gentle heat. After it is cooled, 82 parts of this salt are to be distilled with 98 of strong sulphuric acid, which removes the soda and liberates acetic acid. The acetic acid, being very volatile, distils over, and may be condensed.

Another method of preparation is by the destructive distillation of wood. Wood is heated in closed iron cylinders connected with condensers. In these receivers a watery liquid condenses, consisting of water, alcohol, acetic acid, and other products. This liquid is re-distilled to remove some of the alcohol, and chalk is added to the residue. With this addition the volatile acetic acid is converted into non-volatile calcium acetate, which on further distillation remains behind, the water and other volatile matters escaping. The impure calcium acetate is then gently heated to decompose the tar which it contains, and re-distilled with hydrochloric acid. The density of the acetic acid thus obtained is about 1·06, and it can be purified by re-distillation and the addition of a small quantity of sodium carbonate or potassium dichromate. The wood usually employed in the preparation of acetic acid is known as coppice wood.

Glacial Acetic Acid is a term applied to the pure acid $C_2H_4O_2$ of sp. gr. 1.0635, because at ordinary temperatures it becomes a crystalline solid. Pure acetic acid solidifies at or below 50° Fahr. in colourless prismatic or tabular crystals, soluble in water, alcohol, and ether. If heated above this temperature the crystals will melt, and it becomes a limpid liquid, with a sour, pungent taste and odour. It blisters the skin, and acts as an acid poison. It boils at 118° Fahr., and its vapour is inflammable.

Commercial Acetic Acid is generally described as being "glacial," or solid, at a certain temperature. The higher this temperature the stronger is the acid; therefore it is often diluted with water, and very often adulterated with sulphuric acid, added for the purpose of counteracting the effect of dilution by causing it to still retain its property of solidifying at a moderate temperature, and by this means deceive the purchaser of its true strength. The strength of commercial acetic acid can be approximately judged by its solidifying point. Place two or three drachms in a thin glass test tube, and lower it into powdered hypo to cool. A thermometer placed in the liquid will give the temperature, which should be read off directly the acid is seen to solidify, and compared with the following table.

Solidifying points of acetic acid of different strength :—

Solidifying Point Fahr.	Percentage of Water.
62°	0
60	·5
59	1
57	1·5
55	2
53	3
51	4

Solidifying Point Fahr.	Percentage of Water.
50°	5
46	7
43	8
42	9
40	10
39	11
37	12

It often happens that a trace of sulphuric acid used in its manufacture is unintentionally left in it, and the presence of either sulphuric or hydrochloric acid is fatal to photographic processes, for the reason that they quickly precipitate nitrate of silver. This fact enables one to readily detect the presence of either in the following manner:—Dissolve a small crystal of nitrate of silver in half a drachm of water, and then add another half a drachm of the glacial acetic acid to be tested, and if this mixture remains quite clear when exposed for a little time to the light, the acid can be used with safety. If, on the other hand, there is either hydrochloric or sulphuric acid present, a white deposit of chloride or sulphite of silver is quickly formed, and if aldehyde or any other volatile matter be present, the mixture will soon discolour if exposed to the action of daylight. If we have the white deposit only, and we are desirous of finding out whether it be hydrochloric or sulphuric acid that is present, it is easily done by the addition of nitric acid, which rapidly dissolves the sulphite, but leaves the chloride unchanged.

Another form of acetic acid is sold under the name of *Beaufoy's Acid*. It contains 30 per cent. of real acid, so that in making up formulæ it is necessary to treble the quantity, in order to get the correct amount of acetic acid. It should also be tested for impurities, as it usually contains many. Acetic acid is employed in photography as a solvent for gelatine in acetic gelatine emulsions, and as a restrainer in acid development.

Acetic Ether (Formula, $C_2H_3O_2C_2H_5$).—A compound of acetic acid and ether. It has an agreeable odour of apples, and is easily manufactured artificially by distilling a mixture of alcohol, oil of vitriol, and acetate of potash.

Acetometer (Lat. *acetum*—vinegar, and Gr. *metron*—a measure).—A hydrometer graduated for determining the strength of commercial acetic acid, according to its density. It is not always possible to ascertain correctly the amount of water present by the specific gravity, for an acid that contains twenty-one per cent. of water has a higher specific gravity than either a stronger or a weaker sample.

Achromatic (Gr. *achromatos*—colourless).—A term applied in photography to a lens which has been corrected for chromatic aberration. (See *Chromatic Aberration* under **Aberration**.) This effect is produced by combining two lenses of different dispersive

power, the one being of flint glass and the other of crown glass. A lens is said to be achromatic when it deflects rays of white light without colouring them.

Achromatism.—The destruction of the coloured fringes which accompany the image of an object seen through a prism or lens. The principles upon which achromatism is effected may be briefly explained as follows:—Prisms comprised of different substances do not give spectra occupying the same relative lengths; hence it follows that the primary coloured rays in passing through different substances are not refracted in the same relative proportions, and the angle formed by two rays, the red and the violet for instance, is greater when the light is refracted by some substances than it is when refracted by others. The angle formed between the extreme rays of the spectrum measures the *dispersion* of the rays, and it is found that the dispersive power of flint glass is to that of crown glass in the ratio of 3 to 2, so that if a prism of flint glass gives a spectrum three inches long, a similar prism of crown glass will give a spectrum of only two inches. It is possible, therefore, to arrange two prisms, the one behind the other, so that the chromatic effect of the first may be neutralised by that of the other as to destroy the colour and still retain a certain amount of refraction. The merit of this discovery of achromatic compensation belongs to John Dollond, who arrived at it by skilful and systematic experiments. Upon its principle all achromatic lenses are constructed.

Acid (Lat. *acidus*—sour).—A salt of hydrogen in which the hydrogen can be replaced by a metal, or can, with a basic metallic oxide, form a salt of that metal and water. Acid oxides of the same element are distinguished by the termination of *ous* and *ic*, as sulphurous and sulphuric, the latter containing the most oxygen. They are also called anhydrides. They unite with water, and form acids, having the same terminations. By replacing the hydrogen by a metal they form salts distinguished by the terminations *ite* and *ate* respectively. These acids are called oxygen acids; formerly it was thought that all acids contained oxygen, this element being regarded as the acidifying principle (generating acid). But many acids are formed by direct union of hydrogen with an element, as hydrochloric acid (HCl), hydrosulphuric acid (H_2S), or with an organic radical, as hydrocyanic acid. Acids that are soluble in water will cause blue litmus paper to redden and have a sour taste. Acids are said to be monobasic dibasic, tribasic, &c., according as one, two, or three atoms of hydrogen can be replaced by a metal. Organic acids can be produced by the oxidation of an alcohol or aldehyde. They contain the monad radical (HO·OC) once if they are monobasic, twice if dibasic, thrice if tribasic, etc. They are also classed as monotomic, diatomic, according as they are derived from monotomic or diatomic alcohol. Acids derived from diatomic alcohol can be alcohol acids or aldehyde acids.

Many organic acids occur in the juice of vegetables and in animals. An acid and a base will rarely exist together, but will combine to form the corresponding salt. In adding citric acid to the alkaline developer, it acts not only as a restrainer, but it also combines with some of the free alkali, lessening the amount in the developer.

Acidimeter (Eng. *acid*, and *metron*—measure).—An instrument for measuring the strength of acids.

Acidimetry.—The process of determining the quantity of real acid in a sample of hydrated acid. This is accomplished by volumetric or by weight analysis. The former method is carried out by ascertaining the measured quantity of a standard alkaline solution required to saturate a given quantity of the acid. By weight analysis a known weight is decomposed with an excess of acid, carbonate of sodium or potassium, and estimate by weight the quantity of carbonic anhydride evolved. When this is done the quantity of acid can easily be ascertained.

Actinic (Gr. *aktinos*—a ray of light, lit. pertaining to a ray or rays of light).—A ray of light usually possesses three properties, the luminous, the calorific, and the actinic. The actinic is that peculiar property which produces the chemical changes upon which the whole art of photography is based. Under **Spectrum** this subject is more clearly demonstrated. A ray of white light may be split up into its constituent colours, giving what is termed the solar spectrum. We find that actinism, or the property of producing chemical changes, exists chiefly among the blue and violet rays, while the yellow are termed non-actinic. The violet rays produce the chemical action, but the yellow or luminous rays produce the visible image on the screen. Chromatic aberration in a lens tends to divide these two, so that it is easily seen how important it is to have these two foci combined. For further information on this subject see **Aberration.**

Actinism.—The chemical action of sunlight. See **Actinic.**

Actinograph (Gr. *aktinos*—a ray, and *grapho*—to write down).—An instrument invented by Mr. Hunt for regulating the variations of chemical influence on the solar rays; fully described in the British Association Reports for 1845-46.

The name has also been given to a more recent invention of Dr. Hurter for calculating photographic exposures. It consists of a small box, which can be easily carried in the pocket, and contains four suitably mounted logarithmic scales which correspond with the light, the lens, the speed of the plate, and the exposure. Like all other instruments for calculating the exposure, this is practically useless, although it has proved of much value for self-recording the fluctuations of the light during the year.

Actinometer (Gr. *aktinos*—a ray, and *metron*—a measure, lit. measurer of solar rays).—There are various forms of actinometers, which may briefly be termed instruments for measuring the actinicity of light. In photography, they are used in conjunction with certain logarithmic tables to endeavour to work out the necessary exposure to be given to the dry plate. They may also be used for timing positive prints, especially those in which the image is invisible, such as in the carbon or asphalt process. The terms actinograph, photometer, and other fancy names have also been given to them. A description of the most notable kinds will be given.

Herschel's Actinometer.—An instrument devised by Sir John Herschel for measuring the intensity of the solar rays. It consists of a thermometer with a large bulb, filled with a dark blue fluid, and enclosed in a box, the sides of which are blackened and which is covered with glass. It is placed for a minute in the shade, then a minute in the sun, and then one more minute in the shade. The mean of the two variations in the shade is then subtracted from that in the sun, and the result measures the influence due to the solar rays.

Draper's Actinometer.—Invented by Mr. H. Draper, of New York, is based upon the fact that ferric oxalate, when exposed to the action of the light, gives out carbonic acid. This is explained by the following :—

Ferric oxalate	=	Ferrous oxalate	+	Carbonic anhydride.
$Fe_23C_2O_4$	=	FeC_2O_4	+	$2CO_2$

The action of the light vibrations upon the ferric oxalate molecules is to split them up, and for each molecule so acted upon one molecule of carbonic anhydride is liberated. Draper's apparatus consists of a small glass cistern, containing exactly 500 grains of a standard solution of ferric oxalate. The cistern is covered over with an opaque covering, except one square inch through which the light is admitted. After the exposure to the light, the amount of carbonic anhydride disengaged was calculated by the difference in weight before and after the exposure.

Roscoe's Actinometer.—In this the actinicity of daylight or sunlight is measured by the exposure of sensitive silver chloride paper to its action for certain lengths of time at each hour. To effect this the piece of sensitised paper is fixed round a drum. This drum can turn on a horizontal axis, and the frame which supports it can slide horizontally. A piece of thin sheet brass is fixed over the drum, and a hole is cut through it. It is so arranged that it presses down lightly on the top of the drum, thus a small piece of the sensitised paper is always exposed to the daylight, and the rest is in total darkness. Thus, by the horizontal movement of the frame and the turning of the drum, every part of the sensitised paper will have been brought under the hole. The manner in which it works is this. The frame which supports the drum is continually moving slowly in a horizontal direction.

Between the hours the drum does not turn, but only moves slightly in a horizontal direction. At the hour the drum turns suddenly for a small part of a revolution, thus exposing a fresh piece of paper under the hole. After two seconds it again turns suddenly as before, exposing that piece of paper for two seconds. In a similar manner fresh pieces of paper are exposed for 2, 4, 6, 10, 20, 40, 90 seconds, and after this the drum does not rotate again till the next hour, when a similar set of movements takes place. Hence, between the hours, there is a piece of paper exposed for 57 minutes, and which is useless on account of the long exposure. Owing to the horizontal movement of the drum, a fresh piece of paper is exposed when one complete revolution of the drum has taken place. An instrument of this kind is set up at South Kensington, and Captain Abney has designed a special reading-off apparatus, which greatly facilitates the operations necessary for the daily readings.

Stanley's Actinometer consists of a ribbon of sensitive paper placed upon a reel, so that a small portion may be drawn out at a time under a glass cover, upon the underside of which is placed a piece of tinted paper. By taking the time required for the sensitive paper to arrive at the standard tint, the relative actinicity of the light is ascertained.

Woodbury's Photometer is perhaps the simplest constructed instrument of this kind. It was invented by the late W. B. Woodbury, and consists of a small circular box having something of the appearance of a watch. A slip of paper passes under a hole in the centre of a disc printed with a scale of tints. The portion of the sensitised paper visible through the centre aperture being exposed to the light for one minute, it is carefully compared with one of the surrounding tints, whichever tint it corresponds with; knowing the value of that tint, the necessary exposure is easily arrived at. If a bromide plate is used, bromide paper, sensitised with a 10 per cent. solution of potassium nitrite must be placed in the photometer; for a chloride plate, chloride paper, and suitable tints, to be used as guides, prepared. This little instrument is also extensively used as a guide to the exposure of printing frames when making prints upon a carbon tissue, or by other processes where the action of the light is invisible.

Decondin's Photometer is an instrument for determining the necessary exposure by the apparent brightness of a portion of the image as seen on the ground glass. This is done by rotating a diaphragm pierced with various sized holes, the point at which the illumination of a figure is just extinguished being marked with a letter which, on reference to a table, gives the necessary exposure.

The word sensitometer is often used to denote instruments of the kind described, but this is erroneous. Sensitometers will be found under their own heading, and differ from actinometers insomuch as an actinometer is an instrument to measure the

actinicity of light upon certain photographic preparations, and a sensitometer is an instrument arranged to measure the sensitiveness of such preparations to the actinic rays.

Actinometric.—Pertaining to an actinometer. Under this heading we will give the most interesting results that have (according to Prof. Roscoe) been obtained by actinometers for measuring the chemical action of the solar rays. The accompanying diagrams of curves (fig. 18) show the variation of the chemical action of daylight with the different months. Each curve is marked with the month, and denotes the rise and fall of the chemical intensity from 6 a.m. to 6 p.m. With this chart it will be seen that at mid-day in July the chemical intensity is more than seven times greater than at mid-day in December. This chart was made at Kew, but it is a well-known fact that this chemical action of light varies to a

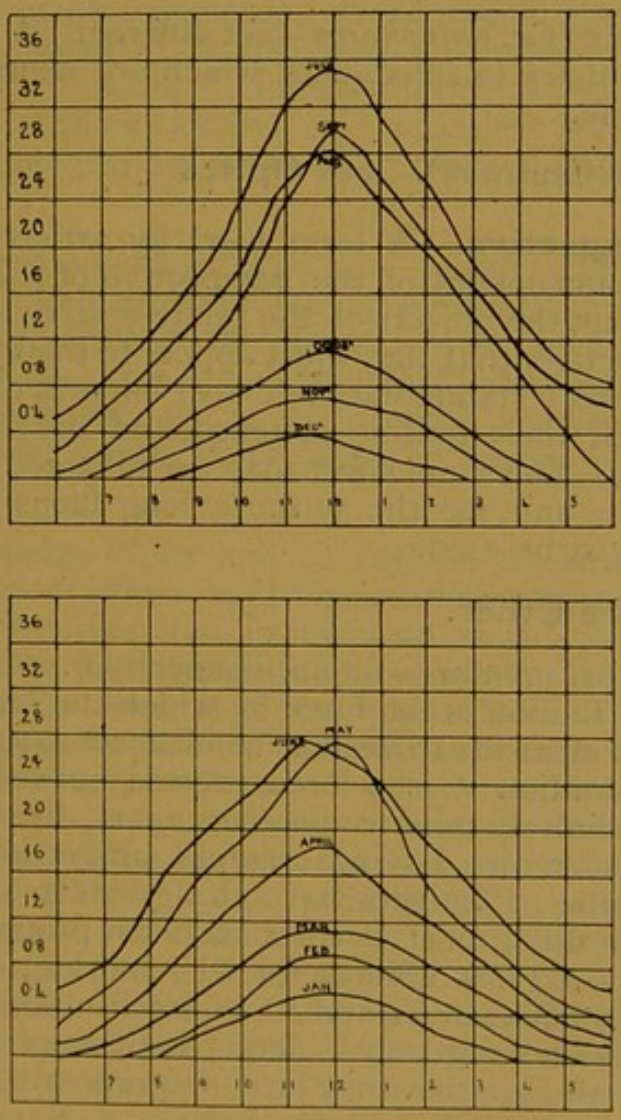


FIG. 18.

Observations made at Kew, showing intensity of light during different months.

very considerable extent in different portions of the globe. According to the various observations of photographic travellers we find that the nearer the equator the more difficult is it to obtain good photographs; also the exposure in the tropics with the blazing sun is required to be much longer than on a gloomy day in England. Careful scientific observations have proved that the chemically active rays of the tropics are much greater than in this country. At Pará, situated nearly under the equator, they were, according to observations made on a certain day by Prof. Thorpe, seven times greater than on the same day at Kew; therefore, if the statement of increased exposure be correct we have to look for some other cause than the diminution of the sun's chemical intensity.

Adapter.—A removable attachment to a camera, enabling the operator to work a plate of larger dimensions than that for which his camera is constructed.

Adiaphorous (Gr. *adiaphoros*—not different.) A term sometimes applied in chemistry to substances which are neutral, *i.e.*, neither acid nor alkaline.

Admission (Centre of).—See **Optics.**

Aerial Perspective.—A term used by artists to denote that high artistic management of the perspective of a landscape which not only presents the objects of the relative size, according to the rules of perspective, that they must appear to the eye when viewed from the observer's standpoint, but also imparts effects as if they were seen with their outline softened and the idea of distance rendered clear. The same effect may be obtained in photographing landscapes, and for the purpose long focus lenses or large diaphragms must be used.

Aether.—See **Ether.**

Affinity (Lat. *affinitas*—union, connection).—Chemical affinity or chemical attraction is the force by which the union takes place of two or more elements to form a chemical compound. According to another definition it is a force exerted between two or more bodies at an infinitely minute distance apart, by which they give rise to a new substance having different properties to those of its component parts. Elements have the greatest affinity for other elements which differ most in their chemical properties. Thus H (hydrogen) has a great affinity for Cl (chlorine) and O (oxygen), but the affinity between Cl and O is much weaker. Acids unite readily with alkalies and most metals with sulphur. When two salts are mixed together they are decomposed if an insoluble substance can be formed. Thus, $AgNO_3$ + NaCl yields $NaNO_3$ and insoluble AgCl, and $BaCl_2$ + $MgSO_4$ yields $MgCl_2$ and insoluble $BaSO_4$. A strong acid generally expels a weaker one, as H_2SO_4 expels HCl or CO_2, and CO_2 precipitates SiO_2, but

when two salts are fused and a more volatile compound is formed it is driven off, as when NH_4Cl is heated with dry $CaCO_3$ then $(NH_4)_2\ CO_3$ volatises. The relative affinities between different substances varies with their temperature, insolubility, and power of vaporisation. Alteration of the temperature alters the affinity. Thus, if mercury be heated to its boiling point it absorbs oxygen, which it liberates at a still higher temperature.

The investigation of the relative proportions in which bodies combine forms the basis of the atomic theory or doctrine of chemical equivalents.

Affinity of Solution is such an affinity as exists between a soluble salt and its fluid in which it is dissolved. Until the liquid is saturated with the salt the two can combine in an indefinite ratio, instead of being limited to the fixed proportions, in which alone chemical affinity operates. (See *Chemistry*.)

Agar-Agar (Bengal Isinglass).—A vegetable gum obtained in China from sea weeds. Transparent colourless strips, almost completely soluble in water. If melted down and allowed to set it forms a quantity of thick tasteless and odourless jelly. It is sometimes used for photographic purposes in place of gelatine, but it is inferior.

Agent (Lat. *agens*—doing, from *ago*—to do).—That which possesses the power of acting or producing effects upon anything else. In photographing, light is the agent which forms the invisible image upon the sensitive emulsion plate, the developer is the agent which causes this image to become visible, and sodium hyposulphite is the agent which fixes, or makes permanent, the same.

Air.—A knowledge of air and its various properties should be useful to the photographer, as it forms an important item in his operations. It deceives him in outdoor work, and is a silent destructive agent to his chemicals and appliances. The greatest point to observe, however, is the supply of fresh air to the dark-room, or other places in which photographic operations take place. This subject is, however, fully treated upon under **Ventilation**, *q.v.*

The air we live in is a mixture of several different kinds of gaseous substances. Oxygen and nitrogen, however, are its chief constituents, the others being present in minute quantities. Roughly speaking, dry air contains in ten thousand parts (by volume) 7,912 of nitrogen, 2,080 of oxygen, 4 of carbonic acid, and 4 parts of carburetted hydrogen, also a trace of ammonia. We cannot see the air in its pure state, although it can be weighed, compressed, or made to expand. The weight of air is about 760 times lighter, bulk for bulk, than water. The actual thickness of the layer of atmosphere surrounding the globe is not correctly known. Wollaston assigned a limit of forty to forty-five miles, but from observations made by M. Lilias at Rio Janeiro on the twilight

arc, he infers that the extreme limit is between 198 and 212 miles, a very considerable difference. Unfortunately, it is not possible for man to ascend to any great height, for at eight miles all animal life would be destroyed. The highest ascent that has been made by persons who have returned alive was that made by Mr. Glaisher and Mr. Coxwell. They ascended to an altitude of 37,000 feet, or a fraction over seven miles, and but for the ability of one of the occupants of the car to open the escape valve (which he did by catching the cord between his teeth, his hands being useless) they would neither have survived many minutes.

The pressure of the atmosphere upon the earth is about 15lbs. to the square inch, which is technically termed one atmosphere. When large surfaces are concerned this increases to an astonishing degree, the pressure of the atmosphere upon a square mile being 263,000,000 tons.

Besides the substances already mentioned the air contains an amount of aqueous vapour which varies with the temperature, and is more abundant with a south and west wind in summer and in warm weather, than with a north and east wind in winter and cold weather. This vapour rises from water in minute molecules, which float freely about in the interspaces between the atoms of the oxygen and nitrogen. And here it is necessary to mention a fact that is essential for photographers to remember. If we bring into a warmer room a glass containing cold water the aqueous vapour condenses, and becomes visible on the surface of the glass. If a cold lens is brought into the room the same effect takes place, and if not noticed the result of using it would be a hazy picture. In such cases it is of no use to wipe away this moisture, but lay the lens in a warm part of the room for a few minutes.

Combustion and respiration both act similarly in vitiating the air by consuming the oxygen and giving back carbonic acid and water. Carbonic acid and water are both considerably heavier than air, and it would be inferred that they would sink to the floor ; but when liberated they are hot, and consequently ascend, being in this state lighter than air. The foul air, therefore, accumulates at the top of the room, and for this reason chemicals—unless in closely-stoppered bottles—and sensitive materials, such as plates and paper, should never be stored higher than about five or six feet from the floor.

Many of the chemicals and solutions used in photography absorb the oxygen from the air. Both the pyrogallic and the ferrous-oxalate developers absorb oxygen, and for this reason will not keep. The best plan to protect oxidisable aqueous solutions from the air is to cover with a layer of about half-an-inch of paraffin. The liquid can be drawn off with a glass tube bent to form a syphon.

There are also many substances which take up water from the air, and dry it, becoming liquid themselves. Among these may be named calcium chloride and potassium carbonate. This property is

utilised in many cases in which it is required to preserve any substance from being spoilt by the aqueous vapour. Platinum paper, for instance, has to be kept perfectly dry, and for this purpose calcium chloride is used.

Air-bells.—Small bubbles of air which frequently make their appearance in photographic operations; for instance, in coating glass with emulsion, paper with albumen, or in development. They can usually be removed by pricking with a needle, which for convenience is fixed in a handle of wood. On immersing a plate in the developer air-bells often adhere to the film, and in consequence development does not take place at those parts appearing as transparent spots in the fixed negatives. To prevent this the exposed plate is sometimes placed for a few seconds under a running tap previous to development, or the air-bells may be removed by a broad camel hair brush after the plate is immersed in the developing solution.

Air-brush.—An American invention which can be used for retouching enlargements. The brush consists of a small machine held in the hand. With this machine the colour is blown in a fine spray upon the paper by means of a foot-bellows connected to it. This spray is regulated by a rapidly-moving needle, controlled by the thumb. Very fine soft effects are thus produced. The machine is especially suitable for retouching bromide enlargements made upon smooth-surfaced paper, which cannot be well worked on with crayons.

Alabastrine Process.—A name given by Archer to one of his early invented processes. The collodion negative was, after fixing and washing, placed in a solution of bichloride of mercury and bleached. By backing with a dark substance a positive is produced. The same effect may be obtained with a gelatine negative preferably under-exposed. The hypo after fixing is thoroughly eliminated from the negative, and the latter is immersed in a solution of perchloride of mercury 20 grains dissolved in half a drachm of pure hydrochloric acid, and to it added common salt 10 grains, iron sulphate 10 grains, and distilled water 1 oz. When immersed the image immediately whitens. It is then well washed and dried, and either varnished at the back with black varnish or backed with black cloth or velvet.

Albertype Process.—A photo-mechanical process known in this country as collotype. The name Albertype is from Albert, of Munich, the inventor. See **Collotype.**

Albumen or **Albumin** (Lat. *white*).—(Formula uncertain, though probably $HNaC_{72}H_{110}N_{18}SO_{22}H_2O$.) Albumen is the chief and characteristic constituent of the white of egg (*albumen ori*) and of the serum of blood. Albumen is also present in many other animal and vegetable substances. Commercial albumen is prepared

either from the white of egg or from blood serum, the colourless liquid in which the corpuscles are suspended. White of egg consists of transparent thin walled cellules enclosing an alkaline solution of albuminate of sodium. On beating it up with water, the cellular substance separates in pellicles, while the albuminate of sodium remains in solution together with chloride of sodium and phosphate of calcium. In order to remove these mineral substances, the liquid after being filtered from the cellular substance is mixed with a small quantity of subacetate of lead, which produces an abundant precipitate (an excess of lead salt would redissolve it). This mass, after being washed, is stirred up with water to the consistence of a paste, and carbonic acid gas is passed through the liquid. The albuminate of lead is thereby decomposed, carbonate of lead remains suspended in the liquid, and the albumen in the free state remains dissolved. The solution is filtered through paper previously washed with dilute acid, and as it still retains traces of lead it is treated with a few drops of aqueous hydrosulphuric acid and carefully heated to 140° until it begins to show turbidity; the flocks of albumen thus precipitated carry down the whole of the sulphide of lead. When the liquid, which after filtration is perfectly colourless, is evaporated in large capsules at 104° Fahr., a residue is obtained consisting of pure soluble albumen. If the same method be applied to the albumen of blood serum it does not yield a perfectly pure product. Egg albumen differs from blood albumen by giving a precipitate when agitated by ether, scarcely soluble in strong nitric acid. If dried in the air it forms a bright yellow gum-like substance, easily triturated and reduced to a white powder which will not putrefy. It swells up in water like gelatine, but dissolves with great difficulty unless the addition of an alkali be made. Blood albumen is usually prepared by collecting the blood in a flat-bottomed vessel, where it is allowed to stand for six or eight hours. The serum is then decanted into a filter and received in a vessel having a hole in the bottom of it fitted with a cork, through which a glass tube passes up above the level of the liquid. When the upper portion of the serum becomes quite clear the tube is lowered, and the clear serum thus drawn off. It is then evaporated with a gentle heat and is ready for use. The blood of five oxen or 20 sheep yields about 2lbs. of dry albumen.

Albumen is capable of existing in two very distinct modifications, viz., the soluble form in which it always occurs in the human body, and the insoluble (in water) form. It is impossible to detect any difference between these two varieties, but when coagulation is determined by certain substances the product is a compound of albumen with the agent used. Soluble albumen may be coagulated or converted into the insoluble form by heating to boiling point or by the action of alcohol or nitric acid. It becomes insoluble in water and alcohol, barely soluble in dilute potash, but soluble in acetic acid. Many of the metallic salts serve to coagu-

late albumen; nitrate of silver or bichloride of mercury will completely. The chemical composition of egg and blood albumen is thus given :—

Egg Albumen (Mülder).		Blood Albumen.	
Carbon	53·4	Carbon	53·4
Hydrogen ..	7·0	Hydrogen ..	7·1
Nitrogen	15·0	Nitrogen	15·6
Oxygen	24·6	Oxygen	22·1
Sulphur	—	Sulphur	1·8
	100·0		100·0

If nitrate of silver is added to a solution of albumen, a white precipitate is formed, caused by the combination of the animal matter with the protoxide of silver, termed albuminate of silver (see **Silver Albuminate**). If heated in a current of hydrogen gas it assumes a reddish-brown colour. Albumen also combines with many other substances. It is preserved by the addition of ammonia or a piece of camphor floated on its surface. Commercial albumen is often adulterated with gum or starch; to detect, dissolve the albumen in warm water and add a little acetic acid; if a precipitate be formed gum is present. Starch may be detected by adding iodine to the solution; it gives a black colour.

Albumen is very extensively used for photographic purposes. It serves as a capital substratum to hold the silver salts, and combines with the silver to form silver albuminate. If the silver nitrate bath be too weak the albumen will become soluble. Egg albumen is the best, though a large quantity of the albumenised paper now sold is prepared with blood albumen; it has a disagreeable smell, however. Formerly it was largely used for glass negatives or positives, but is now used almost solely for paper positive processes, although it is sometimes used in collodion emulsions, owing to its property of giving greater sensitiveness to the film. In photo-mechanical processes it is used on account of its possessing the same property as gelatine of becoming insoluble when potassium dichromate is added to it, and it is exposed to the light.

It is also of great service for clarifying purposes, because if boiled with liquids it coagulates and clutches hold of all impurities and colouring matter, and carries them to the bottom or to the top according, of course, to the density of the liquid. It is used in France under the technical name of *glaise*, to impart a gloss to card, paper, and other surfaces. Its property of forming a hard compound, when mixed with lime, makes it very useful for making cement for laboratory purposes, and for mending broken dishes, measures, etc.

TABLE OF STRENGTH OF SOLUTIONS OF ALBUMEN.

Per cent.	Specific gravity.	Per cent.	Specific gravity.
5	1·031	30	1·078
10	1·026	40	1·106
20	1·052	60	1.135

Albumen—Beer Process.—A collodion is prepared with the following formula :—

Alcohol ·825	12 to 16 ounces.
Ether	12 to 16 ,,
Pyroxyline	4 drachms.
Ammonium iodide	1 ,,
Cadmium bromide	2½ ,,

The relative proportions of ether and alcohol are arranged according to the temperature in which the plates are to be prepared; the warmer the weather the greater must be the proportion of alcohol to the ether. The plate, thoroughly clean, is coated with this collodion and sensitised in—

Recrystallised silver nitrate.. ..	2 ozs. 6 drachms.
Water	36 ounces.
Potassium iodide	4 grains.

After sensitising, the plate is thoroughly washed and the first preservative applied. Formula :—

Albumen	3½ ounces.
Water	3½ ,,
Ammonium hydrate..	3 drachms.

This is beaten up into froth, and immediately before use is mixed with an equal quantity of ordinary beer or stout and floated over the plate. The superfluous solution is drained off, and the film thoroughly washed under the tap for a couple of minutes, and finally rinsed with a solution of plain beer, to which 1 per cent. of pyrogallic acid has been previously added. The exposure is about the same as required for the wet collodion process, although a greater latitude is permissible. Development may take place any time within a month or so after exposure. The developer is made up as follows :—

No. 1.	Pyrogallic acid	15 grains.
	Water	1½ ounces.
No. 2.	Ammonium hydrate ·880	1 part.
	Water	4 parts.
No. 3.	Citric acid	1 drachm.
	Acetic acid (glacial)	1 ,,
	Water	1 ounce.
No. 4.	Silver nitrate	15 grains.
	Water	1½ ounces.

The plate is first washed in water, the temperature of which is not lower than 60° Fahr., and then the developer made up from the four solutions given. To each 2 ozs. of No. 1 add ten drops of No. 2, and after well mixing flow over the plate. The image appears almost immediately. Another seven drops of No. 2 are now added to the solution, which is again floated over the plate. Twenty drops of No. 3 are next poured into the developing cup, and the developer poured into it and well mixed. Again is the plate rinsed, this time by the acidified pyrogallic solution, and intensification given by the use of it with No. 4. It is fixed by hyposulphite of soda, or by potassium cyanide.

The foregoing process was devised by our pioneer of photographic science, Capt. Abney, and used by him successfully at Egypt in 1874, when on the expedition to photograph the transit of Venus. For ordinary landscape or scientific work it answers admirably, and is very certain in its results.

Albumenise.—To treat with albumen.

Albumenised Paper.—Paper coated with albumen, to which salt is added. The introduction of albumenised paper has been credited to Fox Talbot, though the earliest records are to be found in a French work of Le Gray published about 1850. The manufacture of albumenised paper has now become a not unimportant industry, although by far the greater quantity is made abroad, chiefly in Dresden. The low price at which the ready prepared paper is sold makes it far cheaper to purchase than to make it oneself. The paper used must be homogeneous throughout, and of a fine texture and quality. The surface must be uniform, smooth, and entirely free from all chemical impurities which, by decomposition when treated with other chemicals, would spoil the picture. The two most suitable kinds are Saxe and Rive paper. This paper is rolled with cylinders composed of hard paper pulp. If the paper be rolled with metal rollers fine metallic dust impregnates the paper. This is invisible until heated with the silver nitrate, when a combination takes place, and black spots become visible. To prepare the paper, take the whites of fifteen eggs, which must be absolutely fresh, crack each egg separately in a cup, remove the yolk, and place the white into another vessel before cracking the next; remove any impurities with a glass rod, and ascertain the number of ounces. There should be about fifteen, as a good-sized English egg will yield about an ounce of albumen. It may be necessary, however, to break another one to make up the fifteen ounces. Next dissolve 150 grains of ammonium chloride with half an ounce of spirits of wine and four and a-half ounces of water, and add to this the albumen. Beat the mixture into a thick white froth with an egg-beater, then allow it to stand and the deposit in the albumen to settle. It is then filtered through a sponge or piece of cotton wool (previously well washed in distilled water) and poured into a flat, low-edged dish, a few inches larger than the size of the paper to be prepared. Much care is necessary in laying the paper upon the albumen to avoid the formation of air bubbles. Each sheet of paper, cut into a convenient size, is laid hold of at opposite corners with the finger and thumb of each hand, and the two hands brought close together, giving the paper a convex surface. It is then lowered on to the albumen until the middle of the paper touches it, the hands are then separated and brought down until the whole of the sheet floats upon the albumen, except a small corner which is turned up for convenience in laying

hold of the sheet again to remove it. After the paper has laid on the albumen for a few seconds it is lifted up halfway, and the air-bubbles removed with a small camel-hair brush dipped in the albumen, it is then laid carefully back again and the other half treated in the same way. All air-bubbles removed, the sheet must be allowed to rest on the solution for about a minute. It is then lifted up by the turned-up corner and hung up by two corners to dry. If the paper be dry, and the weather also very dry, the albumen does not attach itself very easily to the paper, and in this case, although a sheet has been properly floated, the top part will allow the albumen to run off, so that the film is much thinner at the top than at the bottom. To obviate this the sheet should be suspended by its broadside. American clips attached to wires stretched across the room serve admirably to attach the paper to. When dry the prepared paper is rolled between steel rollers and packed away flat. Paper prepared in this manner is what is termed single albumenised paper. Double albumenised paper is made by coagulating the first layer of albumen by steam, and repeating the operation.

Albumen Process.—The albumen glass positive process is still much used for making transparencies, lantern and stereoscopic slides. The manipulations may be carried on in a yellow light, it being more pleasant to work in than the red. First prepare a solution of albumen by breaking up eggs separately and removing the yolks. When 12 ounces of the whites have been collected, place in a convenient vessel and add half a drachm of glacial acetic acid diluted in one ounce of water. Stir it well with the albumen with a glass rod for about two minutes, a little care being taken that froth is not produced. The addition of the acetic acid causes a flocculent deposit, which in about an hour collects itself in a mass at the top of the solution. This is easily removed with pieces of paper, and the albumen should be perfectly clear and rather limpid. Strain through linen and add 50 minims of ammonia sp. gr. ·880 to restore the viscidity destroyed by the acid. The next addition is one drachm of ammonium iodide and eight grains ammonium bromide. When these ingredients are dissolved, the albumen is ready for use at any time if kept in well-corked bottles, remaining good for at least a year.

We must next select the glass. If for lantern slides it must, of course, be of a better quality, and free from bubbles or other impurities. This is coated with a plain collodion, and as soon as the film has set the whole is plunged in a dish of cold water, where it is allowed to remain from four to five minutes. Each glass so coated and treated is next rinsed under a tap to remove all greasiness, and then stood up on end on a pad of blotting paper.

The albumen is next filtered through cotton wool (a small tuft being placed in the neck of the funnel) into a glass measure. A little of it is then poured on the upper end of the plate and

made to flow over the whole of the film in one continuous wave, driving the water before it off the plate into the sink, and following it itself. Drain the plate well, and then pour on a fresh portion of the albumen, and let it flow backwards and forwards to allow it to soak well into the porous collodion film ; then drain it off into a measure and place the plate carefully in a rack. Coat as many as will be required for some time, as they will keep for a lengthy period. The rack containing the plates should be placed in a warm room to allow them to dry, and as soon as they dry they are placed before a fire and made as hot as the hand can possibly bear. The object of this is to prevent the film blistering during the subsequent treatment, and it is a very effective means. The plates have next to be sensitised. In one pint of distilled water dissolve four grains of potassium iodide and add 2 oz. of silver nitrate. When this has dissolved, add 2¼ oz. of glacial acetic acid, and the sensitising bath is ready for use. The plates can be laid in a dish containing the solution, but, if possible, use a dipping bath, as described in the wet collodion manipulations. The time of immersion should not exceed half or three-quarters of a minute. When taken from the sensitising bath the plates are placed in a dish of distilled water to remove the free silver nitrate. They are then well rinsed under a tap and again placed in the drying rack. These sensitised plates may be made to keep if treated with a solution of gallic acid. If the sensitising bath becomes discoloured, as it will do if many plates are prepared in it, shake up a little kaolin in it, and the discoloration will disappear, and the bath resume its pristine efficacy.

Printing is usually done by superposition. The exposure differs, of course, with the quality of the negative and the light. A negative of medium density will require at one foot from an ordinary fish-tail gas burner an exposure of between 10 to 20 seconds. Practice alone enables one to judge correctly, and with plates of this description there is a great latitude.

For development prepare two solutions, the first containing three grains of pyrogallic acid dissolved in one ounce of water ; and the second five grains of silver nitrate and five grains of citric acid dissolved in one ounce of distilled water. Label these 1 and 2 respectively. First flood the plate with water containing a few drops of sol. 2 until the film is thoroughly permeated. Pour it away and replace by sol. 1, to each ounce of which four drops of sol. 2 have been added. In about a minute the image should make its appearance. When all the details are visible, pour the developer into a measure and add to each ounce half-a-drachm of sol. 2. Mix, and pour on and off the plate until the image has attained the requisite density. This should, however, be very slight, as the colour is obtained in the toning.

The toning bath consists of two ounces of sodium hyposulphite dissolved in eight ounces of water, and when dissolved, four grains of gold chloride added gradually, stirring rapidly the while. The

addition of 30 grains of silver nitrate dissolved in an ounce of water has been recommended as improving the colour obtained in toning. After mixing the toning bath it must be allowed to stand for at least 12 hours. In toning, the plates are placed in a dish, and the solution poured over them. The process is a very slow one; half-an-hour is sometimes required to obtain a rich black tone. In regulating the density of the toning it is necessary to remember that the pictures appear much denser when dry than when wet. The toning bath will keep for any length of time; it improves, in fact, by keeping, and when inclined to be weak add a little more gold. This must be done, however, 10 or 12 hours before using. When the desired tone has been attained, the plates are well rinsed under the tap, and afterwards left to soak for a little time in several changes of water to thoroughly eliminate the hypo from the film.

Albumen transparencies should not be varnished, but mounted with a protecting glass.

Alcohol (Formula, C_2H_5HO; molecular weight, 46); synonyms, *ethylic alcohol*, *aqua vitæ*, *hydrate of ethyl*, *spirits of wine*, *vinic (absolute) alcohol*—Alcohol is obtained by carefully distilling any spirituous or fermented liquor. If wine or beer be placed in a suitable retort and heat applied, the alcohol may be separated by the less volatile matters, and thus obtained it is known in commerce as "rectified spirits of wine." Its specific gravity is usually about 0·840 to 0·850, and it generally contains about 17 to 20 per cent. of water, because although the alcohol is far more volatile than the water, and rises first and is condensed in the receiver, yet a portion of the water also passes over with the alcohol in the proportion already mentioned, and dilutes it to that extent. This water may be removed by adding to it carbonate of potash until that salt ceases to dissolve. This mixture is then thoroughly shaken, and when allowed to stand at rest soon separates into two portions—the uppermost part is the alcohol, and the lowermost an aqueous solution of the carbonate. The alcohol portion is then carefully drawn off by means of a syphon and poured upon a quantity of powdered quicklime of the same weight as the alcohol, and previously placed into a tabulated retort. This is allowed a day or two to digest, and then slowly distilled in a water bath at a temperature of about 200°.

Alcohol is a limpid, colourless liquid, of an agreeable odour and a strong, pungent taste. From its action on the system it may be termed poisonous, and if diluted it is very intoxicating. It absorbs vapour of water, and becomes diluted by exposure to damp air; it requires, therefore, to be kept in well-stoppered bottles. It has never been frozen. It is extremely inflammable, and burns with a pale bluish flame, scarcely visible in daylight, but the heat of the flame is very intense. The uses of alcohol in the photographic art are very numerous. Besides many other purposes to which it is

put, its power of dissolving pyroxyline (gun-cotton) and various gum lacs and resins causes it to be largely used in the manufacture of collodion and different varnishes. It acts as a preservative of pyro, and is used for drying negatives quickly, or in preventing trilling.

It is not really essential that absolute (pure) alcohol should be used for all photographic purposes, as it is very expensive to manufacture. A spirit that contains less than four per cent. of water is quite pure enough, and may be obtained by agitating commercial spirits of wine with carbonate of potash, and then with quicklime in the manner already advised.

Rectified Spirit (Formula, C_2H_6O) contains 16 per cent. of water and 84 per cent. of alcohol. Sp. gr. about ·838.

In rectifying spirits, it is sometimes for economy's sake, adulterated with a liquid known as "faints," and as these faints are usually contaminated with essential oils, it is necessary that such should be avoided. Grain spirit is to be preferred, the specific gravity of which varies from ·817 to ·819 at 60° Fahr. Its smell is very sweet, and although it may not be strong enough for many purposes, a portion of it can be converted into alcohol of ·805 by means of dry chloride of calcium, and this mixed with the remainder. The re-action to test paper of this spirit should be quite neutral; but if, as sometimes happens, a trace of acid is present, one drop of a solution of ammonia sp. gr. 0·93 will neutralise it. The following table shows the quantity of absolute alcohol (sp. gr. ·796 at 60°) contained in diluted alcohol of different specific gravities :—

Alcohol.	Water.	100 parts. Specific Gravity.	Alcohol.	Water.	100 parts. Specific Gravity.
100	0	·796	75	25	·860
99	1	·798	74	26	·863
98	2	·801	73	27	·865
97	3	·804	72	28	·867
96	4	·807	71	29	·870
95	5	·809	70	30	·872
94	6	·812	69	31	·874
93	7	·815	68	32	·875
92	8	·817	67	33	·879
91	9	·820	66	34	·881
90	10	·822	65	35	·883
89	11	·825	64	36	·886
88	12	·827	63	37	·889
87	13	·830	62	38	·891
86	14	·832	61	39	·893
85	15	·835	60	40	·896
84	16	·838	59	41	·898
83	17	·840	58	42	·900
82	18	·843	57	43	·902
81	19	·846	56	44	·904
80	20	·848	55	45	·906
79	21	·851	54	46	·908
78	22	·853	53	47	·910
77	23	·855	52	48	·912
76	24	·857	51	49	·915

Alcohol.	Water.	100 parts. Specific Gravity.	Alcohol.	Water.	100 parts. Specific Gravity.
50	50	·917	24	76	·968
49	51	·920	23	77	·970
48	52	·922	22	78	·972
47	53	·924	21	79	·973
46	54	·926	20	80	·974
45	55	·928	19	81	·975
44	56	·930	18	82	·977
43	57	·933	17	83	·978
42	58	·935	16	84	·979
41	59	·937	15	85	·981
40	60	·939	14	86	·982
39	61	·941	13	87	·984
38	62	·943	12	88	·986
37	63	·945	11	89	·987
36	64	·947	10	90	·988
35	65	·949	9	91	·989
34	66	·951	8	92	·990
33	67	·953	7	93	·991
32	68	·955	6	94	·992
31	69	·957	5	95	·994
30	70	·958	4	96	·995
29	71	·960	3	97	·997
28	72	·962	2	98	·998
27	73	·963	1	99	·999
26	74	·965	0	100	1·000
25	75	·967			

Alcoholise.—To reduce a body to an impalpable powder. To rectify spirits until they are completely deprived of any water commingled with them.

Alcoholmeter, alcoholometer, alcohometer, or alcometer (Eng. *alcohol*, Gr. *metron*—measure).—An instrument devised by Gay Lussac for measuring the proportion of pure alcohol which spirituous liquors contain.

Alcohol (Methylated).—Spirits of wine, to which is added ten per cent. of wood naphtha, is allowed by the Excise laws to be sold free of duty under the name of methylated spirit. It is, however, very inferior in quality, owing to the fact that residues containing fusel oil and other volatile and deleterious substances are often rectified for the purpose of methylating. It is illegal to purify it. It can, however, be used in many of the photographic operations, except for addition to silver compounds. It is sometimes adulterated with gum, and becomes turbid when water is added to it.

Alcohol Methylic (Formula, CH_4O; molecular weight, 32; synonyms, *wood naphtha*, *pyroxylic spirit*, *methyl hydrate*, *wood spirit*.—A product of the destructive distillation of wood, and constitutes a larger portion of wood naphtha or pyroxylic spirit. When pure, it closely resembles common naphtha. It possesses a characteristic odour, has a sp. gr. of 798 at 68° Fahr., and boils at 151° Fahr.

Aldehyde (contraction from Mediæval Lat. *alcohol dehydrogenatus*—alcohol deprived of hydrogen.—Aldehydes differ from alcohols in having two atoms less of hydrogen, which are removed from the carbon atom containing the radical HO (hydroxyl) connected to it in the form of alcohol. Aldehyde is sometimes found in acetic acid. It is a powerful deoxidising agent, and was used to improve the tone of collodion positives by removing organic matter from the picture, and reducing it more completely to the metallic state. It is now but little used.

Alizarin (from *Alizari*, a name given to a madder in the Levant. Formula, $C_{14}H_8O_4$).—The chief colouring matter of madder. It can also be artificially prepared from anthracene, a white solid contained in tar. It crystallises in red prisms slightly soluble in water and alcohol. It is used in orthochromatic photography.

Alkali (Arab. *al*—the, and *kali*—plants of the genus Salicornia, which, being burnt, left behind a white residuum now called alkali).—The term alkali is also given to many substances which are the antithesis of an acid, and are capable of neutralising it, or if the acid be weak, give alkaline reaction. The three principal ones are sodium, potassium, and ammonium. Alkalies turn red litmus paper blue, and turmeric paper brown. They serve to throw down metals dissolved in acids, as oxides or hydrated oxides, and readily unite with acids to form salts.

Alkaline Development.—See **Development.**

Allotropic (Gr. *allos*—another, and *trope*—a change).—A substance is said to be allotropic when it exists in several different states distinguished from each other by different properties. Thus a diamond exists in the form of the hardest of minerals, and also of charcoal. Phosphorous, again, can appear under at least three distinct forms, one waxlike, very fusible and combustible; another red, friable, and much less combustible; and a third, crystalline form. The changes are generally regarded as evidences of a change in the molecular structure. This variation of properties exists in many substances. An American *savant*, Carey Lea, recently made known many interesting experiments in various allotropic forms of silver. Many new facts were thereby discovered, which may probably assist in solving the mystery of the latent image.

Alpha Paper.—A rapid printing paper coated with a gelatine film, in which is contained a combination of silver with chloride and bromide. It is used for obtaining positives by artificial light, and is subjected to much the same treatment in development as bromide paper (see **Bromide Paper**). An exposure somewhat more protracted is, however, necessary, owing probably to the presence of a chloride in the film. The same amount of careful

attention and cleanliness is, however, necessary to obtain good results. The ferrous-oxalate developer gives the best tones, but, if the clearing bath be used, an alkaline developer may be employed. After developing, the prints should be well treated with an alum and acid bath to clear away all yellowness; then they may be toned in a gold or gold and platinum bath. After that, the usual method of fixing, varied in length of time in certain cases according to the colour that is required, warm or cold; finally, a thorough washing in several changes of water. They may afterwards be allowed to dry spontaneously, with a dull surface, or given a polish in the same manner as given under Aristotype Prints. The favourite oxalate developer is the following:—

SOLUTION 1.

Saturated solution of oxalate of potash	2 ounces.
10 per cent. solution of ammonium bromide	60 to 180 drops.
Water	½ ounce.

SOLUTION 2.

Saturated solution of iron sulphate	½ ounce.
Tartaric acid	10 grains.
Water	3½ ounces.

After development the prints are immersed in the clearing solution:—

Alum	4 ounces.
Citric acid	1 ounce.
Warm water	80 ounces.

This must be cold. Then wash for five minutes, and fix and tone in following combined bath:—

Water	10 ounces.
Soda hyposulphite	2½ ounces.
Acetate of soda	4 drachms.
Ammonium sulphocyanide	1 drachm.
Gold chloride solution (15 grs. to 1 oz. water)	4 drachms.

Alto Relievo, or **Alto Rilievo** (Ital. *alto*—high, and *rilievo*—relief).—A term used principally in photo-sculpture. The term should only be applied when the figures project more than half their true proportions. When they project exactly one-half, the term used is *Mezzo-relievo*, and if less than half *Basso-relievo*, or in English, *Bas-relief*.

Alum (Lat. *alumen*—alum).—The name given to double salts of aluminium with sulphates of potassium, sodium, and ammonium, or of other monatomic metals, as silver, thallium, etc. They crystallise in octohedra. The alums of commerce are potash alum (formula $Al_2K_2(SO_4)_4 + 24H_2O$) and ammonium alum ($NH_4Al(SO_4)_2 12H_2O$). Large quantities are manufactured, principally at Hurlet, near Glasgow, and Whitby in Yorkshire. It is prepared by the double decomposition of shale containing iron pyrites FeS_2, which are gently burnt, and exposed to the air in a moist state. It oxidises and forms sulphates, and on the addition

of a potash salt or ammonium sulphate to the solution obtained by water, alum crystallises out. It is then purified by three successive recrystallisations.

Alum has an astringent and acidulous taste, is styptic, and reddens litmus paper. It dissolves in a little less than its own weight of boiling water, but only about 10 per cent. in cold. It is insoluble in alcohol and ether.

Alum possesses the peculiar property of hardening gelatine and rendering it insoluble. Combined with citric or other acids, it serves for clearing and hardening gelatine negatives that have become discoloured by the action of the developer.

Chrome Alum (Formula $CrK(SO_4)_2 12H_2O$) is obtained as a secondary product in the oxidation of substances by potassium bichromate and sulphuric acid, and is formed in the bichromate battery.

This salt forms large dark purple crystals, which exhibit a ruby colour by reflected light. Chrome alum is also used for hardening and rendering insoluble gelatine, for which purpose it is superior to potash alum.

Alum Bath.—An alum bath may be prepared by placing a handful of potash alum in a 20 oz. bottle and filling it up with water, replenishing with the latter whenever the solution is used. By this means a saturated solution is always at hand, and it is often of great use in an emergency to check the frilling of plates or the blistering of paper.

Aluminium (Symbol, Al; atomic weight, 27.5).—The metallic base of alumina. It is obtained principally for the purposes of commerce by the decomposition of aluminium chloride by sodium. It is extremely light, and is now being used for lens mounts. It has the advantage over brass in lightness and appearance. A brass-mounted lens weighing seven ounces would, with an aluminium mount, weigh but three.

Amacratic (Gr. *hama*—together, and *kratos*—strength).—A term used in optics for uniting the chemical rays of light into one focus.

Amalgamate (derivation undecided).—To unite or *allay* a metal with quicksilver.

Amalgamation for Silvered Mirrors.—See **Mirrors.**

Amasthenic (Gr. *hama*—together, and *sthenos*—strength).—Uniting the chemical rays of light into one focus. See **Amacratic.**

Amateur (Lat. *amator*—a lover).—The dictionary meaning of the word amateur is, "One who follows any science, art, or occupation, not from pecuniary motives, but from a love of it, and who, as a rule, is not so proficient in it as if he had to depend upon it for a livelihood." An amateur photographer has been

designated "a spoiler of photographic dry plates;" but it is nevertheless true that a large number of the great body of amateur photographers have succeeded in turning out very high-class work, and, except in portraiture, often superior to that of professionals. This is no doubt owing to the fact that they are able to give more time and attention to details than the ever-busy professional photographer. Nor do a great many of them object to making a little money with their labour. The question as to whether these have any right to the title of "amateur" has already occupied many columns of the photographic journals, but, apparently, no definite decision can be arrived at.

With the wet collodion process of photography there were few amateurs. On the introduction of the dry plates, however, and the many improvements with regard to the apparatus in order to make it as portable as possible, photography has been made to yield delight to thousands of men and women in this country, for the members of the fair sex do not intend to be left behind—they are often possessed of artistic taste to a considerable degree, and have the advantage over men with their natural neatness and dexterity. The number of amateur photographers in Great Britain is estimated to be at present (1890) about 21,000.

Amber (Synonym *succinite*, from Lat. *succinum*—amber).—A fossil resin from an extinct pine, *Pinites*—succinifer. Its colour is generally yellow, but sometimes reddish-brownish or whitish and clouded. It is used for preparing a varnish. See **Varnish.**

Ambrotype (Gr. *ambrotos*—immortal, and *tupos*—type).—An American term for the collodion positive process, still worked by the peripatetic photographer at fairs, etc.

American Clip.—A useful little contrivance, to be attached to string or wires stretched across the room. Sheets of prepared paper can then be hung up, the clips holding them firmly by the corners.

American Cloth.—This is a cloth coated over with a black varnish, and is an article very useful to photographers. It forms an excellent camera-cloth, serving to protect the camera from rain. It is also useful to lay over carbon or other prints when the squeegee is applied to attach them to glass.

Ammonia (Formula, NH_3; atomic weight, 17·01; synonyms, *spirits of hartshorn*, *volatile alkali*).—The name is supposed to be derived from *Ammonia*, the district in Libya where it was first prepared, or from its being first manufactured from camels' dung collected by the Arabs at the Temple of Jupiter Ammon in the same locality.

Ammonia exists in the air as carbonate of ammonium; in rain water, especially in that of thunder showers, as nitrate; in sea water, and in many of the mineral springs. It is present in most kinds of clay and soils, in sesquioxide of iron, and in the majority

of iron ores. Sal ammoniac and ammonium alum are found as minerals, the former chiefly in volcanic regions and in some specimens of rock salt. Ammonia is obtained by the dry distillation of animal or vegetable matter containing nitrogen. The horns and hoofs of animals produce large quantities, and for this reason it is sometimes called *spirits of hartshorn*.

Urine is, no doubt, the oldest source of ammonical compounds as sal ammoniac prepared from it was an article of commerce in Europe as early as 1410. The methodical collection of urine, and working it up into ammoniacal compounds, have been carried out in the neighbourhood of some large towns, *e.g.*, Paris. According to a work entitled "Industrie des Produits Ammoniacaux," we find that in Paris there are daily 2,200 tons of urine and night soil taken out of the *fossés* and left to settle in large reservoirs. Sulphate of iron or zinc is used as a disinfectant, and the solid matter is separated from the liquid sewage, forming 85-95 per cent., which is now called *eau vanne*. In three or four weeks the fermentation is complete, the urea has vanished, and there has been formed principally ammonium carbonate, along with sulphydrate, sulphate, chloride, ammonio-magnesian phosphate, compound ammonias, and other substances of intensely disagreeable smell.

Large quantities of ammonia can be extracted from Peruvian guano, but its value as a manure is so great that the process of extraction patented by Young in 1841 can never be remunerative.

Ammonia is also obtained from peat, from bituminous shale, and as a by-product in the manufacture of beet-root sugar.

In England ammonia is chiefly obtained from gas liquor. In the dry distillation of coal, as practised in gas works for obtaining gas for illuminating purposes, it is necessary to purify the gas by subjecting it to a cooling and washing with water. In this process two products are obtained from the gas—an oily and an aqueous substance, which by settling in the tanks separate from each other and form tar and gas liquor, in which the following ammoniacal substances are contained :—

Ammonium carbonates (mono-sesqui- bi-).
Ammonium sulphide $(NH_4)_2S$.
Ammonium hydrosulphide NH_4HS.
Ammonium acetate.
Ammonium cyanide.
Free ammonia.*
Ammonium sulphite.
Ammonium thiosulphate (hyposulphite).
Ammonium thiocarbonate.
Ammonium chloride.
Ammonium sulphocyanide (thiocyanite).
Ammonium ferrocyanide.
Also many other salts of organic bases.

*The presence of free ammonia in gas liquor is doubted by most chemists, though asserted by two competent observers, Gerlach and Tieftrunck.—See *Wagner's Jahresb*, 1877, p. 1,065.

Ammonia is a colourless gas of an extremely pungent smell, and sharp alkaline taste. It contains one atom of nitrogen, combined with three of hydrogen, which two elementary bodies show when free no tendency to combine, but can be made to unite under certain circumstances, the result being ammonia. These elements, however, may be decomposed by the electric discharge, or very slowly by heat. Ammonia gas does not support either combustion or respiration. Animals die when immersed in it. It is feebly combustible ; when issuing in a fine stream into air it may be kindled, and burns with a pale flame. It colours tumeric paper brown, and reddens litmus blue, both colours disappearing on exposure to air. Taste hot and strongly alkaline, and is poisonous when breathed—it destroys the mucous membrane.

Liquid Ammonia is an aqueous solution of the volatile gas ammonia, and in this state is generally used in photography. Water at ordinary temperatures absorbs about 700 times its volume. A fluid dram of ammoniæ liquor fortior contains 15·83 grains of ammonia, and has a sp. gr. of 0·891. The liquor ammonia of the pharmacopœia has a sp. gr. of 0·959, and a fluid dram contains 5·2 grains of NH_3. It is a common error to confound these two, but it will be seen that the ammoniæ liquor fortior contains 200 per cent. more ammonia. Liquor ammonia is extremely alkaline, but differs from the other alkalies in the fact of its being volatile.

Commercial Aqueous Ammonia differs in many ways, and contains certain impurities. The sp. gr. diminishes of course with the amount of ammonia present, but should be about ·940. A table is given, however, at the conclusion of this article to enable one to determine the quantity of ammonia present by the specific gravity of the liquid. Solution of ammonia absorbs carbonic acid rapidly from the air, forming carbonate of ammonium. It is therefore necessary to keep in a well-stoppered bottle, and to avoid leaving the mouth open as much as possible. A good plan is to smear the stopper with vaseline, which makes it fit perfectly close, and prevents it from becoming fast.

Aqueous ammonia may contain the followirg impurities. Chlorine, which may be detected by adding a small quantity of nitrate of silver ; it gives a cloudiness. Lime gives a precipitate with oxalic acid left as a solid residue on evaporation. Empreumatic oil ; it then has a yellow colour and a disagreeable smell.

Pure aqueous ammonia is a colourless liquid, smelling of ammonia, and has a sharp burning urinous taste. A perfectly saturated solution freezes between 100° and 105° Fahr., forming shining flexible needles. At 120° Fahr. it solidifies to a grey gelatinous mass almost without smell.

Liquid ammonia possesses the property of dissolving many salts which are insoluble in water. Its principal uses in photography are in the emulsion process for dry plates, and in the developing and intensifying of the image. It is also used in the positive process,

when sensitised albumen paper is subjected to its fumes, and by this means increased sensitiveness and brilliancy are obtained.

In development ammonia is used as the accelerator, and it possesses the advantage over all other alkalis of giving greater brilliancy and vigour. With some makes of plates, however, ammonia will produce green fog. In published formulæ ammonia with specific gravity of ·880 is generally recommended. It should, however, be tested by the accompanying table, as it is difficult to obtain with so low a temperature of gravity.

TABLE OF SPECIFIC GRAVITY OF AQUEOUS AMMONIA AT 60° FAHR.

Specific Gravity.	Percentage of Ammonia.
0·990	2·31
0·980	4·80
0·970	7·31
0·960	9·91
0·950	12·74
0·940	15·63
0·930	18·64
0·920	21·75
0·910	24·99
0·900	28·33
0·980	31·75
0·880	35·60

Ammonia Fuming.—See **Fuming.**

Ammonio Nitrate Process (An emulsion process described under **Emulsion**).—In this the boiling of the emulsion is dispensed with, and is substituted by a method of keeping it at a moderate temperature in a state of strong alkalinity with ammonia.

Ammonium Bichromate (Formula, $(NH_4)_2 Cr_2 O_7$; molecular weight, 888·4).—Orange-coloured monochromic crystals, prepared by neutralising chromic acid with ammonia, and adding an equal part of chromic acid and evaporating. The crystals thus formed are soluble in water. Ammonium bichromate possesses the property of rendering certain organic bodies, such as albumen or gelatine, insoluble, when exposed to light. Potassium bichromate also possesses this property, and is usually preferred to ammonium bichromate in photo-mechanical printing.

Ammonium Bromide (Formula, NH_4Br; molecular weight, 98) can be prepared by precipitating bromide of calcium by carbonate of ammonia, or by neutralising hydrobromic acid with ammonia. Ammonium bromide is formed in white crystals, very suluble in water, alcohol or ether. It is used in the manufacture of gelatino- or collodio-bromide emulsions, and as a restrainer in developing.

Ammonium Carbonate (Formula, $(NH_4)_2CO_3H_2O$; molecular weight, 342).—Ammonium carbonate appears to exist in three forms, the normal, the acid, and the sesqui-carbonate. Commercial ammonium carbonate is made by sublimation from chalk and sal

ammoniac. It is bought in large lumps. On exposure to the air the ammonia escapes, and leaves a bicarbonate in the form of a white powder. This should be carefully scraped off, and the hard, unchanged centre portion only made use of. It is soluble in cold water, 100 parts; at 55° Fahr. dissolve twenty-five parts of ammonium carbonate; at 62°, thirty parts; at 89°, thirty-seven parts; at 105°, forty parts; and at 122°, fifty parts.

Ammonium carbonate is used in photography in development to give density to the image. The action, however, is slow.

Ammonium Chloride (Formula, NH_4Cl; molecular weight, 53·5; synonyms, *muriate or hydrochlorate of ammonia*, *sal ammoniac* and *smelling salts*).—Ammonium chloride is a white inodorous salt with a pungent taste. It occurs in small quantities in the neighbourhood of volcanoes, but is usually manufactured by neutralising ammonical gas liquor with hydrochloric acid, and after evaporating the liquid the residue is heated to sublimation, and the salt condenses in the form of a white crystalline mass.

Ammonium chloride dissolves readily in an equal part of boiling water, or in three-parts of cold. Commercial kinds often contain iron. If a strong solution be made with boiling water and allowed to stand, the iron, should it contain any, will be precipitated as iron oxide in the form of a brown flocculent mass, which deposits itself at the bottom of the vessel.

The principal uses of ammonium chloride in photography are in the salting of albumenised paper and in emulsion making. In each case its mission is to form the chloride of silver, and for this purpose it is superior to sodium chloride because it contains more chlorine in proportion to its weight.

Ammonium Iodide (Formula, NH_4I; molecular weight, 145).—Colourless crystals, very soluble in water and alcohol, and very deliquescent when exposed to air; it should therefore be kept in closely-stoppered bottles. It is prepared by mixing equal volumes of hydriodic acid and ammonia, or by adding iodine to a saturated solution of hydrosulphate of ammonia until it begins to be coloured. A precipitate of sulphur is formed, and the solution is now acid. Neutralise carefully with ammonia, and afterwards filter, evaporate and crystallise.

Ammonium iodide is used as an iodiser in the collodion. It is, however, a very unstable composition, deliquesces rapidly, and becomes yellow by the separation of iodine and loss of ammonia.

Ammonium Nitrate (Formula, NH_4NO_3; molecular weight, 80).—This salt is prepared by neutralising nitric acid with ammonia or ammonium carbonate. The solution is then evaporated and crystallised. Ammonium nitrate is not a stable salt, for it releases ammonia, and becomes acid with free acid. It is a solvent of oxide, and also of carbonate of silver. When heated, nitrous oxide, or laughing gas, is evolved. If dissolved in an equal part of water the temperature of the latter is lowered from 40° to 4°, and it is therefore used as a freezing mixture.

Ammonium Oxalate (Formula $(NH_4)_2C_2O_4$).—Formed by the neutralisation of oxalic acid with ammonium carbonate. It produces with calcium salts a white precipitate, soluble in hydrochloric acid. It is used in the platinotype process. (*q.v.*)

Ammonium Sulphide (Formula, $(NH_4)_2S$).—This solution is obtained by passing sulphuretted hydrogen through a solution of ammonia at an ordinary temperature until absorption ceases, and the liquids are mixed. It should be colourless, and kept in a well-stoppered bottle, away from the dark-room. It has a disgusting smell of ammonia and rotten eggs, and its fumes are liable to upset other operations. Exposed to light, it quickly becomes yellow, and changes into ammonium sulphydrate, NH_4HS. It is used in photography for intensifying negatives, and for precipitating silver solutions. Ammonium sulphide is also a good test for iron, forming a black precipitate of iron sulphide.

Ammonium Sulpocyanate (Formula, NH_4CNS; molecular weight, 76).—Obtained by mixing hydrocyanic acid with polysulphide of ammonium (a solution of sulphur in ammonium sulphydrate) and separating the sulphocyanate thus formed by water or alcohol. It crystallises in colourless deliquescent tablets, very soluble in water and alcohol. It is used in the toning bath for gelatino-chloride printing-out papers, though it should be stated that prints toned with a toning bath containing this substance are least likely to be permanent. Ammonium sulphocyanate can also be used as a fixing agent instead of hypo, but it is much inferior.

Amorphous (Gr. *amorphos*—shapeless).—A term applied in chemistry to substances which have no definable determinate or definite form.

Amphitype (Gr. *amphi*—on both sides, and *tupos*—type).—An application of the calotype process invented by Sir John Herschell, in which light produces either a negative or a positive. It is thus described :—A sheet of paper is prepared with a solution either of ferro-tartrate, or ferro-citrate of protoxide, or peroxide of mercury, and then with a solution of ammonia tartrate, or ammonia citrate of iron, the latter solution being in excess. On exposure to light in the camera a negative is produced of more or less vigour, and of a very rich brown tint, when the paper contains a salt of lead. It gradually fades in the dark, but may be restored as a black positive by immersing it in a solution of nitrate of mercury and ironing it with a very hot iron.

Amyl Acetate (Formula, $C_5H_{11}C_2H_3O_2$.) Made from fusel oil ; 1 part potassium acetate (dry) 2 parts ; concentrated sulphuric acid, 1 part ; distilled with the usual precautions from a glass retort into a cool receiver. The distillate is purified by washing with very dilute solution of potassa, and redistilling it from fused calcium chloride. It is a limpid and colourless liquid, insoluble in water, but soluble in alcohol.

Analysis (Gr. *analusis*—releasing).—In chemistry, the examination of bodies with a view of ascertaining of what substances they are composed and in what proportions these substances are contained. The former is termed qualitative and the latter quantitative analysis. There are various methods of analysing or separating the particles of a chemical compound. These may be classified into the following:—Blowpipe, qualitative, gravimetrical, and volumetric, and the proximate and ultimate analyses of organic bodies. Having isolated these constituents we next proceed to put them together again to reproduce the original substance. This is called synthesis. This is more clearly explained under **Chemistry.**

The following information is likely to be of use to photographers wishing to analyse any substance or to detect any impurities.

The substance to be analysed is dissolved in a test tube. If not soluble in water, hot or cold; then in hydrochloric acid or in aqua regia, and if insoluble in these it is fused with sodium carbonate. The solution thus obtained is termed the *original solution*. To this add a few drops of hydrochloric acid. If a white precipitate is formed it is either silver chloride, mercurous chloride, or lead chloride, indicating the presence of these metals. Filter and pass sulphuretted hydrogen gas through the filtrate. If the precipitate turns black, lead, copper, mercury, or bismuth is present. A yellow precipitate indicates cadmium arsenic or tin. A brown precipitate shows tin (in another form), and an orange colour denotes the presence of antimony.

Filter again, and boil the filtrate in order to expel the sulphuretted hydrogen. Now add a few drops of nitric acid, boil to oxidise the iron, and add chloride of ammonium and ammonia. A red precipitate shows the presence of iron; if of a bluish-green colour, chromium. A white precipitate indicates aluminium, or phosphates, borates, and oxalates.

Again filter, and add ammonium sulphide to the filtrate. If it turns black, cobalt or nickel; if pink, turning brown afterwards, manganese is present, or, if white, zinc.

Filter, and add to the filtrate ammonium carbonate. A white precipitate shows calcium, barium or strontium. Filter and divide the filtrate into two equal parts. To one add a small quantity of sodium phosphate, and if a white precipitate is formed, it proves the presence of magnesium. The other portion is evaporated to a dry powder, heated to drive off the ammoniacal salts, and tested for potash and soda.

Take another portion of the original solution and test for ammoniacal salts. Add to it caustic potash. This will liberate the ammonia, which is easily recognised by its smell and its action upon red litmus or turmeric paper.

Arsenic, antimony, and tin sulphides are soluble in ammonium sulphide, and can be reprecipitated by hydrochloric acid.

To test acids, observe the following:—Carbonic, hydrosulphuric and hydrocyanic acids are liberated by stronger acids with

effervescence. Carbonic, arseneous arsenic, chromic, boracic, phospheric, oxalic, hydrofluoric, and sillicic acid, give from a neutral solution a white precipitate, insoluble in acids; tartaric and citric acid may be easily recognised by the precipitate charring when heated, and giving out fumes of a peculiar odour. If calcium chloride be added to phospheric acid, a white precipitate is formed, which is soluble in acetic acid. Oxalic and hydrofluoric also give a white precipitate with calcium chloride, but it is insoluble in acetic acid.

Silver nitrate gives a black precipitate with hydrosulphuric acid, a red precipitate with chromic and arsenic acids, a white precipitate with boracic and oxalic acids, a yellow precipitate with arseneous, phospheric and sillicic acid. All these precipitates can be dissolved in nitric acid. Hydrochloric, hydrocyanic and hydriodic acids, however, give a precipitate insoluble in nitric acid.

Acetic acid and sulphuric acid give with ferric chloride a red colour. If ferric chloride be added to gallic and tannic acids, a black precipitate is the result.

A doubtful substance should be treated in as many different ways as possible, and it is not difficult to prove all the component parts, if each be tested for by the different methods given. With the description of each chemical is given, where possible, one or more methods of testing and proving existence of adulteration.

Angle (Lat. *angulus*—an angle).—Literally the opening between two lines which meet one another. Optics have angles of aperture, of incidence, of reflection, of refraction, of deviation, and of polarisation. See under these respective headings.

Angle, Wide.—A wide angle is a term applied to certain forms of lenses so constructed that they will embrace a larger amount of view than the ordinary or narrow-angle lens. Figs. 19 and 20 will serve to show the meaning of this more clearly.

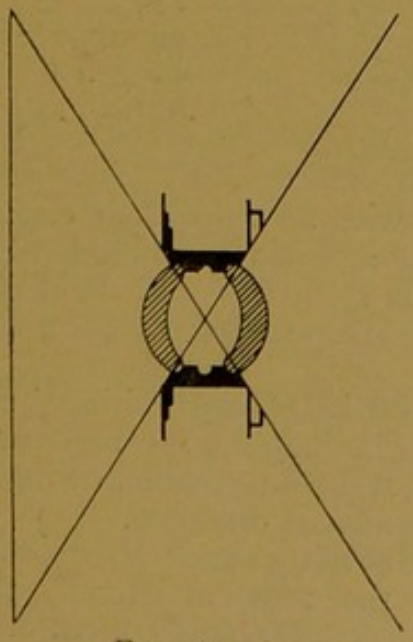


Fig. 19.

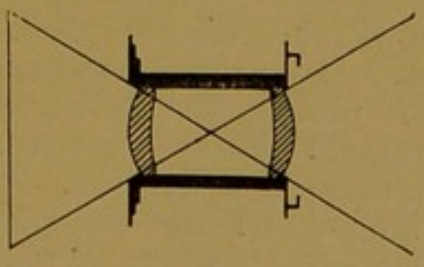


Fig. 20.

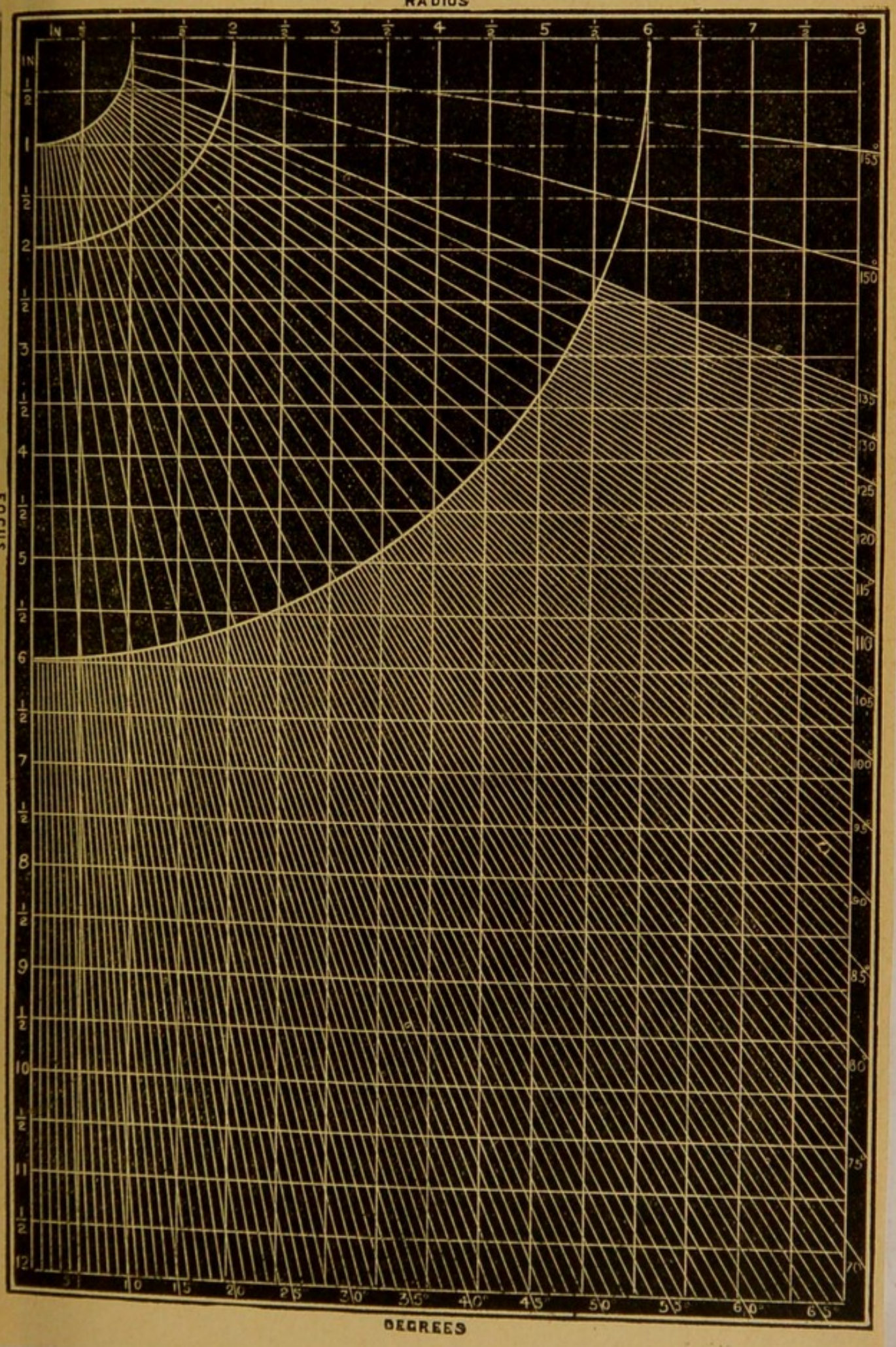
The width of the angle of a lens is determined by the relation of the focal length to the image given by the lens. To determine the width of angle of a lens, divide the base line of the plate by the equivalent focus of the lens (see **Focus**). Having found this out, it will be easy to determine the angle of view included upon the plate by reference to the following table:—

IF THE QUOTIENT IS	THE ANGLE INCLUDED IS	IF THE QUOTIENT IS	THE ANGLE INCLUDED IS
.5	28 degrees	1.155	60 degrees
.517	29 ,,	1.178	61 ,,
.536	30 ,,	1.2	62 ,,
.555	31 ,,	1.225	63 ,,
.573	32 ,,	1.25	64 ,,
.592	33 ,,	1 274	65 ,,
.611	34 ,,	1.3	66 ,,
.631	35 ,,	1.32	67 ,,
.65	36 ,,	1.36	68 ,,
.67	37 ,,	1.375	69 ,,
.689	38 ,,	1.4	70 ,,
.708	39 ,,	1.427	71 ,,
.728	40 ,,	1.45	72 ,,
.748	41 ,,	1.48	73 ,,
.768	42 ,,	1.5	74 ,,
.788	43 ,,	1.53	75 ,,
.808	44 ,,	1.56	76 ,,
.828	45 ,,	1.59	77 ,,
.849	46 ,,	1 62	78 ,,
.87	47 ,,	1.649	79 ,,
.89	48 ,,	1 678	80 ,,
.911	49 ,,	1.7	81 ,,
.933	50 ,,	1.739	82 ,,
.974	51 ,,	1.769	83 ,,
.971	52 ,,	1.8	84 ,,
1.0	53 ,,	1 833	85 ,,
1.02	54 ,,	1.865	86 ,,
1.041	55 ,,	1.898	87 ,,
1 063	56 ,,	1.931	88 ,,
1.086	57 ,,	1.965	89 ,,
1.108	58 ,,	2.	90 ,,
1.132	59 ,,		

Let us take, for example, a lens with an equivalent focus of 15 inches, and we require to know the angle of view included upon a 10 × 12 plate. The base-line here is 12 inches. 12 divided by 15, the equivalent focus, gives 1.25, corresponding as shown in the above table to 64 degrees.

Wide-angle lenses are most useful in photographing buildings or other objects when we require to include a large amount in the picture, yet with an ordinary lens it is impossible, owing to an inability to place the camera at a sufficient distance.

The angle of view of the eye does not exceed 50 degrees. A lens with an angle of 40° gives the most artistically truthful picture, and except for special purposes already mentioned, no


RADIUS
IN
FOCUS
DEGREES

In figures No. 1 and 2, A B represents the longitudinal section of a plate, and C the lens. From C, the centre of the lens, draw a line perpendicular to the plate, as at C D. If the lens is tilted, as in diagram No. 2, the tilting must be disregarded. The essential thing is, that C D shall be perpendicular to A B. The line C D we will call the *principal ray* or *focus*.

We will now view the plate from the front as in figures Nos. 3 and 4.

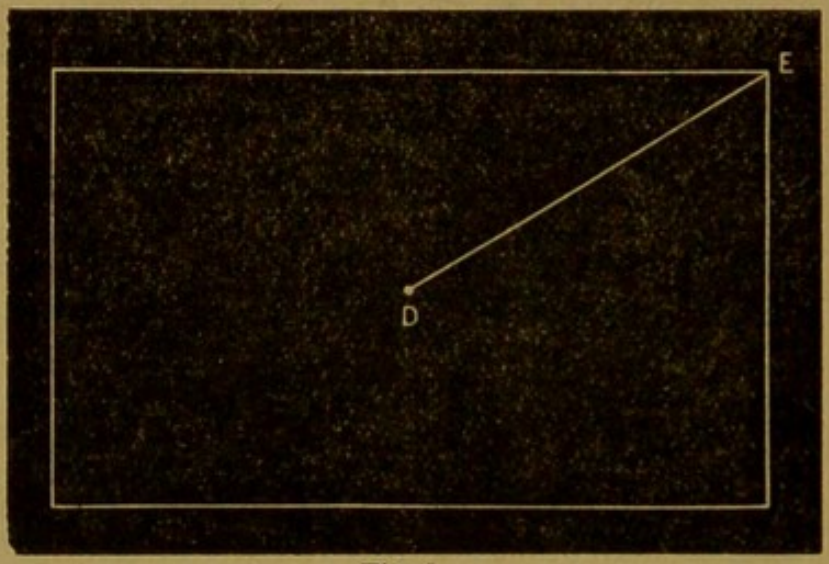


Fig. 3.

If the lens is central on the front of the camera, D will be on the centre of the plate as in figure No. 3. But we may wish to use the cross fronts, in which case D will be as in figure No. 4, or at any other point

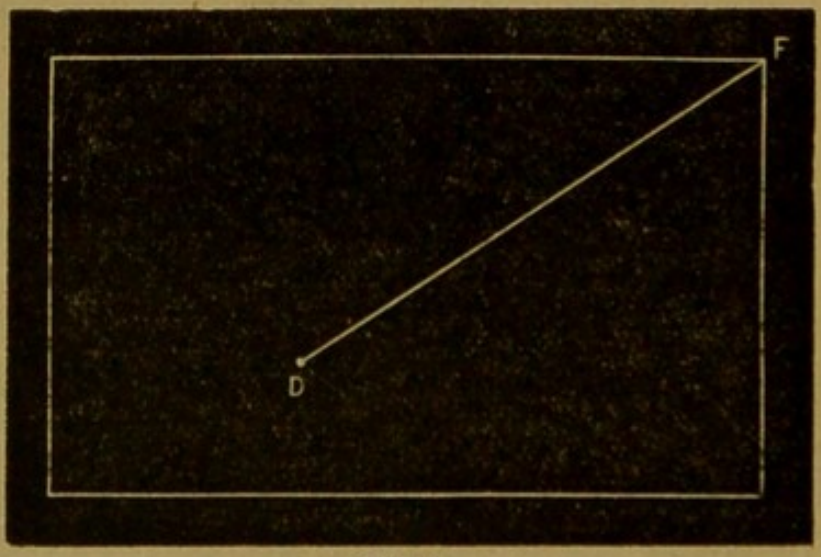


Fig. 4.

we may select. The lines D E and D F represent half the base of the cone of rays used to form the picture. We will call the distance from D to E or D to F the *radius*. Measure the focus and the radius. We will assume the focus to be 10½ inches, and the radius 7½ inches. We can now ascertain the angle under which the picture will be taken = 70°

lens should be used with a greater angle than 50°. The result of using wide-angle lenses is pictures with painfully exaggerated perspective, the objects in the foreground appearing large and out of proportion, while the more distant ones are dwarfed and appear at an exaggerated distance. This power of making exaggerated photographs has been largely made use of for advertising purposes. Photographs taken by wide-angle lenses can be seen every day advertising houses for sale, illustrating the saloon accommodation of steamboats, etc., in every case deceiving the eye of the observer as to the actual size of the object represented.

Wide-angle lenses, however, possess many drawbacks. They require a small diaphragm, in order to obtain sharp definition, by the use of which the light is considerably reduced and the exposure necessary increased in proportion, so that they are at best but slow workers.

They give, too, unequal definition. If we take two equally bright and equidistant objects, the image of one falling on the margin, and that of the other upon the centre of the plate, the area occupied by the first image will be greater than that occupied by the second, and consequently the marginal illumination will be less; the diminution of light from both these causes increases with the angle of view beyond 40°. At this angle the extreme margins receive 80 per cent. of the light falling upon the centre, at 50° but 70 per cent., at 60° only 55 per cent., and at 70° no more than 45 per cent. Therefore, it will be seen that with the increase of angle we get an increase of this defect. Dallmeyer makes a lens with an angle of 100°. A lens of this description, however, would only be useful for certain purposes. Wide-angle lenses give distortion, particularly noticeable in photographing buildings. The swing-back of the camera can be used to remedy it, but with it a small stop must also be added. See **Lenses.**

Angular Aperture.—The relation of the working diameter of a lens to its focal length. The wider the angular aperture the less the depth of focus and covering power of the lens. Drawing two imaginary lines from the two extremities of the landscape through the centre of the lens or combination to the corresponding extremities of the picture, two isoscles triangles are formed with their vertical angle at the centre. This angle or opening of the two outside rays constitutes what is termed the angular aperture.

Anhydrides (Gr. *anudria*—want of water).—An anhydride, or an anhydrous acid, is a chemical substance, formed by the substitution of an acid radical for the whole of the hydrogen in one or two molecules of water.

Anhydrous.—Having no water in its composition. When the water is replaced by a base, or is otherwise entirely removed, the substance is anhydrous.

Aniline (C_6H_7N; molecular weight, 93). — Prepared by reducing benzene with iron filings, in presence of a small quantity of hydrochloric or acetic acid, and separating the aniline formed by distillation. Aniline is a thin, colourless oil, of a burning taste and aromatic flavour, sparingly soluble in water, turns red in the air, and coagulates albumen. With chromic acid it gives a deep green or bluish-black colour; upon this property the aniline process is based, *q v.*

Aniline Development.—See **Aniline Process.**

Aniline Dyes.—There are a large number of aniline dyes, such as rosaniline, chryaniline, etc., nearly all of which can be used as sensitisers in orthochromatic photography. The dry-plate, previous to exposure, is either bathed in a weak solution of the dye, or the latter has been made up in the emulsion with which the plate is coated. Photographs obtained in this manner are more truthfully related in light and shade to nature.

Aniline Process.—A process used for copying tracings, maps, etc., invented by Willis. Paper is sensitised with a solution consisting of potassium dichromate one part, phosphoric acid (sp. gr. 1·124) 8 to 10 parts, and water 10 to 12 parts. This solution is brushed over best Saxe paper with a stiff brush, about one inch wide, and the paper hung up to dry. This operation must be performed in the dark room, as the paper is extremely sensitive. The prepared paper is then exposed under a tracing to direct sunlight. The correctness of the exposure is an important matter, therefore an actinometer should be used. If the paper is correctly prepared, it should be of a yellow colour, and after exposure a faint yellow picture will appear on a greenish ground. The picture is removed from the frame in the dark room, and developed by pinning to the lid of a fuming-box, provided with a sheet of glass, upon which is placed some pieces of blotting-paper, saturated with a solution of aniline oil 1 part, and benzene 10 parts. There it must remain for about half-an-hour, and if properly developed the result will be dark brown lines on a greyish ground. If it be too faint, however, the development must be continued for several hours, until completed; it is then washed for some time in several changes of water, and dried.

Antacid (Gr. *anti*—against, and *acidus*—acid).—Any substance, such as potash, soda, lime, etc., which counteracts acidity or neutralises it.

Anthotype (*Anthos*—a flower, and *tupos*—type).—A process in which paper was saturated with the green juice of the leaves of the young cereals, and used in the same way as chloride of silver paper to copy pictures on. The uncovered parts are speedily bleached under the influence of the luminous rays, and a most delicate and beautiful positive copy is produced from a positive

original. Alcohol solutions of various resins, the juice of the rose and violet, tincture of turmeric, and many other vegetable colouring matters may be used in the same way. They are not permanent, however.

Antichlor. — Any substance that will neutralise chlorine. Sodium hyposulphite acts as a cheap and efficient antichlor.

Antiplanatic (Gr. *anti*—opposite to, and *planao*—to wander, lit. not wandering).—This term is sometimes used instead of **Aplanatic**, *q. v.*

Anti-rust Varnish.—See **Varnishes.**

Antiseptic (Gr. *anti*—against, and *septos*—putrid).—A substance which has the effect of counteracting the tendency to putrefaction. Antiseptics destroy the activity of the infectious matter, in many cases without altering the composition of the body. The principal ones are carbolic acid, alcohol, sulphurous acid, sodium chloride, and corrosive sublimate. Alum, alcohol, carbolic acid, chloral, or zinc salts in small quantities will act as an antiseptic, and prevent the putrefaction of gelatine; as will also glycerine in large quantities.

Aperture (Lat. *apertura*).—The clear space which receives the light of the object. The diameter of the opening of the lens, exclusive of its setting. If a diaphragm be used, the diameter of its opening.

The *working aperture* of a lens is that part of it which is actually used to obtain the image upon the screen or sensitive plate. The diameter of the lens or diaphragm opening is often taken as the working aperture. In doublet lenses, however, the diaphragm aperture does not accurately determine the working aperture of the lens. To obtain the correct value of each stop, draw out the camera to the equivalent focus. The glass of the focussing screen is then removed and replaced by a piece of opaque paper or cardboard, in the centre of which a small pinhole has been punctured. A candle is next brought near to the hole in the card, and upon looking at the front combination of the lens we shall see, if we place a stop in the lens, that only a small disc of the lens is illuminated by the rays of light from the candle coming through the pinhole; and the diameter of this disc is the working aperture of the lens when used with that particular diaphragm. Each one should be calculated in this manner and marked. If any difficulty is found in measuring the illuminated portion of the lens, by breathing on the glass the operation is facilitated.

Aplanat.—A name given to a lens by Steinheil. It is constructed of two kinds of flint glass, a light and a dense kind. By this means achromatism is effected in the same manner as by using

flint and crown glass, with which the majority of achromatic lenses are now made. See **Achromatic.**

Aplanatic (Gr. *a*—privative, and *planao*—to wander, lit. not wandering).—A lens is said to be aplanatic when it is corrected for chemical and spherical aberration as far as practicable by combining two or more lenses of different form and composed of different transparent media. Theoretically, it is impossible to entirely correct these aberrations, but the term means practically that the lens will give reasonably sharp definition with its full aperture, and also that its visual and chemical foci coincide. See **Aberration.**

Apothecaries' Weight.—See **Weights and Measures.**

Apparatus.—The various materials and instruments used in photography, and which are severally described under the various headings.

Aqua Destillata (Lat. distilled water).—See **Water.**

Aqua Fortis (Lat. strong water).—An old name for nitric acid. Still used, however.

Aqua Regia.—A liquid consisting of nitric acid and hydrochloric acids. It possesses the property of dissolving the king of metals (gold), hence the name "regia," or "royal." In reality, however, it is only the chlorine that attacks the gold. See **Nitro-hydrochloric Acid.**

Aqueous (Lat. *aqua*—water).—Made by the addition of water.

Aqueous Ammonia.—Liquid ammonia. See **Ammonia.**

Arabic Gum.—See **Gums.**

Architectural Photography.—In photographing architecture (where parallel, vertical, and horizontal lines are included) it is essential that a lens be used that gives the least amount of distortion. It is clear, then, that a landscape or single combination lens is useless for the purpose. The best results are obtained with a rectilinear lens having a focal length a little shorter than the base-line of the plate. Thus, for a 15 × 12 picture, a lens of 14in. focus, the image would include an angle of 50°. For special purposes, however, such as the photographing of a building in a confined situation, it is necessary to use a wide-angle rectilinear, but for reasons mentioned under **Wide Angle** this kind of lens should never be used unless absolutely necessary.

The camera should be placed perfectly level, and for this purpose a little spirit level fitted into the camera is very useful. When it is necessary to take in the entire building raise the sliding front of the camera. If this is insufficient try to get on to higher ground to take the view. If this is impossible, as a

last resort, to be employed only in such a case, tilt the camera. If this is done, the swing-back must be used to restore parallelism between the planes of the object and the margin lines of the focussing screen. A small stop must then be used, otherwise an imperfect sharp image will be the result.

The photographing of exteriors should rarely be attempted without sunlight striking at an angle to give shadows. Choose a time when, on taking up position with the camera, the sun is shining over the right or left shoulder. If directly behind, flat pictures are inevitable. The exposure varies, of course, with the actinicity of the light and with the distance from the object. The time required, of course, increases the nearer we approach. The colour of the building must also be taken into consideration, and is very deceptive. It is better to err on the side of over-exposure, as the masonry, especially if yellow with age, does not reflect so much light as is imagined. For photographing the interiors of buildings, see **Interiors.**

Area System.—A system invented by Mr. Geo. Smith of calculating relative exposures with various stops and lenses. It is based upon the principles, firstly, that if a given stop with a given lens requires an exposure of one second, then a stop of half the diameter would necessitate four times the exposure; and secondly, that if a given stop with a given lens requires an exposure of one second, a lens of double the focus with that stop would require four times the exposure, and if one of three times the focus, a nine-fold exposure is required approximately.

Areometer (Gr. *araios*—thin, porous, and *metron*—a measure).—An instrument designed to measure the specific gravity of liquids. See **Specific Gravity.**

Areometry.—The act or process of measuring the specific gravity of liquids.

Argentometer.—An instrument for measuring the quantity of silver nitrate contained in an aqueous solution. A hydrometer used for the same purpose is also so called. See **Silver Nitrate.**

Argentic (Lat. *argentum*—silver).—Pertaining or relating to silver composed wholly or part of silver, or obtained from silver.

Argentic Salts.—Silver salts, such as *argentic chloride*, *argentic nitrate*, etc. See **Silver Chloride, Silver Nitrate,** etc.

Argentic Opals.—See **Opals.**

Argentotype.—A name given to a kind of bromide paper sold ready prepared for enlarging or contact printing. See **Bromide Paper.**

Aristotype (Gr. *aristos*—best, and *tupos*—type).—A name given by Dr. Liesegang to modifications of old processes of gelatino and

collodio-chloride of silver printing, first introduced by G. Wharton Simpson in the year 1865, and known as the Simpsontype. The modern aristotype process consists of a gelatine emulsion, and is prepared with an excess of silver nitrate (see **Emulsions**). Paper is coated with this and allowed to dry. Printing is performed in the same manner as with ready sensitised albumenised paper. Almost any toning bath may be used for the prints, which are afterwards fixed. They can, however, be toned and fixed in one bath, made up as follows:—

SOLUTION No. I.

Distilled water	36 ounces.
Hyposulphite of soda	8 ,,
Sulphocyanide of ammonium	1 ,,
Acetate of soda	7 drachms.

Add to this—

Water	6 drachms.
Sodium chloride	2 ,,
Silver nitrate	1½ ,,

After this mixture has been allowed to stand for about twenty-four hours, small flakes of insoluble compounds will be seen. These must be removed by a double filtration. While this is proceeding, make up

SOLUTION No. II.

Distilled water	3½ ounces.
Gold chloride (crystals)	15 grains.
Ammonium chloride	1 drachm.

Add Solution No. II. to Solution No. I., and after thoroughly shaking and allowing impurities to settle, the bath is ready for use.

To the finished print upon aristotype paper a glossy appearance can be given by removing from the final washing water and squeegeeing on to a sheet of glass. If plate glass be used, it is unnecessary to give any special preparation. Inferior glass must, however, be dusted over with French chalk or powdered talc, and then brushed off again previous to placing the print face downwards upon it. When dry, the prints leave the glass with a polished surface. Instead of glass a ferrotype plate or a piece of polished ebonite can be used. The finish is, however, a little less brilliant.

The damp-absorbing nature of gelatine, however, causes this brilliant polish to rapidly disappear. A method of tanning or hardening the gelatine may be employed previous to placing on glass. By this means the gloss is not so easily destroyed. The prints are placed in a solution made up according to this formula:—

Distilled water	36 ounces.
Tannin	15 grains.
Sat. sol. potassium aluminium sulphate	3½ ounces.
Sodium chloride	2 drachms.

Prints upon aristotype paper are best mounted with a warm solution of gelatine and alcohol.

In America, aristotype paper is made with collodion, this substance being used in place of gelatine to suspend the silver salts. Prints upon this paper are treated in the same manner as already described.

Both these papers are said to be permanent. Experience has already proved that prints made upon them are more lasting than those made upon the ordinary albumenised paper.

Arrowroot.—The common name of the plant, *Maranta Arundinacea*, grown in the West Indies and exported to this country. Potato starch is called farina, or English arrowroot.

Arrowroot Paper.—A paper sized with arrowroot, and used for heliotype and photo-lithography. It is also a good paper for the collodio-chloride process.

Arsenic Bromide (Formula, $AsBr_3$; molecular weight, 314·25).—Colourless deliquescent prisms with strong arsenical odour melting to a pale yellow liquid, which fumes but slightly in the air. Volatilises unchanged, and yields a crystalline sublimate. It mixes with alcohol, ether, and liquid oils, and is decomposed by water. It is added to collodion as a preserver, and to increase the intensity of the developed image. A solution for this purpose is prepared by reducing metallic arsenic to a fine powder, and placing it in a dry bottle with alcohol sp. gr. ·805. Bromine is then added, a combination will ensue, and arsenic must be in excess. As before stated, it is decomposed by water; therefore strong alcohol must be used.

Artificial Light.—Artificial light, such as that produced by paraffin, gas, flash powder, magnesium, limelight, or electricity, is largely used in photography for printing, and for lighting in portraiture. For particulars of each see under the different headings. The method of using artificial lights for portrait-taking is given under **Portraiture**, *q.v.*

Artotype.—See **Collotype.**

Asbestos or **Asbestus** (Gr. unconsumable).—A variety of the amphibole or hornblende family of minerals. Asbestos consists of fine crystalline elastic fibres possessing a silky lustre. It varies in colour from white to grey or green. It derives its name from its property of being almost indestructible by fire. The finest quality is amianthus, the fibres of which are beautifully white and long. It is found in the Pyrenees and Alps; the best, however, comes from Tarantaise in Savoy, and from Corsica.

Common asbestos is darker in colour, and of lighter weight than amianthus. There are many varieties.

Asphalt (Synonyms, asphalte, asphaltum, bitumen, bitumen of Judea, mineral pitch, and Jew's pitch).—A natural product of the decomposition of vegetable substances. It is found on the shores

of the Dead Sea, also in a molten state in Trinidad, and as a mineral deposit at Seyssel. Small quantities have been found in our own country in Derbyshire, Cornwall, and Shropshire.

Commercial asphalt is generally in brownish black or black lumps, very brittle, and nearly odourless. It varies in quality, but it can be purified by boiling in water, when the pure asphalt melts and floats upon the surface, while the impurities subside.

Asphalt melts at between 90° and 100°, and burns with a bright flame. It may be dissolved in oil of turpentine, oil of lavender, benzene, and in solutions of alkalies and alkaline carbonates.

Alcohol ether and chloroform will also dissolve asphalt. By dissolving successively, three different kinds, possessing different properties, can be extracted. The alcohol extract is an oily odorous substance, yellowish in colour, and slightly sensitive to light. The ether extract is a brittle substance, of a brownish-black colour, and nearly odourless. It is a little more sensitive to light. The chloroform extract is a black, brittle, odourless residue, containing more sulphur, and much more sensitive to light, than the other extracts.

This property of being sensitive to light makes asphalt exceedingly useful for photographic purposes, especially in photo-zincography and photo-lithography. The action of the light upon a coating of asphalt laid on a zinc plate is to render it insoluble. Those parts not acted upon may be removed by a subsequent operation of washing with a solvent. It withstands the action of acids, which are then employed to eat away into the uncovered portions of the zinc (see **Photo-zincography**). In photo-lithography another property of asphalt is made use of, *i.e.*, its attraction for the greasy ink (see **Photo-lithography**).

Mixed with oil, gutta-percha, or indiarubber, it makes a capital black varnish (see **Varnish**).

Asphalto-Photo-lithographic Process.—A process originally employed by Niepce in the production of heliographic engravings. It was based upon the light-sensitive properties of asphalt.

Astigmatism, or **Astigmation.**—A defect in optics and vision. See **Aberration** and **Vision.**

Astronomical Photography, or **Astro-photography.**—In the very earliest days of photography attempts were made to photograph celestial bodies. In 1838 Daguerre attempted to photograph the moon, but was unsuccessful. In 1840 some experiments by Dr. Draper, of New York, resulted in the production of lunar photographs, 1in. in diameter. In 1850 Prof. Bond, of Cambridge, U.S., secured with the Havard 15in. refractor a daguerreotype of the moon, which was exhibited at the great London Exhibition in 1851, and caused no little sensation, as it was the first time that a distinct image of the moon's surface had been obtained. In 1853 Mr. Warren de la Rue obtained very

successful results in lunar pictures, and in 1857 he constructed an observatory at Cranford, expressly for celestial photographic purposes.

The method of making astronomical pictures differs but slightly from ordinary photography. Pictures of the moon or stars can be made in an ordinary camera, but are too small for any purpose. Fig. 21 shows how a telescope is adapted for photographic purposes. The telescope lens L remains in its position, but the eye-piece at the other end is removed, and an arrangement similar to

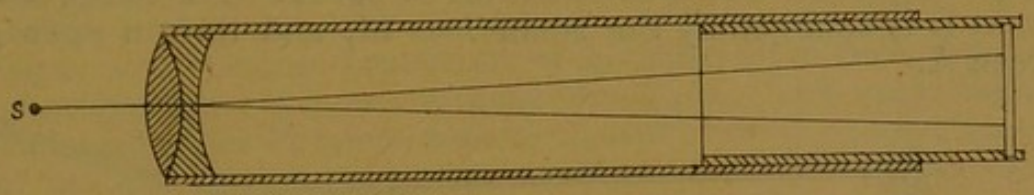


FIG. 21.

the back portion of a camera is substituted. The image of the star is thrown upon the focussing screen A, which is afterwards exchanged for a sensitive plate.

Although astronomical photography was at first regarded more in the light of curiosity than of utility, the advent of the collodion process, and afterwards dry plates, changed all this, and there is no science that has benefitted by the aid of photography to a greater extent than astronomy. To conclude remarks on lunar photography, and to give some idea of the extent of improvements that have taken place within the last few years, the author will state that he has in his possession a portion of a direct photograph of the moon 2ft. 6in. in diameter, taken at Harvard College Observatory, Cambridge, U.S., by Professor Pickering.

With regard to solar photography, the first attempt was made at Paris in 1845, by MM. Foucault and Fizeau, acting on the suggestion of M. Arago. Later, in 1851, attempts were made to photograph the total eclipse. In 1857 Warren de la Rue was commissioned by the Royal Society to construct an instrument specially adapted for photographing the sun at Kew Observatory. The resulting photo-heliograph may be described as a small telescope of 3½in. aperture and 50in. focus, with a plate-holder attached to the eye end, and guarded in front by a spring slide, the rapid movement of which across the field secured for the sensitive plate the virtually instantaneous exposure necessary, owing to the enormous light power of the sun. By means of this instrument the first solar pictures of value were taken, and a photographic record of the solar condition, recommended by Sir John Herschel, was begun, and continued to be carried on at Kew for fourteen years, 1858-72.

For some time it has been believed that the extent and character of the sun's spots have a regulating effect upon this earth, and a German professor has stated that by means of photographs of these

spots it will shortly be possible to foretell the advent of tempests, hurricanes, and other terrestial disturbances.

The work of photographing the sun is now carried on in every part of the world, and there are few days on which the self-betrayal of the camera can be evaded by our luminary.

At Kew Observatory a siderostat on Foucault's principle is used. Rutherford, of New York, has also been successful in his solar photographs. These impressions are not prepared in the principal focus of the lens as shown in fig. 21, but by the image of another image magnified. This is illustrated in fig. 22. The image of the sun at B is enlarged by the small lens M, and thrown upon the screen A.

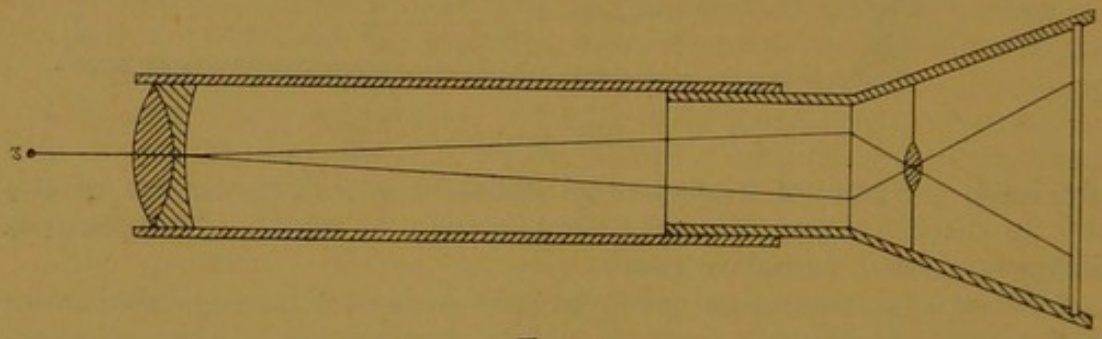


FIG. 22.

Every eclipse expedition is fitted with complete apparatus for taking many views. In Dec., 1889, two expeditions were sent out, the one to Barbados, and the other to Loanda in West Africa, to watch and photograph the total solar eclipse of Dec. 22nd, to detect any possible change in the corona during the two hours and a half that elapse between totality at Loanda and at Barbados, and to determine the photometric intensity of the corona. Each observer took with him a reflecting telescope of twenty inches diameter fully equipped with arrangements for photographing. The focal length was only 45in., and the diaphragm diameter 15in., the focal aperture was therefore f/3. The exposure required in photographing the sun is naturally very small, usually between the two-thousandth and the hundred-thousandth part of a second.

In stellar photography we must go back to about 1850, when pictures of Castor and Vega were obtained by Bond and Whipple. Since this time the uses of photography in celestial investigations becomes every year more manifold and apparent. A star may be so weak that the beam of light it emits is too feeble to render it visible even with the most powerful telescope. But this faint beam of light, acting upon the more sensitive dry plate, will in time (it may be hours) succeed in making an impression made visible by development. So that it will at once be seen how useful it must be to astronomers to have the means of recording faithfully the position of stars which he will never see. Some idea of the increase of astronomical knowledge may be gained from the fact that in Cygnus 170 stars had been carefully mapped

out by hand by a lengthy and laborious process. An exposed dry plate, however, revealed 5,000 on a single plate taken in a few hours, and if we were to construct a telescope that would make these five thousand stars directly visible to the eye there is no doubt that another dry plate exposed at the end of this telescope would reveal many thousands more worlds, rolling and shining beyond, veiled in the obscurity of immeasurable distance.

In pursuance of the decision of the Paris Congress of 1887 some 10,000 or 11,000 charts are to be made, which shall cover the whole extent of the heavens. It will probably be completed in about five or six years, and will embrace millions of stars.

Not only have many thousands of invisible stars been reveaied by photography, but many strange novelties. The great nebula in Andromeda, for instance, was for ages a mystery to astronomers until the photographs obtained by Mr. Isaac Roberts revealed the fact that it was composed of a number of rings of gaseous material apparently in a highly heated state, and undergoing some process of transformation. Photography has, too, been the means of informing astronomers of the existence of a mighty nebula, hitherto unknown, surrounding the well-known group of stars, the Pleiades.

Not only in recording the position and appearances of heavenly bodies has photography been useful, but also as a co-worker with the spectrum in ascertaining the physical condition of these bodies. A photographic investigation on a novel system of the spectra of all the higher northern stars is now being prosecuted at Havard College Observatory. The spectra are taken, as it were, wholesale; a large prism placed in front of the object glass analyses at once the rays of all the stars in the field. Capt. Abney's remarkable extension of the powers of the camera in photographing the red and infra-red rays has made it possible to explore a vast unknown and for ever invisible region of the solar spectrum. (See **Spectrum**) and it will soon be possible to ascertain correctly the condition of the various kinds of matter ignited in the solar atmosphere.

Astro-photometrical (Gr. *astron*—a star, *photos*—light, and *metron*—a measure).—Pertaining to the measurement of the light from the stars. See **Photometric.**

Atmosphere.—The gaseous vapour that surrounds the globe. See **Air.**

Atmometer (Gr. *atmos*—vapour, and *metron*—a measure).—An instrument to measure the quantity of water evaporated in a certain time under ordinary atmospheric conditions.

Atom (Gr. *atomos*—indivisible from *a*—not, and *temno*—to cut). —An atom is the smallest particle into which an element can be divided. Theoretically, an atom cannot exist in a separate state, but unites with one or more atoms to form a molecule. The atoms

of different elements have definite relative weights, fixed and invariable for each. The weight of an atom of hydrogen is regarded as unity. See **Chemistry.**

Atomic Theory.—A theory promulgated by Dr. Dalton, and with few exceptions received by chemists to this day. The theory is that all elementary bodies are formed of individual particles or atoms. That in the same element these atoms are exactly the same in size, weight, and every other respect, and that they differ from those of any other element in mass and in chemical properties. In the outlines of chemistry, this theory is more clearly explained. See **Chemistry.**

Atomic Weight.—The term atomic weight is often employed as synonymous with the term chemical equivalent. But the ideas of the two are distinct, for whereas there can only be one atomic weight of a simple substance, yet there may be two or three chemical equivalents for the same elements. The atomic weights of the different elements are given under **Elements.** See also **Chemistry.**

Attraction, Chemical.—See **Affinity.**

Aurantia.—A beautiful orange dye, the ammonia salt of an acid. It is used as a sensitiser in orthochromatic photography. Mixed with collodion formed into pellicles it is also used in the same process as a screen. See **Orthochromatic Photography.**

Aurantia Screen.—To make an aurantia screen for orthochromatic photographic purposes dissolve a small quantity of the dye in alcohol, and add this to a plain collodion. Talced glass is then coated, and, when dry, the film stripped from it.

Auric is also a derivation from the Latin term, and is used to indicate certain substances having gold as one of its constituent elements, as auric chloride—gold trichloride.

Aurine.—A red colouring matter, obtained from phenol or carbolic acid. It is used in orthochromatic photography.

Aurum.—A Latin name for gold, sometimes used to denote that metal. See **Gold.**

Autogravure.—A photo-mechanical process worked by the Autotype Company. It is a modification of the well-known etching process, by means, first, of a bituminous ground on the copper, and, second, by the transfer of the photographic image from a reversed transparency on to the copper. Etching is then done with solutions of iron perchloride.

Automatic Photography.—The invention of Monsieur Enjalbert, exhibited at the Paris Exhibition of 1889. It consists of an automatic machine designed to perform all the photographic

operations necessary to obtain by the ferrotype process the portrait of an individual who sits in front of it, and who has previously dropped a sufficient number of coins into the cash box. When the money is dropped into the slot, the electric machinery is at once set into motion. On the left of the machine directions are given as to the point upon which the eyes must be fixed during the exposure. Above there is a series of dials, divided into sections, and a revolving hand indicates at every instant the operation that is taking place inside of the apparatus. A few instants before the exposure the hand of the second dial passes over the words "Prepare yourself," and then "Attention," and as soon as it reaches the black section marked "Posé," the exposure begins, and a bell above rings as long as the exposure lasts—usually from three to six seconds. In a few minutes—the total operation lasting but five minutes—the finished ferrotype portrait makes its exit from the side to the astonished if not delighted sitter. The inventor certainly deserves great praise for the wonderful ingenuity displayed in the construction of so elaborate a machine. Similar machines have now been introduced in this country.

Automatic Printer.—A machine devised by Ure, of Glasgow, for automatically printing upon strips of sensitive bromide or chloride paper. A band of the paper passes under the negative, over which is placed a gas burner. Between the burner and the negative is a dish containing cold water. This diffuses the light and prevents the heat from the burner attacking the negative. The whole machine is worked by clockwork, set in motion by weights. The automatic movements of the machine are these. The gas is lowered to a small blue bead, a portion of the band of sensitised bromide paper comes into position under the negative, and is pressed against it with a pad; the gas then turns up, and remains burning for a number of seconds previously regulated. The gas is again lowered, the band makes another revolution, and the same action takes place. The machine requires no attendance after once being set in motion until the band of paper is exhausted. Several thousands of prints per day may be made in this manner. They are developed in strips, as the exposure has been exactly the same in every case.

Autotype (Gr. *autos*—self, and *tupos*—type).—See **Carbon Process.**

Autotypography (Autotype (*q.v.*), and *grapho*—draw).—A process invented by Mr. Willis, by which drawings made upon gelatine may be transferred to metal plates, and afterwards used for printing from like ordinary copper-plates.

Auxiliary Exposure.—The sensitive dry-plate, either before or after exposure in the camera, is exposed for a fraction of a second

to a weak, diffused light. This method has been several times recommended by competent authorities, and softer effects are stated to be the result.

Avoirdupois.—The name of a series of weights. See **Weights and Measures.**

Axis (Lat. *axis*—an axle).—The axis of a lens is an imaginary line passing through the centre of its curved and perpendicular to its plane surface. A ray of light passing along it is the only one that is not refracted. See **Optics.**

Azaleine. See **Rosaniline.**

Azote.—An almost obsolete term for Nitrogen, *q.v.*

Azotic Acid.—An almost obsolete name for Nitric Acid, *q.v.*

Background.—The representation of the most remote portion of a landscape, or of the space and objects behind the principal figures. In studio portraiture artificial backgrounds are placed behind the figure; these may be plain, graduated, or ornamented, but should always be in unison with the subject.

Plain Backgrounds.—For a plain background, a large sheet of brown paper, a brown blanket, or painted canvas stretched on a suitable frame will serve the purpose, but a good effect is hardly ever obtained with an even background.

Graduated Grounds are now largely used. In these the tint is graduated so as to light up the figure on one side and darken it on the other.

The usual method of making a graduated ground is by stretching a piece of wet common sheeting on to a suitable frame. Dry powder colour is then mixed with dextrine and dusted over it. The pigment is next worked into the fabric, and the light and shade delicately blended by skilful application of the brush.

There are other methods for obtaining backgrounds of this description, the best results being obtainable by means of the air-brush. This gives very delicate and soft results. Those, however, who do not possess this instrument may construct a similar contrivance which will answer the purpose almost as well. Get a scent-spray and study the arrangement. It will then be easy to construct something similar on a larger scale. With such an arrangement the most perfect graduated grounds may be produced with a little practice. The colour should be mixed with water and a little dextrine to fix it.

A still more simple method is to take a stiff brush lightly charged with colour and tap it against a stick held firmly in the hand over the paper or canvas, or just moisten the tips of the bristles and draw some rigid substance along them, or rub over a comb or stout wire gauge. The colour will be thrown upon the canvas or paper in little dots, and with a little care can easily be regulated as to density to obtain the right effect of gradation from light to dark.

ERRATUM.

In Part I. of "The Encyclopædia of Photography," the block showing Figures 8 to 13 was by mistake reversed. The correct placing is as follows:—

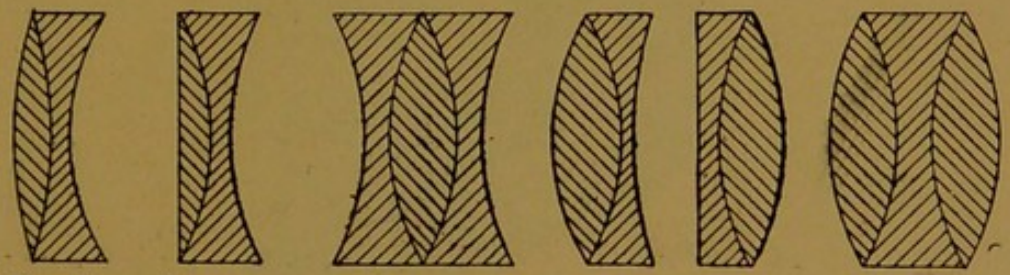


Fig. 8. Fig. 9. Fig. 10. Fig. 11. Fig. 12. Fig. 13.

It is recommended that subscribers should cut this out and paste it in Part 1.

A curved background giving graduated effects at will of the operator was devised bv M. Salomon, and is described as follows: At the back is a rod *e* (fig. 23), terminating in a series of loops and pulleys. Through these pass cords which are attached to the canopies *c* and *d*. The cords are all brought to a position behind or at the side of the background, where the operator can readily manipulate them, each cord having a counterpoise attached so as to maintain the canopy in any position into which it is pulled by the manipulator. The wings and canopy *b* and *c* are light frames covered with thin transparent white muslin, transmitting some light, but arresting or breaking up direct rays of sunlight. At each end of the canopy *c* is attached a piece of thin muslin, which we have not figured, as it would have somewhat confused the diagram. It is the same width as the wings, over the top of each of which a piece hangs to maintain the continuity between the wing screens and the projecting canopy. The canopies *d* are also light frames covered with thick white calico, transmitting very little light.

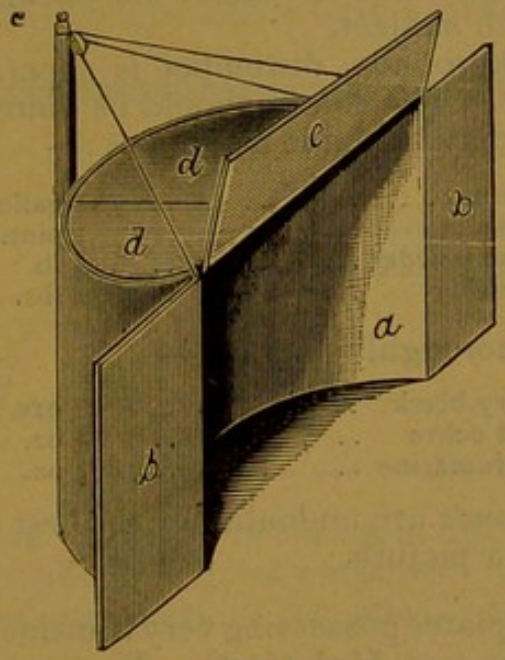


FIG. 23.

The background rests on three feet, one at each side and one in the middle; these each project behind about eight inches to give firmness and steadiness. Each foot has a large caster to permit the whole to be wheeled round easily intc any position. The wings are hinged so as to hang an inch or two from the ground, and are very easily moved backward and forward. The background is papered with salmon-coloured printing paper. The sitter is placed within the curve, and the background, which is made to run easily, is moved round him until the right effect is produced, the curved screen being used to regulate the amount of light admitted on the

lighted side, and to act as a reflector on the shadowed side, as well as to form a background, which, by its light and shade, gives space and relief to the figure.

Other methods of producing graduated effects have been devised; one worth mention is the circular or revolving background. Over a large hoop about 4½ft. in diameter, having cross-pieces and an axis, canvas or muslin is stretched. This is then painted with a neutral tint and graduated. It is started on a revolution at the moment of exposure, or worked half-way round only with a pendulum.

Ornamented Backgrounds are those made to represent scenery or distant objects. They are, however, best avoided, as rarely are pleasing effects obtained by them—so atrociously untruthful, and so glaring the faults of the average scenic background, that the more out of focus they are placed the better they appear.

As a rule, the background should be a shade darker than the middle tints of the picture, and in vignette portraits a shade lighter, though to this rule there are many exceptions, and it is only the true artist who knows how to select his background to the best advantage with each subject.

In painting backgrounds, distemper is superior to oil colours, which have a glaze. The colour should be quite dead and opaque. A good distemper may be made as follows :—

Water	1 gallon.
Treacle	1 pint.
Glue powder	½ lb.
Whiting	2 lbs.

Mix the above thoroughly and add—

Ivory black	2 ozs.
Red ochre	¼ oz.
Ultramarine	½ oz.

Natural Backgrounds are undoubtedly the best when it is possible to include them in a picture.

Backing.—Dry plates possessing very translucent films are much affected by halation (see **Halation**). To remedy the defect the plate is treated with a "backing." This backing may be made as follows :—

Water	10 ounces.
Gum	1 ,,
Powdered burnt sienna	1 ,,

This solution is brushed on the back of the plate with a stiff brush, or an indiaruber roller charged with the colour passed over the back. After exposure, and previous to development, it should be removed with a tuft of cotton-wool. Another formula—

Water	1 ounce.
Glycerine	1 ,,
Gelatine	1 ,,

The gelatine is first soaked and then dissolved in the water, and the glycerine added. Sheets of black paper are then coated, and when set, cut into the sizes required. Before placing the plate in the camera a piece of the paper is pressed on to the back. After exposure it is easily removed and may be used again. A piece of black carbon tissue, black glazed paper, or American cloth, wetted and squeegeed into contact with the back of the plate, will answer the same purpose.

There are also other methods of backing plates equally effectual. Abney recommends ordinary printers' paper coated with gum arabic, stained with aurine or a blue absorbent dye, and fastened on to the plate. Perhaps the best backing for a plate is a thin solution of asphaltum dissolved in benzole.

Bag.—See **Negative Bag** and **Changing Bag.**

Bain Marie or **Balneum Maris.**—A water bath. The substance to be heated being placed in a proper vessel, the latter is placed into another vessel containing water and capable of standing the application of fire by which heat is gradually communicated.

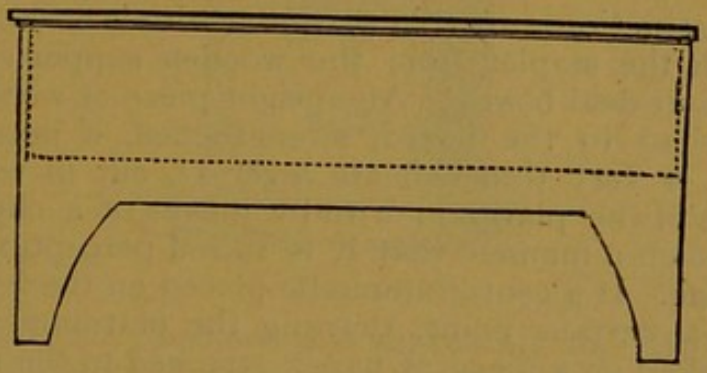


FIG. 24.

An arrangement of this kind, as shown in fig. 24, is used in developing carbon prints and for similar purposes. One of its advantages is that the water contained in the inner vessel can never reach boiling point.

Balance.—An instrument for determining the relative weights or masses of bodies. The ordinary balance consists of a beam with its fulcrum in the centre and its arms precisely equal. From the extremities of these arms are suspended two scales, the one to receive the object or substance to be weighed, and the other the counterpoise.

The possession of a good balance is of great importance to photographers and experimenters, as in many delicate processes a trifling error in the weighing of the necessary chemicals will make an important difference in the results.

A good balance should possess both stability and sensibility, or, in other words, it should not oscillate for any considerable time

after being disturbed, and it should sensibly move upon the addition of the minutest particle of matter to one of the scales. For weights see under **Weights and Measures.**

The following contrivance for weighing very minute quantities can easily be constructed by those possessing skill and perseverance. It is called a torsion balance. Fig. 25 will serve to

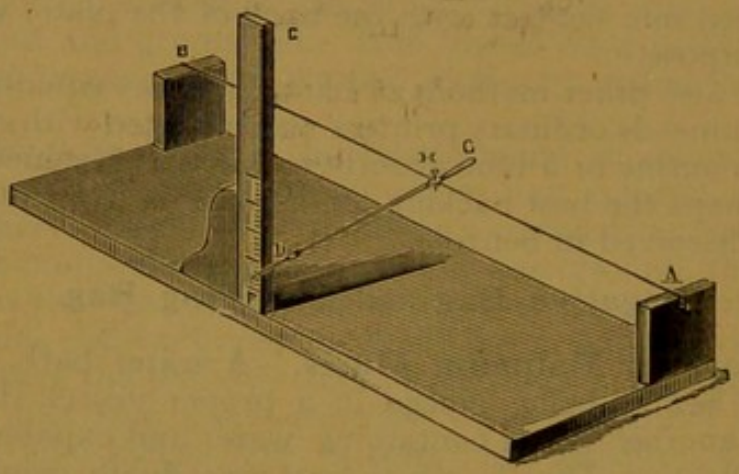


FIG. 25.

show its construction. A thin platinum wire is stretched horizontally through the staples from the wooden supports A B, firmly fixed on a stout deal board. An upright piece of wood G F is also firmly attached to the board, strengthened, if necessary, by a side piece. A very thin delicate lever D, cut in wood, is fixed to the centre of the platinum wire by means of a clip H securing it firmly in such a manner that it is raised perceptibly out of the horizontal line. If a centigramme be placed on the lever at D, it is lowered to a certain point, twisting the platinum wire, and its position marked on a piece of paper attached to the upright piece G F. The space between the two points marked by the lever with and without the weight is then divided and marked into ten equal divisions, which will represent the distance that will be traversed by the lever under the weight of a milligramme. If we wish to weigh, say, five milligrammes, a sufficient quantity of the substance is placed on the lever until it falls five divisions.

Another simple contrivance, which is within the power of anyone to construct, is a Nicholson's Areometer, fig. 26, which serves as an excellent balance. A glass balloon B, filled with air and hermetically sealed with a cork, is made to receive a piece of wood surmounted by a wooden disc D. At the lower end of the balloon is attached a small tray to hold small pieces of lead. It is then placed in a glass filled with water, and the upper portion, and the wooden stem, held in position by means of a ring attached to four pieces of wire which firmly clip the sides of the vessel. Sufficient lead is then placed on the tray C until the stem rises almost entirely above the level of the water. This stem should be divided in such a manner that each division represents the volume of a

cubic centimètre. We have now a perfect balance; the subject to be weighed is placed on the disc D, and the number of divisions the stem sinks corresponds to the number of cubic centimètres of water displaced, or the weight of the substance in grammes. Thus

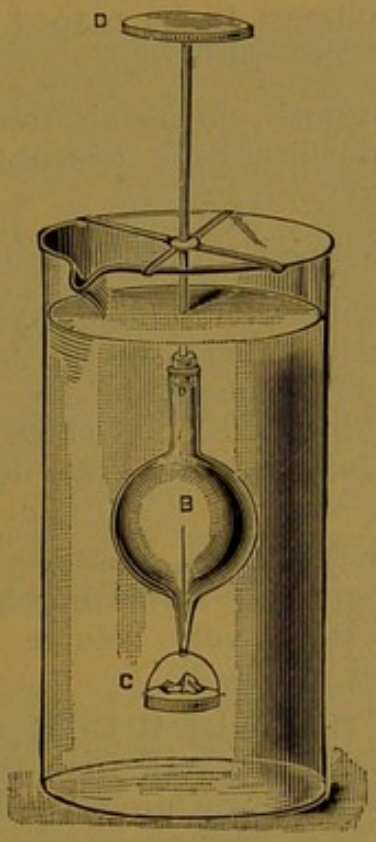


Fig. 26.

if the stem sinks six divisions this represents the displacement of six cubic centimètres of water, and the weight of the substance is therefore six grammes.

Balance of Colour.—Colours are said to balance when by opposition they are so neutralised that no one appears to predominate.

Balloon Photography.—A balloon camera for obtaining photographs from a great height by means of a captive balloon was invented and patented by Woodbury in 1877. To a captive balloon was suspended a camera, fitted with a rapid lens and an instantaneous shutter. Inside the camera two rollers were fitted carrying a band of sensitive tissue moved by clockwork. This clockwork and the instantaneous shutter were both controlled by an electro-magnet communicated to the operator on *terra firma* by electric wires running inside the cord to which the balloon is attached. By means of a small battery the operator below sends a current of electricity through the wire to the electro-magnets. The action of these latter are, first, to release the clockwork and bring into position a piece of sensitive tissue or film, and secondly, to release the shutter and make the exposure. This operation is repeated until the whole of the sensitised tissue contained in the camera is

exhausted, when the balloon is drawn to the earth, and the images upon the exposed tissue developed. The uses of an instrument of this kind are many. For war purposes it would be invaluable, enabling one to photograph and ascertain with certainty the position, strength, and movements of the enemy. For exploring expeditions the advantages to be reaped by the use of such an instrument cannot be over-estimated.

Balsams.—Exudations from certain trees and plants, and consist of liquid or solid substances resembling a resin, combined with benzoic acid.

Balmain's Paint.—See **Luminous Paint.**

Barium (Gr. *barus*—heavy. Symbol, Ba; atomic weight, 137).—A dyad metallic element prepared by the decomposition of barium chloride. Pure barium is never found native, but only in combination with other substances. Its chief sources are the native carbonate and sulphate, *q.v.* The great density of its compounds has given it its name.

Barium Bromide (Formula, $BaBr_2$; molecular weight unknown).—A salt prepared by saturating barium carbonate with hydro-bromic acid. It is very soluble in water and strong alcohol.

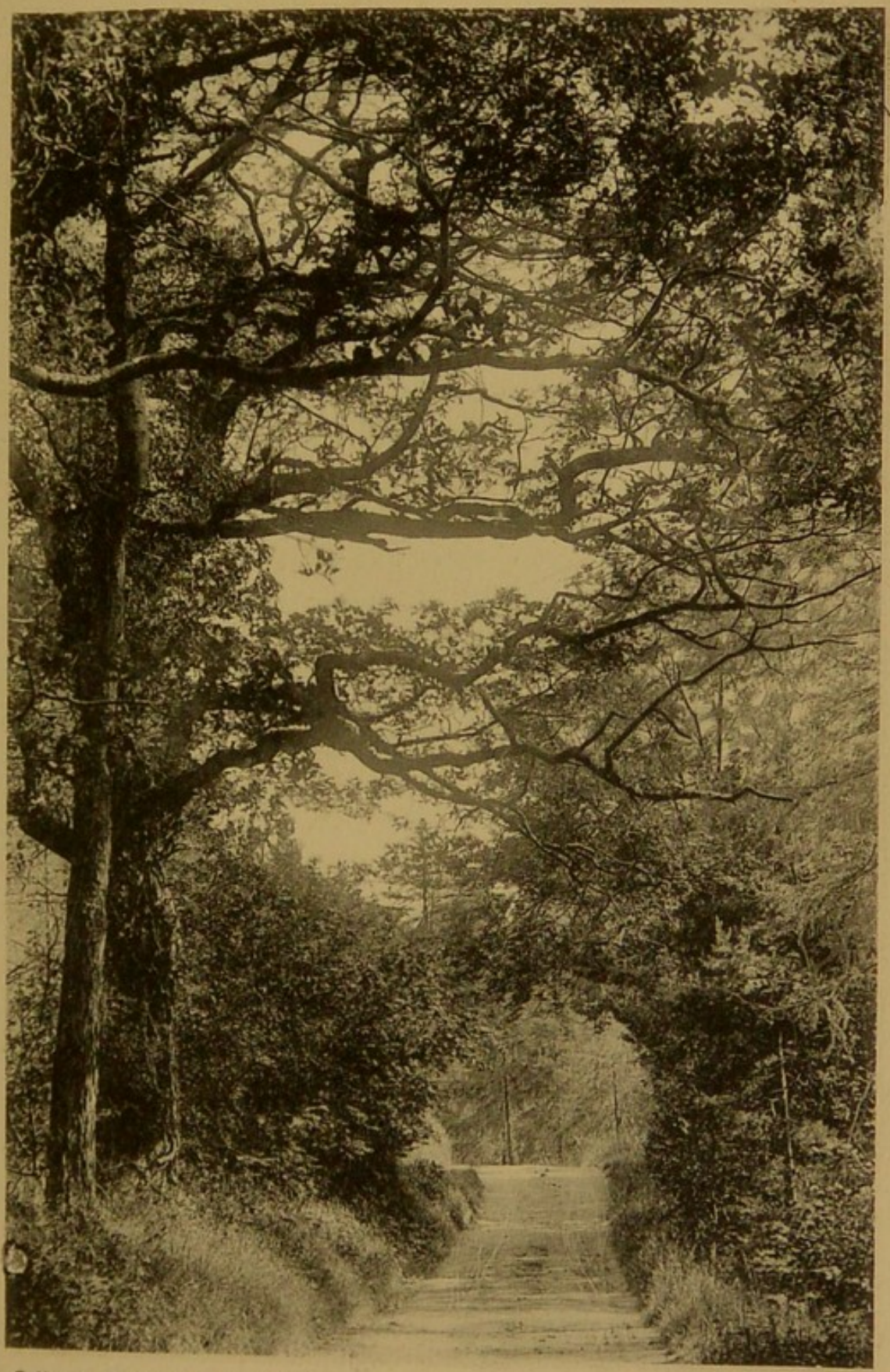
Barium Chloride (Formula, $BaCl_2H_2O$; molecular weight, 244).—Barium chloride is prepared from the native carbonate or sulphate. It takes the form of white crystals, soluble in about two parts of water. The crystals contain two atoms of water, which are expelled at 212° Fahr., leaving the anhydrous chloride.

Commercial barium chloride often contains strontium and calcium chlorides. These impurities may be removed by dissolving the crystals in alcohol.

Barium chloride is extensively used as a reagent for detecting and estimating sulphuric acid, with which it is precipitated as barium sulphate. It also forms a white precipitate with carbonate and sulphate of potassium. Mixed with chloride of gold barium chloride gives a surface sensitive to light.

Barium Nitrate (Formula, $Ba(NO_3)_2$; molecular weight, 261; synonym, *nitrate of baryta*).—Prepared by dissolving barium carbonate in a weak aqueous solution of water, and crystallising. It forms octohedral crystals, permanent in the air and moderately soluble in water. It may be used instead of lead nitrate in the preparation of protonitrate of iron. It is also added to the negative nitrate bath as a preventive against the formation of pinholes in the collodion film.

Barium Sulphate (Symbol, $BaSO_4$; molecular weight, 233).—Found native as heavy spar, or produced as a white salt when sulphuric acid is added to a soluble salt of barium.



Collotype, Waterlow & Sons Ltd. *Negative by P. L. Waterlow.*

ROAD NR. BUTTERMERE.

Barometer (Gr. *baros*—weight, and *metron*—a measure).—An instrument for estimating the weight or pressure of the atmosphere, invented by Torricelli in 1643. Torricelli discovered that if a tube closed at one end and free from moisture be filled with mercury and turned over in a dish containing mercury, the mercury in the tube will sink to a certain height (30in.), leaving a perfect vacuum at the top. When the pressure of the air is increased the mercury rises, and falls on its decrease. Upon this principle barometers are constructed. By means of a float on the mercury and a wheel, the movements of the mercury are communicated to the pointer, or hand on the visible dial.

The aneroid barometer is now largely used. The term "aneroid" is given it because it is "without moisture." In an instrument of this kind the atmospheric pressure is held in equilibrium by an elastic metal spring or tube. A metal box is freed from air and hermetically sealed. This box has a flexible side, the elasticity of which and the pressure of the air upon it keep each other in equilibrium. Upon this elastic side the short arm of a lever is pressed, while the longer arm works an index point, as in the circular barometer. When the pressure increases the elastic box gives, and when the pressure diminishes it returns to its former place, and the index moves in the opposite direction. A curved tube is sometimes used, which coils and uncoils like a spring according to the pressure on it.

The uses of the barometer are various. It is employed to calculate the height of mountains, for a barometer at sea level stands much higher than on a mountain top, because the amount of air is less, and consequently exercises less pressure upon the mercury.

In all barometric observations there are two essential corrections to be made, one for the capilarity or depression of the mercury in the tube, and the other for temperature. The following are the corrections for the capillary or depression of the mercury in tubes of different diameters, as pure mercury always assumes a convex surface in a glass tube. These corrections are made according to the theory of Ivory (*Encyclopædia Brittanica*, art. Capillary Action).

Diameter of Tube. Inches.	Depression. Inches.
·10	·1403
·15	·0863
·20	·0581
·25	·0407
·30	·0292
·35	·0211
·40	·0153
·45	·0112
·50	·0083
·60	·0044
·70	·0023
·80	·0012

Baryta (Gr. *barus*—heavy. Symbol BaO).—The monoxide of barium obtained by heating either the nitrate or the carbonate of barium. Baryta is an alkaline earth, poisonous, and not readily fusible. Its soluble salts are excellent tests for the presence of sulphuric acid, which they indicate in solution by a white precipitate insoluble in water and in acids.

Baryta Paper.—A paper prepared with baryta and colouring matter. It has a fine, smooth surface, and is largely used in collotype printing. This paper is also employed in the aristotype process, as it offers a smooth surface for the gelatine emulsion, prevents it from sinking into the paper, and the colouring matter gives it a pleasing tint. It is manufactured chiefly in Germany, where it is known as Baryt-papier or Kreide-papier.

Base.—In chemistry, a metallic oxide capable of reacting with acids to form a salt. Metals, when they burn, produce bases, which, if soluble in water, have properties the reverse of acids. They are soft and slimy to the taste instead of sharp. They change red litmus paper to blue, or the opposite effect to acids, which change blue to red. If a base be brought together with an anhydride, the resulting compound which is generally formed is called a salt.

Basic.—Pertaining to a base.

Basic Oxides.—Oxides which react with acids to form salts.

Bass Relief, bas relief, basso-relievo (Ital. *basso-rilievo*).—A term used in sculpture to figures in relief, that is, raised slightly above the plane in which they stand. In photography this term is often applied to the image produced by bichromatised gelatine or other similar process, in which certain portions stand out more than others according to the relative degrees of light and shade.

Bates, Black.—See **Varnish.**

Bath.—A term applied to various solutions in which plates, papers or films are immersed or floated, and also to the vessel holding such solution. In chemistry, baths are arranged in six different orders of temperature.

A cold bath	.. .. ..	33° to 60°	Fahr.
A cool bath	.. .. ..	60° to 75°	,,
A temperate bath	.. ..	75° to 85°	,,
A warm bath	.. .. ..	92° to 98°	,,
A hot bath	.. .. ..	98° to 106°	,,

The principal solutions, termed baths, used in the collodion negative and albumen paper processes, are the silver bath, termed the sensitising bath, the toning bath, and the fixing bath, all of which will be found fully treated upon in their respective places.

Baths or dishes to hold the solutions are made of porcelain, wood with glass bottoms, waterproof Willesden paper, Delta metal, papier maché, enamelled iron, vulcanite, glass, and celluloid.

Glass baths are undoubtedly the best, although the most expensive and easiest broken. Porcelain baths will not resist the action of the chemicals. A large quantity of the vulcanite and celluloid dishes are now used. Many ingenious attachments have been made to the baths now in use for rocking the plate when in the solution, or for facilitating the raising of it.

Bay Salt.—A salt made by distilling sea-water.

Beach's Developer.—See **Developer.**

Beaufoy's Acetic Acid.—A commercial acetic acid. See **Acetic Acid.**

Beechey's Process.—An unwashed collodion emulsion process introduced by Canon Beechey. The following is the simple and efficient *modus operandi.*

Cadmium bromide (anhydrous)	200 grains
Alcohol (805)	5 ounces

are placed in a bottle and allowed to stand for some hours. The solution thus formed is then carefully decanted, and 40 minims of strong hydrochloric acid added. Then make up

Absolute ether (.720)	9 drachms.
Pyroxyline	10 to 12 grains.

Add to this ½ ounce of the first mixture, and sensitise by dissolving 40 grains of silver in an ounce of alcohol (·820) and adding to the collodion. The best method of effecting this is to pound up the silver nitrate in a mortar. Place this in a test tube and add to it first a quarter of an ounce of the alcohol. Boil this until the alcohol becomes slightly brown, it should then be decanted off and added to the collodion. To the nitrate of silver remaining another quarter of an ounce of the alcohol should then be added, and the operation repeated until the whole of the ounce of alcohol is used, and the silver should then be completely dissolved. Between each addition of the alcohol and silver solution the collodion should be well shaken, and when all is added the emulsion should be smooth and rather thickish. Although at first transparent, the emulsion should after twenty-four hours be very opaque and creamy, and is then ready for coating the glass plates.

The glass plate is first coated or edged with a camel-hair brush round the edges of the plate with a substratum made as follows :—

White of egg	½ ounce.
Water	10 ,,
Methylated spirit	½ ,,
Carbolic acid	10 drops.

The emulsion, which should be well shaken and filtered, is then poured on and the plates coated in the ordinary manner. When set the plate is placed in a dish of distilled water until all greasiness is removed. It is then immersed in a dish containing beer, to which an ounce of pyrogallic acid has been added, to act as a

preservative. The exposure is about twice that necessary for a wet plate. Between exposure and development the plates should not be kept longer than seven or eight days, as after that period they appear to loose brilliancy.

Beer Preservative.—Abney's beer preservative is made up as follows :—

Beer	1 ounce.
Pyrogallic acid	1 grain.

After the plate is coated it is washed until greasiness disappears. The preservative is then flowed over the film and allowed to remain for about a minute. The beer solution is then drained off, and the plate washed or allowed to dry spontaneously. The use of a preservative of this kind ensures the plate being uniformly sensitive. Instead of ordinary table beer, bitter ale is recommended. Mild or sweet ale should not be used, as they contain too much saccharine matter.

Beer Process.—See **Albumen Beer Process.**

Beeswax.—The wax of bees, used by them in constructing their cells. This is melted down, purified, and sold as an article of commerce. Beeswax should melt at about 65° C. It is partially soluble in alcohol and ether, and totally soluble in chloroform.

Bellows.—That part of the camera which connects the front and back portions. The following instructions for making camera bellows are likely to be useful.

First, with regard to the material to be used. Russia leather is the best for a camera bellows, but, of course, the most expensive. Instead of this, however, an indiarubber cloth, stiffened with best quality brown paper, will answer the purpose very well, and possesses several good qualities. It does not become mildewed, nor is it liable to be attacked by insects. It will stand an English summer very well, but in a hotter climate than ours it would be useless, as the excessive heat would soften the rubber, and the folds of the bellows would be sticking together. To make it, glue the indiarubber cloth to the best brown paper attainable, and work it together in such a manner that they are in close contact all over, and no creases or air-bubbles left between. Instead of this a black leatherette paper can be used ; it is obtainable from any dealer in bookbinders' materials. This is mostly used in the cheaper make of cameras sold in the market.

The size of the paper differs, of course, with the dimensions of the camera to which the bellows is to be fitted. I will first give the dimensions of a plain half-plate camera bellows. I say plain, because there are three forms, *i.e.*, plain, conical, and truncated cornered.

It will be as well that a model of the bellows be first planned out on a sheet of paper, then creased and folded so that the operator may become familiar with the necessary manipulations and peculiarities of the folds and manner of folding.

For a bellows for a half-plate camera we require a piece of leather or paper 26in. by 22in. We next proceed to mark it on the inside surface by drawing a number of lines $\frac{7}{8}$in. apart lengthwise. (See fig. 27.) Then four lines across at distances of $4\frac{1}{2}$, 5,

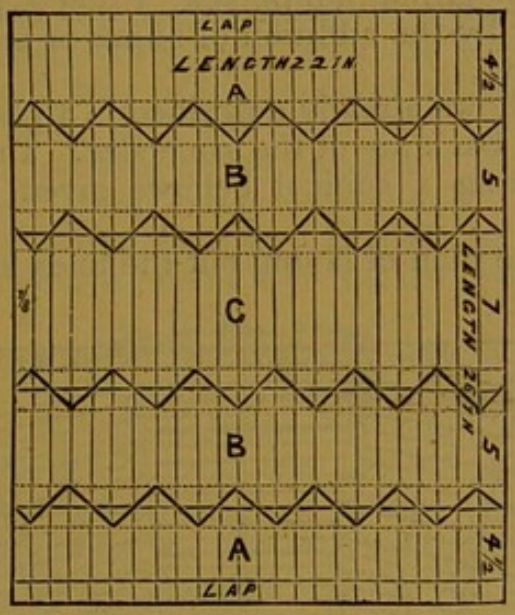


FIG. 27.

7, 5, and $4\frac{1}{2}$in. respectively, representing the four corners. On either side of these four lines rule, at a distance of $\frac{7}{8}$in., dotted lines as a guide for the interlacing diagonal lines, as shown in the accompanying illustration. The spaces marked A B C represent the bottom sides and top respectively, the bottom side being divided, and an allowance made for the lap.

First fold all the $\frac{7}{8}$ lines backwards and forwards until the whole has the appearance of a fan. Care should be taken that every fold is neatly and carefully made, otherwise your bellows when completed will assume a very unsightly appearance. Place, when folded, in between the jaws of a carpenter's bench, and screw tightly. If a carpenter's bench is not handy, apply pressure by any other means you can think of. When this is done lay it out flat, and fold it across the four lines, they being inside. The laps are then glued together by securing one end of a long, flat piece of wood in a vice, and then slide the bellows over it, allowing the lap to rest over the wood. Glue together, and a slight pressure will secure a permanent light-tight joint. If the laps when placed together form too thick a joint, it is as well to thin them with a sharp penknife.

When the joint is perfectly dry, we have to form the bellows. This is accomplished by folding the diagonal lines inside in such a

manner that the outer surfaces touch each other, continuing the manipulation on each corner of each separate fold singly; as the folds are made they should be well rubbed down with a piece of smooth wood or bone handle in order to give a sharp and permanent edge. If the previous operations have been carefully undertaken, it will be quite surprising to the operator to find how easily these folds can be made to harmonise.

The inside of the bellows should then be coated with a dead black, composed of either lampblack, French polish, or shellac, dissolved in water by the addition of borax or ammonia, and lampblack added thereto.

The form of bellows already described is a plain one—that is to say, the front and back are of the same size. I shall next describe a method of making a conical bellows given in the "Scientific American."

Fig. 28 gives the plan of laying out the lines for the folds. It is

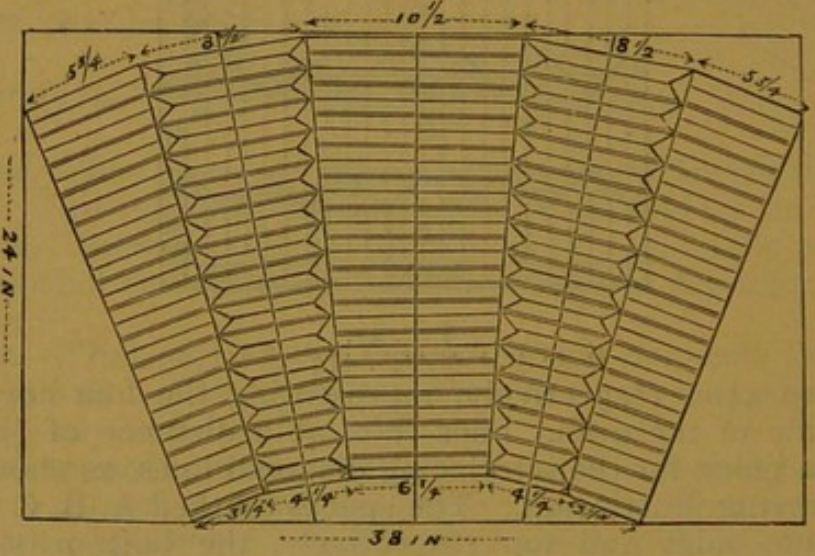


Fig. 28.

similar to the first except that special compensation has to be made for the gradual tapering of the bellows, the width of one-half of the folds being proportionately narrower than the other half. The size given is for a 10 x 8 camera. The size of the sheet of leather or paper required is 38 x 24 inches. In the accompanying drawing the single black lines represent the lines to be folded on the outside and the double lines for the inside folds. Securing our material we cut it to the size required, *i.e.*, 24 by 38 inches, and first draw a centre line in the direction of the length of the bellows. Then our bellows is to measure 10½ inches at the back and 6¼ inches in the front. We calculate half this measurement on either side of the centre line, and then connect the ends of the two front and back cross lines, the oblique lines forming the two upper radial corner lines of the bellows. The sides are to measure 8½ inches at the back and 4¼ inches at the front. We

again divide the distance at each end, and locate the side centre lines. From these we can easily determine the location by measurement of the two lower radial corner lines of the bellows. The bottom of the bellows is then divided, and one-half added to each side of the sides of the bellows, an extra half-an-inch being allowed for the lap or joint. The crease lines for the folds are next determined by first dividing off on the respective centre lines, in equal distances, the width of a double fold, which may be about 1½ inches. The measurement should commence from the wide end, and proceed towards the small end. Cross-fold lines are then drawn between the four radial corner lines in each section at right angles to their respective centre lines, and will meet each other, producing a shape similar to a portion of an octagon. The next step is to locate the position of the intermediate fold. This is done by laying the base of a draughtsman's triangle on the base line or back line, and drawing a line at 45° inward from the intersection of the corner line with the back line nearly across the fold, then by reversing the position of the triangle, so that its base is coincident with the next fold line, and drawing another diagonal line at 45° inward from the intersection of the fold line with the radial corner line to where it will cross the other diagonal line. Where they meet will be the proper location of the intermediate fold line. This will be the same for all the intermediate folds. The points for these should then be located on the centre line, and they should be drawn parallel with the other fold lines between the two centre corner lines. Each side of the bellows is measured off in this manner, the corner folds being located by drawing lines three-quarters of an inch distant from the corner lines parallel with the latter, and crossing the squares so formed by diagonal lines which represent the zigzag lines of the corner folds. In finding out the position of these various lines, dividers or any pointed instrument must not be used, as it is likely to make small holes in the material.

The third and last method of bellows making which I shall describe is that devised by Mr. Bierstadt, and called the truncated cornered Pyramidal bellows, for the reason that the corners of the folds are truncated. The advantage that this form possesses over any other is that it may be folded up into smaller space than others, and at the same time is so elastic that its folds do not adhere to each other.

In Fig. 29 will be seen a plan of a bellows of this form for a 4 x 5 camera. The peculiar manner in which this kind of bellows is folded is best explained by fig. 30. The inside measurement at the back is five inches, and at the front three inches. We draw a centre line C and measure off the side corner line D; we then divide the centre line into inches, and draw lines parallel to A, extending them on either side as far as line B. We next determine the position of the intermediate line I by deducting

from half the distance between E and A the amount of space between G and H, obtained by dropping a line from the intersection of fold line E, with corner line D to the base line A, the said line E F being parallel with the centre line C. Just here

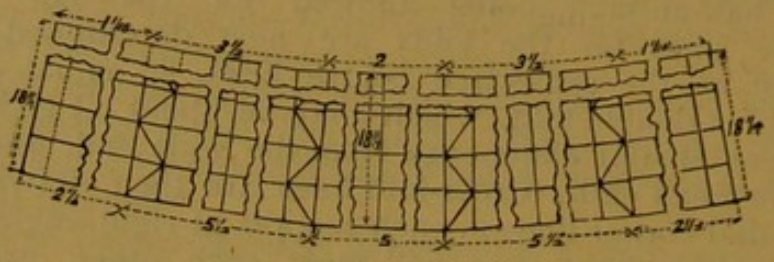


FIG. 29.

is an important difference. Instead of stopping the intermediate line at the corner line D, we extend it to point J, or a distance beyond the perpendicular line I F, equivalent to the space between I and F, or between E and I. We then draw the line J parallel with corner line D, and have a guide where to draw the zigzag lines like A and E to line D. By drawing a diagonal line from H to J across the square K, and from J to E across the square L,

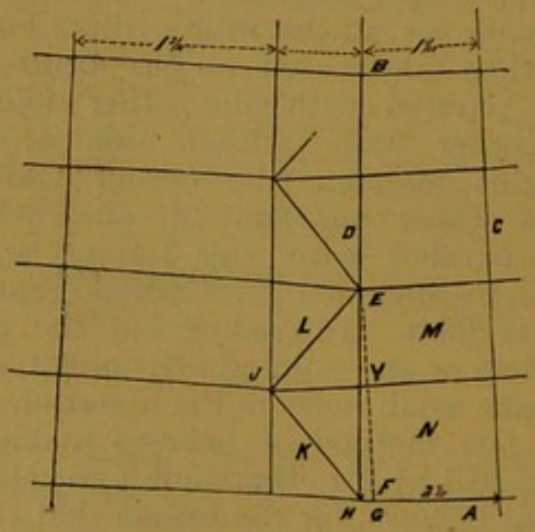


FIG. 30.

we have the proper location and angle for the corner crease lines. From the point H we measure off half the width of the inside of the intended side of the bellows. Draw a centre line perpendicular to its base, and measure off on that the position of the fold lines as described for the top of the bellows. It will be noticed that on the sides of the bellows the intermediate lines stop at line J, while the other fold lines cross the line J, and meet at E. By this method a curious skew shape of the cross lines, especially between lines D and J, is observed, but is necessary in order that the folds may come out in unison.

A bellows constructed after this plan requires a little more leather, but is far superior in appearance to any other.

Benzene (Eng. *benz(oin)*, and suffix *ene*. Formula, C_6H_6; molecular weight, 78; synonym, *benzole*).—This substance was derived from gum benzoin, hence the name benzole, a name still adhered to by many. In scientific literature, however, the name benzene has been universally adopted.

Pure benzene is a colourless, mobile, highly refracting liquid. It is scarcely soluble in water, but very soluble in ether, chloroform, alcohol, and glacial acetic acid. Its chief uses in photography are based upon its property of dissolving caoutchouc, asphaltum, gums, resins, fats, iodine, sulphur, oils, phosphorus, and most of the natural alkaloids.

It burns with a luminous flame, and its vapour is highly inflammable. Considerable care must be taken when using it, as hard friction can develop sufficient heat to inflame benzene vapour, especially if the surface rubbed be varnished with shellac. An iron heated to below red heat will also serve to ignite the vapour. These facts are not generally known, and many accidents have already resulted from ignorance upon the subject. Benzene vapour will also, if inhaled, produce giddiness and final insensibility.

The preparation of benzene is described as follows:—Coal tar is distilled and freed from phenols. It is then rectified in an iron boiler so constructed that pure benzene passes over, while its homologues condense and run back to the boiler. Commercial benzene often contains traces of alcohol. It may be rendered more anhydrous by placing a quantity of freshly prepared chloride of calcium in the bottle which contains it. After twenty-four hours, during which time it should have been shaken freely, it may be used.

Benzoic Acid (Symbol $C_7H_6O_2$; molecular weight, 122).—Obtained from gum benzoin by sublimation, or by extracting with acetic acid, or by the oxidation of benzylic alcohol by aqueous chromic acid.

Benzoic acid has the form of light, feathery, colourless crystals, melting at 121°. It dissolves sparingly in cold, and moderately in hot water, and also in alcohol.

Benzole.—See **Benzene**.

Bi.—A prefix used in chemistry to denote that two atoms of any substance, such as chlorine, sulphur, etc., were united to an element, as bichloride of mercury, $HgCl_2$. Where the word began with a consonant the prefix was changed to bin, as binoxide.

NOTE.—Instead of **bi** the suffix **di** is now used, although it will no doubt be long ere the older terms fall entirely out of use.

Bicarbonate of Soda.—See **Sodium Bicarbonate**.

Bichloride of Mercury.—See **Mercuric Chloride.**

Bichloride of Platinum.—See **Platinum Tetrachloride.**

Bichromate Disease.—A cutaneous disease produced by prolonged and frequent handling of potassium dichromate, whether dry or in solution, or by allowing the solution to enter a scratch or abrasion of the skin. In the first case it takes the form of a thick red rash, which, if closely examined, shows minute watery particles, accompanied by violent irritation. The skin then becomes destroyed, dries up, and exfoliates in bran-like scales. In winter time, when the hands are chapped, they are much more easily affected. The disease is usually confined to the back and sides of the hand and fingers. The hard portions of the palm remain unaffected. If the skin be free from scratches, cuts or abrasions, only a prolonged and constant working with bichromate will produce the disease. There are several remedies, though the prevention by wearing indiarubber gloves is better than any of them. Make up a preparation of

Glycerine	1 ounce.
Carbolic acid	20 to 30 drops.
Water	6 ounces.

Rub this well into the skin, and wash the hands frequently during the day with carbolic soap. Before bedtime apply strong nitrate of mercury ointment. By following this treatment up for several days, and carefully avoiding handling the bichromate, except with indiarubber gloves, no ill effects will be experienced.

If the disease be caused by the solution penetrating a scratch or abrasion of the skin, the matter is more serious, and should be attended to at once. A smarting sensation will be felt, when the hands should be well washed under a tap and the poison sucked out. If after a little time the smarting sensation is resumed, the hands should be placed in warm water, and afterwards in dilute ammonia for a few minutes. This should be followed by poulticing. If these precautions are not taken it is possible that an ulcer may form, which will eat deeply into the flesh, defying all efforts of cure.

Bichromate of Ammonia.—See **Ammonium Bichromate.**

Bichromate of Potash.—See **Potassium Dichromate.**

Bicoloured (Lat. *bicolor*—two colours).—A photograph is said to be bicoloured when it presents two colours to the eye. This effect often takes place in toning. The weaker portions of the image being attacked with greater force by the gold take a different colour to the stronger parts. A bicoloured image is the result.

Biconcave (Lat. *bi*—two, and *concavus*—hollowed out).—A term applied in optics to lenses having two sides, concave or hollowed out. Synonymous terms, *double-concave*, *concavo-concave*. See **Lens.**

Biconvex (Lat. *bi*—two, and *convex*—a periphery).—A term applied in optics to lenses having two sides convex, or extending outwards in the form of a sphere. Synonymous terms, *double-convex*, *convexo-convex*. See **Lens.**

Binary (Lat. *binarius*—consisting of two, lit. consisting of two).—A binary compound is a term used in chemistry to signify a compound of two elements, or of an element and a compound performing the functions of an element, or of two compounds performing the functions of elements.

Binary Theory.—A theory that all definite chemical salts are combinations of two bodies, which may be single elements or compound elements, or one of each. Potassium sulphide is a binary compound containing the elements sulphur and potassium.

Binocular Camera.—See **Stereoscopic Photography.**

Binocular Perspective.—See **Perspective.**

Binocular Vision (Lat. *bini*—two by two, and *oculus*—an eye, and Eng. vision).—Vision when both eyes are employed. This term is used in contradistinction to minocular vision—a sight with one eye only. The stereoscopic effect produced by vision with two eyes is fully treated upon under **Stereoscope.** See also **Vision.**

Bitumen (Lat. *bitumen*).—See **Asphalt.**

Black Cloth.—A cloth used to cover the camera and head of the operator whilst performing the focussing operation. It is usually made of velvet, but superior to this is waterproof cloth, as this may be useful to protect the camera in a sudden shower of rain. Another advantage is that it does not cling to the hair like velvet cloth when the head is being drawn from under it. The cloth should be of ample dimensions, and should be buttoned or otherwise fastened on to the camera front.

Blacking.—The interior of the camera dark slides and lens tubes and the diaphragms must be coated with a dead black colour, otherwise reflected light will fog the image on the plate. A blacking for this purpose may be made by grinding lamp black into a paste with japanners' gold size. (See **Black Varnish.**) The diaphragms or brasswork that undergoes much handling may be blackened as follows: Dissolve one ounce of copper carbonate in half-a-pound of ammonia solution, constantly stir, and add 18 ounces of water. The brass objects should be well polished with emery paper, and attached to brass or copper wires and plunged into the solution until completely blackened. They are then rinsed in water, dried in sawdust, and varnished with an oil varnish considerably diluted with spirits of turpentine.

Blacklead (Synonyms, *graphite* and *plumbago*).—Carbon containing about five per cent. of quartz, with oxides of iron and manganese as impurities. It contains no lead whatever. Besides its use for blacking purposes, it is an excellent lubricant for woodwork. The movable parts of the camera will be found to work much easier and smoother with its use.

Black Tones.—For methods of obtaining black tones with silver prints, see **Toning.**

Black Varnish.—See **Varnish.**

Blanchard's Brush.—Made by fastening a piece of swansdown calico or common flannel, by means of an indiarubber band, round a strip of glass or wood two inches wide and six inches long

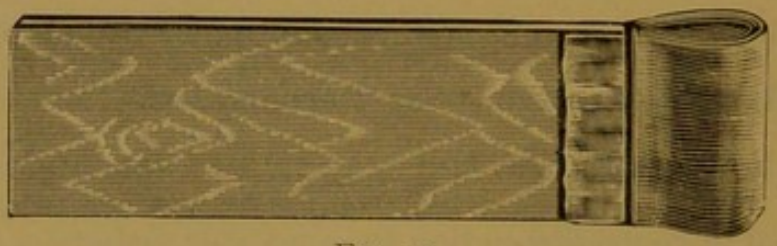


Fig. 31.

(see fig. 31), and is still a useful instrument for coating plates with albumen or for similar purposes. It was used in the collodion process for coating plates with a substratum.

Bleaching.—Before attempting to photograph engravings or old prints that have become yellow, it is well to bleach them in the manner to be described. Unless this be done, or Isochromatic plates be used, the yellowness of the paper will have in the finished print a dark and unsatisfactory appearance.

The engravings or prints to be bleached should be laid in oxygenated muriatic acid, and there allowed to remain until the yellowness has disappeared. They are then thoroughly washed in several changes of water to remove the acid and its attending disagreeable smell.

Bleaching Powder, or chloride of lime, is prepared by passing chlorine over slaken lime. It decomposes rapidly and in different ways by keeping. Its uses in photography are based upon the fact of its containing chlorine in such a loose form that any acid will liberate it.

Blisters.—Blistering of the film is an annoying defect which occurs with plates and papers coated with gelatine, collodion or albumen. Films of this nature expand on being wetted, so that the probable cause of the formation of blisters is due to the non-adherence to the glass or paper of certain portions of the film. It is also probable that blistering is due to the generation of carbonic acid gas underneath the film when treated with the hypo bath.

In the albumen process blisters generally make their appearance in the prints while in the fixing bath or in the first washing water, due probably to a strong saline solution being shut in between the albumen and the paper support, and which is afterwards brought into contact with water. Papers which have received a double or treble coating of albumen are most liable to blister. Blistering in albumen prints is often caused by rough washing, in which the prints are subjected to severe handling or tumbling. The best known remedy is the use of all solutions used in the toning, fixing, and washing operations at a certain temperature, and the addition of a little common salt to the first washing water. If the blistering is very bad, the prints should be plunged immediately after fixing into a saturated solution of common salt, or the following :—

Table salt	1½ lbs.
Ammonia	360 grs.
Water	1 gallon.

In this solution the prints should be floated face downwards for about ten minutes, and afterwards thoroughly washed.

Gelatino-bromide papers are also liable to blister. If during the summer, the temperature of the solutions must be lowered. Blistering with this kind of paper may be cured by laying the prints for a few minutes in a solution composed of ten grains of chrome alum dissolved in four ounces of water, and another four ounces of alcohol added. If the blistering is not, however, very bad, the prints may be laid in methylated alcohol only. The addition of one dram of the following to each ounce of fixing solution is also a preventive of blisters :—

Sulphate of aluminium ..	3 ounces.
Water	24 ,,

This solution should be well shaken and then allowed to stand till clear.

Blisters are often caused by the presence of foreign substances, such as lime, in the water. In this case it should be boiled for about 15 minutes before using.

With developed papers of this kind the method of adding a little methylated spirit to the developer (about five per cent. will suffice) may often be the means of preventing blisters.

Blisters with dry plates may be avoided by immersing the plate immediately upon the first signs of their appearance into methylated spirit, or into a saturated solution of chrome alum.

Blocking Out.—A term used in printing from the negative. When certain portions of the negative are not required to be reproduced in the positive, they are blocked out with an opaque paint of some kind applied to the face of the negative. In blocking out skies when the horizontal line is sharp no difficulty will be experienced, but when trees or branches project the blocking should be done by dapping or stippling the colour on the back of the negative.

Block Printing Processes.—With this term is included all those processes in which by the aid of photography a block is produced capable of being printed from in an ordinary printing press together with the letterpress. To accomplish this the half-tones of the photograph must be broken up into lines, dots, stippling or grain. The principal processes described here are Meisenbach's process, Ive's process, Husnik's process, Mosstype, and Dallastype.

Blood Albumen.—See **Albumen.**

Blotting Paper.—A thick, bibulous unsized paper capable of imbibing superfluous solution from anything laid against it.

Particular attention should be called to the necessity of using the purest chemically clean blotting paper when required for drying silver prints. In the manufacture of the cheaper qualities large quantities of hyposulphite of soda are used. This is of course detrimental to the keeping powers of the silver prints laid in contact with it. The blotting paper used should also be changed as often as consistent with economy, as it soon becomes saturated from foreign matter that is likely to damage the pictures.

Blue Black Tones.—See **Toning.**

Blue Glass.—Blue glass has often been recommended for the studio to modify the glare of the light and relieve the eye of the sitter. By its use the exposure is slightly increased. Other methods of reducing and softening the light are given under **Studio.**

Blue Printing Process.—See **Cyanotype.**

Blue Tones.—See **Toning.**

Blurring.—An image is said to be blurred when it possesses a double or indistinct outline. This indistinctness may be caused by the movement of the camera or the object during the exposure. When photographing on a windy day it is often advisable to steady the camera by suspending a large stone tied to a piece of cord fastened to the centre of the tripod. The stone should hang as near the ground as possible without touching it. Another cause of blurring, or double image, is the use of a shutter having a double motion during exposure. Much care should be taken when purchasing an instantaneous shutter of this description that when employed to work at the highest speed no jarring or jerking takes place, as this will invariably give a double image by shifting the camera during the exposure. Blurred images may also be caused by **Halation** or by **Aberration,** *q.v.*

Boiling.—Boiling gelatine emulsion to procure increased sensitiveness was first discovered by Bennett, an amateur, in 1878. He found that by boiling or long continued heating gelatine

emulsion gradually assumed the granular state and became exceedingly sensitive to light. The emulsion is not, however, boiled, but heated to a certain temperature for several hours, according to the degree of sensitiveness required (see **Emulsion**).

Boiling Point.—The temperature at which liquids are converted into vapour with ebullition. The boiling point of water is 212° Fahr., of alcohol 176°, ether 96°, and of mercury 662°.

Body.—A term applied to substances in allusion to the quantity of solid substance they contain. We have papers without body, *i.e.*, too flimsy; photographs without body, in contradistinction to those which have plenty of reduced material and vigour.

Bone Gelatine.—See **Gelatine.**

Book Camera.—A detective camera made in the form and having the appearance of a book.

Borax (Arabic *baraga* — to shine. Formula, $Na_2B_4O_7 + 10H_2O$; synonyms, *sodium biborate*, *tinkal* or *tincal*).—An exceedingly useful salt, found native in Thibet, California and Peru, also in certain parts of Italy. In the region of hot springs and volcanic action, about 65 miles north-west of Suisan Bay, California, and about 36 miles from the Pacific coast, is situated a clear lake, now called the Borax Lake. Its water contains 2,401·56 grains of solid matter per gallon, of which 535 is crystallised borax. Borax crystals are deposited in large masses in the bed of the lake, and are obtained by sinking caissons, pumping out the water, and digging up the deposit.

According to the method of manufacture, two varieties of borax may be obtained, namely—

Prismatic borax	Formula—	$Na_2B_4O_7 + 10H_2O$
Octahedral borax	,,	$Na_2B_4O_7 + 5H_2O$

Artificial borax contains many impurities, such as sodium carbonate, small quantities of sulphates, chlorides, calcium, and magnesium salts. It is also adulterated with alum and common salt.

Pure borax should form transparent colourless crystals slightly effloresced and having a weak alkaline reaction.

Borax is readily soluble in water; 100 parts of water heated to a temperature of 100° Fahr. dissolve 201·5 parts. An aqueous solution of borax has a slightly alkaline reaction. It is also soluble in glycerine, but insoluble in alcohol.

The use of borax in photography is mostly confined to the toning process.

Breadth.—This term is used by artists to denote the proper balance and relative value that should exist between the lights and shades of a picture. To secure breadth a principal part must

be made predominant, and parts that are secondary should be kept in due subordination, and thus detail in its technical sense is opposed to breadth.

Boric Acid (Synonyms, *boracic acid*, *orthoboric acid*; formula, H_3BO_3; molecular weight, 62).—Boric acid is a bibasic acid, found free in many volcanic districts, or it may be produced by treating a solution of three parts of borax dissolved in twelve parts of hot water with one part of sulphuric acid, or by making a strong solution of borax in hot water and adding hydrochloric acid until an acid reaction takes place. When cooled the boric acid crystallises out, and should be washed with cold water and dissolved for use in rectified spirit. Crystallised boric acid is in colourless crystals soluble in water, alcohol and volatile oils.

Bottles.—The selection of convenient bottles for the various chemicals used in photography requires some little thought. Acids should be kept in glass stoppered bottles, and the stoppers rubbed round with a little vaseline. This renders the stopper perfectly light-tight, and prevents it from becoming fast in the bottle. The same applies to ammonia, and other volatile compounds. Fluoric and other glass destroying acids should be kept in bottles made of gutta-percha. Solids should be kept in bottles with wide mouths to facilitate the removal of large lumps. For coating with gelatine or other similar compounds, the substance should be placed in a convenient bottle. The most suitable are the hock or Rhine wine bottles, for the reason that the long and gradually sloping neck prevents the formation of air bubbles. Their non-actinic colour renders them especially suitable for sensitive emulsions.

All chemicals sensitive to light should be placed in yellow or non-actinic coloured bottles.

For convenient dropping bottles see **Dropping Bottle.**

Boxes for storing the plates should be perfectly light-tight, and made of such wood or material as will not affect the most sensitive plates.

Brass Work.—The brass work of the interior of the lens and the diaphragm stops should be kept a dull black, to prevent the reflection of light upon the sensitive surfaces. For a suitable black, see **Blacking** and **Black Varnish.**

Brenzcatechin.—See **Pyrocatechin.**

Broken Negative.—With a little care and trouble passable prints may be made from broken negatives if the glass only is cracked or broken. If the film is broken, however, it is almost useless to endeavour to hide the defect. Even with a cracked negative it is usually less trouble to make a new negative than to print from the broken one. As this is not always possible, how-

ever, it will be well to give the two methods of printing so as to hide the defect. First method—Place the negative and sensitised paper in the printing frame as usual. Lay or attach a piece of tissue paper over the back of the negative or glass of the printing frame, and lay the frame on a board suspended by the four corners to a roasting jack. The object of this is to keep the printing frame continually turning round during the printing frame. If a meat jack is not obtainable the ingenuity of the operator will easily suggest some similar arrangement. Second method—Lay the printing frame in a narrow box about two feet deep having its sides blackened. Next drop a piece of tissue paper or lay a piece of ground glass over the frame. By this means only direct light from above will attack the silver paper, no side light being admissible, so that the crack or line of break in the glass will not be so distinctly defined.

Bromides.—The principal bromides used in photography are potassium and ammonium bromides. Of these two potassium bromide is the most suitable, owing to its stability.

Ammonium bromide is hygroscopic, and discolours under the action of light. Nearly all bromide contains a slight trace of chloride. If the quantity does not exceed one per cent., however, and soluble bromide be in excess of the silver, its presence is of little consequence. If, however, bromide and silver be used in exactly their combining proportions, or if silver be in excess, silver choride will be formed.

Bromide Emulsion.—See **Emulsion.**

Bromide Enlargements.—See **Enlarging.**

Bromide Paper.—A paper coated with a gelatino-bromide of silver (described under **Emulsions**, *q.v.*) and used for enlargements or printing by contact. This paper, of which there are several makes, may be obtained having a smooth or a rough surface, the latter being most suitable for enlargements. It should be mentioned that there are two kinds of bromide papers—negative bromide paper, which is a paper coated with the same kind of emulsion as used for plates, and is used in the camera for negative making, and a positive emulsion paper coated with an emulsion a little less sensitive to light. The following is a descriptive method of using the positive paper.

The exposure varies, of course, with the intensity of the negative and the quality and intensity of the light, which varies inversely as the square of the distance from the radiant to the recipient. For a properly developed and correctly exposed glass negative, one second by diffused daylight, or ten seconds at a distance of one foot from an ordinary gas burner. An oiled paper negative requires about double this exposure, and an unoiled paper negative about five times the amount of exposure. Over or under exposure

may be judged of upon development. An over-exposed print will present a poor and flat appearance, devoid of vigour in the shadows, and having an excess of half-tone, whilst a want of half-tone and a dark, heavy appearance of the shadows is due to under-exposure. As soon as the correct exposure is ascertained, any number of prints may be made without fear, for if the paper, negative, light, distance, and exposure be the same in each case, the results must likewise be similar, and a large batch may be developed at one and the same time.

Developing is the next operation. The ferrous-oxalate developer gives the best results. Two formulæ will be given.

FERROUS-OXALATE DEVELOPER.

No. 1.

Oxalate of potash	16 ounces.
Hot water	48 ,,

No. 2.

Iron protosulphate	16 ounces.
Hot water	32 ,,
Sulphuric acid	½ dram.

No. 3.

Potassium bromide	1 ounce.
Water	32 ,,

Solution No. 2 should be tested with blue litmus paper, which it should redden distinctly. If this effect does not take place, a very slight addition of sulphuric acid will probably suffice. These three solutions should be kept separately, and only mixed when required for immediate use, when they should be taken in the following proportions:—No. 1, six ounces; No. 2, one ounce; and No. 3, one dram, mixed in the order given.

Many modifications of this developer have been recommended, and consist chiefly in the addition of citric acid (about 1 drachm) to the oxalate solution (No. 1), and the substitution of the same quantity of the same acid in place of the sulphuric acid in the iron solution (No. 2).

Another developer to be recommended is the hydrokinone developer. In twelve ounces of hot water dissolve

Sodium sulphate	1 ounce.
Hydrokinone	15 grains.
Sodium carbonate	1½ ounces.
Potassium carbonate	1½ ounces.
Potassium bromide	20 grains.

For sepia or brownish tones use an alkaline pyro developer, arranged as follows:—

Water	1 ounce.
Pyrogallic acid	1 to 2 grains.
Ammonia	2 minims.
Potassium bromide	3 grains.
Citric acid (sat. sol.)	10 drops.

After exposing the paper it is placed in a bath of cold water until limp. It is then removed and placed face upwards in a tray, and the developer poured rapidly over it. The image should

appear slowly, and should be strong, clear and brilliant, exhibiting, if correctly exposed, all the detail in about three minutes. The dish should be kept rocking; many ingenious contrivances having been made to do this automatically, though the hand supersedes them all. All air-bells should be removed from the film before the development has proceeded far, and when the shadows are sufficiently black the developer is poured off and the clearing solution added. In developing it should be remembered that a too rapid development gives a weak, flat image. A too slow development gives violent contrasts and great hardness. The addition of a further quantity of No. 2 solution strengthens the developer, whilst No. 3 tends to retard its action. By modifying the proportions in mixing the developer much softness and brilliancy can be obtained. For developing a print from a weak, soft negative mix one part of iron to three of oxalate. No larger quantity of iron than this must be taken, as it will then form a precipitate, and the developer will be spoiled. A short exposure and a prolonged development with the above developer will give brilliant results with a thin negative. With a dense, hard negative, however, with hard contrasts, a very small portion of iron solution should be added, say 1 to 12, while for every three or four ounces of developer a single drop of the bromide solution will suffice.

When the print has obtained full vigour, the developer is poured off, and, without any previous washing, the following clearing solution is flooded over it:—

Acetic acid	1 drachm.
Alum	8 ounces.
Water	32 ,,

or this—

Sulphuric acid	1 ounce.
Water	100 ,,

Allow this to act upon the image for about a minute, then pour it away and apply a fresh portion. Then rinse and place in the fixing bath, made up with three ounces of sodium hyposulphite dissolved in 16 ounces of water, and tested for alkalinity.

After fixation, the prints are thoroughly washed in many changes of water for about two hours. They are then hung up and placed across a pole to dry.

The rough or matt surface papers appear to best advantage with most subjects if allowed to dry with their ordinary surface. A beautiful glossy surface may, however, be given to bromide prints upon smooth paper in the following manner:—

After the prints are removed from the final washing water, they are squeegeed in contact with a sheet of plate glass, previously well cleaned and lightly rubbed over with French chalk (a powdered talc). Here they should remain until quite dry, when they are easily peeled off the glass with a surface equal to the glass itself. Instead of plate glass, a sheet of polished vulcanite celluloid, or even a ferrotype plate, may be used. With these, if properly

cleaned, no special preparation is necessary. Bromide prints are mounted in the ordinary way. They appear to best advantage behind a cut out, or on a deep sunk mount.

If proper use of the clearing solution has been made, the pictures should be clear and free from yellow stains, the object being to remove these by preventing the precipitation of the iron from the developer in the paper. Over-printed proofs may be reduced by immersion in chlorine water or in a solution of cupric chloride. If blisters appear in fixing, a little common salt should be added to the first washing water, or the prints placed in a three per cent. aqueous solution of chrome alum. The most scrupulous cleanliness must be observed with regard to the dishes used, and, in fact, with everything with which the paper comes into contact, as the faintest trace of hyposulphite of soda, pyro, or free silver, will ruin the pictures entirely. The tray used for the oxalate development should not be used for any other purpose.

The tone of the prints upon bromide prints differs considerably with the different manufactures of paper, and with the various methods of development. Agreeable tints may be got by the usual method of toning with chloride of gold. Bromide prints may also be toned with platinum by substituting it for the silver image. The prints should be very much over-printed and then soaked in the following bath until the desired tone is arrived at—

Platinum perchloride	8 grains.
Distilled water	30 ounces.
Hydrochloric acid	½ ,,

They are then washed and dried.

Bromide Negative Paper is a paper coated with an ordinary gelatine emulsion as used for dry plates, and described under **Emulsion.** Its treatment is the same as is required for ordinary dry plates. Owing to the opacity of the paper the printing process is much slower. Under **Translucent** will be found one or two methods of making the paper more transparent.

Bromide Pencils.—Pencils specially manufactured for touching up or spotting out bromide contact prints or enlargements.

Bromide of Ammonium.—See **Ammonium Bromide.**

Bromide of Cadmium.—See **Cadmium Bromide.**

Bromide of Potassium.—See **Potassium Bromide.**

Bromide of Silver.—See **Silver Bromide.**

Bromide of Zinc.—See **Zinc Bromide.**

Bromine (Gr. *bromos*—a stink).—A non-metallic element discovered in 1811, having the symbol Br and an atomic weight of 80. It is a dark, reddish-black liquid obtained from sea-water and from saline springs. It has a powerful and irritating smell. When

inhaled it is poisonous. It is soluble in water to the extent of about 30 in 1,000. It is more soluble in alcohol, ether and chloroform. An aqueous solution is used to give off bromine vapour in the Daguerreotype. Bromine has also been added to collodion in place of iodine, but is inferior to it. It is closely analogous to chlorine and iodine, its affinities being weaker than those of the former, but stronger than the latter. Bromine forms a large class of salts, of which the following are most familiar to photographers, and will be found in their respective places in this work:—Ammonium bromide, barium bromide, cadmium bromide, potassium bromide, silver bromide, and zinc bromide. Bromides, with the exception of silver and mercurious bromides, are soluble in water. They can be detected by the following reactions:—Silver nitrate gives a yellowish precipitate of silver bromide insoluble in dilute nitric acid, but soluble in strong ammonia. Chlorine liberates bromine from all its soluble compounds, and if the liquid be shaken up with ether a yellow etheral solution will float on the surface of the liquid. A solution of starch produces a yellowish-red colour; it distils as a liquid.

Bromizer.—A bromide of metal or alkaline added to the plain collodion is called a bromizer.

Bromo-argentotype. (Eng. *bromo*, from *bromine*; Lat. *argentum*—silver; and Gr. *tupos*—type).—A process in which the sensitive compound is composed of silver nitrate and potassium or ammonium bromide.

Bromoform.—A compound analagous to chloroform, but containing bromine instead of chlorine. It is a heavy volatile liquid, and is, when pure, colourless and solidifies at 8°C.

Bromo-iodised Collodion.—A collodion to which an iodide and a bromide have both been added.

Bromuret.—Bromide, *q.v.*

Bronze.—In silver printing the darker portions of the positive assume, after prolonged exposure, an olive green colour, lighter than the dark-brown colour which should precede it in intensity. This is called bronze, and its production bronzing. This bronzing may be removed by chloride of gold, or its appearance prevented by having less free silver in the paper.

Bronze Mounts.—See **Mounts.**

Bronze Powder.—Bronze powder is made by stirring in a crucible over a clear fire equal quantities of sulphur and white tin oxide until it assumes the appearance of a yellow flaky powder. This powder is largely used for edging and lettering the cheapest class of mounts in place of gold leaf. With these mounts, how-

ever, loose bronze powder becomes imbedded in the face, and causes small white spots to appear in the print after it has been mounted a little time. See **Mounts.**

Brunswick Black.—Prepared by fusing 2lbs. of asphalt and mixing thoroughly with about a pint of hot boiled oil. When the mixture is cool, two pints of turpentine are added.

Buckle's Brush.—A convenient little arrangement, easily made with a piece of thin glass tubing, with a diameter somewhat exceeding that of a common lead pencil. Into one end of this tube is drawn by means of a bent silver wire or piece of string a tuft of cotton wool, a good-sized tuft being allowed to remain outside to act as the brush. One of the advantages of this little arrangement is the ease with which the cotton-wool, when dirty, can be replaced.

Buff.—A buff is used in the Daguerreotype process for polishing the silver plate, and also in glass processes for polishing the glass plate. A handbuff is made with a piece of deal about sixteen inches long and five inches wide with a handle either at the back or at one end. The deal is then covered with fine velvet, the ribs of which are laid across the buff, or, instead of velvet, wash-leather is used.

Bunsen Burner.—Named after the introducer, Herr Bunsen, of the Breslau University. It consists of a jet surmounted by a

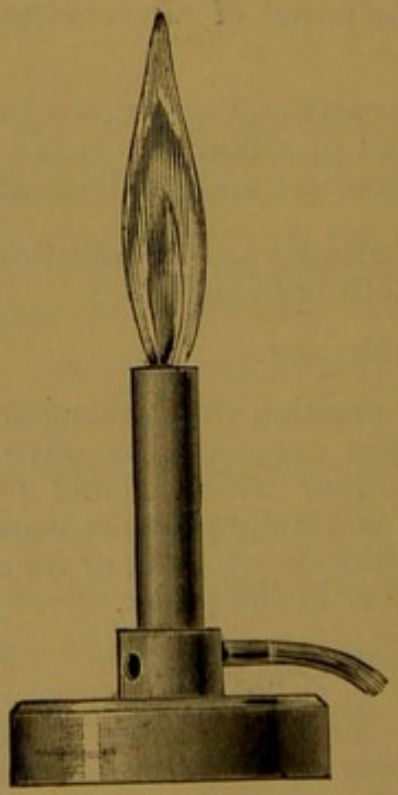


FIG. 32.

wide brass tube, at the bottom of which are several holes for the admission of air (see fig. 32). The air and the gas mix in such pro-

portions that they burn with a non-luminous flame. A reference to the accompanying sketch, fig. 33, will serve to show that the flame thus produced consists of, first, a dark cone, which is cold unburnt coal gas mixed with 62 % of air, and an outer flame

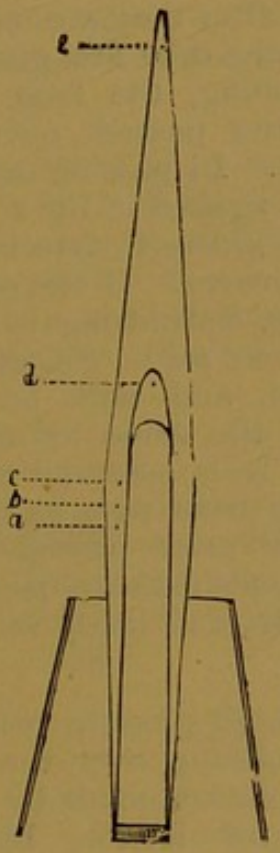


FIG. 33.

mantle composed of burning coal gas mixed with air—a luminous point at the top of the inner zone only visible if the air-holes at the basement are partially closed.

The flame of a Bunsen burner at a low temperature is suitable for observing the flame colourations of volatile substances.

At the highest temperature, a zone of fusion *c*, it is suitable for fusions at high temperatures.

The lower oxidising flame *d* is suitable for oxidation of substances in borax or other beads.

The lower reducing flame *a* is serviceable for reductions on charcoal and for fusing borax or other beads in the reducing flame.

The upper oxidising flame *e*, obtained by admitting the maximum of air, is suitable for oxidation at lower temperatures.

The upper reducing flame *b* is used for reductions, and possesses greater reducing power than the lower reducing flame already mentioned.

The principal advantages of the Bunsen burner are its small consumption of gas, the great heat it gives out, and entire freedom from smoke. They are made in many shapes and sizes.

Burette.—A little instrument consisting of an attenuated tube fitted on to a stand, combined to contain exactly 1,000 grains of water and graduated into one hundred equal parts, so that for each division emptied ten grains have been expended.

Burnisher.—Prints, after they are mounted on cardboard, and before they are perfectly dry, are given a finish by rolling or burnishing. In burnishing, the face of the mounted print is lubricated with soap and passed over a steel burnishing bar heated by a lamp or gas. In passing over the heated steel bar, it is kept tightly pressed against it by a roller at the top, and by this means a polished or glossy surface is given to the print, adding to its beauty and permanency. If the print be enamelled by any of the enamel processes, burnishing is unnecessary. There are various kinds of burnishers sold. Select one with a good piece of hardened polished steel, and with an arrangement for easily removing or getting at the same for cleaning. It should work evenly and smoothly. It is essential that the steel bar be kept perfectly clean and free from rust, as the slightest bit of foreign matter will mark every print passed over it. Should it get scratched it must be re-polished with fine emery powder mixed into a paste with paraffin oil, and lastly with a piece of dry chamois leather.

Burnishing gives a high gloss to prints. The mounted print is first lubricated by rubbing over the face a piece of flannel dipped in Castile soap solution, made by dissolving three grains of Castile soap in an ounce of alcohol. It is then passed through a heated burnisher (see **Burnisher**) several times, the pressure increased each time. No stoppage must occur in passing the prints through, or an ugly ineffacable mark will be the result. The face of the albumen paper passing over the heated bar of polished steel soon takes a gloss. Burnished prints should be stood up to cool; if placed one upon the other, they lose their gloss.

Burton's Process.—See **Emulsions.**

Button-hole Camera.—A small detective camera worn under the vest with the lens protruding through one of the button-holes.

Cabinet (Fr. *cabinet*).—Abbreviated term for a cabinet picture.

Cabinet Mount.—A mount for a cabinet photograph.

Cabinet Picture.—This term was originally applied to small pictures or paintings from the old masters painted on panel, copper or canvas, and which, from their size and value, would be preserved in a cabinet. It is now generally applied to photographs of a size about 6 × 4ins.

Cadmium Bromide (Symbol, $CdBr_2$; molecular weight, 271·2). —Prepared by heating cadmium to a red heat in bromine vapour.

It takes the form of a white crystalline solid, non-hygroscopic, and soluble in water, alcohol and ether. It is used in the collodion process, and is preferable to the other bromides on account of its stability, solubility, and purity.

Cadmium Chloride (Symbol, $CdCl_2$; molecular weight unknown).—Prepared by dissolving the metal cadmium in hydrochloric acid and evaporating.

Cadmium Iodide (Symbol, CdI_2 ; molecular weight, 366).—Prepared by digesting one part of the metal cadmium with two parts of iodine in the presence of water. The solution is then evaporated, and yields large flat micaceous crystals of a pearly lustre. They are anhydrous and permanent in the air, and will only melt when heated to about 600° Fahr., forming an amber-coloured fluid.

Cadmium iodide is freely soluble in water or alcohol. The solution reddens blue litmus paper.

It is used in photography as an iodiser for collodion. Collodion iodised with cadmium ~~bromide~~ iodide does not discolour if kept in a cool dark place unless contaminated with zinc iodide. When this is the case the crystals are imperfectly formed, and when dissolved in ether or alcohol liberate iodine.

Calcination (Lat. *calcino*—to calcine).—The operation of expelling from a substance by the application of heat, or by other means, the water or volatile water combined with it. The operation of reducing a metal to an oxide.

Calcine (Lat. *calcino*—to calcine).—To reduce to a powder ; to oxidise, or reduce a metal to an oxide.

Calcium (Symbol, Ca ; atomic weight, 39.9).—A light brass-yellow metal, malleable, oxidises in damp air (becomes converted into hydrate), decomposes water, and dissolves easily in dilute acids. Calcium unites with all the non-metallic elements to form compounds.

Calcium is found as calcium carbonate in the forms of marble and limestone, in the bones of animals as calcium phosphate, and in various forms in many other substances.

Calcium Bromide (Symbol, $CaBr_2$; molecular weight unknown).—Prepared by burning calcium in bromine vapour, or by saturating hydrobromic acid with carbonate of lime. The solution thus formed is then evaporated, and yields silky hydrated needle-like crystals. These may be converted into the anhydrous salt by ignition. Calcium bromide is deliquescent and very soluble in water or alcohol.

Calcium Chloride (Symbol, $CaCl_2$; molecular weight, 111).—This salt is found in sea-water, but is usually obtained as a bye-

product in the preparation of ammonia gas, or by dissolving chalk, marble or lime in hydrochloric acid and evaporating.

Calcium chloride is highly deliquescent. 100 parts of the powder will, if exposed to an atmosphere saturated with aqueous vapour, absorb 124 parts of water in 96 days. This property makes it very useful in many photographic operations for drying gases or depriving ether and alcohol of water. It is also used for drying photographic preparations, and in the platinotype process for keeping the paper quite dry by absorbing all the moisture contained in the tube in which it and the paper are placed. For these purposes a common quality will be serviceable, as pure dry calcium chloride is rather expensive.

Calcium chloride is very soluble in water and alcohol. It crystallises in prisms, having the formula $CaCl_2 6H_2O$.

Calcium Iodide (Formula, CaI_2; molecular weight unknown).—Prepared by saturating hydriodic acid with carbonate of lime, or by the action of iodine on calcium sulphide suspended in water. This salt is useful for the preparation of other iodines. It takes the form of a white deliquescent mass, soluble in water and alcohol.

Calcium Tube.—A cylinder of metal capped at each end. It is used for keeping ready sensitised platinotype paper. In one of the caps is a perforated chamber containing asbestos, impregnated with calcium chloride, which has the property of absorbing the moisture contained in the air surrounding it. By this means the paper placed in the cylinder or tube is kept perfectly dry. When the asbestos becomes a damp mass, owing to the deliquescence of the calcium chlorine contained in it, it is placed on a metal plate over a fire, and the moisture driven off by heat. It can then be used again.

Calomel (Gr. *kalos* — beautiful, and *melas* — black). — *v.* **Mercurious Chloride.**

Calorific (Lat. *calor*—heat, and *facio*—to make).—Having the property of producing heat.

Calorific Rays.—The heat rays of the spectrum. See **Spectrum.**

Calotype (Gr. *kalos*—beautiful, and *tupos*—type).—A paper negative process patented by Fox Talbot in 1841, and also known as the Talbotype process in honour of the inventor.

The outlines of the process are as follows:—A carefully-selected paper of fine and even texture is brushed over on one side with a solution of silver nitrate (16 grains to the ounce of water) and allowed to dry. It is then dipped in a solution of potassium iodide (500 grains to the pint of water), and allowed to remain for two or

three minutes to allow the iodine to combine with the silver and form silver iodide. The paper is then rinsed in pure water and dried, when it will be seen to be covered with a pale yellow coating of silver iodide, which is practically unacted upon by light. When the paper is desired for use it is taken into the dark room and carefully brushed over with the gallo-nitrate of silver, made by mixing an aqueous solution (50 grains to the ounce) of nitrate of silver with one-sixth its volume of acetic acid, and adding an equal quantity of a saturated solution of gallic acid. This paper is then ready for use either wet, or it can be dried and used at a future period, and the image brought out by brushing more gallo-nitrate of silver over the surface.

Cameo Photographs.—Photographs to the surface of which a slight convexity is given by means of a die and press.

Cameotype.—A small vignette Daguerreotype suitable for mounting in a jewel case like a cameo.

Camera (Lat. *camera*—a chamber).—Essentially a dark box arranged to hold a convex lens at one end and the sensitive plate or paper at the other. The earliest camera made by Daguerre was nothing more than this, but since so many improvements have taken place, and the various branches of photography so largely extended, it will be necessary to describe many different forms of cameras constructed for various purposes.

The most essential qualification for a camera of any description is that it is entirely light tight. Any defect may be detected by carefully examining the interior of the camera in bright sunlight.

The Plain Camera is built entirely of wood. Focussing is accomplished by pushing in or out the back portion, which slides in grooves. A camera of this description is only suited for home work, as it possesses none of the necessary arrangements required for out-door work.

Bellows Camera.—In this the back and front portions are connected by an expanding cover resembling the bellows of an accordion, made either parallel, square or conical. Various qualities are made. The better class are usually fitted with a screw or rack and pinion focussing arrangement (by which means a very exact adjustment may be made), a reversing back, a swing back, and a rising and moving swing front, a description of the uses of which will be found in their respective portions of this work.

The principal requirements in a camera are compactness and portability, though to secure this rigidity must not be sacrificed, as nothing is more fatal to success than vibration of the camera during exposure.

Many of the modern cameras are fitted with detachable fronts to enable the lens to be quickly changed for another. Each lens being fitted to a different front, it is easily fitted into its place and

secured into a light-tight position by clamps or some similar arrangement.

Another modern improvement is the revolving front, which has for its object the bringing of the lens opposite any desired part of the screen, the revolving part being circular, and the lens fitted at one side of the circle.

Double Extension, or *Long-focus Camera*.—To photographers who use a number of lenses of varying foci a double extension camera is a necessity. This camera is specially constructed to be used with a long focus lens, with which the screen must be placed some distance back to secure a sharp picture. A large number of different patents have been taken out for arrangements to secure this result, all being based upon nearly the same principle, which is that the base-board, to which the front and back of the camera are attached, is made double, one part fitting upon, or into, and sliding over the other, so that by this means the base-board, when fully extended by racking it out, is nearly double its usual length. In some cameras the back or front have to be separated by racking out the whole length with the rack and pinion arrangement; in others the front is attached at once to a more distant point, and a few turns of the focussing suffice to secure a sharply-defined image. Extension cameras of this class may also be divided into two classes, *i.e.*, "back extensions" and "front extensions." With the former the back portion of the camera is attached to the extending part of the base-board, and in the latter the reverse. In the opinion of the author the front extension arrangement is the best, as with the other form the double dark slide, containing two heavy plates, is racked out, and will be likely to vibrate from very slight causes. In front extension cameras, however, one is liable when working with a very wide-angle lens to find part of the base-board obstructing a portion of the view, but this defect is removed in some cameras by an arrangement by which when working with this kind of lens the back may be detached from its position and placed close up to the front. In purchasing cameras of this kind it is essential to observe that the base-board is firm and rigid, even when racked out to its fullest length. It should also close up so that a short focus wide-angle lens can be used.

The sizes of cameras that are usually made in England are for plates of the following dimensions:—Lantern size, 3¼in. × 3¼in.; quarter-plate, 4¼ × 3¼ and 5 × 4; half-plate, 6½ × 4¾ and 7 × 5; whole-plate, 6½ × 8½, 8 × 10, 10 × 12, 15 × 12, and 18 × 24.

Studio Camera.—This is a camera specially built for use in the studio. In this many of the arrangements and fittings attached to the tourist or portable camera will be found, though the whole is built in a more solid manner, as it is only necessary to study rigidity and firmness without portability. A good studio camera should have a swing back, a rising and sliding front, and other arrangements for portrait work. By means of masks fitted inside

the camera close to the focussing screen, and grooves in the top of the dark slide and a catch, two pictures can be taken on one plate. This is termed a repeating back.

Stereoscopic Camera (Synonym, binocular camera).—A double camera fitted with two lenses, their centres distant about two and a half to three inches, and their foci equal. The size of the plate receiving the images formed by the two lenses is usually $6\frac{3}{4} \times 3\frac{1}{4}$ inches.

Another method of making stereoscopic views is by using one camera on a sliding arrangement, with which the camera could be shifted the required distance after making the first picture. With this arrangement, however, it is impossible to include moving objects in the pictures taken.

Detective Camera.—Under this heading we may include all those cameras which are disguised in appearance, or which are capable of taking pictures when hidden from sight. A large quantity of these have been manufactured in almost every conceivable form. Among the many we may mention the watch camera, made in the form of a watch; the vest camera, made to be worn behind the vest; the parcel detective camera, disguised in the form of a box wrapped in brown paper, and tied with string like an ordinary parcel; and others of larger size made to appear in the form of a satchel or leather covered case.

Enlarging and Copying Camera.—A camera constructed for copying or enlarging negatives or positives on glass or paper. See **Enlarging.**

Solar Camera.—This apparatus consists of an arrangement for enlarging in which the solar rays of the sun are used for the light to illuminate the negative. There are two methods—one is to illuminate the negative by the direct solar rays, and the other

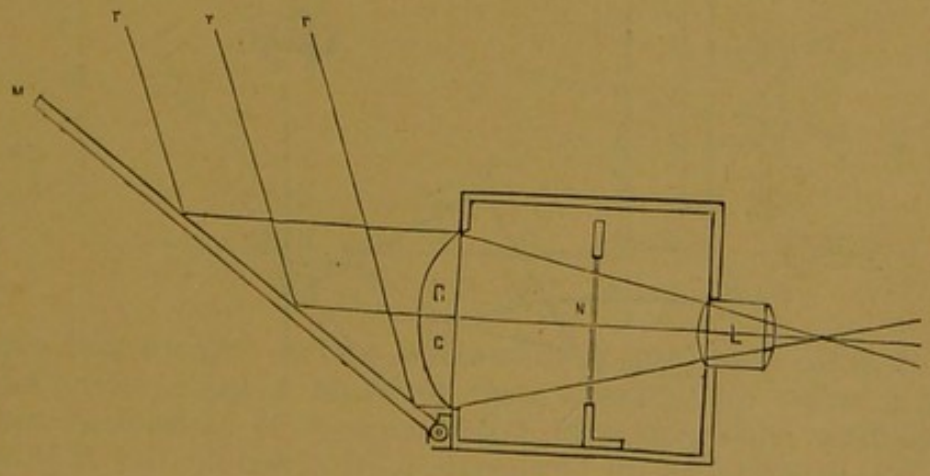


FIG. 34.

is an arrangement by which these rays are first concentrated by a lens. Fig. 34 will serve to explain the construction of the latter form of apparatus. The lens L is fixed at the principal focus of

the condenser C. The mirror M throws the ray of the sun *r r r* on to the condenser, and the negative N to be enlarged is placed between the lens and the condenser at a distance varying with the size of the enlarged image required.

It is only necessary to place this apparatus in a darkened window and adjust the mirror, keeping the solar rays always reflected in the same direction. This apparatus is but little used now. The more modern arrangements for enlarging will be found under that heading.

Micro Camera. — A camera for photographing microscopic objects. The simplest form consists of a long mahogany camera, containing dark slide and focussing screen, and which can be fitted on to the tube of a microscope.

Midget Camera.—A camera fitted with a number of small lenses. It is used for making midget or stamp portraits, a dozen or more pictures being taken at the same time and upon the same plate.

Panoramic Camera.—A camera used for making panoramic views or groups. See **Panoramic Pictures.**

Camera Bag or **Case.**—A bag or case to contain the camera and its fittings for convenience in travelling. These are made of all kinds of material, from the common canvas to the finest leather. A good waterproof canvas answers the purpose well. It should be fitted with lock and key to prevent inquisitive persons examining its contents and the contents of the dark slides. The best camera cases are made of good stout leather, and lined inside with velvet to prevent the scratching of the polished wood of the camera.

Camera Lucida (Lat. *camera*, and *lucida*—light).—An arrangement designed to facilitate the delineation of objects. It consists

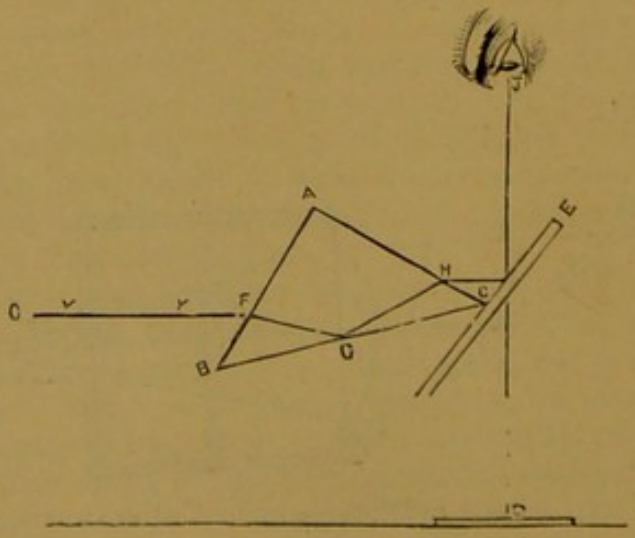


FIG. 35.

of a rectangular glass prism A B C (fig. 35), having one of its sides turned to the object to be depicted, while the other is at

right-angles to the inclosed plane of glass D E. The ray *r* proceeding from the object O enters the prism at F, where it is slightly refracted. It is totally reflected at G, again refracted at H, and partially reflected at I, reaching the eye at J, so that the image is seen apparently at O, whilst the point of a pencil is clearly seen at the same place, enabling one to trace distinctly the image of the object O.

Camera Obscura (Lat. *camera*—chamber, and *obscura*—dark). —An instrument in which, as its name implies, the essential feature is a dark chamber. It is said to have been invented by John Baptista Porta, a Neapolitan philosopher. But although a description of the instrument is given in his "Seventeenth Book of Natural Magick, wherein are propounded burning glasses and the wonderful sights to be seen by them," published in 1658, yet it is generally believed that the invention dates much farther back, and was known to Friar Bacon in the thirteenth century. If we take a room and exclude all light except that which enters at a small hole made in the window-shutter, we shall obtain when the sun is shining an inverted image of the objects outside thrown upon the wall opposite the aperture. The delineation is, however, very imperfect, but by placing a double convex lens in the aperture and a sheet of white paper in its focus we obtain a perfect sharp image. By making a miniature room

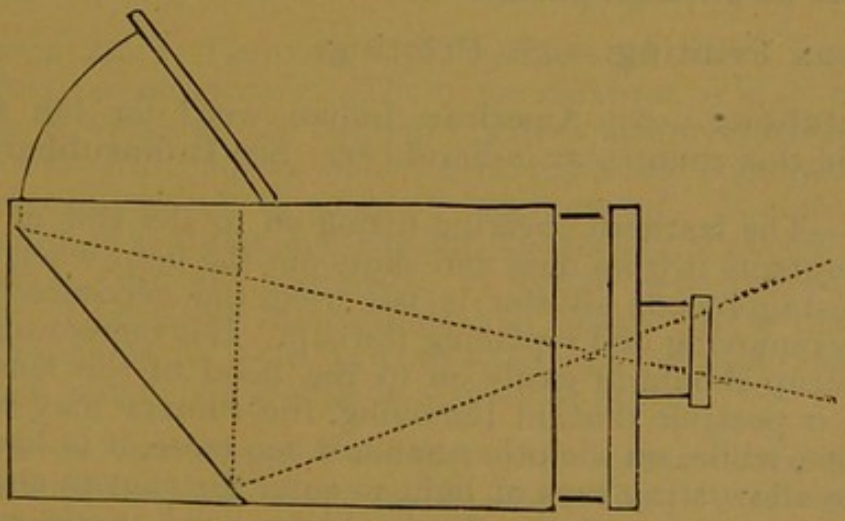


Fig. 36.

out of a box formed of two parts sliding into each other to adjust the focus for objects more or less distinct we have a modern camera obscura. A lens is fitted into one side, and the rays entering it fall on the mirror arranged at an angle of 45°, which will reflect them upwards and reverse the image, which would otherwise appear upside down at the end opposite to the lens. The image is reflected on to a piece of ground glass or a piece of plain glass and a sheet of white paper laid over it, enabling one to trace the outlines of the picture.

Another form of camera obscura is that often seen at fairs. In this a triagular prism, acting as a condensing lens and mirror combined, throws down upon a white table a representation of the surrounding scenery.

Camera Stand.—A table arrangement to hold the camera. The studio camera stand should be solidly built, and have the new arrangements for raising, lowering and tilting the camera. For all other classes of work the camera stand having for stability three legs is termed a tripod, *q.v.*

Camphor (Synonym, *laurel camphor*).—Obtained by dissolving with water the leaves and wood of the camphor tree, a native of Japan, Formosa, and central China. It is a solid white volatile crystalline mass, very tough, and difficult to pulverise. It possesses a peculiar odour, and is soluble in alcohol, ether, and strong acetic acid. It is sometimes added to gelatine, albumen, etc., to prevent them from decomposition and mould.

Canada Balsam.—A pale oleo-resin obtained by incision from the American silver fir, a Canadian tree. It is soluble in benzole, and a solution thus prepared will render paper highly translucent. Its principal uses in photography are in cementing the various components of lenses together, and in mounting microscopic objects to be photographed.

Canvas Printing.—See **Printing.**

Caoutchouc.—An American Indian word for the substance known in this country as indiarubber. See **Indiarubber.**

Cap.—The leathern covering fitting on to the end of the lens, which protects it from dust and shuts out the light when required. If an instantaneous shutter is not used, the exposure is usually made by removing and replacing the cap. It is therefore necessary that the cap should fit easily on to the hood of the lens. If too tight, it is possible that, in removing, the camera may be caused to vibrate, while, on the other hand, if too loose, it is likely to fall off, or to allow stray rays of light to enter the camera and produce fog on the sensitive plate. It should be lined inside with black velvet.

Caragheen Moss *(Sphærococcus crispus).*—An Irish moss or species of sea-weed from which a jelly is manufactured. It has been used in photography in place of gelatine for suspending the silver salts to form an emulsion.

Carbolic Acid (Formula, C_6H_5HO; synonyms, *phenol*, *phenyl-hydrate*, *phenic acid*, *coal tar*, *creosote*). — Amost exclusively manufactured from the coal tar produced in gas manufacture. Pure carbolic acid forms colourless needles, of a distinct odour,

which melt at 95° F. into an oily liquid having a strong odour and taste. Carbolic acid is freely soluble in alcohol, ether and glycerine, and but slightly in water. Unlike other acids, it does not redden blue litmus paper. It is a powerful antiseptic, and is largely used as a disinfectant. A minute quantity, if added to albumen or gelatine, will prevent mould and decomposition. For the former, the quantity must be very small, as carbolic acid coagulates albumen.

Carbon (Lat. *carbo*—coal. Symbol, C; atomic weight, 12).—Carbon occurs in three allotropic forms—diamond, graphite, and charcoal. Carbon for photographic purposes is usually prepared from lamp black. This black being very stable—that is to say, retains its colour for such a long period, as evidenced by the ancient manuscripts—it is clear that photographs made in such a manner that the colouring matter is practically pure carbon will be very permanent. Upon this principle the carbon process and Woodburytype are based.

Carbonate of Ammonia.—See **Ammonium Carbonate.**

Carbonate of Potash.—See **Potassium Carbonate.**

Carbonate of Silver.—See **Silver Carbonate.**

Carbonate of Soda.—See **Sodium Carbonate.**

Carbonic Acid (Formula, CO_2).—The old name for what is now termed carbon dioxide. The name carbonic acid is, however, the one with which all are familiar. Other synonymous terms are carbonic anhydride and carbonic oxide (by a few chemists). It is a colourless gas about 1½ times as heavy as air. It is evolved in large quantities in active and extinct volcanoes; it accumulates at the bottom of deep pits and wells. It has an agreeable odour, but if respired it produces insensibility and death. At a pressure of 38·5 atmospheres at 6° it is converted into a colourless liquid, insoluble in water, but soluble in alcohol or ether.

Carbon or Autotype Process.—A process based upon the fact that gelatine and other organic substances, if heated with a bichromate, become sensitive to light by becoming insoluble in the parts exposed. This fact was discovered by Mungo Ponton in 1838, but it is to the subsequent discoveries and improvements of Becquerel, Porterin, Pouncey, Swann and Sawyer that we are indebted for the simple and efficient carbon or autotype process of the present day.

The carbon tissue prepared for this process consists of paper coated with gelatine containing carbon, lampblack or other pigments (see **Carbon Tissue**).

It can be purchased ready sensitised, but in this condition will not keep for any length of time.

Cutting up the Tissue is performed by unrolling it gently upon a zinc cutting plate, cut square and true, with the inches marked at the bottom and right hand side. By using a T square and observing the numbered inches marked on the plate, it will not be difficult to cut the tissue to any dimension. If the tissue is very curly and unmanageable it should be kept down with convenient weights. After cutting it up to the required sizes, which should be conveniently smaller than the dish to be used for sensitising, it should be kept flat under a metal plate.

Sensitising the Tissue is the next operation. This is performed in a solution of potassium dichromate rendered alkaline with ammonia. Tie over the mouth of a two-gallon jug a piece of muslin, to form a kind of bag, into which place fifteen ounces of potassium dichromate, then fill up the jug with water and allow it to stand till the dichromate is dissolved and the solution become cold. It is sometimes advisable to regulate the quantity of bichromate. In hot weather, or for very thin negatives, the proportion of water should be doubled, while for very hard negatives only half the quantity should be used. In very hot weather it is sometimes advisable to replace about 30 per cent. of the water with the same quantity of alcohol.

The operation of sensitising the tissue must be carried on in a room lighted by a window covered with a yellow blind. A flat dish of porcelain, glass, or *papier maché*, a squeegee, and a sheet of glass or zinc a size larger than the tissue, will be required.

The solution is poured into the dish, and should be at least two inches deep. The tissue is then immersed in it, and the air-bells that form immediately brush away from both sides with a broad camel-hair brush. The temperature of the bath should not be higher than 60°F., and the time of immersion should be from three to five minutes. After the tissue has remained in the solution for the allotted time it is gently removed and laid face downwards upon the glass or zinc plate, and the back squeegeed, removing all superfluous solution. The tissue is removed from the glass and laid over a sheet of cardboard, bent into the form of an arch, to dry.

Another method (H. J. Burton's) of sensitising carbon tissue is to lay it flat on a sheet of clean blotting paper, and sponge on the back a very strong sensitising solution composed as follows:—

Potassium dichromate	4 ounces.
Liq. ammonia fort	1 ,,
Water	20 ,,

First mix the ammonia with the water, then grind up and add the dichromate.

Drying the Tissue should be accomplished in a room perfectly free from the noxious fumes of other chemicals, and lighted only by non-actinic light. Tissues sensitised during the evening should be dry on the following morning. It should then be cut to

the sizes required and kept flat in a pressure frame or other similar contrivance.

Exposing the Tissue.—The tissue can be exposed behind the negative in an ordinary printing frame, or in special frames having no joint in the back, as no image is visible. The negative must be furnished with a safe edge, made by painting an edge about one-eighth of an inch round the negative with black varnish, or by pasting on strips of red or black paper. Exposure must be judged by an actinometer. Several forms of this instrument are described under the heading **Actinometer.** A very suitable instrument for toning the exposure of carbon tissue is Sawyer's actinometer. It consists of a rectangular tin box with a glass lid, bearing twelve tints gradated from slight discoloration to a degree of opacity, representing the extreme amount of deposit upon the lights of the densest negatives, each division of this screen of tints bearing a number in opaque pigments; a roll of sensitive paper is placed in the box, and the end pulled forward so as to pass under the tints. When this arrangement is placed in the light, the silver paper commences to discolour underneath the gradated screen, beginning of course at the lightest, but the number on the tint being in an opaque pigment is preserved white, and serves to register the progress of printing; for if, when the lid is opened, the number one, for instance, shows clearly on a tinted ground, the instrument is said to have registered one tint; by that time the number two will have begun to make its appearance, and if sufficient exposure be given the light will print through the whole scale by successive steps, and show up the numbers one to twelve. With an instrument of this kind it is evident that, by exposing alongside the carbon tissue and determining the number of tints required for the proper exposure of that negative, the same number of tints with the same negative will always prove right. A little practice will enable one to judge the number of tints required for every class of negative.

It will be well to remark here that freshly sensitised tissue will produce inferior pictures to that used a day or two after; the pictures are not so hard, and there is less danger of the high lights being washed away.

Continuing Action of Light.—If the carbon tissue after exposure to the light be kept in the dark for a little time the effect on the print will be precisely the same as if the exposure to light had been prolonged. This continuing action of light may often be utilised to advantage. Pictures known to be under-exposed will, if kept till the morning, by that time have acquired the same force as if they had received the proper exposure.

Development consists simply in dissolving the gelatine unaffected by light, with hot water as the solvent. Now, it will be seen that as the tissue is laid against the negative the parts acted upon by the light and rendered insoluble are on the surface of the gelatine film, the lower stratum next the paper remaining soluble. By

placing the whole in warm water we should dissolve the lower portion of the gelatine film, detach the paper, and leave the insoluble picture floating about helplessly in the water, where it would soon be destroyed. To prevent this we attach the tissue to a rigid or flexible support to retain it intact whilst the process of development is being carried on, for if the pigment film after exposure be placed in water for a short time and then laid upon any plain surface impermeable to water it will firmly adhere to it, provided precautions have been taken to carefully exclude the air from between the surfaces. It will also adhere to paper prepared with an insoluble gelatine film or any other colloid body, provided the two surfaces are brought into contact in a moist condition.

In transferring the pigment picture to a support, we obtain a reversed positive. For portraiture, seascapes, and many landscapes, this is no disadvantage, and the picture may be developed by what is termed single transfer. For subjects which would be spoilt if reversed, what is known as the double transfer must be resorted to, unless in the first instance the negative was reversed.

Single Transfer.—Immerse the exposed tissue in a bath containing cold water. It will first of all curl up, but afterwards lay flat and limp. It is then placed in another bath containing cold water and a piece of single transfer paper (paper coated with a thin and insoluble gelatine) which has been soaked in water for a little time. Bring them together face to face, draw them out, and lay them upon a board, and force into close contact with a large squeegee; then place between blotting paper for five or ten minutes. In squeegeeing, the tissue should be uppermost, and a sheet of American laid over it to prevent the squeegee from damaging it.

Development should not be attempted for at least twenty minutes, during which time the tissue should be placed between sheets of blotting paper, and kept under pressure to ensure its adherence to the paper support. After that time it is placed in a dish, and water heated to a temperature of 100° F. added. The coloured pigment will at once commence to ooze out of the edges, and after a little time the paper originally holding the carbon film may be removed with the hand. Then, by gently laving the picture with the hand, the superfluous gelatine will be washed away, and if the exposure has been correct a perfect image should remain. A certain amount of control can be kept over an autotype picture. An over-exposed print will show itself by insolubility of the gelatine, the high light refusing to be washed clear. The temperature should be raised considerably, and hot water poured over with a jug. If this fails to reduce the intensity, add a little ammonia to the water as a last resource, though the better plan is to make another print, giving less exposure. Under-exposure results in over-solubility of the gelatine. The half-tones will be washed clean away. It is rarely an under-exposed print can be saved. All that can be done is to reduce the temperature of the water.

Development should never be hurried; the slower it is the better the gradation of tone in the results.

After development is complete the bichromate salt is discharged, and the image rendered perfectly insoluble by well washing in cold water and placing in a dish containing a five per cent. solution of potash alum, after which they are again washed and dried.

Double Transfer Process.—In this the development is the same, and the whole process similar, except that the tissue is squeegeed first on to a temporary support, and from this transferred to its permanent support. By this means we get a non-reversed print from an ordinary negative.

For the temporary support we may use paper, zinc, or glass, and treat with a waxy solution of

Yellow resin	6 drams.
Beeswax..	3 ,,
Turpentine	20 ounces.

This solution is rubbed on with a piece of flannel and then polished with another clean piece of soft flannel. The carbon tissue is squeegeed on to this support in the same manner as described in the single transfer process, and after it has been developed, washed, fixed in alum, washed again, and dried, it is ready for transferring to the permanent support. The transfer may take place at once whilst wet, or the pictures may be hung up to dry and transferred at some future time.

The double transfer paper or permanent support is a paper coated with gelatine and barium sulphate. A piece of this paper cut to the right size is steeped in

Potash alum	1 ounce.
Water	1 pint.

some time previous to the transparency operation. This is then squeegeed in the usual manner to the developed print. It is then allowed to dry, and a knife point inserted under one corner will cause the temporary support to separate from the other, leaving the image firmly imbedded in the gelatinous insoluble *couche* of the permanent support.

The temporary support may be employed again by rewaxing in the manner described.

The pictures may be given a brilliant finish by applying a few drops of methylated spirit to the surface, rubbed over with a piece of flannel. Another method is to squeegee on to glass. This method will be found described in finishing bromide prints, and can be adopted with any picture in which the film or image is a gelatinous one.

Among the defects that will arise in carbon printing, it will be well to mention a few of the more important. If the tissue becomes insoluble, it is due to its having been dried in warm, damp air. It may also be caused by the following:—Acid sensitising bath, too long keeping after sensitising, and exposure to light, gas

fumes or damp. Frilling is caused by a neglect of the safe edge, placing the film on the temporary support too soon after the waxing of the latter, or insufficient pressure after development. Spots are due to air bubbles, or dust between the tissue and the support. If the prints refuse to leave the temporary support, it is caused by imperfect waxing.

The carbon or autotype process is also largely used for making lantern slides, opal pictures, and transparencies. See under these headings.

Carbon Enlargement.—An enlargement made by the carbon process. See **Enlarging.**

Carbon Tissue.—Paper coated with gelatine containing one or more pigments, and used in the carbon process, *q.v.*

The composition of the pigments used should be carefully studied. If carbon, lampblack only is used. We get pictures that will last a long time, as proved by the brilliancy of printers' ink many years old. But it is nearly always necessary to add some other colour to give an agreeable tone. The colours of the pigments used depend, of course, upon the kind of picture to be reproduced. For instance, if it is intended to reproduce a red-chalk drawing by incorporating with the gelatine a pigment of the same colour, an almost perfect *facsimile* may be obtained. To manufacture carbon tissue requires too much labour to be profitable to any but very large consumers. The Autotype Company manufacture their tissue, and sell the same plain or sensitised. This tissue may be obtained to give pictures of the following tints:—Standard brown, engraving black, sepia, red chalk, standard purple, warm black, portrait brown, portrait purple, special purple, sea green, and a special for transparencies.

A good carbon paper may be made as follows:—

Gelatine	5 ounces.
Isinglass	½ ,,
Water	70 ,,
Lampblack	¾ ,,
English red (peroxide of iron)	1 ,,
Glycerine	1½ ,,

Dr. Gunther gives this formula, and describes the method of preparing it as follows:—The gelatine should be neither too soft nor too cold, and the quantity of glycerine should be about equal to the volume of the colouring matter added. The black colour is rubbed down on a stone slab, then the glycerine is added and the rubbing continued. Sufficient water is then poured on to obtain the required consistency, and the desired degree of fineness having been certain, the colour is collected with a horn spatula. The red colour is rubbed down with water only. The two colours are then mixed together on the slab. During the time occupied in preparing the colours, the isinglass, cut into

small pieces, is allowed to soak in about 4 ozs. of water. It is then boiled, stirring all the time, until but fine skins are floating in the somewhat muddy solution, when the whole is strained through linen. This solution is then poured into the gelatine, previously dissolved in lukewarm water. The colouring matter is now placed in a large porcelain dish, and the warm gelatine and isinglass solution added in small quantities, stirring all the time with a pestle until an even homogeneous mixture has been produced. The whole is at once strained through muslin or moistened flannel, and the mixture is ready for coating. For methods of coating paper with gelatine see **Coating.**

Carrier.—An arrangement for holding film or paper sensitive surfaces, when exposed in the camera in the same manner as the dry-plate.

Carte-de-Visite.—A small size of professional photograph, measuring about 4 × 2½in.

Caseine.—An albuminoid substance found in milk. It is very similar to albumen. Caseine dissolved in a weak solution of ammonia may be used for coating a plate. It gives a film less hard than albumen. Vegetable caseine is found in the gluten of flour, peas, beans, etc.

Castile Soap.—A fine highly-purified soap, originally made in Castile from olive oil and soda. It is used in photography for lubricating prints previous to burnishing. For this purpose about three or four grains of the soap are dissolved in an ounce of alcohol. The solution thus formed is rubbed over the face of the print with a piece of flannel.

Catalysotype (Gr. *katalusos*—a dissolving, and *tupos*—type).—A calotype process, in which paper is first prepared with a syrup of iron iodide instead of the ordinary potassium iodide. After exposure, the paper is developed by merely keeping it moist. It was supposed that the reason of this change was due to a catalylic action on the silver salt caused by the light, hence the name catalysotype. The correct theory is, however, that the paper, when excited on the silver proto-nitrate of iron, is formed by the same decomposition which produced silver iodide, and this proto-salt being a still more energetic developer than gallic acid the latent image became visible. The process is, however, very defective, and not used now.

Caustic (Gr. *kaustikos*—burning).—Chemical substances which destroy the animal tissue if applied to the flesh. The most commonly used caustics are caustic silver, caustic ammonia, caustic potash, and caustic soda.

Celluloid (Lat. *cellula* — a little cell, and Gr. *eidos* — appearance).—A mixture of soluble pyroxylin with camphor, made by adding pyroxylin to melted camphor, by strongly compressing the two substances together, and by dissolving the two in a mixture of ether and alcohol, and evaporating. It was first made by Hyatt, of Newark, U.S., and takes the name celluloid from its having, when viewed under the microscope, the appearance of little cells (?).

The simplest method of manufacturing celluloid is by dissolving 50 parts of camphor in as little a quantity of alcohol as possible, and sprinkling this solution over dry pyroxylin; then cover over with a second layer of pyroxylin, and again sprinkle the camphor solution over it; 100 parts of pyroxylin should be used. By this means the celluloid mixture is made, and sinks in transparent lumps, which must be worked for about an hour between cold iron rollers, and afterwards for another hour between rollers which can be heated with steam. The layers of celluloid thus formed are placed one above the other and pressed in a hydraulic press at a temperature of about 70° C. for about twenty-four hours. The cakes are then cut into smaller cakes, and dried for eight to fourteen days in a room heated to about 35° C.

Celluloid is an ivory-like material, and can be turned in a lathe like ivory, or if heated to about 175° Fahr. can be moulded into any shape or form. It is highly inflammable unless mixed with a substance of an opposite character. It is non-explosive.

Celluloid Films.—Films of celluloid *(q.v.)* may be coated with a gelatine sensitive emulsion, the celluloid taking the place of the glass of the photographic dry plate, the advantage being in the reduction of bulk and weight.

Cellulose (Formula $C_6H_{10}O_5$).—A substance constituting the basis of vegetable tissues. Pure cellulose is a ternary compound of carbon and the elements of water.

Cement.—A good cement for mending glass, &c., may be made by dissolving isinglass in warm water and adding acetic acid. This cement is sold under the name of coaguline and other fancy names.

Cement for Wood to render Watertight.—A good cement for wooden vessels that are required to be made watertight can be produced with a mixture of lime-clay and oxide of iron. These should be separately calcined and reduced to a fine powder. They are then well mixed together, kept in a closed vessel, and mixed with the required quantity of water when used.

Cement for Iron Pots.—Into an old iron pan place two parts of sulphur, hold over the fire until melted, then add one part by weight of fine black lead. Stir them well together until well mixed, and pour on to an iron plate or smooth stone. When cool

break into small pieces. To mend a crack in a pot, put a small quantity of this composition on it, and solder with a hot iron in the usual manner.

A Cement for Indiarubber.—This can be made with :—

Carbon-bisulphide	5 ounces.
Guttapercha	5 drachms.
Indiarubber	10 ,,
Fish glue	25 ,,

Centigrade Thermometer (Fr. *centigrade*, from Lat. *centum*—a hundred, and *gradus*—a degree).—A thermometer generally used on the Continent. It is graduated on the scale of Celsius. The space between freezing point is divided into 100 parts, freezing point being marked at zero and boiling point 100°. In the Fahrenheit thermometer generally used in England, these points are 32° and 112° respectively. To convert Centigrade into Fahrenheit it is necessary to multiply by 9, divide by 5, and add 32.

Centigramme (the hundredth part of a gramme).—A measure of weight used in the French decimal system of measurement. It is equivalent to ·15433 of a grain troy weight, or ·16924 avoirdupois. The French decimal system of measurement is much superior to the English, and is being largely adopted in this country.

Centilitre or **Centiliter.**—The one-hundredth part of a litre—a French measure of capacity or volume. It is equivalent to 2dr. 50min. English fluid measure, or ·6103 of a cubic inch.

Centimetre or **Centimeter.**—The one-hundredth part of the French measure of length, the metre. It is equivalent to ·0397, or about two-fifths of an English inch.

Centrifugal Separation.—A process of separation used in the gelatine emulsion process, and described under **Emulsion.**

Ceramic Photos.—See **Enamels.**

Chalk.—A well-known substance, a massive opaque carbonate of lime. It is sometimes used in the toning bath. See **Toning.**

French Chalk.—Steatite, or soapstone. Powdered French chalk can be used as a lubricator for woodwork. It is also used to prevent gelatine or other similar substance from adhering to glass. If a clean sheet of glass be rubbed over with French chalk and afterwards coated with gelatine the film when dry can be easily removed from the glass. Powdered talc is also sold as French chalk, and for all photographic purposes is equally good.

Changing Bag.—A light-tight bag in which a number of plates may be kept and put with safety in daylight into the dark slides for exposure. By this means the bulk and weight of carrying a number of slides is considerably reduced.

Changing Box.—A light-tight box constructed for the same purpose as a changing bag, *q.v.*

Chemical Action of Light.—See **Light.**

Chemical Affinity.—See **Affinity.**

Chemical Attraction.—The same as chemical affinity, *q.v.*

Chemical Combination.—When two or more chemical substances combine to form a compound different from any of its constituents which cannot be separated by any mechanical means.

Chemical Equivalent.—The relative proportions in which chemical substances will replace one another according to their atomicity. One atom of oxygen is the chemical equivalent of two atoms of hydrogen.

Chemical Focus.—A lens possesses two foci, the visual and the chemical. Before the many improvements in optical instruments were made these two foci differed; in some cases very considerably, so that it was necessary to determine the difference, and after focussing on the screen at the visual focus, to shift it to the chemical focus determined by photographic surfaces. In a good lens, however, these two foci should coincide. To test for chemical focus, place a few yards from the camera three cards with sharply defined letters on them, as in fig. 37. Focus on the centre card,

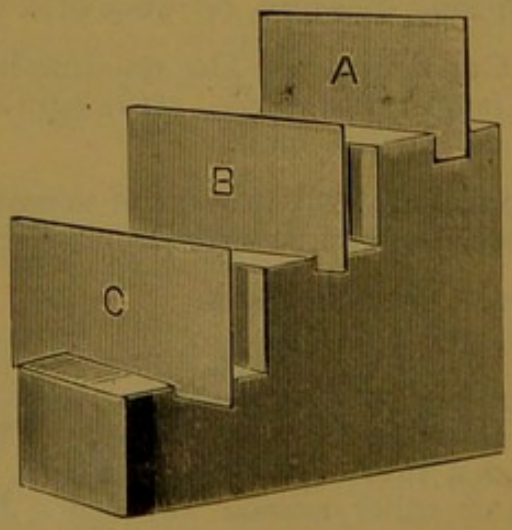


FIG. 37.

and upon developing carefully examine the image with a magnifying glass. If the centre card is not the sharpest of the three, the lens possesses a chemical focus; if the first card is the sharpest, the chemical focus is shorter than the visual. It will therefore be necessary to slightly push in the camera before exposure. If on the other hand the letters on the third card are the clearest defined,

the defect is of an opposite character, and it will be necessary to draw out the camera.

Chemical Formulæ.—The symbolic expressions indicating the chemical constituents of a body, as NaCl indicates sodium chloride contains one atom of chlorine and one atom of sodium.

Chemical Rays.—See **Light.**

Chemical Reagents.—Absolutely pure chemicals used for analysing or testing.

Chemicals.—There is no doubt that a knowledge of chemistry and the various changes that take place by the various actions of light, heat, and exposure to the atmosphere, &c., is useful to all who have to deal with them. Under the various headings, however, the author has endeavoured to explain the nature of the substances and their peculiarities.

Chemical Symbols.—See **Chemical Formulæ.**

Chemistry.—The word chemistry is of unknown origin, but probably derived from *alkemy*, from the Arabic word *kyamon*, meaning "the substance or constitution of anything."

In a work of this kind it is impossible to deal with the history and progress of chemistry, but chiefly to define its objects. There are given in Professor Muller's elements as follows:—1st, to resolve matter into its simplest compounds; 2nd, to ascertain the properties of these simple or elementary forces of matter; 3rd, to combine two or more of these elementary bodies with each other to form compounds; 4th, to study the properties of these compounds; and 5th, to define the conditions under which such compounds can exist. All these objects are embraced by pure theoretical and philosophical chemistry, which may be again divided into organic and inorganic chemistry. These we can also separate, the former into animal and vegetable, and the latter into metallurgical, agricultural, and medical chemistry. By applied chemistry, we mean the application of chemical principles to the various substances used in ordinary life; and by technical chemistry that which relates to our arts and manufactures.

The subject of chemistry is matter which exists in one of three states, *i.e.*, solid, liquid, or gaseous. In the solid state, the molecules are closely pressed together. In the liquid, they are not closely pressed, but can move freely about each other. In the gaseous state, matter is the most porous, the molecules having so little attraction for each other that, were it not for the pressure of the surrounding bodies, they would separate altogether.

Before proceeding farther it will be well to explain the theory of atoms and molecules, and elements and compounds. In nature we have simple and compound bodies. The first are called

elements, which is a substance or gas which is not composed of more than one constituent—in other words, *it is itself* a compound of particles which are perfectly identical. In a compound this is not the case, as two or more elements are required. By analysis the chemist pulls to pieces every compound by separating its constituents until he arrives at the elements which refuse to be separated. We will take, for instance, a piece of alum. By separating its component parts we find that it contains oxides of aluminium and potassium, sulphuric anhydride, and water. These substances we can again separate, and we find that they contain aluminium, potassium, sulphur, oxygen and hydrogen. These we cannot divide, because they are not compounds of various substances as the others are, but complete in themselves, and refuse to be divided. These are called elements. There are about sixty-five of these simple bodies or elements known, but many of them are of no practical or commercial use. The photographer has only to do with about twenty-five. A complete list with their symbols, atomic weights, and derivations will be found under **Elements.** These elements may be divided into two classes—the metallic and the non-metallic—and in chemistry are represented by an appropriate letter or combination of letters, which is termed a symbol.

The idea that matter is composed of atoms was expressed by Democritus and other Greek philosophers; but it was not until 1804 that the English chemist Dalton laid down the following laws, the result of his researches, and which form the basis of our present ideas of chemical combination.

All substances are capable of separation into minute particles until a point is arrived at at which divisibility ceases, the resulting particles being called molecules, which in turn are made up infinitely more minute portions of elements called atoms, the atom of an element being the smallest quantity capable of existence, and absolutely indivisible.

Atoms combine with each other in a fixed and definite proportion by weight and volume. We can prove this. Water invariably contains oxygen and hydrogen in certain proportions, *i.e.*, 16 parts (by weight) of oxygen and two parts (by weight) of hydrogen. These are proportions in which oxygen and hydrogen combine to form water.

As compound bodies are produced by the union of a given number of such atoms, it is evident that the molecules of which these compounds are made up must in their turn possess a fixed and definite combining portion by weight and volume.

For an example of this law we will take the compounds of oxygen and nitrogen. The simplest relation in which these two elements combine is in the proportions of 28 of nitrogen and 16 of oxygen, forming nitrous oxide. The next compound, nitric oxide, contains 28 of nitrogen and 32 of oxygen; the third, nitrous anhydride, 28 to 48; the fourth, nitric peroxide, 28 to 64; and the fifth, nitric anhydride, 28 to 80. Here it will be seen, and it is

exceedingly instructive, that the nitrogen remains constant, while the oxygen unites in the proportions 16, 32, 48, 64, 80, which are all multiples of 16, the simplest proportion. This law is known as the law of combination in multiple proportions.

If a body is capable of uniting with another in more than one proportion, these proportions representing the weights of the several atoms must necessarily be simple multiples of the weights of any one of them.

In the list of elements we have also their atomic or combining weight, and the law of their proportions is called the atomic theory. Hydrogen, being the lightest body known, is taken as unity. Its combining or atomic weight is therefore stated as 1, the other numbers corresponding to the different elements given in the table are the proportions by weight in which the other bodies are found to combine with it.

We have next to deal with chemical affinity, which is a force exerted between atoms, causing them to combine together, and producing a complete change in the bodies affected. Chemical affinity differs from mechanical mixture to a very considerable extent. We may powder sugar and potassium chlorate and mix together in any proportion, but they are not chemically united, for by digesting in spirit we can dissolve the sugar, leaving the potassium chlorate as it was. But if we add to the mixture a drop of sulphuric acid, the whole mass inflames, leaving a black residue from which it is impossible to recover the sugar or the potassium chlorate. Here we have a true chemical combination.

Chemical action is invariably accompanied by an alteration in the temperature of the substances combining. In many this is not appreciable, but if sulphuric acid be added to water contained in a test tube held in the hand the heat caused by the combination will soon be painfully apparent.

In the column of elements we find opposite to the name of each element the symbol which is always employed to represent it. This symbol not only represents the particular element, but a certain quantity of it. The letter H stands for one atom or one part by weight of hydrogen; the letter N for one atom or fourteen parts by weight of nitrogen; and the symbol Cl for one atom or 35·36 parts of chlorine. If these elements be made to combine together to form a compound, the compound must in like manner be represented by writing the symbols of its constituent elements side by side, and if more than one atom of an element be present the number is placed at the right of the symbol either above or below the line. Thus hydrochloric acid is represented by the formula HCl, which signifies that it is a compound of one atom of hydrogen with one atom of chlorine, or one part by weight of hydrogen with 35·36 parts by weight of chlorine. Sulphuric acid is represented by the formula H_2SO_4 or H^2SO^4, which shows to the chemist that it consists of two atoms of hydrogen, one atom of sulphur, and four atoms of oxygen.

The relation of bodies to each other in atom fixing power is called atomicity or quantivalence. Atomicity may, therefore, be considered as the measure of power which one atom possesses of invariably attracting to itself a given number of atoms. This value, which also has hydrogen as unity, must not be confounded with the atomic weight. Atoms which are capable of fixing only one atom of hydrogen to form a compound are called monads, those which can fix two atoms of a monad are called dyads, those that can fix three atoms of a monad are called triads, those which can fix four atoms of a monad are called tetrads, those which can fix five atoms of a monad are called pentads, and those which can fix six atoms of a monad are called hexads. The atomicity of bodies is represented by small ticks or Roman figures placed over the symbol, thus—

Monad	$H^{i.}$
Dyad	$O^{ii.}$
Triad	$B^{iii.}$
Tetrad	$C^{iv.}$
Pentad	$P^{v.}$
Hexad	$S^{vi.}$

The following table gives the valency of a few of the most important elements. Some of them it will be seen occur two or three times—the reason of this is because they form two or three series of compounds :—

Monads.	Dyads.	Triads.	Tetrads.	Pentads.	Hexads.
1	2	3	4	5	6
H	O	Au	Pt	N	S
K	Ca	N	C		
Na	Hg	Fe	S		
Li	Ba				
Ag	Pb				
Cl	Zn				
Br	Mg				
I	Cd				
Am	Cu				
Hg	Fe				
	S				

Let us illustrate the mode of using this table to arrive at the formula of any known compound. If it is desired to write sodium chloride we find that sodium Na is a monad, and so is chlorine Cl. Both elements have equal valency; therefore, it is written NaCl. In determining the formula of gold chloride, we find that gold Au is a triad, and chlorine a monad; therefore, the latter must be multiplied by three to make it balance the former, or, in other words, the gold is equal in combining power to three atoms of chlorine, the formula being $AuCl_3$. Oxide of gold would be one and a half atoms of oxygen to one atom of gold, but as we cannot halve an atom the formula is written Au_2O_3.

It has already been pointed out that some of the elements occur two or three times in the table. In such cases, those compounds

in which the metal has the lower valency have the termination ous to the metal, while those with the higher combining power terminate in ic. Thus, ferrous chloride, $FeCl_2$; ferric chloride, $FeCl_3$.

Let us now sum up what we learn from these theories. First, that an *element* is a substance complete in itself, and cannot be analysed. It is represented by a *symbol*, which indicates when written *one atom* of the element, one *atomic weight*, which represents the unalterable quantity in which it combines with other substances by weight, *the atomicity* or *combining power* of the atom with other atoms, and *a volume* in the gaseous state equal to a single volume of hydrogen. Secondly, we learn that a *compound* or an element in a free state is produced by the union of two or more atoms. It is represented by a *formula*, which in its turn represents *one molecule* of the compound, *one molecular weight* equivalent to the sum of the atomic weights of the elements of which it is composed, its *atomicity* or combining value with other substances, *a volume* in the gaseous state equal to two volumes of hydrogen.

Chemistry of Photography.—See **Photographic Chemistry.**

Chiaroscuro (Ital. *chiaro*—light, *oscura*—dark).—A term used in art to denote the distribution of the lighter and darker shades in a picture.

Chlor-acetic Acid.—Acetic acid in which hydrogen has been replaced by chlorine.

Chloride.—A compound of chlorine with an element or radical.

Chloride of Ammonium.—See **Ammonium Chloride.**

Chloride of Cadmium.—See **Cadmium Chloride.**

Chloride of Calcium.—See **Calcium Chloride.**

Chloride of Copper.—See **Copper Chloride.**

Chloride of Iridium.—See **Iridium Chloride.**

Chloride of Potassium.—See **Potassium Chloride.**

Chloride of Silver.—See **Silver Chloride.**

Chloride of Sodium.—See **Sodium Chloride.**

Chloride of Zinc.—See **Zinc Chloride.**

Chloride Paper.—Paper coated with a gelatine chloride emulsion. For a suitable chloride emulsion see **Emulsion.** This term is also applied to albumen paper containing a chloride.

Chloride Plates.—Plates coated with a chloride of silver gelatine emulsion, and used for transparencies and lantern slides. For the emulsion see **Emulsion**, and for the manipulation of the plates see under **Transparencies.**

Chloro-bromide Emulsion.—An emulsion containing both a chloride and a bromide.

Chloro-iodo-bromide Emulsion.—An emulsion containing a chloride, an iodide, and a bromide.

Chloroform (Eng. *chlor(ine)*, and Lat. *formica*—an ant. Formula, $CH\,Cl_3$; molecular weight, 119·50; synonyms, *methenyl chloride*, *formyl chloride*).—Chloroform is prepared by the distillation of a mixture containing bleaching powder, slacked lime, water, and alcohol. The alcohol and water are added together and warmed in a still fitted with a condenser. The bleaching powder and lime are then added and temperature increased until choroform begins to come over, after which the distillation becomes complete by the heat evolved in the reaction. Chloroform is also largely prepared from rectified spirit and methylated spirit. The purest quality is that prepared by the action of alkalies on previously purified chloral.

Chloroform is a liquid having a sweet pleasant taste and an agreeable ethereal odour. It dissolves in all proportions in alcohol and ether and slightly in water. It burns with a green smoky flame.

Chloroform is used in many photographic operations, chiefly on account of its properties as a solvent for alkaloids, as well as for iodine, bromine, camphor, resins, indiarubber, sulphur, fats, and many other organic bodies.

It is sometimes adulterated with alcohol, wood spirit, methylated chloroform, and sulphuric acid. These impurities may be detected by addition of ferrous di-nitro sulphide, prepared by acting on ferric chloride with a mixture of potassium nitrate and ammonium sulphide. If it acquires a green colour, the impurities already mentioned are present.

Chloroform should be kept in a dark place, for if exposed to air and sunlight it resolves itself into hydrochloric acid, chlorine and other products, unless it be entirely free from nitryl compounds.

Chloro-platinite of Potassium.—A substance used in the platinotype process, *q.v.* For its production Hubl and Pizzighelli give, according to Abney, the following direction: 500 grains of platinum tetra-chloride are dissolved in two ounces of water, and the solution filtered if not clear. This is then heated to 212° Fahr. in a water bath, and a strong stream of washed sulphurous acid n a gaseous state is passed through it. After a while the intensely yellow liquid will begin to turn red, and this is a sign that the platinum chloride has for the greater part been converted into the

platinous chloride. From time to time a drop of the liquid is removed by means of a glass rod, and tested to see whether, with a solution of ammonium chloride, it produces the characteristic yellow precipitate of chloro-platinate of ammonium. This test is best performed by bringing together on a watch glass a drop of the solution of sal-ammoniac and one of the solution of platinum. By a comparison of the quantity of precipitate formed it is easy in this way to regulate the process of reduction ; if only a slight formation of the chloro-platinate of ammonium is observed, the stream of gas should be moderate, in order to prevent the reaction from being completed too quickly. So soon as there is no precipitate formed, and none can be produced by rubbing the watch glass with the glass rod, the flow of gas must be at once interrupted. The conversion of the chloride is now complete, and any further flow of sulphurous acid would be injurious, since a continuation of it means loss of platinum. For, if the action of the gas be continued too long, the platinous chloride is converted into platinous sulphide—a salt which cannot be reduced by an organic ferrous salt. If, on the other hand, the stream of gas is too soon interrupted, the liquid will soon contain some platinic chloride, and this, when the solution of platinum is afterwards mixed with one of potassium chloride, will separate as insoluble chloro-platinate of potassium. Hence the reduction of a solution of platinic chloride, by means of sulphurous acid gas, is an operation requiring the greatest care and attention, particularly towards the end. The solution thus obtained consists of a mixture of platinous chloride, sulphuric acid, and free hydrochloric acid. To convert it into chloro-platinite of potassium, it must be poured when cold into a porcelain basin, and a hot solution of 250 grains of chloride of potassium in one ounce of water mixed with it, stirring all the while. The chloro-platinite of potassium then separates in the form of a crystalline powder. After allowing this to cool for twenty-four hours, the crystalline precipitate is collected in a filter, and the molten liquor is drained off. It is then washed with very little water, and afterwards with alcohol, until the latter shows no signs of an acid reaction.

This powder is then spread out on to sheets of filtering paper, and placed to dry in room free from light. This precaution is absolutely necessary, because the salts of platinum moistened with alcohol are liable to become reduced if exposed to the light. The salt prepared in this manner is perfectly pure, and it is therefore quite unnecessary to further purify it by recrystallisation. If these directions are carefully attended to, 740 to 750 grains of the double salt will be obtained from every 1,000 grains of platinic chloride, which is about 93 per cent. of the quantity, according to theoretical considerations. The molten liquor can be worked up with other platinum residues.

Chlorophyll (Gr. *chloros*—green, and *phullon*—a leaf).—The peculiar substance to which the green colour of the leaves, fruit,

and other parts of plants is due, and the nature of which, notwithstanding the extent of the researches that have been made, is still doubtful. It dissolves in alcohol and ether, but not in water. Its properties are neutral, being neither of an acid nor a base.

Solutions of chlorophyll show a bright green colour and an absorption spectrum that is exceedingly interesting and characteristic. It absorbs nearly the whole spectrum, only a narrow strip of light at the extreme red being visible. This peculiar property has made it of great use in Isochromatic photography. Ive's process is entirely based upon the uses of this substance. See **Isochromatic Photography.**

Chromates.—See **Ammonium Bichromate, Potassium Dichromate,** and **Silver Chromate.**

Chromatics (Gr. *chromatikos*—suited for colour).—Relating to colour or colours. The science which explains the various properties of the colours of light and of natural bodies.

Chromatic Aberration.—See under **Aberration.**

Chrome Alum.—See under **Alum.**

Chromotype.—A name given to a class of processes based upon the deoxidisation of chromic acid. The original process was worked by soaking well-sized paper in a saturated solution of bichromate of potash, and dried rapidly in front of a fire away from daylight. The paper is then of a bright yellow colour, but exposure to the sun under a negative darkens the exposed portions to a deep orange, and water will remove the unchanged parts. The process has now been perfected as the carbon process, *q.v.*

Chrome Alum.—See **Alum.**

Chrysotype (Gr. *chrysos*—gold, and *tupos*—type).—One of Sir John Herschell's processes. A sheet of paper was immersed in a moderately strong solution of ammonio citrate of iron and dried in the dark. The paper is then exposed to the light under the negative until a very faint impression is obtained. The development took place by brushing over the exposed paper a neutral solution of gold of such strength as to appear the colour of sherry. The print then rapidly turns to a purple tint, and is washed in several changes of water, and fixed in a weak solution of iodide of potassium, washed again, and dried.

Chrystallotype.—A name given to a kind of picture printed upon a translucent material.

Circle of Aberration.—See **Aberration.**

Citric Acid (Lat. *citrus*—a citron-tree, and Eng. *acid.* Formula, $H_3C_6H_5O_7 + H_2O$; molecular weight, 210).—An acid which occurs in lemons, oranges, cranberries, and also with

malic acid in gooseberries, whortleberries, raspberries, etc. It also occurs in many plants and roots. It is obtained by allowing the juice to undergo an incipient fermentation, filtered, and neutralised by boiling with chalk and lime. The precipitated calcium citrate is then decomposed by an equivalent quantity of sulphuric acid.

Citric acid is a tetratomic tribasic acid, usually crystallising in efflorescent trimetric prisms, soluble in water, and having an acid taste. It acts as a powerful restrainer of the action of the developer. It is also useful in keeping the shadows clear when intensifying a negative. Mixed with sulphate of iron it becomes useful in clearing yellow stains from negatives. In positive printing it is largely used. If added to the nitrate solution for sensitising it assists in the preservation of the paper, and also in giving more brilliancy to the tone. In gelatino-chloride of silver positive paper large quantities are added, and it assists in keeping the paper in good condition for many months.

Cleaning.—Cleanliness is perhaps more essential in photographic operations than in anything else. Cleaning is an art only arrived at by practice. A skilful operator will clean a glass in a few seconds, while another, unused to the art, will not have produced a chemically clean piece of glass in as many hours.

Cleaning Glass.—There are many methods of cleaning a glass plate successfully. The application of Tripoli powder solution, rubbed well over the surfaces with a piece of old rag, is one to be recommended. This is then removed and a final polish given to the surface with a dry piece of chamois leather or an old silk handkerchief, which should be well washed in carbonate of soda and water, and well dried before use.

A brand of soap known as "Monkey soap," and used only in cleaning non-destructible articles, is an invaluable cleanser of glass plates, as it seems to entirely remove all grease and other foreign matters.

In polishing a glass plate positive electricity is generated on it, and negative on the rubber. This will often produce an evil effect upon the subsequent operations; for instance, if the glass is to be coated with collodion the electricity will prevent its proper adhesion, and it is therefore necessary to dispel the latter by passing the handkerchief gently and slowly over the surface to allow the two electricities to combine.

There are various methods of testing if glass be clean. The simplest is, perhaps, by breathing gently, and observing if the condensed breath leaves the plate regularly and evenly.

Glass which is exceptionally dirty should be immersed in a ten per cent. aqueous solution of nitric acid, then washed and rubbed over with a solution of caustic potash or soda half an ounce, and methylated spirit half an ounce, added to four or five ounces of water, or scoured well with the soap already recommended.

Grease.—Greasy glasses or vessels must not be washed until the grease is removed with a dry cloth (only used for that purpose), and the glass or vessel washed in a ten per cent. solution of nitric acid. It is then washed and treated as described above.

Collodion can easily be removed from bottles by allowing the ether and alcohol to evaporate, filling the bottle with cold water and using a bottle brush. Dry and rinse out with alcohol.

Albumen being soluble in alkaline solutions can be removed by applying a solution of caustic potash, and washing well with water.

Old Films.—Old or spoilt gelatine negatives should be soaked in a solution of chromic acid, or in a warm solution of common soda. This will decompose the gelatine, and the films may be detached and the glasses washed. Another method is to soak in a weak bath of hydrochloric acid, and thoroughly wash and dry.

Varnished Negatives.—In the case of negatives which have been varnished, the varnish must first of all be removed by soaking the plate in strong spirits of benzine, and removing the soluble varnish with a piece of flannel or tuft of cotton wool.

Cliché (Fr.)—A French term for a stereotype used in this country for the same meaning. It is also applied to the negative and to photographic printing blocks.

Clips.—Little clasps made of wood for hanging paper to dry.

Cloud Negatives.—Except with instantaneous exposures it is rare that the clouds are included in landscape or architectural negatives. Separate negatives are made, and what is termed "double" or "combination" printing is carried out. For the manufacture of cloud negatives no special apparatus is required. They can also be purchased in large quantities, being manufactured chiefly by photographers stationed at the sea-coast, where the cloud effects are usually finer; but whether it is correct to use these for any other than seascapes is a doubtful point. For convenience in printing, cloud negatives are usually made upon films or paper. The former are superior to the latter, as they do not require oiling to render transparent. A photographer at Berwick-on-Tweed manufactures large quantities of cloud negatives by the carbon process, transferring the prints from a positive on to films of gelatine or collodion. For making cloud negatives use a slow plate or film. A rapid exposure should be given, and a fairly restrained developer used. The development should not be carried out too far, for if made too dense the negative will cause considerable trouble in printing.

It will, perhaps, be unnecessary to point out that in photographing clouds only those should be chosen which are likely to be useful and suited to the pictures taken. Some very fine stormy cloud effects are often visible in rough weather; but these are of little use, as photographs are rarely made in this kind of weather, and to print stormy clouds on a mild calm landscape would be

ridiculous in the extreme. The position of the sun must also be noted, and it is as well to make a little collection on a good day of clouds taken at different intervals during the day, to be used for differently lighted pictures for it would never do to use a negative of clouds lighted from the left for a landscape lighted from the right.

Cloud Printing.—Almost all landscapes are improved by the addition of suitable cloud effects, although it often happens that one obtains pictures which have a pale grey sky, and this may be shaded off in printing to give a more artistic effect than clouds. The following instructions for "printing-in" clouds is taken from Burton and Pringle's "Processes of Pure Photography:"—If the original sky of the view negative prints any degree beyond a pale grey, the sky will require to be blocked out with opaque paint of some kind. A pale grey horizon over a landscape is better than a hard chalky white for our purpose, but anything darker than pale grey will require blocking out. If the grey is a shade darker than it ought to be, a cloud negative presenting considerable contrast may be chosen, provided it is otherwise suitable. As a rule a very chalky sky means an under-exposed negative.

The blocking out may be done on the face of the negative with a solution as thick as possible of vermilion water colour paint, or Indian ink.

Opaque material is sold for this and similar purposes. So long as the landscape horizon presents a sharp line, there is no difficulty for a steady hand; but if tree branches project into the sky the operation becomes more difficult. Branches are best blocked out, not by straight lines, but by "dabs," or stippling on the back of the negative. Practice alone will teach this. Very intricate architectural lines are often puzzling, but care and practice will enable us to block them out perfectly.

The landscape being printed by a printing out process, and visible as in the albumen process, or partially visible as in the platinotype process, a suitable cloud negative is selected and placed face to face in a suitable position with the landscape print, which has the white sky, or nearly so. The two are then laid in a printing frame together, with the cloud negative undermost, and the frame is then closed in the usual way. If the cloud negative be not too dense, or the landscape sky not too dark, the shape of the cloud will be distinctly seen from the front of the frame, and the horizon line of the landscape will be clearly recognised. The frame is laid face up in the usual way for printing, and the landscape entirely covered with a *limp* opaque cloth, as velvet. When the horizon of the landscape is a sharp line, as of hills, the difficulty is slight; where the outline is jagged the operation requires more skill. To avoid a hard line the upper edge of the velvet must be constantly moved if the printing is done in sunlight, frequently if in diffused light.

The cloud picture is to be graduated or vignetted down to the landscape. Where there is a dark mass already printed against the sky, as in the case of heavy foliage, this may be practically disregarded, as that part being already dark, any clouds in the negative coming over it cannot naturally be printed, the paper being already printed in those parts. Thus where dark tree branches come against the sky the cloud may in most cases be printed right over the branches, and if this is well done the result is very natural and satisfactory.

Cloud negatives upon paper or films may be printed from either side. The paper negatives should be kept between sheets of oiled paper, otherwise they will lose their transparency.

Coagulate (Lat. *coagulo*—to coagulate).—To clot or curd. When a liquid coagulates it changes to a semi-solid state without evaporation and without crystallisation. Thus it differs from congestion for the reason that it is not attended with a fall in the temperature of the substance coagulated.

Coagulum (Lat.)—A coagulated or concreted mass.

Coal Tar.—A tar produced in the destructive distillation of bitumenous coal, and from which many of the aniline colours—naphthalene, phenol, etc.—are prepared.

Coating.—Lit. the act of covering with a coat. The term is largely used in photography to define the act of covering glass, paper, etc., with a film of any kind. In the dry-plate process the glass is coated with a gelatine emulsion—this is described under dry plates—and the paper is coated with a layer of albumen or gelatine. The simplest method of coating glass is to pour the necessary quantity of the solution on to the top right-hand corner of the glass, and by moving the glass in different slanting directions cause the solution to run to the top left-hand corner, and from there to the bottom left-hand, and finally to the lower right-hand corner, from whence the superfluous solution can, if necessary, be poured off into the bottle, or if the whole quantity of the solution is required to be kept on the glass the latter is, after coating, placed on a level stand. In coating glass with gelatine it should be warmed to about the same heat as the solution. Instructions for covering glass with collodion will be found in the description of the collodion process.

The coating of paper is a very simple matter if properly carried out. In coating with collodion the paper should be laid upon a sheet of glass, and the edges turned up all round. It will then be an easy matter to coat in the same manner as with glass. Another method is to place the paper between two suitable frames hinged together, which serve to hold the paper and stretch it tight. The simplest method of coating paper with gelatine is to place the solution in a dish, and draw two pieces of paper placed back to

back through it. The pressure of the liquid keeps the two papers together, and there is no fear of the solution getting in between. A thin coating may be obtained by passing the paper slowly through the emulsion, and a thick film by drawing rapidly. Another way is to float the paper face downwards upon the solution placed in a flat-bottomed dish. With this method the formation of bubbles is extensive, and they should be carefully taken out with a camel-hair brush dipped in the solution, and the paper replaced into position upon the emulsion. Another method of coating paper with gelatine is to first coat a glass, previously rubbed with chalk, with the emulsion, and lay the sheet of paper over it. The gelatine adheres to the paper when dry, and leaves the glass with a very high polish. The methods of coating with machinery are described under coating machine.

Coating Machine.—A machine for coating plates or paper. Among the many different machines for coating glass with a sensitive gelatine emulsion Edwards's no doubt takes the lead. In this machine a silver or glass roller revolves rapidly in a trough filled with the emulsion. In revolving, the roller carries with it a thin film of the emulsion, which is removed with the scraper and conducted to the sheets of glass passing one after another beneath. This method is more clearly described under dry plates, *q.v.* A German method of coating glass is based upon the principle of centrifugal force. A sheet of glass is clamped to a revolving plate, and revolves with it horizontally. A small quantity of the emulsion is placed in the centre and the plate set revolving. This action spreads the emulsion evenly over the plate.

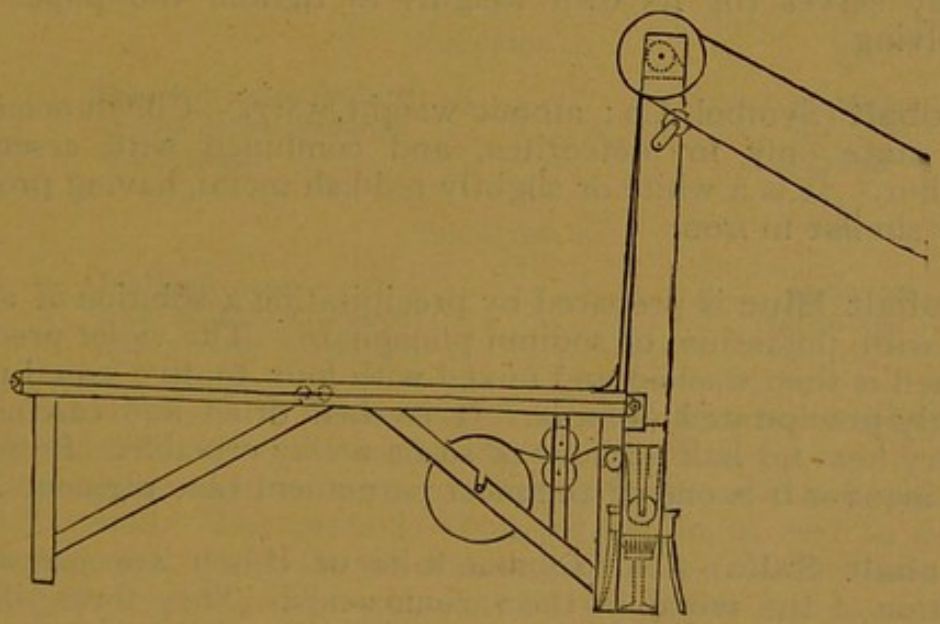


FIG. 38.

Paper is usually coated by machinery by passing it through the solution round a roller. The accompanying sketch (fig. 38) shows a

machine constructed a few years ago by the author for the coating of paper supplied on rolls with a gelatine sensitive emulsion. The roll of paper is placed in position below the long table, and the paper drawn through by a rough roller at the top of the machine, driven by a belted pulley attached to a small gas or hot-air engine. The paper passes first of all through two indiarubber coated rollers, then over another roller, from whence it passes down over another roller, which moves in a few inches of the gelatine emulsion placed in a suitable receptacle and heated with a small gas burner. It then passes up to the roller at the top of the machine, and in passing upwards the operator stands and removes any impurities or breaks any bubbles in the coating. Passing over the roller it falls down and runs along a marble slab, which in summer may be kept cool with ice placed underneath. Along the marble slab run two sets of tapes, revolving at different speeds over pulleys at the ends, and in the centre of the table. Another operator stands here and divides the paper in the centre, which immediately passes over the tapes running at a greater rate of speed, and can be made to pass in this manner to the drying room. The sketch is more to show what is meant than as an illustration of the machine itself, as the marble slab and table are about 50 to 60 feet long. In this manner it is possible to coat paper for bromide or chloride printing, or for the carbon process. With the latter it is sometimes necessary to coat the paper two or three times over. This is done by joining the paper in an endless band and passing it over the top and bottom rollers of the machine. In this manner it can be made to revolve through the emulsion as many times as necessary. A small falling roller beneath the top pulley serves (by its own weight) to tighten the paper whilst revolving.

Cobalt (Symbol, Co; atomic weight, 58·7).—Cobalt occurs in a free state only in meteorites, and combined with arsenic and sulphur. It is a white or slightly reddish metal, having properties very similar to iron.

Cobalt Blue is prepared by precipitating a solution of a cobalt salt with potassium or sodium phosphate. The violet precipitate formed is then washed and mixed with four to five equal parts of freshly precipitated alumina. It is then dried and calcined at a cherry heat for half an hour or so on a clay crucible. Prepared in this manner it is one of the most permanent blue pigments.

Cobalt Salts.—The soluble salts of cobalt are prepared by solution of the metal in the various acids. They form pink solutions when diluted, but if concentrated or dried they are blue. This property has been made use of in the manufacture of sympathetic works and barometers. A weak solution of nitrate of cobalt brushed on to a piece of white paper gives a pink surface,

which if warmed turns blue. The chameleon barometer, invented by the late W. B. Woodbury, was based upon this fact, the cobalt changing with the heat or amount of dryness in the atmosphere. If one writes with a very dilute solution of nitrate of cobalt, the writing when dry will be invisible, but if the paper be heated before a fire the letter will be distinctly visible and of a bright blue colour.

Coffee Preservative.—A preservative used in the dry collodion process. It is made up as follows, and carefully filtered :—

Coffee sol. (ground)	2 ounces.
Boiling water	10 ,,

Coffee Process.—A number of modifications have been made of this process, the best being perhaps that of M. de Constant. Abney's description of this process is as follows :—

The collodion to be recommended for this process, according to M. de Constant, is ordinary collodion, with the addition of two grains of cadmium bromide to the ounce. If collodion be home-made the pyroxyline should be manufactured at a high temperature in the acids (see **Pyroxyline**), and may be known in commerce by its yellow appearance, and by being found to separate in short rather fibrous particles. The plate is given a substratum (see **Collodion Process**), it is then coated, and the film sensitised by placing in the silver bath for seven minutes in summer and ten in winter to convert the greater part of the bromide into the silver salt. It is then well washed.

The preservative is formed as follows :—

Solution 1.

Distilled water (boiling)	5½ ounces
Mocha coffee (ground)	½ ,,
White sugar	90 grains

Solution 2.

Distilled water	5½ ounces
Gum arabic (powdered)	90 grains
Sugar candy (powdered)	20 ,,

Solution No. 1 is first allowed to cool in a well corked bottle. Both solutions should then be filtered and mixed.

Two applications of the preservative are necessary by immersing in a flat dish. The plate is then placed on to end to dry upon blotting-paper to drain off the superfluous solution. It is then transferred to the drying box, and when dry the surface of the film should possess great brilliancy, and be free from fog or stains when viewed by transmitted light. If a cloudy aspect appears on parts of the film a heated flat-iron passed over it an inch or so from the surface will restore its brilliancy.

According to M. Constant the exposure required is about three or four times that necessary for wet plates.

In developing the plates should be placed in rain water for three or four minutes. They are then flooded over with—

Sat. sol. ammonium carbonate*	8 drops
Water	4 drachms

This quantity is sufficient for a whole plate. This is worked over the plate until the image begins to appear, and until there is no further action caused by it. The solution is then returned into the developing cup, in which has been previously dropped one or two drops of—

Pyrogallic acid	60 grains
Alcohol	1 ounce

The solution with this addition is again flooded over the plate as quickly as possible, its action being very rapid. The image now appears fully by reflected light, but hardly at all by transmitted light. When all detail in the shadow is brought out the image is intensified with—

Pyrogallic acid	2 grains
Citric acid	2 to 4 grains
Water	1 ounce

But by this method the image will always appear transparent. To avoid this, M. de Constant recommended the following before the final pyrogallic intensification :—

Ammonia sulphate of iron..	45 grains
Copper sulphate	45 ,,
Citric acid	45 ,,
Water	3½ ounces

Two or three drops of a 20-grain solution of silver nitrate can be added after the first application. On the second application the negative becomes of a colour resembling that of a wet plate. The ordinary intensifier should be used after this. If the negative shows a tendency to become solarised, it should be fixed immediately, and the intensification done after fixing. These plates may also be developed with the ferrous oxalate or the alkaline developer. For fixing use hyposulphite of soda or a weak solution of potassium cyanide, with the addition of a few drops of acetic acid to prevent blistering.

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*One drop of concentrated liquor ammonia may be substituted.—ABNEY.

Cohesion.—Lit., the act of adhering or joining together. In chemistry, the face which unites two molecules of the same nature; strong in solids, weak in liquids.

Cold Bath Process.—See **Platinotype Process.**

Cold Emulsification.—A method of giving sensitiveness to a gelatine emulsion without the application of heat. See **Emulsion.**

Colliquato (Lat. *colliqueo*).—To melt; to change from a solid to a liquid.

Collocine.—A collodial restrainer introduced by Carey Lea, and used in the iron development for wet-plate negatives. The solution being of a syrupy nature offers considerable resistance to the solid particles travelling through it.

It is prepared by softening one ounce of French glue in a mixture of one and a half ounces of water and one drachm of sulphuric acid. When softened the water is boiled to dissolve the glue. Half an ounce of distilled water is then added, and the water boiled for a further period of two hours. Next eighty grains of granulated zinc are added, and the boiling continued for one and a half hours. The solution is then allowed to settle, and the clean fluid decanted off. One minim of this solution is added to every three ounces of a fifteen grain solution of iron.

Collodine (Gr. *kolla*—glue, and *eidos*—equalling in appearance. Formula $C_8H_{11}N$).—An alkaloid obtained chiefly by the distillation of bituminous shale. It is a colourless aromatic smelling oil, a powerful base, and gives white fumes if a rod dipped in strong hydrochloric acid be held over it. It boils at 180°, is insoluble in water, but soluble in alcohol, ether, and different oils.

Collodio-bromide Emulsion.—See **Collodion Emulsion.**

Collodio-bromo-chloride Emulsion.—An emulsion which contains both a bromide and a chloride in its composition. A very good emulsion of this kind can be made by mixing two parts of the unwashed collodio-bromide emulsion with one part of an unwashed collodio-chloride emulsion, the formulæ for both of which will be found elsewhere. By altering and otherwise regulating the proportions of these two emulsions very varied effects can be obtained.

Collodio-chloride Emulsion.—In this a chloride is substituted for the bromide usually used in the manufacture of collodion emulsions. It must be pointed out that there are two kinds of collodio-chloride emulsions used for different purposes—the one in which the image is developed, and the other in which it is printed out in the same manner as albuminised paper. The latter is usually called a collodio-citro-chloride emulsion, because it contains a large proportion of citrate. It will therefore be described under that heading.

The formula for making a collodio-chloride emulsion is thus given by Abney:—

Pyroxyline	15 grains
Calcium chloride	20 ,,
Silver nitrate	50 ,,

The calcium chloride is first dissolved in half an ounce of alcohol ·805 by warming it in a test tube. Five grains of the pyroxyline are then placed in a 2 oz. bottle, and the alcohol containing the calcium poured on to it. After a few minutes the addition of half an ounce of ether should be made, when the cotton will soon dissolve.

In another test tube dissolve 50 grains of nitrate of silver with the smallest quantity of water capable of dissolving it. Then add 1 oz. of alcohol heated to boiling point, and mix. While the silver was dissolving in the test tube the remaining 10 grains of the pyroxyline should have been put into a 4 oz. bottle, and the alcohol and silver solution poured on to it. Now add 1 oz. of ether, gradually shaking the solution the while. We have now two collodions—the one containing the calcium chloride, and the other the nitrate of silver. The two are taken to the dark room, and the calcium chloride collodion is very gradually added to the other, stirring the whole of the time. We have now a silver chloride emulsion with an excess of haloid. A trial plate should be coated, half of it exposed to the light, and the whole placed in a ferrous citrate developer. Only that part which has been exposed to the light should blacken with the action of the developer. If, however, the unexposed portion shows signs of fog, three or four drops of a 20-grain solution of cupric copper in alcohol should be added to the emulsion. (Abney.) The emulsion can be washed before coating the plates; but this is not really necessary.

Glass plates are cleaned, polished, coated with a substratum, then with the emulsion, and afterwards flooded over with the preservative:—

Beer	6 ounces.
Sugar	1 drachm.
Pyrogallic acid	6 grains.

After exposure, the plates are rinsed in water and developed with the ferrous-citro-oxalate developer, and if a warmer tint is required they can be afterwards toned in—

Uranium nitrate	10 grains.
Potassium ferricyanide	10 ,,
Water	12 ounces.

Upon immersion in this toning bath the tint will gradually become warmer, and if kept in long enough will assume a very agreeable chocolate tint.

This process is admirably suited for transparencies and for collodion transfers. Many other developers may be used.

Collodio-citro-chloride Emulsion Process. A process first introduced by G. W. Simpson, in the year 1864.—In the emulsion the principal ingredients are chloride, citric acid, and silver; there being an excess of the latter. It is used chiefly for coating paper with and printing out like an ordinary albumen print. In America this process is known as aristotype, a name first given to it by Liesegang, of Düsseldorf, who endeavoured to revive the process.

It is also possible to coat glass with it for the production of transparencies.

For the manufacture of the emulsion we require first a plain collodion. This is best prepared by mixing equal parts of ether and alcohol, and adding two to three per cent. of English pyroxline. Now the thickness of this collodion is a very important matter. I would recommend a two per cent. in the summer and three per cent. in the winter. A thin collodion is always better to work with; it gives a more even film, and if sufficient density is lacking it is a very simple matter to coat the paper a second time, or it can be allowed to remain longer on the paper before pouring off the superfluous quantity. If, however, a thick collodion is used, all manner of evils arise. The film is likely to be thicker in some parts than others, which would be at once seen in the toning, as the thinner parts would soon become acted upon by the gold-bath, leaving the thicker portions quite red.

Collodion, like wine, improves by keeping. An old collodion that has been allowed to stand some time is always superior to one freshly made, for the reason that it is more perfectly combined, and all sediment and foreign matter having fallen to the bottom, it is much clearer and cleaner. Therefore it is advisable to make the collodion some time previous to use, and after carefully decanting it without disturbing the sediment at the bottom of the bottle, add about one half per cent. of castor oil. The addition of this small quantity of castor oil makes a wonderful difference in the glaze of the finished picture, while materially assisting the toning.

The collodion being ready, we take a glass measure capable of holding about 100 cubic centimetres. Into this place 13 grammes of nitrate of silver and 15 cubic centimetres of water. Thoroughly dissolve the silver, and add 50 c.c.* of alcohol, the addition to be made slowly. Into another small measuring glass we dissolve 3 gr. of citric acid in 50 c.c. of alcohol, and in another 3 gr. of chloride of strontium are dissolved in 50 c.c. of alcohol. Instead of chloride of strontium, many other chlorine compounds have been recommended and may be employed, all varying in their effects. The principal advantage gained by the use of chloride

*For abbreviation, c.c. stands for cubic centimetres, and gr. for grammes (not grains). Those unaccustomed to the French metric system should read the amounts as parts, thus—13 parts of nitrate of silver and 15 parts of water.

of strontium lies in the colour of the print; when toned with this emulsion it is possible to get those rich purplish-brown tints so much admired.

We have now four vessels containing respectively the collodion, the silver solution, the citric acid solution, and the strontium chloride solution. The next operation, when all the ingredients are thoroughly dissolved, is to add the citric acid solution to the strontium solution, and, after stirring well together, place in another vessel containing 100 c.c. of the plain collodion.

All the operations already described can be performed in the strong daylight without any injury, but as we are now about to form the sensitive emulsion it will be necessary to remove our solutions, &c., to a room lighted only by a yellow light. Although a moderately non-actinic light is sufficient, it must be noted that the emulsion is more sensitive than sensitised albumen paper. Green cathedral glass will be found the best and most agreeable light to work by.

We have now the collodion containing the acid and the chlorine, and the silver solution. We mix the two together by dropping the silver solution into the collodion, stirring rapidly the whole time. The dropping is better effected by placing the silver solution into an ordinary dropping bottle. Too much care cannot be observed in this portion of the process. It will be noticed that directly the drop of silver solution enters the collodion it takes a white milky appearance. This is due to the formation of chloride of silver and other compositions which remain suspended in the collodion. It being very necessary that the silver and chlorine be well distributed and thoroughly combined, the gradual addition of the silver solution and continual and violent stirring during the process is absolutely essential. If this is not observed an unevenness in the prints will be the result.

It must be mentioned that after the addition of the alcohol to the silver solution it very often happens that a portion of the silver crystallises. As soon as this is observed the vessel containing it must be placed in warm water until the crystals are re-dissolved, when it must be immediately mixed with the collodion after the manner already described.

We have now a sensitive collodion emulsion. It must be well shaken, and allowed to stand for two or three hours. It must then be filtered in an ordinary collodion filter, and is then ready for use—that is to say, for preparing or coating the paper.

Hiederstadt's formula is as follows:—1·5 gr. of chloride of lithium, 1·5 gr. of nitric acid, are dissolved by the application of heat in 50 c.c. of alcohol; this solution is added to 500 gr. of ordinary 4 per cent. collodion.

14 gr. of acetate of silver are dissolved with the aid of heat in 6·7 gr. of distilled water, then added to 150 c.c. of diluted alcohol, which is heated to ebullition.

The argentiferous solution is poured gradually into the chloride solution, and afterwards from four to six grains of glycerine solution are added.

Dr. Liesegang prepares his collodion after the manner following:—

In a glass measure dissolve 8 gr. of nitrate of silver in 6 c.c. of distilled water, heat being applied. Drop this solution in a bottle containing 135 c.c. of alcohol. In cool weather it is necessary to place the bottle in a vessel containing warm water. Add 8 gr. of soluble gun-cotton, and after a good shaking pour in 160 c.c. of ether. Further violent shaking will produce a greyish-white collodion. In another glass dissolve 1 gr. of chloride of lithium in 35 c.c. of alcohol, together with 1 gramme of tartaric acid. This solution is dropped into the argentiferous collodion, which must be kept continually moving. If preserved in a well-corked bottle this collodion will keep any length of time.

The paper most suitable for our purpose is that known abroad as baryta paper. It is used for collotype or lichtdruck prints, and photographers should have no difficulty in obtaining it from any collotype printing works. This paper is made by coating Rives's or Saxe's paper with a solution of baryta chalk and gelatine. It has a pink or violet surface, which not only presents a very pleasing appearance to the finished print, but serves to hide any discoloration due to the deterioration of the collodion emulsion. There are four different qualities of this paper. The first is ordinary paper coated in the manner already mentioned; the second is a stiffer and stronger paper, resembling thin cardboard; the third is coated with a thick solution of insoluble gelatine, and stripped from glass, presenting a very high polish; the fourth is similar to the latter, excepting that the gelatine is soluble, and by the application of heat dissolving the gelatine the collodion film leaves the paper and can be transferred to another support, after the manner of carbon printing.

For a preliminary trial procure some of the first-mentioned paper. For ordinary purposes it is not necessary to prepare the paper in any way; the keeping properties of the collodion emulsion are excellent, but if necessary to keep several months it should be floated, pink side downwards, on a bath made up as follows:—

Water	100 parts
Hydrochloric acid	2 ,,
Citric acid	2 ,,
Tartaric acid	2 ,,

Allow it to remain on this solution about two minutes, remove, and hang up to dry.

There are several methods of coating the paper with the emulsion. For large quantities a suitable double frame should be constructed, in which the paper is held tight while the collodion is poured over it.

With the collodion emulsion the paper does not expand as it would do with any other preparation.

For our purpose, however, a piece of glass or wooden board of the same size as the paper is all that is necessary. A piece of wood with a knob in the centre underneath is the most comfortable to work with. The paper should be pinned on to the wood or fastened on to the glass in such a manner that the right-hand side and the bottom edges overlap about a quarter of an inch.

Hold the bottle containing the emulsion in the right hand and the board with the paper laid on in the left hand. Carefully wipe round the neck and sides of the bottle and see that there are no air-bubbles on the emulsion, then pour the collodion on to the right-hand upper edge of the paper. A little practice will soon enable you to judge the right quantity, but never be too sparing. With a gentle movement incline the board in such a manner that the emulsion flows well into the top left-hand corner, then down towards the bottom left-hand edge, and finally to the right hand lower corner, where the superfluous collodion is allowed to run off into a separate wide necked bottle. The bottle used to contain the emulsion for pouring on to the paper should not contain more than six or eight ounces, and should never be filled up farther than a couple of inches below the neck. The best bottles for this purpose I have found to be those used for Hock and Moselle wines. They are usually of a non-actinic colour, which is in itself an advantage. But the long gradual sloping neck prevents the formation of air-bubbles. These latter will be found the chief enemy of the collodion worker, but with care and attention they can easily be got rid of. They are usually formed by pouring the collodion on to the paper at too great a height, or by bringing the bottle to an upright position with a jerk. All these little details, trifling as they may seem, are of great importance when good results are desired. The collodion must never be allowed to flow twice over the same spot during the one coating, or an unpleasant ridge visible in the finished print will be the inevitable result.

Carefully wipe the neck of the bottle each time to prevent little pieces of the dried collodion from spoiling the film.

For the production of high-class prints it will be advisable to coat the paper twice. This is done when the first coating is thoroughly set. Turn the paper round the other way, so that the bottom and the top are reversed, and give another coating.

The superfluous collodion poured off into the wide-mouthed bottles is allowed to stand until the air-bubbles have entirely disappeared, when it can be used.

Owing to the speedy evaporation of the ether the collodion will soon become too thick. It should be thinned with a mixture of one part alcohol (·805) and two parts ether (·730). Well shake and allow to stand before using.

In pouring off the superfluous collodion from the paper gradually sway the board from right to left, in order to prevent

the formation of ridges caused by the running of the collodion in one direction.

The collodion emulsion sets very rapidly, in warm weather it requires about one minute, in winter three to four. When the superfluous collodion has run off, the paper is removed from the frame or support, and hung up to dry by means of American clips attached to string stretched across the room.

The temperature of the room in which the paper is dried should be about 70° Fahr. Paper prepared in a moist room and dried slowly gives flat prints, while if dried at too high a temperature it refuses to tone.

The coating of the paper should be carried on in a cool dry atmosphere, the room thoroughly ventilated, as the fumes of ether and alcohol are exceedingly obnoxious and injurious to health. As soon as the paper is coated, it should be removed to the drying room, heated to the temperature given.

After drying, the edges of the paper are trimmed with a pair of shears, and the paper laid out flat and placed under pressure. It should be well preserved from light and moisture. If rolled film outwards, it can be kept in an air-tight tin case, and if required for use will fall into a flat position if unrolled.

The printing of this paper is similar to albuminised paper. It is, however, more rapid. Any toning bath may be used. Fix with sodium hyposulphite.

Collodio-gelatine Process.—A process patented in 1856 by Dr. Norris. In this the collodion film, containing the sensitive silver salts, was immersed in a solution of gelatine, albumen, caseine, or any other similar substance. The object of this was to fill up the pores of the collodion film and prevent its condensation on drying, and retain it in a sensitive and pervious state. After treatment with the gelatine, the films were dried and exposed to the light, or could be kept for some time.

A more modern collodio-gelatine process has been devised by Messrs. Poirin and Graham. In this two emulsions are made, one of collodion and the other of gelatine. The plates are first coated with a washed collodion emulsion, and then washed in hot water, and coated with a thin film of rapid gelatine emulsion.

Collodion.—Collodion is prepared by dissolving certain nitrated products obtained from cellulose in a mixture of alcohol and ether. The cellulose employed for the manufacture of collodion is principally clean cotton-wool nitrated with a mixture of nitric and sulphuric acid of certain strength. Gun-cotton is the product of the extreme nitration of cellulose. It is termed hexa-nitrate $C_{12}H_{14}(NO_3)_6O_4$, and is insoluble in alcohol or ether or mixtures of both, the lower nitrates only being dissolved in these solvents. But if the nitration be stopped previous to the production of gun-cotton by using a mixture of nitric and sulphuric acids with water,

the tri-nitrate $C_{12}H_{17}O_{10}(O\cdot NO_2)_3$ and tetra-nitrite $C_{12}H_{16}O_{10}(O\cdot NO_2)_4$ are formed, and these, having the solubility required, are used for the manufacture of collodion, and are known as "collodion pyroxyline."

Collodion is a viscous fluid largely used in photographic operations. It is principally employed as a vehicle to hold the sensitive salts of silver. It is manufactured by dissolving soluble gun-cotton (pyroxyline) in ether and alcohol of varied proportions. A good collodion should be limpid and structureless, and the film should be smooth, soft, non-contractile, and possess a certain amount of tenacity. When dried upon a surface it should leave by the evaporation of the solvents a perfectly transparent film of pyroxyline. As the quality of the collodion depends almost entirely upon the kind of pyroxyline used, it would be well to study the remarks given under that heading.

For preparing a plain collodion, the following are two serviceable formulæ. The first is more adapted for winter work, and the second for the hotter summer months :—

PLAIN COLLODION No. 1.	
Pyroxyline	55 to 60 grains.
Alcohol ·820	4½ ounces.
Ether ·725	5½ ,,
PLAIN COLLODION No. 2.	
Pyroxyline	55 to 60 grains.
Alcohol ·820	5 ounces.
Ether ·725	5 ,,

In making up collodion the alcohol should be added first to the pyroxyline, and lastly the ether. By this means its solution is aided. The proportions of ether and alcohol given above may be varied to suit the requirements of the operator. It should be noted that the larger the quantity of alcohol in proportion to the ether the slower will be the setting of the collodion; but if too much alcohol be added the film becomes streaky, and if the ether be in excess the film will be too contractile and liable to split in drying.

After the collodion is mixed, and the pyroxyline is dissolved, it should be allowed to remain undisturbed for two or three weeks. This will allow the insoluble particles to settle down, when the clear collodion can be decanted.

In making a plain collodion for emulsion processes, the chief points to be observed are the quality of the pyroxyline used, and the relative proportions of the alcohol and ether. If we take a sample of pyroxyline made at a low temperature and with strong nitro-sulphuric acid containing a minimum of sulphuric acid, it will be necessary to use only sufficient alcohol in the plain collodion to give the requisite solubility. This should be about a tenth or twelfth part by bulk of the amount of ether. Unless this precaution be taken, the iodised collodion will be very easily torn. It will also be so glutinous as to be difficult in working. It will adhere but loosely to the glass, and show peculiar structural markings and lines.

With a pyroxyline made from gun-cotton, with a large excess of oil of vitriol in the formula (see **Pyroxyline**), it is possible to use a larger quantity of alcohol. This has its advantages, as its contractility is lessened, and its setting properties are not so strong, and markings are thereby obviated. The following remarks upon the preparation of collodion, taken from Hardwich's "Photographic Chemistry," will be likely to be of service to those engaged in its preparation:—It will be found that with a tough kind of pyroxyline the solubility is increased by employing the maximum quantity of alcohol, so that if the plain collodion be diluted with ether a precipitate will take place. With other kinds of pyroxyline differently prepared, the addition of ether to the plain collodion produces no precipitate. In the case of pyroxyline prepared in a sulphuric acid containing equal bulks of oil of vitriol and nitric acid, with the maximum of water, it is advisable to reduce the quantity of alcohol somewhat, for if too much alcohol be employed, the setting of the pyroxyline will be so greatly retarded that the upper edge of the film will become dry before the lower part has solidified sufficiently to take the bath without precipitation of pyroxyline. This effect would not happen if the formula containing oil of vitriol in excess be used in the preparation of the pyroxyline, because it would be impossible to use such a mixture in a state sufficiently weak to destroy the property of setting in the resulting pyroxyline; before that point was reached, the cotton would dissolve in the acid.

The effect of the presence of water is to produce viscidity in the collodion, and to cause a rapid decomposition when treated with the iodiser. It is therefore necessary that the exact strength of the alcohol used be carefully noted. Many collodion workers prefer to use a strong spirit. Absolute alcohol of a specific gravity of ·805 at a temperature of 60° Fahr. is used by many.

With the employment of a horny kind of pyroxyline, a small quantity of water seems to be necessary. The following useful remarks concerning the photographic effects of excess of alcohol in the collodion are also taken from Hardwich's work previously mentioned. The addition of alcohol to collodion lessens the contractility of the film, and renders it soft and gelatinous. These conditions are favourable to sensitiveness, perhaps from the play of affinities being promoted by the loose manner in which the particles of iodide are held together. The extra sensitiveness obtained by the use of alcohol, however, does not increase after a certain point; on the contrary, it diminishes, for it appears to be necessary to extreme sensitiveness that the film should coagulate within a certain time after it has been coated, and, therefore, the addition of alcohol must be stopped when the film loses its ready setting qualities, and is not coherent under the finger. Hence a porous collodion is soon injured in sensitiveness on adding too much alcohol, but a strong and tough pyroxyline will bear equal bulks of the two solvents without loss in that respect. These observa-

tions as to the effect of excess of alcohol in diminishing the sensitiveness of the film to dark objects apply particularly when the atmosphere is cold and damp, and evaporation is retarded. At a very high temperature, and in a dry air, it does not apply, since the presence of alcohol is then useful in preventing the film from becoming surface dry, especially when it is necessary to keep the sensitive plate for a long time between exposure and development.

To get a good textureless film a method of refining the pyroxyline should be adopted. This is accomplished by making a plain collodion with cheaper solvents and half the quantities given. This is then poured into cold water in a fine stream. The effect of this is that a portion of the pyroxyline remains in solution in the water, and a portion becomes precipitated, and is of a finer quality than the original. This should be dried and again made up into collodion.

Collodion should be kept in long narrow bottles, to allow of the collodion being drawn off when all the impurities have settled.

Plain collodion sold by dealers usually contains about five per cent. of pyroxyline. Methylated alcohol and ether may be and are chiefly used in manufacturing collodion owing to their cheapness. It may be useful to point out that collodion is an excellent substance to cover over wounds with, and to stop loss of blood. Should the photographer or any member of his household be so unfortunate as to get cut or wounded, a little plain collodion should be poured on. When set it forms a strong skin, and prevents the emission of blood and the admission to the wound of injurious matter.

Collodion-Albumen Emulsion.—A collodio-albumen emulsion. A process introduced by Captain Abney, and thus described by him. The following is the mode of preparation:—16 grains of ordinary cotton are dissolved in 6 drachms of ether (·730) and 4 of alcohol (·805), and the plain collodion thus formed decanted. 20 grains of zinc bromide are dissolved in a small quantity of alcohol, and enough bromine water added to tinge the solution with a pale yellow. This is added to the above amount of plain collodion. To each half-ounce of the above, one grain of dried albumen is taken and dissolved in the least possible quantity of water, or eight drops of the white of an egg may be dropped into a drachm of alcohol and thoroughly stirred. Either of these solutions is then carefully dropped into the collodion, placed in a jar, and well stirred up. This should form an emulsion of albumen in the collodion. Forty grains of silver nitrate are next added, after having been dissolved in the smallest possible quantity of water and boiling alcohol. A beautifully smooth emulsion should result from this. The amount of silver nitrate added ensures that there is an excess of at least two grains in each ounce of the emulsion. Instead of the emulsion being made

entirely of zinc bromide, greater density can be obtained by omitting four grains of it and replacing this by four grains of calcium chloride. The emulsion is next poured into a dish and the ordinary manipulation carried out.

After a couple of washings it may be advantageously covered with a weak solution of silver nitrate, and again washed till the traces of silver are very faint. The pellicle should be redissolved in equal quantities of ether and alcohol, and finally there should be about seven grains of the pyroxyline as originally used to each ounce of the mixed solvents. The emulsion when finished gives a tender blue by transmitted light, and is seemingly transparent. It may have a tendency to curl off the plate on drying, in which case the addition of a little ordinary washed emulsion will correct it. It will develop with plain pyrogallic acid, and can be intensified by pyrogallic and citric acid, with the addition of a few drops of silver nitrate solution, or it can be developed with the alkaline developer, the ferrous-oxalate developer, or the hydrosulphite developer. If the developer be kept above a temperature of 60° Fahr. the tendency to blister will be prevented.

The image obtained by this process is usually very delicate and thin, and the exposure required is a little less than for an ordinary wet plate.

Collodion Dry-plate Process.—The first published practical formula for a collodion emulsion was that by Messrs. Bolton and Sayce in 1864.

With this process a dry collodion emulsion is used, and before going farther it will perhaps be best to explain the difference between the collodion "dry" and the collodion "wet" process. In the wet process we coat the glass with a collodion containing the bromide or the iodide, or both, and immerse it in a nitrate of silver solution. The effect of this is explained in the description given of that process. The silver combines with the bromide or iodide to form the sensitive compound. In the dry collodion process the effect is similar, though the manipulation is different. To the liquid collodion containing the salts the silver nitrate is added, and the sensitive emulsion thus produced is spread on to glass plates and dried. The advantage of this is that after the preparation of the plates they may be kept for some time previous to the exposure, which is not the case in the wet process.

Dry collodion emulsion processes must be divided into two distinct classes, the "washed" and the "unwashed." When the silver is added to the salted collodion a process of double decomposition takes place by which the sensitive salts are formed. But besides these other compounds or bye-products are produced, which, if they were allowed to remain in the film, would crystallise and spoil the plate. It is therefore necessary that these be removed, and this is done either by washing the emulsion before coating the plates, or by washing the film after the plate is coated.

The first process is termed the "washed" emulsion process, and the latter the "unwashed" emulsion process, although it will be seen that in both cases the washing takes place at one stage or another. For description of the two processes see **Collodion Emulsion Process, Beechey's Process,** also **Dawson's Process, Lea's Process.**

Collodion Emulsion (washed).—A plain collodion is first made up after the following formula :—

Alcohol ·820	5 ozs.
Ether ·720	10 ,,
Pyroxyline	200 grs.

If a plain collodion, as sold by dealers, be used it should be remembered that the amount of bromide and silver should be regulated according to the number of grains of pyroxyline in, and not according to the amount of collodion. As a rule, commercial plain collodion contains about five grains of pyroxyline to the ounce, after the addition of the iodiser.

To one quarter of the collodion, or $3\frac{3}{4}$ ounces, we must add 100 grains of zinc bromide. This is done by dividing the amount into two parts of 50 grains. One part is dissolved in a very small quantity of alcohol, and two or three drops of concentrated nitric acid added to it, and the whole is then added to the collodion. The other 50 grains of the zinc bromide is similarly dissolved in the smallest quantity of alcohol, and five or six drops of the nitric acid added. This should be kept in a convenient test tube ready for use. We next take 165 grains of powdered silver nitrate and place it in a test tube with $2\frac{1}{2}$ drachms of water. The test tube is then slightly warmed, when the silver should be completely dissolved, and when this is so, five drops of nitric acid are added to it. In another large test tube, or other convenient vessel, $\frac{3}{4}$ ounce of alcohol ·830 should be boiled and poured on to the silver solution. The two solutions are thoroughly mixed by repeatedly pouring them from one test tube to another. We have now the collodion, the zinc bromide solution, and the silver solution. With these we retire to a room lighted only by yellow light.* The collodion is placed in a large jar, and the test tube containing the silver is held in the left hand, and a glass stirring rod in the right. About three parts of the silver solution is then added drop by drop, vigorously stirring with the rod. The silver solution is then changed for the bromide, which is also added drop by drop. After this addition, the remaining portion of the silver solution is added. If any of the silver be found to have crystallised on the sides of the tube, it is redissolved in a little water and alcohol. After all the additions have been made, the emulsion which is now formed is briskly agitated to thoroughly mix the various ingredients, and a drop of the emulsion placed on a piece of glass and

*Abney is of opinion that the exclusion of light is quite unnecessary, owing to the presence of nitric acid, which renders the sub-bromide inert as fast as it is formed by the action of light, and that the whole of the operations up to the first washing may be carried on in the light.

viewed by transmitted light. The colour of a candle or gas flame should be of a deep orange tint. A little of the emulsion spread on to a piece of glass is then carried out into the daylight, a little potassium chromate is dropped on to it, and it should instantly turn a bright red colour, proving silver to be in excess. The emulsion being satisfactory is decanted into a bottle capable of holding about 12 ounces, and well shaken up. It is then laid aside for twelve to fifteen hours to ripen. In about ten and a half hours it will have attained its maximum sensitiveness. It is now ready for washing. This is accomplished by pouring the emulsion into a large flat dish, so that its depth is not more than a quarter of an inch. The solvents will rapidly evaporate, and a skin will form on the surface; this is broken up, and the emulsion well stirred up. This is repeated every now and then until the emulsion forms into lumps. It is then placed into a glass vessel and covered with distilled water. On the addition of the water some of the lumps will rise to the surface. Only a small portion of it should float, however. If much of it does, the evaporation of the ether and alcohol has been insufficient. If half a drachm of nitric acid be added to the distilled water freedom from fog will be secured. After a couple of hours the emulsion, or pellicle as it is now termed, is thoroughly washed in a running stream of water. A good method is to place it in a china or earthenware teapot. The lid is removed and a piece of fine muslin is tied over the top, and a stream of cold water sent down the spout for several hours.

The next operation is to remove the water contained in the pellicle. It is first transferred to a piece of muslin, and as much of the water squeezed out as possible. It is then placed in a vessel and covered over with alcohol. After about an hour it is again squeezed as before, and again covered with alcohol. At the expiration of another half-hour the alcohol is drained off, and the pellicle is ready for emulsifying. If necessary it can be dried by a few hours' exposure to the air, and kept for future use in a dry state.

The moist pellicle is next dissolved according to the following formula :—

Pellicle	100 grains.
Alcohol (·820)	3 ounces.
Ether (·720)	3 ,,

A trial plate should be coated with this, as it may be necessary to dilute with more alcohol and ether.

The plates are then coated and dried.

Collodion Emulsion (unwashed).—In this process the emulsion is not washed until after the plates are coated. The first operation is the manufacture of the collodion, which is done after the following formula :—

Sulphuric ether (·720)	7 ounces.
Alcohol (·820)	4 ,,
Pyroxyline (high temperature)	70 grains.
Zinc bromide	120 ,,

The pyroxyline is described as "high temperature." This will be clearly explained under **Pyroxyline.**

The ingredients of the above formula should be mixed in the order that they are given, and allowed to stand one clear day.

180 grains of silver nitrate are then dissolved in a test tube with 90 minims of boiling distilled water. In another test tube 1½ ounces of alcohol are boiled, and when both solutions are at their boiling points add one ounce of the alcohol to the silver solution. The test tube containing the silver solution, the tube containing the remaining half-ounce of alcohol and the bromised collodion, are next all removed to the dark room—a room lighted only by yellow light. The silver solution is then added drop by drop to the collodion, which is kept violently agitated with a glass stirring rod. When all the silver solution has been added, the remaining half-ounce of alcohol is poured into the tube to dissolve the crystallised silver, which will probably form, and it is then added to the emulsion. The whole is then well shaken, and the collodio-bromide emulsion, which is now formed, is left several days to ripen.

When thoroughly "ripened" the emulsion is filtered through a funnel containing a tuft of cotton-wool.

Glass plates thoroughly cleaned and polished are provided wi an albumen substratum or an edging of indiarubber solution. The method of making the substratum is as follows:—The white of an egg is beaten up in 40 ounces of water, and a small quantity of ammonia is added until its smell is distinctly perceptible. The whole is then allowed to stand, and filtered carefully. This solution will keep for a great length of time, provided a little ammonia be added when necessary.

With this solution the clean and wetted glass plate is flowed twice over and dried. The plate is then coated with the collodion emulsion, and when it is set the plate is plunged into distilled water, and afterwards washed in clean water until all trace of greasiness has disappeared. The preservative is then applied and the plates dried for use.

Collodion Emulsion Process.—It is intended under this heading to describe the preparation and manipulations of the dry collodion plates. In other places it has been pointed out that there are two distinct methods of preparing the emulsion—the one termed the "washed" emulsion process, and the other the "unwashed" emulsion process. Under collodion emulsion will be found descriptions of making both these emulsions, the descriptions leading up to the preparation and coating of the glass plates. We will now give the process *en detail* of preparing the plates, and the developing and finishing of negatives upon them.

The emulsion used can be either the washed or the unwashed; when any difference is necessary in the manipulation it will be pointed out.

The glass plates to be coated are first soaked in nitric acid and water, and then washed with cold water, rubbed over with tripoli powder and alcohol, and allowed to dry. The plate is then polished with a silk handkerchief or soft cloth, and coated with the following substratum :—

White of egg	1 ounce
Water	100 ounces
Ammonia ·880	6 drops

This should be well shaken and filtered. The plate is first rinsed in distilled water, and the albumen solution flowed over it and drained off as quickly as possible. Another method is to apply the solution with a Blanchard's brush. Instead of albumen some workers prefer indiarubber as a substratum. The formula is one grain of indiarubber dissolved in an ounce of chloroform or benzole. This is flowed over the plate in the same way as collodion. When the plate has been provided with the substratum it is ready for coating with the emulsion.

The emulsion thoroughly filtered is placed in a convenient pouring bottle. It is then poured on to the plate in the usual manner. If the collodion "drags," it should be diluted with a small quantity of ether and alcohol in the proportion of two parts of the former to one of the latter.

The collodion is made to flow over the whole of the plate, and the overflow is returned to another bottle, and the plate kept rocking to and fro to prevent the formation of lines and ridges.

If the emulsion be a "washed" one the plates should now be dried and treated with a preservative (see **Preservative**). An arrangement for the convenient drying of the plates was recommended by Woodbury. It consists of an ordinary iron tripod stand, a flat piece of sheet iron, and a spirit lamp or gas burner. The lamp or burner is placed under the iron tripod, upon which is rested the iron plate. A few pieces of blotting paper are laid upon the iron plate, which is then heated by the burner underneath until the blotting paper is inconveniently warm. Upon this the plates are then laid, and drying will be very rapid. In applying the preservative to a washed emulsion the plate should first be washed with water until all trace of greasiness has disappeared. If an unwashed emulsion is used it is first thoroughly washed in distilled water until all the silver nitrate that is in excess be thoroughly eliminated. They are then flooded with the preservative solution and placed in a drying cupboard to dry.

With many emulsions of this description the films are so translucent that to avoid halation it is necessary to provide the plate with a backing (see **Backing**), which must be removed after exposure.

The exposure necessary with this kind of plate is rather long compared with the modern dry-plate process.

For development perhaps the most suitable developer is that recommended by Colonel Wortley. The film of the exposed plate is first flowed over with—

Alcohol	1 part
Water	1 ,,

This will soften the film. It is then washed under the tap, and the developer applied. This is made up with—

Solution 1.

Pyrogallic acid	96 grains
Alcohol	1 ounce

Solution 2.

Potassium bromide	120 grains
Water	1 ounce

Solution 3.

Liquid ammonia ·880	6 minims
Water	1 ounce

To develop, the following proportions are taken :—

Solution 1	6 minims
Solution 2	3 ,,
Solution 3	3 drams

The plate is laid in a flat dish, and the developer poured over it. Its action is not rapid, but after a little time the image should appear slowly and gradually. It should gain strength as it goes on, and be free from veil. If after the image does not appear readily, a fresh developer should be made with only half the quantity of Solution 2.

If the developed negative is lacking in brilliancy it can be intensified with an ordinary acid intensifier.

Solution 1.

Pyrogallic acid	3 grains.
Citric acid	3 ,,
Water	2 ounces.

Solution 2.

Silver nitrate	30 grains.
Water	2 ounces.

The plate is first of all thoroughly washed. Solution No. 1 is then flowed over the plate, and returned to a cup containing five or six drops of Solution 2 dropped into it. This is then returned to the plate, and then intensification should be carried on until the required density has been arrived at.

With these plates the ferrous-citro-oxalate developer can also be used. Abney's formula is—

Potassium citrate (neutral)	100 grains.
Ferrous oxalate	22 ,,
Water	1 ounce.

The potassium citrate is first dissolved in a flask by heat, and when nearly at boiling point the addition of the ferrous oxalate is made, and shaken up in it. When cold it should have a citrony-red colour. Its action in development is rather slow.

After development, and, if necessary, intensification, the plates are fixed with—

Potassium cyanide	40 grains.
Water	1 ounce.

Or—

Sodium hyposulphite	1 ounce.
Water	8 ,,

The objection to the former fixing agent is that it is a most violent poison, and no little care must be taken in its use. When thoroughly fixed the plates are dried spontaneously, and then varnished to protect the films.

Cold.—It was formerly believed that cold was an entity, and that it could be reflected from polished surfaces like heat and light. This, however, is not the case. Cold is simply an absence of heat. It is essentially a relative term. Ice may be considered a hot substance when compared with frozen mercury, and a very hot substance when compared with solid carbonic acid. If we take three vessels, and pour hot water into the first, cold water into the second, and water of intermediate temperature into the third, and place one hand into the hot water and the other into the cold, we shall find on now placing both hands in the water of intermediate temperature it will feel hot to the hand which has been in the cold water, and cold to the hand which was placed in the hot water; thus water at the same temperature may appear both hot and cold. Absolute cold would be the absolute zero of temperature, at which point matter would possess no heat at all. A substance is relatively cold when it possesses less of the motion called heat than the substance it is compared with. A hot substance—a red-hot suspended ball of metal, for instance—gets colder and colder, because it radiates its heat into space; it loses molecular motion, and the more motion it loses the colder it is said to be. When it cools down to a temperature below that of our bodies, we call it cold to the touch, because it possesses less of the motion of heat than our nerves and abstracts heat from them, and this withdrawal of motion of the nerves produces the sensation cold. (Rodwell's Dict. Sci.)

Cold Tone.—A term often used to distinguish the tone of a photograph having a colour without warmth.

Collidine (Gr. *kolla*—glue, and *eidos*—appearance).—A volatile base first discovered by Anderson in bone oil, and subsequently it was found in stale naphtha. It is a colourless aromatic smelling oil, boils between 178° and 180°, and is soluble in alcohol, ether and oils, but insoluble in water. If a rod dipped in hydrochloric acid be held over it it gives white fumes.

Collodionised Paper.—Paper coated with a film of collodion. It can be used for painting or in oil colours. Photographs if coated

with collodion may be painted over in oils. Very effective pictures are now made in this manner. They are mostly reproductions or miniatures of paintings in the Paris Salon.

Collodion Transfers.—These are usually produced by coating a sheet of talced glass with an iodised collodion, sensitising, developing, fixing, etc., after the usual manner. The film is then transferred to a sheet of carbon double transfer paper. This process is often used for enlarging, and is more carefully described under that heading.

Collodion Wet Process.—A process in which collodion forms the vehicle to hold the sensitive salts. It is commonly known as the wet-plate process, in contradistinction to the dry-plate process, the film being exposed in the one case whilst wet and in the other when dry. Before describing the process in detail it will, perhaps, be better to give an outline of it. A collodion is first prepared, in which are dissolved bromides and iodides. A perfectly clean glass plate is then coated with a thin film of this collodion, and as soon as this is set it is immersed in a solution of silver nitrate (see **Silver Bath**), the silver forming with the salts in the collodion, silver-iodide, or silver-bromo-iodide. The plate is then exposed in the camera, and afterwards treated with a developing solution, which brings out the image. This is then intensified or strengthened and then fixed. Lastly, the collodion is given a protective coating of varnish, and the negative is ready for the printing processes.

Cleaning the Glass.—The importance of having the glass clean cannot be over-estimated. It should be well rubbed with a mixture of alcohol and tripoli powder, sufficient to form a cream; about ten drops of liquid ammonia is then added to each ounce of the cream. Should the plate have been used before, it should be previously laid in a weak aqueous solution of nitric acid. A soap commonly known as "Monkey soap" is an admirable cleanser of glass, removing all traces of grease and organic matter. Common whitening will also remove grease when dry. It should be made into a thick cream with water and applied to the glass, and rubbed off when dry. With regard to the selection of the glass, a careful perusal of the few remarks under **Glass** might be advantageous to the reader.

Salting the Collodion.—The particulars regarding the necessary qualities required in the plain collodion are given under that heading. It will not therefore be necessary to repeat them here, but pass on to the addition of the iodide or bromide to the collodion. The following is the standard formula:—

Cadmium iodide..	4½ grains.
Cadmium bromide	2 ,,
Plain collodion	1 oz.

This should be mixed about six months previous to using. For landscape work the following is to be recommended :—

Ammonium iodide	4 grains.
Cadmium bromide	1¼ ,,
Plain collodion	1 oz.

This may be used two or three days after mixing. A large number of modifications have from time to time been recommended. The following rules may guide the operator :—Should a decrease of contrast and plenty of detail be required, add more bromide ; but if great contrasts are necessary lower the quantity of bromide, and increase the iodides. The lowest quantity of bromide necessary to secure clearness in the shadows is about one quarter grain to the ounce of collodion. The iodides and bromides used are usually ammonium and cadmium. If ammonium be used the collodion is more fit for immediate use ; cadmium causes collodion to become glutinous when first iodising, and it is therefore necessary to keep it for several months previous to using. If an iodide alone be used the resulting image will be very dense, but lacking in detail in the shadows; and if a bromide only be used a much flatter image, but full of detail, will be obtained. It will therefore be seen that by a judicious mixture of the two a suitable film can be made, which, when sensitised, will give the detail and delicacy of the bromide combined with sufficient density of the iodide, or a mean between the two extremes.

The plain collodion should always be kept in a cool, dry place, otherwise the ether is liable to decompose, and in its turn decompose the pyroxyline. If the collodion be made with a pure spirit and a neutral cotton it should be quite colourless after iodising, but should any of the solvents be impure a slight discoloration will result, as the contact of iodine with ether compounds will sometimes form an organic compound. Again, if the pyroxyline be acid the collodion will become sherry coloured immediately, and will keep good for any length of time.

The customary method of iodising a collodion is to omit half the quantity of alcohol in the plain collodion, and use it to dissolve the iodide or bromide which is then added. The addition of the iodide or the iodide and bromide to the plain collodion is termed iodising, and the collodion is said to be iodised.

All good workers with collodion adopt the method of writing upon the label of the iodised collodion the date of its manufacture, the date when iodised, and the various ingredients and proportions used in both processes. This will be found of much use, and a convenient guide for future operations.

It may be as well to state that both time and trouble may be saved by those who object to lengthy processes by purchasing the iodised collodion sold in the market ready for use.

Coating the Plate.—The next operation is to coat the glass with the collodion. It is one that requires no little care. The iodised collodion is kept in a suitable bottle, guarded from dust,

and free from solid particles of dry collodion. The form of the bottle should be similar to that depicted in fig. 39, which

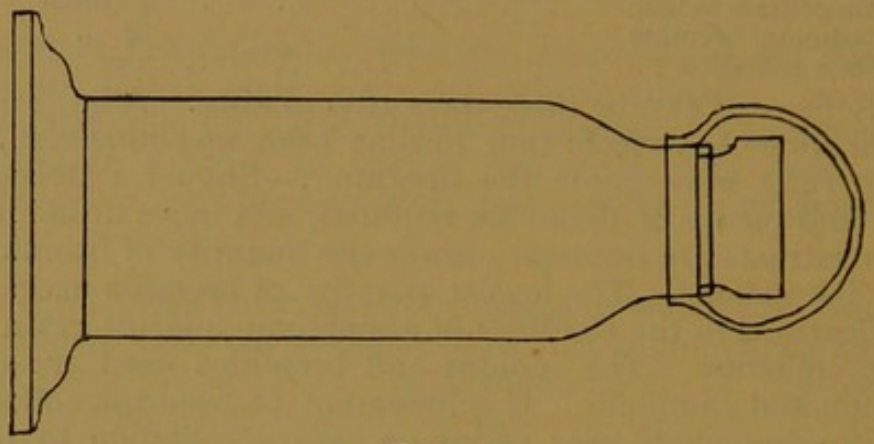

Fig. 39.

permits of the collodion being poured out evenly, and prevents the formation of bubbles and solid particles from settling on the film.

The glass cleaned and polished is held at one corner by the thumb and first finger of the left hand by allowing the extreme corner to press into the ball of the thumb, and the under side of the glass to rest upon the first finger bent into position to receive it. By this means wrecking the upper surface is avoided, and the collodion can be coated over the whole of the surface of the glass save a very small corner nearest the thumb. A still better method is to employ a pneumatic holder, which can be attached to the back of the glass and allow the whole surface to be coated. The glass plate is first dusted over with a broad camel-hair brush scrupulously clean, and a pool of the collodion, of more than sufficient quantity to cover the glass plate, is poured on towards the top right-hand corner. The plate is then slowly tilted to allow the collodion to first run in and fill up the top right-hand corner without overflowing. The collodion is then made to run along the plate to the top left-hand corner, and then to the bottom left-hand corner. Another movement of the plate serves to bring it to the bottom right-hand corner, the whole of the plate having been covered. From this corner the superfluous collodion is poured off the plate into another bottle, rocking the plate from side to side to prevent the collodion leaving traces of its downward flow towards the bottle. As soon as the collodion is "tacky," it is placed into the "nitrate" or "silver bath."

The coating a glass plate with collodion requires considerable practice; it will therefore be as well for the operator to make his first attempts with spoilt collodion, glycerine, or thin cream.

The Silver Bath is one of the most important solutions used in wet-plate photography, and upon its purity and strength a great deal depends. The salt invariably used is the silver nitrate, and this should be of the purest quality obtainable. The strength of the solution varies. With a collodion which contains iodides and

bromides the greatest strength permissible is 50 grains of silver nitrate to each ounce of water. According to Abney, even this proportion is too large, since the silver nitrate in solution will dissolve up a certain amount of silver, the quantity depending upon the silver solution and on the temperature. If, therefore, it were not that the solution becomes saturated with silver iodide on the immersion of a collodion film, the iodide would be dissolved out, either partially or wholly, according to the time of the immersion. Now, as it is easier to saturate a dilute than a strong solution, and as a variation in the temperature will cause a less marked difference in the former than in the latter, it will be evident that the less the amount of silver salt in solution, the greater the probability that the solution will not show signs of under or over-saturation of iodide.

Another point to be observed is the acidity or alkalinity of the bath, as upon this the sensitiveness of the plate partially depends. If a collodion be used containing an iodide only the bath should be either neutral or very slightly acid, but with a collodion containing bromide and iodide it should be distinctly acid unless a considerable amount of free iodine be present.

For a bromo-iodised collodion the following sensitising bath may be used :—

Silver nitrate (re-crystallised)	40 grains
Distilled water	1 ounce
Potassium iodide	$\frac{1}{8}$ grain

This is made up by dissolving the silver nitrate in a quarter of the quantity of water. The potassium iodide is next added. This will form silver iodide, and will be partially re-dissolved when the solution is agitated. The remaining quantity of water is then added, and a re-emulsification of the silver iodide will take place. It is then filtered and tested for acidity or alkalinity. A piece of blue litmus paper after immersion for a minute in the solution should redden slightly. If it redden immediately on immersion a small quantity of sodium carbonate should be added. This will form a precipitate, which is then filtered out, and a few drops of nitric acid solution (1 to 12 of water) added. If the litmus paper remains blue on immersion a small quantity of the nitric acid solution must be added. Instead of nitric acid acetic acid is sometimes used. With this, however, silver acetate is sometimes formed, which is not easily eliminated.

The silver bath will after a time become supersaturated with iodine or ether and alcohol. The presence of iodine is indicated by "pinholes" in the negatives. To eliminate, the bath should be diluted to about one-half its strength, and silver nitrate added to make up to its original strength. It should then be filtered. If ether and alcohol be present, unequal sensitising and streaky development will be the effect. If the bath be gently heated, both the alcohol and ether will be driven off. The presence of organic matter in the silver bath will result in foggy, dirty, veiled

negatives. The removal of this is not easy. The solution should first be made distinctly alkaline with sodium carbonate, and then placed in the sun for some days. A black deposit will be formed in the bottle, and the liquid should be filtered, acidified with nitric or acetic acid, and again filtered. The bath prepared, we have next to sensitise our plates, coated with the iodised collodion, by immersing them in it.

Sensitising the Plate.—We have already stated that the glass coated with the collodion is, when in a tacky state, ready for immersion in the sensitising bath. This is usually done by employing what is termed a dipping bath (fig. 40). This is made of glass, en-

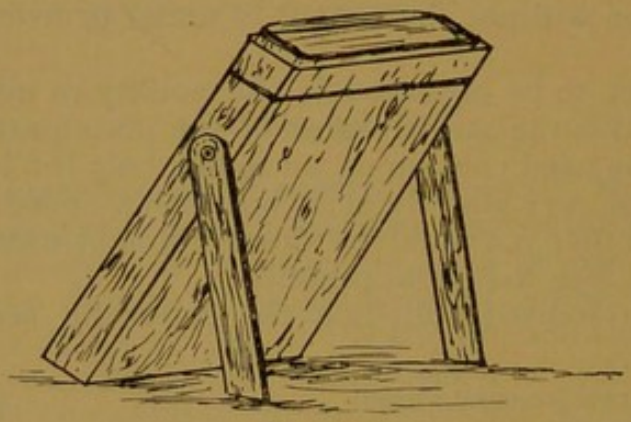

FIG. 40.

closed in a wooden box supported in an upright position. Into this the silver solution is poured. The collodionised plate is laid upon a dipper (fig. 41) made of ebonite or porcelain, and plunged into the

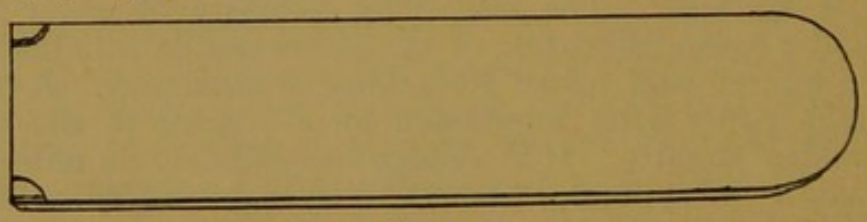

FIG. 41.

silver solution, the lower end of the plate being immersed first, as the collodion is probably thicker at that part. This operation is of course done in non-actinic light. In a few seconds the plate will be seen to change to a grey, or bluish grey colour, according to the salts in the collodion. This is due to the double decomposition of the silver haloids giving a layer of silver bromide or iodide, thus—

$$NH_4I + AgNO_3 = AgI + NH_4NO_3$$
$$CdBr_2 + 2AgNO_3 = 2AgBr + Cd(NO_3)_2$$

After the plate has been immersed in the bath for about forty-five to fifty seconds it should be gently raised. When there is no longer any appearance of greasiness on the plate the sensitization is complete. It is then raised slowly from the bath, and the

solution at the lower end blotted off on to clean blotting paper. The back is then wiped with the same material, and the plate placed into the dark slide of the camera. A special kind of slide is necessary, in which the plate is kept in position by glass or silver corners. A piece of damped red blotting paper is next placed behind the plate, and the slide closed, and the plate is ready for exposure. After exposure, the plate is returned to the dark room, and is ready for development.

The Developer.—There are two methods of development, *i.e.*, iron and pyrogallic acid. The latter is but rarely used at the present time, since the former has been discovered to be such a superior reducing agent. If, however, a collodion is employed containing an iodide only, the pyro developer may still be used. It gives a very dense image, and for this reason is specially useful for copying purposes. A longer exposure is necessary than with the iron developer. The pyrogallic developer is made up in the following manner :—

Pyrogallic acid	1 grain.
Glacial acetic acid	20 minims.
Alcohol	quant. suf.
Water	1 ounce.

The most suitable developer in this process is undoubtedly the ferrous sulphate ; a convenient formula runs—

Iron protosulphate	12 grains.
Acetic acid (glacial)	20 to 25 minims.
Water	1 ounce.
Alcohol	quant. suf.

Instead of acetic acid, 1 minim of nitric acid may be used. No definite quantity of the alcohol can be given, as it must be regulated by the amount of alcohol in the bath. For instance, a new bath requires a very small quantity of alcohol in the developer, but as it grows old the quantity of alcohol in the developer must be gradually increased, or streaky development will be the result.

The iron should be quite fresh, and of a light green colour. Iron which has been exposed to the atmosphere for some time becomes oxidised, having a yellow coating, which, if used for development, acts as a powerful restrainer.

Another formula which is used by several photographers for landscape work is—

Ferrous sulphate	20 grains.
Copper sulphate	10 ,,
Acetic acid (glacial)	15·20 minims.
Alcohol	quant. suf.
Water	1 ounce.

This will give very clear and brilliant images, and the exposure is said to be shortened.

The addition of many organic substances to the developer has been recommended. Gelatine, sugar, glycerine, and collocine, if added to the developer, cause the silver to deposit much slower,

and greater density is obtained. A developer containing an "organifier," as it is termed, is made up as follows :—

Ferrous sulphate	20 grains.
Acetic acid (glacial)	10 to 15 minims.
Lump sugar	10 grains.
Alcohol	quant. suf.
Water	1 ounce.

Developing the Image.—The plate is removed from the dark slide, and held over the sink either by one corner or preferably with a pneumatic plate-holder. The developing solution is placed in a developing cup, and sufficient quantity of it to well cover the plate is swept over in one wave, entirely covering it in one operation, but if possible without spilling the solution. Practice alone will enable the operator to do this successfully. The developing solution is kept moving over the plate for twenty or thirty seconds, when it is either thrown away or transferred to the residue jar. If the image flashes up quickly, and is of an even grey, the exposure has been too great, and if, on the contrary, it comes up tardily, or in black and white patches, the exposure has been too short. This is, of course, supposing that all the previous operations have been correctly carried out.

If development has not been carried out far enough the plate can be washed under the tap, and a fresh supply of developer applied. If a small quantity (ten drops to each ounce of developer) of a ten per cent. solution of silver nitrate, acidified with nitric acid, be added, it will give considerable increase in both detail and density. This is termed re-development, and should only be practised if the image, after the first application of the developer, is weak and wanting in detail. If, however, it be weak, and yet full of detail, intensification is necessary.

Fixing.—The plate is, after development, washed and fixed by by pouring on—

Potassium cyanide	25 grains.
Water	1 ounce.

Or—

Sodium hyposulphate	100 grains.
Water	1 ounce.

In one of these solutions the plate must remain until the yellowness disappears entirely from the plate. If potassium cyanide be used as a fixing agent it should be remembered that it is a violent poison ; even its fumes dangerously affect some persons.

After fixing, the plate is well washed in water.

Intensifying the Image.—If the plates are wanting in density the image must be intensified. The plate is taken on a pneumatic holder and flooded with—

Pyrogallic acid	2 grains
Citric acid	2—4 ,,
Water	1 ounce

Or

Ferrous sulphate	6 grains
Citric acid	12 ,,
Water	1 ounce

The pyro intensifier brings up the image much quicker than the iron, which is suitable for a picture that has been properly exposed.

Another method of intensifying collodion wet plates is with an alkaline solution of silver. This method was first pointed out by Abney in 1874, and worked out later by Mr. Farmer. The following is a description of the method :—

A.—Silver nitrate	1	ounce.
Water	12	,,
B.—Potassium bromide	¾	,,
Water	2	,,
C.—Sodium hyposulphite	2	,,
Water	6	,,

Add solution B to A, and after washing the precipitated bromide thoroughly by decantation, dissolve it with agitation in C. The liquid will at once become muddy, when it should be either filtered clear, or allowed to stand for a day or two and the clear part filtered off. It is then made up with water to sixteen ounces and kept ready for use. Other intensifiers are given under that heading. Intensifying may be done either before or after fixing. If the image is clear and free from fog, intensification is best accomplished before fixing, but if the plate has been over-exposed it is best done after fixing, as before fixing it acts as a development and would produce fog.

After intensification and fixing the plate is thoroughly washed and dried. If dried quickly by the application of heat the density of the negative will be slightly increased. When dry the plate is ready to be varnished.

Varnishing.—The collodion film being very delicate and easily scratched it is necessary to give it some hard protective coating. This is usually a resin dissolved in spirit. This varnish may either be purchased ready for use, or it can be manufactured by dissolving one pound of seed lac in a gallon of methylated spirits. It will require keeping several days in a warm place before it is all dissolved. It must also be well shaken every now and then. When it is quite dissolved the solution is decanted off and filtered. Other methods of making varnish will be found described under that heading.

To coat the plate with varnish heat the former to a blood heat, and apply the varnish in the same manner as described for coating the plate with the collodion. When the superfluous varnish is drained off into another bottle rest the lower edge of the plate upon botting paper to remove any drops of the varnish. The plate is then heated till the back becomes uncomfortably hot. A good method of heating the plate is by moving it briskly over a lamp chimney or a Bunsen burner. It must not, however, be placed near enough for the solvent of the varnish to catch fire. If amber varnish be used it must be applied cold.

The negative is then ready for the printing operations.

Collodion Wet Process for Positives.—Very little difference in the manipulation is necessary for the production of positives by the wet process than for negatives as described under **Collodion Wet Process.** The chief object is to obtain the deposit of silver as white as possible. The collodion is the same as that recommended for the production of negatives. The silver bath should be weaker. A good formula is—

Silver nitrate (recrystallised)	250 grains.
Nitric acid	¼ minim.
Water	10 ounces.

For development the pyrogallic developer recommended for negatives can be used. Abney recommends the following :—

Ferrous nitrate	110 grains.
Ferrous sulphate..	60 ,,
Nitric acid	20 minims.
Alcohol	quant. suf.
Water	4 ounces.

The ferrous nitrate may be prepared by taking barium nitrate 130·5 grains, and dissolving it in two ounces of water. A solution of 76 grains of ferrous sulphate, dissolved in two ounces of water, is next added to it. A precipitate of barium sulphate falls. This must be filtered out, and 110 grains of ferrous nitrate are left in solution. The nitric acid should be dropped in, diluted with half-an-ounce of water. The alcohol is added after the 60 grains of sulphate of iron have been dissolved. The effect of the nitric acid is to cause the silver to deposit with a white lustre by reflected light. The exposure required is less than for a negative. The cyanide fixing solution should be used. As soon as dry the film side is varnished with a black varnish. The image is then seen from the back in its proper position. A recipe for a good black varnish will be found under **Varnish.**

Instead of glass, ferrotype plates may be used. These are thin iron plates enamelled with black or chocolate-brown enamel. They are first cleaned by the application of a little dilute potash or dilute nitric acid, and finally washed in distilled water, and polished with a silk handkerchief. They are then coated with collodion, sensitised, exposed, developed, and fixed in the manner described. The dried picture only requires to be coated with a protected transparent varnish. It must be remembered, however, that with positives of this kind the image is reversed.

Collodion Ferrotypes.—See **Collodion Wet Process for Positives.**

Colloids (Gr. *kolla*—glue, and *eidos*—appearance).—This name was given by Graham to those non-crystalline substances which do not diffuse through porous membranes. The chief organic colloids are cellulose, gum, starch, dextrine, tannin, gelatine, caramel, and albumen. The inorganic colloids are hydrated oxides of iron, hydrated silica, alumina, chromium, &c.

Collographic Processes.—Under collographic methods of photo-mechanical printing may be classed such processes as collotype, heliotype, &c. These processes are analogous in principle, but vary considerably in detail. They are fully described under their respective headings.

Collotype.—A photo-mechanical printing process based upon the fact that if a film of bichromated gelatine be dried at a moderately high temperature and exposed under a negative, it may, when washed and dried, be treated in the same manner as a lithographic stone, to which it shows similar properties—that is to say, it will absorb water and refuse greasy ink in some parts, whilst in others it will refuse water and take up the ink. The discovery of this property was made by Fox Talbot in 1853. His researches were followed up by Poitevin. For the first practical process of collotype we are, however, indebted to Tessie de Motey, who used a copperplate to support the gelatine film, and potassium bichromate as the reducing agent. The present perfect method of collotype printing is, however, due to the labours of Albert, Husnik and Obernetter, who worked hard to surmount the innumerable difficulties which first arose.

The process of collotype is now very largely used in nearly all countries, and is worked under various names. In Germany chiefly as lichtdruck, in France as phototypie, and in England as collotype, phototype, albertype, and various other fancy names. It may be briefly described as follows:—A thick sheet of plate glass is carefully ground with fine emery or silica powder. It is then coated with a mixture of white of egg and silicate of soda. After rinsing in water and drying, it is warmed and coated with a thin film of dichromatised gelatine, and allowed to again dry in a suitable heating apparatus. When dry the plate is placed under a reversed negative and exposed to light. The back of the film is also given a slight exposure. It is then laid in cold water, and the dichromate thoroughly removed from the film. The plate is then allowed to dry, after which operation it is first soaked in cold water, and afterwards in a mixture of glycerine and water. It is then ready for the printing press. When in the printing press the plate has to be kept well moistened with glycerine and water. The effect of this is to cause the unexposed parts of the gelatine film to swell, and upon this property of bichromatised gelatine the process of collotype is based.

Preparing the Plate.—The following is a more detailed description of the process. Some sheets of thick British plate glass, at least ¼in. in thickness, are first procured, somewhat larger than the size of the picture. For small sizes a margin of three inches outside the picture should be given, while for larger sizes it is well to have a margin of from four to six inches. The glass selected should be quite free from scratches or other defects, and should have its edges well rounded

for convenience and safety in handling. These sheets of glass are intended as supports for the collotype image, and have now to be ground true. This operation is performed by first laying one sheet of glass upon a firm support, dusting it over with the finest emery powder, sprinkling it with water, and then laying another sheet of glass over it. The upper sheet of glass is then moved in every possible direction, a circular motion being kept up as far as possible. The underneath plate should be repeatedly supplied with the emery powder and water until the two plates have been evenly ground all over. This is easily seen by washing away the emery powder. The presence of shiny or unground parts is at once detected, and the grinding process must be proceeded with. To assist in the moving of the top plate glass a pneumatic holder, or, better still, two of them, will be found very serviceable to obtain a better hold of the plate. The grinding of the glass in this manner ensures a perfect flat surface. It also causes the chromated gelatine to adhere with greater tenacity, and assist in the formation of the necessary grain in the case of thin layers.

After grinding, the plate is well washed and freed from the emery powder. It is then flooded with—

Liquor ammonia	1 ounce
Alcohol	1 „
Water	5 „

It is then well washed with clean water and coated with the substratum of albumen and waterglass. The formula is—

Distilled water	4 ounces.
White of egg (whisked)..	3 „
Silicate of soda	1 „

This should be well beaten up into a froth, and placed in a bottle containing some pieces of broken glass. Here it is allowed to settle for five or six hours, when it is filtered. The wet plate is covered over with this two or three times, and placed in a rack to dry in a warm current of air.

Instead of albumen stale beer is sometimes used, to which caustic potash has been added until it ceases to show an acid reaction if tested with blue litmus paper.

The most careful attention must be paid to the filtration of the substratum, and to the even coating and drying in a clean place quite free from dust.

The next operation is the coating of the plate with dichromatised gelatine. This is the most important part, and on it rests the success of the whole of the subsequent operations. The principal points to be observed are that the exact quantity only of the solution be allowed to remain on the plate, and that this quantity be evenly distributed over the surface.

The gelatine sensitive solution is made up by first soaking 2 ounces of Nelson's gelatine No. 2, and ½ ounce of Nelson's No. 1, in 30 ounces of water, to which 10 drops of a saturated solution of chrome alum have been added. When quite soft it is heated to a temperature of 125° to 150° Fahr., when the gelatine will have dissolved. Then add, with constant stirring, 150 grains of finely-powdered potassium dichromate. The solution is then well stirred up and strained through muslin, or Japanese filter paper, into a suitable porcelain jar. If kept in a cool place it may be used as required. The ground glass plates which have been washed and treated with the substratum as described are placed in a warm drying box, and then levelled on a levelling stand. Sufficient quantity of the dichromatised gelatine is then dissolved and strained into a warm glass beaker thoroughly clean. Out of this the solution is poured on to the plate balanced on the palm of the left hand. The plate is then inclined in different directions until the solution has been made to run all over it. Air-bubbles or other imperfections are removed, and the plate returned to the level in the drying box. The box is then closed, and the heat gradually increased to a temperature of about 120° Fahr. A drying box for this purpose is described elsewhere. It is important that a current of air freely circulates in all parts of the box, and also that the flow is constant. If any fluctuations in the current or in the temperature take place, the plates will dry unevenly and unsafe for use.

If kept at an even temperature of 120° Fah., the plates should take about two or three hours to dry. At this period they are removed or allowed to remain in the box to cool gradually, the source of heat being extinguished, and should have a fine even matt surface. If there is any appearance of gloss over the whole or part of the film, the gelatine is too hard, and requires the addition of a small quantity of parchment size.

Instead of gelatine, isinglass is used by some workers. The following formula is given in Dr. Schnaus's valuable treatise upon this subject * :—Two grammes of the best Russian isinglass are cut up into the smallest possible pieces with a pair of sharp scissors, soaked in 25 c.c. of water for twelve hours, heated nearly to boiling point until solution is effected, and then filtered while hot through close flannel. Cover six grammes of good collotype gelatine with 50 c.c. of water and allow to stand. Heat nearly to boiling point and thoroughly incorporate the two solutions; again while hot filter through paper or close flannel. To this add 11 c.c. of a filtered solution (1·8) of ammonium dichromate. The solution is then heated to 50°C., and the plates warmed, coated and dried in the manner described with the previous solution given.

"Collotype and Photo-Lithography," Iliffe & Son.

When the plates are dry it is not necessary to use them at once, but they may be kept in a cool, dry and dark place for several days. Some operators prefer to use a plate two or three days old.

The next process is the exposure to light of the plate under a negative. By a careful perusal of the subsequent operation the reader will see that if an ordinary negative be used a reversed picture would be the result. For some purposes this is of little matter, and an ordinary negative may be used. In the majority of cases, however, the reversal of the image would be a serious matter, and it is therefore necessary to prevent this by reversing the negative. There are many methods of doing this, any of which may be employed. One method is to strip the negative from the glass and reverse it in the printing frame. Another is to make the negative from a mirror, instead of directly from the object. The negative films now in the market are very convenient, as it is only necessary to print with the back in contact with the plate. For detailed methods of reversing negatives see **Reversed Negative.**

The exposure to light will, of course, vary with the density of the negative and actinicity of the light. The best negatives are those which show a fine gradation between the shadows and the high-lights. The negative is placed in an ordinary printing frame and the collotype placed face downwards upon it. The back is then put in and the frame closed. The exposure should be continued until the image is well defined upon the gelatine film. This can easily be seen by opening one-half of the back of the printing-frame in the dark room. Some operators, however, prefer to use an actinometer. Dr. Schnauss recommends the printing of half-tone plates in diffused light.

The accurate judging of the right exposure is not an easy, although an important, matter. The greater the quantity of dichromate contained in the film the shorter the necessary exposure. It may also be noted that a thin layer will require less exposure than a thicker one. In very dark weather many hours would be required, but in direct sunlight a few minutes would perhaps suffice.

Before printing it is a good practice to "mark" the negative by forming a margin at least an inch wide round the four sides of the negative. This may be accomplished either by painting with Indian ink or attaching strips of thin black paper or tinfoil.

After exposure under the negative the printing-frame is laid on a piece of black velvet on a table in the light, the back removed, and the back of the film exposed for from five to ten minutes to the light (not sunlight) in order to harden the back of the print. This should be done without disturbing the positions of the collotype plate or the negative.

The plate is next removed from the printing-frame, and immersed in clear cold water for from six to eight hours, changing the water every now and then. This will remove the dichromate from the film and leave the picture only visible as a slight brown image. The film of the plate is then hardened by soaking for about fifteen minutes in a one per cent. solution of alum. The plate is then given a final wash and placed aside for two or three days to dry.

It is then ready for putting in the press and printing from.

Printing.—The printing from collotype is usually done in an ordinary typographic press, but many finely constructed steam machines are now made for this purpose, notably by Alauzet and Co., of Paris, and Koch, of Leipzig. These differ but little from the ordinary lithographic presses, and an output of between 1,000 to 1,500 copies per day can be obtained with them.

The back of the plate is first cleaned and then immersed in the etching or damping solution—

Water	5 parts.
Liq. amm.	1 part.
Glycerine	3 parts.
Nitrate of lime	$\frac{1}{10}$ part.

Dilute when required for use with 150 parts of water.

In this solution the plates may remain for an hour or so. Instead of the one given the following may be used :—

Glycerine	5 ounces.
Water	10 ,,
Sodium chloride	30 grains.

The next operation is the fixing of the collotype plate in the bed of the press. The plate is removed from the etching solution and fixed by adhesion to the bed of glass or polished iron plate. Another method is to spread some fine plaster of Paris over the bed of the press, made into a cream with water, and lay the dry collotype plate on it. It is then well pressed down in a level position, and the plate flooded with one of the etching solutions given.

A piece of the best chalk ink is next taken with a spatula, and spread upon the inking slab of the machine. A small quantity of refined middle varnish, one drop of olive oil, and one or two drops of the best French turpentine are then added, and the whole well mixed up with the palette knife. The usual methods of distributing the ink and rolling up are then carried out. The printing plate should have been well secured, and the moistened surface evenly dried with a roller covered over with fine quality wash-leather. The inky roller is passed over the plate with light pressure several times, and rolled backwards and forwards until

the ink is evenly and perfectly distributed over the surface of the plate. If it be rolled slowly, with pressure applied, ink deposits itself upon the plate, but if rolled quickly and lightly, it removes the ink from the print layer. The most careful collotype printers use two rollers, one of leather, and a smoother roller of glue composition, which is applied after the other, and serves to considerably improve the half-tones.

When the plate is properly inked the frame of the press is brought down into position, and the paper adjusted over the mask. With regard to the quality of the paper, it should be of good quality, well sized; a most suitable paper is that known as dull enamel. In France and Germany a paper prepared with a pink or other tested chalk is used. It is largely manufactured in Germany, and sold as Kreide Papier. It has a dull enamel surface, and its tint gives a pleasing effect to many subjects. A good collotype printed upon this paper and varnished would be taken by many for a silver print.

After the paper is laid on it is backed with a few pieces of smooth paper, and covered with the tympan attached to its frame. The bed of the press is then pushed under the scraper, and the latter regulated to give sufficient pressure.

After the pressure is applied the paper is carefully lifted up from the printing surface, to which it will slightly adhere. After each impression the plate is damped with the damping solution applied with a sponge, and blotted off with a clean piece of plate paper, otherwise the whites will become tinted. With some plates the application of the damping solution will not be necessary so often.

The practice of printing from a collotype plate is only one that can be acquired by constant perseverance and application of hand and mind. No further description of any practical use could be given here.

After printing from the plate it may be cleaned with a little turpentine, which will remove all the ink, and after its evaporation the damping solution is removed by washing in water, and the plate dried and kept for future use in a cool place.

We must now turn our attention to the collotype prints pulled from the plate. They very often contain little white spots or other imperfections, which can be touched up with a finely-pointed camel-hair brush and a little of the printing ink thinned with turpentine. Any finger marks or ink stains upon the white margins of the prints can be removed with an indiarubber ink eraser.

The prints can next be mounted and rolled or burnished.

If the prints are upon sized paper they may be varnished with a varnish of white lac dissolved in wood naphtha in the proportions 1 to 6, and filtered. This varnish is best applied with a piece of

soft flannel made in the form of a dabber. If the prints have not been made upon sized paper it will be necessary before varnishing to brush them over with a ten per cent. solution of gelatine applied with a broad camel-hair brush.

Another method given in Dr. Schnauss's book by which sizing may be avoided is to dip each picture after drying into the following solution :—

Water	500 c.c.m.
Borax	130 grammes
White shellac	100 ,,
Sodium carbonate	6 ,,

Both the borax and the carbonate are dissolved in boiling water, and the powdered shellac added in small quantities. When solution is completed it is carefully filled and allowed to cool. The impressions are placed two and two back to back on a frame and dipped into the varnish, which gives them a shellac coating. To unite the solution must be kept at a temperature of between 15° and 20°C.

The enamel paper referred to is best done with an alkaline solution of shellac, which can be prepared by dissolving eight ounces of powdered bleached shellac in a quart of alcohol and a quart of ammonia liq. fort. After solution three pints of hot water are added, the whole allowed to cool, and then filtered. It is applied to the prints with a piece of flannel or a Blanchard brush.

When perfectly dry mounted prints may be burnished or rolled.

Collotype, Coloured.—A method of collotype printing in colours has been worked for some time in Germany. A number of negatives are made according to the number of different colours required. A collotype plate is then made from each negative, having all its parts blocked out except those parts required to be printed of that colour. The printing is then done as in chromolithography, the prints being printed from all the plates and kept into position by a suitable arrangement.

Colophony.—A black resin, the solid residuum of the distillation of turpentine after the oil has been worked off.

Colorimeter (Lat., *color;* Gr., *metron*—a measure).—An instrument for measuring the colour of a liquid. In the volumetric estimation of silver with potassium chromate it is very often a difficult matter to make a proper and correct test owing to the original yellow colour of the solution itself. A colorimeter introduced by Dupré interposes between the eye and the test liquid a flat glass cell (of which the faces are about half-an-inch apart) containing a solution of potassium chromate of such strength as will neutralise the colour of the test liquid, which thus appears colourless, and in which the faintest tinge of red formed by the silver chromate is easily visible.

Colour.—See **Light** and **Optics.**

Colour Blindness.—Also known as Daltonism, after the chemist Dalton, who laboured under this infirmity of the human eye, by which it fails to distinguish certain colours. The vision of a colour blind person may be perfect with regard to distinguishing the form of bodies, but different colours, such as red and green, are totally indistinguishable. Some persons see everything either to be light or dark, and have no conception of any other colours. This, however, is rare. It is usually the primary or secondary colours which cannot be distinguished from each other.

Coloured Photographs.—By coloured photographs is meant the production of photographs coloured by artificial means, and not the making of photographs in natural colours—a process not yet accomplished except in very unsatisfactory manners.

There are various methods of colouring photographs which may briefly be divided under two headings—the application of colour to the surface of the print, and its application behind the photographic image. The art of harmoniously colouring photographs is one that is only acquired by practice and natural artistic abilities. Many text-books upon the subject have been published, which the beginner should study to become acquainted with the mechanical part of the art.

The process of colouring at the back was one that was adopted with the old alabrastine process, and a "penetrating varnish" was used which had the effect of rendering the colours visible upon the contrary side.

The late W. B. Woodbury invented a method of producing coloured photographs, or photo-chromographs as they were called. Photographic prints produced by the Woodburytype were transferred to paper supports previously painted or coloured with the necessary pigments, which, seen through the thin film containing the image, possessed the appearance of coloured photographs, and in many cases closely resembled delicate oil paintings. A similar effect can be produced by the carbon process

Another method of producing coloured photographs with very delicate effects is by fixing a paper photograph upon a cushion shaped glass with transparent cement. When this is dry, two-thirds of the paper support of the photograph are rubbed away with sand-paper, and the remaining part made transparent with melted paraffin wax. Transparent colours are then applied, which appear very soft when viewed from the front. A second coating of paraffin wax is then applied, and the heavier colours laid on. Another layer of wax is then applied as a protective coat.

Carbon prints may be coloured with oil, water, or powder colours. Before colouring with oil colours, the print should be sized with a solution of isinglass dissolved in equal parts of hot wa er and spirits of wine.

Colour-sensitive Plates.—See **Isochromatic Process.**

Colour-sensitive Process.—See **Isochromatic Process.**

Coloured Screen.—A coloured screen used in the process of isochromatic photography, *q. v.*

Coloured Sensitising.—A process employed in isochromatic photography in which the gelatine plate is sensitised with a dye of some kind, which has the effect of causing the plate to give a truer representation of the colour value of the image. See **Isochromatic Photography.**

Colour Test for Emulsions.—See **Emulsion.**

Colza Oil.—A non-drying oil obtained from the seeds of *Brassica napus*. Pure colza oil is comparatively inodorous, has a specific gravity of 0·9,128 at 60° Fahr., and solidifies at 22° Fahr. It is an excellent lubricant for machinery, and was formerly much used for lighting purposes.

Combination, Chemical.—Chemical combination is governed by certain laws. In chemistry we have two kinds of matter, *i.e.*, elements and compounds. Elements can only undergo chemical change by combining with other elements or compounds, but compounds can combine with elements or other compounds, and can also be separated with two or more elements or compounds each unlike the others, and each weighing less than the original quantity of the compound used (Watts).

The laws of chemical combination are as follows (Watts's "Dictionary of Chemistry," 1889) :—

Law of Constant Proportions.—The masses of the constituent elements of every compound stand in an unalterable ratio to each other, and also to the mass of the compound formed.

Law of Multiple Proportions.—When two elements combine to form more than one compound, the masses of one of the elements which combine with a constant mass of the other element bear a simple relation to each other.

Law of Recipro al Proportions, or Law of Combining Weights.—The masses of different elements which severally combine with one and the same mass of another element are also the masses of these different elements which combine with each other, or they bear a simple relation to these masses. See also **Chemistry.**

Combination Printing.—A method of printing in which the whole or portions of two or more negatives are combined.

Combining Weights.—See **Elements.**

Combustion (Lat. *comburo*—I burn).—Chemical combination. Chemical action producing the sensation of heat and sometimes light.

Comets.—Peculiar defective markings which make their appearance upon gelatine plates, and which have the form of a comet.—See **Dry Plates.**

Commercial Acetic Acid.—See **Acetic Acid.**

Common Salt.—See **Sodium Chloride.**

Comparative Exposure.—For comparative exposures with the different stops see **Diaphragm.**

Complementary Colours.—See **Light** and **Optics.**

Composite Portrait.—A process of obtaining a normal or average type of the features of a number of individuals either by photographing one over the other upon the same plate, or making one print from a number of negatives.

Compound.—Anything which is composed or compounded of two or more elements or parts—a combination.

Compound Condenser.—See **Condenser.**

Compound Microscope.—A microscope made with a combination of lenses.

Compound Prism.—A prism formed by several prisms being cemented together one over the other base to apex.

Compound Radical.—A chemical term given to a radical which operates as if it were but single, while it is in reality only composed of two.

Compound Spirits.—Rectified spirits to which other ingredients have been added.

Concave (Lat. *concavus*—hollowed out).—In optics, a lens hollow or depressed in the centre. There are three kinds—(1.) Plano-concave, in which one side is plane or flat and the other hollowed out. (2.) Concavo-convex, in which one side is concave or hollowed out and the other side is raised or convex. (3.) A double concave, bi-concave, or concavo concave, in which both sides are hollow or concave.

Concavo-concave.—Concave on both sides.

Concavo-convex.—Concave on one side and convex on the other.

Concentrated Solution.—A solution prepared by concentration, a process which has for its object to increase the amount of a dissolved substance in a liquid relatively to the quantity of the solvent, without adding any more of the dissolved substance itself. When the solvent is volatile this object is effected by evaporation,

as when water, alcohol or ether is expelled from a solution by heat, by exposure to the air, or *in vacuo*. If the dissolved substance is more volatile than the solvent, the concentration is effected by distillation, the more concentrated liquid being then found in the distillate, as in the rectification of hydrated alcohol and of volatile oils dissolved in water. In the case of aqueous liquids concentration is sometimes effected by freezing out the water; in this manner a solution of salt may be obtained from sea water, strong spirit from vinous liquids, etc. (Watts's Dict. Chem.)

Conchinine (Formula, $C_{20}H_{24}N_2O_2$).—Also known as Quinidine. It is an organic base, isomeric with quinine, occurring in cinchona bark. It crystallises in bitter colourless prisms, soluble in dilute sulphuric acid, the solution showing blue fluorescence. It is used in the manufacture of luminous paint (*q.v.*)

Concoagulation.—A coagulation of two or more bodies in a mass.

Condensate (Lat., *condensatus*).—To condense—to compress into a close form.

Condensation in Density.—The passage of gases or vapours, liquid state, liquefaction. It may be produced by cooling, compression, or chemical affinity.

The reduction of a liquid to a smaller bulk, with proportionate increase in the specific gravity.

Condenser.—A lens which gathers the rays of light together and concentrates them upon one point. A compound condenser is a combination of two or more lenses having the same object. In photography the condenser is principally used for enlarging purposes, where it collects the rays of light and passes them through the negative or the positive, and brings them to a focus in the lens which projects the image. For further information upon the condenser see **Enlarging.**

Condenser for Liquids.—A liquid condenser is an apparatus in which a coil of piping traverses a tub, which receives a constant accession of cold water, condensing the vapour in the coil.

Condy's Fluid.—A solution of manganate of sodium. It acts as a powerful and efficient disinfector by the oxidation of putrid matter. A quantity of it should occasionally be poured down bad-smelling drains. It also acts as a test for the purity of water. A few drops of the solution added to the water will, if any impure matter be present, turn the colour of the water to a brownish colour.

Cone.—A term sometimes used in optics to denote a pencil of rays of light, emanating from a point, and diverging as they proceed on their course.

Congelation (Lat. *congelatio*).—The passage of a body from the liquid to the solid state. This phenomenon is regulated by two known laws—(1.) Every body under the same pressure solidifies at a fixed temperature, which is the same as that of fusion.* (2.) From the commencement to the end of the solidification the temperature of a liquid remains constant.

There are some liquids, as ether, alcohol, &c., that have never been seen in a solidified state.

Conjugate Foci (Lat. *conjugatus*—to join together, and *foci* plural of focus).—A lens has two foci having a definite relation to each other, and are therefore termed the "conjugate foci." See **Focus.**

Besides the equivalent focus of the lens, which should be known by the worker, it is often useful to know—1st, the size of the image that will be obtained; 2nd, the distance between the object and the camera; 3rd, the size of the object to be photographed; and 4th, the distance of the focussing screen from the centre of the lens. All this information can be obtained from the following table of conjugate foci, compiled from Suter's metrical tables by Mr. J. R. Gotz.

To explain the table, the top line of Table I. contains the equivalent foci of different lenses from 3 to 36 inches, and the relative proportions of the images and the object itself are given in the vertical column at the left-hand side. The other figures are the distance that the object is from the lens, and the distance of the lens from the ground glass focussing screen.

If it is required to reduce with a lens of a given focal length, follow the horizontal line from the figure denoting the proportion required until the column headed by the equivalent focus of the lens used. If the tables be reversed they may be used for enlargement.

Table II. gives the approximate sizes of the image of a figure of a man 5ft. 9in. from life size to a reduction of $\frac{1}{300}$. As an example, a head 3in. would be a third of its natural size (taken at 9in.). If a lens of 15in. focus be used it will, according to the table, require a distance of 5ft., the posterior focal distance being 20in.

Another instance of the use of a table of this kind: If a building, say 25ft. high and 25ft. wide, is to be taken at a distance of 40ft., with a 6in. lens, the reduction will be, according to the table, $\frac{1}{80}$, and the image will, therefore, occupy about $4\frac{1}{2}$in. horizontally and 3in. vertically, and would require a half-plate camera to get a good picture.

These tables will also be referred to in the articles on enlarging and reducing.

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*Some fats are exceptions to this rule.

Table I.—For Equivalent Foci from 3in. to 5in.

Relative Proportion of Image.	3	3¼	3½	3¾	4	4¼	4½	4¾	5
1/1	0 6	0 6½	0 7	0 7¼	0 8	0 8¼	0 9	0 9½	0 10
1/2	0 9	0 9¾	0 10½	0 11¼	0 12	0 12¾	0 13½	0 14¼	0 15
1/3	1 0	1 1	1 2	1 3	1 4	1 5	1 6	1 7	1 8
1/4	1 3	1 4¼	1 5½	1 6¾	1 8	1 9¼	1 10½	1 11¾	2 1
1/5	1 6	1 7½	1 9	1 10½	2 0	2 1½	2 3	2 4½	2 6
1/6	1 9	1 10¾	2 0¼	2 2¼	2 4	2 5¾	2 7½	2 9¼	2 11
1/7	2 0	2 2	2 4	2 6	2 8	2 10	3 0	3 2	3 4
1/8	2 3	2 5¼	2 7½	2 9¾	3 0	3 2¼	3 4½	3 6¾	3 9
1/9	2 6	2 8¼	2 11	3 1½	3 4	3 6½	3 9	3 11½	4 2
1/10	2 9	2 11¾	3 2½	3 5¼	3 8	3 10¾	4 1½	4 4¼	4 7
1/12	3 3	3 6¼	3 9½	4 0¾	4 4	4 7¼	4 10½	5 1¾	5 5
1/14	3 9	4 0¾	4 4½	4 8¼	5 0	5 3¾	5 7½	5 11¼	6 3
1/16	4 3	4 7¼	4 11½	5 3¾	5 8	6 0¼	6 4½	6 8¾	7 1
1/18	4 9	5 1¾	5 6½	5 11¼	6 4	6 8¾	7 1½	7 6¼	7 11
1/20	5 3	5 8¼	6 1½	6 6¾	7 0	7 5¼	7 10½	8 3¾	8 9
1/24	6 3	6 9¼	7 3½	7 9¾	8 4	8 10¼	9 4½	9 10¾	10 5
1/30	7 9	8 4¾	9 0½	9 8¼	10 4	10 11¾	11 7½	12 3¼	12 11
1/40	10 3	11 1½	11 11½	12 9¾	13 8	14 6¼	15 4½	16 2¾	17 1
1/50	12 9	13 9¾	14 10½	15 11¼	17 0	18 0¾	19 1½	20 2½	21 3
1/60	15 3	16 6¼	17 9½	19 0¾	20 4	21 7¼	22 10½	24 1¾	25 5
1/80	20 3	21 11¼	23 7½	25 3¾	27 0	28 8¼	30 4½	32 0¾	33 9
1/100	25 3	27 4¼	29 5½	31 6¾	33 8	35 9¼	37 10½	39 11¾	42 1
1/120	30 3	32 9¼	35 3½	37 9¾	40 4	42 10¼	45 4½	47 10¾	50 5
1/150	37 9	40 10¾	44 0½	47 2¼	50 4	53 5¾	56 7½	59 9¼	62 11
1/180	45 3	49 0¼	52 9½	56 6¾	60 4	64 1¼	67 10½	71 7¾	75 5
1/240	60 3	65 3¼	70 3½	75 3¾	80 4	85 4¼	90 4½	95 4¾	100 5
1/300	75 3	81 6¼	87 9½	94 0¾	100 4	106 7¼	112 10½	119 1¾	125 5

For Equivalent Foci from 5¼in. to 8½in.

Relative Proportion of Image.	5¼	5½	5¾	6	6½	7	7½	8	8½
1/1	0 10¼	0 11	0 11½	0 12	0 13	0 14	0 15	0 16	0 17
1/2	0 15⅜	0 16½	0 17¼	0 18	1 7½	1 9	1 10½	2 0	2 1½
1/3	1 9	1 10	1 11	2 0	2 2	2 4	2 6	2 8	2 10
1/4	2 2¼	2 3½	2 4¾	2 6	2 8½	2 11	3 1½	3 4	3 6½
1/5	2 7½	2 9	2 10½	3 0	3 3	3 6	3 9	4 0	4 3
1/6	3 0¾	3 2½	3 4¼	3 6	3 9½	4 1	4 4½	4 8	4 11½
1/7	3 6	3 8	3 10	4 0	4 4	4 8	5 0	5 4	5 8
1/8	3 11¼	4 1½	4 3¾	4 6	4 10½	5 3	5 7½	6 0	6 4½
1/9	4 4½	4 7	4 9½	5 0	5 5	5 10	6 3	6 8	7 1
1/10	4 9¾	5 0½	5 3¼	5 6	5 11½	6 5	6 10½	7 4	7 9¼
1/12	5 8¼	5 11½	6 2¾	6 6	7 0½	7 7	8 1½	8 8	9 2½
1/14	6 6¾	6 10½	7 2¼	7 6	8 1½	8 9	9 4½	10 0	10 7¼
1/16	7 5¼	7 9½	8 1¾	8 6	9 2½	9 11	10 7½	11 4	12 0½
1/18	8 3¾	8 8½	9 1¼	9 6	10 3½	11 1	11 10½	12 8	13 5½
1/20	9 2¼	9 7½	10 0¾	10 6	11 4½	12 3	13 1½	14 0	14 10½
1/24	10 11¼	11 5½	11 11¾	12 6	13 6½	14 7	15 7½	16 8	17 8½
1/30	13 6¾	14 2½	14 10¼	15 6	16 9½	18 1	19 4½	20 8	21 11½
1/40	17 11¼	18 9½	19 7¾	20 6	22 2½	23 11	25 7½	27 4	29 0½
1/50	22 3¾	23 4½	24 5¼	25 6	27 7½	29 9	31 10½	34 0	36 1½
1/60	26 8¼	27 11½	29 2¾	30 6	33 0½	35 7	38 1½	40 8	43 2½
1/80	35 5¼	37 1½	38 9¾	40 6	43 10½	47 3	50 7½	54 0	57 4½
1/100	44 2¼	46 3½	48 4¾	50 6	54 8½	58 11	63 1½	67 4	71 6½
1/120	52 11¼	55 5½	57 11¾	60 6	65 6½	70 7	75 7½	80 8	85 8½
1/150	66 0¾	69 2½	72 4¼	75 6	81 9½	88 1	94 4½	100 8	106 11½
1/180	79 2¼	82 11½	86 8¾	90 6	98 0½	105 7	113 1½	120 8	128 2½
1/240	105 5¼	110 5½	115 5¾	120 6	130 6½	140 7	150 7½	160 8	170 8½
1/300	131 8¼	137 11½	144 2¾	150 6	163 0½	175 7	188 1½	200 8	213 2½

For Equivalent Foci from 9in. to 14in.

Relative Proportion of Image.	9	9½	10	10½	11	11½	12	13	14
1/1	0 18	1 7	1 8	1 9	1 10	1 11	2 0	2 2	2 4
1/1	0 18	1 7	1 8	1 9	1 10	1 11	2 0	2 2	2 4
1/2	2 3	2 4½	2 6	2 7½	2 9	2 10½	3 0	3 3	3 6
	1 1½	1 2¼	1 0	1 3¾	1 4½	1 5¼	1 6	1 7½	1 9
1/3	3 0	3 2	3 4	3 6	3 8	3 10	4 0	4 4	4 8
	1 0	1 0 1/16	1 1 5/16	1 2	1 2 11/16	1 3 5/16	1 4	1 5 5/16	1 6 11/16
1/4	3 9	3 11¼	4 2	4 4½	4 7	4 9¾	5 0	5 5	5 10
	0 11¼	0 11⅞	1 0½	1 1⅛	1 1¾	1 2⅜	1 3	1 4¼	1 5½
1/5	4 6	4 9	5 0	5 3	5 6	5 9	6 0	6 6	7 0
	0 10 13/16	0 11 7/16	1 0	1 0 5/16	1 1 3/16	1 1 13/16	1 2⅜	1 3⅝	1 4 13/16
1/6	5 3	5 6½	5 10	6 1⅔	6 5	6 8½	7 0	7 7	8 2
	0 10½	0 11⅛	0 11 11/16	1 0¼	1 0 13/16	1 1 7/16	1 2	1 3 3/16	1 4 5/16
1/7	6 0	6 4	6 8	7 0	7 4	7 8	8 0	8 8	9 4
	0 10 5/16	0 10⅞	0 11⅜	0 12	1 0 1/16	1 1⅛	1 1 11/16	1 2⅞	1 4
1/8	6 9	7 1½	7 6	7 10½	8 3	8 7½	9 0	9 9	10 6
	0 10½	0 10 11/16	0 11¼	0 11 13/16	1 0⅜	1 0 15/16	1 1½	1 2⅝	1 3¾
1/9	7 6	7 11	8 4	8 9	9 2	9 7	10 0	10 10	11 8
	0 10	0 10 9/16	0 11⅛	0 11 11/16	1 0 3/16	1 0¾	1 1 5/16	1 2 7/16	1 3 9/16
1/10	8 3	8 8½	9 2	9 7½	10 1	10 6½	11 0	11 11	12 10
	0 9½	0 10 7/16	0 11	0 11 9/16	1 0⅛	1 0⅝	1 1 3/16	1 2 5/16	1 3 7/16
1/12	9 9	10 3½	10 10	11 4⅓	11 11	12 5½	13 0	14 1	15 2
	0 9¾	0 10⅜	0 10¾	0 11⅜	0 11⅞	1 0½	1 1	1 2⅛	1 3 3/16
1/14	11 3	11 10½	12 6	13 1½	13 9	14 4½	15 0	16 3	17 6
	0 9¾	0 10⅜	0 10¾	0 11¼	0 11¾	0 12 5/16	0 12⅝	1 1 1/16	1 3
1/16	12 9	13 5½	14 2	14 10½	15 7	16 3½	17 0	18 5	19 10
	0 9 9/16	0 10⅛	0 10⅝	0 11⅛	0 11 11/16	0 12¼	0 12¾	1 1 1/16	1 2⅝
1/18	14 3	15 0½	15 10	16 7½	17 5	18 2½	19 0	20 7	22 2
	0 9½	0 10	0 10 9/16	0 11 1/16	0 11⅝	0 12¼	0 12 11/16	1 1 1/16	1 2¾
1/20	15 9	16 7½	17 6	18 4½	19 3	20 1⅝	21 0	22 9	24 6
	0 9 7/16	0 10	0 10½	0 11	0 11 9/16	0 12 1/16	0 12⅝	1 1⅛	1 2 11/16
1/24	18 9	19 9½	20 10	21 10½	22 11	23 11½	25 0	27 1	29 2
	0 9 5/16	0 9 15/16	0 10 7/16	0 10 15/16	0 11½	0 12	0 12½	1 1 1/16	1 2⅝
1/30	23 3	24 6½	25 10	27 1½	28 5	29 8½	31 0	33 7	36 2
	0 9 5/16	0 9 13/16	0 10⅜	0 10⅞	0 11⅜	0 11 15/16	1 0½	1 1½	1 2½
1/40	30 9	32 5½	34 2	35 10½	37 7	39 3½	41 0	44 5	47 10
	0 9¼	0 9¾	0 10¼	0 10¾	0 11¼	0 11¾	0 12 5/16	1 1 5/16	1 2⅜
1/50	38 3	40 4½	42 6	44 7½	46 9	48 10½	51 0	55 3	59 6
	0 9 1/16	0 9 11/16	0 10 3/16	0 10 11/16	0 11 3/16	0 11 11/16	0 12¼	1 1¼	1 2¼
1/60	45 9	48 3½	50 10	53 4½	55 11	58 5½	61 0	66 1	71 2
	0 9 1/16	0 9 11/16	0 10 3/16	0 10 11/16	0 11 3/16	0 11 11/16	0 12¼	1 1¼	1 2¼
1/80	60 9	64 1½	67 6	70 10½	74 3	77 7½	81 0	87 9	94 6
	0 9⅛	0 9⅝	0 10⅛	0 10⅝	0 11⅛	0 11⅝	0 12⅜	1 1⅜	1 2⅜
1/100	75 9	79 11½	84 2	88 4½	92 7	95 9½	101 0	109 5	117 10
	0 9 1/16	0 9 9/16	0 10⅛	0 10⅝	0 11⅛	0 11⅝	0 12⅜	1 1⅜	1 2⅜
1/120	90 9	95 9½	100 10	105 10½	110 11	115 11½	121 0	131 1	141 2
	0 9 1/16	0 9 9/16	0 10 1/16	0 10 9/16	0 11 1/16	0 11 9/16	0 12⅜	1 1⅜	1 2⅜
1/150	113 3	119 6½	125 10	132 1½	138 5	144 8½	151 0	163 7	176 2
	0 9 1/16	0 9 9/16	0 10 1/16	0 10 9/16	0 11 1/16	0 11 9/16	0 12 5/16	1 1 5/16	1 2 5/16
1/180	135 9	143 3½	150 10	158 4½	165 11	173 5½	181 0	196 1	211 2
	0 9 1/16	0 9 9/16	0 10 1/16	0 10 9/16	0 11 1/16	0 11 9/16	0 12 5/16	1 1 5/16	1 2 5/16
1/240	180 9	190 9½	200 10	210 10½	220 11	230 11½	241 0	261 1	281 2
	0 9	0 9½	0 10	0 10½	0 11	0 11½	0 12	1 1 1/16	1 2 1/16
1/300	225 9	238 3½	250 10	263 4½	275 11	288 5½	301 0	325 1	351 2
								1 1	1 2

For Equivalent Foci from 15in. to 23in.

Relative Proportion of Image.	15	16	17	18	19	20	21	22	23
1/1	2 6	2 8	2 10	3 0	3 2	3 4	3 6	3 8	3 10
1/2	1 10½	2 0	2 1½	2 3	2 4½	2 6	2 7½	2 9	2 10½
1/3	1 8	1 9 5/16	1 10 11/16	2 0	2 1 5/16	2 2 11/16	2 4	2 5 5/16	2 6 11/16
1/4	1 6¾	1 8	1 9¼	1 10½	1 11¾	2 1	2 2¼	2 3¼	2 4¾
1/5	1 6	1 7 3/16	1 8⅜	1 9⅝	1 10 13/16	2 0	2 1 3/16	2 2⅜	2 3⅝
1/6	1 5½	1 6 11/16	1 7⅞	1 9	1 10 5/16	1 11 5/16	2 0½	2 1⅝	2 2 13/16
1/7	1 5⅛	1 6 5/16	1 7⅜	1 8 9/16	1 9 11/16	1 10⅞	2 0	2 1⅛	2 2¼
1/8	1 4⅞	1 6	1 7⅛	1 8¼	1 9⅜	1 10½	1 11⅝	2 0¾	2 1⅞
1/9	1 4 11/16	1 5 13/16	1 6 15/16	1 8	1 9⅛	1 10¼	1 11 5/16	2 0 7/16	2 1 9/16
1/10	1 4½	1 5 5/16	1 6¾	1 7⅞	1 9	1 10	1 11⅛	2 0 3/16	2 1¼
1/12	1 4¼	1 5 5/16	1 6⅜	1 7½	1 8⅝	1 9⅝	1 10¾	1 11⅞	2 0 15/16
1/14	1 4 1/16	1 5⅛	1 6¼	1 7 5/16	1 8⅜	1 9 7/16	1 10½	1 11 9/16	2 0⅝
1/16	1 3 15/16	1 5	1 6 1/16	1 7⅛	1 8¼	1 9¼	1 10 5/16	1 11⅜	2 0 7/16
1/18	1 3 13/16	1 4⅞	1 5 15/16	1 7	1 8 1/16	1 9⅛	1 10 3/16	1 11¼	2 0 5/16
1/20	1 3¾	1 4 13/16	1 5⅞	1 6 15/16	1 8	1 9	1 10 1/16	1 11⅛	2 0⅛
1/24	1 3⅝	1 4 11/16	1 5¾	1 6¾	1 7 13/16	1 8 13/16	1 9⅞	7 10 15/16	2 0
1/30	1 3½	1 4 9/16	1 5 9/16	1 6⅝	8 7⅝	1 8⅝	1 9 11/16	1 10¾	1 11¾
1/40	1 3⅜	1 4 7/16	1 5 7/16	1 6 7/16	1 7 7/16	1 8½	1 9½	1 10½	1 11 9/16
1/50	1 3 5/16	1 4 5/16	1 5 5/16	1 6⅜	1 7⅜	1 8⅜	1 9⅜	1 10 5/16	1 11½
1/60	1 3¼	1 4 5/16	1 5 5/16	1 6 5/16	1 7 5/16	1 8 5/16	1 9 5/16	1 10⅜	1 11⅜
1/80	1 3⅛	1 4 1/16	1 5 1/16	1 6¼	1 7¼	1 8¼	1 9¼	1 10¼	1 11 1/16
1/100	1 3⅛	1 4⅛	1 5⅛	1 6 1/16	1 7 1/16	1 8 1/16	1 9 1/16	1 10 1/16	1 11¼
1/120	1 3⅛	1 4⅛	1 5⅛	1 6⅛	1 7 1/16	1 8 1/16	1 9 1/16	1 10 1/16	1 11 1/16
1/150	1 3⅛	1 4⅛	1 5⅛	1 6⅛	1 7⅛	1 8⅛	1 9⅛	1 10⅛	1 11⅛
1/180	1 3 1/16	1 4 1/16	1 5⅛	1 6⅛	1 7⅛	1 8⅛	1 9⅛	1 10⅛	1 11⅛
1/240	1 3 1/16	1 4 1/16	1 5 1/16	1 6⅛	1 7⅛	1 8 1/16	1 9 1/16	1 10 1/16	1 11 1/16
1/300	1 3	1 4 1/16	1 5 1/16	1 6 1/16	1 7 1/16	1 8 1/16	1 9 1/16	1 10 1/16	1 11 1/16

For Equivalent Foci from 24in. to 36in.

Relative Proportion of Image.	24	25	26	27	28	29	30	32	36
1/1	4 0 ... 4 0	4 2 ... 4 2	4 4 ... 4 4	4 6 ... 4 6	4 8 ... 4 8	4 10 ... 4 10	5 0 ... 5 0	5 4 ... 5 4	6 0 ... 6 0
1/2	6 0 ... 3 0	6 3 ... 3 1½	6 6 ... 3 3	6 9 ... 3 4½	7 0 ... 3 6	7 3 ... 3 7½	7 6 ... 3 9	8 0 ... 4 0	9 0 ... 4 6
1/3	8 0 ... 2 8	8 4 ... 2 9 5/16	8 8 ... 2 10 11/16	9 0 ... 3 0	9 4 ... 3 1 5/16	9 8 ... 3 2 11/16	10 0 ... 3 4	10 8 ... 3 6 11/16	12 0 ... 4 0
1/4	10 0 ... 2 6	10 5 ... 2 7¼	10 10 ... 2 8½	11 3 ... 2 9¾	11 8 ... 2 11	12 1 ... 3 0¼	12 6 ... 3 1½	13 4 ... 3 4	15 0 ... 3 9
1/5	12 0 ... 2 4 13/16	12 6 ... 2 6	13 0 ... 2 7 3/16	13 6 ... 2 8⅜	14 0 ... 2 9⅝	14 6 ... 2 10 13/16	15 0 ... 3 0	16 0 ... 3 2⅜	18 0 ... 3 7 3/16
1/6	14 0 ... 2 4	14 7 ... 2 5 3/16	15 2 ... 2 6 5/16	15 9 ... 2 7½	16 4 ... 2 8 11/16	16 11 ... 2 9⅞	17 6 ... 3 0¾	18 8 ... 3 3	21 0 ... 3 6
1/7	16 0 ... 2 3 7/16	16 8 ... 2 4 3/16	17 4 ... 2 5 13/16	18 0 ... 2 6⅞	18 8 ... 2 8	19 4 ... 2 9⅛	20 0 ... 2 10 5/16	21 4 ... 3 0 9/16	24 0 ... 3 5⅛
1/8	18 0 ... 2 3	18 9 ... 2 4⅛	19 6 ... 2 5¼	20 3 ... 2 6⅜	21 0 ... 2 7½	21 9 ... 2 8⅝	22 6 ... 2 9¾	24 0 ... 3 0	27 0 ... 3 4½
1/9	20 0 ... 2 2 11/16	20 10 ... 2 3¾	21 8 ... 2 4⅞	22 6 ... 2 6	23 4 ... 2 7⅛	24 2 ... 2 8¼	25 0 ... 2 9⅜	26 8 ... 2 11 9/16	30 0 ... 3 4
1/10	22 0 ... 2 2⅜	22 11 ... 2 3½	23 10 ... 2 4⅝	24 9 ... 2 5 11/16	25 8 ... 2 6 13/16	26 7 ... 2 7⅞	27 6 ... 2 9	29 4 ... 3 1¼	33 0 ... 3 3⅝
1/12	26 0 ... 2 2	27 1 ... 2 3 1/16	28 2 ... 2 4⅛	29 3 ... 2 5¼	30 4 ... 2 6 5/16	31 5 ... 2 7 7/16	32 6 ... 2 8½	34 8 ... 2 10⅝	39 0 ... 3 3
1/14	30 0 ... 2 1 11/16	31 3 ... 2 2¾	32 6 ... 2 3⅞	33 9 ... 2 4 15/16	35 0 ... 2 6	36 3 ... 2 7 1/16	37 6 ... 2 8⅛	40 0 ... 2 10¼	45 0 ... 3 2⅝
1/16	34 0 ... 2 1½	35 5 ... 2 2 9/16	36 10 ... 2 3 10/16	38 3 ... 2 4 13/16	39 8 ... 2 5¾	41 1 ... 2 6 13/16	42 6 ... 2 7⅞	45 4 ... 2 10	51 0 ... 3 6¾
1/18	38 0 ... 2 1⅜	39 7 ... 2 2 7/16	41 2 ... 2 3½	42 9 ... 2 4 9/16	44 4 ... 2 5⅝	45 11 ... 2 7 1/16	47 6 ... 2 7¾	50 8 ... 2 9⅛	57 0 ... 3 2
1/20	42 0 ... 2 1 3/16	43 9 ... 2 2¼	45 6 ... 2 3 5/16	47 3 ... 2 4⅜	49 0 ... 2 5 7/16	50 9 ... 2 6½	52 6 ... 2 7 9/16	56 0 ... 2 9⅝	63 0 ... 3 1 13/16
1/24	50 0 ... 2 1	52 1 ... 2 2	54 2 ... 2 3 1/16	56 3 ... 2 4⅛	58 4 ... 2 5⅛	60 5 ... 2 6 3/16	62 6 ... 2 7¼	66 8 ... 2 9⅜	75 0 ... 3 1½
1/30	62 0 ... 2 0 13/16	64 7 ... 2 1⅞	67 2 ... 2 2⅞	69 9 ... 2 3 15/16	72 4 ... 2 4 15/16	74 11 ... 2 6	77 6 ... 2 7	82 8 ... 2 9 1/16	93 0 ... 3 1 3/16
1/40	82 0 ... 2 0 9/16	85 5 ... 2 1⅝	88 10 ... 2 2⅝	92 3 ... 2 3 11/16	95 8 ... 2 4 11/16	99 1 ... 2 5¾	102 6 ... 2 6¾	109 4 ... 2 8 13/16	123 0 ... 3 0⅜
1/50	102 0 ... 2 0½	106 3 ... 2 1½	110 6 ... 2 2½	114 9 ... 2 3½	119 0 ... 2 4 9/16	123 3 ... 2 5⅝	127 6 ... 2 6⅝	136 0 ... 2 8⅝	153 0 ... 3 0⅝
1/60	122 0 ... 2 0⅜	127 1 ... 2 1 7/16	132 2 ... 2 2½	137 3 ... 2 3½	142 4 ... 2 4½	147 5 ... 2 5½	152 6 ... 2 6½	162 8 ... 2 8½	183 0 ... 3 0½
1/80	162 0 ... 2 0 5/16	168 9 ... 2 1 5/16	175 6 ... 2 2 5/16	182 3 ... 2 3 5/16	189 0 ... 2 4⅜	195 9 ... 2 5⅜	202 6 ... 2 6⅜	216 0 ... 2 8⅜	243 0 ... 3 0 7/16
1/100	202 0 ... 2 0¼	210 5 ... 2 1¼	218 10 ... 2 2¼	227 3 ... 2 3¼	235 8 ... 2 4¼	244 1 ... 2 5¼	252 6 ... 2 6¼	269 4 ... 2 8¼	303 0 ... 3 0⅜
1/0	242 0 ... 2 0 3/16	252 1 ... 2 1 3/16	262 2 ... 2 2 3/16	272 3 ... 2 3 3/16	282 4 ... 2 4¼	292 5 ... 2 5¼	302 6 ... 2 6¼	322 8 ... 2 8¼	363 0 ... 3 0 5/16
1/150	302 0 ... 2 0⅛	314 7 ... 2 1⅛	327 2 ... 2 2⅛	339 9 ... 2 3⅛	352 4 ... 2 4 3/16	364 11 ... 2 5 3/16	377 6 ... 2 6 3/16	402 8 ... 2 8 3/16	453 0 ... 3 0¼
1/180	362 0 ... 2 0⅛	377 1 ... 2 1⅛	392 2 ... 2 2⅛	407 3 ... 2 3⅛	422 4 ... 2 4⅛	437 5 ... 2 5⅛	452 6 ... 2 6⅛	482 8 ... 2 8⅛	543 0 ... 3 0 7/16
1/240	482 0 ... 2 0 1/16	502 1 ... 2 1 1/16	522 2 ... 2 2 1/16	542 3 ... 2 3 1/16	562 4 ... 2 4 1/16	582 5 ... 2 5 1/16	602 6 ... 2 6⅛	642 8 ... 2 8⅛	723 0 ... 3 0⅛
1/300	602 0 ... 2 0 1/16	627 1 ... 2 1 1/16	652 2 ... 2 2 1/16	677 3 ... 2 3 1/16	702 4 ... 2 4 1/16	727 5 ... 2 5 1/16	752 6 ... 2 6⅛	802 8 ... 2 8⅛	903 0 ... 3 0⅛

TABLE II.

Proportion to Natural Size.	Size of Image.	
	Of a Man.	Of a Head.
	ft. in.	ft. in.
1/1	5 9	0 9
1/2	2 10½	0 4½
1/3	1 11	0 3
1/4	1 5¼	0 2¼
1/5	1 1 3/16	0 1¾
1/6	0 11½	0 1½
1/7	0 9 13/16	0 1 5/16
1/8	0 8 9/16	0 1⅛
1/9	0 7⅝	0 1
1/10	0 6⅞	0 0⅞
1/12	0 5¾	0 0¾
1/14	0 4 15/16	0 0⅝
1/16	0 4 5/16	0 0 9/16
1/18	0 3⅞	0 0½
1/20	0 3 7/16	0 0 7/16
1/24	0 2⅞	0 0⅜
1/30	0 2 5/16	0 0 5/16
1/40	0 1¾	0 0¼ approx.
1/50	0 1⅜	0 0 3/16 ,,
1/60	0 1⅛	..
1/80	0 0⅞	0 0⅛ ,,
1/100	0 0 11/16	..
1/120	0 0⅝	..
1/150	0 0 7/16	0 0 1/16 ,,
1/180	0 0⅜	..
1/240	0 0 5/16 approx.	..
1/300	0 0¼ ,,	..

Contact, Optical.—See **Optical Contact.**

Contact Printing.—Used to describe those processes in which the paper glass is printed in contact with the negative. The term is more often applied, however, to printing upon bromide paper placed behind and in contact with the negative held a few feet from a light. Thin negatives give the best prints if a weak yellow light be used. The light from an ordinary oil lamp answers well if turned down below its usual intensity. Strong negatives should be printed in daylight.

Continuating Action of Light.—For some time it was believed that if exposed plates were kept for any length of time previous to development a continuating action of light took place, with the result that correctly-exposed plates would become over-exposed, and under-exposed plates would reach the requisite amount of ripeness if kept for a sufficient length of time. It has been proved, however, that no measurably appreciable alteration takes place in the undeveloped silver image between the time of exposure and development, and that an under-exposed picture will be just as under-exposed if kept for many months previous to developing.

In the autotype or carbon process, however, a continuating action does actually take place; due to the action of the light in the first place, and afterwards to the presence of moisture in the atmosphere.

Contrast.—A negative is said to possess great contrast when the high-lights and shadows show much dissimilitude.

Contretype (Fr. *contre*—against, and Lat. *tupos*—type).

Convergent (Lat. *convergens*).—A term used in optics to rays of light which being continued will meet in a focus.

Convergent Lens.—A lens that will cause rays of light to converge and meet in a focus.

Convex (Lat. *convexus*—a periphery).—In optics a lens or mirror having the surface of a sphere.

Convexo-concave.—Convex on the one side and concave on the other. A lens having this form is also termed a meniscus.

Convexo-convex.—Convex on both sides. Synonym, double convex.

Convexo-plane.—Convex on one side and plane on the other. Synonym, plano-convex.

Copal.—A resinous substance produced by the plant *Rhus copallinium*, which grows in Mexico, and from the *Elæocarpus copalifer*, which grows in India. It is also obtained from Africa

and the coast of Guinea. It is obtained in round semi-transparent masses, colourless, and slightly yellow and very brittle. It is soluble in alcohol, ether, and essential oils. It is largely used in the making of varnishes *q. v.*

Cooking.—In the gelatine dry plate process the emulsion undergoes a process of cooking, to give increased sensitiveness. See **Emulsion.**

Cooling Chamber.—An arrangement used in the manufacture of dry plates (*q.v.*) It is used in warm weather for cooling the gelatine emulsion.

Cooper's Process.—A printing process, the invention of Mr. Henry Cooper. The basis of the process lies in the substitution of a resin or substance of a resinous nature, in the place of albumen or other sizing matter. Prints obtained by this process have a more artistic appearance than pictures printed upon albuminised paper, as they are devoid of the inartistic gloss. The two formulas given were communicated to Captain Abney by the inventor.*

Frankincense	10 grains
Mastic	8 „
Calcium chloride	5 to 10 „
Alcohol	1 ounce

As soon as the resins are completely dissolved in the alcohol, the paper to be prepared is immersed in the solution, and then taken out, dried, and rolled. It is best to hang the paper in drying, and to increase the temperature of the room to about 80° Fahr.

The sensitising silver bath recommended is made up as follows:

Silver nitrate	60 grains
Water	1 ounce

To the water as much gelatine should be added as possible without gelatinising at 60°Fah.

The second formula alluded to gives very fine prints, remarkable for their softness and delicacy of gradation of the half tones.

A suitable paper is first prepared by coating with an emulsion of white lac in gelatine. This is prepared by dissolving three ounces of fresh white lac in a pint of strong alcohol. It is important that the lac be fresh, as on exposure to the air it becomes insoluble after a time. When dissolved it is filtered and decanted, and as much water added as it will possibly bear without precipitating the lac. To find out the largest quantity of water permissible, take a given quantity of the solution in a test tube and add water minim by minim until the lac is precipitated. A careful calculation will then show how much water to add to the bulk of the solution, which will, of course, be under the amount required for precipitation.

* "Abney's Instruction in Photography," eighth edition.

One ounce of good hard gelatine is next soaked in a pint of cold water, and when soaked the temperature is raised to a temperature of between 180° to 200°Fah., when the lac solution is added, constantly agitating the solution the while. It sometimes happens that at this stage the gelatine becomes precipitated. A little hot water should at once be added. The pint of lac solution should, however, be emulsified in the gelatine solution.

To prepare the paper, the emulsion is just warmed and placed on a flat dish, and the paper either immersed in or floated on the solution for about three minutes. It is then hung up to dry. When dry, the coated surface is floated for about two minutes on

Ammonium chloride	10 grains.
Magnesium or ammonium lactate	10 ,,

It is again put away to dry, when it is ready for sensitising, which should be done on a moderately strong bath. This will answer well—

Silver nitrate	50 grains.
Distilled water	1 ounce.

To obtain a greater amount of vigour in the prints, they may be floated on

Citric acid	5 grains.
White sugar	5 ,,

This bath will be found to improve by use, due in all probability to its absorbing silver nitrate from the paper after sensitising.

Cooper's toning formula is the following:—

Gold trichloride	2 grains.
Precipitate chalk (pure)	a pinch.
Hot water	10 ounces.

Two drachms of sodium acetate are placed in the stock bottle, and this solution filtered on to it. Water is then added to make up to 20 ounces, and in a few hours the solution is ready for use. It improves by keeping, however.

In toning, place a few ounces of water in the dish, and add an equal quantity of the stock solution. The prints are then laid in, and if the toning process is slow, some more of the solution is added. Over-toning is to be avoided in this process. Fixing is done with sodium hyposulphite in the usual manner.

Copper Acetate.—Prepared by the action of copper sulphate on acetate of lead or barium. It forms prismatic crystals of a deep green colour, soluble in water and alcohol.

Copperas.—See **Zinc Sulphate.**

Copper Bromide (Formula $CuBr_2$).—Used for intensifying collodion negatives. See **Intensifying.**

Copper Chloride (Formula $CuCl_2$. Synonym, *Cupric Chloride*).—An exceedingly deliquescent substance, soluble in alcohol. It can be prepared by heating copper in excess of chlorine, or in

solution by dissolving copper oxide in strong hydrochloric acid. It crystallises in green prisms.

Copper Oxides.—Two oxides of copper are at present known' the red or sub-oxide (cuprous oxide), Cu_2O, and the black or protoxide (cupric oxide), CuO. Both are valuable ones, and occur native. The cuprous oxide may be prepared artificially by the addition of grape sugar to a solution of blue sulphate of copper, treating the product with an excess of caustic potash, and then boiling the solution. The sub-oxide gives a fine ruby red colour to glass, and can be used for making non-actinic media for dark-room windows. Protoxide of copper can be prepared artificially by calcining copper, or by the ignition of copper sulphate or nitrate. It communicates a green colour to glass, which can be used for rooms in which the sensitising of photographic paper or other similar operations take place. It is sufficiently non-actinic, and possesses the advantage of being far more agreeable and less hurtful to the eyes than a red or yellow colour.

Copper Process.—An unused process, introduced by Obernetter. It is based upon the fact that copper forms with chlorine a green salt, soluble in water—chloride of copper. This is sensitive to light, which reduces it to hypo-chloride of copper. Paper is saturated with a mixture of copper chloride and iron chloride. This when dry is exposed to the light under a negative, and afterwards plunged into a solution of potassium sulphocyanide, and ultimately treated with red prussiate of potash. The result is a brown picture.

Copper Sulphate (Formula $CuSO_4 = 5H_2O$. Synonyms, *Cupric Sulphate*, *Blue Vitriol*).—A salt prepared by dissolving copper oxide in sulphuric acid. It can also be prepared from the metal itself. Copper plates are heated to dull redness and plunged into dilute sulphuric acid. Copper sulphate forms large blue transparent crystals, soluble in water. It is sometimes added to the ferrous sulphate developer in the wet collodion process.

Copper Sulphides.—There are two distinct sulphides of copper which may be prepared. Copper and sulphide, when melted together, combine with vivid incandescence, and produce the subsulphide or disulphide (cuprous sulphide), Cu_2S. Cupric sulphide is found native as covelline, but can be artificially prepared by precipitating a salt of copper with sulphuretted hydrogen.

Copying.—This term is usually applied to the copying of engravings, drawings, plans, sketches, &c., with the camera. Formerly, suitable cameras for this purpose were made, but with a little manœuvring an ordinary camera can be made to serve the purpose. The lens which should be employed in copying should be a landscape doublet or triplet, or a portrait combination.

Single lenses cannot be used without distorting the lines of the copy. It is advisable to use one possessing the least possible distortion. Abney recommends a Dallmeyer's D lens with a small stop. In photographing it is necessary that the copy and the screen of the camera be both perfect and upright, and in consequence parallel to each other. The light should fall direct upon the copy in a horizontal direction. If side lights be used the texture of the paper is clearly represented, giving the picture an unnatural, rough appearance. The light should also be a brilliant one ; for Indian ink or sepia sketches direct sunlight should be used. If it should be required to enlarge or reduce the image, information will be found under **Enlarging.**

For copying pictures in black and white ordinary dry plates will answer the purpose, but are inferior to collodion wet plates, which are almost universally used for this purpose. They give better brilliancy and contrast, and the increased exposure is in this case of no consequence. A plain iodised collodion should be used, and the plates developed with the ferrous sulphate or the pyrogallic developer described in the collodion wet process.

Copying Photographs.—Photographs may be copied in the same manner as described above, using a strong light.

Copying Paintings.—For copying paintings, or any description of coloured picture, it will be sometimes necessary to employ orthochromatic or isochromatic plates, which materially assist in rendering the colours in their true relation to each other. With ordinary plates the yellows have hardly any action at all, while the blues have a very bright action. This process is fully described under **Isochromatic Photography,** and is equally serviceable in photographing manuscripts or engravings which have become yellow by age. It gives increased sensitiveness to this yellow, which would otherwise have but little effect upon the plate.

Copyright.—The Copyright Act of Great Britain is undoubtedly of importance to photographers. It will, perhaps, be well, therefore, to give here the law relating to copyright of works. It runs as follows :—

" 25 and 26 Vict., c. 68. An Act for amending the law relating to copyright in works of the fine arts, and for repressing the commission of fraud in the production and sale of such works. 29th July, 1862.

" 1. The author, being a British subject, or resident within the dominions of the Crown, of every original painting, drawing, and photograph* which shall be, or shall have been, made either in the British dominions or elsewhere, and which shall not have been sold or disposed of before the commencement of this Act, and his assigns, shall have the sole and exclusive right of copying, engrav-

*Note.—This also includes photographs from paintings, drawings, engravings, or from other photographs.

ing, reproducing, and multiplying such painting, drawing, or photograph, and the negative thereof, by any means and of any size, for the term of the natural life of such author, and seven years after his death, provided that when any painting or drawing, or the negative of any photograph, shall for the first time after the passing of this Act be sold or disposed of, or shall be made or executed for or on behalf of any other person for a good or a valuable consideration, the person so selling or disposing of or making or executing the same shall not retain the copyright thereof, unless it be expressly reserved to him by agreement in writing, signed at or before the time of such sale or disposition by the vendee or assignee of such painting or drawing, or of such negative of a photograph, or by the person for or on whose behalf the same shall be so made or executed, but the copyright shall belong to the vendee or assignee of such painting, drawing, or of the negative of such photograph, or to the person for or on whose behalf the same shall have been made or executed, nor shall the vendee or assignee thereof be entitled to any such copyright unless at or before the time of such sale or disposition an agreement in writing signed by the person so selling or disposing of the same or by his agent duly authorised shall have been made to that effect.

"2.—Nothing herein contained shall prejudice the right of any person to copy or use any work in which there shall be no copyright, or to represent any scene or object, notwithstanding that there may be copyright in some representation of such scene or object.

"3.—All copyright under this Act shall be deemed personal or movable estate, and shall be assignable at law, and every assignment thereof, and every license to use or copy by any means or process, the design or work which shall be the subject of such copyright shall be made by some note or memorandum in writing, to be signed by the proprietor of the copyright or his agent appointed for that purpose in writing.

"4.—There shall be kept at the hall of the Stationers' Company, by the officer appointed by the said company for the purpose of the Act passed in the sixth year of her present Majesty, intituled 'An Act to amend the law of copyright,' a book or books entitled 'The register of proprietors of copyright in paintings, drawings, and photographs,' wherein shall be entered a memorandum of every copyright to which any person shall be entitled under this Act, and also of every subsequent assignment of any such copyright, and such memorandum shall contain a statement of the date of such agreement or assignment, and of the names of the parties thereto, and of the name and place of abode of the person in whom such copyright shall be vested by virtue thereof, and of the name and place of abode of the author of the work in which there shall be such copyright, together with a short description of the nature and subject of such work, and in addition thereto if the person registering shall so desire, a sketch outline or

photograph of the said work, and no proprietor of any such copyright shall be entitled to the benefit of this Act until such registration,* and no action shall be sustainable nor any penalty be recoverable in respect of anything done before registration.

"5.—The several enactments in the said Act of the sixth year of her present Majesty contained, with relation to keeping the register book thereby required, and the inspection thereof, the searches therein and the delivery of certified and stamped copies thereof, the reception of such copies in evidence, the making of false entries in the said book, and the production in evidence of papers falsely purporting to be copies of entries in the said book, the application to the courts and judges by persons aggrieved by entries in the said book, and the expunging and varying such entries shall apply to the book or books to be kept by virtue of this Act, and to the entries and assignments of copyright and proprietorship therein under this Act, in such and the same manner as if such enactments were here expressly enacted in relation thereto, save and except that the forms of entry prescribed by the said Act of the sixth year of Her Majesty may be varied to meet the circumstances of the case, and that the sum to be demanded by the office of the said Company of Stationers for making an entry required by this Act shall be one shilling only.

"6.—If the author of any painting, drawing or photograph in which there shall be subsisting copyright after having sold or disposed of such copyright, or of any other person not being the proprietor for the time being of copyright in any painting, drawing or photograph shall without the consent of such proprietor repeat, colourably imitate, or otherwise multiply for sale, hire, exhibition or distribution, or cause or procure to be repeated, copied, colourably imitated or otherwise multiplied for sale, hire, exhibition or distribution any such work or the design thereof, or knowing that any such repetition, copy or other imitation has been unlawfully made, shall import into any part of the United Kingdom, or sell, publish, let to hire, exhibit or distribute, or offer for sale, hire, exhibition or distribution, or cause or procure to be imported, sold, published, let to hire, distributed or offered for sale, hire, exhibition or distribution any repetition copy or imitation of the said work or of the design thereof, made without such consent as aforesaid, such person for every such offence shall forfeit to the proprietor of the copyright for the time being a sum not exceeding ten pounds,† and all such repetitions, copies, and imitations made without such consent as aforesaid, and all negatives of photographs made for the purpose of obtaining such copies shall be forfeited to the proprietor of the copyright.

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* A person to whom the copyright in a picture has been assigned by the author, of which assignment a memorandum has been duly registered, has a good title, although the original copyright of the author has not been registered.—CHITTY.

† This penalty can be enforced on each and every copy sold.

"7.—No person shall do or cause to be done any of the following acts, that is to say—

"First, no person shall fraudulently sign, or otherwise affix to or upon any painting, drawing, or photograph, or the negative thereof, any name, initials, or monogram.

"Secondly, no person shall fraudulently sell, publish, exhibit, or dispose of, or offer for sale, exhibition, or distribution, any painting, drawing, or photograph, or negative of a photograph having thereon the name, initials, or monogram of a person who did not execute or make such work.

"Thirdly, no person shall fraudulently utter, dispose of, or put off, or cause to be uttered or disposed of, any copy or colourable imitation of any painting, drawing, or photograph or negative of a photograph, whether there shall be subsisting copyright therein or not, as having been made or executed by the author or maker of the original work from which such copy or imitation shall have been taken.

"Fourthly, where the author or maker of any painting, drawing, or photograph or negative of a photograph, made either before or after the passing of this Act, shall have sold or otherwise parted with the possession of such work, if any alteration shall afterwards be made therein by any other person by addition or otherwise, no person shall be at liberty during the life of the author or maker of such work, without his consent, to make or knowingly to sell, or publish, or offer for sale such work or any copies of such work so altered as aforesaid, or of any part thereof, as or for the unaltered work of such author or maker.

"Every offender under this section shall upon conviction forfeit to the person aggrieved a sum not exceeding ten pounds, or not exceeding double the full price of any at which all such copies, engravings, imitations, or altered works shall have been sold or offered for sale, and all such copies, engravings, imitations, or altered works shall be forfeited to the person, or the assigns, or legal representatives of the person whose name, initials, or monogram shall be so fraudulently signed or affixed thereto, or to whom such spurious or altered work shall be so fraudulently and falsely ascribed, as aforesaid, provided always that the penalties imposed by this section shall not be incurred, unless the person whose name, initials, or monogram shall be so fraudulently signed and affixed, or to whom such spurious or altered work shall be so fraudulently or falsely ascribed, as aforesaid, shall have been living at, or within, twenty years next before the time when the offence may have been committed.

"8. All pecuniary penalties which shall be incurred, and all such unlawful copies, imitations, and all other effects and things as shall have been forfeited by offenders pursuant to this Act, and pursuant to any Act for the protection of copyright engravings, may be recovered by the person hereinbefore, and in any such Act as aforesaid empowered to recover the same respectively,

and hereinafter called the complainant, or the complainer, as follows:—

"In England and Ireland, either by action against the party offending, or by summary proceedings before any two justices having jurisdiction where the party offending resides.

"In Scotland, by action before the court of sessions, in ordinary form, or by summary action before the sheriff of the county where the offence may be committed or the offender resides, who, upon proof of the offence or offences, either by the confession of the party offending, or by the oath or affirmation of one or more credible witnesses, shall convict the offender, and find him liable to the penalty or penalties aforesaid, as also in expenses, and it shall be lawful for the sheriff, in pronouncing such judgment for the penalty or penalties and costs, to insert in such judgment a warrant in the event of such penalty or penalties and costs not being paid, to levy and recover the amount of the same by poinding: provided always that it shall be lawful to the sheriff, in the event of his dismissing the action, and assoilzieing the defender, to find the complainer liable to expenses, and any judgment so to be pronounced by the sheriff in such summary application shall be final and conclusive, and not subject to review by advocation, suspension, reduction, or otherwise.

"9.—In any action in any of her Majesty's superior courts of record at Westminster and in Dublin, for the infringement of any such copyright as aforesaid, it shall be lawful for the court in which such action is pending, if the court be then sitting, or if the court be not sitting then for a judge of such court, on the application of the plaintiff or defendant respectively, to make such order for an injunction, inspection or account, and to give such directions respecting such action, injunction, inspection and account, and the proceedings therein respectively as to such court or judge may seem fit.

"10.—All repetitions, copies, or imitations of paintings, drawings, or photographs, whereon or in the design whereof there shall be subsisting copyright under the Act, and all repetitions, copies and imitations of the design of any such painting or drawing, or of the negative of any such photograph, which, contrary to the provisions of the Act, shall have been made in any foreign State, or in any part of the British Dominions, are hereby absolutely prohibited to be imported into any part of the United Kingdom, except by or with the consent of the proprietor of the copyright thereof, or his agent authorised in writing; and if the proprietor of any such copyright, or his agent, shall declare that any goods imported are repetitions, copies, or imitations of any such painting, drawing, or photograph, or of the negative of any such photograph, and so prohibited as aforesaid, then such goods may be detained by the officers of Her Majesty's Customs.

"11.—If the author of any painting, drawing, or photograph in which there shall be subsisting copyright, after having sold or

otherwise disposed of such copyright, or if any other person, not being the proprietor for the time being of such copyright, shall without the consent of such proprietor repeat, copy, colourably imitate, or otherwise multiply, or cause or procure to be repeated, copied, colourably imitated, or otherwise multiplied for sale, hire, exhibition, or distribution, any such work, or the design thereof, or the negative of any such photograph, or shall import, or cause to be imported, into any part of the United Kingdom, or sell, publish, let to hire, exhibit, or distribute, or offer for sale, hire, exhibition, or distribution, or cause, or procure to be sold, published, let to hire, exhibited, or distributed, or offered for sale, hire, exhibition, or distribution, any repetition, copy, or imitation of such work or the design thereof, or the negative of any such photograph made without such consent as aforesaid, then every such proprietor, in addition to the remedies hereby given for the recovery of any such penalties and forfeiture of any such things as aforesaid, may recover damages by and in a special action on the case to be brought against the person so offending, and may in such action recover and enforce the delivery to him of all unlawful repetitions, copies, and imitations, and negatives of photographs, or may recover damages for the retention and conversion thereof, provided that nothing herein contained, nor any proceeding, conviction, or judgment for any act hereby forbidden shall affect any remedy which any person aggrieved by such act may be entitled to either at law or in equity.

"12.—This Act shall be considered as including the provisions of the Act passed in the Session of Parliament held in the seventh and eighth years of her present Majesty, intituled 'An Act to amend the law relating to international copyright,' in the same manner as if such provisions were part of this Act."

So runs the law relating to national copyright of works of art.

Cork.—The bark of the *Quercus Suber*, or cork oak, a tree which grows in France, Italy, Spain, and several other countries. It is a very elastic tissue, and is largely used for making corks for stopping the mouths of bottles, jars, &c. The bark is stripped from the tree in square sections, steeped in water, flattened with weights, and dried before fires. For the protection of chemicals good corks should be used. Those known as velvet corks are the finest quality, and are imported in large quantities from France. Corks should not be placed in bottles containing acids or any substances of a like nature. For these purposes glass stoppered bottles should be used.

To make corks perfectly air-tight they are soaked or melted in paraffin-wax.

Cork, Printing on.—Prints may be made upon thin sheets of cork, if treated in the same manner as described in the process of printing on wood (*q.v.*)

Corn Starch Paste.—See **Mountants.**

Corrosive Sublimate.—See **Mercuric Chloride.**

Corundum File.—A piece of corundum formed into a convenient shape for taking the sharp edges from a glass plate and rounding them for more convenient handling. Corundum is a very hard mineral of a light brown, blue, grey or black colour; also the commoner adamantine spar, found chiefly in the Carnatic, near Alva, in China.

Cosmorama (Gr. *kosmos*—the world, and *horama*—a view).—A series of pictures or views generally seen through lenses and lighted with suitable lamps.

Cosmorama Stereoscope.—A stereoscope in which the lenses through which the picture is viewed are made nearly as large as the picture itself, and a portion cut off, so that the cartes can be brought to about three inches apart.

Cotton.—(Formula, $C_{36}H_{30}O_{30}$; molecular weight 486.)—A substance familiar to all in many states. Raw cotton consists almost of pure cellulose. In photography its principal use is in the manufacture of pyroxyline (*q.v.*) For this purpose it must be thoroughly combed and cleansed from all impurities. As it often contains oily matter, it is necessary to saponify this by boiling in a very weak solution of potash, and thoroughly washing and drying before treating with the acids.

Cotton Wool.—Raw cotton. The hairs of the seeds of various species of gossypium. A very useful substance in the laboratory. A tuft placed in a funnel makes a convenient filter for collodion and other similar substances. Cotton or wool is used for the manufacture of gun-cotton and pyroxyline.

Cotton, Gun.—See **Pyroxyline.**

Cowan's Developer.—A developer for gelatino-chloride plates, used chiefly for lantern slides and other transparencies. There are three formulæ by which differently-toned pictures can be produced. They are—

No. 1.—For Cold Tones.

Potassium citrate	136 grains
Potassium oxalate	44 ,,
Hot distilled water	1 ounce

No. 2.—For Warm Tones.

Citric acid	120 grains
Ammon. carb.	60 ,,
Cold distilled water	1 ounce

No. 3.—For Extra Warm Tones.

Citric acid	180 grains
Ammon. carb.	60 ,,
Cold distilled water	1 ounce

To three parts of either of these add one part of the following previous to using :—

Iron sulphate	140 grs.
Sulphuric acid	1 drop.
Distilled water	1 oz.

No. 1 is the quickest, No. 3 the slowest developer. A variety of tones may be obtained by mixing the first and last developers.

Crape Markings.—Peculiar marking of the appearance of crape, which sometimes make their appearance in the film of collodion in the wet-plate process. This defect is usually due to too great a specific gravity of the ether and alcohol employed. To the collodion should be added a quantity of an iodised collodion, made with absolute alcohol or ether, until the defect varnishes.

Crape markings also make their appearance in the collodion emulsion process, which may be due to the cause mentioned or to the fact of the bromide used being too coarse.

Crawling.—A term applied to the movement of the sensitised paper while in the printing frame. With many papers this effect often takes place on account of the contraction of the paper support or of the film itself. If the paper be slightly moist when placed in the printing frame, and then laid out in a warm place during the printing operation, the contraction or "crawling" will be so great as to give a blurred image. Some recent experiments proved that paper when moistened expanded in some cases as much as the eighth of an inch in a single sheet.

Crayon (*Fr.*, a pencil).—Small cylinders of charcoal or of pipe-clay or chalk, coloured with various pigments, which are used for drawing.

Crayon Enlargement. — An enlargement executed with crayons. A photographic enlargement is usually made upon rough bromide enlarging paper, which acts as a guide for the artist to work upon. Or the enlargement may be properly done by photography, and crayons used only in retouching and adding the darker parts of the shading.

Cream of Tartar (Formula $KHC_4H_4O_6$). Hydrogen potassium tartrate.—A salt obtained from tartar or angol. It is a gritty, white powder, sparingly soluble in water and insoluble in alcohol.

Creases.—Creases in paper or pictures are often difficult of removal. The paper or picture should be laid face downwards upon a sheet of smooth unsized white paper. Cover it over with another sheet of the same very slightly damped, and then iron with a moderately warm flat iron.

Creosote, Kreosote, or Creasote (Gr. *kreas*—flesh, and *sozo*—to save).—One of the numerous bodies found by Reichenbach in coal tar. It is a colourless liquid, and takes its name from its

peculiar antiseptic properties. It has a strong empyreumatic odour, is slightly soluble in water, and readily in alcohol, ether, and glacial acetic acid. It coagulates albumen, and turns the plane of polarisation of a ray of polarised light to the right.

Cribriform (Lat. *cribrum*—a sieve, and *forma*—appearance).—A term applied to paper which has a number of intersecting diagonal lines like network, visible when viewed by transmitted light. This is produced by the frame of wire upon which the paper is laid in manufacturing. For the production of paper negatives these lines would, of course, be harmful. They can sometimes be removed by immersing the paper in a bath of dilute muriatic acid.

Critical Temperature.—The temperature below which a substance may and above which it cannot be liquefied by pressure alone.

Crown Glass.—See **Glass.**

Crucible.—A melting pot of earthenware adapted to stand very high temperatures. A perfect crucible must withstand the highest temperature without fusion, and should be capable of bearing sudden changes of temperature without fracturing. It should also be incapable of being acted upon by the materials heated in it. Clay crucibles are made from a clay specially selected, and exposed in a moist state to the atmosphere for about three or four months. This process is termed weathering, and the clay becomes disintegrated, and the removal of foreign matter facilitated. It is then well beaten and mixed with the proper quantity of the refractory material. London crucibles are of a reddish brown colour, and have a close texture. They do not stand sudden changes of temperature well, but successfully the action of litharge. Graphite crucibles are of fine grain, and will stand the highest temperatures possible, and will not fracture if subject to repeated sudden changes in temperature. Crucibles are also made of porcelain and platinum.

Crystal (Gr. *krustallos*—crystal).—A body more or less symmetrical in form, and commonly bounded by plane surfaces. Crystals of various substances may be formed by dissolving, or by fusing and allowing to cool gradually. The multitudinous forms of crystals have been distributed into six primary classes, distinguished from each other by the relative position of the three axes about which the planes or faces are arranged. These six crystalline systems are the following :—

1. Regular system.	The three axes equal and rectangular.
2. Square prismatic system—two equal axes.	The three axes unequal and rectangular.
3. Right prismatic system—all unequal.	
4. Rhombohedral system.	The three axes equal, but not rectangular.
5. Oblique prismatic system—1 axis rectangular to 2.	The three axes not equal and not rectangular.
6. Doubly oblique prismatic system—none rectangular.	

Crystal Cubes.—An application of the angle of total reflection of glass surfaces to stereoscopic purposes devised by Swan. The small photographs are taken in the usual way in a stereoscopic camera, and the combination of the two flat pictures so as to produce the true stereoscopic effect is managed by taking two rectangular prisms of glass ground to an angle of about 39° to 40°. These two prisms are placed together with their widest sides in contact, or nearly so. One of the pictures is then attached to one side of the combination and the other behind. On looking at them the rays which reach one of the eyes are transmitted direct from the picture on the back of the glass; but the rays which reach the other eye are not from the back but from the side only, being reflected from the surfaces of the prisms where they touch. Thus it appears to be from the back also, and is made to coalesce with the other to give stereoscopic relief. (Sutton's Dict. Phot.)

Crystalhydration.—The formation of a hydrate which is also a crystalline body.

Crystallin.—An albuminous substance found in the crystalline lens of the eye.

Crystalline Lens.—A transparent solid body placed behind the iris of the eye. See **Vision.**

Crystallisation.—The process of becoming crystallised. Most bodies which pass slowly from the liquid to the solid state tend to crystallise before the process is complete. If this action takes place with a solid body in the state of fusion crystallisation is said to take place in the dry way. If, on the contrary, it is produced during the slow evaporation of a salt in solution, it is said to be effected by the moist method. Some bodies, as iodine, crystallise when passing from the gaseous to the solid state.

Crystallotype (Gr. *krustallos*—a crystal, and *tupos*—type).—A name given to a photographic picture on glass.

Crystal Markings.—The formation of crystals and tree like markings under the collodion film is due to the hyposulphite solution being improperly washed away. This defect will not make its appearance in some cases till many days.

Crystal Varnish.—See **Varnish.**

Cubic Centimetre.—A French (symbol C.C. or C.C.M.) liquid measure, equivalent to nearly 17 minims. See **Weights and Measures.**

Cumulose.—Full of heaps or lumps.

Cumulo-stratus.—A cloud resembling something between the cumulus and the stratus.

Cumulus (*Lat.*, a heap).—One of the simplest forms of clouds. Cumuli clouds have the appearance of fluffy masses of cotton wool. They are more frequent in summer, and are best seen in the morning, as they have a tendency to lessen in bulk and vanish before the evening.

Cumuli clouds often give good effects to suitable landscapes. A few negatives should be made giving very rapid exposure.

Cup, developing.—A cup for holding the developer is a convenient utensil, essential in the wet-collodion process, but practically unnecessary for the present dry plate development. It should be preferably made of glass, or white stoneware, so that it keeps clean the more easy. A small graduated glass measure is the best article for the purpose.

Cupric Chloride.—See **Copper Chloride.**

Cuprotype.—See **Copper Process.**

Curvature of the Field.—See under **Aberration.**

Cuticle.—A thin skin or coating sometimes formed on the surface of a liquid.

Cutting.—The cutting or trimming of the print may be done before or after toning. By trimming previous to the toning operation a slight saving in the gold is made, but the prints must be handled carefully to prevent the edges becoming torn or frayed. In cutting, the prints should be laid face upwards upon a sheet of zinc or glass, a glass shape or cutting edge laid upon it, and the edges trimmed with a sharp knife or suitable cutter. Many of these are made, good, bad, and indifferent. For cutting out ovals it is necessary to have a cutter for the purpose, which is usually a sharp wheel revolving in two directions.

In cutting or trimming prints great care should be given to the proper position of the picture itself. Very often a fraction of an inch less foreground, and the same amount more sky, or *vice versâ*, will make a wonderful difference in the appearance of the picture.

All cuttings and trimmings from paper or prints containing silver should be kept in one place, and when a large quantity of them has accumulated, it should be burnt in the open air, and the ashes either sent to a refiner, or the silver extracted in the manner given under **Residues.**

Cutting Moulds.—Thick plates of glass cut to various sizes, and used in trimming prints.

Cutting Plates.—When it is necessary to cut a plate coated with a gelatine emulsion, first divide the film with a sharp penknife. The straight edge should be perfectly clean, or a piece of paper laid between it and the film. The knife must be perfectly sharp, otherwise the film will be dragged from the glass. The glass can then

be cut without fear of the film leaving it. In cutting a number of plates care should be taken that the chips and dust from the glass does not rest on the film, as pinholes and scratches would result.

Cwt.—Abbreviation for hundredweight, C being the symbol for Lat. *centum*—a hundred, and wt a contraction of "weight."

Cyanic Acid (Formula uncertain).—A colourless volatile liquid having a pungent irritating odour.

Cyanide.—A cyanide is a compound of the radical CN or Cy. It may be formed by dissolving a metallic oxide or hydroxide in a solution of hydrocyanic acid, H·CN, or by double decomposition of metallic salts with potassium cyanide, provided the resulting cyanide is insoluble. The cyanides principally used in photography are cyanide of silver, potassium and platinum.

Cyanide of Platinum.—See **Platinum Cyanide.**

Cyanide of Potassium.—See **Potassium Cyanide.**

Cyanide of Silver.—See **Silver Cyanide.**

Cyaniline (Formula, $C_{14}H_{14}N_4$).—A crystalline substance formed by the action of cyanogen on aniline.

Cyanine.—Chinoline blue (Formula, $C_{28}H_{35}IN_2$). A blue dye sometimes used as a sensitiser in the isochromatic process (*q.v.*) It is dissolved in heated alcohol, but very sparingly in water.

Cyanogen (Formula $(NC)_2$).—First discovered by Guy Lussac. It may be prepared by heating perfectly dry mercuric cyanide in a hardened glass retort, when the cyanide will break up into metal and cyanogen, the latter coming off as a gas having a pungent and irritating smell. It is highly poisonous.

Cyanogen Soap.—A soap containing cyanogen used for removing stains of silver nitrate from the hands.

Cyanose.—Native sulphate of copper.

Cyanotype (Gr. *kuanos*—dark blue—and *tupos*—type).—A process discovered by Sir John Herschell, about the year 1848. It is also known as the "blue process" owing to the colour of the pictures. Owing to its simplicity in manipulation, the paper is largely used by draughtsmen and others for copying plans, maps, etc. Paper is coated with a mixture of ammonia, citrate of iron, and potassium ferricyanide. Upon exposure to light, this is changed into insoluble Prussian blue. The paper is exposed beneath a negative or a drawing, and cleared and fixed by simply washing the soluble parts away in water.

Since the process was made known by Herschell, very many improvements and additions have been made. They may be divided into three classes—*i.e.*, 1st, those giving white lines upon a blue ground ; 2nd, those giving blue lines upon a white ground ; and 3rd, those which give black lines upon a white ground.

White Lines upon a Blue Ground.—This process, which was the one devised by Herschell, is the simplest, although the effect is not so good as with the process giving blue or black lines upon a white ground.

Two solutions are made—20 parts of red prussiate of potash are dissolved in 100 parts of water, and 10 parts of ammonia citrate of iron in 60 parts of water. These two solutions should be mixed together immediately before using, and the operation must be performed in the dark. Paper is floated on this solution, and applied with a broad camel-hair brush, and then hung up to dry. If it is well dried and carefully preserved from light, moisture, and air this paper will keep for some time. After printing, which when sufficient should show the lines copied of a yellow colour upon a blue ground, the prints should be washed in several waters, and if a few drops of chlorine water or dilute hydrochloric acid be added to the washing water the blue ground will appear much darker, and the lines rendered clearer and whiter. By this method the commercial paper sold is generally prepared. The prints may, if desired, be changed from blue to black by immersing in a four per cent. solution of caustic potash until the blue is changed to yellow. After being well washed they are laid in a solution of tannin.

Vogel's method is thus described—10 parts of potassium ferric oxalate in 100 parts of water, and 10 parts of ferricyanide of potassium in another 100 parts of water. The remaining operations are the same. With this method the red prussiate may be used in dilute form as a developer after exposure instead of being added to the mixture. Paper prepared without it can also be developed after printing in the usual way.

If prints upon cyanotype paper be over printed the following is a method of reducing them :—The over-printed picture is laid in a weak solution of caustic potash until the lines become clear and the ground of a grey colour. They are then immersed in a weak solution of hydrochloric acid, when it once more appears of a fresh blue colour. It is then washed and dried in the usual way.

Blue Lines upon a White Ground. — In this process it is necessary that the action of the light shall be to convert the iron compound into one that can be discharged from , instead of being fixed in, the paper, so that we obtain a positive from a positive. Abney describes the process as follows :—Thirty volumes of gum solution (water five parts, gum one part) are mixed with eight vols. of a citrate of iron and ammonia solution (water two parts, double citrate one part), and to this is added five vols. of a solution of ferric chloride (water two parts, ferric chloride one part). This solution thus formed is limpid at first, but will gradually become

thicker, and should be used soon after mixing. It is then applied with a brush to the paper, which should be well sized, and dried in the dark. Exposure is accomplished in a few minutes, the paper being placed under the drawing in the printing frame. It is then developed with—

Potassium ferrocyanide	50 grains
Water	1 ounce

applied with a brush until all the detail appears of a dark blue colour. The print is then rapidly rinsed, and placed in a dish containing the clearing solution made of one ounce of hydrochloric acid and ten ounces of water.

Pellet's process is as follows:—Paper is coated with boiled starch, so that the solution will remain on the surface, and not sink into the paper. This is then floated on a solution of—

Chloride of iron	10 parts
Citric acid	5 ,,
Water	100 ,,

After drying, the paper is pressed flat and kept from light and moisture. The visible change in printing is very slight. A good plan to get the accurate exposure required is to place some few strips of the paper underneath another piece of paper, similar to the paper upon which the tracing or design from which you are printing has been made. One of these strips should be from time to time taken and placed in the developer, which is composed of a 24 per cent. solution of yellow prussiate. When these strips develop perfectly white the print has been sufficiently exposed. In direct sunlight one minute may possibly be sufficient, but on a dark or cloudy day half-an-hour, or an hour it is possible, may be necessary. After developing the prints are rinsed with water, washed with a dilute solution of hydrochloric acid, and again washed and hung up to dry.

Violet Black Lines on a White Ground.—The sensitising solution required is composed of the following:—

Water	16 ounces
Gelatine	4 drachms
Perchloride of iron (in a syrupy condition)	1 ounce
Tartaric acid	1 ,,
Sulphate of iron	4 drachms

The requisite exposure is about the same as with the last process. When sufficient the greenish yellow colour will turn white except the lines, which should be somewhat dark. The developing solution is composed of one part of gallic acid in ten parts of alcohol and fifty of water. When immersed in this solution the lines will turn blacker. The finish is then made by thoroughly washing in water.

Cylinder Glass.—See **Glass.**

Cylindrical Lens.—A lens whose curvature is that of a cylinder instead of a sphere. A cylindrical glass rod may be considered to

be a cylindrical lens, although lenses of this kind are usually cylindrical one side and flat on the other. They bring the image of a source of light to a line instead of a point.

Cylindrograph.—A name given to a kind of panoramic camera (*q.v.*), capable of producing photographs embracing half the horizon on films from 16½ inches to 55½ inches long.

Daguerreotype.—One of the earliest of photographic processes first published by Monsieur Daguerre in Paris, January, 1839. With this process a direct positive was obtained upon a silvered metal plate, sensitised by exposure to fumes of iodine in a dark chamber. The latent image was developed by fumes of mercury and fixed by hyposulphite of soda. A more detailed description of the process is as follows:—

The first operation is to prepare the silver plate. These are usually made of copper, on which a film of metallic silver is deposited by one of the electro-plating processes. These plates may be purchased ready silvered, and only require polishing, but this must be very carefully done. First, for convenience sake, the corners should be clipped off about ⅛th of an inch. The plate is then laid upon the work table, and four pieces of wood nailed round it to hold it firmly into position. The pieces of wood should not be quite as high, or at least should not be higher than the plate itself. A little powdered rottenstone or tripoli powder in alcohol is then laid on, and worked about the plate with some canton flannel. If the plate is very dirty it should be previously rubbed with dilute nitric acid. After the application of the tripoli powder the plate is removed, and the back and sides cleaned. It is then returned to its former position, and is ready for polishing. This is done with a buff of the finest chamois leather, and some prepared charcoal or jeweller's rouge. The polishing should be done just before sensitising, otherwise the polished surface is liable to attract impurities from the atmosphere. In polishing rub well with the buff from side to side and from end to end alternately, but the last rub should be horizontally when looking at the picture.

For sensitising we require two boxes containing two compartments. Fig. 42 is an illustration of the one usually employed

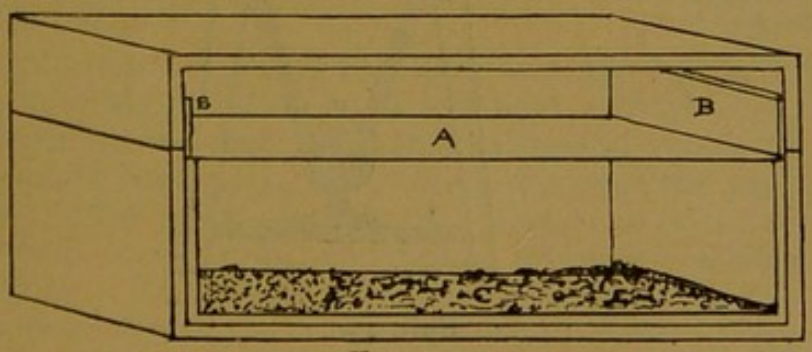

FIG. 42.

during the time when the Daguerreotype was practised for portraiture. Some iodine in powder is spread evenly over the bottom

of the box at C. A is a piece of stout cardboard sliding into grooves, and B B are the supports upon which rests the silver plate to be sensitised. First, the iodine will volatilise at an ordinary temperature, and condense on the underneath part of the cardboard. This is then reversed, and the iodine volatilises on to the plate, which gradually receives a thin coating of iodide. With this process the plate passes through many stages of colour, and when it has arrived at a ruddy tint it is placed in another box similar to the one described and shown on fig. 42, except that no piece of cardboard is required. At the bottom of this should be placed a mixture of bromine and calcium hydrate. This bromine is then allowed to attack the plate, and form with the iodide silver bromo-iodide. It will now assume a beautiful steel blue colour, and at this stage is removed, and returned to the iodine box, and again subjected to the iodine for about a third of the time formerly given. The plate is now sensitised, and is ready for exposure in the camera, which may be done at once, or it may be kept for several hours. After the last exposure to the bromine fumes the plate must be kept in the dark; should any white light reach it, however, by accident, it should be again subjected to the iodine vapour in the box.

The exposure is made in the well-known way. With regard to the time required, it of course varies with the light and subject. If the picture be over-exposed the lights become blue and solarised.

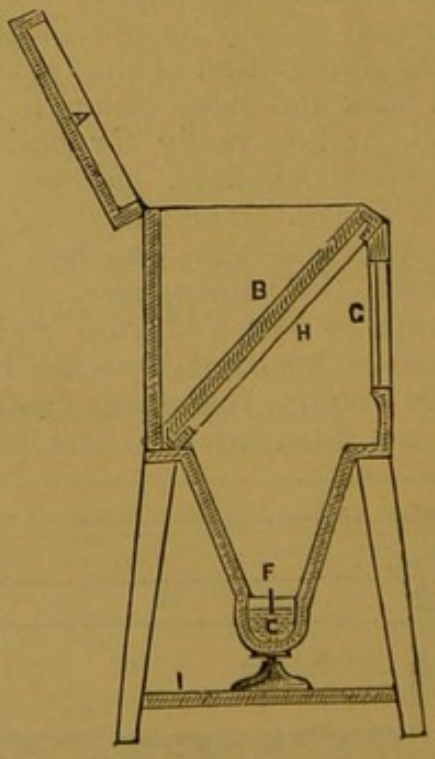

FIG. 43.

Development is effected with mercurial vapour. A tray made of cast iron, and provided with wooden sides, a lid, and a thermometer,

is required. Into the tray about a table spoonful of mercury is filtered with a filter having a very small bore. The plate when removed from the camera has no visible image. It is now supported face downwards over the mercury, and the latter gradually heated to a temperature of 140° to 150° Fahrenheit. In a few minutes the image will be developed. The process can be watched by examining it from time to time in non-actinic light, and the development proceeded with until all the detail is properly visible. If the plate has been under-exposed the image will be weak and lacking detail, and if over-exposed it will be covered with a thin veil of mercury. In developing, if over-done, or if the mercury be over-heated, the shadows will be covered with fine specks, and if under-developed the lights will lack solidity, and the shadows detail. The box employed by Daguerre for mercurial development is shown in fig. 43. It consists of a box mounted on legs, having a close-fitting cover, A, and an iron bottom, in which is placed the mercury, C, with a small thermometer, F, to indicate the proper temperature. G is a piece of glass let into the side of the box, through which the Daguerreotype plate fixed in the frame, B, can be seen. D is the spirit lamp, and I the platform on which it stands. The cause of the change in development and the production of the image is due to the attraction the subiodide has for the metallic mercury vapour.

The next process is to fix the image. This may be done at once, or it may be left till a more convenient opportunity. Fixing is accomplished with a 10 per cent. solution of sodium hyposulphite in distilled water. In a few seconds the unaltered iodide, Ag_2I_2, and the AgI of the subiodide will have been dissolved by the hypo, and the image will remain as a white amalgam of mercury and silver on a darker coloured support.

The plate is then thoroughly washed in distilled water, and the appearance considerably improved with a hot toning solution, which darkens the silver, and gives a purer colour to the amalgam. This solution is made with—

Gold bichloride..	15 grains.
Distilled water	2 ounces.

and—

Sodium hyposulphite	60 grains.
Distilled water	2 ounces.

These two solutions are mixed together, and the plate is flowed over with as much of the solution as it will hold. With a spirit lamp placed underneath the plate is gradually heated evenly all over by moving the plate continually over the flame until the toning action commences. After a few seconds the image will darken, and then gradually begin to clear up, the lights becoming whiter and the shadows darker. The more rapid the deposition of the gold the more satisfactory will be the resulting image. When it has attained a satisfactory stage the plate is well rinsed in a dish of cold water, and finally in distilled water. The plate is then dried in the following manner: Hold the plate by one corner, or, with

suitable nippers, inclined at an angle of 45°. Pass it gently over the flame of a spirit lamp, beginning with the upper corner, and proceed to dry gradually downwards. As the fluid dries from the plate a line of wet gradually recedes till it reaches the edge, when it is removed with a piece of blotting paper. Should this method of drying be considered troublesome the plates may be dried spontaneously on a piece of blotting paper. Black spots which sometimes appear in drying may be removed with a dilute solution of potassium cyanide. This substance may be used to fix instead of hypo ; it can also be used for restoring the brilliancy of a faded Daguerreotype. The plate is now finished, and only requires placing and sealing up in the *passe-par-tout* to protect from dust and scratches.

Daguerreotype, Etching.—A process of etching Daguerreotype plates by means of acid and a battery was introduced by Sir W. R. Grove. He immersed the plate in an aqueous solution 1 to 2 of hydrochloric acid ; to the plate was attached a wire from the battery, and opposed to it was a platinum plate connected with the other pole of the battery, and placed at a distance of 2in. from the Daguerreotype. A current was then sent through the circuit thus formed by a couple of Grove's cells. An oxy-chloride of silver was formed ; at the end of thirty seconds the plate was sufficiently eaten away. The oxy-chloride was then removed, and for very delicate work the plate could be printed from in an ordinary printing press, great care being exercised. It is, however, a process far too delicate for everyday work, and has been completely abandoned.

Daguerreotypes, Electrotyping.—Daguerreotypes may be reproduced by electrotypy in the ordinary manner. The plate is immersed in the copper solution employed by electrotypers immediately after toning, and the usual manipulations carried out. The image of the Daguerreotype, although in relief, is naturally so to a very slight extent.

Dallas Rubber-type.—A method of making a photograph in caoutchouc or indiarubber, so that it will give prints in a press or with a hand stamp.

Dallastint.—A secret process of photo-mechanical printing invented by D. C. Dallas. It is exceptionally suitable for half-tone work, as it is a species of aqua-tint, capable of rendering fine detail and delicate gradation of tint. It is also used for decorative purposes by transfer to pottery, stone, wood, etc., and for printing on calico, linen, and other textile fabrics.

Chromo Dallastint.—An adaptation of the Dallastint process to colour printing.

Dallastype.—A secret process of photographic engraving for typographic printing, invented by D. C. Dallas.

Daltonism.—See **Colour Blindness.**

Dammar (Malay Damar).—A pale yellow or white resin obtained from the *Dammara Australis*, commonly known as the kawrie or cowdie pine in New Zealand, and the *Dammara alba*, Dammar pine, or cat's-eye resin of India. Dammar resin is also obtained from the Amborgna pine growing in the Malay Archipelago. It is largely used in the manufacture of varnishes, and is easily soluble in oil of turpentine, benzole, or chloroform. See **Varnish.**

Damp.—Moisture or dampness is a silent and secret enemy to the photographer. In a damp atmosphere nearly all photographic preparations will suffer. It is, therefore, necessary to keep the chamber containing them in a dry state. This may be done by the application of heat in the damp weather, or by using calcium chloride, which effectually absorbs moisture from the atmosphere.

Damp walls are not conducive to longevity of silver prints hung against them. In such cases precaution should be taken to back the frames with good stout waterproof paper.

Dark Room.—The name given to the room in which all sensitive materials are handled. The term is somewhat erroneous, as it is not necessary that the room should be dark in a usual, but in a chemical, sense only. To explain this—We know that dry plates are very sensitive to light, but only certain rays of light are capable of making any change. We also know that a ray of white light passed through a prism can be broken up into a band of colours known as the spectrum band, and their order is always the same, *i.e.*, violet, indigo, blue, green, yellow, orange and red. The first are termed rays of high refrangibility, and those at the end, rays of low refrangibility. In photography we find that the change that takes place with sensitive plates is produced almost entirely by the rays of high refrangibility, the violet and blue having the most powerful effect, whilst the rays of low refrangibility, as yellow and red, have comparatively no effect whatever. The first are therefore termed actinic, and the last non-actinic.

It is this discovery which enables us to handle the sensitive plates in a room lighted only by non-actinic light without fear of spoiling them.

The question as to which is the best colour for the light is a disputed one. It is evident that what we require is a medium which shall give the brightest possible light to work with, but will at the same time be perfectly non-actinic, and have no effect upon sensitive dry plates exposed to it for some time.

A little reflection will show that this depends to a great extent upon the sensitiveness of the material with which one operates. For instance, for the wet or dry collodion processes, gelatino-chloride plates, or paper, a canary-yellow glass, will be sufficient protection from the actinic rays of daylight. For slow plates and

for bromide enlarging two thicknesses of canary-yellow medium will suffice; while for rapid gelatino-bromide plates a ruby-red glass will perhaps be necessary; although two thicknesses of orange paper should be sufficiently non-actinic for the most rapid plates, if they are not exposed to it for too long a period, as no light is absolutely safe, but will affect a gelatine dry plate if sufficient time be allowed it to act. The yellow glass is considered superior and safer than red, but it is necessary that precautions be taken to avoid using a yellow medium which will allow too much green light to pass through it.

Besides the quality of the light the quantity must also be considered. Daylight should never be recommended, as it is too variable. The window in the room should be blocked up with two or three thicknesses of brown paper, and artificial light employed. A large number of different dark-room lamps have been devised for this purpose.

The dark room should be as large as conveniently possible. It is a great mistake to suppose that any little closet or cupboard will suffice, and for those who require to be in it for prolonged periods it is extremely dangerous to their health. The room should be fitted with a sink having a tap above it, and several tables and shelves. Fig. 44 is a plan of a dark room with convenient fittings. D D are the two doors, so arranged that anyone may enter without letting in the light. S is a sink with water-

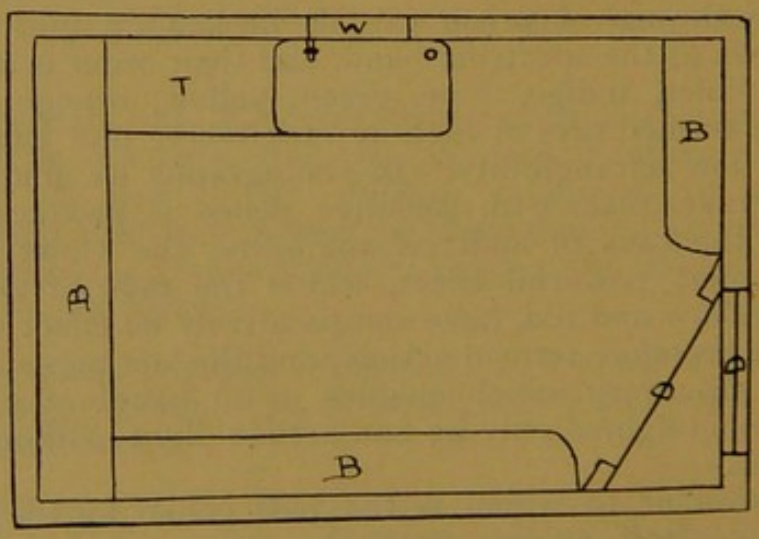

FIG. 44.

tap, and T is a board covered with sheet lead. It is used as a bench, and should be inclined a little, so that any water spilt will flow into the sink. B B B are conveniently-arranged benches. W is a window introducing the necessary amount of light. Instead of this a non-actinic lamp may be used. A number of shelves should be fitted up in convenient places.

Another important consideration is the ventilation of the room. It should be as lofty as possible, and an outlet for the vitiated air should be made in the ceiling or high up in one of the walls. It must be so arranged that it will let out the air without letting in light. Fig. 45 explains how this is done.

Fig. 45.

Besides this there should also be an inlet for the fresh air. This may be provided by piercing some holes at the bottom of the door and attaching a piece of wood outside in such a position, as shown in fig. 46, as to prevent light from coming in, but without preventing the entrance of pure air.

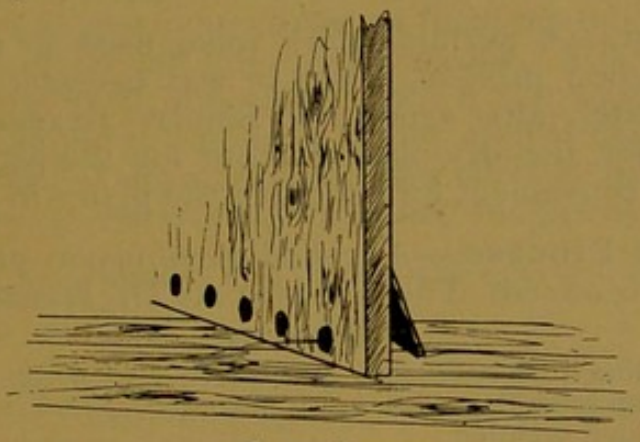

Fig. 46.

The dark room should be kept perfectly clean, and everything cleared up and put into its proper place after every operation. Have a place for everything, and keep them all in their places.

Dark Room Lamps.—See **Lamps.**

Dark Slide, also termed the single or double back, is the case in which the plate or plates are carried. The double backs are the most convenient, as they carry two plates in but little larger space than required for one. The dark slide, usually made of wood or metal, must be perfectly made so as to be absolutely light tight. It should also fit easily in the grooves of the camera made to receive it; no jarring or sticking must take place. In a double dark slide two plates are placed with their sensitive faces outwards. They should fit exactly into the places provided for them and held firmly into position by means of catches. A piece of blackened tin or cardboard is placed between them to prevent the light passing through one and affecting the other. On both sides is a sliding shutter, which is either drawn up or right out before the plate is exposed, and returned to its position after exposure.

In some makes of dark slides spring catches are fitted to prevent the slides from being drawn out by accident, and others have the shutter hinged, so that when drawn up they fold back on to the top or side of the camera away from the wind and danger of being broken.

Cameras are usually provided with three double dark slides, but if a changing bag be employed one will be sufficient. The slides should be plainly numbered to prevent the same plate receiving two exposures. To obviate this many arrangements have been devised by which the slide, when once drawn out and replaced, cannot be withdrawn a second time until another plate has been placed in.

Dark slides should be fitted with carriers if more than one size of plate is used. These are frames of blackened wood fitting into the space made for the plate, so that plates smaller than the ones the camera is intended for can be used. Carriers are also made for exposing films on negative paper.

Dark Tent.—A portable dark room used in the old days of the wet-collodion process, when it was necessary to develop the plate immediately after exposure. Similar arrangements are still constructed for the dry-plate process for the benefit of tourists, and are very convenient for changing the plates in the dark slides.

Dawson's Process.—A collodion-emulsion process to which an organifier is added. The following are Dr. Dawson's formulæ:—

COLLODION.

Pyroxyline	8 grains
Cadmium bromide	7 ,,
Ammonium bromide	2 ,,
Ether ·725	½ ounce
Alcohol ·810	½ ,,

The collodion should be allowed a few days to settle; it is then decanted off.

To sensitise the following mixture is made up:—

Silver nitrate	13 grains
Acetic acid	2 drops
Glycerine	1 drachm
Alcohol ·830	4 drachms

This is then added to the collodion to form the emulsion, and, after standing for about a day, two drops of hydrochloric acid are added. It is again allowed a day to rest.

After this time the emulsion is poured out into a flat dish to allow the solvents to evaporate, which they will do in from five to six hours. The pellicular mass thus formed is then covered with water for one hour, and after pouring off it is covered for the same length of time with—

Tannin	5 grains.
Gallic acid	2 grains.
Acetic acid	2 drachms.
Distilled water	1 ounce.

The pellicle is then washed until all traces of acid are removed. The water is then squeegeed out, and the emulsion dried in a hot water bath or spread out on blotting paper placed in a warm room.

The method of eliminating the water with alcohol is not possible with this emulsion, as it would dissolve the tannic and gallic acids.

To re-dissolve the pellicle for use take equal quantities of ether and alcohol of the same specific gravity as given. Dawson recommends soaking the pellicle in alcohol for twelve hours before adding the ether. A strong alkaline developer should be used.

Dead Black.—A good dead black for brass work can be made by grinding four grains of lampblack on a plate with about six drops of gold size.

Decantation.—The separation of a clear liquid from a precipitate or deposit. This is done by gently inclining the vessel and allowing the liquid to run out without disturbing the precipitate at the bottom. The glass should not be filled too full, or the liquid on inclining the vessel will run down the edge. If a wet glass rod be held in a nearly vertical position against the edge of the glass it will cause the liquid to run down it and fall into the lower vessel without splashing. Decantation is also effected by means of a syphon, there being less risk of disturbing the precipitate.

Decarbonise (*de*—away, and *carbonise*).—To rid a substance of carbon.

Decimal System.—A system of weights and measures in which the values of the different weights proceed by multiples of ten. (See **Weight and Measures.**)

Decolour (Lat. *decolor*—without colour).—To deprive of colour.

Decompose.—*In chemistry*, to resolve a compound into simpler compounds or elements, as chloride of silver is decomposed by light, which resolves it into subchloride of silver and chlorine. *In optics*, to resolve or break up a beam of light into its constituent prismatic colours.

Decomposition of Light.—If a ray of white light be made to pass through a prism it is at once decomposed or separated into its constituent coloured rays, which may, by means of another prism, be brought together again in the original form.

Decripitation.—The crackling noise made by many substances when heated, their parts flying asunder.

Definition (Lat. *definitio*—to define).—In optics, the defining power of a lens, or, in other words, its accurate concentration of the rays of light from a point in an object to the corresponding point in the image, so that it be perfect in the most important

detail without blurring. To obtain perfection in this respect, the lens must be perfectly free from aberration (*q.v.*)

Definition, Depth of.—See **Focus** and **Diaphragm.**

Deflection (Lat. *deflexio*—to turn aside).—In optics, the deviation of a ray of light towards the surface of an opaque body.

Deliquescent.—A solid is said to be deliquescent when it possesses the property of becoming soft or liquid by absorbing moisture from the air. Potash and calcium chloride are deliquescent.

Demi-tint.—A half-tint or medium shade of colour.

Demy.—Paper of a particular size. (See **Paper.**)

Density.—If two bodies have equal bulk, but one contains more matter than the other, it is said to have greater density; or, if two bodies contain the same quantity of matter, but one of different bulk, then the body which is of less bulk is of greater density than the other. Thus density is directly proportional to the quantity of matter, and indirectly proportional to the bulk. Lithium is the least dense metal known; taking water as unity its density would be 0·59. Iridium is the densest, it being 2·24 times denser than water. The density of the ordinary metals is in the following order:—Aluminium, antimony, zinc, iron (wrought), copper, bismuth, silver, lead, gold, platinum.

The term density is also employed in photographic language to signify opacity. A perfect negative should possess correct density, which is proved in the printing process. If the density of the negative be just sufficient as to allow the detail in the high lights to impress itself upon the print it is correct. The density or opacity of the negative depends upon the amount of metallic silver deposited, and it is in the knowledge of when to stop development to obtain the right density that the success of developing lies. Several instruments have been constructed for the measurement of the density of negatives. Among these may be mentioned Captain Abney's and that of Messrs. Hurter and Driffield. With the first instrument Captain Abney's investigations show that the logarithm of the amount of silver on the plate is proportional to the square root of the logarithm of the opacity, the inverse of the transparency. Messrs. Hurter and Driffield's instrument is a much simpler affair, as no calculations are required, a number being read off the instrument proportional to the amount of silver on the plate.

See **Development.**—In the collodion process a lack of density is caused by the collodion being too thin or by an insufficient sensitising in the silver bath, or by too weak an alkaline developer (*q.v.*) With gelatine plates want of density may be caused

by the emulsion. Too great a density may also be met with in a reducing agent. (See **Reducer.**)

Deoxidation.—The abstraction of oxygen. (See **Reduction.**)

Depth of Focus. (See **Focus.**)

Desiccation (Lat. *desiccatio*).—The evaporation, or drying off, of the aqueous portions of bodies. It may be done by exposure to the sun, by a current of dry air, or by many other devices.

Desk.—See **Retouching Desk.**

Destemper.—See **Distemper.**

Destructive Distillation.—Dry distillation. The heating of non-volatile organic bodies in a retort.

Detachable Fronts.—An arrangement in the camera for quickly changing one lens for another. The centre of the front is made detachable, being secured into lightest position by small clamps. Each lens is attached to a different front, and, as they all fit in the same place, any one can be put in as required.

Detail.—A minute or particular part of the negative, or picture therefrom, as distinguished from the work as a whole. The negative, or picture, is said to possess detail when these parts are sharply or clearly defined. The introduction of the diaphragm gives more detail to the image at the sacrifice of the light, and necessitating increased exposure.

Detective Camera.—See **Camera.**

Developer.—The agent which builds up, or otherwise renders visible, the latent image. When the plate is exposed on the camera no visible change takes place, but some of the particles have been affected by the light, whilst others remain as they were. The action of the developer may be merely to change the colour of these light affected particles, and render them visible to the eye ; or it may be to build up an image upon those which have been altered. In general terms, the developer may be described as the agent which exerts an action upon those portions of a sensitive compound which have been exposed to light in a different manner to that which it has upon those parts which have not been so exposed. The two principal developers are the pyrogallic acid and the ferrous oxalate. In the first the reducing action of the pyrogallic acid is assisted with an alkali, such as ammonia, and in the second we have the ferrous oxalate as the reducer.

Alkaline pyrogallic development is perhaps the one chiefly used for developing gelatino-bromide dry plates. If we take a dry

plate and expose it to the light, we have a certain quantity of silver sub-bromide. If the plate be then immersed in a solution of plain pyrogallic acid, scarcely any perceptible change will take place, but if a small quantity of an alkali, such as ammonia, be added, the plate will instantly blacken, forming metallic silver. The action that is supposed to take place is this:—The silver bromide is split up into silver and bromine, which is immediately laid hold of by the ammonia to form ammonium bromide, and possibly other complex compounds, and the oxygen of the ammonia combines with the pyrogallic acid, causing some immediate actions to take place. The whole theory of the latent image and development is wrapped up in apparently unfathomable obscurity. Many theories have been put forward by able scientists, differing considerably from one another.

With the ferrous-oxalate developer the action is somewhat similar to the alkaline. This method of development was introduced almost simultaneously by Carey Lea and W. Willis, jun. The oxalate of potash should be neutral, and the iron sulphate slightly acid. When saturated solutions of these two chemicals are added together in the proportions of one of iron to three of potash the following change takes place:—$FeSO_4 + K_2C_2O_4 = FeC_2O_4 + K_2SO_4$. The ferrous oxalate is the developing agent; the potassium sulphate is useless, and has apparently no action whatever upon the plate. If much more iron be added than the proportion given a large quantity of ferrous oxalate will be formed than the solution will hold, and it will fall as a yellow precipitate, rendering the developer useless.

The action of this developer upon the silver bromide is a little clearer if the following accepted theory be correct:—$3(Fe, C_2O_4) + 2Ag_2Br = Fe_2, (C_2O_4)_3 + FeBr_2 + 4Ag$; or, in plainer language, ferrous oxalate and silver sub-bromide give ferric oxalate, ferrous bromide, and silver. With the development it will be seen that ferric salts are produced. These have a directly opposite action to the ferrous salts, so that the developer rapidly loses its strength.

If an old developer be exposed to light the ferric oxalate will become decomposed into ferrous oxalate and carbonic anhydride, thus, $Fe_2(C_2O_4)_3 = 2FeC_2O_4 + CO_2$. Owing to the non-actinic colour of the solution the action of the light is slow; the bottle should be occasionally shaken up. This old developer can then be used to start the development of an exposed plate, adding fresh developer afterwards to give strength to the image. Old developers may also be regenerated by the addition of zinc, which abstracts from the iron the bromine that it has taken during development. $2FeBr_3 + 2Fe_2(C_2O_4)_3 + 3ZnBr_2 + 6FeC_2O_4$. The non-actinic colour of the ferrous oxalate developer allows of a little brighter light being used in the dark room during development.

Many other kinds of developers, such as hydrokinone hydroxylamine, eikonogen, acetate, phosphate, lactate of iron, etc., etc., are

used. Some thousands of different formulæ have been given. The most important are the following :—

PYROGALLIC DEVELOPER NO. 1.

SOLUTION NO. 1.

Pyrogallol	50 grains.
Sodium sulphite	200 ,,
Sulphuric acid	6 minims.
Distilled water to make	1 fluid ounce.

SOLUTION NO. 2.

Liquor ammonia ·880	1 ounce.
Distilled water	9 ounces.

PYROGALLIC DEVELOPER NO. 2.

SOLUTION NO. 1.

Pyrogallol	1 ounce.
Citric acid	¼ ,,
Water (distilled) to make	9 ounces.

SOLUTION NO. 2.

Potassium bromide	1 ounce.
Water to make	9 ounces.

SOLUTION NO. 3.

Ammonia ·880	1 ounce.
Water to make	10 ounces.

To make up, take for every ounce of water twenty minims No. 1, twenty to forty of No. 2, which acts as a restrainer, and twenty to forty minims of No. 3, according to the exposure of the plate.

PYROGALLIC DEVELOPER NO. 3.

SOLUTION NO. 1.

Potassium carbonate	1 ounce.
Sodium sulphite	2½ drachms.
Distilled water	5 ounces.

SOLUTION NO. 2.

Pyrogallic acid	3½ drachms.
Sodium sulphite	6 ,,
Citric acid	¾ scruple.
Distilled water	5 ounces.

For developing, take 6 parts of each solution, and add 60 parts of water.

PYROGALLIC DEVELOPER FOR ISOCHROMATIC PLATES.

SOLUTION NO. 1.

Pyrogallic acid	1 ounce.
Methylated alcohol	7 ounces.
Glycerine	½ ounce.

SOLUTION NO. 2.

Potassium bromide	60 grains.
Distilled water	7 ounces.
Ammonia ·880	1 ounce.

To develop, add one part of No. 1 to fifteen parts of water, and in another bottle mix one part of No. 2 with fifteen parts of water. The dilute solution should be made fresh every day.

Pyrogallic Developer for Films.

Solution No. 1.

Pyrogallic acid	80 grains.
Bisulphite of potash	80 ,,
Water	20 ounces.

Solution No. 2.

Liquor ammonia ·880	2 drachms.
Ammonium bromide	20 grains.
Water	20 ounces.

Dissolve the bisulphite in the water, and add the pyro. For development, mix equal parts of the two solutions together, adding more of No. 2 if necessary.

Pyrogallic Developer for Bromide Lantern Plates.

Solution No. 1.

Pyrogallic acid..	40 grains.
Meta-bisulphite of potash	120 ,,
Distilled water..	20 ounces.

Solution No. 2.

Liquor ammonia	2½ drachms.
Ammonium bromide	40 grains.
Distilled water	20 ounces.

Take equal parts for development, which, with this developer, proceeds slowly.

Stolze's Pyro Developer.

Solution No. 1.

Neutral sulphite of soda	1 ounce.
Pyrogallic acid	3 drachms.
Sulphuric acid	3 to 4 drops.
Water	4 ounces.

Solution No. 2.

Potassium carbonate	3 ounces.
Neutral sulphite of soda	6 drachms.
Water	7 ounces

For use take three parts of each solution in 100 parts of water. Citrate or bromide of potassium can be used as a restrainer.

Ferrous-oxalate Developer No. 1.

Solution No. 1.

Water	30 ounces.
Potassium oxalate	10 ,,

Solution No. 2.

Water	30 ounces.
Iron sulphate	10 ,,
Tartaric acid	2 drachms.

Solution No. 3.

Ammonium bromide	1 ounce.
Water	10 ,,

For use take one part of No. 2 and add it to four parts of No. 1; a few drops of No. 3 are then added. This last solution acts as a restrainer. If the plate be over exposed add from 10 to 20 drops.

FERROUS-OXALATE DEVELOPER NO. 2.—ONE SOLUTION FORMULA.

Neutral potassium oxalate	5 ounces.
Ferrous sulphate	2 ,,
Citric acid	100 grains.
Boiling distilled water	20 ounces.

This solution to be diluted when required for use with about three times its volume of water.

FERROUS-OXALATE DEVELOPER FOR ISOCHROMATIC PLATES.

Neutral oxalate of potash	10 ounces.
Distilled water	35 ,,
Protosulphate of iron	7 drachms.
Distilled water	4 ,,
Sulphuric acid	2 to 3 drops.

FERROUS-OXALATE DEVELOPER FOR FILMS.

SOLUTION NO. 1.

Oxalate of potash	16 ounces.
Hot water	48 ,,

Acidify with sulphuric acid.

SOLUTION NO. 2.

Protosulphate of iron	16 ounces.
Hot water	32 ,,
Sulphuric acid	½ drachm.

SOLUTION NO. 3.

Bromide potassium	1 ounce.
Water	32 ounces.

When cold take six ounces of No. 1, one ounce of No. 2, and ten drops of No. 3, and add together in the order named.

FERROUS-OXALATE DEVELOPER FOR CHLORIDE PLATES AND PAPER, OPALS, ETC.

SOLUTION NO. 1.

Potassium citrate	200 grains.
Potassium oxalate	60 ,,
Water	1 ounce.

SOLUTION NO. 2.

Iron sulphate	80 grains.
Sulphuric acid	1 drop.
Water	1 ounce.

For use take equal parts of No. 1 and No. 2. (See also Cowan's developers.)

FERROUS-OXALATE DEVELOPER FOR BROMIDE PAPER.

SOLUTION NO. 1.

Neutral oxalate potash	1 lb.
Citric acid	1 drachm.
Hot water	50 ounces.

SOLUTION NO. 2.

Protosulphate of iron	15 ounces.
Citric acid	1 drachm.
Hot water	30 ounces.

SOLUTION NO. 3.

Potassium bromide	1 ounce.
Water	20 ounces.

For normal developer add to 6 oz. of No. 1, one ounce of No. 2, and 6 drops of No. 3. Mix in the order given and immediately before required for use.

HYDROKINONE DEVELOPER FOR CHLORIDE PLATE OR PAPER.

SOLUTION NO. 1.

Hydrokinone	6 grains.
Water	10 ounces.

SOLUTION NO. 2.

Potassium carbonate	
Water to make sat. sol.	

SOLUTION NO. 3.

Sodium chloride	20 grains.
Water	1 ounce.

To each ounce of No. 1 add half a drachm of No. 2 and four drops of No. 3.

HYDROKINONE DEVELOPER FOR BROMIDE PLATES OR PAPER.

SOLUTION NO. 1.

Hydrokinone	6 to 12 grains.
Water	1 ounce.

SOLUTION NO. 2.

Ammonium carbonate sat. sol.

To each ounce of No. 1 add one drachm of No. 2.

HYDROXYLAMINE DEVELOPER FOR CHLORIDE PLATES OR PAPER.

SOLUTION NO. 1.

Hydroxylamine hydrochloride	20 grains.
Alcohol	1 ounce.

SOLUTION NO. 2.

Potassium carbonate	6 drachms.
Water	1 ounce.

SOLUTION NO. 3.

Ammonia ·880	1 drachm.
Water	1 ounce.

For sepia brown tones take half a drachm of Solution 1, forty minims of Solution 2, and one ounce of water. For chocolate tints add one minim of Solution 3 to the above. A somewhat bluer image is obtained by adding half a drachm of Solution 3 and half a drachm of Solution 1 to an ounce of water.

BEACH'S POTASH DEVELOPER.

SOLUTION NO. 1.

Distilled water (hot)	2 ounces.
Sodium sulphite	2 ,,

When cool add—

Sulphurous acid	2 ounces.
Pyrogallol	½ ,,

SOLUTION NO. 2.

Potassium carbonate	3 ounces.
Sodium sulphite	2 ,,
Water	7 ,,

Dissolve separately and mix. For development of a correctly exposed plate take equal parts of both solutions and add eight times its volume of water. For an under-exposed plate use more potash solution, and less if over-exposed.

FERROUS-SULPHATE DEVELOPER FOR COLLODION PROCESS.

Ferrous sulphate sat. sol.	2 ounces.
Glacial acetic acid	¼ ,,
Alcohol	1 ,,
Water	16 ,,

This developer is also known as Wortly's. (See also collodion processes.)

SODA DEVELOPER.

SOLUTION NO. 1.

Pyrogallic acid (dry)	3 grains.

SOLUTION NO. 2.

Sat. sol. dry monocarbonate of soda	1 drachm.

SOLUTION NO. 3.

Potassium bromide sol. (2 per cent.)	1 to 20 minims.

SOLUTION NO. 4.

Water	2 ounces.

Dissolve Nos. 2 and 3 separately, and add together with the pyro to Solution 4.

SODA AMMONIA DEVELOPER.

Water	1 ounce.
Pyro	2 grains.
Ammonium bromide	1 ,,
Common washing soda	100 ,,
Ammonia	1 minim.

Make up the pyro and the ammonia in the form of 10 per cent. solutions, and add the ammonia during development as required.

EIKONOGEN DEVELOPER.

Distilled water	50 ounces.
Sodium sulphite	2½ ,,
Sodium carbonate	1½ ,,
Potassium carbonate	½ ,,
Eikonogen	½ ,,

HYDROKININE AND EIKONOGEN DEVELOPER.

SOLUTION NO. 1.

Distilled water	10 ounces.
Hydrokinine	1 drachm.
Eikonogen	1 ,,
Potassium meta-bisulphite	1 ,,

SOLUTION NO. 2.

Distilled water	10 ounces.
Potasium carbonate	5 drachms.
Sodium carbonate	5 ,,
Ferrocyanide of potassium	5 ,,

For developers for collodion, platinotype and other processes, see under their respective names.

Developing Tent.—See **Dark Tent.**

Developing Tubes.—Glass tubes with closed ends, one containing pyro and the other ammonia. They are made for the convenience of tourists. When required for use the ends are broken off and the solution mixed with the proper quantities of water.

Development.—The process of rendering the latent image visible by means of a suitable agent. Under developer we have a large quantity of formulæ, and we have under this heading to describe the method of applying to the exposed plate.

Before proceeding to develop it is almost essential that the operator should have some knowledge of the plate about to be developed. If he has himself made the exposure he will generally be able to tell whether the error in exposing, if there is likely to be one, will be in under or over-exposure. For this he will be guided principally by the subject itself. The developer is then mixed up accordingly. In all developers we have an accelerator and a retarder, and the careful and judicious arrangement of these solutions is one of the secrets of success in development.

It must not, however, be imagined that a short exposure in the camera can be righted by prolonged development. There is a certain time necessary for the formation of the invisible image, which can only be shortened or lengthened to a very limited extent. With the pyrogallic acid developer more latitude is allowed, with ferrous oxalate very little.

The exposed plate in the dark slide is removed to the dark room, and there it remains until the developing solutions have been made up and are perfectly ready. With each make of plate is usually given the formula for development most suitable, and as this is usually the result of careful investigation of the various formulæ it should be carried out wherever possible.

The following method of developing with pyro and ammonia serves well with almost every kind of dry plate: Take about four grains of dry pyro and 1½ ounces of water. This quantity is sufficient for a half-plate; for larger sizes multiply proportionately. Dissolve the pyro in the water, place the exposed plate in the developing dish, and flow the solution over it. To the pyro should be added a small quantity of a restrainer. With a soft camel-hair brush then remove all air-bubbles or foreign matter from the surface of the film. Into a clean measure next place about ~~two drachms~~ of a ten per cent. aqueous solution of ammonia, and pour into this the pyro solution from the developing dish. Next return the whole solution to the dish by flooding the plate quickly and evenly. The dish is then gently rocked, causing the developer to flow backwards and forwards. An American arrangement for rocking the plate automatically is shown in fig. 47.

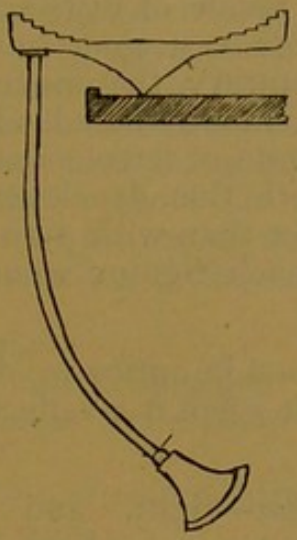

FIG. 47.

After the space of one minute if no image appears pour another drachm of the ammonia solution into the measure, and pour on to it the developer from the dish, again flood the plate with the strengthened solution, and continue the rocking motion. If the plate has been correctly exposed the image should now make its appearance, the high lights coming up first. If not, another quantity of the ammonia solution must be added in the same manner as described, and the solution returned to the dish. The image will now gain in density and opacity, and it should be examined from time to time by the light of the lamp. The back should also be examined when the required density is obtained, which is only arrived at by practice; the plate is removed from the developer and thoroughly rinsed in water. This done, it is removed to the fixing bath.

The process of development is one that requires considerable care and attention, and it is only by practice and patience that success is arrived at. To develop a plate which has received the correct amount of exposure to light is a comparatively easy matter, but to develop and make good printing negatives from plates which have been either under or over-exposed is where the skill of the operator is taxed to the utmost.

For beginners the ferrous-oxalate developer offers many advantages, although it possesses one drawback, *i.e.*, there is less control to be had over it than with the pyro developer, and therefore it is almost essential that the exposure be correct, otherwise the method is a very simple one. Stock saturated solutions are made of potassium oxalate, iron sulphate, and ammonium bromide. To the iron a small quantity of tartaric or sulphuric acid is added to preserve. For developing we pour into a glass measure four ounces of potash solution, and add to it one ounce of the iron and three or four drops of ammonium bromide. Dilute the whole with an equal quantity of water and flood over the plate. If the image

appears too quickly (the result of over-exposure) about 20 drops of the ammonium bromide restrainer must be added to the developer. If, on the contrary, the image is slow in appearing a little more of the iron solution may be added. If too much be taken, however, a yellow precipitate of ferrous-oxalate will be formed and the developer spoilt. With this developer the image should be allowed to get much darker than with pyro, as the density is very deceiving and becomes much lighter when placed in the fixing bath.

Deviation.—A term used in optics to denote the alteration of the course of a ray of light when it is reflected or refracted from its direct course.

Dextrine (Lat. *dexter*—right, and Eng. *ine*. Formula, $C_6H_{10}O_5$).—A substance made by heating starch paste to about 170° to 200° C. until it loses its gelatinous property. Also by the action of boiling dilute sulphuric acid on starch paste, and afterwards neutralising with chalk. If boiled for a longer time the dextrine is converted into dextrose.

Dextrine is a gummy, amorphorus mass, soluble in water, and precipitated by alcohol. It takes its name from its dextro-rotatory action on polarised light. It is very largely used as a substitute for gum, and is known also by the names of British gum, starch gum, etc. It makes a good mountant for photographic prints. See **Mountant.**

Dextrose (Formula, $C_6H_{12}O_6$.; synonym, *grape sugar*, *dextro-glucose*, etc.)—Occurs in grapes and other sweet fruits, also in honey. It can also be produced by boiling starch with dilute sulphuric acid for several hours. The solution is then neutralised with chalk, filtered, boiled with animal charcoal, to remove traces of colour. The whole is then evaporated to dryness, forming an amorphorus mass containing about 60 per cent. of dextrose, the remainder being chiefly dextrine.

Di (Gr. *dis*—twice.)—A prefix expressing "double," twice. In chemistry the prefix di is now used instead of bi, as dichloride of mercury, dichromate of potassium, etc.

Diactinic (Pref. *di*—twice, and *actinic*).—A term applied to any medium which allows both the actinic and non-actinic rays of light to pass through it. Substances which allow only non-actinic rays of light to pass are termed adiactinic.

Dialyser (Gr. *dialysis*—a separating).—The parchment paper or septum stretched over a wooden ring, and used in the process of dialysis. A similar arrangement is sometimes used in the emulsion process for washing the gelatine emulsion. It may be constructed as follows:—Take a box having a tight-fitting lid; knock out the top and bottom, and stretch over one end a piece

of parchment paper, fitting the rim of the lid over it to keep it tightly into position. This arrangement is then allowed to float on water. The substance to be dialysed is poured on to the septum, when diffusion immediately takes place, the crystallised elements passing through and being dissolved in the pure water, while the colloid remains behind. In the case of emulsions the unnecessary salts, such as nitrate of soda, &c., pass through the septum, leaving the colloid gelatine holding the sensitive silver salts behind.

Diameter.—A straight line drawn passing through the centre of a circle, or other curvilinear figure, and terminating each way at the circumference.

Given the diameter of a circle, multiply it by 3.1416 to obtain the circumference, and *vice versâ*.

To obtain the area of the circle, square the diameter and multiply by ·7854.

To obtain the solid contents of the sphere, multiply the cube of the diameter by ·5236.

Diamond.—A small piece of diamond mounted in a handle, and used for cutting glass.

Diamond Cement. — Soak a small quantity of isinglass in cold water until soft, then dissolve it in the smallest quantity of proof spirit by gently warming. In ½ oz. of this dissolve 20 grains of ammoniacum, and, while still liquid, add a solution of two drachms of rectified spirit ; stir them well together, and place in covered bottles. When required for use, stand the bottle in hot water till the solution liquifies.

Diamond Lens.—A lens made with a diamond. It possesses very high refractive and small dispersive power, and consequently requires much less curvature than glass lenses of the same focal length.

Diaphanous (Gr. *diaphaino*—to show through).—Transparent, translucent.

Diaphanoscope (Gr. *diaphaino*—to show through, and *skopeo* —to see). — A dark box for exhibiting transparent pictures with or without a lens. The positive should be placed in the box at a distance from the eye equivalent to the focal length of the lens with which the negative was made.

Diaphragm (Gr. *diaphragma*—a partition).—These are metal plates, each having a hole in the centre with different diameters, ranging in diameter in geometrical proportion to the focus of the lens to which they belong. Fig. 48 shows the form in which they are usually made. Each plate is made to slip in front of or between the combination of the lens, and ob-

struct the transmission of the marginal rays, and allow only those to enter which are parallel to the axis of the lens. The

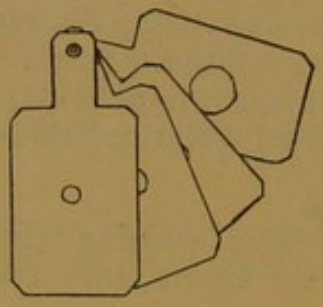

FIG. 48.

larger the aperture, or the longer the focus of a lens, the less depth of focus. By inserting a "diaphragm," or "stop"* as it is sometimes called, we are able to reduce the aperture of the lens and increase the depth of focus, and the smaller the stop the greater the depth. But in doing this we also reduce the amount of light, and cause the lens to work much slower, as the rapidity of the lenses, caused by the amount of light which it transmits, is directly proportioned to the area of the diaphragm aperture. Some idea of the effect of the stop is shown in Fig. 49. Here we have the stop

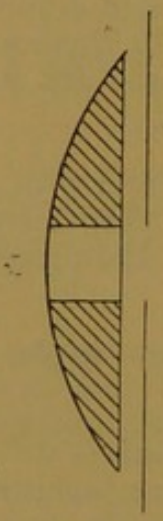

FIG. 49.

placed close to the lens, which immediately reduces it very considerably. In Figs. 50 and 51 we see the effect of the diaphragm upon the depth of focus of the lens. The rays *r r*

* The stop and diaphragm, although synonymous in optics, are not so, however, in photographic optics, and it is an error to confound the two. A *stop* is placed *in contact* with the lens, and a *diaphragm* some distance from it. The *stop* reduces the lens to its central aperture; the *diaphragm*, on the contrary, allows all the segments of the lens to act, but from different radiating points.

coming from a distant point, form after passing through the lens L, an image at or on the ground glass B. If we move

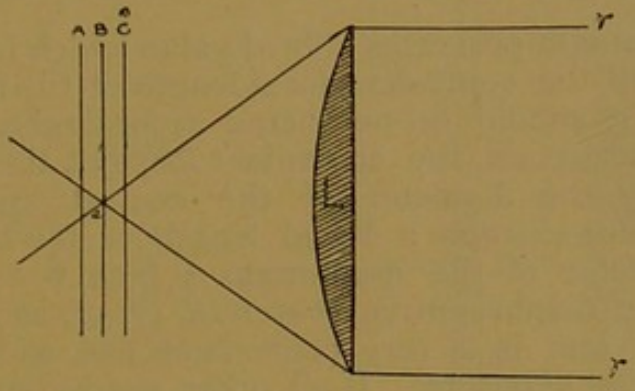

FIG. 50.

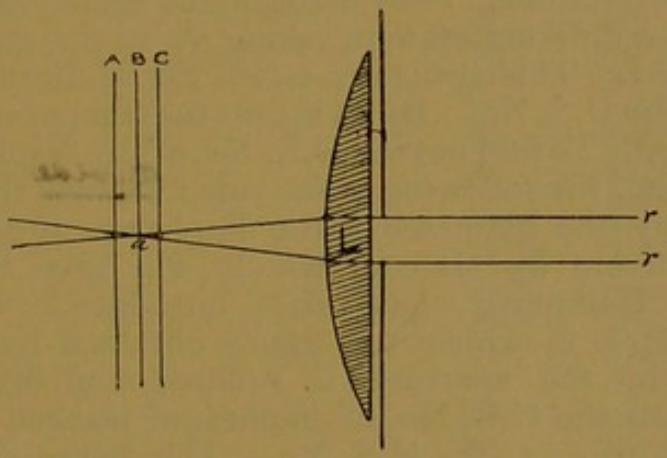

FIG. 51.

the ground glass to C or to A, the image would immediately spread out and become indistinct. But in the next illustration we see the rays *r r* are caused by the stop to be much less convergent when leaving the lens, and, in consequence, the ground glass could be moved to A or to B without any appreciable alteration taking place in the image.

If we now move the stop to a proper distance from the lens it becomes a diaphragm. In single lenses it is usually placed from $\frac{1}{4}$ to $\frac{1}{2}$ of the focal length in front of the lens. In this position it limits the diameter of the pencils of light, causing them to cross the axis at the aperture of the diaphragm before refraction. In symmetrical doublet lenses the position of the diaphragm should be in the centre of the two combinations. In combinations which are not symmetrical the position is proportionate to the foci of the combinations.

Besides giving greater depth of focus the effect of the stop is also to correct spherical and other aberrations in a lens (see **Aberration**). The principal points to be remembered in using a diaphragm are these: The larger the aperture the bolder the picture and the more rapid the exposure required. In focussing

always remove the diaphragm. The smaller the diaphragm, the longer the exposure, the greater the depth of focus, and the flatter the image.

Every diaphragm possesses a focal value which is the relation of its diameter to the equivalent focal length of the lens to which it belongs, and it should be numbered accordingly. To find this number first ascertain the equivalent focus of the lens, and then divide this by the diameter of the central aperture of the diaphragm. For example: Focal length of the lens is 6 inches, and the diameter of the diaphragm $\frac{1}{2}$ inch $6 \div \frac{1}{2} = 12$. The number of the diaphragm is, therefore, 12, or, as it is expressed, $f/12$. This system is a very convenient one, as it assists in the calculation of the exposure. If all other conditions be equal the exposures required are proportional to the squares of the denominators of these fractions. The Photographic Society of Great Britain have adopted a different system, taking $f/4$ as the standard, which is termed No. 1. This system is called the Uniform System, and the numbers the U.S. No. By its means the comparative exposures are at once seen. To find out the U.S. No. of any diaphragm marked upon f/x system, the following is the rule: Divide the focal length of the lens by the diameter of the diaphragm to f/x, square the result, and divide by sixteen, which will give the U.S. No. Mr. T. R. Dallmeyer has also introduced a system of numbering stops in which the figure obtained by dividing the focal length by the aperture is squared and divided by ten. Example: Find the U.S. No. of diaphragm marked $f/20$, $20 \times 20 = 400$; $400 \div 16 = 25$ the U.S. No. The following table gives the U.S. Nos. for all diaphragms marked on the f/x system.

F.	U.S. No.	F.	U.S. No.
1	$\frac{1}{16}$	28	49
$1\frac{1}{4}$	·097	29	52·56
1·414	$\frac{1}{8}$	30	56·25
1 5	·140	31	60·06
1·75	·191	32	64
2	$\frac{1}{4}$	33	68·06
2·25	·316	34	72·25
2·5	·390	35	76·56
2·828	$\frac{1}{2}$	36	81·0
2·75	·472	37	85·56
3	·562	38	90·25
3·25	·660	39	95·06
3·5	·765	40	100
3·75	·878	41	105 06
4	1·0	42	110·25
4·25	1·12	43	115·56
4·5	1·26	44	121·0
4·75	1·41	45	126·56
5	1·56	45·25	128
5·25	1·72	46	132·25
5·5	1·89	47	138·06
5·656	2	48	144
5·75	2 06	49	150·06
6	2 25	50	156·25

F.	U.S. No.
6·25	2·44
6·5	2·64
6 75	2·84
7	3·06
7·25	3·28
7·5	3·51
7·75	3 75
8	4
8·25	4 25
8·5	4·51
8 75	4 78
9	5·06
9·25	5·34
9·5	5·64
9·75	5·94
10	6·25
11	7·56
11·31	8
12	9
13	10 56
14	12·25
15	14·06
16	16
17	18·06
18	20·25
19	22·56
20	25
21	27·56
22	30·25
22·62	32
23	33·06
24	36
25	39·06
26	42 25
27	45·56

F.	U.S. No.
51	162 56
52	169
53	175·56
54	182·25
55	189·06
56	196
57	203·06
58	210·25
59	217·56
60	225
61	232·56
62	240·25
63	248·06
64	256
65	264 06
66	272 25
67	280·06
68	289
69	297·56
70	306·25
71	315 06
72	324
73	333·06
74	342·25
75	351·56
76	361
77	370·56
78	380·25
79	390 06
80	400
81	410·06
82	420·25
83	430 56
84	440

It is not absolutely necessary that the aperture on the diaphragm shall be circular. Many other forms have been devised. Fig. 52 is a diaphragm much used by the writer in hot climates when the distant mountainous background was so actinic that it was almost

FIG. 52.

impossible to obtain correct exposure of background and foreground together. By using a stop of this kind the actinicity of the sky

and background was reduced. A similar effect is obtained with Sutton's sky diaphragm (figs. 53 and 54).

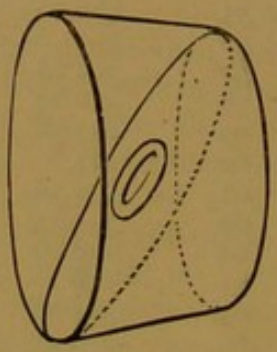

FIG. 53.

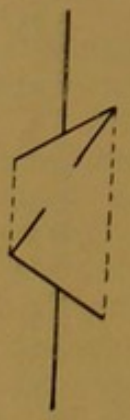

FIG. 54.

The object of this is more clearly shown in fig. 55. The largest

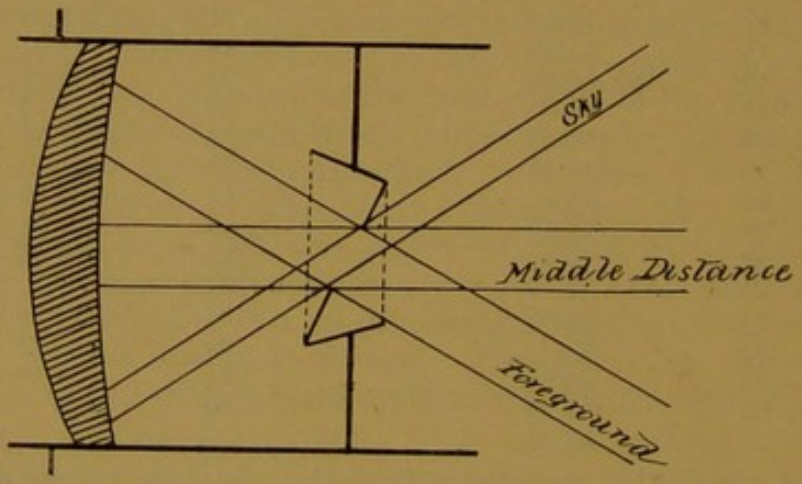

FIG. 55.

amount of light entering the lens is from the foreground, whilst the sky receives the least.

Fig. 56 is the form of aperture recommended by Fisck for stereoscopic diaphragms.

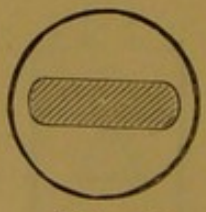

FIG. 56.

Within the last few years a new kind of diaphragm, termed the Iris diaphragm, has been devised. It consists of a number of thin pieces of metal fastened to a ring in the lens mount. By turning the ring backwards or forwards the aperture of the diaphragm may be enlarged or diminished at will. A pointer on the outside of the ring indicates the different apertures of the diaphragm. Loose dia-

phragms are very apt to get mislaid or lost. They should be riveted together, as shown in fig. 48. Another form is the rotating diaphragm. In this the apertures are cut upon a circular plate, which is centred, so that its revolution may bring either aperture exactly central with the lens, a small catch indicating to the operator when it is in its proper position. This kind of diaphragm is generally fitted to wide-angle and view lenses.

Diapositive.—A positive made from a negative.

Diathermanous (Gr. *dia*—through, and *thermaino*—to heat).—Any substance through which heat can freely permeate is said to be diathermanous or diathermal.

Dicarbonate.—Carbonate containing ~~one~~ two atoms of carbonic acid with ~~two~~ one of the element with which it is combined. Synonym, bicarbonate.

Dichloride.—A compound of two atoms of chlorine with an element. Synonym, bichloride.

Dichroic (Gr. *dichroia*—double colour).—A substance is said to be dichroic when it assumes two or more colours, according to the direction of the light transmitted to it.

Dichromate. (Gr. *dis* — two, and *chromate*). — A double chromate, as potassium dichromate. Synonym, bichromate.

Dicyanide (Gr. *dis*—two, and *cyanide*).—A compound containing the radical cyanogen (CN) twice united to another element, or dyad radical. In the case of metallic cyanides the prefix *di* is often omitted, the atomicity of the metal indicating the number of CN contained in it.

Diffraction.—In optics, the peculiar modification that light undergoes when it passes by the edge of an opaque body by being deflected from its direct course.

Diffraction Grating.—A number of fine parallel lines placed closely together. When light falls on them it diffracts and produces a spectrum with the rainbow colours.

Diffusion (Lat. *diffusus*—to pour about).—Literally the act of diffusing or spreading a liquid, &c.

Diffusion of Light.—A ray of light when it does not arrive direct, but is spread about, is termed diffused light. The light of the *atelier* is usually diffused with ground glass or translucent material. Diffused light in the camera resulting in fog is that light which does not come direct from the lens on to the plate.

Diffusion of Gases—The passing of one gas into the space occupied by another. The diffusion of gases takes place at a rapidity that is inversely proportional to the square roots of their densities or specific gravities.

Diffusion of Liquids.—If two liquids capable of mixing are placed in contact with each other they will gradually diffuse one into the other.

Diffusion of Focus.—When the focus of the image is spread out it is termed diffused. Dallmeyer constructed a lens in which the back portion of the combination could be moved backwards to diffuse the focus, and give a hazy, soft appearance to the portrait.

Digestion.—A process of digestion is used in emulsion-making. The emulsion is exposed to a gentle heat for some time to obtain sensitiveness.

Dilute.—To make thin with water.

Dimorphous.—Substances which exist in two different forms are termed dimorphous.

Dioptrics.—That branch of science which treats of the different refractions of light on passing through different mediums.

Diorama.—A mode of scenic representation in which the spectator and picture are placed in separate rooms, and the picture viewed through an aperture, the sides of which are continued towards the picture so as to prevent the distraction of the eye by other objects. All light admitted passes through this aperture from the picture, which is illumined by light from above at such an angle as to be reflected through the aperture towards the spectators. By an arrangement of shutters, screens, reflectors, &c., the light can be modified to represent changes of sunlight, cloud and moonlight, transparent portions of the picture admitting light from behind certain portions which are brilliantly illuminated (Knight). Dioramas were first exhibited in London on September 29th, 1823, by M. Daguerre, one of the fathers of photography.

Dioxide (Gr. *dis*—twice, and *oxide*).—A term applied to an oxide consisting of one atom of a metal combined with two atoms of oxygen.

Dipper.—The holder for the glass plate when immersing in the nitrate bath used in the wet-collodion process, *q.v.*

These dippers are made of glass, ebonite or of silver wire with hooks at the bottom to hold the plate.

Dish.—The dish, or bath as it is more often called, is a very necessary article in all photographic processes. It is made of various materials—glass, earthenware, celluloid, vulcanite, metals, wood, papier maché, etc. For the principal operations, such as developing, fixing, toning, etc., separate baths should be kept, which should not be used for any other purpose. See also **Bath.**

Disinfectant.—A substance which will destroy or neutralise bad odours, and prevent infectious diseases from spreading.

Carbolic acid is the most powerful disinfectant known. As a deodoriser, however, carbolic acid is not so energetic as chlorine or permanganate of potash. Sulphuric acid in the liquid state is a powerful disinfectant, as also are mercury salts, such as corrosive sublimate and biniodide; these are much used as antiseptics. A quantity of a disinfectant should occasionally be poured down the dark room sink and into the various drains about the house.

Dispersion.—A term used in optics denoting the separation of a ray of homogeneous light by refraction into an infinity of refracted rays of different refrangibility.

Different transparent media have different dispersive powers measured by the length of the spectrum made by them. Flint glass is more dispersive than crown glass, because the spectrum which it furnishes is longer, and it is owing to this difference in dispersive power that we are enabled to eliminate chromatic aberration.

In optical formulæ the measure of the dispersive power of the medium is the fraction—

$$\frac{n_v - n_r}{n_y - 1}$$

n_v being the refractive index for the violet ray, n_r for the red ray, and n_y for the ray of mean refrangibility.

In general, rays of short wave length are more refracted than rays of long wave length, but in some refracting media this law breaks down in part. This is known as *anomalous dispersion*. The term *false* dispersion is applied to the scattering of light by reflection from moles suspended in transparent media.

Dissolution.—In chemistry, the re-solution of any body the smallest parts by chemical agency.

Dissolving Views.—See **Magic Lantern.**

Distance.—The extreme boundary of view in a picture, that part which appears farthest from the eye. In perspective the *point of distance* is that point of a picture where the visual rays meet. The *middle distance* is the central part of the picture, and the *line of distance* is a straight line drawn from the eye to the principal point on the plane. See also **Aerial Perspective.**

Distilled Water (Formula, H_2O; molecular weight, 18).—Pure water obtained by distillation. In all delicate and important photographic operations distilled water should be used. Pure distilled water should give no precipitate with $AgNO_3$ showing absence of any chloride; nor with ammonia oxalate, which would otherwise show the presence of lime; nor with barium chloride $BaCl_2$, proving the absence of sulphuric acid. If a drop of permanganate of potassium or Condy's fluid be dropped in the water it should give a pink tint, thus proving the absence of organic matter.

Distortion.—When the image formed by a lens upon the focussing glass of the camera does not coincide with the laws of perspective it is said to be distorted. There are two kinds of distortion—one in which objects are exaggerated in dimensions quite contrary to the laws of perspective. A wide-angle lens is guilty of this distortion, and therefore should never be used unless absolutely necessary to include a view which cannot otherwise be made. The other kind of distortion is produced in most lenses by the refraction of the oblique eccentrical pencils of light by the margin of the lens. Distortion by divergent lenses is just the reverse of that by convergent lenses. Thus the lines fig. 58 would be distorted as in fig. 59 with a divergent lens, but with a convergent one they would appear as in fig. 60.

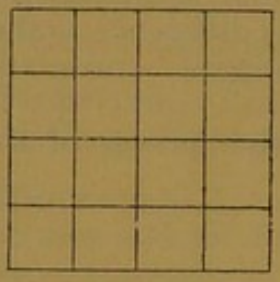

FIG. 58.

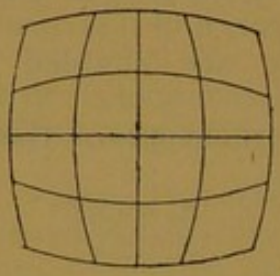

FIG. 59.

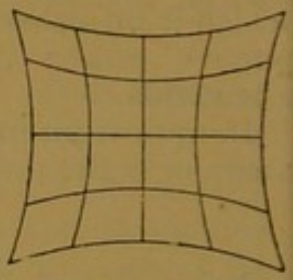

FIG. 60.

The position of the diaphragm in a single lens alters the distortion also. If placed in front of the lens the distortion is as in fig. 59, but if behind the lens it would appear as in fig. 60.

It is therefore clearly seen that if we use two symmetrical lenses, and place the diaphragm between, the distortion of one is counteracted by the distortion of the other, and the lens is said to be rectilinear. Upon this principle all the non-distorting doublets are manufactured.

The distortion of a single lens is not great unless its focus be very long, and it is only noticeable in taking buildings near to, which should never be done except with a correct lens. Dallmeyer has recently introduced a rectilinear single lens which may be considered a great achievement.

Divergent.—A term given to lenses which cause divergence of the rays of light entering them.

Divergent Rays.—Those rays which, starting from a certain point, diverge or recede from each other in proportion as they recede from the object. The opposite of convergent.

Dodging Negatives.—Comparatively but few negatives are absolutely perfect. The term dodging is used in the printing process to methods of improving the printing qualities of a negative by various dodges. If the negative be very hard and chalky, printing in the sun will sometimes result in a good print. While, on the other hand, if the negative be very weak and flat,

it should be printed in the shade, or with a piece of green glass placed over the printing frame. Some negatives are thinner at one end or at one part than another. In such cases the printing frame is placed in a deep box without a lid, with the densest part uppermost, or by sticking pieces of paper over the weaker parts. The high lights of a weak negative can often be improved by touching up with a little yellow dye mixed in varnish.

Double Concave.—See **Bi-concave.**

Double Convex.—See **Bi-convex.**

Double Dark Slide.—A dark slide capable of holding two plates. (See **Dark Slide.**)

Double Decomposition.—The mutual interchange of the atoms of two compounds. With solutions this is often attended by precipitation. Thus, if a solution of silver nitrate $AgNO_3$, and another of salt NaCl, be added together, the following change takes place—$AgNO_3 + NaCl = NaNO_3 + AgCl$, the silver chloride being precipitated. In the silvering of albuminised paper the same effect takes place, the silver chloride precipitate being held on the paper.

Double Exposure.—An error often made by amateurs in unconsciously exposing the same plate on two occasions. To obviate this, each dark slide should be numbered and fitted with a little tablet, upon which the subject of the exposure may be written. Many devices have recently been made to prevent double exposure. They mostly consist in self-acting locks or catches on the dark slide, which cannot be opened a second time without the knowledge of the operator.

Double Extension.—An arrangement in a camera by which the base-board, to which the front and back of the camera are attached, being made double, is extended nearly double its usual length, one portion falling upon or into and sliding over the other. The object of this is to allow of long focus lenses being used.

Double Image.—A double or blurred image is sometimes obtained in the camera, caused by movement during exposure on a windy day. The camera should be steadied with a heavy weight attached to it. The camera should fit firmly on to the stand, and be free from vibration, otherwise double images will be the result. Double images are also sometimes caused by rapid shutters having a double movement; the shutter flying up hits the top and shifts the position of the camera.

Double Printing.—A method of printing from two negatives, or the combination of portions of two negatives.

Double Refraction.—See **Refraction.**

Doublet Lens.—See **Lens.**

Double Transfer Paper.—A paper used in the double transfer process. See **Carbon Process.**

Double Transfer Process.—See **Carbon Process.**

Drachm or Dram.—A small weight. In *apothecaries' weight*, the eighth part of an ounce, or 60 grains. In *avoirdupois weight*, the sixteenth part of an ounce. ≈ 27⅓ grains

Dragon's Blood.—A resin, so called on account of its red colour. It is very opaque and brittle, and is tasteless and without odour. Pure dragon's blood dissolves with a fine red colour in alcohol or ether, and also in both fixed and volatile oils. It is largely used in the preparation of varnishes.

Draining Rack.—Racks made of wood, metal, or porcelain for draining or drying plates.

Drawing Paper, Printing on.—Very good effects may be produced by printing with silver chloride on a rough drawing paper such as Whatman's. The picture should not be mounted, but printed like engravings with very wide margins. The roughness of the drawing paper gives that artistic dull appearance of the engraving. The method of preparing the paper is as follows:—The drawing paper is cut into convenient sizes and floated on a shallow dish containing—

Gelatine	25 grains
Water	6 ounces.
Salt (pure)	25 grains

One minute will suffice, when it is removed and hung up to dry. When dry a slight pencil mark is made on the salted side for future guidance. The paper may be sensitised by floating on the silver bath used for albuminised paper, or the silver solution can be applied with a broad camel-hair or bristle (*q.v.*) The strength of the solution should be about 60 grains of silver nitrate to the ounce. When sensitised the paper is attached to American clips and hung up to dry in a yellow light. When dry the usual printing operations are performed. A piece of black paper is cut the size of the sensitised paper, and a hole cut in the centre the size and shape of the picture. This is used as a mask in printing, and gives the wide margin. Printing is carried out to a deeper extent than with albumen paper, as there is always an unavoidable loss of brilliancy in the toning and fixing operations. The following toning bath answers well:—

Gold bichloride	1 grain.
Sodium bicarbonate	40 grains.
Distilled water	10 ounces.

This gives the black engraving tone so much admired. After toning fix with ordinary ten per cent. hyposulphite bath and well wash.

Dropping Bottle.—A small bottle for supplying liquids in small quantities or in drops. See fig. 61.

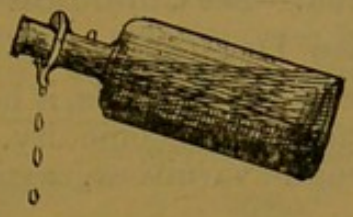

FIG. 61.

Drop Shutter.—See **Shutters.**

Dropping Tube.—A tube open at both ends, the lower aperture being quite small. The tube is charged with the liquid, and the finger closed upon the upper end, and when relaxed it allows the liquid to exude in drops from the lower end. The dropping bottle, pipette, burette, and drop meter have all a similar purpose.

Drying Box.—A light-tight box used for the drying of p'ates and other preparations. The arrangements necessary to constitute a good drying box, or cupboard, are first a contrivance by which a current of air is made to pass through it and take up all the moisture. In order to do this the air passing through should be slightly warmed, so that it will take up more moisture. Fig. 62 shows the principle upon which the shelves to hold the plates should be fitted, so as to allow a free current of air to pass through. The temperature of the drying box should, of course, be raised, but without ventilation this would be useless, as water may be saturated with moisture at any temperature below that of boiling point, but the moist air must be removed to allow the dry air to come and carry away the moisture.

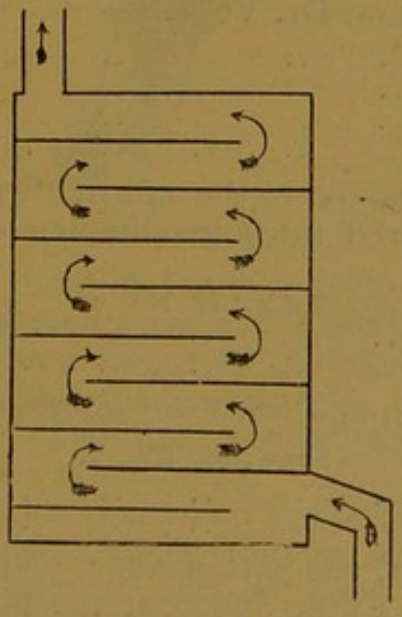

FIG. 62.

A good form of drying cupboard for gelatine plates is given under **Dry Plates.**

Dry Collodion Process.—See **Collodion Emulsion Process.**

Dry Distillation.—See **Destructive Distillation.**

Drying Oils.—Linseed and other oils, if heated with lead oxide, absorb oxygen from the air, and become dry. They are used as a base to many paints and varnishes, assisting in the drying operation.

Dry Plates.—Plates of glass of different sizes, coated with a film of gelatine in which a sensitive silver salt is emulsified. Dry plates are now manufactured in such large quantities that it is rarely beneficial to either amateur or professional photographer to manufacture his own, unless for special purposes. The competition in price of commercial dry plates has resulted in the manufacture of many kinds which are weak in emulsion and silver. These should be avoided, as the slight difference in price is by no means economical.

Under the heading **Emulsion** will be found the necessary instructions for making the bromide of silver, or other gelatine emulsion ready for coating the glass plates. We shall first describe the method of preparing dry plates by hand, and afterwards by machinery.

The emulsion ready filtered is placed in a convenient flask for pouring. Some glass plates of the required size are then thoroughly cleaned by immersion in nitric acid, and then rubbed with caustic soda and a little alcohol, and set up on end on blotting paper to dry.

With some kinds of emulsion it is necessary, to prevent frilling, to first coat the plates with a substratum, which may be made up from either of the two following formulæ. The first is Mr. Forrest's, and the second Dr. Vogel's—

White of egg	1 ounce
Water	20 ounces
Methylated spirit	1 ounce
Carbolic acid	20 drops

The carbolic acid is added to the spirit, stirring the mixture the while, when it is poured into the albumen and water previously mixed together.

SOLUTION No. 1.

Gelatine	50 grains
Acetic acid	½ ounce

Place these in a bottle, and warm till solution takes place.

SOLUTION No. 2.

Chrome alum	10 grains
Water	½ ounce

Take 2½ parts of No. 1, one part of No. 2, and add them to 70 parts of methylated spirit. Filter and coat the plates, then clean and dry as with collodion.

The next point to be considered is the levelling stand, or shelf, upon which the plates are to rest after coating. An ordinary triangular levelling stand will answer the purpose. The following contrivance is, however, simpler (see fig. 63). A piece of thick plate glass about three feet long and two feet broad is laid upon

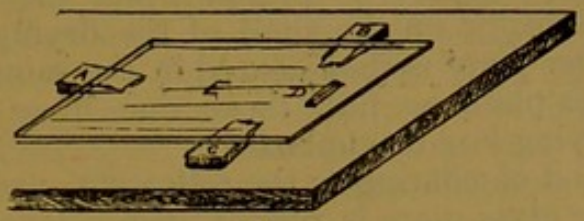

Fig. 63.

the table, and three mahogany wedges placed under it in the position shown. A small spirit level D is placed across the plate, as shown, and the two wedges C and B are altered until the bubble in the level is in the centre. It is then turned lengthways across the plate, and the bubble again adjusted to the centre by altering the position of wedge A, not disturbing the other two in the least. The plate should now be perfectly level.

The emulsion should be kept at a temperature of about 90° Fahr. by a hot water bath. The plate is laid hold of by a pneumatic holder, or by the tips of the fingers, and the necessary quantity of the emulsion poured on. For a whole plate 8½ by 6½ inches about three drachms is required, and other sizes in proportion. This is

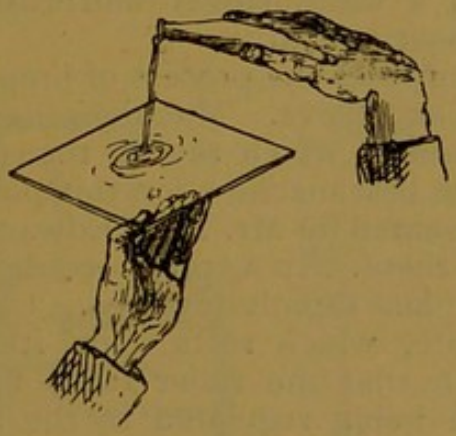

Fig. 64.

poured on as shown in fig. 64, care being taken that no air-bubbles are formed. Arrangements are now made for pouring emulsion on to plates. They are somewhat in the shape of teapots, with an inner vessel into which the emulsion is poured. The emulsion that is poured out comes from the bottom of the bulk, so that bubbles on the surface are avoided.

When the emulsion is poured on to the plate the latter is slightly tilted, and the emulsion made to run into the right-hand top corner, and from there to the left-hand top corner, left-hand bottom corner, and finally to the right-hand bottom corner. To facilitate the coating a larger amount than required may be poured

on, and after flowing over the plate a portion may be returned to the bottle, leaving only the required quantity on the plate.

The temperature of the room should be between 55° and 65° Fahr.

The plate after coating is slowly rocked about until the emulsion is evenly spread, when it is placed upon the levelling stand, levelled glass plate, or on the shelf of the drying-box previously levelled. Another plate is then coated in the same manner, and if the levelled glass plate be full, those that have set may be removed to the drying box or cupboard.

Another method of coating is the following, usually adopted by the writer. The glass plate is placed upon a levelling stand, and arranged perfectly level. The exact quantity of the emulsion is then poured on to the centre of it, and with a spreader (fig. 65), made of a piece of bent glass rod or tubing, the emulsion is spread evenly over the plate.

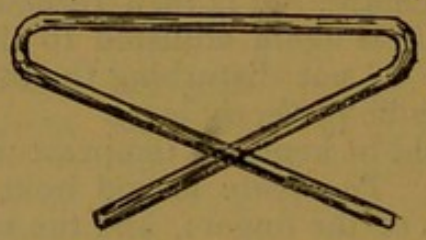

FIG. 65.

Plates may also be coated by brushing a small quantity of the emulsion over with a wide badger hairbrush, and afterwards pouring on the necessary quantity.

For commercial purposes the process of preparing dry plates by hand would be too expensive. Machines have, therefore, been constructed, by means of which several thousands can be coated per diem. About the best machine for this purpose, and the one mostly used, was invented by Mr. B. J. Edwards. The principles of the machine are these. In a trough containing the emulsion a roller of silver or glass rapidly revolves. Upon one side of the roller is a metal plate, which rests upon it and scrapes off the thin film of emulsion that the roller takes up in revolving, the thickness of the film being regulated by the speed of the roller. This thin layer of emulsion scraped off runs down on to the glass plates, passing one after another beneath, giving a perfectly even coating. The coated plates then run through a part of the machine, which is kept very cool, and they are very soon set. An operator at the other end then removes them one by one as they come out, and places them in a rack, which, when full, is sent up to the drying room. Another machine for coating plates is that of Mons. Hutinet. It has the appearance of a long, skeleton table, about 60 or 70 feet long. Along this table endless bands of a stout material are constantly travelling, kept in motion by a small gas or hot-air engine. At one end of the table is the arrangement for coating. A small hot-water cistern, containing the jar with the

prepared emulsion, is placed on a raised platform. A small pipe fitted with a glass stop cock conveys the emulsion from the cistern in an even stream to an open glass cylinder. This cylinder is perforated on its lower part with a number of holes, through which the emulsion oozes, and spreads itself over an indiarubber roller below. Underneath this roller the glass plates are made to pass along by the endless band, and as it presses lightly upon them it applies the emulsion in a thin even layer. The plates, after they have received the necessary coating, pass along the lengthy machine, kept quite level, so that they are quite set before they reach the other end, from whence they are conveyed to the drying room.

The drying of gelatine plates is by no means an easy matter. The principal desideratum is a current of dry air, which carries with it the moisture from the gelatine, and escapes with it out of the drying chamber or cupboard. In fig. 66 we have a good form of drying box recommended by Dr. Eder in his work on "Die Photographie mit Bromsilber-gelatin." The direction of the arrows shows the passage of current of air. In the pipe which conveys the vitiated air out of the room is a gas flame, which can be regulated through the door.

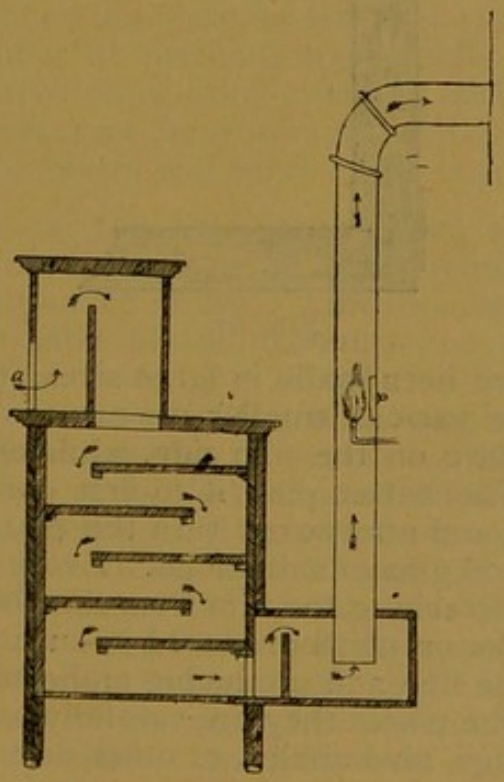

Fig. 66.

The heated air from this flame will rapidly ascend, drawing with it the air from the drying box in which the plates are placed. Some small holes are made to allow of the entrance of the fresh air.

Great care should be taken to prevent dust from reaching the plates during the drying operation, also that the temperature of

the room or cupboard be kept even. About 80° Fahr. is about correct. Sudden changes of temperature will produce markings upon the surface of the plates. The door of the drying cupboard should never be opened after the plates are put in until they have been allowed ample time to dry.

The drying operation should take from six to eight hours. It should not be hastened, as quick drying is a great mistake, and often results in bad plates and frilling.

Plates may be dried in an hour, if urgently required, by placing each plate when thoroughly set into a dish of methylated spirit, quite free from resinous matter, for about ten minutes. When taken out it will dry in less than an hour.

With all these operations the most careful precautions must be taken to exclude all light, especially if the emulsion be very highly sensitive. In coating the plates the light used should be only sufficient to enable one to work carefully. All parts of the room should be carefully looked to. Fig. 67 shows a plan of a light-tight door, upon which principle it would be well to construct the door of the room or of the drying box.

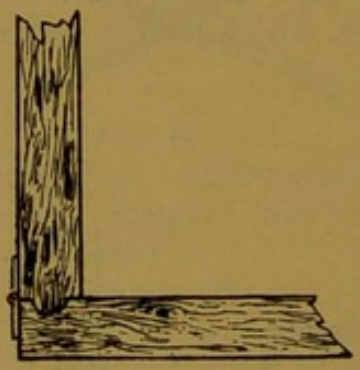

Fig. 67.

If the plates have been made in large sizes, it will be necessary to cut them to the various smaller dimensions required. Some workers cut the plate on the film side, while others prefer to cut from the back. The better plan is to first cut the gelatine film with a sharp knife, and afterwards turn the plate over and divide the glass with a good glazier's diamond. Every precaution should be taken to avoid detaching the film from the glass, and to prevent the fine glass powder or chips produced in cutting from getting on to the surface of the film and producing pinholes.

Before packing the plates they are carefully examined and those which have markings, air-bubbles, or other defects are put aside.

Air-bubbles are usually caused in the pouring out of the emulsion. The vessel containing the emulsion should be held as near to the plate as possible.

Frilling of the film is sometimes due to unequal drying. If plates be dried in a box that is imperfectly ventilated the outside parts become dry, leaving a patch of undried emulsion in the centre. At the junction of the two parts frilling may be looked for. In warm

weather plates are more likely to frill than in cold, as the emulsion remains upon the plate in a liquid state for a longer time, allowing the silver salts held in suspension in the emulsion to fall down and settle on the glass, thus diminishing the adhesive surface. Plates that frill easily may be used with safety if coated with a plain collodion made up with—

Pyroxyline (tough)	6 grains.
Alcohol (·820)	½ ounce.
Ether (·725)	½ ounce.

immediately preceding development, the solvents being washed away in a dish of clean water, and the developer applied; or the plates may be coated with the collodion and allowed to dry if they be immersed in one part of ether and three parts of alcohol previous to development.

Opaque spots found on the film are generally due to dust settling on the film in drying.

Comet-like and other peculiar markings are due to irregular drying. Precautions should be taken that a perfectly even current of air passes through the drying box.

There are several methods of packing gelatine dry plates. The most simple way is to place them face to face with little frames, made the same size as the plate, of strips of cardboard about $\frac{3}{16}$in. wide. All the different methods have really the same end, *i.e.*, to keep the sensitive films from touching each other. For those who do not manufacture large quantities light-tight boxes with grooves to hold the plates will serve every purpose.

Dust.—Present in the atmosphere from various causes. Its existence is most easily seen when a beam of light traverses the air, lighting up the suspended moles. Aiken has devised an apparatus for counting the number of dust particles in a given sample of air or gas.

Dust is a great nuisance to the photographer, producing black or white specks in the positive or negative. Before a dry plate is laid in the dark-slide it should be dusted with a camel-hair brush, or if any dust be adhering to it during exposure it will show in the negatives as tiny white spots, and in the positive as black ones. The negative should also be dusted before placing it in the printing-frame, or the same result will occur, except that this time we obtain little white spots in the positive. In the manufacture of photographic plates and paper the utmost precautions must be taken to prevent dust settling on and adhering to the wet films.

Dusting-on Process.—See **Powder Process.**

Dutch Varnish.—See **Varnish.**

Dyes.—A large quantity of coal-tar and other dyes are used in photography, in the orthochromatic or isochromatic process, as

sensitisers to the yellow and orange rays. The principal of these are coralline, aldehyde, green chinolin, eosin, erythrosin, and cyanin. (See **Isochromatic Photography.**)

The use of the dye as a sensitiser is more clearly explained under **Isochromatic** process. It might be as well here to mention, however, that errors have often been made by writers in stating that red dyes render the plate sensitive to red rays, green dyes to green rays, and so on. Many dyes act quite to the contrary. Fuchsine or magdala red cause bromide of silver to be sensitive to yellowish green and not to red, while aldehyde green sensitises for red rays. The general rule is that dyes make bromide of silver sensitive to those rays which they absorb, although all dyes do not act in this manner. Those dyes which bleach rapidly in the light are usually the best, although there are many exceptions to this rule. Triphenylic red, fuchsine, eosine, cyanine, picrate of methyl, magdala green, carmine, annatto, turmeric, chlorophyl, methyl violet, alkaline blue, rosaniline and aldehyde green have very peculiar effects. If these dyes be mixed with bromide or chloride of silver, and exposed to light, the bromide or chloride of silver shows an increased sensitiveness to those parts where the absorption spectra of the respective dyes lie ; the action being only visible if certain substances which serve as sensitisers are present, such as silver nitrate, tannin, pyrogallic acid, etc. *

Dyed Screen.—A coloured screen used in the isochromatic process, *q.v.*

Dye Sensitisers.—Dyes used as sensitisers in the isochromatic process, *q.v.*

Dynactinometer.—An instrument for measuring the intensity of actinic power, or for comparing the rapidity of lenses.

Drainage.—The condition of the drains is, to the photographer, a most important consideration. In operating with photographic chemicals sinks should be provided with a large sized waste pipe, down which quantities of water should be made to flow at convenient periods. Very often several different chemicals are thrown down the drainpipes which mix together, forming bad and noxious gases. Acids should never be emptied down the sinkpipes, as it will quickly eat its way through the metal tubing. Large quantities of disinfectants should be used, especially in the warm weather.

Drawings.—Chalk and pencil drawings may be fixed so as not to suffer from slight abrasion by washing them with skimmed milk, or with water holding in solution a little isinglass or gum. If milk be used, great care must be taken to thoroughly

* Vogel, in "Photographische Mittheilungen.

deprive it of the whole of the cream, or it will cause the drawing to look streaky. An easy way is to float the drawing on the surface of the liquid placed in a shallow dish, after which it is placed in an inclined position upon white blotting-paper to dry.

In photographing drawings the paper or board upon which they are drawn is sometimes yellowed by age. This gives with the ordinary photographic process a dull, dirty appearance. It is very necessary in these cases to make use of the Isochromatic process *(q.v.)*

Decimal.—A tenth part. A decimal fraction is one whose denomination is 10 or some power of 10. It is not usual, however, to express this denominator, but a period called a decimal point is placed between the unit and the first fractional number; thus, 1·5 is the same as $1 + \frac{5}{10}$, or one and five-tenths. In like manner 1·05 means one and five-hundredths; 1·673 signifies one unit six-tenths seven-hundredths and three-thousandths of the unit, and so on.

The value of a decimal of any denomination is found by multiplying it by the number of parts in the next less term, and cutting off as many places from the right hand as there are decimals, and continuing this until the terms are exhausted, thus ·423 oz. is—

$$\begin{array}{r} \cdot 423 \\ 8 \\ \hline 3 \cdot 384 \\ 60 \\ \hline 23 \cdot 040 \end{array}$$

or a fraction over 3 drachms 23 grains.

Decoction.—The operation of boiling. This term is also used to denote the liquid itself, which has been made to take up certain soluble substances by boiling.

Defication.—The freeing from impurities.

Deflagration.—A rapid combustion, attended with much evolution of flame and vapour.

Deodoriser.—Any substance which has the power of destroying fœtid or noxious effluvia, chloride of lime, carbolic acid, etc., are excellent. (See **Disinfectant.**)

Detergent (Lat. *detergo*—to wipe away). — Any substance possessing the property of cleansing. Alkalies have the power of dissolving both soap and grease, hence both are used as detergents. For cleansing glass the agents used are generally Tripoli powder, ammonia, alcohol, caustic soda, potash and diluted acids. A solution of potassium dichromate and sulphuric acid is an effective cleanser, although the use of acids is always open to objection.

Cyanide is also a very good detergent, although highly dangerous to use. A glass can usually be rendered perfectly clean by rubbing well with a rag dipped in a cold solution of caustic potash, and then immersing it into a dilute solution of nitric acid, and giving it a thorough washing afterwards.

Devitrification.—The process by which glass loses its characteristic vitreous properties, and becomes opaque. The change can be produced by slow cooling, or by prolonged heating.

Distillation.—The process of applying heat to a liquid, or it may be a solid, in order that certain constituents may pass away in vapour, and by suitable arrangements be obtained in liquid form. When the vapour does not condense as a liquid, but only as fine dust or flour, the process is called sublimation (*q.v.*)

The apparatus for artificial distillation consists of three parts—the still, the condenser, and the receiver. The still is usually made of glass, copper, iron, or earthenware, according to the nature of the substances to be placed in it. In experimental chemical work glass is almost the only material admissible, while in the preparation of alcohol from grain copper stills are commonly employed. The condenser is made in an infinity of forms, the object being to condense the vapours disengaged from the still rapidly and as effectually as possible. For this purpose it is important that the condenser shall expose a larger surface to the cooling medium—water or air. Whatever the form the principle is the same, in that the hot vapours pass through a tube or vessel surrounded with cold water, which, running in a constant stream, passes away more or less warm after it has done its work. The receiver merely consists of a suitable vessel to receive the distillate.

There are various forms of distillation. Those best known are fractional distillation, destructive distillation, and distillation in vacuo.

Fractional Distillation.—A mixture of liquids having different boiling points is placed in a still, and heat is applied. If the temperature be raised slowly, and especially if the vapour requires to rise through a high tube before passing into the condenser, it will be found that the more volatile liquids pass over first in a state of purity and while the others follow as the heat is increased. If the receiver be frequently changed a series of fractions are obtained corresponding to the different substances in the still. For example, if a mixture of glycerine, water, alcohol, chloroform, and ether were distilled, the ether would distil first, then the chloroform, next the alcohol, and lastly the water, while nearly all the glycerine would be left behind. This, then, is fractional distillation.

Destructive Distillation is accomplished by heating non-volatile organic bodies in a retort.

Distillation in Vacuo.—If water is heated in a kettle it eventually boils, and if a thermometer be plunged in it will register 212° Fahr. If the barometer is low, however, the temperature of the boiling water will be somewhat lower than 212° Fahr., and if the barometer is very high the temperature is also high. On the summit of Mont Blanc water boils at 180°, while in a vessel from which the air has been removed by an air pump it continues to boil even when the temperature falls down below freezing point. These substances which are injured by heat are distilled in this manner in vacuo.

Eau de Javelle.—A solution of chloride of potash, sometimes used for eliminating the hyposulphite of soda from the films of the negative, or from the prints after fixing. It is also used for the reduction of too intense negatives, its reducing action being due to the free chlorine evolved. It may be prepared as follows:—

Dry chloride of lime	2 ounces.
Potassium carbonate	4 ,,
Water	40 ,,

Mix the chloride of lime with 30 ounces of the water, and dissolve the potassium carbonate with the remainder. Then mix, boil, and filter, and it is ready for use.

Ebonite.—A black ebony-like substance prepared with sulphur and caoutchouc. The proportion of sulphur is from forty to sixty per cent., and to this may be added shellac, guttapercha, zinc sulphates, antimony, or copper. It is used for making photographic dishes, and for dippers in the collodion process.

Ebullioscope (Lat. *ebullio*—to bubble up, and Gr. *skopeo*—to see).—An instrument for determining the strength of a liquid by ascertaining its boiling point.

Ebullition (Lat. *ebullio*—to bubble up).—The act of boiling, the condition into which a liquid is thrown by the application of heat, which causes an agitation, or bubbling, arising from the escape of portions of the liquid in an aeriform state. If the bottom of an open vessel containing water be exposed to heat, the lowest stratum of fluid will expand, becoming specifically lighter, and rising through the colder or heavier particles. In this manner the heat is diffused through the whole mass of liquid by a translation of the several particles from the bottom to the top, and the top to the bottom, in rapid succession.

The temperature at which liquid boils in the open air varies with the degree of atmospheric pressure—as we ascend from the sea level the boiling point becomes lower. At St. Gothard, at an altitude of 7,000 feet, the boiling point of water is 199·22, while at Farm of Antesana, 13,000 feet high, the boiling point is only

187·34. The following numbers, taken from Regnault's tables show how the boiling point is affected by pressure:—

TEMPERATURE CENTIGRADE.

0°, 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80°, 90°, 100°.

PRESSURE IN ATMOSPHERE.

0·006, 0·012, 0 023, 0·042, 0·072, 0·121, 0·196, 0 306, 0 466, 0 691, 1 000.

If, therefore, the pressure be 0·023 atmosphere, water will boil at 20° C. or 68° Fahrenheit. In *vacuo* all liquids boil at a temperature of about 124° Fahr. lower than under the average atmospheric pressure. The following is a table of the boiling points of the most important fluids:—

	Fahr.
Ether	96°
Ether sp. gr. 0 736	100°
Alcohol sp. gr. 0 813	173·5°
Nitric acid 1 500	210°
Water	212°
Ammonia	140°
Sulphuric acid sp. gr. 1 848	600°
Linseed oil	640°
Mercury	662°

Efflorescence (Lat. *efflorescentia* from *effloresco*—to begin to blossom).—A term applied in chemistry to the formation of loose fine crystals on the surface of a porous substance by gradual decomposition on exposure to the air.

Edging.—In the collodion dry-plate process the plate is sometimes edged with albumen, gelatine or indiarubber, to cause adhesion to the film during development. The usual practice is, however, to coat the whole of the plate with a substratum.

Egg Albumen.—The albumen contained in the eggs of birds and largely used for the manufacture of albumen paper. See **Albumen.**

Egg, White of.—Is used as a glaze or varnish. Separate the white from the yolks, whisk into a froth, and let it stand for about twenty-four hours, then strain through muslin.

Effluviography.—A term applied by Tomassi to the action which the silent discharge has upon a sensitised gelatino-bromide plate. An image is obtained in complete darkness after a few minutes' exposure, and may be developed in the usual manner, the silent discharge producing the same effects as the ultra violet rays, and forms, possibly, a connecting link between the two extreme rays of the spectrum of what may be termed electric rays.

Elasticity.—That property of matter which enables a body whose form or bulk has been changed by force to support without disintegration or further yielding to the continued action of that force, and to recover its original form when left to itself. With

gases and liquids the only kind of elasticity that can exist is elasticity of bulk, but no portion of a fluid can sustain the action of a deforming force.

Electric Light.—The electric light is now used in many large photographic works, and in a few studios for portraiture. For enlarging and printing it is now much used. The heavy outlay in an electric installation is, however, the chief drawback to its more universal use.

For portraiture at night the electric light is generally used, the light being fitted in the focus of a parobolic reflector, so that it will be reflected in parallel rays.

Element (Lat. *elementum*—a first principle).—An element is a substance that has hitherto resisted all efforts to divide it into simpler forms of matter, and it is therefore supposed to consist of one kind of matter only. The following is a list of the various elements at present known, with their symbol and atomic weight. Those marked with an asterisk are non-metallic elements, the remainder being metals, although the distinction is in reality not clearly defined, as one or two—arsenic and antimony, for instance—are on the border line.

TABLE OF ELEMENTS.

Name.	Symbol.	New Atomic Weight.
Aluminium	Al	27
Antimony (*Stibium*)	Sb	120
Arsenic	As	75
Barium	Ba	137
Beryllium	Be	9
Bismuth	Bi	208
Boron *	B	11
Bromine *	Br	80
Cadmium	Cd	112
Cæsium	Cs	133
Calcium	Ca	40
Carbon *	C	12
Cerium	Ce	140
Chlorine *	Cl	35·4
Chromium	Cr	52
Cobalt	Co	58·6
Copper (*Cuprum*)	Cu	63
Didymium	Di	142
Erbium	E	166
Fluorine *	F	19
Gallium	Ga	70
Germanium	Ge	72·3
Gold (*Aurum*)	Au	196·5
Hydrogen*	H	1
Indium	In	113·4
Iodine*	I	126.5
Iridium	Ir	192.5
Iron (*Ferrum*)	Fe	56
Lanthanum	La	138
Lead (*Plumbum*)	Pb	206.4
Lithium	Li	7

TABLE OF ELEMENTS—(*Continued*).

Name.	Symbol.	New Atomic Weight.
Magnesium	Mg	24
Manganese	Mn	55
Mercury (*Hydrargyrum*)	Hg	200
Molybdenum	Mo	96
Nickel	Ni	58.6
Niobium	Nb	94
Nitrogen*	N	14
Osmium	Os	195
Oxygen*	O	16
Palladium	Pd	106
Phosphorus*	P	31
Platinum	Pt	194·4
Potassium (*Kalium*)	K	39
Rhodium	Rh	104
Rubidium	Rb	85
Ruthenium	Ru	103·5
Samarium	Sa	150
Scandium	Sc	44
Selenium *	Se	79
Silicon *	Si	28
Silver (*Argentum*)	Ag	108
Sodium (*Natrium*)	Na	23
Strontium	Sr	87·5
Sulphur *	S	32
Tantalum	Ta	182
Tellurium *	Te	125
Thallium	Tl	204
Thorium	Th	232
Tin (*Stannum*)	Sn	118
Titanium	Ti	48
Tungsten (*Wolfram*)	W	183·6
Uranium	U	240
Vanadium	V	51
Ytterbium	Yb	173
Yttrium	Y	89
Zinc	Zn	65
Zirconium	Zr	90

Besides these there are one or two other doubtful elements, such as davyium, decipium, mosandeum, nephmium, etc., which cannot be entered in the above list, as their existence is doubted by many chemists, and the atomic weight unknown.

In the third column we have the atomic weight; hydrogen, being the lightest element known, is taken as unity. See also **Chemistry.**

Elemi. — The resinous product of various terebinthinous trees used for making varnishes. There are many varieties. The principal are obtained from the *Balsamodendron ceylonicum* of the West Indies, and the *Icica icicariba* of the Brazils. A Mexican elemi is obtained from the *Elaphrium elemiferum* It is a brown-yellowish translucent resin having a peculiar odour resembling fennel. If added to varnishes it prevents their cracking as they dry. If distilled with water it yields a transparent colourless oil, which boils at 166°C.

Eliminator, Hypo.—Any solution used for the purpose of eliminating all traces of sodium hyposulphite from dry plates or paper pictures after fixing. Hypochlorite of zinc, eau de javelle, alum, lead acetate, peroxide of hydrogen, and many other substances will effect this.

Abney recommends the employment of a saturated solution of alum as the best hypo eliminator. The following will also serve the purpose :—

Barium dioxide	1 ounce.
Glacial acetic acid	1 ,,
Water	4 ,,

The barium dioxide is first reduced to a fine powder, and then added gradually to the water and acid, shaking till dissolved. A few minutes' immersion in this solution will remove all hyposulphite.

Elliotype.—An unused process, patented some years ago, for enabling artists to obtain an indefinite number of copies of their works. A painting is made upon glass in body colour, more or less transparent according to its density and the thickness with which it is applied, the painting being then treated as a negative, and positives printed in the usual manner.

Elutriation.—A term applied to the process of separating by means of water the finer particles of a powder from the heavier ones. A stream of water is flowed in a vessel containing the substance, carrying with it the fine powder, which is conveyed to settling vats, where it settles at the bottom, and the water is run off.

Embolite (Gr. *embolum*—something thrown in, so named because it is intermediate between chloride and bromide of silver). —A chloro-bromide of silver in the form of an isometric mineral of a green yellow or dark colour, and found in Chili and Mexico. Its composition is said to be silver 61·1 to 71·9, bromine 7·2 to 33·8, chlorine 5·0 to 20·1.

Emery.—A dark coloured, exceedingly hard mineral. It is reduced to powder, and used for grinding and polishing metal, glass, &c.

Empyreuma (Gr. *empyreuo*—I kindle).—The burnt smell and acid taste which results when vegetable or animal substances are decomposed by strong heat.

Emulsify.—To make or form an emulsion.

Emulsion. (Lat. *emulsus* from *emulgeo*—to milk out).—In photography this term is usually applied to a mechanical mixture of a sensitive salt of silver in extremely minute division, the particles being held in suspension in some viscous substance, such as gelatine, collodion or albumen, and usually having the appearance of thick milk. To more clearly explain the foregoing, if in a vessel containing water, we pour a small quantity of a

solution of common salt, and afterwards pour in a little nitrate of silver solution, a white substance (silver chloride) is instantly formed, which would soon fall to the bottom, and the clear water could be decanted off. But if instead of water we take a warm solution of gelatine, and place both salt and silver solutions into it, the same formation instantly takes place, with this difference, it does not sink to the bottom of the vessel, owing to the viscous nature of the gelatine, which holds it up and allows it to be spread evenly over plates and paper.

There are a great variety of emulsions for different purposes, the chief being the bromide or bromo-iodide for plates and bromide paper, and the chloride emulsion for lantern plates, transparencies for development, or for printing out.

In the manufacture of bromide emulsions a knowledge of chemical combination and equivalents is almost essential, as a definite quantity of the bromide, iodide or chloride must be taken to unite with the silver. If too little be taken we get an excess of free silver which would be ruinous. With a view to the simplification of the calculations necessary in emulsion-making, Mr. William Ackland* has worked out the following useful tables by which any person can calculate the proper quantity of silver or of haloid salts in any formula. In this table the principal bromides, chlorides, and iodides likely to be used in emulsions of either gelatine or collodion have been included. Table I. gives the actual weight of haloid or silver required to convert or combine with one grain of the other, so reducing the operation to one of simple multiplication or division.

TABLE I.

	Equivalents.	Weight of $AgNO_3$ required to convert one grain of silver haloid.	Weight of soluble haloid required to convert one grain of $AgNO_3$	Weight of *silver* haloid produced by one grain of *soluble* haloid.	Weight of soluble haloid required to produce one grain of silver haloid.	Weight of silver haloid produced from one grain of $AgNO_3$
Ammonium bromide	98	1·734	·576	1·918	·521	
Potassium ,, ...	119·1	1·427	·700	1 578	·633	
Sodium ,, ...	103	1·620	·606	1 825	·548	1·106
Cadmium ,, (coml.) ..	344†	·988	1·012	1 093	·915	
,, ,, (anh.) ..	272†	1·25	·800	1·382	·723	
Zinc ,, ...	225·2†	1·509	·663	1 670	·600	
Ammonium chloride	53·5	3·177	·315	2 682	·373	.844
Sodium ,, ...	58·5	2 906	·344	2·453	·408	
Ammonium iodide	145	1·172	·853	1·620	·617	
Potassium ,, ...	166·1	1·023	·977	1·415	·707	1·382
Sodium ,, ...	150	1·133	·882	1·566	·638	
Cadmium ,, ...	366†	·929	1·076	1·284	·778	

* *British Journal*, September 20, 1880.

† These salts combine with two equivalents of silver nitrate, so that practically the real equivalent is one-half that given.

The manner in which this table is used is this. Supposing we wish to make an emulsion, say, about ten ounces of a new formula, which is written down, say, as follows :—

Potassium bromide	150 grains.
Potassium iodide	10 ,,
Ammonium chloride	10 ,,
Gelatine	200 ,,

We require to know how much silver nitrate should be used for sensitising the mixture. We take the first column, in which is given against each haloid the exact quantity of silver nitrate required to fully decompose one grain. Taking, then, the salts in the above formula, and multiplying the figures found in the first column by the number of grains of each used, we get the following :—

Potassium bromide	150 × 1·427 = 214	Weight of silver nitrate required.
,, iodide..	10 × 1·023 = 10·23	
Ammonium chloride	10 × 3·177 = 31·17	

Total quantity of silver nitrate required for conversion, 256·00 grains. Two hundred and fifty-six grains of silver nitrate would thus make an emulsion in which the salts were equally balanced, but as it is desirable that the haloids should be in excess we might write down 250 grains as the amount of silver to be used.

Some operators prefer to calculate from the quantity of silver contained or used in the emulsion, that is to say, they fix the quantity of silver to be used, and then find out how much salt is required to convert it. Here we use the second column in the same manner. Thus, if we decide on using in ten ounces of emulsion two hundred grains of silver nitrate, and to employ ammonium bromide as the haloid, then ·576 × 200 = 115·2 grains of ammonium bromide will be required, or practically 120 grains, to allow for an excess.

Columns III. and IV. will be found useful for calculating and working out the best proportions for emulsions containing a mixture of different haloids, as the effect depends upon the proportions in which the bromide, iodide and chloride of silver be present. These columns show the relation which exists between the quantity of soluble haloid employed and the actual weight of silver salt formed, supposing, for instance, we desire to make a bromo-iodide emulsion in which the proportions of silver iodide to bromide are to be as 1 to 15, and the quantity of emulsion, we will say, five ounces. In that bulk of emulsion a suitable and convenient proportion of silver bromide would be 105 grains. The iodide would, therefore, be seven grains. If ammonium salts be employed we have the figures (see Column IV.)—

·521 × 105 = 54·7 weight of ammonium bromide required
·617 × 7 = 4·3 ,, ,, iodide ,,

or, practically, fifty-five grains of bromide and five of iodide.

The fifth column is intended for estimating the probable density of the emulsion, as owing to the very different combining equivalents of bromine, iodine and chlorine, their corresponding silver haloids vary greatly in bulk when precipitated from the same quantities of silver nitrate.

TABLE II.

	Ammonium Bromide.	Potassium Bromide.	Sodium Bromide.	Cadmium Bromide (Coml.)	Cadmium Bromide (Anhy.)	Zinc Bromide.	Ammonium Chloride.	Sodium Chloride.	Ammonium Iodide.	Potassium Iodide.	Sodium Iodide.	Cadmium Iodide.
Ammonium bromide ..	1	·823	·951	·57	·72	·87	1·832	1 675	·676	·59	·653	·535
Potassium bromide ..	1·215	1	1·156	·692	·876	1·058	2 226	2·036	·821	·717	·794	·651
Sodium bromide ..	1·051	·865	1	599	·757	·915	1 925	1·761	·71	·62	·686	·563
Cadmium bromide (coml.) ..	1·755	1·444	1·67	1	1·265	1·527	3·215	2·94	1·186	1·035	1·146	·94
Cadmium bromide (anhy) ..	1·387	1·141	1·32	·79	1	1·207	2·542	2·324	·938	·819	·906	·743
Zinc bromide ..	1·149	·945	1·093	·655	·828	1	2·104	1 925	·776	·678	·75	·615
Ammonium chloride ..	·546	·449	·519	·311	·393	·475	1	·914	·369	·322	·356	·292
Sodium chloride ..	·597	·491	·568	·34	·43	·519	1·093	1	·403	·352	·39	·319
Ammonium iodide	1·479	1·217	1·408	·843	1·066	1·287	2·712	2·478	1	·873	.966	·792
Potassium iodide	1·695	1·394	1·612	·965	1·221	1·475	3·104	2·839	1·145	1	1·107	·907
Sodium iodide	1·53	1·259	1·456	·872	1·103	1·332	2·803	2·564	1·034	903	1	·819
Cadmium iodide	1·867	1·536	1·776	1·064	1·345	1·625	3·42	3·128	1·262	1·102	1·22	1

Table II. will be found exceedingly useful if the operator is desirous of experimenting or substituting one salt for another in a formula. The necessary calculations are seen at once, and a knowledge of chemistry, so far as this part is concerned, is quite unnecessary.

In separate columns are given the relative converting values of each of the soluble haloid salts in ordinary use, showing how much of any salt must be used to replace one grain of any other. Supposing, for instance, we have a formula containing sixty grains of ammonium bromide, sensitised with a hundred grains of silver, and we require to substitute potassium bromide for the ammonium salts. In the first column we find under "Ammonium bromide," opposite to "Potassium bromide," the figures 1·215, the amount required to replace one grain, so that $1{\cdot}215 \times 60 = 72{\cdot}9$, the quantity of potassium bromide necessary to replace the sixty

grains of ammonium salts. Or again, if we desire to introduce a small quantity of iodide and chloride into the formula without altering the quantity of silver employed—say, five grains each of potassium iodide and sodium chloride—we refer to the column headed ammonium iodide, and opposite ammonium bromide we find the figures ·59, and in the like manner we have under sodium chloride 1·675. Therefore—

$$\begin{aligned} \cdot 59 \times 5 &= 2\cdot 95 \\ 1\cdot 675 \times 5 &= 8\cdot 375 \end{aligned}$$

or a total quantity of 11·325, which represents the number of grains of bromide of ammonium that must be deducted from the original sixty grains, to make room for the iodide and chloride.

By reading the figures in the contrary direction across the table horizontally they may be taken to represent the relative proportions of silver converted by a given quantity of the different salts. Thus, in the fifth line from the top we find, under the respective headings of ammonium bromide and cadmium bromide (anhyd.), the figures 1·387 and 1; that is to say, the same weight of these salts convert respectively these quantities of silver.

Bromide Emulsion for Dry Plates.—Under this heading will be given the method of preparing an emulsion for dry plates of varying rapidity.

The first consideration is the room to work in. Every possible inlet for light must be stopped up, and a lamp procured of a deep ruby red. If the emulsion to be made be a very sensitive one the least amount of light possible must be used. A clear table to work on is a necessity. Some jars with suitable lids, a pan to hold one of them, and a small Bunsen burner with stand for the pan, will be required. For a slow-working emulsion for landscape work weigh out the following :—

1.	Potassium iodide	10 grains
2	Potassium bromide	272 ,,
3.	Nelson's No 1 photographic gelatine	60 ,,
4.	Silver nitrate	350 ,,
5.	Hard gelatine	1 ounce

Nos. 3 and 5 are rapidly washed in water by pouring some on and draining it off again as soon as possible without allowing it to soak up much water, but merely to get rid of any adherent dust.

In two small test tubes place Nos. 1 and 2, and add 3 ounces of water to each. To No. 2 add 2 minims of strong hydrochloric acid, together with sufficient of a solution of iodine in alcohol to turn it a deep sherry colour. The gelatine No. 3 is then placed in two ounces of water, and when it is properly swollen it should be dissolved. No. 4 is dissolved in an ounce of water, and heated to about 120° Fahr.

We now remove the different solutions to the dark room. The gelatine No. 3 is placed in one of the jars standing in the pan of

hot water, and No. 4 added to it. The whole is then shaken up until thoroughly mixed. Three-quarters of the bromide solution No. 2 is then added very slowly, violently stirring the whole time. No. 1 is then added to the remaining portion of No. 2, and the mixture added to the emulsion now formed.

The addition of the bromide to the silvered gelatine is not to be done carelessly. It is of great importance that the mixture should be thorough. For this purpose many contrivances have been made. Fig. 68 illustrates a spray apparatus, easily constructed by

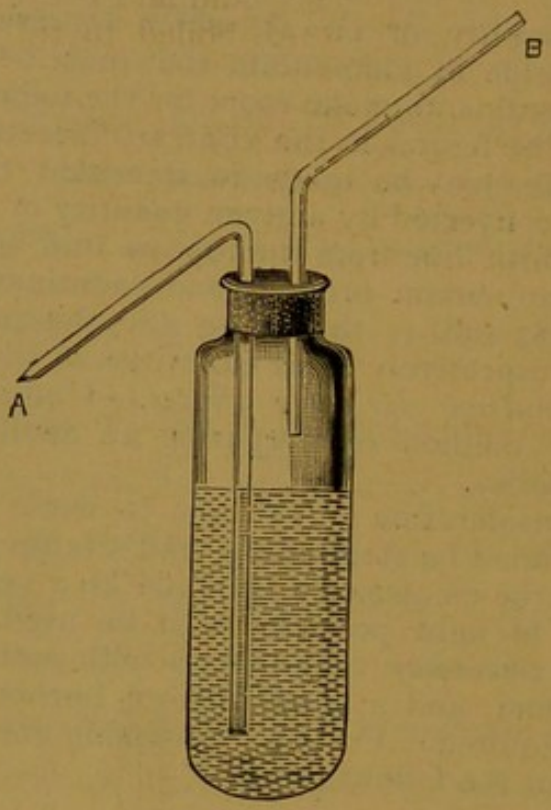

FIG. 68.

bending two thin glass tubes in the manner shown. The end of the tube A should then be drawn out until quite closed with a file; the point is filed away until a small orifice is obtained. The two tubes are fitted with the cork inserted in the bottle. The bromide is placed in the bottle, and a fine spray can be forced through the orifice of the tube A by blowing down the other tube, insuring a more equal division in the emulsion.

A small drop of the emulsion should next be placed on a piece of glass, and should appear of a ruby colour when examined by gaslight looking through it. The pan containing the jar with the emulsion is now placed on the Bunsen burner, and the flame lighted. The water is then brought to boiling point, and the emulsion boiled for about three-quarters of an hour. The jar containing it should be shaken every ten minutes or so. When boiled for the required length of time the pan is removed. It will be seen that we have still the hard gelatine No. 5 unused. This

is placed in four ounces of water, allowed to swell, and dissolved at a temperature of about 100° by immersing in the pot containing the hot water. The emulsion and this gelatine are then cooled down to a temperature of about 70° to 80°, and added together. A thorough mixture must be made by violently shaking. When the froth thus produced has subsided the emulsion is poured out into a flat porcelain dish, quite clean, and then laid away in a dark place to set, which should require about one hour in winter and two or three in summer.

When thoroughly set it should be carefully scraped from the dish with a piece of clean glass, and laid on to a piece of coarse canvas netting which has been boiled to rid of dirt or greasy matter.

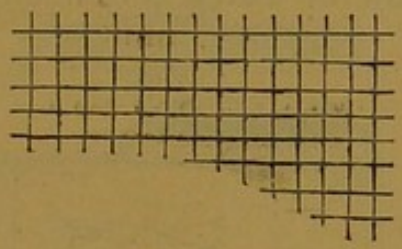

FIG. 69.

This figure will give some idea of the kind of material required. When all the emulsion is collected from the dish and placed in the netting the latter is twisted up, and the emulsion squeegeed through the openings of the netting into a vessel containing water, the whole being kept below the surface the whole time. The

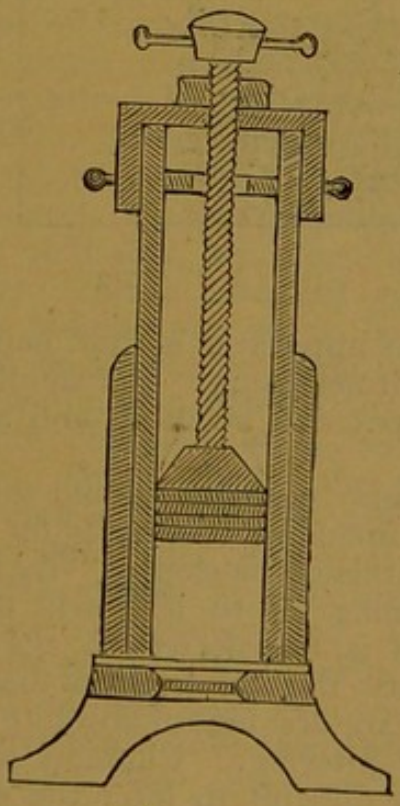

FIG. 70.

emulsion is thus broken up into little strips in the water, which soon has the desired effect of dissolving the soluble salts from the emulsion. For large quantities of emulsion a more convenient manner for breaking up the emulsion is shown in fig. 69. It consists of a piston in a cylinder. In the cylinder is placed the emulsion, and at the bottom is fitted a piece of silver wire gauze. The piston is then made to force the emulsion through the interstices. After the gelatine emulsion has thus been broken up, it is well washed in a running stream of water. Fig. 70 gives a plan for effectually washing it. It will be seen to consist of a tin case, made quite light-tight, into which is placed the glass containing the emulsion. The direction of the arrows shows the flow of water continually passing through it.

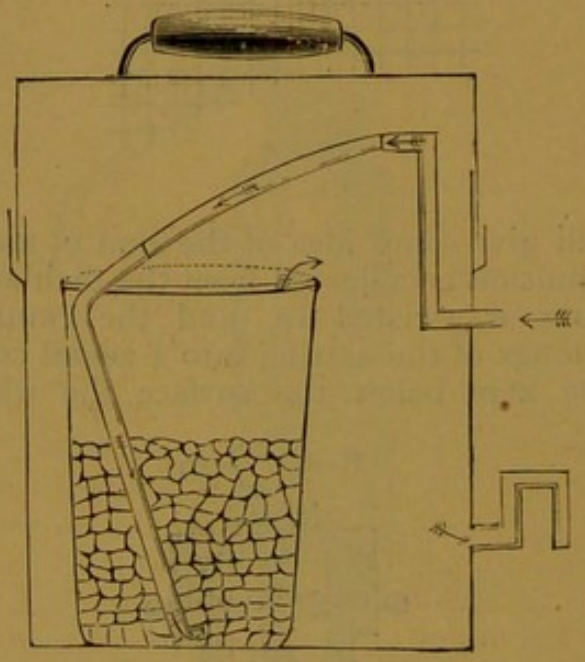

Fig. 71.

The advantage of this apparatus is that, being light-tight, it can be used in the daylight if necessary. For small quantities of emulsion an earthenware teapot can be used, and a current of water sent down the pipe.

Two or three 'hours' washing should suffice. The emulsion is then thoroughly drained, and is ready for melting. This should not be done if the emulsion be sloppy. By pouring a few ounces of alcohol before draining on to it it will become firmer. When drawn the emulsion is transferred to the jar, and this placed in boiling water until the emulsion is dissolved. Half a grain of chrome alum and six drachms of absolute alcohol are now added, and it is ready for filtering. Chamois leather makes the best filter, although it is difficult to force the emulsion through. An apparatus similar to that depicted in fig. 65 is used. A small

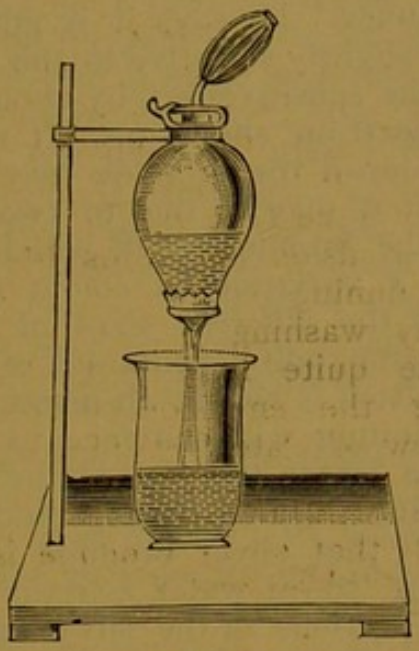

FIG. 72.

pneumatic ball at the top enables the operator to force the emulsion out of the top flask through two thicknesses of chamois leather tied to the bottom into the flask beneath. The emulsion when filtered is ready for coating and making dry plates. For instructions regarding this part of the process see **Dry Plates.**

Bromide Emulsion for Rapid Plates.—With the formula of the emulsion just given a very good dry plate may be made for ordinary work where rapid exposures are not required. If the plates, however, are required for instantaneous work, it will be necessary that an emulsion be specially prepared for the purpose. Sensitiveness in an emulsion may be obtained by several different methods. Charles Bennett, in 1878, prepared a sensitive emulsion by heating it to about 90°Fahr., and keeping it at that temperature for five or six days. In the following year, however, Mr. G. Mansfield proved this tedious process to be unnecessary, as by heating the emulsion in boiling water he obtained the same degree of sensitiveness in a few minutes, instead of days. A high sensitive condition is only obtained when soluble bromide is in excess in emulsion, and only when in the presence of gelatine. When the emulsion is first formed it has an orange colour, when viewed by transmitted light, and the emulsion if used then will absorb the blue rays and transmit the red rays, the work of forming the image being done by the blue rays. When the emulsion is cooked, however, to obtain extra sensitiveness, it becomes of a cold, grey colour by transmitted light, and yellowish green by reflected light, showing that the yellow and red rays are absorbed, and some of the blue rays transmitted; but curiously enough, however, this emulsion is more sensitive to the blue rays than the other. Abney explains this curious phenomenon in his work on emulsion

processes* in this manner. He says it is not owing to the fact that the silver salt is slightly sensitive to the yellow rays, for this would only increase the sensitiveness by about one-twentieth, as photographing the spectrum shows us. It must be recollected that the apparent colour of the bromide may be produced in two ways, or, rather, that it may be due to two causes. It may be due to the colour of the bromide itself, which is what we call its molecular colour, or a variation in colour may be due to the scattering of light by the different sizes of the particles, each particle being in all probability composed of thousands of molecules. When an emulsion is boiled, an inspection of the film after different lengths of boiling will convince us that the longer an emulsion is boiled the larger the size of the particles which are imbedded in the gelatine. Hence boiling produces large particles. The cause is probably that silver bromide is slightly soluble in water, and much more so in water containing soluble bromide. Without doubt some portions of the silver bromide are dissolved and re-precipitated on the coarser particles or other portions of the finer bromide being taken up, and they in their turn deposited, and so on.

In an emulsion of this kind the proportions of the soluble bromide and the silver nitrate exercise a very important influence over its character. The larger the excess of soluble bromide, the quicker is the silver bromide converted, and a much shorter cooking will be required to an emulsion which has but little excess. † There is, however, a limit to the amount of excess, which, if too great, would tend to form fog, very difficult to get rid of. The following rapid gelatino-bromide emulsion, by Mr. Wilson, gained the prize in the Paget competition of 1880. The description of the process is thus given.

To make a pint of emulsion, select a twenty-ounce narrow mouth stoppered bottle, with a well-fitting stopper and thin bottom. Make it perfectly and thoroughly clean.

Make a stock solution of—

Hydrochloric acid (pure)	1 fluid drachm.
Distilled water	12½ ounces.

Place in the 20-ounce bottle—

20 minims of the above dilute acid.
3 fluid ounces distilled water.
210 grains of ammonium bromide.‡
80 grains of Nelson's No. 1 photographic gelatine.

Allow the gelatine to swell for about fifteen or twenty minutes. The addition of the small quantity of diluted hydrochloric acid to the soluble bromide and gelatine is recommended in the formula

* PHOTOGRAPHY WITH EMULSIONS, by Captain W. de W. Abney, F.R.S.

† Abney is of opinion that if exactly the equivalent quantities could be used no possible amount of cooking would give the sensitive condition.

‡ Potassium bromide will be found to be superior. It must, however, be obtained neutral.

given for the following reasons:—If the soluble bromide be absolutely neutral and the gelatine of good and suitable quality the trace of hydrochloric acid is quite unnecessary and had better be omitted. With gelatine, however, that is slightly alkaline or apparently neutral, but does not give a clear solution the addition of the acid solution is necessary. In order to ensure a fine precipitate the bromised gelatine solution should contain a trace of hydrochloric acid, and the silver solution should not be stronger than 110 grains per ounce. If it be a solution of from 50 to 60 grains per ounce it may be poured in all at once. Mr. Wilson considers that the elaborate apparatus constructed for this purpose is quite unnecessary.

With regard to the quality of the gelatine to be used, something has already been said, and further information on the best gelatines for emulsion work will be found under **Gelatine.** A good test for the suitability of the gelatine for this process is to add the silver, and see if a fine precipitate can be obtained without the necessity of adding the hydrochloric acid. If the quantity of the latter be too large it will retard the conversion of the silver bromide into the sensitive form in cooking, and also has a destroying action upon the gelatine, so that it will be obvious to the reader that the addition of this small quantity of hydrochloric acid must be done thinkingly and according to the quality of the other materials. The silver used should be of good quality. It is usually slightly acid, with an excess of nitric acid, and can be used in this condition. Better results are, however, obtained by neutralising the silver solution with sodium carbonate. By so doing the condition of the silver can be made to be always the same, and the presence of nitric acid in the emulsion, producing a tendency to various discolorations in the finished negative, is avoided.

In a perfectly clean glass measure dissolve 330 grains of silver nitrate (re-crystallised) in three ounces of water (distilled).

Pour about two fluid drachms of this silver solution into another vessel, and dilute it with an equal quantity of distilled water.

Now remove the 20-ounce bottle and the two silver solutions to the dark room, in which all the subsequent operations are carried on. The light should be as non-actinic as possible. Mr. Wilson prefers a paraffin lamp, protected with one sheet of ruby and one sheet of dark orange-yellow glass.

In the dark room should be fitted a gas boiling-stove, with a saucepan of convenient size to contain the 20-ounce bottle when the lid is placed on. The pan should be fitted with a tin perforated false bottom to prevent the bottle resting on the bottom of the saucepan. The pot should contain three or four inches of boiling water. The gas of the stove should then be turned out, and the bottle plunged into the water two or three times until it is heated (this is to prevent cracking it), and then leave it in the saucepan for a little time to allow the gelatine to become dissolved. Immediately it is dissolved remove the

bottle, shake up the contents, and place the bottle near the light for better convenience. Add the four drachms of dilute silver solution by pouring it in all at once, then shake it well up for about a minute or so. The second strong silver solution is then added in small quantities of three or four drachms, well shaking the emulsion during the addition, and giving it a final thorough shaking afterwards for about two or three minutes. Provided these instructions have been carefully carried out there should be no coarse precipitate in the finished emulsion.

The emulsion now complete, the next process is to render it sensitive. The bottle containing it is returned to the hot-water pan, the cork containing a slit to allow of the escape of hot air is fitted in, and the saucepan lid covered over the whole. Light the gas burner, and when the water is brought to a boil keep boiling for fifty-five minutes. At the expiration of this period turn out the gas, and remove the bottle and cool it down as quickly as is consistent with safety, care being taken that the bottle is not cracked in the operation. In winter it should be stood on a table for ten or fifteen minutes, and then cooled with water. Another way is to leave the bottle in the saucepan containing the hot water, and allow a little cold water to flow slowly in the pan, gradually cooling it. The bottle should be shaken up now.

In a 16-ounce glass beaker put one ounce of Nelson's No. 1 photographic or X opaque gelatine, and pour over it ten ounces of clean water. Allow it to remain until the gelatine has absorbed four ounces of the water, then pour off the remaining six ounces, and melt the swollen gelatine by placing the glass beaker in the hot water pan. When dissolved pour it into the 20-ounce bottle containing the cooled emulsion, shake up well so as to thoroughly mix, and then pour the whole back into the beaker. Place this in a cool part of the room, and leave it for about a day. It is recommended that the addition of the gelatine to the boiled emulsion should be made when both are at a low temperature, and during the period between the addition and the washing it should be kept at as low a temperature as possible, for the reason that the excess of alkaline bromide has a most destructive effect upon the gelatine last added, and the lower the temperature and quicker the time in which the two are in contact the better. Another rather curious effect in the addition of the second quantity of gelatine should be noted. If the temperature be cold the plates will dry with a matt surface; the higher the temperature the richer the gloss obtained.

We now come to the washing of the emulsion. This should be done in clean cold water. Mr. Wilson's instructions are:—In a glazed earthenware vessel place about three pints of cold water, and add to it three ounces of a saturated solution of potassium dichromate. When the emulsion is cooled down, and is quite firm, it is squeezed through the canvas in the manner described in the last emulsion formula; or the emulsion may be washed by precipitating with alcohol, squeezing the clot, breaking it up, and

soaking in water. After squeezing through the meshes of the canvas held under the surface of the water, the emulsion is allowed to remain for about an hour, when the operation is repeated a second and a third time in a further supply of cold water. After the last straining the emulsion is placed in a large beaker standing in warm water, and heated to a temperature of about 115° Fahr. The emulsion should now measure about 16 or 17 ounces. Add to it two ounces of alcohol and mix thoroughly; next place in a measure, and if less than 20 ounces make up to that quantity by the addition of clear water. The emulsion is now ready for filtering and coating the plates. In the absence of a proper filter for this purpose, place a small tuft of cotton-wool in a glass funnel, and allow the emulsion to run through this.

Bromide Emulsion with Ammonia.—In the two foregoing emulsion processes for dry-plate bromide emulsions, the emulsion undergoes a cooking process. In the methods now to be described, instead of boiling, the emulsification is produced by treating with ammonia. This plan is originally due to Dr. Van Monckhoven, and has been brought to a more perfect state by Dr. Eder and others. Eder's process with ammonia is thus given by him:* Dissolve 370 grains of chemically pure air-dried potassium bromide in 10½ ounces of water, and add from 520 to 700 grains of gelatine, and, after soaking for about 15 minutes, the pot containing the whole is dipped in a water bath, and the gelatine dissolved and raised to a temperature of about 95° or 120° Fahr. Next dissolve 460 grains of silver nitrate in 10½ ounces of water, and add ammonia drop by drop until the precipitate at first formed is dissolved, and the solution becomes quite clear. The two solutions are now removed to the dark room, and the silver solution gradually added to the gelatine solution, which should now be cooled to about 75°, shaking frequently, and finally rinse the remains of the silver out of the bottle with one ounce of water, and add to the emulsion. Then replace the jar containing the emulsion in the water bath, which should have a temperature of 75° Fahr. (not more), and allow it to remain in this for a quarter-of-an-hour, gradually cooling the emulsion to about 75°, but not lower, or the gelatine will set. The salts and the gelatine do not require to be so carefully chosen for this method as for that which follows. Should the bromide of potassium have an alkaline reaction, it does no harm, neither is the neutrality of the nitrate of silver imperative, nor the acidity of the gelatine, which may be alkaline. The reason is that, without these requirements, the method is adapted to the alkaline reaction, which would be neutralised by the ammonia. The specific gravity of the emulsion regarded as determining its strength is a secondary consideration. Take a strong solution of ammonia. As one is deprived of any indication by which to regulate properly the addition of ammonia in adding it to the gelatine containing potassium bromide (instead of

*See Photographic Journal," 1890; and "Eder's Ausführliches Handbuch der Photographie."

to the nitrate of silver) ; this process is not to be recommended.* Care must be taken that the temperature does not exceed 105° Fahr. when adding the ammoniacal silver solution or during digestion. After digestion the emulsion is allowed to set, pressed through coarse canvas, and washed in several changes of water for one or two days, suspended in a coarse stuff bag. As a great deal of water adheres to the gelatine particles it should be allowed to drip for at least half-an-hour, otherwise the emulsion will be too fluid. The finely-divided emulsion may be deprived of water by placing it in a bath of alcohol, and then dried in the air for future use, or it may be immediately liquified by heating in the water bath. After filtering it is ready for use. If, however, it is intended to be kept, an antiseptic must be added. To every ten ounces of emulsion add ten grains of salicylic acid dissolved in one drachm of alcohol, or replace the salicylic acid by the same weight of thynol oil, as a protection of the gelatine against the change caused by keeping the solution warm for so long. The alcohol has also a favourable action, accelerating the setting of the gelatine and the drying of the film.

Bromide Emulsion by Boiling and Subsequent Digestion with Ammonia.—Dr. Eder has also a second method slightly more complicated than the last. It is based on the observations that the modification of bromide of silver, which transmits blue light, is produced very rapidly at a temperature of from 140° to 212°Fahr., and, further, that the sensitiveness of such emulsion can be increased by subsequent treatment with ammonia at a gentle heat, while if the boiling were continued fog would be produced. The proportions of the various ingredients required are the same as those just given in the method with ammonia. After mixing the emulsion it is boiled in a bottle placed in a light-tight tin saucepan to prevent even the light from the spirit lamp beneath the pan reaching the emulsion. The emulsion is now highly sensitive, and can be used in this condition. When it has become quite cool (70° F.), however, its sensitiveness can be highly increased by adding two drachms of liquid ammonia ·880, and placing it in a water bath of from 95° to 100° F., and digesting it at this temperature for from half an hour to an hour. It is then set and washed in the manner already described. With regard to these two methods of Eder's, it may be stated that the first is more suitable for hard negatives, and the second for a softer image and where greater rapidity is desired. In the preparation of this second method, however, great care must be exercised. The gelatine should not have an alkaline reaction, or fog will be produced in boiling.

Monckhoven's Emulsion Process is given by him in these words: "I prepare very pure and dilute hydrobromic acid, and I determine accurately the exact quantity of it necessary to precipitate exactly

*When gelatine, bromide of potassium and ammonia are dissolved, and the nitrate of silver is then added, the ammonia should not be allowed to act too long upon the gelatine. The ammonia is best added immediately before the addition of the nitrate of silver to the gelatine.

150 grains of silver nitrate. I then dissolve this amount of acid in seven ounces of water, and afterwards add to it 40 grains of gelatine, and evaporate by heating. I now remove to the dark room where all the subsequent operations take place, and here I precipitate 130 grains of silver nitrate by a very slight excess of sodium bicarbonate. I allow this to settle for twenty-four hours, and then renew the same amount of water, after which I allow it to settle previous to decanting. On this precipitate of silver carbonate I pour a hot solution of gelatine, made by dissolving 30 grains of it in 70 ounces of water. This I stir well up, and pour on the solution of hydrobromic acid. The mixture is thoroughly shaken every quarter-of-an-hour, and kept at a constant temperature of 120° F. The silver carbonate will slowly dissolve in the hydrobromic acid, and the silver bromide is formed in the colloidal liquid in a state of extreme sub-division. At the expiration of from ten to twelve hours, the mixture, if flowed over glass, would have a greenish-white colour. I next introduce 150 grains of gelatine cut into very thin shreds, and this I dissolve by stirring, and when dissolved I flow the emulsion over the glass plates without any washing."

Henderson's Emulsion Process.—This process may be considered to be a modification of the cold emulsification method. The formula is as follows :—Ten grains of gelatine are dissolved in one ounce of water by gentle heat, and add—

Ammonium carbonate *	20 grains.
Potassium bromide	150 ,,
Potassium iodide	2 ,,
Alcohol	3 ounces.
Ammonia ·880	60 minims.

The ammonia and alcohol are mixed together before adding to the gelatine. When quite cold stir in—

Silver nitrate	200 grains.
Water	2 ounces.

Shake it up occasionally, and in about an hour it will be quite ripe enough for ordinary purposes. The maximum sensitiveness is reached in about ten or twelve hours ; further than this no action seems to take place.

The convenience of this method is that a large stock of the above emulsion can be made and kept for use at different times as required.

For use take for the above quantities from four to five drachms of dry gelatine and warm gently to dissolve. When this occurs stir in 12 ounces of methylated alcohol heated to a temperature of about 100°. When cool the emulsion will precipitate on the bottom of the vessel, and it is then broken up and well washed in a running stream from two to twelve hours. Make up bulk to eight

* The ammonia causes effervescence.

to ten ounces. Gelatine dissolved in alcohol, ammonia and water will not set so firmly as the same amount of gelatine in water, yet if the salts and ammonia are removed by precipitation with excess of alcohol the gelatine recovers its setting powers. One of the chief drawbacks to this method is the large quantity of alcohol required.

Bromide Emulsion Process by Cold Emulsification without Ammonia.—This is a process described by Mr. Cotesworth. An ordinary emulsion is allowed to gain sensitiveness by remaining liquid at ordinary temperatures. Other similar methods have been devised in which the emulsification takes place at a low temperature in gum Arabic or other similar substance. The process cannot be said to be perfect. No further description of it will, therefore, be given.

Bromide Emulsion by Precipitation.—This process was described by Captain Abney. It is a method of preparing an emulsion by adding *washed* silver bromide. The following are the eminent scientist's instructions.* Let us suppose we are going to make up about seven ounces of gelatine emulsion. Weigh out 40 grains of ammonium bromide (or its equivalent† in zinc potassium or any other bromide), and dissolve in 20 ounces of water. Next weigh out 250 grains of silver nitrate, and dissolve in six ounces of water, and add six drachms of glycerine to it, and stir thoroughly with a glass rod. We prefer to put this mixture in a glass jar holding about 40 ounces. The bromide solution should now be added very cautiously. Take a ten-ounce measure, and fill it up to six ounces or thereabouts, so that it is not too full, and gradually drop, little by little, the solution into the silver solution, stirring very thoroughly the whole time. A milky emulsion forms, and gets thicker and thicker, till the whole bromide in the 20 ounces is added, though of course the fluid is *per se* thinner; a quarter of an ounce of nitric acid is then added and well stirred up. This addition is made to prevent fog, which might be caused by the excess of silver present.

This emulsification is better carried on in a dark room, though this is not absolutely necessary. *The bromide solution must be poured into the silver solution, and not* vice versâ, *or a failure will be most probable.* The glass jar and its contents are now placed in a cupboard and left for as long time as convenient, but not for less than a quarter of an hour. By the latter time the silver bromide will have fallen to the bottom of the jar with the exception of a very slight milkiness, which will subside in a couple of hours. The quantity of silver bromide left in suspension after a quarter of an hour is, however, so small that it may be decanted off without detriment to the emulsion. The jar is tilted and the liquid poured gently off, or a syphon may be used, and the liquid syphoned off close to the precipitate at the bottom. Next pour 20 ounces of water into the jar, stir the precipitate well up, and again allow it to subside. As soon as subsidence takes place,

* See Abney's "Photography with Emulsions." † See under Emulsion calculations.

the water is again decanted or syphoned off. Repeat this operation three or four times, and test the water for acidity with blue litmus paper, and for silver nitrate by adding one drop of potassium chromate. A red coloration indicates the presence of silver nitrate. If either be present, the washing must be continued till freed.

The second part of the process has now to be described. 100 grains of Nelson's No. 1 photographic gelatine are soaked in two ounces of water, and another 100 grains of a harder gelatine, such as Autotype or Heinrich's hard gelatine, soaked in three ounces of water. The No. 1 gelatine when soaked is taken up on a rod, and the vessel containing the precipitate is placed in hot water, and the gelatine used as a mop to collect it. The gelatine gradually melts, and the bromide becomes emulsified. It is then transferred to a flask heated in boiling water for about five minutes, and well shaken up. When all the froth has subsided the bottle is again shaken, and the warming process repeated. After two or three such shakings a little of the gelatine emulsion may be dropped upon a glass plate, and examined for granularity. If absent, so much the better; but if present, half the second lot of the harder gelatine, which has meanwhile been dissolved, must be added.

If this emulsion be raised to boiling point for five minutes, then shaken, and the operation repeated a second time, a fairly rapid emulsion is obtained. When ready, the remainder of the gelatine solution is added, together with half an ounce of alcohol, and after a final shake the emulsion is filtered through washed cotton-wool, and is ready for the coating operation.

Bromide Emulsion for Paper. — Although almost any of the bromide or iodo-bromide emulsions may be satisfactorily used or coating paper for printing out or enlarging, yet in the opinion of the author the following formula is the most suitable. It is a slow emulsion used for coating plates for landscape work, and was first given by Mr. W. K. Burton. The author has added a small quantity of glycerine to make the film less brittle when dried on the paper support :—

A	Silver nitrate	200 grains.
	Distilled water	3 ounces.
B	Potassium bromide	160 grains
	Potassium iodide	10 ,,
	Nelson's No. 1 gelatine	40 ,,
	Hydrochloric acid	2½ minims.
	Water	3 ounces.
C	Hard gelatine	150 grains.
D	Hard gelatine	150 grains.
E	Glycerine	1 drachm.
	Alcohol	½ ounce.

The gelatine of B is allowed to soften, at the same time water may be poured over the gelatine C and D, and allow them to swell separately. A and B are now heated to 120° Fahr., and A is

poured into B slowly with vigorous stirring. The emulsion thus formed is allowed to stand ten minutes with occasional stirring. In the meantime, as much water as possible is squeezed out of the gelatine C by wrapping it up in a piece of cloth and wringing the cloth round. In ten minutes the emulsion (having been allowed to remain without stirring for at least two minutes to allow any granular bromide which may have been formed to subside) is poured over C, heat being, if necessary, applied to melt the gelatine. When the gelatine and the emulsion are thoroughly mixed, the jar containing them is set on one side to allow it to set in a stiff jelly. It is then squeezed through canvas and washed. When thoroughly washed D (having had as much water as possible wrung out of it) is added. It is then melted up, well mixed, and E added. It is then ready for coating the paper for the production of bromide paper, for positive printing, or for negatives. For the latter, however, one of the quicker emulsions is more suitable.

Chloride Emulsion.—In this emulsion we have chloride instead of bromide of silver. The rapidity of the emulsion is thereby lessened, but it is most suitable for the production of lantern slides or transparencies.

SOLUTION NO. 1.

Sodium chloride*	160 grains
Nelson's No. 1 gelatine	60 ,,
Hydrochloric acid	10 minims
Distilled water	3 ounces
Glycerine	4 drachms

The gelatine is first soaked, then dissolved, and the other ingredients added.

SOLUTION NO. 2.

Silver nitrate	400 grains
Distilled water	1 ounce

SOLUTION NO. 3.

Nelson's No. 1 gelatine	60 grains
Distilled water	2 ounces

SOLUTION NO. 4.

Hard gelatine	200 grains
Nelson's gelatine	80 ,,
Distilled water	4 ounces

Soak Nos. 3 and 4, and dissolve slowly by heat. No. 2 is then added to No. 3 at a temperature of about 100° Fahr., and added very gradually to No. 1, rapidly stirring. Shake the bottle containing it well up, and when nearly cool add No. 4 solution, and

*Instead of sodium chloride other chlorides may be used. Ammonium chloride gives softer pictures, but should be used in the form of powdered crystals, sold as sal. ammoniac. It should be dried before using, however.

the emulsion is ready. This is not a rapid emulsion, and for transparency work this is not necessary. Greater rapidity can be given to it, however, by boiling for half an hour or an hour before the addition of solution No. 4.

Chloro-bromide Emulsion.—A gelatine emulsion containing a chloride and a bromide, and used for printing direct or enlarging by exposure and subsequent development, as with the latter emulsion. The following formula for the emulsion was given by Wellington about the year 1885. The advantage it is supposed to possess is that warmer tones may be obtained than with an emulsion containing bromide only.

Two solutions are made up—

SOLUTION NO. 1.

Silver nitrate	100 parts
Citric acid	100 ,,
Water	1440 ,,

SOLUTION NO 2.

Sodium chloride	20 parts
Potassium bromide	40 ,,
Citric acid	100 ,,
Gelatine	40 ,,
Water	1440 ,,

Both solutions are heated to a temperature of about 150° Fahr., and Solution 1 is added slowly to Solution 2, shaking it well up. 200 parts of gelatine, soaked, drained and melted, are then added, and the emulsion poured into a dish to set. On the next day it is washed. The emulsion is then melted, and should measure about 4,800 parts. It is now ready for spreading on to glass or paper.

Aceto-gelatine Emulsion.—A patent was taken out by Vogel for the production of an emulsion which should combine the rapidity of the ordinary gelatine plate with the ease of coating of a collodion emulsion. An ordinary emulsion is dried, and the pellicle dissolved in one of the fatty acids, such as formic acetic or propunic (acetic acid is preferable, owing to its cheapness). About three times the quantity of acid is added to the pellicle, and gently warmed until the latter is dissolved. A sufficient quantity of alcohol is then added, till it is of a proper consistency for flowing over the plate when heated to a temperature of about 90° Fahr. When cold the emulsion sets in a gelatinous mass. Plates may be coated in the same manner as with collodion. To give greater tenacity to the emulsion Vogel mixes pyroxyline with it, his formula being—

Pyroxyline	20 grains.
Acetic acid	1 ounce.
Alcohol	1 ,,

This is mixed with an equal quantity of the gelatine emulsion. Plates coated with it may be used either wet or dry.

Chloride Emulsion (Printing-out).—This is an emulsion of a different character to any of the preceding. In these the silver bromide or chloride is formed, with an excess of the salt afterwards washed out. The image is produced by a short exposure, and made visible by development. In this class of emulsion, however, we have an excess of silver formed into silver citrate, and the image is formed visibly by prolonged exposure—somewhat less than required for albuminised paper. As this emulsion contains a large percentage of citrates, it is also termed a "Citro-chloride of silver emulsion."

Various formulæ for the production of the emulsion have been given. Abney's process is thus described by him. The original method of preparation is as follows:—

No. 1.—Sodium chloride	40 grains.
Potassium citrate	40 ,,
Water	1 ounce.
No. 2.—Silver nitrate	150 grains.
Water	1 ounce.
No. 3.—Autotype gelatine	320 grains
Water	3½ ounces.

Nos. 3 and 2 are mixed together, and then an emulsion formed by adding No. 1 in the usual way when forming a gelatine emulsion.

Ashman and Offord give the following modification of the above:—

A.—Ammonium chloride	53 grains.
Gelatine	420 ,,
Water	20 ounces.
B.—Silver nitrate	150 grains.
Water	½ ounce.
C.—Sodium citrate	30 grains.
Gelatine	100 ,,
Water	3½ ounces.
D.—Silver nitrate	45 grains.
Citric acid	80 ,,
Water	½ ounce.

The gelatine A is one-third soft and one-third hard, that in C is all hard; A and B of the solution of each are mixed to form the emulsion. When set it is squeezed through canvas and washed. C and D are emulsified together, and kept at as low a temperature as possible, and then slightly washed. The two emulsions are mixed together, and 15 grains of citric acid are added.

Henderson has a method somewhat different to the above. He dissolves 16 parts of gelatine, 11½ parts of sodium acetate in 1,200 parts of water, and adds 42 parts of silver nitrate dissolved in 480 parts of water, and also five parts of sodium chloride and 7½ parts of sodium citrate, dissolved in 480 parts of water. Lastly, 480 parts of swollen and dissolved gelatine are added, and the quantity of the whole made up to 4,300 parts by the addition of more water. Without washing the emulsion is ready for coating.

Papers prepared with printing-out emulsions of these descriptions are now largely sold under various names, such as Celerotype, Aristotype, Obernetter, etc. They are usually kreide or baryta paper, coated over with a thick film of the emulsion. The paper prints much rapider than ordinary albumen paper, especially in winter, as it is particularly sensitive to the green ray, and does not rely upon the ultra-violet rays of the spectrum, which are almost deficient in winter. It is also believed that prints upon emulsion paper of this description will last much longer than albumen prints, as the organic salt is a definite compound, and not so complex or uncertain as the albuminate of silver.

Emulsion (Collodion).—See under **Collodion Emulsion, Collodio-chloride Emulsion, Collodio-bromo Chloride Emulsion, Collodio-citro Chloride Emulsion, Collodion Albumen Emulsion.**

Emulsion Pourer.—An arrangement for pouring out the emulsion when coating plates. A most convenient form is that devised some little time ago by Herr Barth, of Deschny. The accompanying illustration, fig. 73, illustrates the apparatus. Its chief advantage lies

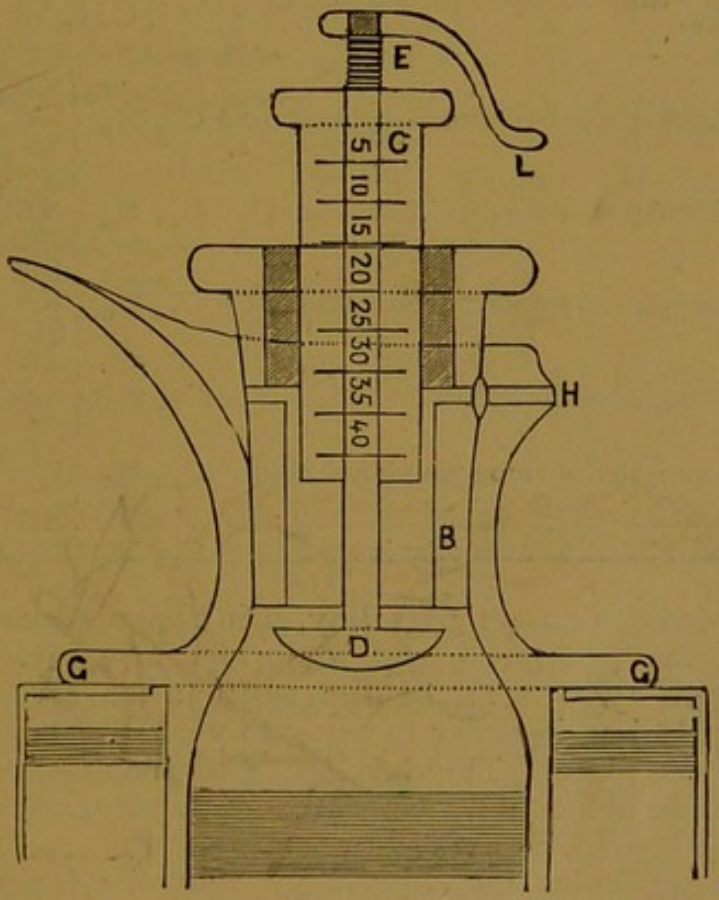

FIG 73.

in the fact that, besides being a handy pourer, it is also a measurer of the quantity of emulsion or other liquid poured out. B is a hollow stopper; C a measuring tube with the necessary divisions marked on the sides of the stopper; D the stop valve, the stem passing

through a spiral spring; E the stem which passes through cylinder C, and can be worked by a pressure of the index finger; F india-rubber ring, by which the holding in position of the measuring cylinder is certain; G the rim round the bottle for supporting a tin vessel with hot water; CC holes which permit the free flow of emulsion or other liquid; K outflow; L lever screwed in D so as to reach it with the index finger; H vent-hole managed by the thumb.

Eikonogen.—A name given to a new substance, discovered by Dr. Andresen, of Berlin, to have a superior developing action upon dry plates and bromide paper. Chemically, it is the sodium salt of amido-β-napthol-β-sulphonic acid, having the symbol—

$$C_{10}H\begin{cases}SONa\\OH\\NH_2\end{cases}$$

Dr. Andresen's patent runs as follows :—

My invention relates to the development of photographic pictures by means of diamidonaphthaline $C_{10}H_6\begin{cases}NH_2\\NH_2,\end{cases}$ amidonaphthol $C_{10}H_6\begin{cases}OH\\NH_2,\end{cases}$ and dioxynaphthaline $C_{10}H_6\begin{cases}OH\\OH,\end{cases}$ as well as their sulpho-acids :—

Diamidonaphthaline monosulphonic acid	$C_{10}H_5\begin{cases}NH_2\\NH_2\\SO_2OH\end{cases}$
Diamidonaphthaline disulphonic acid	$C_{10}H_4\begin{cases}NH_2\\NH_2\\(SO_2OH)_2\end{cases}$
Amidonaphthol monosulphonic acid	$C_{10}H_5\begin{cases}OH\\NH_2\\SO_2OH\end{cases}$
Amidonaphthol disulphonic acid	$C_{10}H_4\begin{cases}OH\\NH_2\\(SO_2OH)_2\end{cases}$
Dioxynaphthaline monosulphonic acid	$C_{10}H_5\begin{cases}(OH^2)_2\\SO_2OH\end{cases}$
Dioxynaphthaline disulphonic acid	$C_{10}H_4\begin{cases}OH\\OH\\(SO_2OH)_2\end{cases}$

As is well known in photography, it is the practice to treat the sensitive plates (prepared with chloride, bromide, or iodide of silver, or with two or all of the salts) after exposure with a developing solution, in order to bring to view the image produced on the sensitive plate. The developing solution hitherto employed for this purpose has usually consisted of a solution of oxalate of iron, pyrogallic acid, or hydroquinone.

Now I have found by experiment that the before-mentioned substances—diamidonaphthaline, amidonaphthol, and dioxynaphthaline, as well as their sulpho-acids, are exceptionally suitable for developing photographic pictures produced on the said sensitive plates, and give better results than can be obtained with an alkaline pyrogallol developer, and excel the latter by giving the

plates a blue-black tint similar to that produced when developing in a bath of oxalate of iron, without in the least colouring the sensitive plate, but enabling the plate to better resist the alkaline action of the bath. I thus obtain the advantages possessed by known developing baths without their disadvantages.

A developing bath prepared with my naphthol developer, in which it is intended to immerse the sensitive plate after having been exposed for the purpose of producing a visible picture, is for instantaneous photography advantageously composed of the following ingredients:—

Five grammes of the hereinbefore described naphthol developer; 15 grammes of sulphite of soda; 250 grammes of distilled water; and 5 grammes of potash.

The above proportions can, however, be varied, or one or the other of the ingredients can be substituted by others providing the essential part, namely, the before-mentioned naphthol developer, is contained in the developing bath.

Instead of potash, soda carbonate, soda lye or potash lye may be used, in which case it is perferable to replace the before-mentioned five grammes of potash by twenty drops of a concentrated or saturated soda or potash lye, and this is especially recommended when diamidonaphthaline or its sulphonic acids are used. In the same proportion the quantity of sulphite of soda can be advantageously increased when alphanaphthol derivatives (such as amido-alphanaphthol) or their sulpho-acids as mentioned above, are used.

The before-mentioned five grammes "naphthol developer" may be used with any of the above combinations.

As any one of the "naphthol developers" is suitable for the present purpose, I find it is not absolutely necessary to restrict myself to the use of only one of the "naphthol developers" for the bath, so that the quantity of "naphthol developer" to be used refers also to mixtures of the above-named "naphthol developers."

After having immersed the photographic plate in this bath till the picture becomes completely developed, it is then fixed in the usual way.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—The process herein described of developing photographic pictures on coatings of chloride of silver, bromide of silver, or iodide of silver, or of any two or of all three of them in combination, such process consisting in treating such coatings in a developing bath containing diamido-naphthaline, amidonaphthol, or dioxynaphthaline, or their sulpho-acids.

The formula for using eikonogen is, like its action, closely analogous to hydroquinone. One of its chief advantages over other developing agents is in the fine and delicate bluish black deposit. This beautiful colour, which the images therefore assume, makes

this developer particularly suitable for lantern slides and transparencies. For negative making it is also recommended on account of its action of bringing out the finest detail in a clear manner.

For bromide contact prints and enlargements, it is probably superior to any other developer. It is very clean, and the liability to stain is diminished. The following two formulæ have been tried successfully :—

FORMULA No. 1.

SOLUTION A.

Distilled water, heated to 104°F.	500 parts.
Sodium sulphite (pure)	50 ,,
Eikonogen	8 ,,

SOLUTION B.

Distilled water	500 parts.
Sodium carbonate	25 ,,
Potassium carbonate	25 ,,

In developing, equal parts of both A and B solutions are mixed, or the quantities regulated according to the qualities of the exposed plate.

FORMULA No. 2.

SOLUTION A.

Sodium sulphite	15 grains.
Eikonogen	7½ ,,
Water	1 ounce.

SOLUTION B.

Potassium carbonate	80 grains.
Water	1 ounce.

For use, add six parts of solution A to two or three parts of solution B.

The solution can be used over and over again until it becomes exhausted, when it can be revived by the addition of a little of the fresh solutions.

Emulsion Preservatives.—See **Preservatives.**

Enamel Albumen Paper.—A name given to a thickly-coated albumen paper.

Enamel Collodion.—A plain collodion used for giving a protective film to prints or to negatives. The following will be found serviceable :—

Pyroxyline	12 grains.
Alcohol	1 ounce.
Ether	1 ,,
Castor oil	2 drops.

Enamelling.—A method of giving prints made upon smooth paper a brilliant polished surface, superior to that finish obtained by burnishing. This is effected by coating the print with a film of collodion, which not only gives it a brilliant surface, but also acts as an excellent protector.

A glass plate is thoroughly cleaned and dusted over with French chalk. This is rubbed over the glass with a tuft of cotton-wool, and with another piece of wool lightly removed. The plate is then coated with enamel collodion (see **Enamel Collodion**), and having made up a gelatine solution consisting of 10 or 12 grains to the ounce of distilled water, place it into a dish and insert the collodionised plate and the print. Next lay the print face downwards into contact with the film side of the coated plate, and remove together from the solution. Squeegee into optical contact, and allow it to dry. When dry it will not be a difficult matter to remove the prints from the glass by raising one corner with a knife, inserted between the collodion film and the glass. The collodion film adheres to the print, and leaves the glass with a very high polish.

With gelatine printing papers, such as Celerotype, Aristotype, or bromide and chloride developed papers, the process may be somewhat simplified. The glass plate is cleaned and dusted over with the French chalk. The gelatine prints are then removed from the final washing water and laid face downwards upon it. With a squeegee they are pressed into contact, and when dry they will leave the glass with a brilliant surface. The collodion film and the gelatine solution are, therefore, dispensed with, but the gelatine polished surface obtained in this manner is much more easily affected by moisture than the collodion surface.

Instead of glass the prints may be squeegeed on to polished ebonite, celluloid, or on to ferrotype plates.

Enamel Paper.—Paper with a glazed metallic coating. Various metallic pigments that will spread quickly and take a polish are employed. Of these are white lead, zinc oxide, sulphate of barytes, china clay, whiting, chalk laid on in a menstruum or upon a previous coating of glycerine, size, collodion, varnish, &c., and afterwards polished with agate or between calendering or burnishing cylinders.

Enamels.—The name given to photographic images burnt into porcelain and coated with a glaze to render them permanent. An early description of this process was given in the "Comptes Rendus" of June 11, 1855, by M. A. Lafon de Camassac. The best description of the process is, however, that of Mr. N. K. Cherrill, and from which the following information is mostly taken.

It is what is known as a substitution process. A piece of glass is first cleaned with nitric acid, well washed, dried, polished, and coated three times with collodion.

This done, the plate is plunged into the nitrate bath before the collodion has been allowed to become too much set. The nitrate bath is a solution of thirty grains of pure silver nitrate dissolved in an ounce of pure water, and sunned all the while it is not in use, and when used rendered acid in the proportion of two drops of

*Photographic Year Book, 1886.

pure nitric acid to a half-gallon of solution. The plate is left in this solution until all the greasy marks have disappeared; it is then taken out at once and placed in a funnel to drain for about five minutes, and is then inserted in the dark slide of the copying camera. The camera is so arranged that the light which passes through the negative to be copied comes only through one of the side lights of the studio. The exposure varies from five to twenty seconds. If the enamel to be taken is of small size it is preferable to put a mask on the negative and to block out all the light except that actually needed, as this enables one to take four or five images side by side by simply pushing the camera dark slide a little way each time. The exposure and development of the image is a matter requiring great care and attention, as on the complete success of the transparency the whole process lies. The developing solution is made up with—

Pyrogallic acid	12 grains
Glacial acetic acid	4 drachms
Alcohol	4 ,,

Water to fill a 12 oz. bottle.

In warm weather this may be more dilute—say, as far as giving 20 ounces of water to the same quantity of pyro. Then, of course, more alcohol will be needed. The developer should be made three days before required for use, as at first it is too vigorous, although it must not be kept too long, as it then deteriorates in the other direction.

The image of the positive is developed slowly and until it obtains the exact density required, and at the same time gives the right amount of detail in the high lights. The image, when examined by reflected light, should show nearly all the drawing and shading of the subject, while, when viewed by transmitted light, it would show up with great perfection.

The plate is then well washed and fixed with a weak solution of cyanide of potassium, after the application of which it is again thoroughly well washed.

After washing, a small portion of the film at one corner of the plate is broken away, and a direct stream of water is made to run on this corner, striking the bare glass. This will gradually detach the film from the glass. The detached film is then floated on to a clean piece of glass and all unnecessary parts removed. The film is again washed while on the glass, and then lowered gently into a dish of water.

The next operation is the toning. A 16-ounce bottle, half filled with water, is placed in a saucepan containing water. This arrangement is set on the fire or on a gas stove until the water in the pan begins to boil. Next is placed in the bottle an ounce of potassio-chloride of iridium, and it is filled up with cold water and returned to the saucepan. The water is then kept hot and the bottle shaken occasionally. After half-an-hour remove the bottle and place it where the contents will become quite

cold. To make up the toning bath place twelve ounces of pure water in a bottle; add to it 14 drachms of the iridium solution, and shake up well. Now add drop by drop, and shaking well between each addition, seven drachms of a solution of gold chloride (1 grain to 1 drachm). The bath is then ready for use, but improves by keeping, which it will do indefinitely. It is particular to note that the solution in the iridium bottle will have a nearly black sediment, which is undissolved chloride. When all the clear solution has been used up, more water is added, and this remainder used in the same manner as the first, but care being taken, however, that too much water is not added, as a quarter of an ounce of the chloride will not make two sixteen ounce bottles full of the saturated solution, but only about one and a half.

To use the bath, pour it into a dish to the depth of about half-an-inch, and have ready at hand another dish containing clean water, and a small dish containing some pieces of glass somewhat smaller than the films to be toned. Now take one of these pieces of glass, and slip it under the film containing a transparency to be toned, and gently raise the glass to the surface (at the same time manipulating the film with a camel-hair brush, held in the right hand) in such a manner that when the glass and film on it are lifted out of the water there will be an edge of film about a quarter of an inch wide lapping over one edge of the glass. The action of the water as the plate is taken out will wash this piece or edge of film round to the back of the plate, and by so doing will fix the transparency on the glass in a very satisfactory manner. If care be taken that the edge where the film laps over is kept uppermost or highest, a very considerable stream of water may be poured on the film without any danger of it slipping. Having got the film on the glass it should be rinsed under the tap, and can then be transferred to the toning bath. To do this, turn the glass over so that the body of the film is underneath, lower it gently under the surface of the solution, and with a brush disengage the lap of the film where it had turned over the edge of the plate, now, of course, uppermost. As soon as this is done the film will move off into the solution free of the glass, which can then be removed. When the film has floated free for about a minute turn it over with a brush and note carefully if the deeper shadows are toned through, so as to give one uniform tint to the whole film. When this is effected it is removed with the piece of glass used in the same manner as before described and transferred to a dish of cold, clean water. Free it from the glass and gently agitate the water to remove the toning solution adhering to it. As each film is toned it is placed in this dish of water, and when all are finished they are changed to another dish of cold water, taking each film up with the glass as before described.

The films are then ready for mounting on to the tablets. Have two dishes, one containing cold water, and another filled about half an inch deep with ammonia solution.

Ammonia ·880	6 drachms.
Water	12 ounces.

(Keep well corked.)

Half an ounce of this mixture diluted with one pint of water makes the bath into which the films are to be plunged.

Place in the dish of clean water a clean glass, and on that an enamel tablet carefully washed. Take another glass, and with it remove one of the toned films from the dish in which it was washed, and plunge the same into the ammonia bath. As the film enters the solution the time is noted by the second hand of a watch, and after it has been in twenty seconds it is removed and plunged quickly into the water where the tablet is. Disengage the glass and slightly agitate the water in the dish to give the film a wash. Then take up with the left hand the piece of glass on which the tablet rests, and raise it about half-way to the surface, then, manipulating with the brush, bring it into its proper position on the tablet. It is then removed and placed slighly on edge to drain.

The tablets being curved, it is necessary to remark that a little care must be taken in the manipulation in order to make the films lie flat.

When almost dry the tablets are to be removed from the glass plates upon which they were lifted from the water. To do this, place the plate in a level position, and with a sharp-pointed stick tear away the useless film around the edges of the tablet, slip a thin knife under the latter, and lift it off the glass on to a sheet of blotting paper, and cover over with a bell jar or similar contrivance to protect from dust.

The next process is the burning-in ; this may be done at once, or it may be left for weeks without any change.

A gas muffle furnace should be used in preference to one heated by coke. Whichever is used, however, it should be ready and at the full heat, a clear cherry red inclining to white, but by no means a full white heat. Too much heat is a mistake, as it renders the process quite unmanageable, and produces no better results for the extra difficulty in working.

Figure 74 illustrates the furnace used, E is the muffle door closed, with fire-brick shown in section, D shows the draught holes opposite the burners, which are a series of pipes, C is a movable piece, to which is attached a chimney. The muffle part can be removed, and an alternative portion is supplied for heating crucibles, etc.

The burning is the most delicate operation, and every care is necessary to secure the result at the very best point.

Take one of the tablets and place it upon a piece of fireclay in front of the muffle at a distance of about six or eight inches. The fireclay should be supported in such a way as to tip the enamel towards the heat, so that the rays may fall upon it as near as possible equally all over. When it is roasted in this manner it is moved a little nearer, and then a little nearer, examining it

each time. As soon as the heat has turned the colour of the film brown in the least degree it may be dealt with fearlessly. The fireclay with the enamel on it may be placed level, just in the mouth of the muffle, where, in a few moments, the film will take all the shades of brown until it gets quite dark, when it is pushed into the heat. As soon as it is pushed in the heat it must be

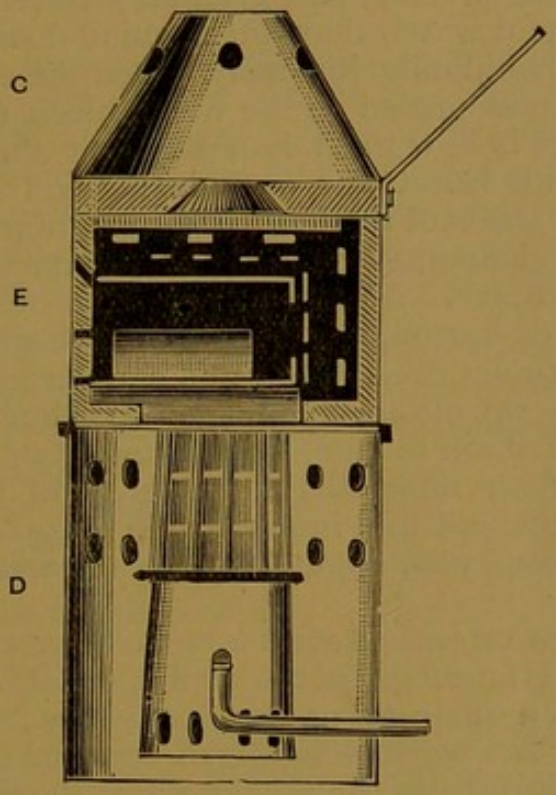

FIG. 74.

watched carefully. It will appear to get perfectly black all over, and then, all of a sudden, the whites of the picture will be seen coming out quite clear. Directly this takes place draw the tablet to the mouth of the muffle and remove it to the outside to cool a little gradually, and then take the tablet and place on a piece of wood to get cold. All the beauty of the enamel will by this time have disappeared, the whites will stand out, and the few tones near them will have some clearness, but all the other tones will be a dark and confused mass, hardly distinguishable one from the other. This is the true characteristic of a good enamel at this stage. It is now ready to glaze.

The enamel glaze is made in large quantities at Worcester, and can be bought in the form of a fine powder resembling flour. Place about a thimbleful of this in a bottle, and add an ounce of alcohol. To make the glazing solution, take a two-ounce bottle, and put into it half-an-ounce of plain collodion, and add to it a quarter of an ounce of methylated ether and half an ounce of alcohol. Next add as much water as possible without precipitating the pyroxy-

line. About six or eight drops will suffice. Shake up the bottle containing the glaze in alcohol, and let it remain for a few minutes, and then carefully add some of the upper part of the mixture to the diluted collodion—sufficient to make it slightly opaque.

When the enamel is quite cold some of this glaze mixture is poured over it, and it is immediately tilted to allow the superfluous glaze to run off. When the collodion is set, place the tablet in a muffle on a piece of fireclay, and gradually introduce it to the full heat, keeping careful watch that the burning does not proceed too far. The glaze should only just melt, when the enamel should be pulled out again, and placed on the wood block to get cold once more. The image is now fixed indelibly, but the picture is not, however, at its full beauty, as one glazing will not be sufficient; the dark portions will still retain a matt appearance. This is overcome by repeated glazing, no enamel being perfect until it has been glazed five or six times. A little trouble may be saved by lessening the number of burnings and making the glaze thicker, but the best results are not obtained in this manner.

By this process we obtain an image consisting of pure metallic silver, gold, and iridium in an extremely fine state of division fixed to the surface of an imperishable tablet, and protected by an equally hard, permanent and impermeable glaze.

Ceramic colours may be applied to enamels, and burnt in in the same manner.

Enamels may be retouched with a medium prepared by burning waste films and trimmings in the muffle, collecting the ash, and adding to it a small quantity of the glaze powder and a drop of an essential oil. The work being burnt into the enamel takes the same colour and surface as the rest of the picture. With enamels that have been spoiled, the image can be removed with a little fluoric acid, and the tablet used again.

Enamelled Iron.—Iron covered over with a vitreous surface. Photographic dishes and other utensils made of enamelled iron are extensively sold. The drawback to their use is chiefly in the fact that the effect of heat is to expand the metal more than the enamel, which consequently peels off. Another fault is often in the incompleteness of the enamel surface, which often contains very fine holes. A good way of testing for these is to fill the enamelled vessel with a solution of copper sulphate. The acid will attack the iron wherever it can reach it through the small pores, and little beads of copper are deposited in small spots, gradually increasing in size until they become plainly visible. Dishes containing such holes in the enamel would, of course, be of little use for many photographic operations.

Encaustic Painting.—An old method of painting in which wax was used with the colours in order to give them greater gloss and preserve from injury.

Encaustic Paste.—A paste giving a brilliant surface to finished prints without the necessity of using burnishers, hot rollers, or collodion. Among the various formulæ published the following, recommended by Salomons, is probably the best :—

Pure white wax	500 grains.
Gum elemi	10 ,,
Benzole	4 drachms.
Essence of lavender	6 ,,
Oil of spike	1 ,,

First melt the wax and elemi, and then add the benzole and other ingredients, and allow it to cool, stirring frequently. A little of the paste is rubbed over the surface of the print with a piece of soft flannel or cotton wool, and then polished with a clean piece of either material until it is quite free from markings. It increases the brilliancy of the surface, and appears to give a greater depth of shadow, and improves the general beauty of the picture.

Endemann's Process.—An aniline black printing process. The paper used should be well sized with an aqueous solution of gelatine in proportion one to fifty. The sensitising solution consists of

Sodium chloride	48 grammes
Potassium bichromate	48 ,,
Sodium vanadiate	0·10 ,,
Distilled water	960 c.c.

Another solution is made of

Sulphuric acid	96 c.c.
Water	480 ,,

When this is cold it is added to the first solution ; the paper is floated on the mixture and allowed to dry in a dark place. When dry, or while slightly damp, it is exposed under the negative in a printing frame for about seven minutes, after which it is kept in the dark until developed, which is done by exposing it to a mixture of the vapours of aniline and water for about a minute, after which it is placed in an atmosphere of water vapour kept at a temperature of from 24°C to 30°C. The image is thus developed in black lines on a green ground. To remove the green colour the paper is soaked in a one to six solution of ammonia.

Engraving.—See **Photo-engraving.**

Enlarging.—The operation of obtaining a larger image of a negative or positive upon a sensitive surface of some kind. There are a large number of methods of enlarging, differing firstly in the method employed, and secondly in the sensitive medium used. The simplest form of making an enlarged positive from a negative is by the use of bromide paper. If a large number of enlarged positives are required, however, it would be simpler to make an enlarged transparency from the negative, and from this make an enlarged negative by contact, and from which copies could be made in the usual way.

First, with regard to the light to be employed, as this is by no means an unimportant question. The negative from which an enlarged positive is to be made must be evenly and brilliantly illuminated.

Daylight enlarging is usually done with a solar camera (see under **Camera**), but a simpler contrivance can be made, as shown in fig. 75.

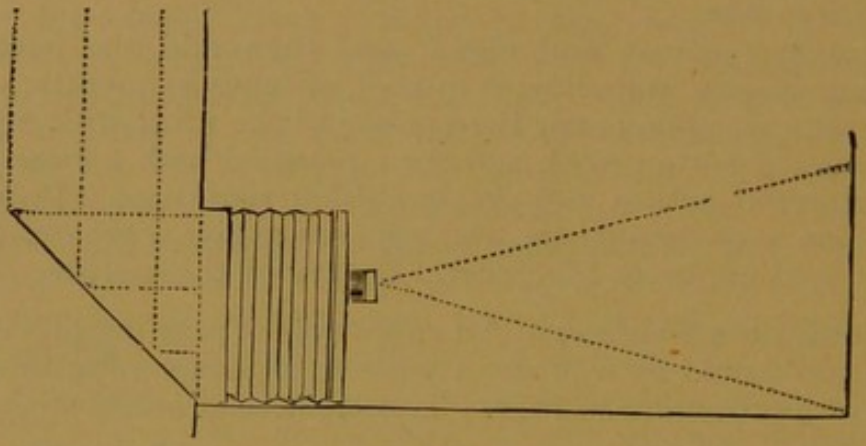

FIG. 75.

All light from the window is blocked out, excepting a small space a little larger than the negative from which an enlarged positive is to be made. The negative is placed in the dark slide, and the two slides drawn out, and the black partition removed. The camera is fixed as close as possible to the hole, and outside the window is placed a mirror or a large white card at an angle of 45°, so as to reflect the light through the negative. At a distance from the lens is placed an easel or board to receive the sensitive paper or plate. No light enters the room except that which passes through the negative and lens to form the enlarged image. This method of daylight enlarging is, for some reasons, to be preferred, but the standard of illumination is not constant. With artificial light properly arranged good effects are obtained, and with this method it permits of the work being done in the evening or at night-time.

Of all artificial lights the electric is undoubtedly the best, but this is unfortunately beyond the reach of a great majority. Limelight is also very suitable, and now that compressed oxygen is obtainable anywhere its use is much simplified. Gas may be also used. The best arrangement is that known as the albo-carbon gaslight. In this the gas passes through paraffin wax, and its brilliancy is thereby considerably increased. Oil lamps can also be used.

The principal method of obtaining even illumination with artificial light is by means of condensers. This is, however, expensive, as an eight-inch condenser is the smallest that will do for a half-plate negative. The function of the condenser is to turn the diverging rays that impinge upon it into a bundle of converging

rays, and the enlarging lens must be placed where it can best receive as much of the light as possible that passes through the condenser. The form of condenser usually employed is shown in fig. 76. It consists of two plano-convex lenses mounted with the convex face inwards. It will be seen that but few of the rays would pass through the negative N were they allowed to proceed in the direction of their propagation, as shown by the dotted lines.

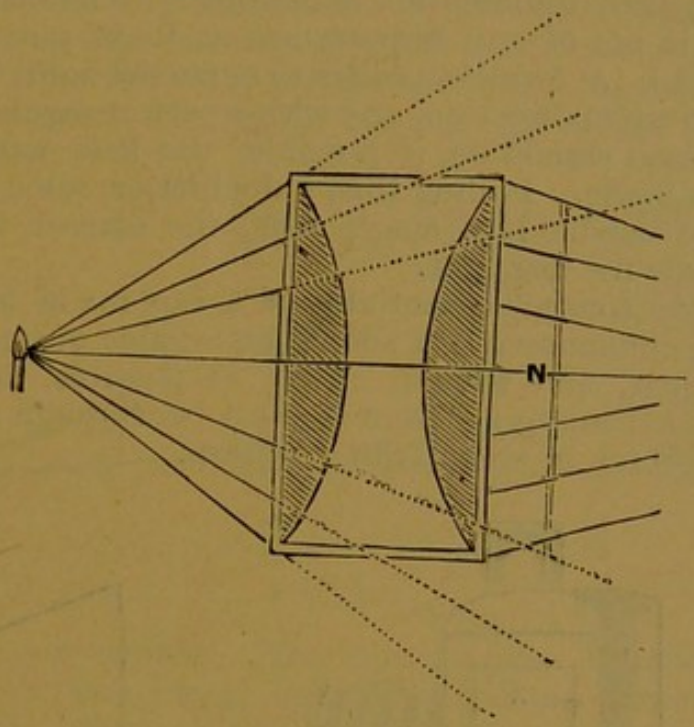

FIG. 76.

A condenser is not, however, absolutely necessary, provided a perfectly uniform surface can be produced. Ground glass, although often recommended, is but an imperfect diffuser; opal glass is superior. If this is placed halfway between the negative and four or six gas burners arranged in a group, a fairly even illuminant is obtained.

In order to better understand what even illumination means, we must take a glance at a book on elementary optics. In fig. 77 we

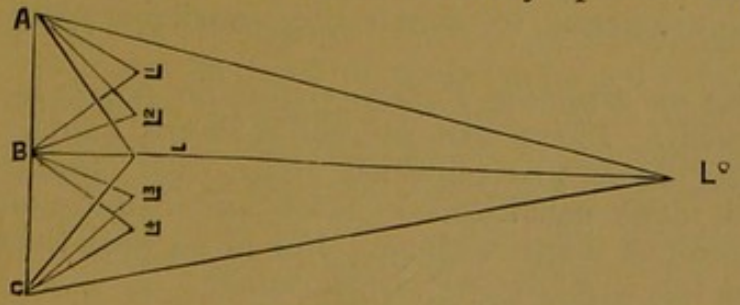

FIG. 77.

will suppose A B C to be a negative, L a source of light, the rays of which proceed from a point.

The lines L A L B will be the relative intensities, and it will be seen that by no means can even illumination be obtained. If the light be removed to L°, although its intensity will be greatly diminished, even illumination will be secured. But to do this we must employ a very bright light, such as the electric one. Supposing, however, we substitute a much larger luminous surface by placing lights also at L_1, L_2, L_3, and L_4, it is easily seen that a much more even illumination is obtained. The distance from L to A or to C is not of any importance, as these parts are lighted up by L_1 and L_4. Another plan is to move the light, but this must be done in an equal direction, and with a perfect regularity of speed.

The lens used should be, if possible, the lens with which the negative was made. Failing this, a doublet or some other kind of lens must be used. If a single lens, the convex face must be turned towards the negative.

The lantern consists essentially of a box made to contain the light and the condensers. It should be capable of standing a great amount of heat, and should, as far as possible, be light-tight. The only light emerging from it must be through the negative. Fig. 78 is a sketch of an enlarging lantern.

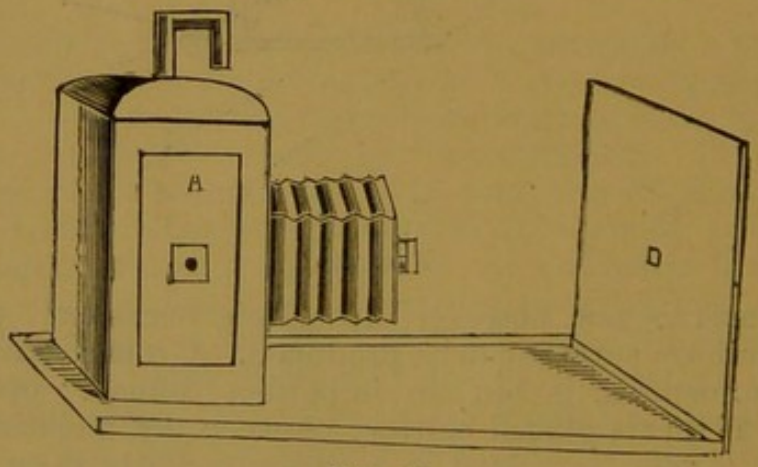

FIG. 78.

A is an iron or wooden box containing the light, B a frame holding the condenser and the negative holder, C the lens, and D the movable screen, to which the sensitive plate or paper is attached.

Enlarging on Bromide Paper.—Bromide paper is the simplest to work with. There are several different kinds. With some much better tones are obtained than with others. The paper is supplied ready sensitised in rolls, and can be obtained either with a smooth or rough surface. For large work the rough surface usually has the more artistic appearance.

A piece of white paper is attached to the movable screen, and upon this the image of the negative is sharply focussed. The lens is then capped with a piece of yellow paper or glass, and the piece of sensitive bromide paper fixed firmly into its place. A small

stop may then be placed in the lens to give increased sharpness. Exposure is made by uncapping the lens, but the precise duration required is only found out by practice. It differs with every kind of negative, with the strength of the illuminant, and with the distance of the screen from the camera. With regard to the first two points no law can be given, but it is not a difficult matter to find out the relative exposures required for images placed at different distances from the camera, as these are regulated by the following law: "*The intensity of illumination on a given surface is inversely as the square of its distance from the source of light.*"

We see this more clearly in fig. 79. L is the illuminant—

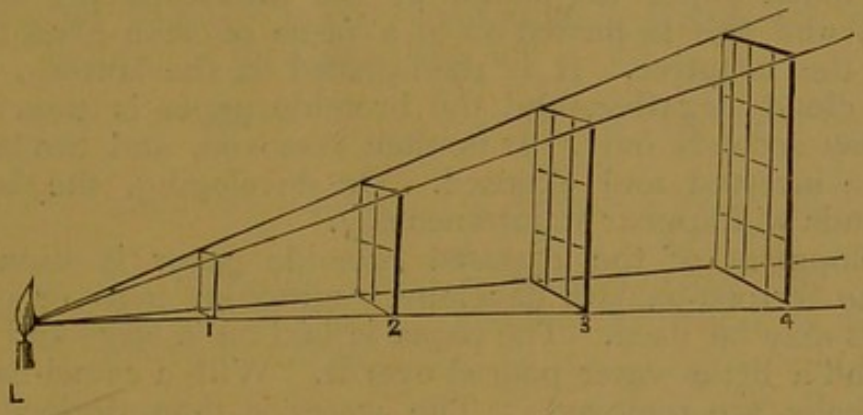

FIG. 79.

in this instance a candle. Now suppose the bromide paper be placed at 1 (one foot away), and the exposure required was 30 seconds. If we remove it to 2, or two feet away from the candle, the exposure required would be four times as great or two minutes, while at 13, or three feet from the illuminant, it would be nine times as long or 4½ minutes, while at 4 it would require an exposure of eight minutes or 16 times as long as at 1.

But even this useful law does not help us unless we know the correct exposure with a given negative at a given distance, and with a given illuminant. To prevent large pieces of the sensitive paper from being spoilt, it would be advisable to make the first attempts upon small pieces only until the correct exposure is ascertained.

The distance to place the screen from the camera lens to obtain the image the necessary number of times enlarged is easily found by reference to the tables given on page 167. It is necessary only to know the focal length of the lens, and turn to that column to obtain, first, the distance of the sensitive paper from the lens, and, secondly, the distance between the negative and the lens. Thus if the focal length of the lens be 9½ inches, we turn to the column headed 9½. On the left of the page will be found the number of times of enlargement or reduction, as the case may be. Supposing, for instance, we desire to enlarge four times linear (*i.e.*, sixteen times in area). We refer to ¼, and under column headed 9½ we find 3ft. 11½in. and 11⅞in., the first being the distance of the

screen from the centre of the lens, and the second number the distance of the negative from the lens centre.

The negative to be enlarged should be as sharp as possible, as any ill-defined parts have a very hazy and indistinct appearance in the enlarged image.

Vignetting can be done by putting a vignetting glass in front of the negative, or if an easel be used a suitable hole is made in a piece of cardboard, and this is held in the hand and moved to and fro between the lens and the easel during exposure, the rays of light passing only through the aperture in the cardboard.

Clouds may also be printed in. This is best done by cutting out in black paper the shape of the landscape portion of the picture, and this is pasted on to a piece of clean glass the same size of the negative. It is then placed on the lantern, together with a cloud negative, and the bromide paper is thus exposed for a few seconds only. It is then removed, and the landscape negative inserted and exposed. On developing, the landscape and clouds will appear simultaneously.

Development of the exposed bromide paper is usually done with the ferrous-oxalate developer, although pyro or other developers may be used. The paper is laid on a large and shallow dish, and a little water poured over it. With a camel-hair brush all air-bells are removed. The water is then drained off, and some weak developer poured on. Make up three stock solutions, the first with a pound of potassium oxalate, dissolved in a quart of water; the second, six ounces of granulated sulphate of iron and 50 grains of tartaric acid, dissolved in 16 ounces of water; and the third a ten per cent. solution of ammonium or potassium bromide. These solutions should be labelled 1, 2, and 3 respectively. For use, take eight parts of No. 1, and add to it one part of No. 2 and half a minim of No. 3. It is advisable to first use a very weak developer until the image makes its appearance, when the operator should be able to tell the best strength of the developer required. If a vigorous print be desired, a developer strong in iron should be used. Exposure should always be as full as possible; with an under-exposed print nothing can be done to get a really satisfactory image. Fuller particulars for working with bromide paper will be found under that heading. After development the pictures are well rinsed and fixed in a one to six fixing bath. They are then well washed in several changes of water, and hung up to dry. When dry, they can be worked up with crayon or lamp-black.

Enlarging on Plain Paper.—Enlargements may be made upon plain paper in the following manner. A good quality of plain paper is salted with the solution.

Sodium chloride	200 grains.
Hydrochloric acid	12 minims.
Water	24 ounces.

The paper is immersed for about a couple of hours, when it is hung

up to dry. When dry it is floated for about three minutes upon a silver bath composed of

Silver nitrate	1 ounce.
Citric acid	8 grains.
Water (distilled)	8 ounces.

As soon as moderately dry, the paper may be pinned on to the enlarging screen, and the image of the negative thrown on to it. A faint image only will be visible, but this is developed with

Pyrogallic acid	2 grains.
Citric acid	1 grain.
Water	1 ounce.

As soon as developed it is well washed, and, if desired, it can be toned. The print is then fixed in

Sodium hyposulphite	1 ounce.
Water	16 ounces.

and should remain until all trace of colour in the high-lights has disappeared.

Enlarging on Albumen Paper.—Enlargements may also be made upon albuminised paper. The paper should be sensitised on a bath composed as follows :—

Silver nitrate	40 grains.
Glacial acetic acid	30 minims.
Water	1 ounce.

After exposure the paper is developed with

Gallic acid	3 grains.
Acetic acid	5 minims.
Water	1 ounce.

The paper is immersed in this solution, and development will take place very rapidly. When sufficiently developed it is removed from the dish and well washed. It can then be toned and fixed.

Enlarging by Collodion Transfer Process.—Enlargement by the collodion transfer process is not employed now to the extent that it was formerly. The following is a *résumé* of the process. The collodion to be used may be any good negative collodion, which has been prepared for a few months at least, as the older it is the purer will be the image. This is diluted by the addition of from one-third to an equal part of a plain uniodised collodion. This addition is to insure a fine, soft gradation of tints, from the highest light to the deepest shadow. The following is a good formula :—To 25 ounces of a plain collodion, containing about seven to eight grains of pyroxyline per ounce, add a bromo-iodiser composed of

Cadmium iodide	65 grains
Ammonium iodide	25 ,,
Cadmium bromide	19 ,,
Ammonium bromide	11 ,,
Alcohol	5 ounces

A small quantity of an alcoholic solution of iodine is then added to give a deep sherry colour, but this is not necessary if the collodion be allowed to stand two or three months after mixing and before using. Glass plates, previously rubbed with French chalk, are coated with the collodion.

The silver bath should not exceed twenty grains to the ounce. With regard to the exposure, that, as in nearly every other case, can only be ascertained by experiment, but usually varies in a solar camera between thirty to sixty seconds, according to the quality of the negative and the actinicity of the daylight. The developer is—

Pyrogallic acid	100 grains.
Citric acid	60 ,,
Acetic acid	2 ounces.
Water	20 ,,

Development should not be carried too far. Fix with hypo-sulphite of soda. After fixing and washing, a sheet of transfer paper (previously soaked in cold water for a few minutes until it feels slightly slimy) is laid face downwards upon the collodion picture squeegeed thoroughly into contact with it, and allowed to dry spontaneously. When dry it can be raised at one corner with a knife, and the whole stripped away from the glass, taking with it the collodion picture.

The picture has an extremely glossy appearance, and can be mounted on to cardboard, and, if desired, finished off in oil colours, without any preparation being required. If the collodion picture be stripped off before it is perfectly dry a duller surface is given.

The transfer paper used in this process is made by soaking four ounces of gelatine in a quart of water and dissolving it. Four grains of chrome alum are then added. Good stiff paper cut into sheets is then floated on the surface of the gelatine, which is kept warm by means of a water bath.

Enlarging on Canvas.—See **Printing.**

Enlarging by Dusting-on Process.—This is a process suitable for making enlargements on opal. A transparency is first made, as by this method a positive is produced from a positive. The plate is coated with the following solution :—

Dextrine	40 grs.
White sugar	50 ,,
Ammonium dichromate	20 ,,
Glycerine	4 or 5 drops.
Water	2 ounces.

When dry it is exposed to the image of the transparency, after which powdered blacklead is brushed over with a soft camel-hair brush. The fine powder adheres to those portions that have not been acted upon by the light. The plate is then coated with collodion, washed in dilute hydrochloric acid, and afterwards in water. It is then dried.

Carbon Enlargements. This process is undoubtedly the finest one for the production of enlargements, as not only beautiful results are obtained, but these results are permanent, and will outlive all the silver pictures by many years. Carbon enlargements can be most successfully made in a solar camera, although the usual proceeding is to make an enlarged reversed negative, and from this to print the carbon positives by the single transfer process. For details of the process see **Carbon Process.**

The process of making enlarged negatives is very similar to that required for positives, except that a positive be placed in the lantern, and the image thrown upon a dry plate.

Eosin (Gr. *eos*—the red, morning sky). Tetra-bromo-fluoreceïn, $C_{20}H_8Br_4O_5$.—Formed by adding bromine to a solution of fluoresceïn in acetic acid. It is a roseate dye stuff, very slightly soluble in water and benzene. Its alkaline solutions are pink. It is used in the isochromatic process as a sensitiser to the yellow and green rays. See **Isochromatic Process.**

Erythrosin.—A name given by Staedler to a red substance produced by the action of nitric acid on tyrosine. It is used as a sensitiser in the isochromatic process (*q.v.*)

Equation, Chemical.—A symbolic representation of a chemical reaction. See **Chemistry.**

Equivalency, Chemical.—The quality in elements of combining with or displacing one another in certain definite proportions. When the atomic weight is taken into consideration the equivalency of an element is termed its atomicity.

Equivalent Focus.—See **Focus.**

Essential Oils.—Oils, usually obtained from plants, which are volatile either alone or with steam. See **Volatile Oils.**

Etching.—See **Photo-etching.**

Etching Solution.—A solution used in photo-zincographic and engraving processes. A solution for etching zinc is made up as follows:

Decoction of galls.	1 quart
Gum water	3 quarts
Phosphoric acid	3 ounces

An etching solution for copperplate is—

Potassium chlorate	1 part
Hydrochloric acid	10 parts
Water	48 ,,

Ether (Formula, $C_4H_{10}O$; molecular weight = 74; synonyms, *ethylic ether*, *vinic ether*, and *sulphuric ether*).—An exceedingly volatile colourless liquid, prepared from alcohol by the action of sulphuric

acid at an elevated temperature. Alcohol is first placed in a retort, and about an equal volume of sulphuric acid is added to it. This addition immediately develops heat, and by raising the temperature ether vapour passes away with a proportion of alcohol. A stream of alcohol is made to pass into the still, and the heat regulated at a temperature of about 266°. As soon as five volumes of alcohol have been added, the temperature is raised to 286°, at which point the impurities commence to pass over. Ether thus obtained contains sulphurous acid, alcohol, and water. These are subsequently removed by heating with a calcium chloride solution.

The action that takes place in the manufacture of ether after this method is rather interesting—

Sulphuric Acid. Alcohol. Ethyl Sulphuric Acid. Water.

$$H_2SO_4 + C_2H_5OH = C_2H_5HSO_4 + H_2O.$$

Thus the sulphuric acid acts on the alcohol, forming ethyl sulphuric acid and water. This acid is again acted upon by alcohol, producing the re-formation of sulphuric acid and ether, thus—

Ethyl Sulphuric Acid. Alcohol. Ether. Sulphuric Acid.

$$C_2H_5HSO_4 + C_2H_5OH = (C_2H_5)_2O + H_2SO_4.$$

The sulphuric acid is restored again, and can be used to attack more alcohol to form fresh ether. This action goes on until the acid becomes too weak, owing to the water in the first action diluting it.

Ether has a strong, sweet odour and a burning taste. Its vapour is very heavy, and highly inflammable. It has a specific gravity of about ·730 at a temperature of 60°. It boils at 96°, forming a heavy vapour two and half times as dense as air, and freezes at —24°. If a small portion be poured into the palm of the hand it will be found to vaporise so quickly that it will produce the most intense cold. It is so highly inflammable that it is not advisable to work with it in a room that has a naked light, unless with great care. If inhaled too freely it will also produce drowsiness and complete insensibility. If equal bulks of water and ether be added, and well shaken together, the liquids will appear to separate, but the water will have taken up about one-eighth of its volume of water, and the water has dissolved the same amount of the ether. If it absorbs more it is fairly good proof of the presence of alcohol.

If pure ether be exposed to the light it ozonises and becomes acid, and in this state it is liable to decompose photographic substances placed in it. It is, therefore, advisable to keep it in a dark, and also a cool, place. The presence of water in ether is detected by dropping a little into a flask containing spirits of turpentine. If it be present it will cause instant turbidity, but otherwise it will unite perfectly.

The employment of ether in photographic operations is very large, owing to its properties of dissolving iodine, bromine, sulphur, phosphorus, as well as of other essential oils, corrosive sublimates,

and other salts. It mixes with alcohol in all proportions, and is thus used in the manufacture of collodion.

Methylated Ether is prepared in the same manner as above described, except that methylated spirit is used instead of alcohol.

If properly rectified and purified it answers very well for the manufacture of collodion, and is much cheaper than ethylic ether. Before using it, however, it should be quite free from methyl, and should not have become ozonised by exposure to light. Test for this in the manner given.

Ethyl Acetate (Acetic ether, $C_4H_8O_2$).—Prepared by heating concentrated sulphuric acid to 130°, and then allowing a mixture of 60 parts of glacial acetic acid, and 46 parts of 93 % alcohol to run slowly into the flask. The ether distils over and is washed in a solution of soda, and then dried over calcium chloride. Ethyl acetate is a fragrant, colourless, limpid liquid. It is soluble in 17 parts of water; 28 parts of the ether dissolve in one part of water. It boils at 73°.

Ethyl Alcohol.—Obtained from acetic acid by converting the acid into acetyl chloride by distillation with phosphorus pentachloride, and acting on a mixture of acetyl chloride and glacial acetic acid with sodium amalgam, which decomposes the acetic acid, liberating hydrogen, which acts on the acetyl chloride, converting it into aldehyde, which, by the further action of hydrogen, is converted into alcohol, and this is converted by acetyl chloride into acetic ether. This is then saponified by distilling with potash, yielding potassium acetate and ethyl alcohol.

Euryscope (Gr. *eurus*—broad, wide, and *skopeo*—to see).—A name given to a kind of wide-angle lens.

Evaporate.—To transform into vapour. Liquids evaporate at temperatures below their boiling point. The rising vapour converts sensible into latent heat, with the effect of producing cold.

Exciting.—See **Sensitising.**

Expansion.—All substances, whether gaseous, liquid or solid, when chemical change does not take place, expand more or less by heat, and contract by cold. This property should be carefully noted. Glass, for instance, expands very considerably by heat, and if the expansion be unequal it will crack. Any glass vessel into which hot water is to be poured should be previously warmed, unless the glass be very thin, when this precaution is not necessary.

Moisture will also cause expansion. This, with gelatine films, is often very annoying, as it causes them to leave the glass. The only remedy is to lay the plate in a strong solution of alum or alcohol.

Explosive Powder.—A powder used in the flash-light process of illuminating during exposure. See **Flash-light.**

Exposure.—By exposure is meant the exposing to the action of light any sensitive surface, either in the camera to the image formed by the lens, or behind a negative in a printing frame. The exposure being the most important of all the photographic operations, it is lamentable that but little useful information can be given upon the subject. The proper knowledge of the length of the exposure is only attained by practical experience. With such sensitive substances as albuminised paper, or with any other printing-out process, the difficulty of exposure is reduced to a minimum, as the operator can see the image, and by attention stop the progress of the action of the light at the right moment required. With dry plates, however, or with any other process in which the image is invisible, it is a very different matter. The exposure of the dry plate is the most important point, as unless correctly exposed a satisfactory picture can rarely be made. The exposure of the plate is principally governed by the following—(1) The subject to be photographed, its distance from the camera, and darkness of the shadow detail; (2) the rapidity of the lens, and its working aperture; (3) the actinicity of the daylight; and (4) the rapidity of the plate.

There have been many tables and arrangements invented for calculating the necessary exposure, but some of which are more likely to lead to confusing the beginner than to aid him. The actinicity of the light varies so with the different days, or even

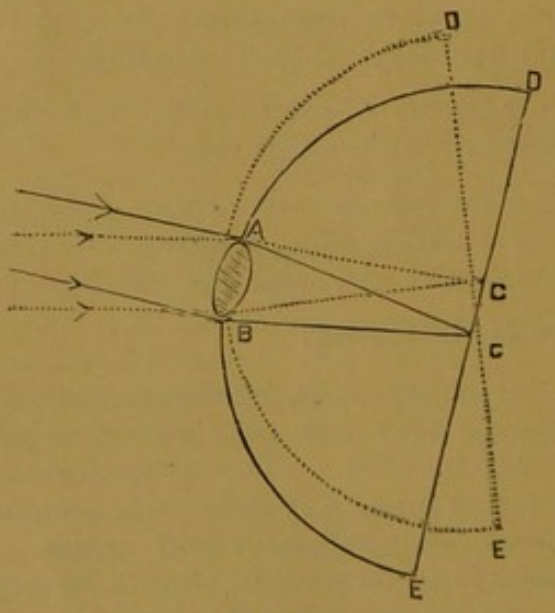

Fig. 80.

times of the day, and some subjects require so much longer exposure than others, that this information can only be got by practice. There is, however, a law relating to the comparative exposures required with different stops or diaphragms. The stops

are usually marked with their fractional value, found by dividing the focal length of the lens by the diameter of their apertures. If all other conditions be precisely the same the exposures required are proportional to the squares of the denominators of these fractions.

Abney in his "Instructions on Photography" gives a very good method of calculating the exposures with lenses of different focal lengths and different sizes of diaphragms (stops). Fig. 80 shows the arrangement more clearly. Let A B be a lens having a focal length (A C or B C), describe a circle with distance A C and centre C. It is easily seen that the parallel rays in proceeding from a distant point form an image of the point at C only; and a small part of the theoretically possible rays are collected, viz., those falling on a circle having a diameter A B. The theoretically possible rays would be collected on the surface of a hemisphere D A B E. The proportion of rays collected to those theoretically possible is therefore

$$\frac{\pi(AB)^2}{2\pi(BC)^2} \quad \text{or} \quad \frac{(AB)^2}{2(BC)^2}$$

which proves that the illumination varies directly as the square of the aperture of the lens, and inversely as the square of the focal length, or as $\left(\frac{f}{a}\right)^2$, calling f the focal length, and a the aperture of the lens. If we desire, therefore, to compare two lenses having different apertures and focal lengths, we require only to use the following formula :—

$$\frac{\left(\frac{f_1}{a_1}\right)^2}{\left(\frac{f}{a}\right)^2} \times s = x.$$

where x is the exposure required with the second lens, and f_1 and a_1 are the focal length and aperture respectively of the second lens. Example, a lens of 12in. focal length and $\frac{1}{4}$in. aperture requires an exposure of ten seconds. What exposure would be necessary to obtain the same picture with a lens of ten inch focus and an aperture of the one-eighth of an inch? The formula would be—

$$\frac{\left(\frac{10}{\frac{1}{8}}\right)^2}{\left(\frac{12}{\frac{1}{4}}\right)^2} \times 10 - x = 27 \text{ seconds nearly.}$$

This rule will be found of great help when the exposure of one lens is known and it is necessary to compare another with it.

In exposing a plate, probably the best guide is the image upon the ground glass screen. If the same kind of plate be always used, the operator, by examining the appearance of the image, will soon be able to judge the correct exposure almost immediately. The

following table might be useful as giving some idea of the proportional exposures necessary with a moderately quick plate and working with a lens aperture of f/16 with a good light :—

Sea and sky	$\frac{1}{10}$ second
Animated scenes	$\frac{1}{5}$,,
Landscape, distant	$\frac{1}{2}$,,
,, little foreground	1 ,,
,, dark foliage foreground	2 ,,
Buildings	2 ,,
Interiors, well lighted	3 minutes
,, badly lighted	45 ,,
Outdoor portraiture	5 seconds

The measurement of the light value is a very difficult proceeding, and cannot be accurately determined by exposing a piece of sensitive paper.

The rapidity of plates is also very confusing. Warnerke's sensitometer is usually employed, and plates are sold by manufacturers of various sensitometer numbers, as "30 times," "60 times," etc., intended to represent the number of times the plate is more sensitive than a wet collodion plate. But no reliance at all can be placed on these, some experiments proving nearly all to be incorrect, and some not possessing one-half the sensitiveness they were stated to have.

The following tables by Professor Burton and D. J. A. Scott may also be found of use in estimating comparative exposures :—

PROF. BURTON'S TABLE OF COMPARATIVE EXPOSURES.

Apertures calculated on the Standard System of the Photographic Society.	Sea and Sky.	Open Landscape.	Landscape with Heavy Foliage in Foreground.	Under Trees up to	Fairly-lighted Interiors.	Badly-lighted Interiors up to	Portraits in Bright Diffused Light out of Doors.	Portraits in Good Studio Light.	Portraits in Ordinary Room.
	SEC.	SEC.	SEC.	M. S.	M. S.	M. S.	SEC.	M. S.	M. S.
No. 1 or $\frac{f}{4}$	$\frac{1}{160}$	$\frac{1}{80}$	$\frac{1}{8}$	0 10	0 10	0 2	$\frac{1}{8}$	0 1	0 4
No. 2 or $\frac{f}{5\,656}$	$\frac{1}{80}$	$\frac{1}{40}$	$\frac{1}{4}$	0 20	0 20	0 4	$\frac{1}{3}$	0 2	0 8
No. 4 or $\frac{f}{8}$	$\frac{1}{40}$	$\frac{1}{20}$	$\frac{1}{2}$	0 40	0 40	0 8	$\frac{2}{3}$	0 4	0 16
No. 8 or $\frac{f}{11{\cdot}314}$ ...	$\frac{1}{20}$	$\frac{1}{8}$	1	1 20	1 20	0 16	$1\frac{1}{3}$	0 8	0 32
No. 16 or $\frac{f}{16}$	$\frac{1}{10}$	$\frac{1}{5}$	2	2 40	2 40	0 32	$2\frac{2}{3}$	0 16	1 4
No. 32 or $\frac{f}{22{\cdot}627}$ ...	$\frac{1}{5}$	$\frac{2}{5}$	4	5 20	5 20	1 4	$5\frac{1}{3}$	0 32	2 8
No. 64 or $\frac{f}{32}$	$\frac{2}{5}$	$1\frac{1}{5}$	8	10 40	10 40	2 8	$10\frac{2}{3}$	1 4	2 8
No. 128 or $\frac{f}{45{\cdot}225}$ ...	$\frac{4}{5}$	$2\frac{2}{5}$	16	21 20	21 20	4 16	21	2 8	8 32
No. 256 or $\frac{f}{64}$	$1\frac{3}{5}$	$5\frac{1}{5}$	32	42 40	42 40	8 32	42	4 16	17 4

Dr. Scott's table of comparative exposures, showing the comparative value of daylight at different hours of the day and months of the year :—

COMPARATIVE EXPOSURES.

Hour of the Day. a.m.	p.m.	*June.*	*May.* *July.*	*April.* *August*	*March.* *Sept.*	*Feb.* *Oct.*	*Jan.* *Nov.*	*Dec.*
12		1	1	1¼	1½	2	3½	4
11	1	1	1	1¼	1½	2½	4	5
10	2	1	1	1¼	1¾	3	5	6
9	3	1	1¼	1½	2	4	*12	*16
8	4	1½	1½	2	3	*10		
7	5	2	2½	3	*6			
6	6	2¾	3	*6				
5	7	*5	*6					
4	8	*12						

In the exposure of bromide paper it is usual to make a few experiments upon small pieces of paper. When once the correct exposure has been obtained it is possible to expose any number correctly, provided the same negative be used, placed at the same distance from the same light, and provided artificial light such as a gas flame be used.

In exposing platinotype or carbon paper actinometers will considerably aid the operator in judging the exposure time.

Eye.—See **Vision.**

Fabric.—Photographic fabric is a name generally given to a translucent cloth dyed of a golden yellow or red colour, and used for dark room windows. It is always advisable to use two thicknesses, as there are usually a number of fine holes almost invisible, but which, at the same time, allow of the entrance of white light.

Fading.—A sad defect to which negatives and prints (particularly silver prints) are liable.

The cause of negatives fading is usually insufficient fixing with the sodium hyposulphite or the incomplete removal of the hyposulphite from the film after fixing. The remedies are obvious.

The fading of silver prints has long occupied the attention of scientists who, apparently, have not yet arrived at any really satisfactory conclusion.

* The accuracy of these figures would be affected by yellow sunset.

The most important causes of unmounted photographs fading are probably—First, the imperfect coagulation of the albumen and the presence of some organic matter liable to rapid decomposition liberating sulphurous gases, which attack the silver. Sulphur is the most dangerous substance to be present in the print. Albumen, unfortunately, contains minute quantities of it, which probably give rise to some compound of silver and sulphur. This is perhaps why prints upon gelatino-chloride papers are so much more permanent than upon albuminised paper, although the ingredients are almost precisely the same, except that the silver salts are held in gelatine instead of albumen. A second cause of the fading of prints may be in the insufficient deposit of gold in the toning process. Prof. W. K. Burton recently pointed out that the less gold a sample of paper required to tone it, the less likely would be that paper to produce permanent prints, and it should therefore be rejected. A third cause of fading is the trace of organic salts of silver remaining in the film as a compound of albumen and the metal. The presence of this causes the print to decay slowly. Its action can be arrested by treating the prints with bichloride of mercury, a very powerful antiseptic and coagulator of albumen. Yet another cause of faded prints is in the insufficient fixing or removal of the sodium hyposulphite from the paper prints. It is not an easy matter to tell exactly when prints are fixed, and there is no doubt whatever that many make the mistake of removing them too soon from the bath.

In the removal of the hypo from the prints a great deal of the probable permanency depends. The washing of the prints should be rapid and thorough. If a print be laid a few minutes in clean cold water, kept moving about and then removed, the water allowed to drain off and the print placed in a fresh supply of cold water, and this operation repeated, say, ten or twelve times, the print will in one hour have received a more thorough freeing from hypo than it would have done had it been placed in a running stream of water for 24 hours.

There are a number of solutions for removing the fixing salts (see **Eliminator**), but none are to be recommended. Water changed frequently is the best eliminator.

With regard to mounted photographs, fading can very often be traced to the mount or to the mounting solution employed. In the manufacture of mounts hyposulphite of soda is often used as an anti-chlor. This should be tested for, and the mounts containing it discarded. The mountant should be as pure and as simple as possible.

Fahrenheit Thermometer.—A thermometer introduced by Fahrenheit in 1714, and still largely used in England. In this scale the freezing point of water is + 32°, and the boiling point of water + 212°, leaving 180 degrees between them. In the centigrade thermometer used on the Continent the space is divided

into 100 degrees, freezing point being 0°, and boiling point 100°. To reduce Fahrenheit degrees to centigrade, subtract 32, multiply by 5, and divide by 9.

Falling Front.—See **Rising Front.**

False Perspective.—See **Perspective.**

Ferric Chloride (Formula, FeCl.; synonym, *perchloride of iron*).—Usually purchased in solutions of a reddish-brown colour. If it contains free hydrochloric acid its colour will be somewhat lighter.

Ferric Oxalate (Formula, $Fe_2(C_2O_4)_3$; synonym, *sesquioxalate of iron*).—Commercial ferric oxalate is usually a solution of the salt in oxalic acid. It can be prepared by adding ammonia to a hot dilute solution of ferric chloride. The precipitated hydrate of iron is then thoroughly washed and drained. Finely powdered oxalic acid is then added in small quantities to the gelatinous mass, vigorously shaking. After a few hours the whole will then be dissolved, and the solution is filtered. As soon as the oxalic acid is added the whole must be protected from the light.

Ferric oxalate is sparingly soluble in water. It is used as the sensitive salt in platinotype paper.

Ferric Sulphate (Formula, $Fe_2(SO_4)_3$; synonyms, *persulphate of iron*, *sesquisulphate of iron*.)—Obtained by oxidising ferrous sulphate with nitric acid, and adding sulphuric acid. It is a yellowish brown deliquescent mass, readily soluble in water, but insoluble in alcohol.

Ferricyanide of Potassium.—See **Potassium Ferricyanide.**

Ferrocyanide of Potassium.—See **Potassium Ferrocyanide.**

Ferro-gelatine Developer.—A name given by Carey Lea to one of his old, now unused, collodion developers.

Ferro Prussiate Process.—See **Cyanotype.**

Ferrotype.—A name given by Hunt to a process in which collodion positives were made upon thin plates of black or chocolate enamelled iron instead of glass. The results are called "ferrotypes" or "tintypes." Itinerant photographers still employ this method of producing positives direct in the camera, as they are able to supply their customer with the finished print in a few minutes. The process is the same as that employed in the manufacture of collodion positives (*q.v.*), save that the metal plates are used in the place of glass.

Ferrotype Plate.—A thin sheet of iron, coated over with a black or chocolate enamel, and used for making positives on, in the ferrotype process.

Ferrotype plates can also be used instead of glass in surfacing or enamelling gelatine prints. See **Enamelling.**

Ferrous Citro-oxalate Developer.—A developer for dry plates introduced by Abney. It is made as follows :—

Potassium citrate (neutral)	100 grains
Ferrous oxalate..	22 ,,
Water	1 ounce.

The potassium citrate is first dissolved in a flask by heat, and when nearly boiling the ferrous oxalate is added and shaken up in it, a cork being used to prevent the access of air to it. This amount of ferrous oxalate should just dissolve. It is cooled by allowing cold water to flow over it, and should then have a citrony red colour.

Ferrous Oxalate (Formula, FeC_2O_4).—A yellow powder obtained by warming a mixture of solutions of ferrous sulphate and oxalic acid. Ferrous oxalate is practically insoluble in water, but will dissolve to a certain extent in solutions of alkaline oxalates, such as the oxalates of potassium, sodium and ammonium. Oxalate of potassium is the one generally preferred and used in the ferrous oxalate developer, because a saturated solution of it dissolves more of the ferrous salts than any of the other oxalates.

Ferrous Oxalate Developer.—See under **Developer.**

Ferrous Oxalate Intensifier.—See **Intensifier.**

Ferrous Sulphate (Formula, $FeSO_4, 7H_2O$; molecular weight, 278 ; synonyms, *green vitriol* or *copperas*, *protosulphate of iron.*)—Obtained by acting on iron wire or filings with dilute sulphuric acid, evaporating and crystallising. Pure ferrous sulphate forms bright green crystals. If kept in a perfectly-stoppered bottle it is remarkably permanent. In dry air they effloresce, and in damp air become coated with a brown coating of ferric-sulphate.

Ferrous sulphate is insoluble in alcohol, but soluble in twice its weight of water. In solution it rapidly becomes oxidised, and rendered useless by exposure to the air. If a small crystal of an acid, such as citric or tartaric, be added, it will prevent the fall of the precipitate, though not the oxidation. A solution that has burned quite yellow can be revived by placing in it a small quantity of citric acid and a few pieces of zinc.

Ferrous sulphate is used in the ferrous oxalate developer ; it forms double salts with the alkaline sulphates. The double sulphate of iron and ammonium gives a more permanent solution than ferrous sulphate, and is for this reason preferred by many as a developer for wet collodion plates.

The rapid deterioration of the ferrous oxalate solution can be avoided if the latter be placed in a bottle similar to that shown in Fig. 81. A film of oil rests upon the solution, and entirely pro-

tects it from the air. The two tubes are arranged so that the developer may be drawn off without disturbance. By blowing down the tube pointing upwards, the pure developer will be forced out of the opposite tube into the vessel ready to receive it.

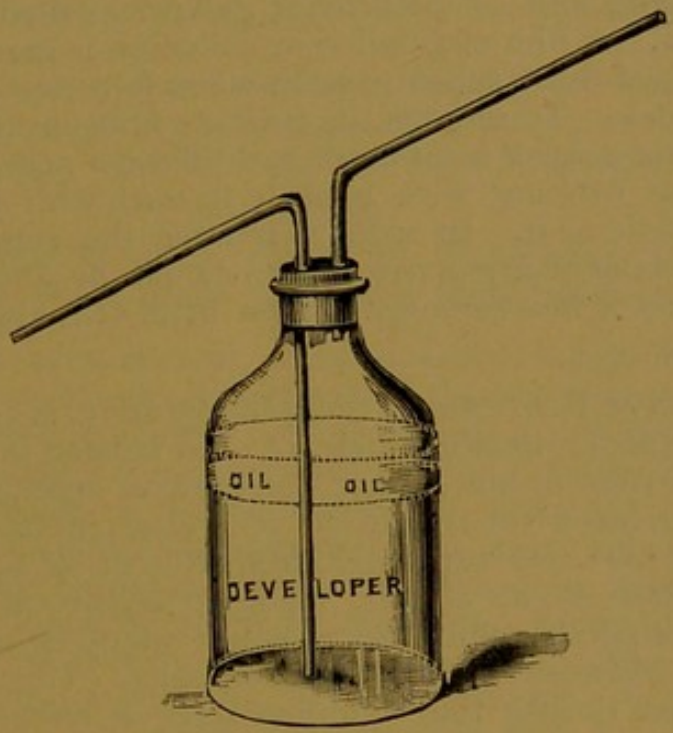

FIG. 81.

Field of a Lens.—The illuminated space on a screen made by any lens working with full aperture.

Figures in Landscapes.—Nothing adds more to the beauty of a landscape than the introduction of well-selected and properly posed figures. Nothing goes farther to mar the beauty of a landscape than the introduction of badly selected or inartistically posed pictures. Robinson, in his *Pictorial Effect in Photography*, says: "Before placing figures in a landscape the artist should first make up his mind whether the composition requires the introduction of any subject to add to its completeness. If he considers it does, do not let anything induce him to take the view without the figure, because he will be doing something which he can see could be done better with the assistance of a little more trouble; above all he should avoid incongruity, and never, for the sake of pleasing a friend by putting him in the picture, introduce an element of discord. The figures should look so right where they are placed that we should have no suspicion that it would be possible to place them anywhere else. . . . The figures and the landscape should never be quite equal in interest or pictorial value. The one should be subordinate to the other. The pictures should consist of figures with a landscape background (if they are represented in the open

air), or of a landscape in which figures are introduced merely for the sake of impressing a point, or adding life to the more important scene."

Filigrane.—See **Photo-filigrane.**

Film.—A thin skin or pellicle of gelatine, collodion, etc., on plates or paper. A film of gelatine or collodion is given to a glass by pouring one of these substances on when in a liquid state, and allowing it to dry. To remove the gelatine films from glass they should be laid in a weak solution of hydrofluoric acid, or they can be removed by rubbing with a paste formed with pumice-stone powder and acetic acid. In order to remove the superfluous film found on the backs of dry plates, they should be allowed to dry, and the portions of film removed with a little salt applied with a moistened rag.

Film Negative Process, or film photography, is a term applied to processes in which flexible films are used instead of glass plates. As far back as 1855 Scott Archer patented a method of coating collodion negatives with a solution of gutta-percha in benzole. When dry the film was separated from the glass by soaking in water. The glass might also be made to receive a preliminary coating of gutta-percha, the effect of which would be to enclose the collodion film between two waterproof films. The late W. B. Woodbury used during the collodion days a method by which glass was superseded in part. A sheet of glass was first rubbed over with powdered talc, and then coated with a collodion emulsion. After exposure these plates were developed, fixed, and washed, and a sheet of gelatine paper was squeegeed to the finished negative. When dry, the whole could be peeled off the glass, which was again used.

The recent advances in film photography consist in the coating of paper, insoluble gelatine, celluloid, or other flexible material with the sensitive bromide gelatine emulsion. These films are then exposed in the camera, developed, and fixed in the same manner as dry plates. Their principal advantage over glass is, of course, in their lightness, and they have been largely used by tourists and travellers. They have also the advantage of being flexible, unbreakable, and can be packed in a very small space. In the photography of brightly-lit objects they are superior to glass, as halation is avoided. Another advantage is that prints can be made from either side with equal facility—a great advantage to the carbon or collotype printer.

The best kind of films are those made upon insoluble gelatine or celluloid. To make the former, clean a large sheet of glass and rub it well with French chalk. A thick solution of gelatine is then poured over it, and the plate placed on a levelling stand to set. When dry the plate is placed in a saturated solution of chrome alum. This effectually renders the gelatine insoluble. It

is then washed, dried, and removed to the dark room to receive the dry-plate emulsion in the manner described under Dry-plate. When dry the film is stripped from the glass and cut up to the required sizes. Instead of chrome alum, the gelatine film may be hardened by soaking with potassium dichromate, exposing to the light, and then well washing; but I believe this method is covered with a patent.

Sensitive films are now made in lengths, and can be used in suitable holders, so that a roll of, say, 25 exposures can be obtained without changing. (See also under **Paper Negatives, Stripping Films.**)

Filmograph.—A name given by Pumphrey to a camera adapted for the use of films. (See also **Roll-holders.**)

Filter.—An arrangement through which a liquid is passed to arrest matters mechanically suspended therein. An ordinary filter is made by twisting a piece of filtering paper into proper shape in a funnel. Collodion is usually filtered through tufts of cotton-wool. Gelatine emulsion is filtered through chamois leather. An arrangement is shown on page 245. A very simple method of filtering aqueous liquids which do not deteriorate when exposed to the air, is by drawing them off from one vessel to another by means of a few threads of loosely twisted cotton or worsted arranged to form a syphon. The little twist of cotton at once performs the operations of decantation and filtration. This method will very often be found convenient when it is required to draw water off from a precipitate.

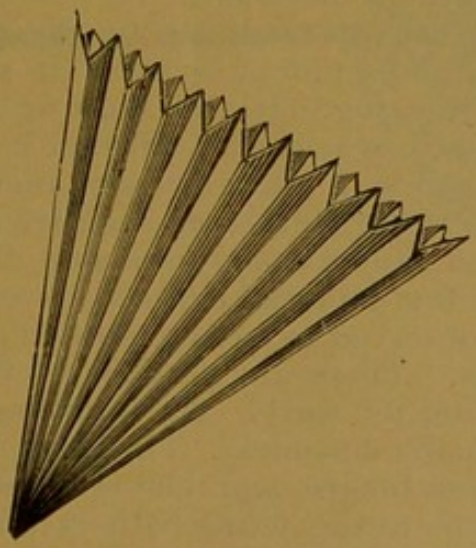

FIG. 82.

Filtering Paper.—A bibulous, unsized paper, thick and woolly in texture, and used for filtering solutions. Swedish filtering paper is thinner, but of superior quality. It is usually sold cut in round discs. Before placing in the funnel these should be folded

until they have the appearance of fig. 82. This will allow of the solution filtering through the sides of the paper, and not at the bottom of the cone only. Good filtering paper should not contain any soluble matter, and when burnt should not give more than $\frac{1}{250}$ to $\frac{1}{280}$ of its weight in ashes. Any soluble matter in the paper can be removed by washing it in hydrochloric acid and afterwards in distilled water.

Filtrate.—Any liquid which has passed through a filter.

Finder.—See **View Meter.**

Fixing.—A term applied to the dissolving away of the sensitive salt unacted upon by light. In the collodion process, potassium cyanide is used as the agent, but in the dry-plate process it is not to be preferred for three reasons—first, because it dissolves to a slight extent the finely divided silver that constitutes the image; secondly, it has a strong alkaline and softening effect upon the gelatine; and thirdly, it is a most powerful poison.

Sodium thiosulphate, or, as it is more commonly known, sodium hyposulphite, is usually employed. It possesses none of the disadvantages of the potassium cyanide. Its action is to first change the silver bromide into silver hyposulphite, thus—

$$2AgBr + Na_2S_2O_3 = Ag_2S_2O_3 + 2NaBr$$

and a further quantity of the salt combines with this silver hyposulphite formed to produce a double salt. There are thus two double hyposulphites of silver and sodium, the first $Ag_2S_2O_3Na_2S_2O_3$ is practically insoluble in water, but the second $Ag_2S_2O_32Na_2S_2O_3$ is exceedingly soluble. It is for this reason that it is necessary to have a large excess of the sodium salt.

The fixing bath is usually made up by dissolving four or five ounces of hyposulphite in a pint of water. It should be made a day or so previous to using. It will keep for a great length of time, but is liable to become acid. In this case it should be tested, and, if required, restored with a few drops of ammonia.

On the introduction of the developed negative in the fixing bath the action of the latter can be easily seen as it dissolves the silver compound. After a few minutes if the back of the negative be examined, it will be observed to have a mottled appearance, or to possess white patches. These are portions of the film where the hypo has not yet done its work. On returning to the solution these parts will eventually disappear. The plate should be allowed to remain a few minutes longer, and then removed.

The addition of alum to the fixing bath is often recommended for simultaneously hardening the negatives and preventing blisters. It is not advisable, however, to mix anything with the hyposulphite bath. Alums and acids decompose it rapidly with precipitation of sulphur and liberation of sulphurous anhydride. If an alum bath is to be used, it should be after fixing and washing.

The strength of the fixing bath for silver prints is about the same as that already given. The prints after toning and washing are laid in it for from ten to fifteen minutes. The action is quicker than with negative films, as the bath can attack both sides at one time. Care should be taken that the prints are not removed before they are thoroughly fixed, otherwise they will rapidly fade.

The difficulty of removing the hyposulphite from films and paper prints is the chief drawback to its use. It can only be done satisfactorily by repeatedly washing in many changes of water.

Other fixing agents have been introduced from time to time. Some years ago the sulpho-cyanides were proposed; careful trial, however, proved them to be inferior. Dr. Liesegang recommended magnesium chloride, it being an easily obtainable and harmless salt.

Flare.—A defect in a lens, when the image of the aperture of the diaphragm or of the lens itself shows itself as a circular patch of light on the focussing screen, and in the developed plate as a fogged patch in the centre of the negative. Although this is usually considered to be an image of the diaphragm or lens aperture, Monckhoven, in his work on "Photographic Optics," considers that it is due to the too close adherence to the globular form in the construction of the lens.

If this defect makes its appearance, the diaphragm apertures should be painted with a dead black varnish, as it is sometimes due to the edges having been worn bright. The Iris diaphragm is particularly liable to this defect by reason of the friction of the tongues of metal forming the apertures.

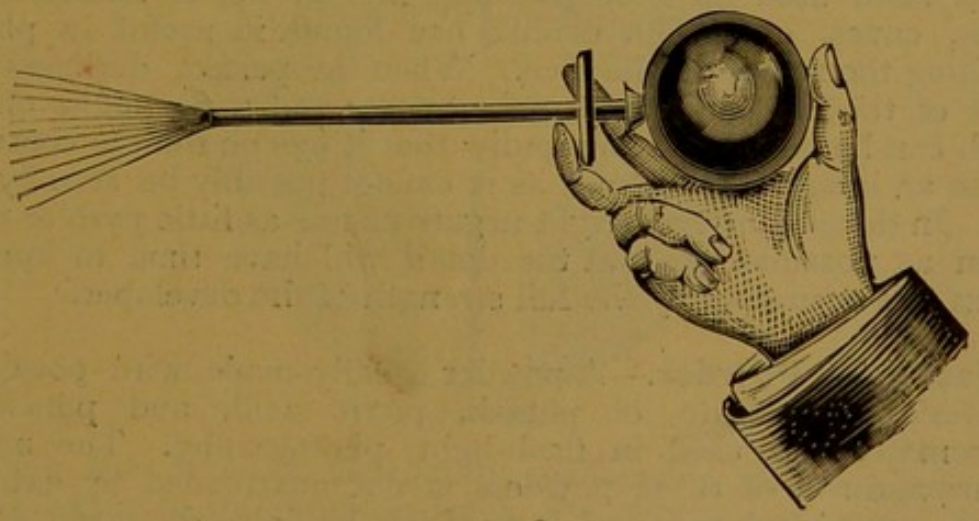

FIG. 83.

Flashlight.—Usually made by blowing magnesium powder through a small flame. This produces a flash of bright light sufficiently actinic for the purpose of making portraits or groups. In the purchase of the magnesium powder care should be taken that it does not contain a large portion of zinc, as many of the

cheaper kinds do. It should be carefully stored in tightly-fitting tins or stoppered bottles, otherwise it will be rendered useless by absorbing moisture from the air. There has been recently a number of different patents and inventions for flashlight apparatus. All that is really required is an arrangement similar to that depicted in fig. 83, by which a spray of the magnesium or flash powder can be ejected through a gas flame, and if the gas bracket be fitted with universal joints it will be possible to throw the light from any desired angle. If improperly managed, flashlight photographs present a very ghastly black and white appearance. We have to remember that the conditions under which we are working with flashlights are very different from those made by daylight. In the latter the light is diffused throughout the room, while with the flash lamp it is concentrated to what may almost be termed a point. The effect of this is not difficult to imagine—high lights and dark shadows and absence of detail in both. All defects in the skin are magnified a hundredfold, the slightest personal defect being exaggerated to an unpleasant degree. To avoid this it will be necessary for the artist to carefully study the position of the light, and the distribution of it over the sitter by reflecting screens and contrivances. If properly and judiciously managed, this power to concentrate, diffuse, and distribute the light at will is one of the chief advantages, and, if carefully carried out, some very striking effects may be produced.

Besides the production of portraits at night time, the flashlight has been put to other very useful purposes. For making photographs of interiors, its utility cannot be over estimated. In science it has been used for photographing the interior of tunnels, coal mines, caves, etc. The oculist has found it useful in photographing the retina of the eye. When in perfect darkness the pupil of the eye is dilated to its utmost, and a flashlight photograph can be made of it so rapidly that it has no time to contract, and so an image is made of it as it cannot possibly be seen by the eye. In developing flash light negatives use as little pyro or eikonogen as possible, so that the detail will have time to appear. When this occurs apply the full strength of the developer.

Flashlight Powder.—A powder usually made with powdered magnesium, chlorate of potash, picric acid, and potassium dichromate, and used in flash-light photography. The manufacture and use of these powders is not unattended by extreme danger, many accidents and loss of life has already taken place. For all ordinary purposes the pure magnesium powder may be used. The addition of a small quantity of ammonio-chlorate of copper will give a blue flash light.

Flatness.—A term used in photography to denote a lack of vigour or contrast in the negative or in the positive. The effect is usually due to over-exposure, or to over-development.

Flexible Support.—An improvement in the carbon process, patented by J. R. Sawyer in 1874. (See **Carbon Process.**)

Flint Glass.—A species of glass usually composed of white sand, potassium carbonate, lead oxide, alumina, with metallic addition to neutralise the colour. The flint glass of Guinand (one of the first optical glass makers) is composed of

White silicious sand	37·5
Red oxide of lead	37·5
Potash (best)	8.5
Borax	.15
Nitre	.18
Manganese	.17
Arsenious acids	16
Waste pieces of previous meltings	100

The silica for the manufacture of flint glass was formerly manufactured from pulverised flints, hence the name.

Flint glass is largely used in the manufacture of photographic lenses. (See **Glass.**)

Fluid Lens.—A lens containing water was patented by Thos. Sutton in 1859. The patent rights were afterwards bought by Ross, and since then other fluid lenses have been constructed.

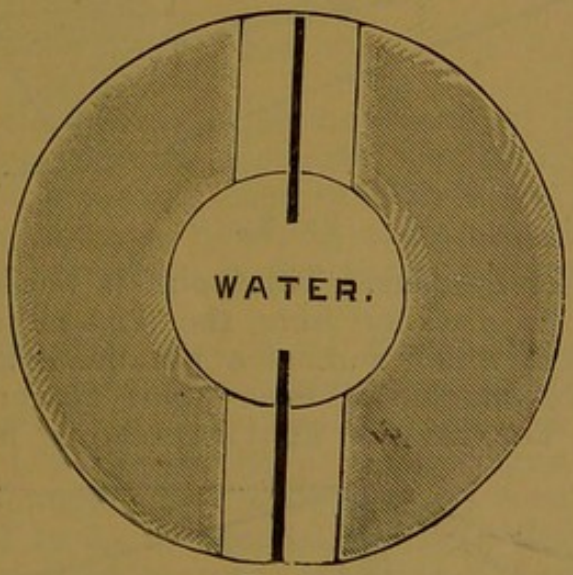

FIG. 84.

Sutton's lens was an achromatic panoramic (see fig. 84), with which, owing to its spherical form, the oblique rays were transmitted almost as perfectly as the central ones.

Fluid lenses have never become popular, owing to the chance of leakage, and also to the impossibility of keeping the temperature of the liquid perfectly equal, which was necessary, as a change in the temperature means also a change in the refractive power of the lens.

Fluorescence.—In optics—a quality which exists in rays of light by which, under certain circumstances, they undergo a change of

refrangibility. Certain solutions, if viewed by transmitted light, are colourless, but become of a bluish tint if viewed by reflected light.

Fluorhydric Acid. See **Hydrofluoric Acid.**

Fluorine.—(Symbol F ; atomic weight 191.) A non-metallic element, only recently obtained in a free state. It is an isometric transparent mineral usually obtained from fluor spar.

Focal Length.—See **Focus.**

Focimeter.—An instrument used in testing for chemical focus (see Fig. 37).

Focus (Lat. a fireplace, literally any place from which an influence emanates).—A term used in optics.

Principal Focus.—If a pencil of parallel rays enter a convergent lens, they will be brought together at a point F (fig. 85)

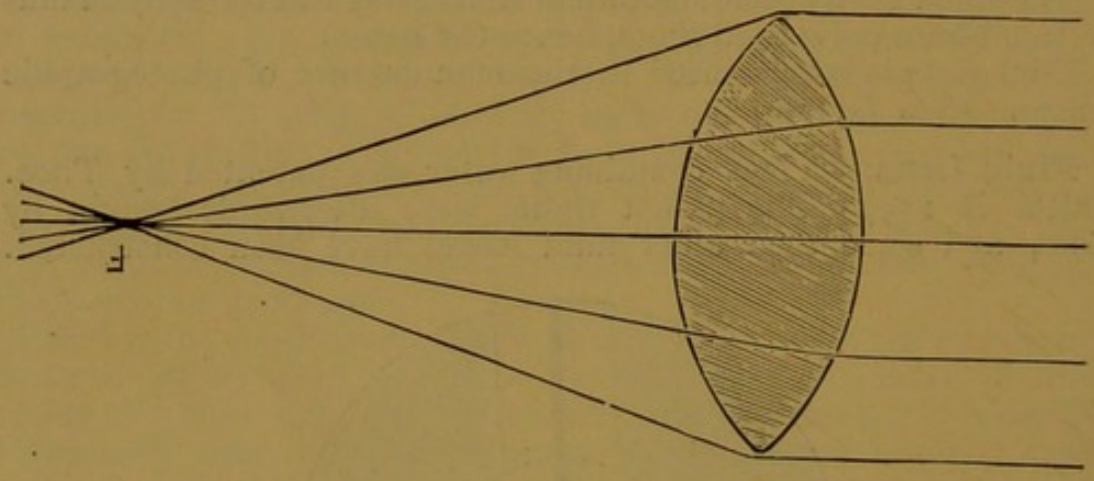

Fig 85.

on the other side of the lens. This point is termed the *principal focal point*, and its distance from the lens is termed the *focal length*. Those rays which pursue a parallel course before they enter the lens are condensed to a point nearer the lens than diverging rays. The rays of light proceeding from very distant

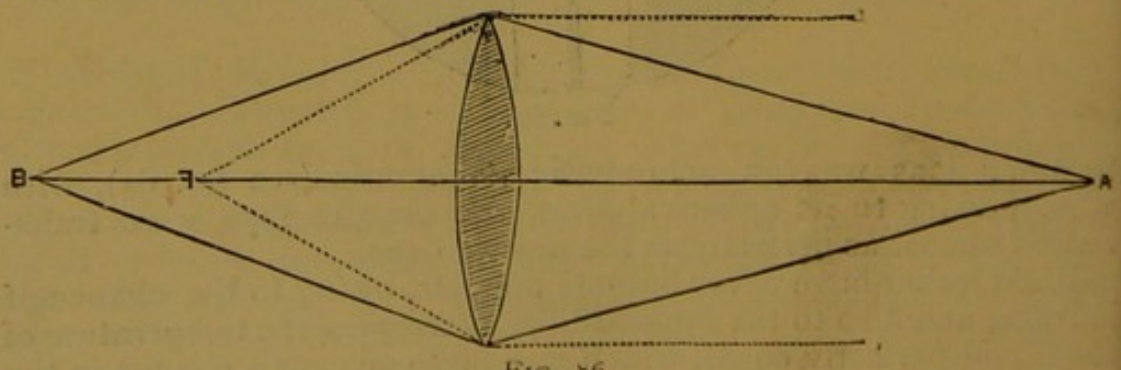

Fig. 86

objects are parallel, while those from near objects diverge. When the rays diverge from a point, that point is associated with the focus, and the two are termed conjugate foci. In Fig. 86 F is the

principal focus, and A and B are the conjugate foci. If an object be placed at A it will have its focus at B, and conversely, if placed at B, its focus will be at A. It will therefore be seen that the principal focus of the lens never varies, but the length of focus for objects near at hand becomes greater the nearer they are brought to the lens. The relation of the conjugate foci is governed by certain laws. On page 167 will be found a table of conjugate foci, which should be carefully studied.

Actinic Focus.—Under the heading **Aberration** will be found some remarks concerning chromatic aberration, by which it will be seen that unless the lens be rendered achromatic the actinic or chemical focus does not coincide with the visual focus. To make this clearer we have in fig. 87 the focus of an non-achromatic lens. Its visual focus is at V, while its chemical focus is at C. The

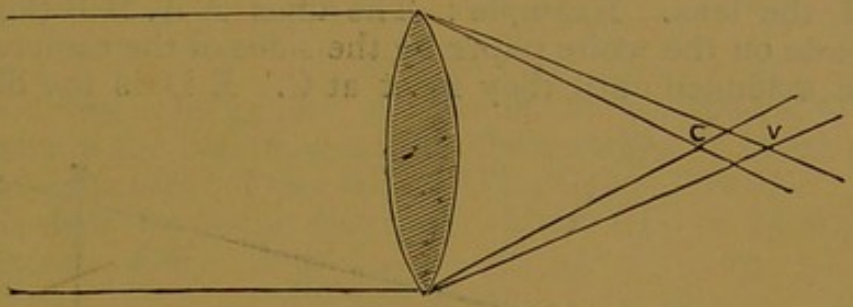

FIG. 87.

ground glass of the camera would be placed at V, and the image focussed to the eye, but the chemical focus being at C it would be necessary to push it to that point, in order to get a sharp negative. Most modern lenses are, however, achromatised. The method by which this is performed is explained in *Chromatic Aberration*, under **Aberration.**

Depth of Focus of a lens is its power of rendering a sharp image upon the plane ground glass screen of objects situated at varying distances. A lens working at full aperture rarely renders near and remote objects perfectly clear at the same time. By using a diaphragm a portion of the rays is cut off, and a much greater depth of focus is obtained, but with the sacrifice of illumination, necessitating increased exposure. (See also **Diaphragm.**)

Equivalent Focus.—A term applied to a compound or doublet lens. It is the focus of parallel rays entering the lens, and is termed equivalent from being compared with a single lens producing the same size image when placed at the same distance from the object. To be perfectly correct, the point from which this focus should be measured is situated between the diaphragm slot and the back combination. It is, however, usually measured from the slot itself, and this measurement will usually be found sufficiently accurate if an object over 150 yards away be focussed on the ground glass and the distance between the diaphragm slot and the screen be measured.

Grubb, the well-known optician, gives the following method for obtaining the true equivalent focus of a lens :—"Set the camera before a window upon a flat table, upon which is spread a sheet of white paper. Focus upon some distinct object about 150 or 200 yards away. Draw two upright lines on the focussing screen at one inch from the right and left sides respectively. Make the focussed image fall on one of these lines, and with a pencil draw a line upon the paper along the side of the camera. Now move the camera so that the image appears on the other line, and draw another mark alongside the camera. Take away the camera, and continue these lines with a ruler until they meet to form an angle. Next draw a line across to form a triangle, the line being exactly the same length as the distance between the two lines on the screen. Find the centre of this line, and connect it with the junction of the two angular lines ; this will represent the true equivalent focus of the lens. Example : The lines A A, B B (fig. 88), are those made on the white paper by the sides of the camera. These lines are extended until they meet at C. E D is the distance of

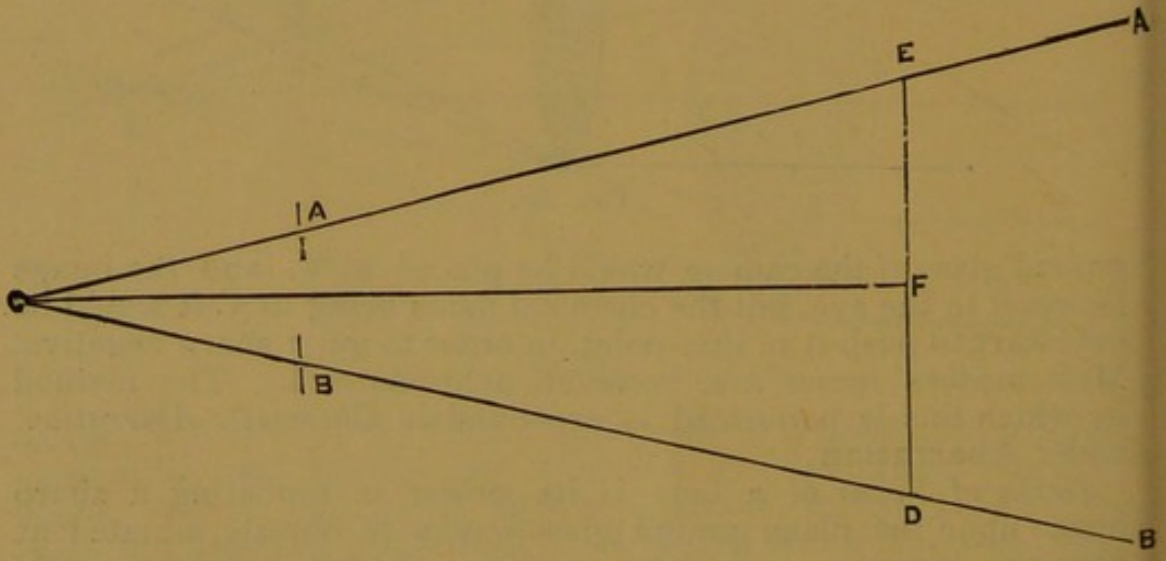

Fig. 88.

the two pencil lines drawn on the focussing screen. F is the centre of this line, and F C the equivalent focus of the lens."

Abney, in his instruction book, gives the following method of discovering the true equivalent focus of a lens :—

Measure a distance of, say, one hundred feet away from a fixed point, and place a rod at one extremity. From this point measure a line of some forty feet in length at exactly right angles to the first, and place another rod at the other end. Next place the front of the camera containing the lens to be tested exactly over the starting point of the first line, and level it, the lens being in the direction of the first line. Having marked a central vertical line on the ground glass with a pencil, focus the first rod accurately so as to fall on the pencil line on the ground glass. Take a picture of the two rods in the usual manner, and measure back as

accurately as possible the distance of the centre of the ground glass from the starting point, and also the distance apart of the two images of the rods (at their base) upon the resulting negatives.

Suppose the first measured line A B (fig. 89) be 149 feet, B D

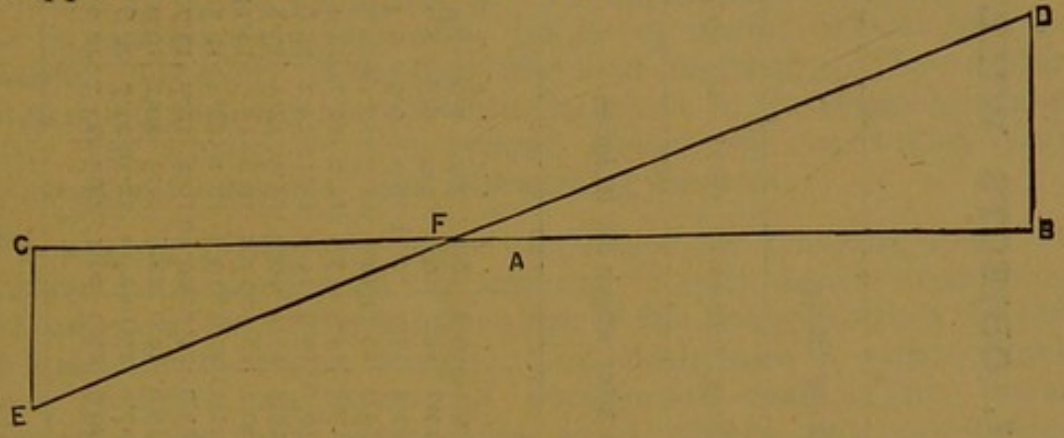

FIG. 89.

the second line to be 35 feet, A C to be one foot, and E C the distance apart of the two images to be three inches, F being the point where DE cuts CB. Then BD + CE : CB : : CE : CF, which is the equivalent for focal distance. Here CB = 150ft., BD + CE = 35·25ft., CE = ·25ft.

$$\therefore \text{CF} = \frac{150 \times \cdot 25}{35 \cdot 25} = 1 \cdot 063\text{ft.}$$

This gives us the equivalent focal distance, which is the distance of the ground glass from the optical centre of the lens. The thickness of the ground glass having been previously taken, the distance should be set off from its smooth side, on to the brass-work of the lens. This point, which is the optical centre, should be clearly marked on the lens, as from it all measurements can be calculated, and the knowledge of its position will be found very useful.

A very simple method of ascertaining the equivalent focus of a doublet lens is to multiply the foci of the two combinations and divide by the sum obtained by adding them together and subtract the distance of separation, the result being the equivalent focus of the two lenses combined. For example, we require to know the equivalent focus of a lens, the front combination of which has a focus of ten inches and the back of eight inches, while they are separated from each other by a space of two inches, then $10 \times 8 \div [(10 + 8) - 2] = 80 \div 16 = 5$in., the true equivalent focus.

After a certain distance all objects will be in focus. The following table will be found useful for many purposes. It shows at a glance the distance beyond which all objects will be sharply defined, and it is a good plan to mark the stops with this distance, so that if a subject be taken requiring a particular stop to obtain correct focus, and it is discovered that this stop requires too long an exposure, the subject should not be taken and thus a plate will be saved. For detective camera work this table is very useful.

TABLE OF DISTANCES AFTER WHICH ALL OBJECTS WILL BE IN FOCUS.

Focus of lens in inches.	Decimal Standard Stop Numbers.								Ratio Marked on Stops.													Focus of lens in inches.
	5	10	15	20	25	30	35	40	*f*-7	*f*-8	*f*-9	*f*-10	*f*-11	*f*-12	*f*-13	*f*-14	*f*-15	*f* 16	*f*-17	*f* 18	*f*-19	*f*-20	
	Number of feet and inches after which all in focus.								Number of feet and inches after which all in focus.														
4	′ ″ 19·4	′ ″ 13·8	′ ″ 11·5	′ ″ 9·10	′ ″ 8·9	′ ″ 8·0	′ ″ 7·5	′ ″ 7 0	′ ″ 19·4	′ ″ 17·0	′ ″ 15·1	′ ″ 13·8	′ ″ 12·5	′ ″ 11·5	′ ″ 10·7	′ ″ 9·10	′ ″ 9·2	′ ″ 8·8	′ ″ 8·2	′ ″ 7·8	′ ″ 7·4	′ ″ 7·0	4
4¼	21·10	15·4	12 10	11·1	9·10	9·0	8·4	7·10	21·10	19·2	17·0	15·4	14 0	12·10	11·10	11·1	10 4	9·9	9·2	8 8	8 3	7·10	4¼
4½	24·5	17·3	14·5	12·5	11·1	10 1	9·4	8·9	24·5	21 5	19·1	17·3	15·8	14·5	13 3	12·5	11 7	0·11	10·3	9·9	9·3	8·9	4½
4¾	27·3	19·2	16·0	13·9	12·4	11·3	10·5	9·9	27·3	23·10	21·3	19·2	17·5	16 0	14·10	13 9	12 11	12·1	11·5	10·10	10·3	9 9	4¾
5	30·2	21·3	17 9	15·3	13·7	12·5	11·6	10·10	30·2	26·5	23·6	21·3	19·4	17·9	16 5	15·3	14·3	13·5	12 8	11·11	11 4	10·10	5
5¼	33·3	23·4	19·6	16·10	15·0	13·9	12·8	11·11	33·3	29·1	25·11	23·4	21·3	19·6	18·1	16·10	15·9	14 9	13·11	13·2	12·6	11·11	5¼
5½	36·5	25·8	21 5	18 5	16·5	15·0	13·10	13·0	36·5	31·11	28·5	25 8	23·4	21·5	19 10	18·5	17·3	16 2	15·3	14·5	13·8	13 0	5½
5¾	39·10	28·0	23·5	20·1	17·11	16 5	15·2	14·3	39·10	34·11	31·1	28·0	25·6	23·5	21 8	20·1	18·10	17 8	16 8	15 9	14·11	14 3	5¾
6	43·4	30·6	25·6	21·11	19·6	17 8	16·6	15·6	43·4	38·0	33·10	30·6	27·9	25·6	23·6	21·11	20·6	19 3	18 1	17·2	16 3	15·6	6
6¼	47·0	33 0	27 7	23·9	21·2	19·4	17·10	16·9	47·0	41·2	36 8	33·0	30·1	27·7	25.6	23·9	22·2	20·10	19·8	18·7	17·7	16·9	6¼
6½	50·10	35 9	29 10	25·8	22·10	20·11	19·3	18·1	50 10	44·6	39·7	35·9	32·6	29·10	27·7	25 8	24·0	22 6	21·3	20.1	19·0	18 1	6½
6¾	54·9	38·6	32·2	27·8	24 8	22·6	20 9	19·6	54·9	48·0	42·9	38 6	35·0	32·2	29·9	27·8	25·10	24·3	22·10	21·7	20 6	19 6	6¾
7	58·11	41·5	34·7	29·9	26·6	24·3	22·4	21·0	58 11	51·7	45·11	41·5	37·8	34·7	31·11	29·9	27·9	26 1	24·7	23·3	22 0	21·0	7

Focussing.—The act of bringing the image into focus. When the camera is set up it should be racked out to its equivalent focus, which, for convenience sake, should be marked on the baseboard of the camera. The cloth is then covered over the head, and an object about midway in the middle distance of the view is sharply focussed. The image of nearer objects will be indistinct, however. The stops are then inserted in their order, commencing with the largest until the whole of the image becomes clear. The quality of the ground glass will be found very important in focussing. See **Focussing Screen.**

Focussing Cloth.—A black cloth used for covering over the head and back portion of the camera to exclude all extraneous light, and to allow of the examination of the image thrown by the lens upon the focussing screen. The cloth used is either black velvet, twill, or an American waterproof cloth. This latter material is the most serviceable, as it serves as a convenient waterproof covering for the camera in case of sudden showers. The cloth should always be of sufficiently large dimensions, about 36 to 40 inches square is about right, although for a large camera it would have to be bigger. It should be fitted with buttons and loops, so that it can be secured to the camera if the weather be windy. Other methods for shutting out the light in focussing have been devised, but it will be long ere the black cloth is superseded.

Focussing Glass.—Also called the focusser, focussing magnifier, compound focusser, etc. A magnifying glass fitted in a tube and so arranged that the image upon the focussing glass is exactly in focus with the lens of the magnifier. By its means microscopic sharpness of focus can be obtained, which is almost a necessity if the negatives are intended to be enlarged. The magnifying glass is usually composed of two plano-convex lenses, equal in all respects, and mounted with their plane sides outwards at a distance equalling two-thirds of the focal length of the lenses. It is preferable that the lenses should be achromatic, although this is not absolutely necessary.

Focussing Screen.—The material upon which the image formed by the lens is seen. This is usually a piece of ground glass of the best quality. It can be made by grinding a piece of patent obscure plate with very fine emery powder. The most convenient plan is to grind two pieces together by firmly securing one piece to a table and rubbing over it a paste of fine emery powder and water. The second piece of glass is then laid on and rubbed over the other in all directions. The upper piece of glass can best be manipulated by employing a pneumatic holder to lay hold of it. Another method of preparing glass is by treating with hydrofluoric acid, which gives it a dull matt surface superior to ground glass. (See **Hydrofluoric Acid.**)

By oiling the ground glass the detail of the image is seen better. If the ground glass should happen to get broken, and another not easily obtainable, a rough temporary substitute can be made by coating a piece of glass with a paste of flour and water, or even a piece of tissue paper or fine cambric handkerchief can be used.

There have been many substitutes for ground glass recommended. A glass plate coated over with a matt varnish of—

Sandarac	18 grains.
Mastic	4 ,,
Ether	200 mins.
Benzole	100 ,,

will make an excellent focussing screen, or even an ordinary varnish can be used if a little tartaric acid be added, and the varnish applied cold.

A paper focussing screen can easily be made with a piece of strong, but thin, paper rendered translucent. See **Translucence.**

Carey Lea coated glass with an emulsion of barium sulphate, made by dissolving thirty grains of gelatine in an ounce of water, and adding a small quantity of ammonium sulphate and a solution of barium chloride, stirring the while.

The side of the focussing screen next to the lens should be in exactly the same position that the film of the dry plate or other sensitive medium will occupy, otherwise unsharp images will be the result. It is a good plan to mark the focussing screen, as shown in fig. 90, with the different sizes smaller than the camera is intended for, so that in working with smaller plates the position of the view is plainly seen. The upright lines are also useful in detecting the verticality of architectural subjects, etc.

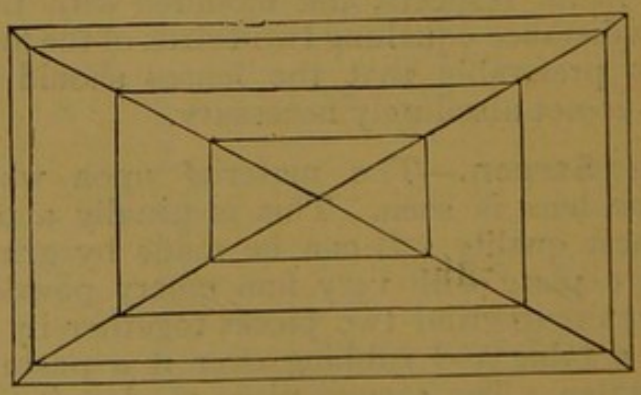

Fig. 90.

Fog.—A very common defect in gelatine negatives. It appears as a veil covering the whole or part of the negative, and may be due to

faulty emulsion, to the admission of stray light in the camera or elsewhere, or it may be due to over-exposure or to faulty development.

Chemical Fog.—When the error can be traced to the emulsion itself, it is thus termed. It usually makes its appearance as—

Green Fog.—It appears green by reflected, and pink by transmitted light, being dichroic. It is produced by reduced metallic silver in a fine state of division, and also by the gelatine becoming decomposed by prolonged heating in the cooking process. The plates should be immersed in a strong solution of potassium dichromate, and then well washed. If any of the emulsion itself be left it should also be treated to the dichromate solution by squeezing it into the latter through coarse canvas, and afterwards well washing in water. It is as well to mention that this treatment will not always effect a cure, but it has been known to do so on many occasions, and is therefore well worth trying.

Plates liable to green fog should be developed with ferrous oxalate or a potash and soda developer, as there is less likelihood of it appearing with these developers than with ammonia.

Green fog may be eliminated from a plate by treating it after fixing and washing to a bath composed of

Ferric chloride	50 grains.
Potassium bromide	30 ,,
Distilled water	4 ounces.

for about two or three minutes. This serves to convert the image into silver bromide, and at the same time to bleach the green fog, and reduce the density of the negative. A ferrous oxalate developer is then applied, and the negative brought up to its required density, when it is re-fixed and washed.

Red Fog occurs when the silver nitrate is in excess of the salts with which it should combine in the emulsion. A careful study of the tables given on pages 238 and 240 will prevent this. The only remedy for this kind of fog is potassium cyanide, but its action is uncertain, and it is highly dangerous to use.

General Fog is produced in development, and is caused by the partial reduction of the silver salt all over the film. This may also be due to the decomposition of the gelatine by prolonged heating. The products of the decomposed gelatine in the presence of the developer have a tendency to react on the silver salt, producing partial reduction and general fog. It has been noted that in stormy weather, when the air is charged with electricity, that this defect is more easily produced. The remedy is to add a few drops of a carbolic acid solution to the gelatine solution during the cooking process. This will usually prevent decomposition.

Light Fog is caused by the action of light upon the whole or a a portion of the film. The only actinic light that should reach the

plate before fixing should be that light which enters through the lens and forms the image. Light fog may be caused by the light of the room in which the plates are made (or placed in the dark slides) being too actinic. It very often happens, however, that the camera or the dark slide is at fault. If there is any defect in the camera producing fog the edges of the plate which are covered by the rabbet of the slide will remain clear.

To examine the camera take it out into strong sunlight, place the cap on the lens, remove the focussing screen, and, with the black cloth covered over the head, make a thorough examination of the inside of the camera (racked out to its full extent), and see if there are any holes or other places where light is admitted. If the dark slide be at fault the fogging will usually be in streaks. The inside of the camera and slides should be painted a dull black, as fog is easily produced by reflecting surfaces.

Fogged plates will be produced if white light be not excluded from the dark room, or if the light employed be too actinic.

A peculiar kind of fogging sometimes makes its appearance round the edges of plates, and is due to some impurities in the strips of paper placed at the edges of the plates to separate them.

In the collodion process the principal causes of fog are—the alkalinity of the silver sensitising bath, or the neutrality of the same if a bromo-iodised collodion be employed. Other causes may be in over-acidity of the bath, diffused light in the camera, dark room, &c.

Folding Racks.—See **Racks.**

Formic Acid (H.COOH, hydrogen, carboxylic acid; molecular weight, 46).—It was first found in the red ant (*Formica rufa*), hence its name. The original method of preparing it was by distilling these ants with water. It occurs, however, in many plants and fruits, in the products of oxidation of crude turpentine, oil, &c. It is usually prepared by the oxidation of wood spirit. Another method—take one part sugar, two parts of water, and three parts of binoxide of manganese, and mix in a retort sufficiently large to hold ten times the bulk of the ingredients. Next add cautiously three parts of oil of vitriol diluted with an equal weight of water. Directly the first violent effervescence has subsided, heat is applied, and the product collected and purified by saturating with pure sodium carbonate, and subjecting the liquid to a gentle heat, liberating formic acid from the salt with sulphuric acid, and afterwards distilling the mixture when the hydrated acid will pass over quite pure.

Formic acid is a colourless liquid of a pungent odour. It freezes at 30° and boils at 210°, giving an inflammable vapour, which burns with a blue flame. It is a powerful reducer of the salts of silver and mercury, and has been recommended as a restrainer in the developer.

Formula (Lat. *forma*— a form).—The term is used in chemistry to denote a collection of symbols representing a compound. The formula of a compound is written by placing side by side the symbols of the elements which it contains, and also the small figures indicating the number of combining proportions of each element which are present in the compound represented, or, in other words, the chemical formula of a compound is intended to represent the quantitative composition of the compound, and to tell what atoms and how many are combined to make the smallest particles of the compound itself. The method by which formulæ are determined is this:—First the substance must be analysed, and secondly the molecular weight must be determined. We will take, for example, water. By analysing this compound called water we find it consists of hydrogen and oxygen, one part of the former and eight parts of the latter, both by weight. We have next to determine the specific gravity of water vapour, and find that, as compared with air, its specific gravity is 0·623. We have now the relative weight of the molecule of water, and by adopting the usual standard it shows the molecular weight to be 18. The atomic weight of oxygen is 16, and that of hydrogen 1. So we now have all we require for writing the formula. A molecule, consisting of hydrogen and oxygen in the proportions given, and the weight of which is 18 in terms of accepted unit weight, must contain two atoms of hydrogen and one atom of oxygen. The formula is therefore written H_2O or OH_2.

Mercurous chloride contains one combining portion of mercury and one of chlorine; its formula is therefore written HgCl. Mercuric chloride, however, contains one combining proportion of mercury and two of chlorine; its formula is $HgCl_2$. In the table of elements is given their respective symbols, by which it will be found easier to understand the formulæ given.

Chemical formulæ have a quantitative besides a qualitative meaning; for instance, HgCl, not only signifies that mercurous chloride is composed of mercury and chlorine, but it also means 235·4 of mercurous chloride composed of 200 parts of mercury and 35·4 of chlorine. These numbers will be found opposite to the elements. Formulæ of compounds have still another meaning, which it is necessary to understand. They always represent one molecule, and the numbers indicate the number of atoms of the different elements in that molecule. For instance, $K_2Cr_2O_7$ serves to represent one molecule of potassium dichromate, consisting of two atoms of potassium weighing 39·1 each, two atoms of chromium each weighing 52·3, and seven atoms of oxygen weighing 16 each. By adding the weights of all the atoms we get the molecular weight. (See also **Chemistry.**) In the following table the formulæ of the most important compounds used in photography are given, together with their molecular weights. When the latter is not given, it is either because it is unknown or too uncertain:—

Table of the Formulæ of the Most Important Chemicals Used in Photographic Operations.

Name.	*Formula.*	*Molecular Weight.*
Acetic acid	$HC_2H_3O_2$	60
Alcohol	C_2H_5HO	46
Alcohol (methylated)	CH_3HO	32
Alum	$Al_2(So_4)_3, K_2SO_4\ 24\ H_2O$	948
Alum, Chrome	$Cr_2(SO_4)_3K_2SO_4, 24\ H_2O$	999
Ammonium bichromate	$(NH_4)_2Cr_2O_7$	888·4
Ammonium bromide	NH_4Br	98
Ammonium carbonate	$NH_4HCO_3, NH_4CO_2NH_2$	342
Ammonium chloride	NH_4Cl	53·5
Ammonium iodide	NH_4I	145
Ammonium nitrate	NH_4NO_3	80
Ammonium oxalate	$(NH_4)_2C_2O_4$	124
Ammonium sulphide	$(NH_4)_2S$	51
Ammonium sulphocyanide	NH_4CNS	76
Barium bromide	$BaBr_2$	—
Barium chloride	$BaCl_2H_2O$	244
Barium iodide	BaI_2	391
Barium nitrate	$Ba(NO_3)_2$	261
Barium sulphate	$BaSO_4$	233
Borax	$NA_2B_4O_7 + 10H_2O$	382
Boric acid	H_3BO_3	62
Cadmium bromide	$CdBr_2$	271·2
Cadmium chloride	$CdCl_2$	—
Cadmium iodide	$Cd\ I_2$	366
Calcium bromide	$CaBr_2$	—
Calcium carbonate	$CaCO_3$	100
Calcium chloride	$CaCl_2$	111
Calcium hypochlorite	$CaCl_2O_2CaCl_2$	254
Calcium iodide	CaI_2	—
Copper acetate	$Cu(C_3H_3O_2)_2H_2O$	200
Copper bromide	$CuBr_2$	223 4
Copper chloride	$CuCl_2$	171
Copper sulphate	$CuSO_45H_2O$	249
Dextrine	$C_6H_{10}O_5$	—
Eikonogen	$C_{10}H_6OH_2$	—
Ether	$C_4H_{10}O$	74
Ferric chloride	Fe_2Cl_6	325
Ferric oxalate	$Fe_2(C_2O_4)_3$	376
Ferric sulphate	$Fe_2(SO_4)_3$	400
Ferrous ammonium sulphate	$FeSO_4,(NH_4)_2SO_46H_2O$	392
Ferrous bromide	$FeBr_2$	—
Ferrous iodide	FeI_2	310
Ferrous nitrate	$Fe(NO_3)_26H_2O$	288
Ferrous oxalate	FeC_2O_4	144
Ferrous sulphate	$FeSO_47H_2O$	278
Formic acid	$HcHO_2$	46
Gallic acid	$Hc_7H_5O_5$	170
Glycerine	$C_3H_5(HO)_3$	92
Gold chloride	$AuCl_3$	302·5
Hydrobromic acid	HBr	81
Hydrochloric acid	HCl	36 5
Hydroquinone	C_6H_42HO	110
Hydroxylamine chloride	NH_3OHCl	

Table of the Formulæ of the Most Important Chemicals Used in Photographic Operations—(*Continued*).

Name.	*Formula.*	*Molecular Weight.*
Lead acetate	$Pb(C_2H_3O_23)_2H_2O$	379
Lead carbonate	$PbCO_3,Pb(HO)_2$	774
Lead iodide	PbI_2	460
Lead nitrate	$Pb(NO_3)_2$	331
Lead oxide	PbO	223
Lithium bromide	$LiBr$	87
Lithium chloride	$LiCl$	42·5
Lithium iodide	LiI	134
Magnesium bromide	$MgBr_2$	184
Magnesium chloride	$MgCl$	95
Magnesium iodide	MgI_2	278
Magnesium sulphate	$MgSO_47H_2O$	246
Mercuric chloride	$HgCl_2$	271
Mercuric iodide	HgI_2	454
Mercurous chloride	$HgCl$	235·5
Mercurous cyanide	$HgCy_2$	252
Mercurous iodide	HgI	327
Nitric acid	HNO_3	63
Oxalic acid	$H_2C_2O_4,2HO_2$	126
Platinum chloride	$PtCl_4$	339
Potassium bicarbonate	$KHCO_3$	100
Potassium bromide	KBr	119·1
Potassium carbonate	K_2CO_3	138·2
Potassium chlorate	$KClO_3$	122·4
Potassium chloride	KCl	74·5
Potassium citrate	$K_3C_6H_5O_7H_2O$	324·3
Potassium cyanide	KCN	65
Potassium dichromate	$K_2Cr_2O_7$	294·6
Potassium ferricyanide	$K_6Fe_2C_{12}N_{12}$	658
Potassium ferrocyanide	$K_4FeC_6N_63H_2O$	422
Potassium ferrous oxalate	$(CO_2)_4K_2Fe$	—
Potassium hydrate	KHO	56·1
Potassium iodide	KI	166·1
Potassium nitrate	KNO_3	101·1
Potassium permanganate	$K_2M_2O_3$	316·2
Potassium sulphocyanide	$KCNS$	97
Pyrogallic acid	$H_3C_6H_3O_3$	126
Salicylic acid	$HC_7H_5O_3$	138
Silver acetate	$AgC_2H_3O_2$	167
Silver bromide	$AgBr$	188
Silver carbonate	Ag_2CO_3	276
Silver chloride	$AgCl$	143·5
Silver citrate	$Ag_3C_6H_5O_7$	513
Silver fluoride	$AgFl$	127
Silver iodide	AgI	235
Silver nitrate	$AgNO_3$	170
Silver nitrite	$AgNO_2$	154
Silver oxalate	$Ag_2C_2O_4$	304
Silver oxide	Ag_2O	232
Silver sulphide	Ag_2S	248
Sodium acetate	$NaC_2H_3O_2,6H_2O$	190
Sodium bromide	$NaBr$	103
Sodium bicarbonate	$NaHC_3O$	84

Table of the Formulæ of the Most Important Chemicals Used in Photographic Operations—(*Continued*).

Name.	*Formula.*	*Molecular Weight.*
Sodium carbonate	$NaCO_3IOH_2O$	286
Sodium chloride	$NaCl$	585
Sodium citrate	$Na_3C_6H_5O_7$	258
Sodium hydrate	$NaHO$	40
Sodium hyposulphite	$Na_2S_2O_35H_2O$	248
Sodium iodide	NaI	150
Sodium nitrate	$NaNO_3$	85
Sodium sulphate	$Na_2SO_4IOH_2O$	322
Sodium sulphide	Na_2S9H_2O	240
Sodium sulphite	$NaSO_37H_2O$	252
Stannic chloride	$SnCl_4$	260
Stannous chloride	$SnCl_22H_2O$	225
Sulphuric acid	H_2SO_4	98
Sulphurous acid	H_2SO_3	82
Strontium bromide	$SrBr_26H_2O$	355·5
Strontium chloride	$SrCl_26H_2O$	266·5
Strontium nitrate	$Sr(NO_3)_2$	211 5
Tannic acid	$H_4C_{27}H_{18}O_{17}$	618
Tartaric acid	$H_4C_4H_2O_6$	150
Uranium bromide	UBr_24H_2O	352
Uranium nitrate	$UO_2(NO_3)_26H_2O$	384
Uranium sulphate	$UO_2(SO_4)3H_2O$	302
Zinc bromide	$Zn\ Br_2$	225·2
Zinc chloride	$Zn\ Cl_2$	136·2
Zinc iodide	ZnI_2	319·2
Zinc nitrate	$Zn(NO_3)_26H_2O$	189
Zinc sulphate	$ZnSO_4.7H_2O$	872

The word formula is also applied to recipes for making compounds expressed in ordinary words and figures.

Fothergill Process.—A dry process introduced by Fothergill in 1858. In this, sensitive collodion plates were washed, first in distilled water, and then in the usual developing solution of pyrogallic acid, after which they were dried and kept till required.

Fraunhofer Lines.—Certain dark lines in the solar spectrum discovered by Fraunhofer. If a ray of light be admitted through a narrow slit in a dark room, and this slit examined through a prism of flint glass, besides the spectrum band of colours, a number of lines will be observed delicately traced parallel to the edge of the prism, and at unequal distances from each other. Fraunhofer distinguishes the most remarkable of these lines by the letters A, a, B, C, D, E, b, F, G and H. A is at the beginning of the red ray, B in the middle, and C at the boundary between it and the orange, E in the green, F in the blue, G in the indigo, and H in the violet ; *a* is in the red and *b* in the green. Since Fraunhofer's time, however, some three thousand or more of

these lines have been discriminated, some being fixed in position, and others are variable. The latter are often termed telluric or atmospheric lines, as it is probable that they are due to the absorption of the air. The study of these lines has led to a method of analysis termed spectrum analysis, to which photography has been essentially useful. (See also **Spectrum.**)

Freezing.—The transformation of a liquid into a solid by the influence of cold. A liquid always solidifies at the same temperature, which is termed its freezing point, and the solid returns to its liquid state at the same temperature, the freezing point and the melting point being always the same for each substance.

The freezing point of water or the melting point of ice is 32° Fahr., and is taken for one of the fixed points in thermometrical calculations. The freezing point of mercury is 39° below zero, of sulphuric ether 46° below zero, and of alcohol 203° below zero Fahrenheit. By increasing the pressure upon water or upon any substance which expands when freezing, its freezing point will be lowered, but with such substances as wax, sulphur, paraffin, etc., which contract in freezing, the freezing point is raised by increasing the pressure.

Freezing Mixtures.—In warm weather it is often useful to have some means of lowering the temperature of a liquid. Artificial freezing is obtained by the liquefaction of solids or the evaporation of liquids. The following table gives the most important freezing mixtures, and shows the number of degrees the thermometer falls:—

FREEZING MIXTURES WITHOUT ICE.

	Mixtures.	*Parts by Weight.*	*Thermometer Sinks.*	*Degrees of Cold Produced.*
1	Ammonium nitrate ..	1	From + 50° to + 4°	46°
	Water	1		
2	Sodium sulphate	8	From + 50° to — 0°	50°
	Hydrochloric acid ..	5		
3	Sodium sulphate	3	From + 50° to — 3°	53°
	Dilute nitric acid	2		
4	Ammonium nitrate ..	1	From + 50° to — 7°	57°
	Sodium carbonate.. ..	1		
	Water	1		
5	Sodium sulphate	6	From + 50° to — 10°	60°
	Ammonium chloride ..	4		
	Potassium nitrate	2		
	Dilute nitric acid	4		

FREEZING MIXTURES WITH ICE.

	Mixture.	*Parts.*	*Thermometer Sinks from any Temperature*
1	Snow or powdered ice	2	to — 5°
	Sodium chloride	1	
2	Snow or powdered ice	5	to — 12°
	Sodium chloride	2	
	Ammonium chloride	1	
3	Snow or powdered ice	12	to — 25°
	Sodium chloride	5	
	Ammonium nitrate	5	

A mixture of snow and potash will reduce the temperature from + 32° to — 51°, producing 83° of cold.

A very intense cold can be produced by the evaporation of a mixture of solid carbonic acid and sulphuric ether, a temperature of 166° Fahrenheit below the freezing point of water being obtained. Natterer obtained a temperature as low as — 220° Fahr. by evaporation *in vacuo* of a mixture of liquid nitrous oxide and carbon bi-sulphide.

French Chalk.—A variety of talc usually sold in a finely powdered state. It is used for cleaning glass. If a glass be rubbed over with French chalk, and then be coated with a film of gelatine or collodion, the same will not thoroughly adhere to the glass, but can be removed when dry. Gelatino-chloride prints are squeegeed on to glass rubbed with French chalk, and when dry they can be peeled away, leaving a beautiful polished surface. French chalk also acts as a lubricant for wood-work, but is not superior to finely powdered blacklead.

Fuchsine (aniline red).—See **Rosaniline.**

Fuller's Earth.—A variety of clay or marl of various colours usually of a greenish tint. It is very useful for cleansing purposes, as it absorbs grease. It is composed of silica 50, alumina 20, water 24, and small quantities of magnesia lime and peroxide of iron. It is found in large quantities in several parts of England.

Fulminating Powder.—The substance generally known as fulminating powder is composed of three parts of nitre, two parts of dry carbonate of potash, and one part of flower of sulphur, reduced to a fine powder before mixing.

Frilling.—A defect common to the dry plate process. The gelatine leaves the glass in frills or wrinkles. It generally commences at the edge of the plate, and is extremely annoying. It usually occurs when the plate is being fixed, but is sometimes met with in developing, more especially in warm weather.

The causes of frilling are numerous. It may be that the gelatine used in the emulsion possesses too little tenacity. Emulsions that have been boiled for a long time to obtain great sensitiveness are peculiarly liable to frilling. The addition of a small quantity of chrome alum will often prevent it; in adding it, however, it should be done sparingly, as it increases the tenacity of the gelatine and makes development more difficult. If the glass plate upon which the emulsion is spread has not been properly cleaned, the emulsion will leave the glass in frills, or it may also be caused by unequal drying. In the latter case the plates must be dried by means of alcohol, or in a suitably constructed drying cupboard. The best and most effectual remedy to prevent frilling is to coat the plate with a collodion formed of tough pyroxyline 6 grains, alcohol (·820) half-ounce, ether (·725) half-ounce, applied before developing the plate. The solvents are removed by washing in clean water previous to development.

If the plates have been properly made, however, frilling is more often caused by the operator himself by allowing too strong a force of water to strike the edge of the plate, or by using too strong a developer. The following remarks will be found useful in warm weather when plates are particularly liable to frill:—First, the water and solutions used in developing, fixing, and washing the plate should all be of equal temperature. Secondly, a small drop of methylated spirit should be added to the developer. Thirdly, after developing, the plate should be rinsed under the tap and laid for a few minutes in pure methylated spirit. Fourthly, the fixing bath should not be too strong. Fifthly, after fixing rinse the plate well under the tap, and then place for five minutes in a saturated solution of alum. Sixthly, well wash in a dozen or more changes of water, and soak the plate for ten minutes in methylated spirit. Remove it, and it will be dry in about ten minutes.

If these instructions be carried out no frilling will result even in hot climates.

It is a good plan in developing to have in readiness a dish containing methylated spirit or chrome alum solution. Immediately any signs of frilling make their appearance, the plate is rinsed under the tap and placed in this bath for a few minutes, after which development is proceeded with.

Fuming.—A process of subjecting albuminised paper to the fumes of ammonia, by which means the paper prints a trifle quicker, the prints are more brilliant, and the purple tone, so much admired, is more easily obtainable. In America the fuming of paper is considered a great point, but it is hardly ever practised in this country.

Fuming is accomplished by placing a little strong ammonia at the bottom of an air-tight box, and pinning the sensitised albumen paper to the lid, film side downwards. The lid is then closed

tightly, and the fumes of the ammonia act upon the surface of the paper. About ten minutes in warm and 15 in cold weather will suffice to complete the process. Fumed paper should be used within a day or two after fuming, as the effect is not permanent. Fumed paper also discolours more rapidly than ordinary.

Funnel.—A conical vessel which terminates below in a spout, and is used for conducting a liquid into a vessel having a small opening. For photographic purposes funnels are usually made of glass or ebonite. They are also very useful for filtering liquids through filtering paper, and for this purpose ribbed funnels are to be preferred. If made of glass it is much more easy to see if quite clean than with ebonite or guttapercha funnels.

Fused Nitrate of Silver.—See **Silver Nitrate.**

Fusel Oil.—A heavy oily inflammable fluid with a high boiling point, a disagreeable cutting odour and a pungent taste. It is the oily product formed during the fermentation of potatoes, corn, and the juice of grapes.

Fusible Metal.—An alloy usually of lead, tin, and bismuth compounded in such proportions as to melt at given temperatures—

8	parts of	bismuth,	5	of lead,	3	of tin;	melt at	212° F.
2	,,	,,	1	,,	1	,,	,,	201° F.
5	,,	,,	5	,,	4	,,	,,	199° F.

Another good fusible alloy is made with cadmium 2 parts, bismuth 8 parts, tin 2 parts, lead 4 parts. This composition melts at 160° Fahrenheit.

An alloy of this kind is often useful for producing metal casts. If a metal cast be made of a gelatine relief, the same can be printed from in the same manner as the Woodbury or Stannotype process.

Fusion (Lat., *fusio*—melting).—The act of fusing, melting, or becoming liquid by heat. In chemistry, every substance begins to fuse at a certain temperature, provided the pressure be constant. The term is specially applied to the action of heat upon metals, but is extended to any solid matter. Platinum fuses at 3,082° Fahrenheit, iron at 2,912°, steel at 2,552°, manganese and gold at 2,282°, copper at 1,922°, silver at 1,832°, bismuth at 512°, sulphur at 239°, iodine at 225°, potassium at 136·4°, acetic acid at 113°, ice at 32°, bromine at + 9·5° sulphuric acid at — 30·0°, and mercury at — 37·9°.

Gallic Acid (Formula, $HC_7H_5O_5$; molecular weight, 170).—Exists in small quantities in gall nuts and in other vegetables. It is generally obtained from gall nuts, which, in addition to gallic acid, usually contain a large quantity of tannin (tannic acid, or gallo-tannic acid). The gall nuts are boiled with water, and the solution filtered while hot. On cooling, gallic acid crystallizes

out, and it may be purified by re-dissolving and boiling with a little animal charcoal.

It forms white silky crystals, having a sour taste. It is soluble in three parts of boiling water, but in only 100 of cold. If the crystals are strongly heated, pyrogallic acid is produced, and sublimes over. Gallic acid was used in development in the wet-plate process, but was superseded by other reducing agents possessing more energy. In order to obtain excessive density with gelatine dry plates, they should be soaked in an aqueous solution previous to alkaline development.

Gallon.—See **Weights and Measures.**

Gallo-nitrate of Silver Process.—An early process employed by Talbot in 1840. He discovered that if the sensitive paper used in the Talbotype process be brushed over with a mixture of gallic acid and silver nitrate, and be then exposed while in a wet state in the camera, the exposure time was considerably reduced. Another discovery was that the paper might be dried and exposed in that state, the image being afterwards developed with gallo-nitrate of silver solution.

Galls (synonyms, *nut galls*, *gall nuts*).—An excrescence formed upon the branches and shoots of the *Quercus Infectoria*, or gall oak, produced by the puncture and deposited ova of the *Diplolepsis. Gallæ Tinctoria*.

The best galls are imported from Aleppo, and sometimes called Aleppo balls. These balls are hard and very heavy—about halt an inch or so in diameter. Their colour varies from bluish green to light brown. They are largely used in the manufacture of gallic acids, tannin, and pyrogallol.

Gamboge or **Camboge.**—An orange-coloured gum resin, chiefly produced from the *Garcinia Morella*, a native of Cambodia (hence the name), Siam, and Cochin China. When the bark of the gamboge tree is cut, the gamboge exudes as a thick, viscid yellow juice, hardening on exposure to the air. It is generally collected in bamboo canes. The best quality should be of a rich orange brown tint, and when broken should not show a rough granular surface. Gamboge is sold in commerce in three forms, *i.e.*, in rolls or solid cylinders, in pipes or hollow cylinders, and in cakes. The latter is of inferior quality.

It is almost entirely soluble in alcohol, and forms with water a thick yellow emulsion, possessing but little smell or taste. It is employed in colouring, wood staining, and in colouring lacquers and varnishes. It is useful for painting out the skies or otherwise "dodging" negatives.

Gas and Gases.—Gas is a term formerly applied to vapour that had not been condensed. It is now applied to vaporous substances not condensed into liquid form, at ordinary terrestial

temperatures and pressures, and also to those, which, at ordina temperatures, are not condensable into a liquid by pressure only. In both these senses, therefore, air, under ordinary atmospheric conditions, is a gas, when cold enough it is not a gas but a vapour, and pressure alone will condense it.

The most dangerous gas that photographers deal with is hydrogen, used in the oxyhydrogen lime-light. See **Hydrogen**, also other gases under their respective headings.

Gas Light is used in photography, chiefly for exposing bromide prints in contact printing. Its steadiness makes it preferable to ever-changing daylight. Gas light may also be used in the Isochromatic process, especially for copying oil paintings, etc. It is but little used for portraiture, as the light obtained from a few burners is very non-actinic, and consequently the exposure would be very great. With a large number of burners, however, very good interiors may sometimes be made at night time.

Gelatine or Gelatin (Lat. *gelatus*—frozen. So called because of the tendency the substance has of becoming solid).—An animal glutin, obtained by boiling bones, hoofs, horns, and many other animal substances. Little is known of the chemical nature of gelatine, because it cannot be converted into vapour, and does not form well-defined compounds with other bodies. Its composition varies with the source from which it is obtained, but the following is about the average.

Carbon	50·1
Hydrogen	6·6
Nitrogen	18·4
Oxygen	24·8
Sulphur	0·1

The term gelatine, however, although usually applied to one variety of the substance, properly belongs to isinglsas, glue, and other modifications of the same material. Vegetable jelly is also an analogous substance.

Gelatine is prepared for commercial purposes from a large variety of animal substances; chiefly, however, from the softer parts of the hides of oxen and calves, and the skins of sheep and other animals. The parts used are usually the thin portions covering the belly, the ears, etc. The bones and other parts of animals are also used. The method usually adopted in making gelatine from skin parings or hide clippings is first to wash the pieces very carefully, after which they are cut into small strips and immersed in a weak solution of caustic soda for about 7 or 8 days. After this process of digestion is completed, the pieces of skin are transferred to revolving cylinders which are abundantly supplied with clean cold water. Here they are well washed, and are then transferred, while still wet, to another chamber lined with wood. In this they are bleached and purified by exposure to the fumes of

burning sulphur. The next process is to give a final washing in cold water to remove the sulphurous acid. After this they are squeezed as dry as possible and removed to the gelatinising pots, which are large earthenware pots, enclosed in wooden cases, made perfectly steam tight. Water is also poured in with the pieces, and the temperature is kept very high by means of the steam passing through the cases surrounding the pots. After a time the gelatine becomes completely dissolved out of the skin. It is then strained off, while hot, and poured out in thin layers. When set it is cut up into small oblong plates and laid on to netting, stretched horizontally, to dry. The cross markings observable on these plates of gelatine are caused by the meshes of the nets. When string nets are employed, small pieces of the hempen fibre will often be found adhering to the gelatine. When dissolved it should be carefully filtered.

The process of obtaining gelatine from bones is carried out in this manner :—Bones are first digested in cold dilute hydrochloric acid till the calcium phosphate and other salts are dissolved, leaving a residue of the same form, but of a soft flexible character. This is termed osséin, and has the same composition as gelatine, into which it can be converted by prolonged boiling with water.

Another process consists in treating pieces of calf-skin by water alone, without the soda and sulphur processes. The pieces, after washing, are transferred at once to the steam-heated pots.

Gelatine contains about 15 to 20 per cent. of water. It softens and swells in cold water, absorbing from five to ten times its own weight, but does not dissolve. Hot water dissolves it, and the solution gelatinises on cooling, even if it contains but one per cent. It is also soluble in acetic acid and in cold sulphuric acid, but is insoluble in alcohol, ether, and other organic liquids.

A good sample of gelatine will absorb a sufficient quantity of water to dissolve it when heated to 90° Fahr., the solution setting to a jelly when cold. By the continued application of heat, gelatine loses its setting properties, a new compound, termed meta-gelatine, being said to be formed. It keeps indefinitely in a dry state, but when water is present it putrefies rapidly, the liquid becoming first acid and then alkaline, giving off ammoniacal vapours. To prevent speedy decomposition many antiseptics may be used. The principal are alum, alcohol, carbolic, salicylic and boracic acid, thymol, hydrate of chloral, fuchsine, and zinc salts. Glycerine (in large quantities) will also act as an antiseptic. Alcohol will precipitate gelatine from its aqueous solution in white flakes. It is also precipitated by tannin, forming an insoluble, non-putrescible compound. By dry distillation gelatine yields a quantity of ammonium carbonate, and a vile-smelling brown oily substance, containing carbonate, sulphide and cyanide of ammonium, aniline, methylamine, picaline, and a number of pyridine bases. When

boiled with strong alkalies, or with diluted sulphuric acid, it yields succine and glycocine (sugar of gelatine).

The uses of gelatine in photography are innumerable. It is used in the manufacture of emulsions, its duty being to hold the silver salts in suspension, and enable them to be spread over plates, paper, etc. For emulsion work a good quality of gelatine is essential. There are many ways of testing it. Dr. Eder recommends that the gelatine be incinerated, and the ash weighed. This should vary from ½ per cent. in good qualities, to 5 per cent. in inferior gelatine. When adulterated with alum the ash will sometimes reach 10 per cent. One of the best tests for gelatine is the amount of water it will absorb. This varies with good gelatine between 5 and 10 times its own weight. In the following table will be seen the percentage of ash obtained, and the absorbing powers of several of the best known gelatines.

	Gelatine.	Character.	Ash per cent.	Water absorbed by 150 gr.	Times its weight.
1.	Coignet's gold label	hard	1	7 drachms	8½
2.	,, special	,,	1	7 ,,	8½
3.	Nelson's No. 1 photographic	soft	2	5½ ,,	6¾
4.	,, opaque	hard	2	8 ,,	9¾
5.	,, amber	soft	1	4 ,,	5
6.	French gelatine	medium	2	6 ,,	7¼
7.	Swinborne's No. 2 pat. Isinglass	soft	1	5¾ ,,	7
8.	Cox's gelatine	,,	1	4¾ ,,	5¾
9.	Simeon's "Winterhur"	hard	1	7¼ ,,	8¾
10.	Heinrich's	,,	1	8 ,,	9¾
11.	Batty's gelatine	soft	2	5 ,,	6

It will be seen by this that the amount of ash left after incineration does not exceed 2 per cent.; also that the amount of water absorbed is in every case less than ten times its own weight. Another test is its solubility, as a gelatine which becomes soluble at too low a temperature would be quite unsuitable for emulsion making. When thoroughly soaked in cold water the temperature of the latter is gradually raised, and the degree of the thermometer noted when solution takes place. A further test must be made by noting the expansive power. This is important when plates or other substances are to be coated with it, as upon the expansive properties of the gelatine depends to a very considerable extent the frilling or non-frilling of the film. The greater the expansion, the greater the possibility of frilling, or the film leaving the glass.

Abney, in his work on emulsion processes, gives the result of his experiments in this direction. He coated plates with the different gelatines, and dried them under the same conditions under which plates are dried in the drying box. The films were then stripped from off the plates, and different portions cut away, and accurately measured whilst dry. The films were then allowed to swell in

water, ammoniacal water, or a solution of mono-carbonates of soda and potash, and again measured. Results:—

Gelatine.	Dry.	Water.	Water and Ammonia.	Carb. Soda. and Water.
Nelson's No. 1	1	1·2	1·39	1·29
Autotype	1	1·09	1·28	1·21
Heinrich's	1	1·08	1·22	1·15
Simeon's	1	1·05	1·14	1·09
Batty's	1	1·32		
Nelson's X Opaque	1	1·19		
Crosse and Blackwell's ..	1	1·09		
Nelson's Amber	1	1·43		

The next important test is for acidity or alkalinity. This is easily done by test papers. For emulsion work a gelatine which is slightly acid is to be preferred.

The difficulty of obtaining suitable gelatine for photographic work is now removed owing to the energies of a well-known firm of gelatine manufacturers, Messrs. Nelson, Dale and Co., who have produced several kinds specially prepared for photographic purposes.

The property of alkaline dichromates to render gelatine insoluble and incapable of absorbing water when exposed to the light is the basis of the carbon process, and also of a large number of photo-mechanical printing processes. This peculiar property was first observed by Mungo Ponton about the year 1839, and was utilised by Poitevin in 1855.

Gelatine is also a sensitiser. Silver bromide mixed in collodion does not possess nearly so much sensitiveness to light as if mixed in gelatine. Knopp, a German chemist, showed how gelatine is capable of combining with bromine, thus assisting the action of light in decomposing the silver bromide by attracting and uniting with the bromine given off from the silver salt under the action of light.

Other uses to which gelatine is put are based upon the fact that it is rendered insoluble by substances such as chrome alum without the action of light.

Gelatine dissolved in acetic acid forms a very useful substance, *i.e.*, liquid glue, retaining its adhesive properties, but losing its setting powers.

It also dissolves cold in a solution of barium chloride, and also, but to a lesser degree, in strontium chloride. This discovery was made in 1890 by MM. Lumiere, who state* that with a solution of 15 per cent. of barium chloride the solubility is so great that sufficient gelatine may be dissolved to render the solution syrupy. The liquid keeps well, and does not decompose. This property may be made useful in recovering residues from emulsion. The gelatine is dissolved in the chloride, and diluted, when the haloid salts fall to the bottom of the vessel, and the liquid can be decanted. Bolton observed that one ounce of crystallised barium chloride dissolved

* *Moniteur de la Photographie.*

in six ounces of water will readily dissolve 120 grains of Coignet's gelatine, the time occupied being about two hours, at a temperature of 65° Fahr.

Corrosive sublimate, platinic chloride, cadmium bromide, chrome alum and chlorine gas will cause gelatine to become insoluble.

Gelatine Dry Plates.—Plates usually of glass coated with a film of gelatine containing sensitive silver bromide. (See **Dry Plates.**)

Gelatine Emulsion.—An emulsion of gelatine containing a sensitive silver compound. (See **Emulsion.**)

Gelatine Mountant.—A mountant composed of gelatine. A good formula is—Gelatine 1 oz., water 3 oz., alcohol 3 oz., glycerine ¼ oz., carbolic acid solution 10 drops. This is especially suitable for mounting gelatine emulsion pictures to which a gloss has been given.

Gelatine Negative.—A negative produced on a gelatine dry plate. (See **Negative.**)

Gelatine Relief.—An image composed of gelatine in relief. It is prepared by means of a thick film of gelatine, containing a pigment, sensitised with potassium dichromate. This is exposed under the negative for somewhat longer than required in carbon printing. The action of the light is to render certain parts insoluble. The development is almost the same as with that process, though much more prolonged. The soluble parts are washed away in warm water, leaving those portions standing that receive the action of the light. The relief thus obtained is hardened with alum and dried. The basis of the Woodburytype process lies in the production of a suitable gelatine relief; under this heading (**Woodburytype**) will therefore be found a clearer and more detailed description of its manufacture.

Gelatino-bromide Emulsion.—A gelatine emulsion containing silver bromide. (See **Emulsion.**)

Gelatino-chloride Emulsion.—An emulsion of gelatine containing silver chloride. There are two kinds; the one with which the image made by the light is a latent one and rendered visible by development, and the other contains a certain percentage of free silver nitrate, and the image is printed out direct by the action of light. (See under **Emulsion.**)

Gelatino-citro-chloride Paper.—A paper coated with a gelatino-chloride emulsion, containing a large quantity of citrate. A paper of this description is manufactured in this country under the name of Celerotype. It prints out in the same manner as with albumen paper, although much quicker. The image should be a little darker than required for the finished print.

The prints are first washed in two or three changes of water, and are then ready for toning. Almost any toning bath can be used, the tones varying with the different formulæ used, so that the operator can select any bath. The following are recommended:—

TUNGSTATE TONING BATH.

Sodium tungstate	¼ oz.
Gold chloride	4 grs.
Water	20 ozs.

ACETATE TONING BATH.

SOLUTION 1.

Sodium acetate (recrystallised)	¾ oz.
Gold chloride	4 grs.
Water	20 ozs.

SOLUTION 2.

Ammonium sulphocyanide	100 grs.
Gold chloride	2 ,,
Water	8 ozs.

Keep Nos. 1 and 2 separate. For toning take in the proportion of twenty ounces of No. 1 to six ounces of No. 2.

After toning the prints are fixed in a solution of sodium hyposulphite, two ounces to twenty of water.

Or the following method of toning and fixing in one operation may be employed. The bath is made up of—

Water	24 ozs.
Sodium hyposulphite	6 ,,
Ammonium sulphocyanide	1 ,,
Sodium acetate	1½ ,,
Alum (saturated solution)	10 ,,

Fill the bottle containing the solution with scraps of sensitised paper, spoilt prints, etc., which have not been fixed. Stand in the open air for a day, and filter. Then add—

Ammonium chloride	30 grs.
Gold chloride	15 ,,

With this bath the operations of washing, toning, and fixing are reduced to one. The prints are plunged into the solution without any previous washing, and are there allowed to remain until the required tone is obtained. They are then removed and well washed.

After removing from the fixing bath the prints are well washed in several changes of water. One hour will suffice, provided the water is changed often and completely. After washing, the prints are laid in a saturated solution of alum for a few minutes, and again washed.

On removal from the final washing water the prints are squeegeed on to clean plate glass, previously rubbed with French chalk.

When dry they are peeled off the glass, and will have a very high polish. For fuller description of this process see **Enamelling.**

If ground glass be used a matt surface is given to the prints, and they resemble an engraving.

For methods of mounting gelatino-chloride prints see **Mounting.**

General Fog.—See under **Fog.**

German Silver.—A triple alloy of copper, nickel, and zinc. The best quality consists of four parts copper, two parts nickel, and two parts zinc. For convenience in working, however, a larger proportion of copper is generally added.

Gilding.—A term sometimes applied to the gold toning process.

Glaire.—See **Albumen.**

Glass (Anglo-Saxon—*glaes*).—A hard, brittle, transparent substance—a combination of silica with some alkali or alkaline earth, such as lime, barytes, etc. Its invention dates from the earliest antiquity. It is certain that the Egyptians carried the art to perfection as early as 3000 B.C., and most probably earlier. The Assyrians, the Phœnicians, the Greeks, and Etruscans were all acquainted with the manufacture. Benedict Bishop is said to have introduced glass windows into Britain A.D. 674. This country, however, did not distinguish itself for the manufacture of glass until as late as the sixteenth century.

Large quantities of glass are now made in this country. Some of this is exported to other countries, but England also imports a large quantity of special kinds.

There is an infinite variety of glass. The chief of these are green or common bottle glass, broad, spread or sheet window glass, crown glass, plate glass, and flint glass. Special kinds of glass are also manufactured for the production of lenses.

The qualities of glass are its hardness, transparency, homogeneity, strength, and power of resisting the action of water, air, light, and the stronger acids and alkalis.

The principles of glass manufacture are very simple. Silica, in the shape of fine sand, is heated with carbonate of potash, or soda and slaked lime, or oxide of lead. At a high temperature, fusion and combination occur, and carbonic acid is expelled. When the melted mass has become clear and free from air-bubbles, it is left to cool slowly, until it assumes the peculiar tenacious condition suitable for working.

Window Glass is usually made of sand 100 parts, sodium sulphate 40 to 45 parts, chalk or limestone 40 parts, powdered anthracite coal 2 parts, cullet 100 parts, and a small quantity of an oxidising agent added, such as nitre, arsenious acid, or peroxide of manganese.

Crown Glass is composed of almost the same materials as above, except that a smaller quantity of lime is used, and the

materials are, as a rule, more carefully selected. The method by which sheet glass is made is very interesting, and is thus described.* The metal being brought to a workable state and skimmed, a sheet of crown glass is made in this manner: A workman, by dipping his long iron blowpipe two or three times into the pot, takes up on the end of it a gathering of about 10lbs. of metal, which, when the pipe is held upright, lengthens by its own weight into a bulb shape (fig. 91). Rolling this on the marver, the workman makes

FIG. 91.

FIG. 92.

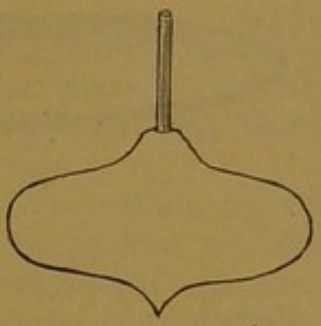

FIG. 93.

the outer portion conical, and then by blowing forms it into a pear shape (fig. 92). Further heating and blowing brings it into the shape of a flattened sphere, and to a much-increased size, with a point called the bullion point (see fig. 93). At this stage the glass is transferred from the blowing pipe to an iron rod called a ponty, on the end of which a lump of hot iron metal has been placed. This lump is made to assume the form of a little cup by pressing it on an iron point, and is then pressed against the bullion point of the flattened sphere, to which it becomes firmly attached.

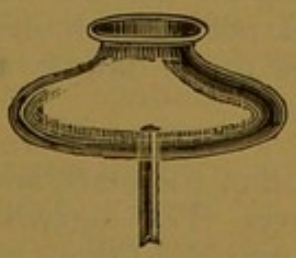

FIG. 94.

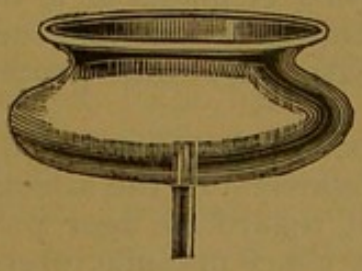

FIG. 95.

The pipe is detached by means of a piece of iron dipped in cold water (fig. 94). The globe of glass is now held with the ponty. The operator next carries it to the nose-hole, and presents the opening formed by the detachment of the blowpipe to the action of the furnace. This again softens the glass, which is taken to the flashing furnace and kept constantly revolving by turning the ponty on a rest in front of the furnace opening. The revolutions

* Chambers's Encyclopædia, 1890.

are at first slow, but are gradually accelerated as the softening of the glass goes on, and the centrifugal force so produced throws the edges of the orifice outwards, as in fig. 95. As the glass flattens it is revolved with greater rapidity, and advanced so near to the mouth of the furnace as to draw the flames outwards by contracting the draught. This completes the softening of the glass. It then opens suddenly with a rushing noise, caused by the rapid flying

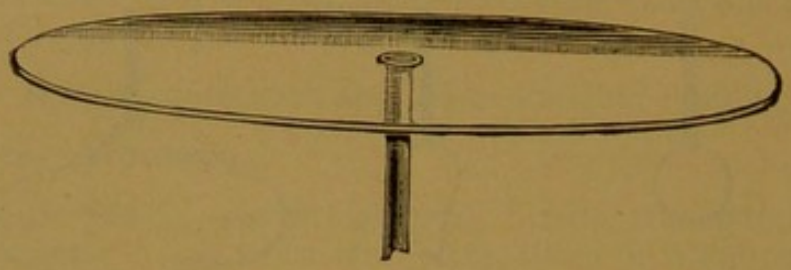

Fig. 96.

outwards of the softened glass and the rushing out of the flames. It becomes perfectly flat and of equal thickness, except at the bullion or centre. The *flashing* is now complete, and after being detached from the ponty it is taken to the annealing oven, into which it is passed through a long horizontal slit which forms the opening, and when fairly in it is dexterously turned on its edge. Here it remains at a temperature somewhat below that required to soften glass until the oven is filled with these *tables* of glass, when the heat is suffered to decline until the whole is cool, when they are removed and are ready for sale.

Cylinder Glass is made in a different manner to crown glass. The blower first makes a long and perfect cylinder instead of a sphere of glass. By this process much larger sheets can be obtained.

Plate Glass is manufactured by a totally different process to either of the above. In the selection of the materials greater care is taken with regard to their purity. The ingredients, although differing with every manufacturer, may be taken as—Fine sand, 100lbs.; sodium sulphate (refined), 42lbs.; powdered carbon, 2½lbs.; carbonate of lime, 20 to 25lbs.; arsenic, 8 oz.; cullet or broken pieces of plate glass *ad lib.* When these have been melted and the molten metal ready, it is poured on to a flat table, and spread over it with the degree of thickness required. It is then removed to the annealing oven. After the annealing process has been carried out, and the plate cooled, it is removed to the grinding room. Here it is imbedded in plaster, and its surface ground by a revolving iron plate set in motion while in contact with the glass. Sand and water first take off the rough surface, and then powdered emery. After one surface has been properly ground, the

other is taken in hand and similarly treated. They are then removed to another machine for the polishing process. Here one sheet of glass is made to rub another. The very finest emery powder is used in the final touches given by hand. After both sides have been smoothed in this manner, the plate is placed in another movable machine, where it is brought under the action of the polishers. These consist of padded iron buffers, covered with felt, which rub the glass as it passes from side to side. The surface of the glass is kept supplied with an aqueous solution of oxide of iron in a very fine state of division.

Patent Plate is much used in photographic operations on account of its lightness. It is cylinder glass (selected free from flaws and of good colour) ground and polished very much after the same process as employed for plate glass.

Flint Glass.—The following may be taken as the average formula :—sand 100, red lead 66·66, potassium carbonate 33·33, and a small quantity of peroxide of manganese. In some cases a small portion of the potassium carbonate is replaced by a little refined potassium nitrate. The materials are all carefully selected. Its manufacture is very similar to the other kinds of glass. It possesses a very high power of refracting and dispersing light, owing to its comparatively high density.

Optical Glass is made both of flint and crown glass, lenses being made of both kinds and placed together to obtain achromatism. It must be perfectly homogeneous, free from striæ, colourless and transparent. The operation of making flint or crown glass for the manufacture of lenses is thus described. A crucible is first heated to whiteness in a furnace, and when the fuel ceases to emit smoke, the material is added in small quantities, covering the crucible over each time to prevent the smoke getting in to it. After about ten hours' heating it is finished. The crucible is then raised to a white heat for about four hours, and the molten metal continually stirred. The heat is then reduced to allow the bubbles to rise to the surface. After two hours the furnace is again raised to activity and the glass made fluid once more. It is again stirred for about two hours and then left to cool. When cold the crucible is broken away, and the result is a cake of glass, which may be worth pounds or pence according to the number and position of the flaws. If there are many the cake is cut up into smaller discs or slabs, from which lenses are made.

The crown glass used for optical purposes is usually composed of silicates of potash, lime, and alumina. It has a specific gravity of 2·487, and a refractive index of from 1·542 to 1·514. Flint glass for lenses is very difficult to make, especially when required to be of large size. It is generally composed of a mixture of silicates of potash, alum and lead. It has a specific gravity of 3·60, and a refractive index of about 1·639.

The following represent the specific gravity and the refractive index of the optical flint glass manufactured by the three chief makers :—

	Sp. Gr.	Refraction=D.
Abbe-Schott	3·63	16,206
Feil	3·60	16,169
Chance Bros.	3·60	16,147

These two kinds of glass are chiefly used in the manufacture of lenses for optical instruments, for photographic work, etc., although other kinds have been used. Under **Aberration** can be seen how these two glasses are used in lens making, the defects of one being made to counteract those of the other. (See also **Lens.**)

Toughened Glass.—The discovery of M. de la Bastie. Glass is heated to a point of plasticity and immediately plunged into a heated bath of molten fat, the temperature of which is adjusted to the chemical nature of the glass. Glass treated in this manner is very tough ; it cannot be cut with the diamond, and is not easily breakable ; but when breakage does occur it flies into thousands of pieces.

Coloured Glass.—When light falls on a transparent body the body appears colourless, if all the vibrations are transmitted in the proportion in which they exist in the spectrum. If some of the vibrations are checked or extinguished the emergent light will be of the colour produced by the co-existence of the unchecked vibrations. Certain metals, when in combination with glass, have the power to effect this. Gold, for instance, even in so small a quantity as the $\frac{1}{100000}$ part, will impart a rose colour to glass. A crimson glass is made with a compound of gold and tin. A red colour from protoxide of copper, and a yellow from oxide of antimony, sesquioxide of iron or carbon ; chloride of silver is also used to stain glass yellow. All these colours can be used for photographic purposes for light for the dark room, &c. A blue glass may be made from oxide of cobalt or copper, and green from sesquioxide of chromium. Coloured glass is made either by the colour being all through the body or only flashed—a thin veneer of the colour coating a clear glass of greater thickness.

For photographic purposes coloured glass can easily be made by simply coating a sheet of glass of the required size with collodion or gelatine containing the dye colour.

Soluble Glass.—See **Soluble Glass.**

Stained Glass.—A transparent effect of colour obtained by applying certain metallic oxides to the surface of the glass, and subjecting it to heat. Glass used for dark rooms is usually prepared in this manner. A yellow stain is produced by oxide of silver, and a ruby by cuprous oxide. The stain should be incorporated in the glass, and be as durable as the glass itself.

Opal Glass is made by fusing one of the oxides of tin or zinc with the metal. Flashed opal is made by laying a thin veneer of the opal glass on to a greater thickness of clear glass.

Glass Dishes.—Dishes made of glass. For this purpose it is the most suitable material, owing to its property of resisting acids and other chemicals, which speedily destroy porcelain or ebonite dishes. Its fragile nature is, however, a drawback. Glass dishes are made solid, or can be manufactured by cementing small side strips to a sheet of glass. Good thick glass should be used. The strips are cut to their required length, and their edges ground. These are then cemented to the flat piece with marine glue. To do this they are heated with a spirit lamp and the glue rubbed on while hot. The pieces are then applied together and pressed well into contact with the flat plate.

Glass House.—See **Studio**.

Glass Paper or **Cloth** is made by powdering glass more or less finely, and sprinkling it over paper or calico still wet with a coating of thin glue. When it is dry the powdered glass adheres firmly, and can then be used for polishing woodwork, etc.

Glass Plates.—Glass plays such an important part in photographic operations, that a few words with regard to its choice must be given. The different methods of its preparation have been given under **class**. It is usually used in sheets or plates. Patent plate is often recommended. It is, however, very expensive, and it must be remembered that this kind of glass, although perfectly flat and having a good polish, does not possess its proper hard surface. This has been ground off in the process of manufacture, and an artificial surface put on. The plate having been denuded of its hard outer skin, will not easily resist the action of acids and chemicals. It has also been found that this glass absorbs impurities If it be packed with pieces of printed paper between the sheets the glass will often absorb the ink from the type, and a permanent impression, in some cases irremovable by acids, is fixed on the glass, and will reproduce itself on the photographic positives printed from the negative made on the glass.

The difficulty to be experienced with other kinds of glass is their want of flatness, due to the manner in which they are manufactured. Sheet glass, for instance, is true one way, but slightly curved another. For small-sized plates this curvature is so slight that it does not make any difference, and the glass has the advantage of a hard surface.

Crown glass usually possesses a double curvature, and its employment for large-sized negatives is to be avoided, because of its liability to crack in the pressure frame. Flatted crown glass, if perfectly flat, is the best kind to use, although a good quality is nearly as costly as patent plate. It has a hard surface, and is, for this reason, superior to plate. It must be noted, however, that only one surface is perfectly flat and smooth, as it is heated and one side flattened on a plain surface, the other becoming by this process slightly irregular.

A good method of testing the evenness of the glass is to hold it in a slanting direction from the eye, and examine the reflection of the sides of the room or any straight lines. If these do not appear quite straight the glass is not perfectly true.

The most important sizes of photographic plates of glass are the following :—

Ninth-plate	2½in. × 2in.
Sixth-plate	3¼in. × 2⅝in.
Quarter-plate, or Carte-de-visite ..	4¼in. × 3¼in.
Third-plate	5in. × 4in.
Half-plate	6½in. × 4⅜in.
	7in. × 5in.
Whole-plate	8½in. × 6½in.
Stereoscopic	6¾in. × 3¼in.
	10in. × 8in.
	12in. × 10in.
	15in. × 12in.
	20in. × 18in.
	24in. × 20in.

Air and light both act upon glass, probably by their oxidising properties. Flint glass, which contains lead, is acted upon by sulphuretted hydrogen, the surface becoming opaque and iridescent. Lenses should, therefore, be carefully preserved from the action of sulphur.

Glauber's Salt.—A name often given to the neutral sulphate of soda ; chemical composition, $Na_2SO_4 + 10H_2O$.

Glaze.—Used in the enamel process *(q.v.)* It usually consists of felspar 27 parts, borax 18, finest siliceous sand 4, nitre, soda, and purest china clay 3 parts. These are heated to a frit mass and 3 parts of calcined borax added.

Glazing Enamels.—See **Enamel Process.**

Globe Lens.—A lens invented by Messrs. Harrison and Schnitzer, of New York. It is formed of two achromatic and identical convergent mensicus lenses, placed so that the external surfaces form one and the same sphere. Fig. 97 shows the construction of the globe lens. It is a symmetrical doublet,

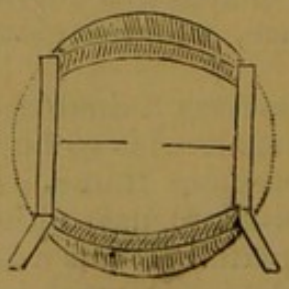

Fig. 97.

and the principal focal point of each combination is at the centre of the arrangement. See also **Lens.**

Glucose (Synonym, *grape sugar*).—A variety of sugar found in the grape and other fruits. It is occasionally used in photography as a preservative for dry collodion plates.

Glue.—An impure kind of gelatine (*q.v.*) A large variety of different glues are sold. Russian glue is said to be the purest, and should, when possible, be obtained in preference to the Scotch or English for mounting photographs, as the latter often contain impurities not conducive to the stability of the image.

Glue, Liquid.—Many substances go under this name. A good liquid glue can be made by dissolving gelatine in acetic acid, which destroys its setting properties, though retaining its adhesive powers. Another formula is powdered orange shellac, one ounce; alcohol (·805), two fluid ounces. Digest in a stopper bottle placed in a warm situation until the resin is dissolved.

Glycerine (Formula, $C_3H_5(OH)_3$; molecular weight, 92; synonyms, *glycerin*, *glycerol*, *pupenyl alcohol*). Discovered by Scheele in 1779. It is a colourless, viscid, neutral, inodorous fluid, having a very sweet taste. It is soluble in water and alcohol in all proportions, but insoluble in ether and in chloroform. It should possess a specific gravity of above 1·23. If below this, it is in all probability diluted with water. To ascertain the quantity of water present the following formula is generally used:—

$$P = \frac{1266 - 1000d}{2{\cdot}66d}$$

Here d is the specific gravity of the sample tested as compared with water, at a temperature of 60°F, and P the percentage of glycerine actually present, provided also that it contains no other matters.

Glycerine occurs ready formed in a few fats, and is always produced in the alcoholic fermentation of sugar; hence it occurs in all fermented liquors.

The usual method of its production for commercial purposes is by distilling fats in a current of superheated steam at 300°, when the fats are decomposed, and the glycerine which distils over is finally rectified *in vacuo*.

A simple method of obtaining it on a small scale is from olive oil, which is saponified by treating it with an equal weight of lead oxide. This is mixed with water and added to the oil, with which it is boiled till the saponification is complete. The glycerine is dissolved by the water, and is easily separated from the insoluble lead plaster. Any traces of lead are removed by sulphuretted hydrogen, and the water is expelled *in vacuo*, as the glycerine would turn brown in the air.

The adulterations used in the manufacture of glycerine are glucose and cane sugar. Other matters are often present, such as lead, calcium, and formic and oxalic acid, their presence being due to imperfect purification. To detect the presence of glucose, boil

a small portion of the sample with an excess of caustic soda and a few drops of copper sulphate. If any be present a red precipitate will be the result. To test for cane sugar boil for half-an-hour with sulphuric acid; this will convert any cane sugar into glucose, when it can then be tested as described above. Lead and calcium are detected by burning the glycerine, and dissolving the residue in a few drops of nitric acid. The solution thus obtained is then diluted with water and divided into two quantities. Pass sulphuretted hydrogen through one and a black precipitate will show the presence of lead, and add a small quantity of ammonium oxalate to the other portion, and a white precipitate proves calcium to be present. Oxalic acid is detected by the white precipitate it yields with calcium acetate and formic acid by blackening on warming a diluted sample with ammonio nitrate of silver.

Glycerine is an antiseptic, and is used in photography principally for this reason. It is used as a preservative of pyro solutions, and is added to gelatine emulsions to prevent decomposition. A small quantity added to water will prevent it freezing, except at a low temperature.

Glycerine is extremely hygroscopic, and cannot be dried by heat without decomposition. Its non-drying property causes it to be used for many purposes to prevent too rapid drying of substances. A small quantity is added to gelatine emulsion spread upon paper, which causes the film to become more pliable and less easily cracked. Glycerine burns with a colourless flame, and dissolves iodine.

Table showing strength of solutions of glycerine by specific gravity:—

Glycerine. %	Specific Gravity.	Freezing Point C.
10	1·024	1°
20	1·051	2·5°
30	1·075	6°
40	1·105	17 5°
50	1·127	31·34°
60	1·159	Below 35°
70	1·179	
80	1·214	
90	1·232	
100	1·241	

Gold (Symbol, Au.; atomic weight, 196·85).—The most widely and universally sought metal in the earth's crust, and too well-known to require any description. It is only used in photographic chemistry in combination with other substances.

Gold Chloride.—There are two gold chlorides known to be in existence—aurous chloride (AuCl) and auric chloride ($AuCl_3$). The existence of another gold chloride ($AuCl_2$) called auro-auric chloride has been asserted by some chemists and denied by others. The gold chloride used in photographic operations is the auric

chloride, $AuCl_3$; molecular weight, 302·5; synonyms, *terchloride* or *perchloride of gold*, etc. It is formed by dissolving gold in aqua regia (a mixture of nitric and hydrochloric acid) and drying on a porous tile over concentrated sulphuric acid for several days.

A simple method of making gold chloride for photographic purposes is the following:—Mix in a suitable vessel two fluid drachms of nitric acid and one ounce of hydrochloric acid. Into this place a sovereign or other gold coin—the newer the better—and apply a gentle heat. For this purpose a sand or water bath is preferable. A considerable quantity of gas will be evolved, and the gold will disappear. If the acids are weak, and complete solution of the metal cannot be effected, a little more of the acids mixed in the same proportion should be added. The solution of perchloride of gold in excess of acid thus obtained is next evaporated in a sand or water bath, and the crystals formed are preserved in hermetically-sealed bottles, as they are very deliquescent. The trouble of crystallisation may, however, be saved, as it is necessary to use the gold chloride in solution, and in this state it is quite stable if kept in the dark. To the solution add five ounces of distilled water, and sufficient carbonate of soda to neutralise the acid. Filter, and add water to make 174 drachms. This solution will contain about one grain of terchloride of gold to the drachm of water, as a sovereign contains 113 grains of pure gold, which should yield 174 grains of gold chloride.

Commercial chloride of gold takes the form of reddish orange needle-like crystals, extremely deliquescent and soluble in alcohol and ether. It is sold in small hermetically-sealed tubes, containing 15 grammes of gold chloride. This weight, however, is no criterion of its value, but the weight of the actual gold contained in it.

Many inferior makes of gold chloride are sold, most of which are, correctly speaking, gold sodio-chloride, with formulæ $AuCl_3$, $NaCl$, $2H_2O$.

Nearly every substance which is capable of combining with oxygen or with chlorine tends to reduce the metal from a solution of gold chloride, and it is for this reason that gold chloride is used for the purpose of toning silver prints. For this it is mixed with the soluble salts of free acids, such as the phosphates, acetates, carbonates, etc. The action of the different toning solutions is given by C. J. Leaper in the following equations, assuming in each case that the darkened silver reduction product consists of silver oxychloride ($Ag_2O.2AgCl$.) *

1. Sodium acetate.—$15(Ag_2O{\cdot}2AgCl) + 2AuCl_3 + 6NaH_3C_2$ (Acetic acid.) $= 6NaClO_3 + Au_2 + 15Ag_2 + 30AgCl + 6H_4C_2O_2$.

2. Calcium hypochlorite.—$Ag_2O{\cdot}2AgCl + 2AuCl_3 + 3H_2O + CaCl_2O_2 = Ca(ClO_3)_2 + Au_2 + Ag_2 + 2AgCl\ 6HCl$. (Calcium chlorate.)

* "Materia Photographica" (Iliffe and Son).

3. Sodium pyroborate.—$15(Ag_2O\ 2AgCl) + AuCl_3 + 18H_2O$ + $3Na_2B_4O_7$ (Sodium chlorate.) = $6NaClO_3 + Au_2 + 15Ag_2 + 30AgCl +$ $12H_3BO_3$ (Boric acid.).

4. Sodium carbonate.—$15(Ag_2O\ 2AgCl) + 2AuCl_3 + 3H_2O$ + $3Na_2CO_3 = 6NaClO_3 + Au_2 + 15Ag_2 + 30AgCl +$ $3H_2CO_3$ (Carbonic acid.).

5. Sodium phosphate.—$15(Ag_2O{\cdot}2AgCl) + 2AuCl_3 + 3H_2O$ + $3Na_2HPO_4 = 6NaClO_3 + Au_2 + 15Ag_2 + 30AgCl +$ $3H_3PO_4$ (Phosphoric acid.).

Gold chloride is very freely soluble in water, giving a yellow solution. It is, however, only feebly soluble in alcohol. To test for salts of gold, note that solutions containing them give the following reactions: A blackish brown precipitate with sulphuretted hydrogen, and a brownish precipitate with ferrous sulphate or oxalic acid. A solution of ferrous sulphate is usually employed to precipitate the gold from old or spoilt toning baths.

Gold Hyposulphite (Formula, $Au_2S_2O_3$; molecular weight, 506; synonym, sel d'or).—A salt formed by adding sodium hyposulphite solution to a solution of gold terchloride. It was used in the old Daguerreotype process (*q.v.*) for toning the image. It has recently been recommended for the toning of chloride emulsion papers upon which the image is produced by development.

Grain.—The unit of weight in the English system. A pound avoidupois contains 7,000, and a pound troy contains 5,760 grains. (See **Weights and Measures.**) The grain is also the 20th part of a scruple in apothecaries' weight, and a 24th part of a pennyweight troy. A grain is equal to ·0647990 gramme.

Grained Negative.—A negative in which the half-tones of the image are broken up into a fine grain. This is usually accomplished by interposing a fine netting, or wire gauze, between the lens and the object photographed. Grained negatives are used in photo-mechanical printing.

Gramme is the standard unit of French measures of weight, and is the weight of a cubic centimetre of distilled water at O° centigrade (32° F.) It equals 15·43248 grains. The English equivalents for the other French weights corresponding to the number of grammes they contain is easily found thus:—

	Grains Troy.	Avoidupois. lbs
Centigramme	·1543248	·0000220462
Decigramme	1·543248	·000220462
Gramme	15 43248	·00220462
Decagramme	154·3248	·0220462
Hectogramme	1543.248	·220462
Kilogramme	15432 48	2 20462
Myriagramme	154324 8	22·0462 = ·19684 cwt.
Quintal	1543248	220·46 2 = 1·9684 ,,

Gramme Atom.—A quantity of an elementary substance, such that the number of grammes weight is the same as the atomic number of the element—*e.g.*, 40 grammes of calcium (Ca=40).

Gramme Equivalent.—A number of grammes weight of a substance, elementary or compound, equal numerically to the quantity of that substance which is chemically equivalent to unit weight of oxygen.

Gramme Molecule.—A quantity of a substance either elementary or compound such that the number of grammes and the molecular weight are numerically the same.

Granulation (Lat. *granum*—a grain).—The process of becoming granular or formed into grains. Zinc and tin may be granulated by pouring the melted metal into cold water.

The term is also applied in photo-mechanical printing to the processes of breaking up the image into a granular state so that the half-tones of the picture may be represented although only one coloured ink is used.

Graphite (Gr. *grapho*—to draw).—An iron-black mineral commonly known as blacklead, and largely used in the manufacture of pencils. Ground up with diluted negative varnish it gives a dull black coating. Carbon in another form, *i.e.*, lampblack, is largely used as a colour in carbon printing and Woodburytype, but usually with some other tint to make the colour more agreeable. (See **Lampblack.**)

Graphoscope (Gr. *graphne*—a drawing, and *skopeo*—to look at).—An optical apparatus for magnifying photographs or other pictures.

Green Copperas.—See **Ferrous Sulphate.**

Green Fog.—See **Fog.**

Green Glass.—Glass coloured green has recently been found to be of great service in printing upon chloride of silver paper, such as albuminised paper, etc. It is found that by laying a piece of green glass over the printing frame, and allowing the light to shine through it before reaching the negative, a far more vigorous print is obtained if a weak negative be employed. The reason of this is that, when the paper is floated on the nitrate bath, two compounds are formed, albuminate and chloride of silver. The silver chloride is insensitive to green light, but the silver albuminate is sensitive. Now, the more albuminate of silver contained in the sensitive film, the greater will be the contrast when printing with a weak negative, and if we rob the light from the silver chloride, and allow it to act on the albuminate of silver, we obtain the same result. Green glass has this effect by absorbing those rays which have an actinic effect upon the chloride of silver, and allowing those to pass through which will affect the silver albuminate, and

by this means much more rapid gradation is obtained, although, of course, the exposure is considerably increased. It also exercises an effect upon the subsequent toning operation. See **Toning.**

With a gelatino-citro-chloride paper the same effect, but in a greater degree, is obtained, as the citrate of silver is more sensitive than the chloride. With Celerotype vigorous prints may be obtained from weak negatives, and from the very weakest by employing green-coloured glass.

Greenlaw's Process.—A modification of the old calotype paper negative process. It is thus described :—

Thin negative paper is first selected quite free from holes and of equal thickness. Then make up a solution of

Potassium iodide..	1,000 grains.
Potassium bromide	300 ,,
Distilled water	40 ounces.

Then add enough pure iodine to give the solution a dark claret colour. Filter. In a room lighted with yellow light, place as many sheets as required into this solution, care being taken against the formation of air bubbles. Allow the paper to remain in it for about an hour. Then turn the lot upside down and hang the sheets up to dry. The paper thus prepared will keep any length of time. To sensitise prepare—

Silver nitrate	2½ ounces.
Glacial acetic acid	2½ ,,
Distilled water..	40 ,,

Float a sheet of the iodised paper, smooth side downwards, upon this until the purple colour of the paper is turned to yellow (silver iodide).

After it has been allowed to rest for about a minute, remove it and immerse in distilled water. Next place it between two sheets of clear blotting paper, and remove all superfluous solution, and hang up to dry. When perfectly dry the paper may be exposed in the camera in the ordinary manner. Prepare—

Gallic acid	200 grains.
Spirit of camphor	1 drachm.
Distilled water	40 ounces.

and, previous to development, add to every five ounces of the solution—

Silver nitrate	30 grains.
Glacial acetic acid	¾ drachm.
Distilled water	1 ounce.

Pour quickly into a shallow dish, and float the picture side of the paper upon it. The image will be slightly visible, so no difficulty will be experienced in detecting the exposed side. Watch carefully until the image is visible on the back, and continue the

development until, in holding up a corner, where the sky of the picture is, before the light, you cannot see the finger if moved about between the light and the paper. If the image be insufficiently developed before the silver gallate decomposes, it is under-exposed. As soon as the silver gallate is decomposed it ceases to develop.

A more convenient method of developing is by brushing the solution over the paper previously wetted with water.

After development the negative is well washed, and fixed by placing it in a solution of sodium hyposulphite, 1½ ounce to one pint of water, until all yellow silver iodide disappears. After this it is well washed in many changes of water, and a clear, fine and dense negative is the result.

Green Paper.—An albuminised paper can be obtained of a slight greenish tint. It is often preferred for printing landscape negatives.

Green Pictures.—Obtained by floating paper on a 60-grain solution of uranium nitrate, and exposing for about ten minutes under a negative. Hardly any effect is visible until the paper is washed and brushed over with a weak solution of potassium ferrid-cyanide, which will develop a red image. While still moist it is immersed in a solution of sesquichloride of iron (10 grains to the ounce), and the tone will soon change to a bright green.

Green Spots.—These sometimes make their appearance in prints, and are due to the presence of small particles of inorganic matter in the paper.

Green Vitriol.—See **Ferrous Sulphate.**

Ground Glass.—Glass which has been ground on one or both surfaces. Its principal use in photography is for the focussing screen of the camera. (See **Focussing Screen.**)

It can easily be manufactured by rubbing two pieces together and sprinkling between the two surfaces some fine emery powder and water.

Ground glass is also used for backing transparencies, and for many other purposes where the light is required to be diffused, as in the studio skylight, but for this a substitute is usually employed. (See **Studio.**)

Ground Glass Plates.—Dry plates used principally for making positive transparencies. The emulsion is spread upon ground glass instead of plain, and this obviates the necessity of framing a piece of ground glass with the picture, a protective glass only being required.

Group (Ital. *groppo*—a knot or heap).—In art, the term is used to signify the union of several figures, or of various material objects, placed in contact with each other for the purpose of forming

a single group. Robinson, in his "Pictorial Effect in Photography," says: "The great art in the composition of a group is in so arranging the figures that they shall have some relation to each other, as well as the ordinary elements of pictorial construction. There should be some bond of union between those who compose the group, some incident should be represented in which they are mutually interested, or something must be imagined out of the picture to attract the attention of both, if only two are represented, or of many of them if there is a number. The figures should be massed together, and not scattered over the picture, so as to make it necessary to examine each portrait in detail, until it has been seen and the effect agreeably felt as a whole. . . . When the picture is larger than *carte de visite* or cabinet size, it is always better and much easier to produce a group by combination printing. To accomplish this, a sketch should be made of the composition, no matter how roughly done, so that the artist knows what is intended by it, or the figures may be placed in position, and a small photograph taken of the arrangement. They should be so grouped that the joining should come in unimportant places. When a sketch or small photograph is made, the groups or single figures should be photographed in detail by preference against a white or very light screen if a background is also to be put in."

Guaiacol (Formula, $C_6H_4.OH.OCH_3$; synonym, *methylpyrocatechin* or *methycatechol*).—Obtained by distilling *guaiacum*, a resinous exudation from the West Indian tree *Lignum vitæ*. It is a colourless aromatic liquid, sp. gr. 1·12, boiling point 200°C., miscible sparingly in water, and easily in alcohol. It has rather a pungent smell.

Guaiacol has recently been recommended by Colonel Waterhouse as a preferable developer to pyrocatechin, on account of its being a much cheaper product. 25 to 30 minims of it are dissolved in a 4 per cent. solution sodium carbonate (crystals). This acts as a fairly rapid developer for dry plates. The deposit is even and fine grained, of a yellowish brown tint, but with good printing powers.

Gum Arabic.—A gummy exudation from the various species of acacia, principally, however, from the *Acacia senegal*, a tree of some twenty feet height, growing abundantly in West Africa. It occurs in irregular lumps, odourless, soluble in cold water, and very rapidly in boiling water, forming a clear, viscid, adhesive solution, and in this form is used as an adhesive agent. It makes a fairly good mountant. Gum arabic is insoluble in alcohol, ether and oils.

Gum Dammar.—See **Dammar**.

Gum Dragon.—See **Gum Tragacanth**.

Gum Elemi.—A terebinthinate concretion from a species of the genus *Elaphrium*. It has a pale yellow colour, is rather brittle

outside, but soft within. It is used to give toughness, and reduce the brittleness of lacquers and varnishes. In conjunction with other gums it is used for making transparent paper for negative work. (See **Woodbury Tissue.**)

Gum Gallic Process.—An old process, in which the plate was edged with albumen, coated with iodised collodion, and immersed in the nitrate bath for a few minutes. It was then well washed and flowed over with a solution containing gum arabic, sugar candy and gallic acid. The plate was then drained and dried. The exposure necessary was from four to twenty times that required for a wet plate.

Gum Guaicum.—A resinous exudation from a lofty tree named the *Guaiacum officinale*, which grows in St. Domingo and Jamaica. It is soluble in absolute alcohol to the extent of 90 per cent. If triturated with water it forms a pale greenish mucilage. It is slightly sensitive to light, and was used by Niepce in his experiments in photo-lithography. It was also used as a preservative in the collodion process. (See **Preservative.**)

Gum Process.—An unused dry collodion process, in which gum arabic is the preservative. A trace of free nitrate is left upon the sensitive plate, along with the solution of gum. The exposure is the same as for wet plates, and the development is the old way, with acid pyrogallo-nitrate of silver.

Gum Process.—A process used in photo-lithography *(q.v.)*

Gum Tragacanth.—Obtained from the *Sterculia tragacantha* of Sierre Leone, and the *Astragalus verus* of Asia Minor. It should be nearly white, but is usually of a slightly reddish colour. If plunged in water it dissolves in part, swells, and forms a thick mucilage. Boiling water will dissolve it much more readily, as will also alcohol.

Gun Cotton.—See **Pyroxyline.**

Gutta Percha.—A substance similar to caoutchouc. It is the dried milky juice of the various trees of the order *Sapotaceæ*, the chief being the lofty forest tree, the *Isonandra gutta*, a native of the Malayan Archipelago.

Gutta percha is an extremely useful substance because of its property of resisting the action of cold water and damp. It is not acted on by alkalies, and many of the strongest acids. Hydrofluoric acid, which dissolves glass, may be kept with safety in vessels made of this substance.

It may be softened by hot water, and pressed into various forms, it becoming hard when cool. Only a small portion of it is soluble in absolute alcohol and ether. Benzol and spirits also partially dissolve it. Sulphide of carbon and chloroform, however, completely dissolve it.

A process has been patented by which gutta percha can be vulcanised with sulphur, and in this state it can be made to have a hard glazed surface.

It was formerly much used for making baths and dippers for the collodion process.

A good cement for gutta-percha articles is made as follows :—

Carbon bisulphide	5 ozs.
Gutta-percha	10 drams.
Indiarubber	5 ,,
Fish glue	25 ,,

Halation.—Sometimes called Irradiation. A term used to express a curious effect, often observable in photographic negatives, *i.e.*, the spreading of light beyond its proper boundaries, the high lights encroaching upon the surrounding shadows, or darker portions, producing local fog. This effect is very often met with in photographing interiors in which are windows facing the sky, and sometimes in landscape pictures, especially during autumn and winter, when the bare tree branches stand out against the sky. These are fogged in the negative, all the fine detail being lost. The defect is also visible if a plate be exposed in the direction of the sun and the direct rays enter the lens.

There are two or three causes of halation; the principal one, however, is the reflection of the light from the back surface of the glass plate. Abney, in his "Instruction in Photography," gives a very good explanation of the effect of halation, the results of very

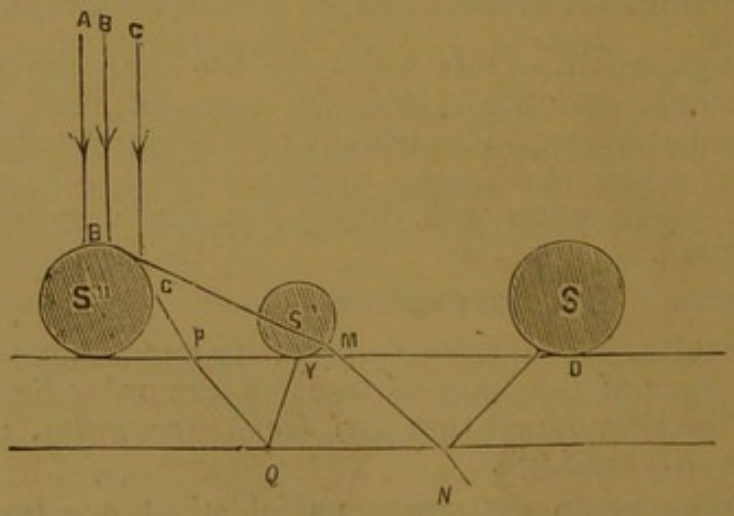

FIG. 98.

careful investigations. He says: "Rays of light entering a film are scattered by the particles of silver salt, and obey certain well-known optical laws. Suppose S'' (fig. 98) to be a magnified image of a grain of the silver salt lying on the glass plate G. Let A B and C be three of the rays falling on S''. They will each be reflected according to the ordinary laws of reflection. A, which falls on the top of the grain, will be reflected vertically back; B will be

reflected to m, the top surface of the glass, and be refracted to n, and will be totally reflected from n to o, where another particle (S) may be situated; B, by reflection, will then act on S. The ray C will be reflected immediately between S'' and S' to p, and will be refracted to q. Part will pass out to t, and part be

Fig. 99.

reflected to Y, where another grain of silver (S') may be situated, and therefore the ray C will also act on S', as well as on S. This will be the case, although no direct rays fall on S' and S. More rays are reflected back at what is known as the critical angle

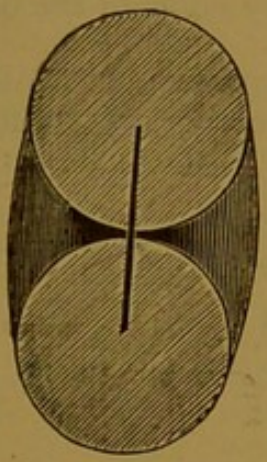

Fig. 100.

Fig. 101.

of the glass than any other part. Thus, a dot will be surrounded by a circle of great intensity, shading off towards the centre and to

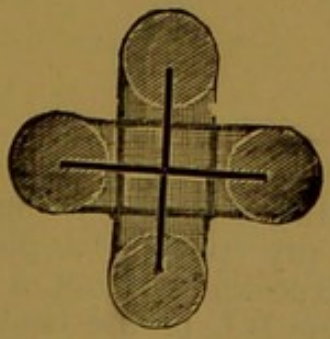

Fig. 102.

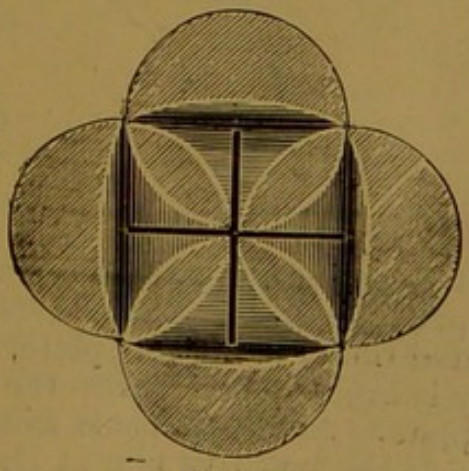

Fig 103.

the outside (fig 99.) A line will show a halo, as in fig. 100, and this can be built up of a series of circles (fig. 101). A cross can then be traced to the figures surrounding two lines at right

angles (fig. 102). Again, by increasing the thickness of the plate, the figure is seen to be extended (fig. 103), as should be the case as required by theory.

FIG. 104.

FIG. 105.

The image of a disc will be surrounded by a halo encroaching up to its edge, as shown in fig. 104, and this again can be shown to be built of a series of circles formed by every point in the disc, as can the image of a triangle (fig. 105).

In Eder's "Handbuch" the following concerning halation is given:—"Halation is usually produced by the reflection of a portion of an incident ray from the under surface of the glass plate.*

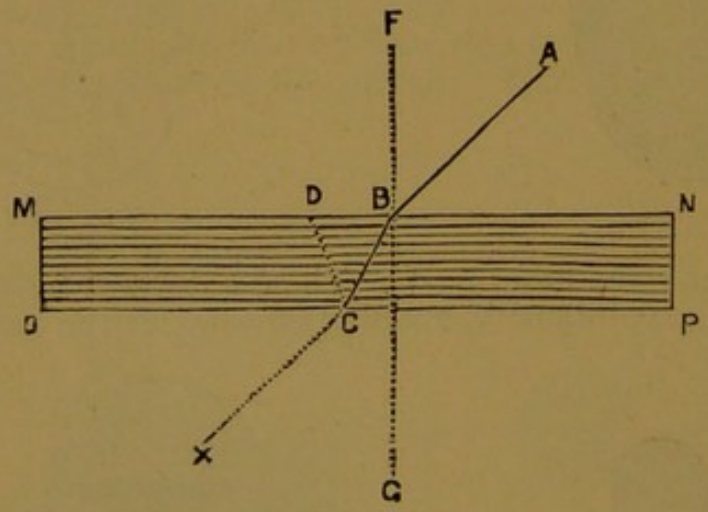

FIG. 106.

"Let us consider a simple case. If a ray of light A B (fig. 106) falls upon the glass plate M N O P (by placing a piece of perforated tinfoil upon the plate, and exposing without a lens), this ray is broken, and takes the direction B C to the back part of the plate. At C part issue from the plate and part is reflected back on to the sensitive film at D. This reflection may take place several times, as shown in fig. 107. O C is the incident ray. A

* The rays of light after passing through the bromide emulsion film are still sufficiently actinic as to cause an effect after being reflected from the back of the glass plate. It is possible to place behind the dry plate in the camera a second one, and develop a picture upon it.—EDER.

portion is reflected in the direction of 1, and part penetrates the glass, here it partly escapes to a and partly becomes reflected at d. It now diverges in the direction 2, and is partly reflected along 5, the process being repeated several times. If the glass is held at a certain angle towards a shining light it is possible to see the secondary images by looking in the direction of the arrows 8 to 13.

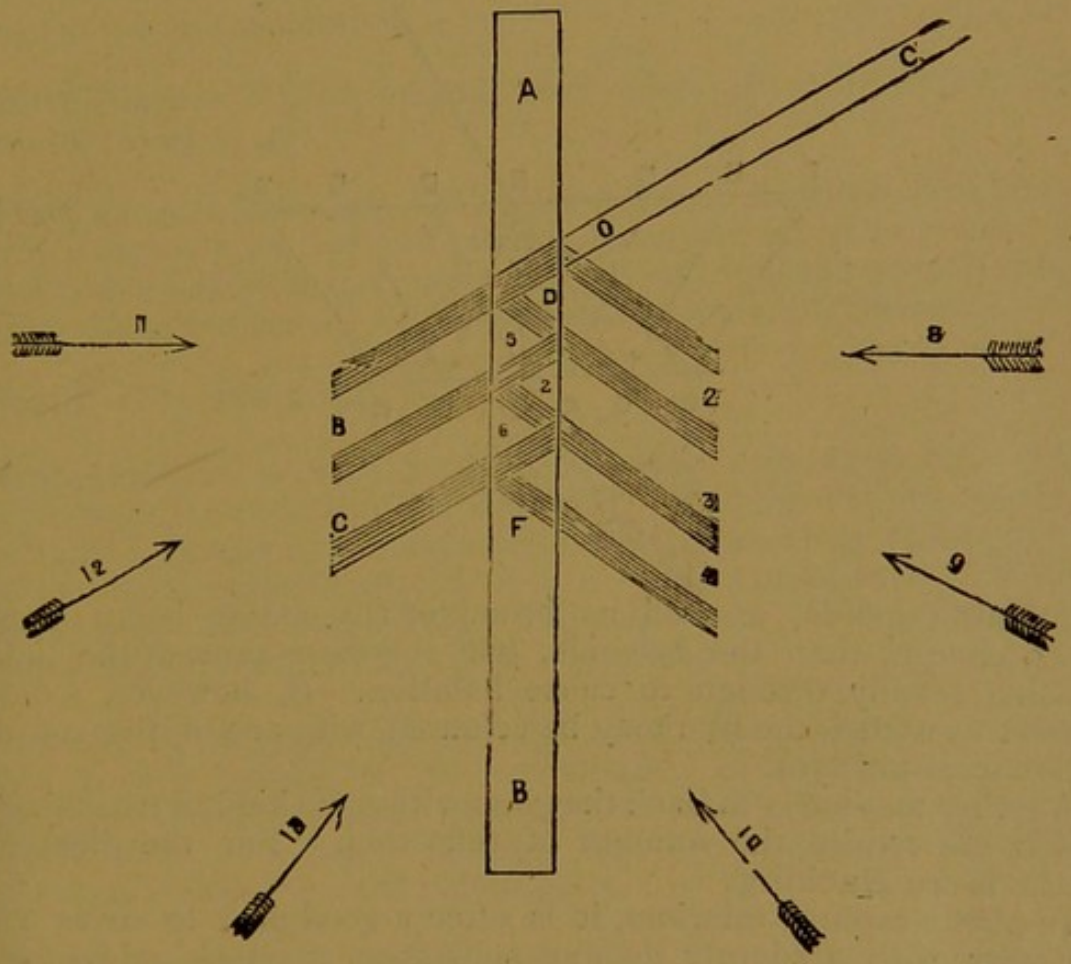

FIG. 107.

In photographic practice, however, this effect does not take place, as the semi-transparent emulsion film diffuses the light. These rays which strike point B (fig. 108) do not all follow the line B C, as would be the case were they passing through clear glass, but are partly reflected in the directions C′D′, etc., according to the principles of refraction.

This explains the halo which surrounds the bright parts.

As this defect generally proceeds from the reflection of the glass, it is obvious that by substituting paper or card for the glass support we should effectually prevent its occurrence. Thus gelatine or

celluloid negative films will give this defect, but only in a very slight degree, owing to the thinness of the support. Halation can also be to a certain extent prevented by making the film opaque, and thus prevent the light from passing through it. The amount of opacity necessary must be regulated by the brightness of the subject to be photographed, and the duration of the exposure necessary. Matt surface plates, thickly coated with an emulsion

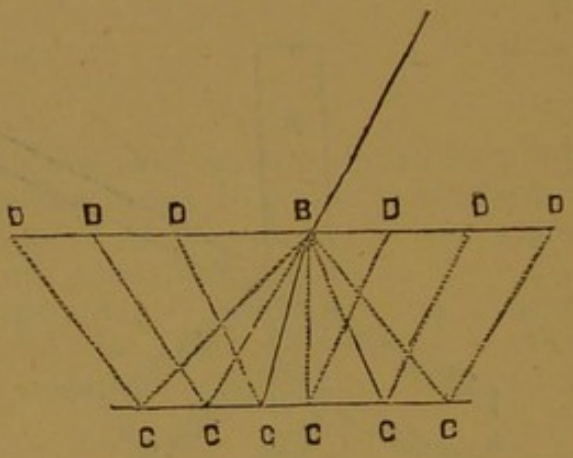

FIG. 108.

containing iodide, as well as bromide, the iodide being much more opaque than the bromide, will therefore prevent the light passing readily through to cause halation. If, however, iodide cannot be added, the film may be coloured with one of the red or yellow coal-tar dyes.

Another method is to back the glass with some kind of "backing" which will reduce the amount of reflection. For the different methods see **Backing.**

In photographing interiors, it is often a good plan to cover the windows with a slightly opaque substance, such as unbleached calico. This will effectually reduce the intensity of the light. Some operators hang small strips of black velvet in front of the camera during exposure in such a position that they will block out the windows in the image. Before the completion of the exposure, however, they are removed for a short time.

Up to the present we have only considered halation which proceeds from the reflection of the glass. But this defect will also make its appearance at times even if the sensitised film be mounted on a perfectly opaque support. The cause of this is not known with certainty, but it is generally believed to be due to the billions of tiny motes we see so clearly in the air when a beam of strong light passes through it. These little motes all reflect light, and it is possible that those contained in the camera scatter the light

coming through the lens in all directions, and thus produce fog. The defect when resulting from this cause is usually, however, so slight as to be hardly worth troubling about.

Halation may be due to the lens itself, which is a source of scattered light, as photographic lenses are rarely polished to perfection. The imperfections are easily seen if one holds the lens between the eye and a bright gas flame and move it sideways until the flame becomes invisible. The lens now has the appearance of being luminous, and the irregularities of its surface will often reflect the light in stray directions in a very similar manner to the motes in the camera.

Half Plate.—A photographic size, $6\frac{1}{2} \times 4\frac{3}{4}$; the correct half plate size is $6\frac{1}{2} \times 4\frac{1}{4}$.

Half Tone.—The shades of colour between the black and white of the image are termed half tones. In reproduction processes, in which one coloured ink is employed, the half tones are represented by fine dots or stipple. See **Photo-Mechanical Processes.**

Halo.—See **Halation.**

Halogen (Gr. *hals*—sea-salt, and *gennao*—to produce).—The electro-negative radical of a haloid salt. The term is also applied to chlorine, bromine, iodine, and fluorine, from their tendency to produce salts resembling sea-salts in their composition. These elements are also termed salt radicals from their property of forming salts by direct union with the metals.

Haloid Salts (Gr. *hals*—sea-salt, and *eidos*—form).—A name given to salts formed by the combination of a halogen element with a metal, or the union of a radical which does not contain oxygen with a metal. Sodium chloride, cadmium bromide, potassium iodide, etc., are haloid salts.

Hand Camera.—A small camera held in the hand when exposing instantaneous subjects. See **Camera.**

Head-rest.—An apparatus used in portrait photography to keep the head steadily in position during the exposure. With the present rapid plates this is hardly ever necessary, except with very nervous sitters. It is usually made of iron, the base being very heavy, to obtain firmness. If used, it should be brought gently to the sitter's head, so as to give sufficient support without being used as an instrument of torture. It must be arranged behind the sitter in such a manner that none is visible in the picture.

Several kinds of head-rests have recently been manufactured, which can be fitted on to the back of the chair upon which the sitter is, and used in that position.

Hectogramme (Fr., from Gr. *hekaton*—a hundred, and Fr. *gramme*).—A French weight or measure containing 100 grammes, or 3 oz. 8·4383 drams avoirdupois.

Hectolitre (Fr., from Gr. *hekaton*—a hundred, and Fr. *litre*).—A French measure of capacity for liquids, containing 100 litres = $\frac{1}{10}$ of a cubic metre, or 22·009668 imperial gallons; as a dry measure it contains 10 decalitres, or about $2\frac{5}{6}$ Winchester bushels.

Hectometre (Fr., from Gr. *hekaton*—a hundred, and Fr. *metre*).—A French measure of length containing 100 metres = 109·3633 yards.

Heliochrome.—A name given by Niepce to the products of his process for photographing in natural colours.

Heliochromy (Gr., *helios*—the sun, and *chroma*—colour).—A name given to the process of making photographs in natural colours, as yet a long way from perfect. As far back as 1848 naturally coloured photographs were obtained. But these are, however, fleeting, and fade away instantly the pictures are exposed to the light. Many clever and persevering experimentalists have endeavoured to perfect a process by which a lasting image could be formed precisely the same in colour to the image formed by the lens upon the ground glass screen of the camera. Among the scientists may be mentioned Dr. Seebeck, of Jena, Sir John Herschel, Robert Hunt, Becquerel, Carey Lea, and Abney, none of whom, however, succeeded in obtaining satisfactory results.

It is probable that the French physicist, Edmond Becquerel, produced the most successful photographs of colour. The following is his method* :—Taking a silver plate, such as is used in Daguerreotype, he obtained a thin and very uniform coating of silver chloride on its surface. This he sometimes effected by soaking it in chlorine water until the silver assumed a rose tint, or by dipping it into solutions of cupric or ferric chloride. By preference, however, he placed the silver plate in a solution of hydrochloric acid, and attached to it a wire from the positive pole of a voltaic battery, the wire from the negative pole being fastened to a plate of platinum which also dipped into the acid solution. By this means the hydrochloric acid was decomposed, and the chlorine being drawn by electrical attraction to the silver plate, combined with it chemically, forming a surface of silver chloride of great purity. As the combination of silver and chlorine took place, the layer of silver chloride gradually increased in thickness, and as it did so its colour changed to grey, yellow, violet, blue, and continuing the action, these colours appeared a second time. When the second violet tint had been obtained the silver plate was withdrawn from the solution, washed and dried, and gently heated until the surafce assumed a rosy hue. When the spectrum of sunlight or of the electric arc was received

* "History of Photography" by W. J. Harrison, F.G.S.

upon a plate so prepared, an exposure of a few minutes was sufficient to impress the diverse colours. Images of highly-coloured dressed dolls were also obtained.

Abney is of opinion that these colours obtained by Becquerel upon Daguerreotype plates are due to the oxidation of the silver compounds employed. When the sensitive plates are exposed in the presence of an oxidising agent, as by dipping them into peroxide of hydrogen before or during exposure, the colours are more readily produced.

At a recent meeting of the French Photographic Society M. Vallot described his process of photography in colours, the same being a modification of that of Poitevin.

A strong photographic paper (Rive's 12 kilos., answers admirably) is floated five minutes on—

Water	100 parts.
Sodium chloride	10 ,,

and dried as rapidly as possible.

When dry the paper is sensitised on—

Distilled water	100 parts.
Silver nitrate	20 ,,

It is then drained for a few seconds, and washed in distilled water, and afterwards for ten minutes in running water; finally, to thoroughly eliminate all traces of free silver, the paper is placed for five minutes in a bath of—

Water	1000 parts
Sodium chloride	20 ,,

After leaving this bath the sheets are well washed in running water, and laid while moist, sensitive side under, on a bath containing 500 parts of water, to which 20 parts of the following solution has been added—

Distilled water	100 parts.
Protochloride of tin	5 ,,
Sulphuric acid	2 drops.

The whole is then exposed to diffused light to transform the white silver chloride into violet sub-chloride.

After washing, the paper is then dried in the dark, and afterwards laid in a mixture of equal parts of the following solution—

SOLUTION 1.

Potassium bichromate	5 parts.
Water	100 ,,

SOLUTION 2.

Saturated solution of copper sulphate.

The exposure required is about three-quarters of an hour to strong sunlight.

After exposure the colours are already perceptible. The paper is then plunged into—

Water	1000 parts
Sulphuric acid	20 ,,

It will be seen, therefore, that the production of coloured images is not altogether impossible, as it has already been achieved. These coloured images are, however, far from being perfectly true to the natural colours of the object photographed; some of the colours are entirely missing, whilst others are represented by colours certainly not natural, the whole being a very poor imitation of the glorious tints of nature.

Another serious difficulty confronts the experimenter. These coloured images obtained, how can they be fixed? As yet no method has been discovered, and heliochromy, or photography in natural colours, still remains a dream of the future.

Heliograph (Gr. *helios*—the sun, and *grapho*—to draw).—A combined astronomical and photographic instument used for obtaining photographs of the sun. A picture made by the process of heliography.

Heliography.—Another name for photography. Niepce also gave this term to one of his processes of obtaining bituminous images upon polished metal plates.

Heliostat.—See **Heliograph** (first definition).

Heliotype.—A modification of the collotype process, the principal feature being that the gelatine film can be hardened with chrome alum and afterwards detached from the support upon which it is first prepared. It thus forms a tough and flexible skin of gelatine, which can be used at any time for printing from by attaching to a zinc plate or to a cylinder.

Hellenotype.—See **Ivorytype.**

High Lights.—A photographic term applied to the highest parts of a positive picture. In the negative these portions possess the greatest density or opacity.

Hillotype.—This was the name given to an imaginary process discovered by a hypocritical American preacher. The process was said to produce photographs "glowing with all the glorious colours of nature." A large sum of money was advanced the "discoverer" for the details of his process, which was discovered to be a fraud.

History of Photography.—See **Photography.**

Holders.—See **Plate-holder, Slide-holder,** etc.

Honey Process.—A collodion dry-plate process independently proposed by George Shadbolt and Maxwell Lyte about the year 1854. The principle of the process was the use of a solution of honey or of grape sugar to coat the sensitised plate, previously

washed, until the greater portion of the free silver nitrate had been removed.

Previous to development the honey was washed away and the plate again dipped in the nitrate bath. The object of coating with honey was to keep the surface moist and prevent crystallisation of the remaining silver nitrate. Double the exposure of wet plates was, however, necessary.

Horn Silver.—If white silver chloride be dried in the dark and heated in a crucible, it fuses at 451°C. to a brownish liquid, which solidifies on cooling to a transparent, almost colourless mass, somewhat resembling horn, and is for this reason called horn silver. Strong heat will convert it into vapour, but will not decompose it.

Husnik's Process.—See **Leimtype.**

Hydriodic Acid (Formula HI; synonyms, *iodhydric acid*, *hydric iodite*, *hydrogen iodide*).—Iodine vapour combines with hydrogen under the influence of heated platinum to form hydriodic acid. It is a colourless gas condensed to a liquid by a pressure of four atmospheres at 0°. It is very soluble in water.

Hydro.—A prefix derived from the Latinised form of *Gr. hudro*, the form in which *hudor* = water. Before a vowel it is sometimes changed to *hydr*. In chemistry this prefix is used to denote that the acid contains no oxygen, it being a combination of hydrogen with a non-metallic element as HCl, hydrochloric acid, or with a radical as HCN, hydrocyanic acid.

Hydrobromic Acid (Formula, HBr; molecular weight, 80·75; synonyms, *bromhydric acid*, *Hydrogen bromide*).—A colourless gas with a pungent acid, very irritating odour, which dissolves largely in water.

An aqueous solution of hydrobromic forms a colourless liquid. The amount of acid contained in it can be ascertained by the following table of its specific gravity compiled by weight.

Specific grav. at 15° C.	Percentage of pure hydrobromic acid.
1 080	10·4
1·190	23·5
1·248	30·0
1·385	40 8
1·475	48·5
1·515	49 8

Samples of hydrobromic acid sometimes contain a little iodide. This may be detected by adding a small quantity of starch paste and a little bromine to it. If iodide be present, a blue colour will be visible. It can be purified by re-distilling over potassium bromide.

Aqueous solutions of hydrobromic acid are decomposed by most metals, with formation of metallic bromide and hydrogen. Its use in photography is mainly confined to the production of certain bromides.

Hydrocarbons.—A series of compounds, consisting of carbon and hydrogen only, produced chiefly by the natural or artificial decomposition of organic substances. Among those best known may be mentioned paraffin, benzine, turpentine.

Hydrochloric Acid (Formula, HCl ; molecular weight, 36·5 ; synonyms, *chlorhydric acid*, *hydrogen chloride*, *muriatic acid*, *spirits of salts*).—This acid is found in nature among the gases emanating from the active volcanoes, and occasionally in the spring and river waters which take their rise in volcanic districts, especially in South America. It is produced artificially by warming together common salt and strong sulphuric acid—

Common salt.		Sulphuric acid.		Hydro sodium sulphate.		Hydrochloric acid.
$2NaCl$	+	H_2SO_4	=	Na_2SO_4	+	$2HCl.$

the sodium of the common salt changing place with the hydrogen of the sulphuric acid. The hydrochloric acid escapes as a colourless gas with a most irritating acrid odour. It is very soluble in water, and in this form it is sold as "spirits of salts," hydrochloric acid, or muriatic acid. The most concentrated solution has a specific gravity at 15°C. of 1·2, and contains 40·777 per cent. of the gas. The solution commonly sold is, however, weaker, having a specific gravity of from 1·14 to 1·16, and contains about 28 or 30 per cent. of real acid.

Hydrochloric acid becomes weaker by heating, as it rapidly volatilises at boiling point of water. The pure acid should be quite colourless and free from perchloride of iron or organic matter. Free chlorine and sulphuric acid are also sometimes present. Chlorine may be detected by adding a drop or two of the solution to a mixture of starch paste and potassium iodide; if present, a blue colour will be obtained. Absence of sulphuric acid may be proved by diluting the hydrochloric acid with six times its volume of water, and adding barium nitrate, no precipitate should be formed.

For photographic purposes this acid should be used as pure as possible. It must be kept in closely stoppered bottles, kept covered from too strong light, because light decomposes it, and gives free chlorine. It is used in photography for dissolving out ferric oxalate from platinotype, bromide prints, &c., acting as a clearing solution. It is also used in the preparation of various chlorides.

Hydrofluoric Acid (Formula, HF ; molecular weight, 20 ; synonyms, *fluorhydric acid*, *hydrogen fluoride*).—An acid obtainable

either in liquid or gaseous form. It is prepared by decomposing calcium fluoride by sulphuric acid, and by heating acid potassium fluoride.

Its chief use is in etching glass, as it decomposes and dissolves silicates. Glass, being a complex silicate, is readily attacked by the acid, tetrafluoride being formed. The liquid acid etches glass bright, and is used for producing bright designs on ground glass. The gaseous acid etches it with a dull appearance, and is used for producing matt designs upon bright-surfaced glass. The glass is covered with a thin coating of wax, and the design traced through the wax down to the glass with a sharp-pointed instrument. It is then treated with the acid, which etches the exposed parts. By this means the names of the contents of bottles can be written on the glass, the same being perfectly ineffaceable.

This action of the acid upon glass causes it to be used in photography for stripping gelatine films from the glass. When working with it, however, it must be remembered that porcelain or glass dishes cannot be safely used unless coated with beeswax. Dishes made of guttapercha will resist the strongest acid. Vessels to contain the acid are also made of this substance, as glass bottles cannot be employed.

Hydrogen.—An important elementary substance, one of the elements of water, and contained in all vegetable and animal products. It may be obtained by passing the vapour of water over red hot iron filings. The change that takes place may thus be represented—

$$3Fe+4H_2O=Fe_3O_4+H_2$$

It may also be produced by submitting water to the action of an electric current, by which the elements, hydrogen and oxygen, of which it is composed, are separated. Pure hydrogen is a colourless gas, without taste or odour. It burns readily in the air, combining with the oxygen to form water. Its flame is very slightly luminous, but of intense heat.

Hydrogen is the lightest substance known, being about 14½ times lighter than air, and having a specific gravity of 0·693. Owing to its characteristic lightness, it is taken as the standard of unity in referring to the atomic weight of bodies. Two volumes of hydrogen with six of air form an explosive mixture. Hydrogen is only but slightly soluble in water, nor is any other liquid capable of dissolving it in great percentage. It can be liquefied by exposing it to a pressure of 650 atmospheres and a temperature of 140°C. It, however, remains liquid at 320 atmospheres pressure, the temperature remaining the same. It unites with all other elementary gaseous bodies to form a large number of important compounds.

Hydrogen Peroxide (Formula, H_2O_2 ; synonyms, *peroxide of hydrogen, hydrogen dioxide, hydroxyl, oxygenated water*).—A colour-

less liquid, either neutral or faintly acid, prepared by decomposing barium dioxide by dilute acids. The presence of a little free acid renders it more stable, and it is usually sold with the addition of a small quantity of hydrochloric acid. Its uses in photography are not numerous. It has been recommended as an eliminator of the sodium hyposulphite, which it converts into a salt of one or more of the higher sulphuric acids. A very weak solution, about one dram to four ounces, must be used, however, otherwise the tones of the prints will be reduced and sulphur deposited. It is principally used, however, as test for iodine when combined with chlorides or bromides, owing to its action of liberating the iodine from its metallic compounds without affecting either the bromides or the chlorides.

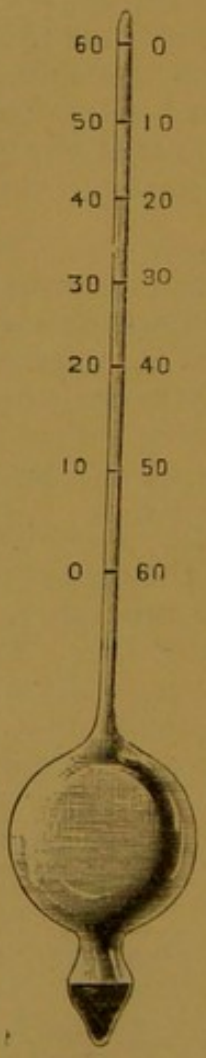

FIG. 109.

Hydrometer or **Areometer.**—An instrument for determining the specific gravities or relative densities of liquids. The principle upon which it works is that when a body floats on a liquid, and

thus displaces a quantity of the liquid, the weight of the solid body is equal to the weight of the liquid which it displaces. The density of the liquid is determined either by the depth to which the hydrometer sinks in the liquid, or by the weights required to cause it to sink to a certain depth. With both kinds, however, correction must be made for variations in temperature.

Baume's Hydrometer is largely employed on the Continent. It consists of two different instruments, one for liquids heavier than water, and one for those which are lighter. The first floats at the zero point, in distilled water, at a temperature of 58° F., and each degree marked downward indicates a density equal to one per cent. of common salt. The hydrometer for liquids lighter than water is poised so that the zero point of the scale is at the bottom of the stem when it is floating in a solution of 1 oz. of common salt in 9 oz. of water, and the depth to which it sinks in distilled water shows 10°, the space between these two points being equally divided, and the same graduation continued to the top of the scale. * Fig. 109 is an illustration of a Baumé hydrometer having the two different scales. For liquids lighter than water the figures on the left hand side are read, and for liquids heavier than water those on the right hand side.

Table showing the relation between specific gravities and degrees of Baumé's hydrometer for liquids heavier than water.

S.G.	B.	S.G.	B.	S.G.	B.	S.G.	B.	S.G.	B.
1·000	0	1·116	15	1·264	30	1·454	45	1·714	60
1·007	1	1·125	16	1·275	31	1·470	46	1·736	61
1·014	2	1·134	17	1·286	32	1·485	47	1·758	62
1·022	3	1·143	18	1·298	33	1·501	48	1·779	63
1·029	4	1·152	19	1·309	34	1·526	49	1·801	64
1·036	5	1·161	20	1·321	35	1·532	50	1·823	65
1·044	6	1·171	21	1·334	36	1·549	51	1·847	66
1·052	7	1·180	22	1·346	37	1·566	52	1·872	67
1·060	8	1.190	23	1·359	38	1·583	53	1·897	68
1·067	9	1·199	24	1·372	39	1·601	54	1·921	69
1·075	10	1·210	25	1·384	40	1·618	55	1·946	70
1·083	11	1·221	26	1·398	41	1·637	56	1·974	71
1·091	12	1·231	27	1·412	42	1·656	57	2·002	72
1·100	13	1·242	28	1·426	43	1·676	58	2·031	73
1·108	14	1·252	29	1·440	44	1·695	59	2·059	74
								2·087	75

In the above scale 0 corresponds to pure water at 58° Fahr., and the numbers 1, 2, 3, etc., correspond to water containing 1, 2, 3, etc., per cent. by weight of common salt.

* Note.—These instruments were originally adjusted by Baumé to a temperature of 12·5° Centigrade, equal to 54·5 Fahrenheit. Now, however, they are commonly adjusted in this country to a temperature of 58° or 60° Fahrenheit. Hence the discrepancies so often observed between degrees of Baumé and real specific gravity.

Table for Liquids Lighter than Water.

S.G.	B.	S.G.	B.	S.G.	B.
1·000	10	·896	27	·811	44
993	11	·890	28	·807	45
·987	12	·885	29	·802	46
·980	13	·880	30	·798	47
·973	14	·874	31	·794	48
·967	15	·870	32	·789	49
·960	16	·864	33	·785	50
·954	17	·859	34	·781	51
·948	18	·854	35	·777	52
·942	19	·849	36	·772	53
·936	20	·844	37	·769	54
·930	21	·840	38	·764	55
·924	22	·834	39	·760	56
·918	23	·830	40	·756	57
·913	24	·825	41	·753	58
·907	25	·820	42	·749	59
·901	26	·816	43	·745	60

As the whole weight of the hydrometer and the weights when adjusted in distilled water is to the *number* 1,000, so is the *whole weight when adjusted in any other fluid to the number expressing its specific gravity.*

Nicholson's Hydrometer or *Areometer* is constructed on a similar plan to Fahrenheit's. It has, however, in addition to the dish for the weights above, a small cup below for convenience in ascertaining the weight of a solid body in water. It is chiefly used for ascertaining the specific gravity of minerals (see fig. 26).

Fahrenheit's Hydrometer.—This instrument consists of a little hollow ball, having a counterpoise below, and a very slender stem above, terminating in a small dish. The half length of the stem is distinguished by a fine line across it. The instrument is immersed in the liquid to this line by placing weights in the little dish above. Then, seeing that the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known, this last weight, added to the weights in the dish, will be equal to the weight of fluid displaced by the instrument, according to the laws of hydrostatics. The specific gravity will be found by the proportion.

Twaddel's Hydrometer.—With this instrument 0 is equal to 1,000, or the spec. grav. of distilled water, and each degree is equal to ·005, so that by multiplying this number by the number of degrees marked on the scale and adding 1 the real spec. grav. is obtained.

Alcoholmeters, *Argentometers*, *etc.*, are all simple hydrometers graduated so as to adapt them to the testing of spirits, silver solutions, etc.

Hydroquinone (Formula, $C_6H_6O_2$; molecular weight, 110; synonyms, *hydrokinone*, *hydrochinone*, *pyroquinol*, *pyrogentisic acid*).—A constant product of the action of reducing agents on quinone. The most convenient method of preparing it is by passing sulphur dioxide (sulphurous acid gas) through a warm

saturated solution of quinone. It is also prepared commercially by oxidising aniline sulphate with potassium dichromate. Hydrokinone is isomeric with pyrocatechin,* but is distinguished from it by the action of oxidising agents, such as ferric chloride, which converts hydrokinone into fine green metallic prisms of green hydrokinone or quinhydrone, $C_6H_4O_2.C_6H_4(OH)_2$, which may also be obtained by mixing aqueous solutions of quinone and hydroquinone.

Hydroquinone is dimorphous, crystallising in monoclinic plates and from solutions in hexagonal prisms. It has a slightly sweet taste, and is soluble in water, ether, alcohol, and glycerine. An aqueous solution slowly turns brown on exposure to the air, losing its reducing power, and if it be alkaline it will brown more rapidly.

It has recently been discovered to be an excellent developing agent for dry plates, bromide paper, transparencies, etc., bringing out the detail to perfection. Further, it allows of a great latitude in the exposure, as it is slow in action, and consequently easily controlled.

Commercial hydroquinone is usually in the form of nearly white or pale yellowish needle-like crystals. These must be kept protected from light and damp, otherwise they will darken. The best method of preserving it is in solution with alcohol and glycerine, and used either with ammonia or the fixed alkalies, potash and soda, as accelerators. The following are two such solutions† :—

Hydroquinone	8 grains.
Glycerine	1 drachm.
Methylated spirit	7 drachms.

Keep in stoppered bottle, excluded from light.

Hydroquinone	8 grains.
Citric acid	8 ,,
Distilled water	8 drachms.

The use, however, of a preservative such as potassium metabisulphite, or sodium sulphite, is always an advantage, as it enables a large number of plates to be treated with the same developer without fear of producing stains or discolouration.

A good formula for a hydroquinone developer for dry plates is the following :—

Hydroquinone	1 grain.
Sodium carbonate	2 grains.
Sodium sulphite	,,
~~Potassium bromide~~ Water	1 ounce.

One of the chief features of this developer is that a restrainer is rarely necessary, as it does not possess the vigour of pyrogallic acid in attacking the very lightly exposed portions of the image. It does not, however, suit every manufacture of plates. With some it hardly seems to have any developing action, while with others it brings up a clear, sharp, and brilliant negative.

* "Bloxham's Chemistry," p. 651. † E. J. Wall's "Dictionary of Photography," page 87.

It is also a very suitable developer for bromide paper, or developing contact prints or enlargements. For this purpose the formula reads :—

SOLUTION 1.

Hydroquinone	350 grains.
Sodium sulphite	2 ounces.
Potassium bromide	45 grains.
Water	45 ounces.

SOLUTION 2.

Potash (ordinary granulated)	6 ounces.
Sodium carbonate	2 ,,
Water	40 ,,

This gives a rich black colour to the image.

Another formula is—

Bitartrate of potash	90 grains
Potassium sulphite	45 ,,
Potassium carbonate	4 ounces
Water	16 ,,

Filter and add—

Hydroquinone	½ ounce

A developer for chloride plates for lantern or other transparencies can be made up as follows :—

Hydroquinone	2 grains
Sodium sulphite	10 ,,
Ammonium carbonate	10 ,,
Potassium bromide	1/10 ,,
Water	1 ounce

A simple hydroquinone developer, made up in a solution that will keep for a great length of time, is the following :—

Hydroquinone	10 grains
Sodium sulphite	20 ,,
Lime water	2 ounces

For use, take 100 minims of the above solution and dilute it with one ounce of water This developer is specially suitable for lantern slides or transparencies. For negatives double the strength would be required.

Hydroquinone also acts as an efficient intensifier, and is especially suitable for the production of very dense collodion negatives as used in photo-mechanical printing processes. The following formula was introduced by Captain Hübl, of Vienna :—

SOLUTION I.

Hydroquinone	10 parts.
Water	1,000 ,,
Citric acid	6 ,,

SOLUTION II.

Silver nitrate	1 part.
Water	30 parts.

For use take three parts of solution 1, and mix with one part of solution 2. According to Professor Eder, this intensifier not only effects, with an unfixed wet collodion plate, a harmonious strengthening of the image, but it also continues the action of the developer that has preceded it, and brings out the details. If applied after fixing no injury to the clear shadows takes place.

Hydroxylamine Hydrochloride (Formula, NH_3OHCl; molecular weight, 69·5; synonym, oxyammonium chloride).—Colourless tubular crystals, very soluble in water and alcohol.

The best method of preparing it is probably the following, given by Ruschig :—

Hydrogen sulphite in concentrated aqueous solution, is added to an alkaline nitrate at a temperature not exceeding freezing if the soda salt be used, or 40° of the potassium salt; or the same product is obtained by passing sulphurous anhydride to excess in a solution of the alkaline nitrate, containing also a carbonate or hydroxide. The resulting solutions being heated for a short time at 130°, or a longer period at 100°, are resolved into hydroxylamine and alkaline sulphates, easily separable by fractional crystallisation. It was recommended in 1884 by Messrs. Egli and Spiller as a developer claiming a wide latitude in exposure and permanency of the solution, unaffected by the air. Their formula runs as follows :—

SOLUTION 1.

Hydroxylamine hydrochloride	32 grains.
Citric acid	15 ,,
Distilled water	1 ounce.

SOLUTION 2.

Potassium carbonate	480 grains.
Sodium carbonate	480 ,,
Distilled water	1½ ounces.

DEVELOPER SUFFICIENT FOR HALF-PLATES.

Solution 1	30 minims.
Solution 2	120 ,,
Distilled water	1½ ounces.

This developer will be found more suitable for chloride plates, and bromide contact and enlarging papers.

The hydroxylamine is usually obtained by the reduction of nitric acid with tin and hydrochloric acid. Chapman Jones says * that a simple solution of this salt appears to be useless as a developer, and the addition of ammonia or sodium carbonate makes but little difference; with caustic potash or caustic soda, however, a solution

* "Science and Practice of Photography."—Iliffe & Son.

can be prepared that will give as much detail as an ordinary pyrogallic developer.

In the production of the image the chemical changes that in all probability take place are thus expressed—

$$2NH_3O\,HCl + 6NaOH + 4AgBr = 4Ag + 4NaBr + 2NaCl + 7H_2O + N_2O$$

One of the principal drawbacks to this developer, besides its expensiveness, is its peculiar expanding action upon the gelatine film, causing frilling.

Hygrometer.—An instrument for measuring the degree of moisture of the atmosphere. The principle of these hygrometers depends chiefly upon absorption or condensation. An instrument of this kind is often useful in the photographic laboratory to detect the amount of moisture in the atmosphere. A very simple one was constructed and used by the late W. B. Woodbury in his laboratory. It consisted simply of a piece of carbon tissue fixed in an upright support. Fig. 110 will show the arrangement. The

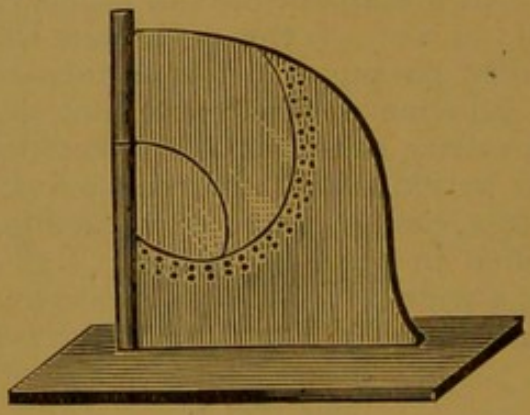

Fig. 110.

piece of carbon tissue absorbed the moisture of the air, the gelatine expanded, and the strip was made to move or curl downwards on a piece of cardboard at the back; a scale was drawn showing the amount of moisture present.

For more delicate purposes, however, the most efficient hygrometer is one recently invented by Dr. C. Koppe.* Fig. 111 is an illustration of it. It consists of a frame, to which one end of a human hair, carefully freed from grease, is fixed, the other end is wound round one groove of a pulley wheel with two grooves. Round the second groove a filament of silk is wound in a reverse direction to that of the hair, and, at the lower end of the hanging silk or filament, a little weight is attached so that the hair is kept constantly under tension. An index needle attached to the wheel in front of a scale of 90 degrees, divided into 100 parts, shows the amount of any elongation or contraction of the hair. When the hair grows dry the needle turns to the left, and when the hair grows damp the needle turns to the right. If the surrounding air be completely saturated, the needle points to 100 on the scale.

Photographic News, 1850, page 547.

Hypo.—An abreviation for hyposulphite of soda, largely used as a fixing agent in photography.—(See **Sodium** hyposulphite.)

Hypochlorites.—The salts of hypochlorous acids, usually obtained in solution by neutralising hypochlorous acid with bases. They are oxidising agents, and for this reason have been recommended for eliminating the last traces of sodium hyposulphite from the fixed and washed prints. Like all other so-called "eliminators," however, they have a tendency to attack the picture themselves.

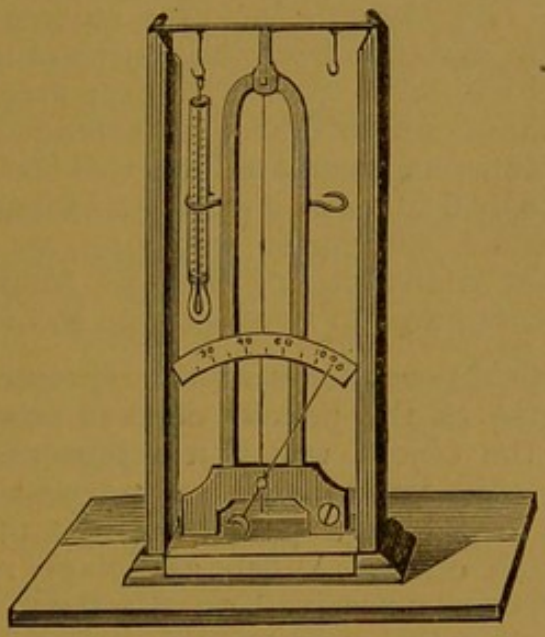

FIG. 111.

Hypo-eliminators.—See **Eliminators.**

Hyposulphite of Gold.—See **Gold Hyposulphite.**

Hyposulphite of Soda.—See **Sodium Hyposulphite.**

Ice.—Water frozen to a solid mass; under ordinary circumstances this occurs at 32° Fahrenheit. Ice has a specific gravity of 0·9184. When in the act of freezing, water expands very considerably, and will burst any vessel which contains it. It is for this reason that in winter, when the weather is very cold, the room containing the various photographic chemicals should always be kept warm. Ice is very useful in photographic operations, especially in the summer, when it is, however, more difficult to obtain. Many freezing mixtures can be made, however, to act as substitutes. These are all given under **Freezing Mixture.** (*q.v.*)

Iceland Moss (*Letraria islandica*).—A species of lichen found in the Arctic regions, and in the high parts of the mountainous districts in Scotland. If boiled in water and allowed to cool, it forms a jelly. It resembles gelatine in many ways, and can be used in its stead. It is, however, inferior.

Iceland Spar.—A transparent variety of calc spar found in crystallised masses. It is noted for its peculiar property o exhibiting double refraction of light to a remarkable degree, and is used in experiments on polarised light.

Illuminating Lens.—A large lens, which has for its purpose the concentration of the light from the sun or a lamp at the focus, is sometimes termed an illuminating lens. Condenser is, however, the more general term.

Illumination.—The illumination of a surface varies inversely as the square of its distance from the source of light. The same quantity of light which falls upon a certain area at a distance of one foot from the illuminant will become extended over four times that area if the distance be increased to two feet, nine times at a distance of three feet, 16 times at a distance of four feet, and so on. If, therefore, in contact printing or enlarging, an exposure of one second is required at a distance of one foot from the illuminator, four seconds will be required at two feet, and so on.

Image.—An optical term, denoting the representation of objects formed by concourse of the pencils of rays proceeding from the various points of the object which it represents. In optics, a luminous body is considered to be an assemblage of luminous points, from each of which a pencil of light proceeds, without interfering with each other. When an image is formed in the focus of a lens, and can be received on a screen, as, for example, at the focus of a convex lens it is termed *real* or *positive*. When, however, it is not formed by the actual union of rays in a focus, but only apparently so, and cannot be received on a screen, it is termed a *virtual* image. The following useful remarks regarding this subject are from Sir T. Longmore's optical manual:—"An image is *erect* when the object and image lie on the same side of the centre of the lens; is *inverted* when the object and image lie on opposite sides of the centre. The retinal image of an object situated in front of the eye is an example of a *real* and *inverted* image. The diameters of an object and its image are directly as their distances from the centre of the lens; as they separate from this point, the farther off either is, the greater its proportionate size. (See **Conjugate Foci.**)

When an object is placed between a *convex* lens and its principal focus, an eye on the other side of the lens sees a *virtual* image of the object erect, magnified on the *same side* of the lens as, but at a greater distance from it than, the object.

When an object is placed in front of a *concave* lens, an eye on the other side of the lens sees an image of the object, which is virtually erect, and diminished on the same side of the lens as, and nearer to it than, the object. The image is diminished when the distance between the lens and the object is increased, but when the distance of the object is a large multiple of the focal length of

the lens, further increase of its distance does not appreciably alter the distance of the image, or consequently its size.

The image formed by a lens on the screen of the camera is a *real* image, and its distinctness will depend upon the accuracy with which the rays of each pencil are brought to a focus. When an object is placed at a distance in front of the lens an image is formed on the ground glass screen of the camera smaller than the object itself. But if the object be brought nearer the lens the image will increase in size until it becomes equal to, and afterwards larger than, the original. The focus will, at the same time, recede to a greater distance from the lens. (See also **Optics, Vision, Light,** etc.)

Image, Latent.—See **Latent Image.**

Image, Reversal of.—See **Solarisation.**

Imperial Measure.—See **Weights and Measures.**

Incidence, Angle of (Lat. *in*—in, and *cado*—to fall).—The angle of incidence is the angle which a ray of light falling on a surface forms with the perpendicular to that surface, or to the tangent if curved. The angle formed by the perpendicular and the line of departure is termed the angle of reflection, and is always equal to the angle of incidence.

Incidence, Line of.—The straight line taken by a ray of light moving to strike a plane at an acute or right angle.

Incorrodible Ink.—Under this heading Sutton, in his "Dictionary of Photography," gives the following instructions for making an incorrodible ink for writing the labels on bottles which contain strong acids or alkalies:—Dissolve one part of asphaltum in two parts of oil of turpentine.

Another formula is—Boiled linseed oil, ground with lampblack and Prussian blue—of each quantity sufficient to impart a deep black colour—then with oil of turpentine.

Indian Ink.—A black pigment manufactured in China, and should therefore be called Chinese ink. It is composed of an exceedingly fine lampblack, produced by burning oil of sesame mixed with some vegetable gum, and afterwards dried in the sun until it turns into a cake. It is sold in sticks and cakes. Inferior kinds are manufactured in this country. It is largely employed in colouring.

Indiarubber.—See **Caoutchouc.**

Indiarubber Cement.—A cement for indiarubber may be prepared as follows:—

Carbon bisulphide	5 ounces.
Gutta percha	5 drachms.
Indiarubber	10 ,,
Fish glue	20 ,,

Indiarubber Solution.—A solution made by dissolving indiarubber in benzole, ether, naphtha, chloroform, or any other of its solvents. Used in photographic operations for various purposes.

A solution of rubber is used occasionally for mounting prints, and is especially suitable for gelatino-chloride high-surfaced prints, as this mountant does not affect the gloss. A little of the solution is sometimes run round the plate to prevent frilling. It is also employed as a substratum in the collodion and albumen processes

Indigo (Lat. *indicum*).—A vegetable colouring matter, obtained chiefly from the leaves of the various species of *Indigofera isatis tinctoria*, etc. Its lustre is dark coppery red, semi-metallic when in mass, and deep blue in powder. It is insoluble in water, cold alcohol, and ether, slightly soluble in boiling water, but very soluble in concentrated sulphuric acid.

Infinite Rays.—A term employed in optics to express rays of light proceeding from an object and entering the eye in parallel lines, or, more correctly speaking, in lines which are so nearly parallel to each other that the amount of divergence is inappreciable, and the expression "infinite distance," or *infinity*, is applied to the distance from which the incident rays possessing, collectively, such a parallel direction might have originally started.

Indotint.—A photo-mechanical process invented by Roche, of New York. In this a copper plate roughened by exposure t the sand-blast to cause the sensitive film to adhere firmly is used instead of the glass plate. The rest of the process is similar to the collotype.

Ink.—A liquid or pigment used for writing or printing.

Writing Ink.—Take 4 oz. of well-bruised Aleppo galls in 1 quart of clean soft water, and macerate in a clean corked bottle for a fortnight or so, with frequent agitation. Next add 1¼ oz. of gum arabic and ½ oz. lump sugar dissolved in a wineglassful of water; mix well and add 1½ oz. of sulphate of iron (green copperas) crushed small. Shake the bottle well up for two or three days, and allow it some time to digest. One quart of good writing fluid will be the result. The writing will be pale at first, afterwards turning a deep black.

Copying Ink.—This is manufactured by adding a little saccharine matter to an ordinary black ink. The following proportions are employed:—Sugar candy or lump sugar, 1 oz.; or treacle or moist sugar, 1¼ oz., dissolved in 1½ pints rich black ink.

Coloured Inks can be made from a strong decoction of the ingredients used in dyeing processes, mixed with a small quantity of alum and gum arabic.

Indelible Ink.—Lampblack ground in a lye of caustic soda, combined with a mixture of gelatine and caustic soda, is said to be indelible. Many other inks have been recommended that will resist the action of chemicals. A quarter of an ounce of lampblack (previously heated to dull redness in a covered vessel), triturated with one pint of good black ink, added gradually, will form an ink that will resist chlorine and weak acid and alkaline lyes.

Marking Ink.—Made by dissolving ¼ oz. of silver nitrate in ¾ oz. of water, and adding as much of the strongest liquid ammonia as will dissolve the precipitate formed when it is first added. Next add 1½ drachms of mucilage, and a small quantity of finely-powdered indigo or syrup of buckthorn to colour. The writing will turn black if held to the fire, or if passed over a hot iron.

Printing Ink.—Inks used for printing consist chiefly of well-boiled drying oils mixed with lampblack or other pigments. Soaps and resins are also frequently added to give the required consistency.

Lithographic Ink.—Thirty parts each of dry tallow, soap, mastic (in tears), and common soda (in fine powder), 150 parts of shellac, mixed with 12 parts of lampblack.

Authographic Ink.—Ten ounces each of white soap and white wax, 3 ounces of mutton suet, and 5 ounces each of shellac and mastic. Mix with 3½ ounces of lampblack.

Eikonogen as Ink.—Eikonogen has proved such a successful developing agent that it is usually found in every photographic laboratory. It is not generally known, however, that a very fine writing fluid can also be made with it. To accomplish this, boil a quantity of it in a flask so as to make a saturated solution. When quite cold it is decanted from the crystals, and without requiring any further addition to be made to it, can be used as a writing fluid. It will be found to flow easily from the pen, and has no objectionable tendency to thicken or corrode the steel pen. The solution itself is of a reddish brown colour, but when applied to paper, however, it becomes of a pure, rich black.

Ink for Writing on Photographs.—Make up a solution of

Iodide of potassium	10 parts.
Water	30 ,,
Iodine	1 part.
Gum	1 ,,

An ordinary pen is used, and the writing with this fluid is made on the dark portions of the photograph. The action of the solution is to bleach by converting the silver into silver iodide, and thus it is possible to obtain white letters, which show well on the black or dark ground.

Ink Photo.—A term applied to the products of several photo-mechanical printing processes.

Ink Pictures.—Ink pictures can be made from photographs by a very simple means, and one that is often employed by artists. A print is first made upon plain salted paper, the image being brought out until the most important details appear. These are traced over with a pen and ink, using the photograph as a guide. When dry the print is bleached in a solution of perchloride of mercury. This has the effect of causing the photographic image to entirely disappear, leaving the ink sketch standing alone. It is then fixed.

Ink Process.—A method of obtaining positive prints in ordinary writing ink. A good quality of paper is first immersed in a nearly saturated solution of potassium dichromate, and dried in the dark. When dry, the paper will have a bright yellow colour. It is then placed under the negative in a printing-frame and printed until all the details appear. The picture will appear as a brownish image on a yellow ground. The time required in printing is somewhat less than for albuminised paper.

The prints are first washed in water to eliminate the undecomposed chromium salts. The washing operation must take place in the dark, and requires about two or three hours with running water. The print is now fixed, and should appear as a brown image upon a white ground.

The next process is to colour the image black or purple. This is accomplished by causing writing ink to adhere to the dark portions of the picture, acting as a mordant. To do this the print is immersed in a weak aqueous solution of ferrous sulphate (five grains to the ounce of water), and allowed to remain therein for a few minutes, when it is removed, immersed in a weak solution of hypochloric acid for 15 minutes, and thoroughly washed in several changes of water. It is then immersed in a strong solution of tannin (20 grains to the ounce), when the image will instantly turn black, this change being due to the formation of tannate of iron or writing ink. The light should remain unchanged if the print has been properly exposed.

Insensitiveness.—The insensitiveness of substances which should be sensitive is usually caused by careless manipulation or faulty chemicals, the action of light having little or no effect upon them.

Insolation (Lat. *in*—in, and *sol*—the sun).—Exposure to the heat of the sun.

Instantaneous.—A word much used in photography in connection with exposure, shutter, dry plates, lenses, etc. The term "instantaneous exposure" is usually applied when the duration of the exposure is a fractional part of a second. An instantaneous shutter is one that will allow of such exposures being made, and instantaneous dry plates are those coated with a very highly-sensitive emulsion that will become sufficiently impressed by the rapid exposure of the image upon it. An instantaneous lens is one that admits a large amount of actinic light. For instantaneous work the rapid rectilinear is the most suitable, because it works with a large aperture, which is the essential point in a rapid lens. So-called instantaneous portrait lenses are now manufactured, by means of which portraits of restless children can be taken in the studio in a fraction of a second. This lens, of course, gives sharp definition with a wide aperture. The purity of the lens will also affect its rapidity; with some the glass absorbs the chemically-active rays, and makes it useless for instantaneous photography.

Instantaneous Photography.—In the very earliest days of photography this term was applied to what would now be considered very slow work indeed. We now usually apply this term when the exposure does not exceed one second. In some cases this only amounts to the $\frac{1}{1000}$ part of a second. This exceedingly brief exposure is usually given to the plate by means of a suitably constructed shutter. Under **Shutter** the arrangements for giving instantaneous exposures will be found, also the method employed of calculating the duration of time in fractions of a second.

The immense strides that have recently been made in instantaneous photography, owing chiefly to the advent of the dry-plate process, have caused photography to become useful to almost every branch of science.

To Muybridge and Anschütz we are greatly indebted for the strides made in instantaneous photography. These gentlemen have succeeded in photographing moving objects hitherto considered impossible to be photographed. Galloping horses, swift flying birds, and even bullets and cannon-balls projected from guns have been successfully photographed, showing even the little head of air driven along in front of the bullet.

Both Muybridge and Anschütz have also succeeded in making series of 24 or more photographs of a horse during the time it makes a single leap, and thus illustrate its every movement. The value of these and other possibilities with the camera for artists cannot be over-estimated. Its aid to meterologists in photographing the lightning, to astronomers in stellar, lunar and solar photography, and to all other sciences would require a work as large as this to describe.

For the making of instantaneous pictures a large number of suitable cameras have been devised. In most of these the lens is a very rapid one, and in some cases so arranged that all objects beyond a certain distance are in focus (for latter see **Focus**). With an instantaneous camera a secondary image is necessary, so that the right second can be judged for making the exposure. This is usually produced by a finder. In making instantaneous exposures the following tables may be useful :—

	Approximate distance per second.
A man walking 3 miles per hour moves	4½ feet per second.
A man walking 4 miles per hour moves	6 ,, ,,
A vessel travelling at 9 knots per hour moves ..	15 ,, ,,
A vessel travelling at 12 knots per hour moves ..	19 ,, ,,
A vessel travelling at 17 knots per hour moves ..	28 ,, ,,
A torpedo boat travelling at 20 knots per hour moves	35 ,, ,,
A trotting horse	39 ,, ,,
A galloping horse (1,000 yards per minute) ..	50 ,, ,,
An express train travelling at 38 miles an hour ..	59 ,, ,,
Flight of a pigeon or falcon	61 ,, ,,
Waves during a storm	65 ,, ,,
Express train (60 miles an hour)	88 ,, ,,
Flight of the swiftest birds	264 ,, ,,
A cannon-ball	1625 ,, ,,

An object moving—

1	mile	per	hour	moves	..	..	1½	feet per second.
2	,,	,,		..	..	..	3	,, ,,
5	,,	,,		..	..	..	7½	,, ,,
6	,,	,,		..	..	..	9	,, ,,
7	,,	,,		..	..	..	10½	,, ,,
8	,,	,,		..	..	..	12	,, ,,
9	,,	,,		..	..	..	13	,, ,,
10	,,	,,		..	..	.	14½	,, ,,
11	,,	,,		..	..	..	16	,, ,,
12	,,	,,		..	..	..	17½	,, ,,
15	,,	,,		..	..	..	22	,, ,,
20	,,	,,		..	..	..	29	,, ,,
25	,,	,,		..	..	..	37	,, ,,
30	,,	,,		..	..	..	44	,, ,,
35	,,	,,		..	..	..	51	,, ,,
40	,,	,,		..	..	..	59	,, ,,
45	,,	,,		..	..	..	66	,, ,,
50	,,	,,		..	..	..	73	,, ,,
55	,,	,,		..	..	..	80	,, ,,
60	,,	,,		..	..	..	88	,, ,,
75	,,	,,		..	..	..	110	,, ,,
100	,,	,,		..	..	..	147	,, ,,
125	,,	,,		..	..	..	183	,, ,,
150	,,	,,		..	..	..	220	,, ,,
200	,,	,,		..	..	..	257	,, ,,

With these tables it will be very easy to find the distance that the image of the object will move on the ground glass screen of the camera. To do this, multiply the focus of the lens in inches by the distance moved by the object in the second, and divide the result by the distance of the object in inches.

Example, find the movement of the image of an object moving 50 miles per hour at a distance of 100 yards with a lens of 9in. focus.

$$9 \times 876 = 7{,}884 \div 3{,}600 = 2\tfrac{1}{8} \text{ per second.}$$

We must also find out the speed of the shutter required to take the object in motion, so that it will appear as sharply defined as possible under the circumstances. To do this the circle of compass must not exceed $\frac{1}{100}$th of an inch in diameter. We therefore divide the distance of the object by the focus of lens multiplied by 100, and then divide the rapidity of the object in inches per second by the result obtained. This will give the longest exposure permissible in the fraction of a second. For example, we require to know the speed of a shutter required to photograph an express train travelling at the rate of 50 miles per hour at a distance of 50 yards with an 8½in. focus lens.

The train moves 876 inches per second.

1,800 distance in inches $\div (8\tfrac{1}{2} \times 100) = 1{,}800 \div \quad = \frac{36}{17}$.

$$876 \text{ speed of object per second} \div \tfrac{36}{17} = \frac{876 \times 17}{36} = 413 = \tfrac{1}{413}$$

second.

Given the rapidity of the shutter, and the speed of the moving object, we require to find the distance from the object the camera

should be placed to give a circle of compass less than $\frac{1}{100}$th of an inch. Multiply 100 times the focus of the lens by the space through which the object would pass during the exposure, and the result obtained will be the nearest possible distance between the object and the camera. For example, we have a shutter working at $\frac{1}{50}$th of a second, and the object to be photographed moves at the rate of 50 miles per hour. How near can a camera fitted with a lens of $8\frac{1}{2}$in. focus be placed to the moving object?

Object moving 50 miles per hour moves per second 876 inches and in the $\frac{1}{50}$th part of a second it moves 17·52 inches, so that—

$8\frac{1}{2} \times 100 \times 17{\cdot}52 = 8{\cdot}5 \times 100 \times 17{\cdot}52 = 14{,}892$ inches $= 413$ yards.

Instantaneous photography can only be successfully performed in very bright and actinic light, and should never be attempted on dull days, as under-exposure will be the inevitable result. In developing it is necessary to employ a strong developer to bring up the detail. Some operators make use of an accelerator for this purpose, but it is not to be recommended; the simplest is a few drops of hyposulphite solution added to about 10 ounces of water. In this the plate is bathed for a few seconds previous to development. (See **Alcohol.**)

Intensification.—Any method of increasing the opacity of a negative. It frequently happens that either from under-exposure, insufficient development, or other cause, the negative does not possess sufficient density to yield satisfactory prints. It will then be necessary to "intensify" it, or increase the opacity by "intensification" with an "intensifier."

There are two chief methods of intensification very distinct from each other in the actions of the chemicals used. The first is a method of increasing the density by thickening the deposit of metallic silver, and the second is by substituting another metal for the silver, having a more opaque colour, causing the negative to become less transparent. There are also other methods of intensifying, by which the deposit is not only increased, but a change in colour also takes place. It will be as well to state that it is useless endeavouring to improve the printing qualities of a much over-exposed or fogged negative by intensification, because nothing will be gained, and the lack of contrast will become more apparent.

Possibly, the simplest method of intensifying a weak negative is to flood the plate with a ferrous sulphate or pyrogallic developing solution, to which has been added a little silver nitrate. The chief drawback to this kind of intensifier is, however, that the gelatine film is not easily rid of hyposulphite of soda or silver, and unless this is entirely eliminated decomposition and fog will result. Abney recommends for this purpose, the application of a solution of peroxide of hydrogen in water (1 drachm of a 20-volume solution in 5 ounces of water.) In this the negative is soaked for

half an hour, and then washed, after which intensification can be proceeeded with. Make up a solution of—

Pyrogallic acid	2 grains.
Citric acid	2 to 4 ,,
Water	1 ounce.

or

Ferrous sulphate	5 grains.
Citric acid	10 ,,
Water	1 ounce.

and add a few drops of a two per cent. solution of silver nitrate before applying to the negative.

A method of intensifying that has found considerable favour with practical workers is the following: The plate is first of all thoroughly freed from the hypo, and immersed in a ten per cent solution of perchloride of mercury until the image becomes bleached and appears quite white on both sides of the film. It is then thoroughly washed. A solution of silver nitrate (100 grains in 10 ounces of water) is then taken, and sufficient potassium cyanide in solution added, to nearly dissolve the precipitate first formed on making the addition. In this solution the bleached negative is laid, when it will at once commence to darken and when the required density is obtained. It will be necessary to bear in mind that the negative, while wet, will appear slightly denser than when dry. Also the plate should not be allowed to remain too long in the silver cyanide solution or reduction will take place. The chemical actions that take place with this method are briefly these. The mercuric chloride becomes reduced when it comes into contact with the silver image, and forms calomel and silver chloride, thus—

$$2\,HgCl_2 + 2Ag = Hg_2Cl_2 + 2AgCl.$$

The potassium cyanide and silver can be taken as a solution of silver cyanide, reduced by the mercurous chloride to a dense black deposit of metallic silver.

There are a number of other methods of intensifing the image, by first bleaching it with mercury and afterwards darkening it with other chemical agents.

The negative is laid in the bleaching solution composed of—

Mercury perchloride	100 grains.
Potassium bromide	100 ,,
Distilled water	10 ounces.

until the silver image is whitened. To do this properly it is absolutely necessary that the negative be free from hyposulphite or silver, otherwise stains will be the inevitable results.

When the negative is perfectly white when viewed both from the front and back of the film, the plate is removed and thoroughly washed. We have now to change the colour of the image to a more opaque one. This can be done in several ways. If the plate

be immersed in a weak solution of ammonia, the chloride of silver will become dissolved away, and the mercurous chloride is changed into mercurous ammonium chloride (a dark coloured substance) and ammonium chloride, thus

$$Hg_2Cl_2 + 2NH_3 = NH_2Hg_2Cl + NH_4Cl.$$

If ammonium sulphide be used instead of ammonia the mercurous chloride will be split up into mercuric sulphide and finely divided mercury, and the silver chloride will become converted into a form of silver sulphide. By this means we get a very dense negative, the process being more suitable for intensifying photographs of line drawings for photo-mechanical printing.

If the plate, after being bleached and washed, be treated to a solution of sodium sulphite, the silver chloride will become dissolved away, and the white mercurous chloride will become reduced to black metallic mercury, thus :—

$$2HgCl + Na_2SO_3 + H_2O = Hg + Na_2SO_4 + 2HCl.$$

A darkening action will commence at once, and when sufficient density is obtained, the plate is removed and thoroughly washed. This is probably the most convenient and easiest method of intensifying, as the washing of the plate after treating with the mercury need not be prolonged. The sodium sulphite solution should be of about ten per cent. strength, and slightly acidulated with a little citric acid.

Another method of darkening the bleached image is with ferrous oxalate. With this the mercurous chloride is reduced to metal, as with sodium sulphite, but the s lver chloride also becomes reduced. By this method greater opacity is obtained than with the previous one. To prepare the ferrous oxalate solution pour one ounce of a saturated solution of ferrous sulphate into a vessel containing five or six ounces of a saturated solution of potassium oxalate, acidified with a little oxalic acid. Next add three or four ounces of water, and the solution is complete.

Instead of ferrous oxalate, an old hydroquinone can be used with very successful results.

The following method of intensifying has also been recommended, one of its advantages over other methods being that it is not necessary to be so particular with regard to the perfect elimination of the hyposulphite.

Bichloride of mercury	60 grains.
Water	8 ounces.

To this is added a sufficient quantity of potassium iodide to nearly dissolve the red precipitate first formed. About 150 grains will be required. Next add 120 grains of sodium hyposulphite in crystals.

In this solution the plate is immersed until sufficient density is obtained. It is then placed for from ten to fifteen seconds in the

weak fixing bath. Well wash and dry. The resulting image will consist of a double iodide of silver mercury of a reddish brown colour, with good printing qualities.

The following intensifier was recommended by Farmer:—

SOLUTION 1.

Silver nitrate	480 grains.
Distilled water	12 ounces

SOLUTION 2.

Potassium bromide	360 grains.
Distilled water	2 ounces.

No. 2 is added to No. 1, and the precipitate formed is collected, thoroughly washed, and added to—

Sodium hyposulphite	960 grains.
Distilled water	6 ounces.

The mixture is thoroughly well stirred and then allowed to stand a few hours, when it should be filtered, and distilled water added to it to make up to 16 ounces.

To intensify, the plate is immersed in this solution for about five minutes. It is then drained and a ferrous oxalate developer applied. It is then washed and dried. Instead of the ferrous oxalate developer the following may be used—

Pyrogallol	4 grains.
Distilled water	2 ounces.
Silver solution	60 minims.

with about 30 minims of a 10 per cent. solution of liquid ammonia ·880 added immediately before using.

Uranium Intensifier.—Eder recommends the following method of intensifying with uranium. A solution is made up after the following formula :—

Uranium nitrate	15 grains
Potassium ferricyanide	15 ,,
Water	4 ounces

In this the plate is immersed when the details in the shadows are first attacked, then the half-tones, and finally the high lights.

Another method is to first soak the plate in a solution of uranium nitrate (60 grains in 10 ounces of water), and then immerse it in a solution of potassium ferricyanide. The ferricyanide becomes converted into ferrocyanide, and the resulting image is formed of a compound of ferrocyanide of silver and uranium. With this process of intensification it will be necessary to entirely eliminate the hypo, otherwise a reduction of the uranic salt will take place, producing a chocolate-coloured stain. This stain can be removed by immersing in a solution of soda or ammonia, but the density which has been given to the negative will disappear.

Intensification can be effected in many ways by substituting some other metal for the silver forming the image. For example, if the plate be treated with platinic chloride, or gold chloride solution, the image would be formed in platinum or in gold, thus—

$$4Ag + PtCl = Pt + 4AgCl$$
$$3Ag + AuCl_4 = Au + 3AgCl$$

In the latter, however, the image would be reduced in density, as one atom of gold takes the place of three of silver.

Lead Intensifier.—Eder and Toth's ferrocyanide of lead intensifier is based upon the following chemical changes—

$$2K_6Fe_2Cy_{12} + 4Ag + 6Pb_2(NO_3)_2 = Ag_4FeCy_6 + 3Pb_2FeCy_6 + 12KNO_3,$$

or, in simple terms, potassium ferridcyanide, silver, and lead nitrate form silver ferrocyanide, lead ferrocyanide, and potassium nitrate. This intensifier is but little used on account of its extreme liability to cause fog.

Potassium Permanganate Intensification.—This method of intensifying is an extremely old one, and was used in the wet collodion process. The theory is in all probability the following :—

$$K_2Mn_2O_8 + 4Ag_2 = 4Ag_2O + K_2O + Mn_2O_3,$$

or the silver of the image is attacked by the permanganate, and forms silver oxide, potassium oxide, and manganic oxide. The manganic oxide, being an insoluble compound, is precipitated on the silver, which, however, has been converted into oxide. This is more transparent than metallic silver, and in consequence requires to be reduced to silver by the application of a ferrous oxalate developer. The process is as follows :—One drachm of a ten per cent. solution of potassium permanganate is diluted with two ounces of water, and the plate immersed in this solution for about fifteen minutes. Four drachms of a saturated solution of potassium oxalate and one drachm of a saturated solution of ferrous sulphate are then mixed and added. Instantly intensification proceeds rapidly. When the required density is obtained the plate is thoroughly washed.

We have now considered the various means by which the opacity of the negative can be increased, and the theories of the different chemical actions that take place. To make this article, however, of more practical value it would be well to consider which is the best method, as the reader is very liable to become confused with so many. It is possible to formulate a system of intensification by which any degree of density can be obtained. With nearly all these intensifiers the negative must be thoroughly freed from the fixing soda. If a varnish negative is required to be intensified it will be necessary to first remove the varnish by soaking the plate in methylated spirit, and then gently rubbing it with a tuft of cotton-wool. If the negative has been allowed to become dry it will be advisable before applying the intensifier to soak the plate in a dish of distilled water.

We have, then, to consider the amount of additional density we require. By bleaching the plate with mercuric chloride, and after-

wards with sodium sulphite, we obtain but a slight addition to the density. In many cases, therefore, when but little increase of opacity is required, this method of intensification is the one most to be recommended.

To obtain a full degree of density the method of ~~heating~~ bleaching the plate with mercuric chloride, and afterwards thoroughly washing and applying a ferrous oxalate solution, should be followed. By repeating the application of mercuric chloride and ferrous oxalate we obtain a still fuller degree of density. This experiment can be made any number of times, when a satisfactory amount of opacity is obtained.

When a very great degree of intensity is required, the mercury and ammonia, uranium and lead intensifiers can be used.

Collodion negatives are usually intensified with—

Pyrogallic acid	2 grains.
Citric acid	2 to 4 ,,
Water	1 ounce.

or

Ferrous sulphate	5 grains.
Citric acid	10 ,,
Water	1 ounce.

A few drops of a two per cent. solution of silver nitrate is added, and the mixture flooded over the plate either before or after fixing.

Intensifiers.—Those agents which are employed to increase the opacity of the developed image to the chemically active rays, either by increasing the thickness of the deposit of metallic silver or by changing its colour to one less transparent. (See **Intensification.**)

Interiors.—In photographing interiors, especially darkly lighted ones, the operator is confronted by several difficulties. First the want of actinism in the light itself, and further the excessive contrasts, the dark portions requiring such a long exposure that the high-lights become solarised, and the effect of halation is also produced. For churches or similar dark interiors, a dull day, or when the clouds obscure the sun, is a preferable time to make the exposure. In photographing private rooms, etc., blinds can be hung over the windows to subdue the light. To avoid halation it is a usual practice to back the plate with some black substance. (See **Backing.**) Thickly-coated plates should also be used.

With regard to the lens to be employed, the rectilinear doublet is the one usually preferred, although in confined situations a wide-angle lens will be necessary. It is usually necessary to have the picture as sharp as possible, therefore a very small stop will be used. To avoid distortion the swing-back must be perfectly vertical. No rule can be given for the exposure. It varies from ten minutes to three or four hours with an f/32 stop. A good plan

to adopt is to expose for the shadows and let the high-lights take care of themselves. To make a *picture* it will be necessary to study the lighting effect, and hit upon the right time, as the interiors of buildings often present totally different and opposite appearances under different conditions of lighting. In developing interior negatives it will be necessary to force the detail out as much as possible.

Invisible Image.—See **Latent Image.**

Invisible Rays.—Those rays beyond the extreme violet and the extreme red of the spectrum. The former, although invisible, will darken sensitised paper. They are the most refrangible, and can be rendered visible by being passed into a solution of sulphate of quinine. Their undulations are the shortest. The invisbile rays beyond the red end of the spectrum are for a certain distance calorific. They are the least refrangible, and have the longest undulations.

Iodic Acid (Formula, HIO_3).—Prepared by boiling iodine with nitric acid. Crystallised iodic acid forms white hexagonal tables, having the composition HIO_3 Ag. This acid is more stable than chloric and bromic acids, its solution reddens litmus paper, and afterwards bleaches it by oxidation.

Iodides.—Combinations of iodine with a metal or with acid organic radicals. The metallic iodides are the ones principally used in photography.

Iodide of Ammonium.—See **Ammonium Iodide.**

Iodide of Cadmium.—See **Cadmium Iodide.**

Iodide of Potassium.—See **Potassium Iodide.**

Iodide of Silver.—See **Silver Iodide.**

Iodide of Zinc.—See **Zinc Iodide.**

Iodizer.—Iodides of metals and alkalies are added to the collodion, and termed iodisers; when bromides are added they are termed bromisers. The iodides and bromides of zinc, potassium, ammonium, and cadmium are used, but chiefly the two last. The following table may be useful in showing the amounts of iodine in the iodides of the metals :—

In 10 grains of potassium iodide there are	..	7·6455 grains of iodine.
In 10 grains of cadmium iodide there are	..	6 9398 ,, ,,
In 10 grains of ammonium iodide there are	..	8·7586 ,, ,,
In 10 grains of magnesium iodide there are	..	9 1366 ,, ,,
In 10 grains of zinc iodide there are ..	..	7·9608 ,, ,,

Iridescence (Gr. *iridos*—a rainbow).—A term usually applied to the phenomena of interference colours as seen in thin films in a

soap bubble, mother of pearl, etc. Iridescent colours sometimes make their appearance on the negative, also in a lens. Their appearance in the latter is due to a defect in the cementing together of the combinations. The lenses should be separated and re-cemented with Canada balsam.

Iridium (Gr. *iridos*—a rainbow).—A very rare metallic element, usually found with platinum. The compounds of iridium and chlorine assume many colours, hence the name.

Iris Diaphragm.—See **Diaphragm.**

Iron (Symbol, Fe; atomic weight, 56).—A well-known metallic element. It occurs abundantly in nature as magnetic iron ore, or ferrous ferrate (Fe_3O_4); ferric oxide as specular iron ore, or red hematite; but it more often occurs as different varieties of ferrous carbonate $FeCO_3$. Iron is a soft, tenacious, tough, malleable, ductile, silver white metal with a texture resembling vegetable fibre. Pure iron has a specific gravity of 7·8. It is not affected by dry air, but moist air containing carbonic acid quickly rusts it, forming a hydrate of the sesquioxide.

Iron is soluble in dilute hydrochloric acid and in sulphuric acid, forming ferrous sulphate.

It is used in photography for making ferrotype plates, which are merely thin sheets of the best Russian iron coated over with a thick black or chocolate colour varnish. In this case the iron only acts as a support, no chemical action taking place whatever.

Iron, Ammonio-citrate of.—Prepared by dissolving ferric oxide in citric acid and adding liq. ammonia ·880 until the solution becomes neutral. It is sold in small transparent scales of a dirty reddish brown colour, and having a peculiar odour. One part is soluble in 0·5 parts of water, but nearly insoluble in alcohol. Paper prepared with it bleaches in the light, but darkens again in the dark. It is used in the ferro-prussiate process.

Iron, Ammonio-sulphate of (Formula, $Fe(NH_4)_2SO_4\,6H_2O$ = 328).—A double salt of iron and ammonium prepared by dissolving 139 parts of proto-sulphate of iron and 75 parts of ammonium sulphate together in a minimum of water, and afterwards placed in a basin to remain till the double salt crystallises. It is soluble in five times its weight of water. It has been recommended as a substitute for ferrous sulphate on account of its greater stability. There is, however, but little advantage to be gained, and its action is much feebler.

Iron Chlorides.—See **Ferrous Chloride** and **Ferric Chloride.**

Iron Iodide (Formula, FeI_2; molecular weight, 310). Formed by digesting iron filings or wire in water with pulverised iodine

with an excess of metal. A greenish solution is formed, and on evaporation crystals may be obtained soluble in alcohol.

Iodide of iron is rarely, if ever, used as an iodiser in collodion, as proto-nitrate of iron will be formed in the silver bath and in the film. This acts as a developer, and rapidly blackens the bath. It also develops the image, so long as the plates are kept moist.

Iron Oxalate.—See **Ferrous Oxalate.**

Iron Perchloride.—See **Ferric Chloride.**

Iron Protoacetate (Formula, $FeO, C_4H_3O_3$).—Made by mixing two solutions containing equal equivalents of ferrous sulphate and lead acetate, and filtering out the sulphate of lead precipitate. This substance was sometimes used as a developer in the collodion process.

Iron Sesquioxalate.—See **Ferric Oxalate.**

Iron Sulphates.—See **Ferrous Sulphate** and **Ferric Sulphate.**

Irradiation (Lat. *irradio*—to irradiate).—The act of irradiating or emitting beams of light. This term is also applied to the phenomenon more commonly known as halation. (*q.v.*)

Isinglass.—The purest variety of gelatine, obtained from the swimming bladders of various fish, but principally of the sturgeon. The best kind of isinglass, known as "leaf," comes from Astrakan, other inferior varieties being imported from Brazil and Hudson's Bay. It is prepared by first steeping the bladders in water, and then treating with various substances to remove grease and other foreign matter. It is then carefully washed and dried.

Isinglass is used in many cases instead of ordinary gelatine; some collotype printers prefer it. It is also used instead of gelatine in the printing of lantern slides by the Woodbury process. It is, however, considerably more expensive than ordinary gelatine, and therefore cannot be recommended in place of that substance except in cases where great advantage or superiority is derived from its use.

Isochromatic.—See **Orthochromatic.**

Isochromatic Process.—See **Orthochromatic Process.**

Isomerism (Gr. *isomeris*—having an equal share).—A term applied in chemistry to those bodies which are composed of the same elements in the same proportions, but differ either in their

physical characteristics or chemical properties. Such bodies are said to be isomeric, metameric, or polymeric, also termed isomerides, metamerides, and polymerides.

Isomeric Bodies are those which show similar decompositions and changes when heated, or if treated with reagents, but differ in physical properties.

Metameric Bodies are those which exhibit dissimilar transformations when heated or when acted upon by reagents.

Polymeric Bodies are those which contain the same elements in the same proportion, but have different molecular weights.

Isomorphism (Gr. *iso*—equal, and *morpha*—form).—A term applied in chemistry to bodies which have the same crystalline form, but may be analagous or different in chemical constitution. Isomorphous bodies are generally arranged according to the crystallograph system. Bodies which crystallise in two different forms are termed *dimorphous*.

Ivorine.—Imitation ivory, a compound of caoutchouc, sulphur, and some white ingredients, such as gypsum, sulphate of baryta, oxide of zinc or pipe clay.

A good formula for making artificial ivory is as follows:—

White shellac	10 ounces.
Acetate of lead	4½ „
Ivory dust	8 „
Camphor	5 „

These ingredients are reduced to a powder, heated and mixed, then pressed in heated moulds, or made into sheets.

Pinson's process of manufacturing artificial ivory is one much used on the Continent. Sheets of gelatine are immersed in alumina, dissolved in acetic acid. The two combine, and when the gelatine has absorbed sufficient of the alumina, the sheets are hung up to dry, and when dry, are polished.

Ivory.—Specifically, the material constituting the tusk of the elephant, but the term also includes the tusks and teeth of the hippopotamus, walrus, narwhal, wild boar, and other animals.

The African ivory is preferred to any other.

Ivory can be made flexible by steeping in a solution of pure phosphoric acid, specific gravity 1·130, and leaving them in this solution until they lose their opacity. It is then washed and partially dried. It will become hard again, however, when perfectly dry, but may be softened by placing in hot water.

Photographic positives made upon ivory or upon ivorine have a very delicate appearance. These are best made by coating the ivory with a gelatine or collodion chloride of silver printing-out emulsion, and printing, toning, and fixing in the ordinary way.

In the earlier days collodion positives were made upon ivory, dyed black by boiling first in a decoction of logwood, and then in

a solution of red acetate of iron ; or violet, by first boiling it for a little while with proto-chloride of tin, and then in logwood.

Ivory Black.—A species of bone black made by the calcination of ivory scrap turnings, sawdust, &c. It is used as a pigment in the manufacture of paints, varnishes, &c.

Ivory Paper.—A superior paper, having a finely-prepared and polished surface.

Ivorytype.—An American term for a kind of picture, in which two finished photographs are taken, one light in colour, made translucent by varnish tinted on the back, and placed over the stronger picture so as to give the effect of a photograph in natural colours. Also known as *Hellenotype*.

Japan.—Black japan is made with

Boiled linseed oil	1 gallon.
Burnt umber	8 ounces.
Asphaltum	3 ,,

Boiled together, and sufficient oil of turpentine to obtain the right consistence. This is very suitable for japanning bath or other articles.

Japan Varnish.—A hard black varnish obtained from the *Stagmaria verniciflua* of the East Indies. An asphaltum varnish. (See **Varnish.**)

Javelle Water.—See **Eau de Javelle.**

Jena Glass.—A new optical glass manufactured at Jena. According to Mr. Conrad Beck, the advantages of the new glass largely depend upon the fact, whereas previously we had some dozen or so different kinds of glass, all more or less similar in their refractory qualities, we have now offered to us by the Jena glass factory some ninety kinds of glass, all possessing different refractory powers, and some of which have entirely new qualities.

Kallitype Process.—A printing process giving a dull matt-surfaced picture, similar to platinotype or bromide paper. The formula for the manufacture of the paper is not published. The paper is, however, sold commercially.

The paper is much more sensitive than ordinary albuminised paper ; it will, therefore, be necessary to see that all operations with it, such as cutting-up, placing in the printing frames, developing, etc., are all conducted either in yellow or in very weak daylight. It should be kept guarded from light and moisture.

Printing.—Kallitype may be said to be a combination of a printng-out and a developed process, as the image prints out visibly, but is not sufficiently brilliant until treated with a developing agent, which has the effect of bringing up the image bright and clear, provided the exposure has been correctly given. When placing in the printing frame it is necessary to see that the paper is quite dry, otherwise the correct exposure cannot so easily be determined, and the print will also lack brilliancy in colour. When the air is very moist it will be advisable to dry it carefully. It must not, however, be made too warm, or it will produce fog. In a good actinic light, with a correctly exposed and developed negative, about five to ten minutes will be found necessary, in sunlight only about two or three minutes. The image can be examined, but is rather faint. As soon as the detail in the densest part of the negative appears it has been sufficiently exposed, and may be removed.

Developing.—The prints (which must be quite dry) are floated face downwards upon the following solution :—

Nitrate of silver	50 grains.
Sodium citrate	1 ounce.
Potassium dichromate	1 grain.
Tap or rain water	10 ounces.
Ammonia ·880	½ drachm.

This is made up by dissolving the silver nitrate in about an ounce of the water, and the sodium citrate and potassium dichromate in the remainder, and the two solutions thus formed are mixed together. The ammonia is then added, and the whole filtered.

Upon this solution the prints are floated for from ten to twenty seconds, after which they are placed face upwards upon a piece of clean glass for two or three minutes, in order to gain density. They are then immersed in washing solution No. 1, composed of

Kallitype developer (as above)	½ ounce.
Sodium citrate	2 „
Rain or tap water	20 „

This solution can be used over and over again. In it the prints must remain for at least twenty minutes, a longer time will not hurt them. The object of this solution is to remove the yellow colour from them.

The developed prints are next washed in a solution made up with

Sodium citrate	1 drachm.
Ammonia ·880	2 „
Tap or rain water	1 quart.

for about ten minutes. The solution is then poured off, and the prints treated with a fresh supply. This solution, after the prints have been in it for about ten minutes, should not show any signs of yellowness. If so, a fresh supply should be taken, other-

wise the prints will be yellow. The print should be kept moving in the different baths, and after the last they are removed, washed for a little time in water, and dried.

The correct exposure of the print can be seen in developing. When it has been insufficient the action of the developer will be very slow. If over-exposed the prints will appear mealy, and when much overdone they will develop very heavy and muddy.

The developing solution can be used over and over again, until it loses its power and the prints lack brilliancy. It can then be restored by adding, to every 10 ounces of it, 20 grains of silver nitrate dissolved in as little water as possible.

The following should be noted. Prints, when not developed the same day as printed, must be kept quite dry or they will suffer. The washing solution used at the end should always have a distinct smell of ammonia. In printing from weak negatives additional contrast may be secured by adding a little more of the potassium dichromate to the developer. A stock solution, made up of 8 grains to the ounce of water, should always be kept in hand, so that a little may be added when required. One drop of this added to 10 ounces of developer will give greater brilliancy and contrast.

Knife, Cutting.—The most convenient shape for a knife for cutting or trimming paper prints is shown in fig. 112.

FIG. 11

Kaolin (synonym, China clay).—A celebrated porcelain clay of China. It is very pure and white, and is furnished by the decomposition of a granitic rock, the constituents of which are quartz, felspar, and mica. The felspar gradually disintegrates into this substance. It is used in photography for cleaning and removing grease from glass, and in the collodion process for decolorising discoloured nitrate baths and other solutions. A small quantity is added to the solution, and shaken well up. It is then allowed to settle, and the clear liquid decanted. For this purpose the kaolin must be quite free from iron. If its presence is suspected, test by boiling a small quantity with hydrochloric acid, neutralise the acid liquid with ammonia, and add potassium ferrocyanide. If iron be present, a blue precipitate will form. Chalk and whiting adulterations can be detected by effervescence when treated with hydrochloric acid.

Lacquer.—A varnish chiefly composed of an alcoholic solution of shellac, coloured with gamboge, dragon's blood, etc. The formula is—

Seed lac..	120 parts.
Gamboge	120 „
Dragon's blood	120 „
Saffron	39 „
Rectified alcohol	1000 „

Digested in a convenient vessel, with heat, and strained through fine muslin.

Lamp.—The various lamps used in photography are dark-room lamps, portable non-actinic lamps for travelling and exposure lamps.

The chief points to be observed in a dark-room lamp are that it shall give a non-actinic light, and not allow any stray light through any of its joints or parts. Its colour depends upon the stained glass through which the light is transmitted. The best lamps are

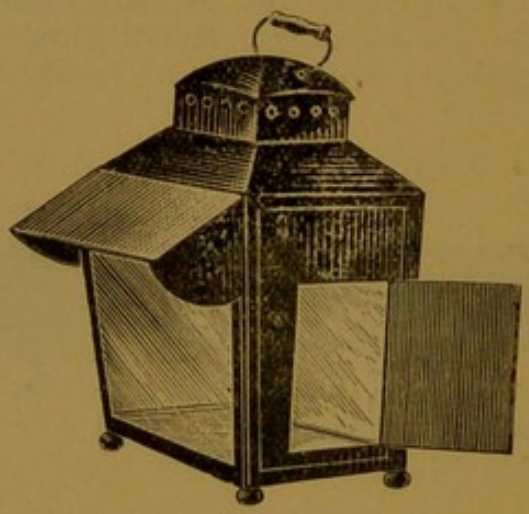

Fig. 113.

those in which the glass can be changed, or another piece inserted so as to allow the operator to work conveniently, and with safety, with very sensitive dry plates, or with much less sensitive bromide or chloride paper. Other desiderata are in simplicity of construction, and in its cleanliness and ease of management. Fig. 113 is a sketch of a lamp devised by Carbutt, of Chicago, and possesses many conveniences, such as a shade to protect the eyes, and a side-door for exposing or viewing the negative.

With regard to the best non-actinic media that should be used for dark-room lamps, it depends, naturally, upon the sensitive materials that one is working with. The property of light to affect sensitive compounds will be found under the article relating to light. (See also **Spectrum.**)

With regard to the second class of lamps, *i.e.*, those useful for tourists, it needs only to be said that the chief desideratum is in portability and bulk. A very large quantity have been constructed which answer the purpose well, and when not required for use fold up into a very small space. Fig. 114 is a very convenient form of

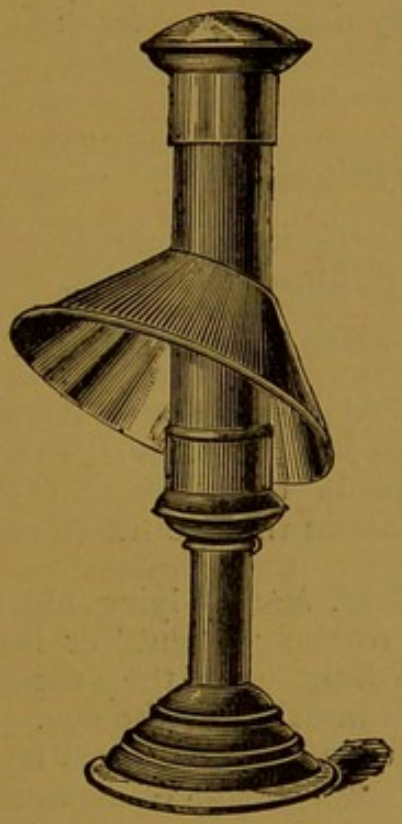

FIG. 114.

lamp. The lower part is a spring candlestick, which keeps a carriage lamp candle flame always at the same level. Above this is a cylindrical chimney of ruby glass with a conical reflector hanging upon its exterior, which serves to shade the light from the eyes and throw it down upon the work. Very fine portable electric dark-room lamps are now manufactured, and are to be recommended in hot weather, when the air in the dark-room usually gets very hot and close.

The third class of lamps, *i.e.*, those used for exposing in making or exposing negatives, are principally the electric lamp, magnesium lamp, and flash lamp. (See **Electric Light**, **Flash Light**, and **Magnesium Light**.)

Lampblack.—A fine carbon, formed by the condensation of the smoke of burning oil, pitch, or resinous substances, in a chimney terminating in a cone of cloth.

A conical funnel of tin, covered over with cloth, and fitted with a pipe to convey the fumes from the apartment, is suspended over

a lamp fed with oil, tallow, coal tar, or crude naphtha, the wick being large and turned up high so as to give a smoky flame. The soot collects in the funnel, and is removed from time to time.

Lampblack is the basis of Indian ink, printers' ink, and most black colours.

It is principally used in photography for colouring gelatine for the carbon or Woodburytype process. This colour being permanent, the prints by these processes are also unchangeable.

Landscape Lens.—See **Lens.**

Lantern.—See **Optical Lantern.**

Lantern Plates.—Usually chloride of silver emulsion plates used for making lantern transparencies.

Lantern Slides.—See **Transparency.**

Lanternoscope.—An instrument devised by Tylar, of Birmingham, for viewing lantern slides. The lantern slide is inserted through an aperture in the side, and is examined through a small magnifying glass in the eye tube in front.

Latent Image (Lat. *latens*—lying hid or concealed, invisible). —The name given to the "latent" or invisible image, resulting from the impact of light upon the sensitive photographic plate. This image, although invisible to the eye, quickly becomes perceptible when treated with a reducing agent termed a developer.

The theory of the latent image is surrounded in mystery. Many attempts to solve it have been made by a number of eminent chemists and scientists. The results of numerous experiments regarding the action of the light upon silver compounds show in a fairly clear manner that when in a vacuum pure silver haloids do not become decomposed by light at all, but if moisture be present a change takes place with the silver bromide or chloride, and a dark-coloured compound containing a lower percentage of the halogen than contained in the original salt, a substance also being formed having the power of liberating iodine from potassium. The dark solid product has never been clearly explained. It is generally considered to be a sub-bromide or sub-chloride, but many scientists dispute this.

One of the first theories of the latent image was that the colour of the light upon the sensitive salts was to set up a vibratory motion. Although this theory is still considered the correct one by a few, the experiments of Abney, Bothamley, Meldola, Carey Lea, and others clearly proves it to be erroneous.

Chemically the action of the light is expressed thus—

Silver bromide. Silver sub-bromide. Bromine.

$$2AgBr + \text{light} = Ag_2Br + Br.$$

The following remarks are mostly taken from an excellent summary (by Mr. C. H. Bothamley, F.I.C.*) of what is already known about the matter :—

The physical theory of the latent image assumes that the energy of the light rays is transferred to the molecules of the silver haloid, which are thereby thrown into a state of unstable equilibrium such that the compound is reduced to the metallic state by reagents which, under normal conditions, would have no action on it. The chief evidence in support of this view was the observation that the latent image spontaneously disappeared. There is, however, a considerable amount of evidence to show that the latent image does not fade spontaneously, but, in all cases where its disappearance is observed, it is destroyed by the action of atmospheric impurities, or by secondary reactions with substances retained in the film. Carey Lea showed that silver iodide will absorb free iodine, and hence the gradual disappearance of the latent image on Daguerreotype plates, or any of the films obtained by treating silver with an iodising agent, may be traced to the fact that the silver iodide has absorbed an excess of iodine during its preparation, and this iodine gradually acts upon the product of the action of light and re-converts it into normal silver iodide.

Analogy would lead us to expect that if the silver haloid were thrown into an unstable condition by the action of waves of light, it would gradually and somewhat rapidly return to its normal condition when the disturbing cause ceased to act. Gelatino-bromide plates have been kept two or three years after exposure, without any reduction in the character of the image on development. It is in the highest degree improbable that a mere *condition* of unstable equilibrium would persist for so long a time, and these facts, combined with the fact that the latent image is destroyed by reagents of a particular kind, but not by others, seems to be conclusive against the physical theory.

All evidence indicates that the formation of the invisible image is a photo-chemical operation, the composition of the material forming the image being different from that of silver bromide. The difference between the formation of a visible image and a latent image is a difference in degree, and not in kind.

Bothamley further remarks that, it seems that it has not been clearly recognised that the formation of a developed photographic image takes place in three distinct stages, which may, and probably do, differ considerably in the nature of the changes which occur. First, we have the *latent photo image*, formed solely by the action of light, and therefore of photo-chemical origin ; secondly, we have what he calls the *primary* or *fundamental image*, formed by the latent image by the action of the developer, and, therefore, partly of photo-chemical and partly of chemical origin ; and, thirdly, the *developed image*, formed by the action of the

* 'British Journal," 1890, p. 235.

developer from the primary image and the unaltered silver bromide in the film. This last process is probably mainly electro-chemical. It has not yet been definitely proved that the material composing the latent image is identical in composition with the visible products formed by the more prolonged action of light, although the various known facts furnish very strong proof that this is the case.

The results of the experiment seem to be in a point being reached that the latent image is a photo-mechanical reduction product containing a lower proportion of halogen than normal silver chloride, or bromide, or iodide, and much more easily reduced to the metallic state. The problem of its composition and constitution still remains to be solved.

Latitude of Exposure.—This term is applied to the extent of deviation possible either way from the exact exposure necessary without effecting to any harmful degree the character of the image.

The amount of latitude in exposure naturally varies with the sensitive media employed. With very highly-sensitive plates requiring exposures of the fraction of a second, very little latitude is permissible unless the subject be a very dark one, or a very small diaphragm be employed.

With ordinary plates more latitude is permissible than is usually imagined, although it is always advisable to err on the side of over rather than under exposure.

Lavender Oil.—Several species of *Lavandula* are cultivated for the sake of this oil. The plants of the *Lavandula vera* are clipped before flowering, and treated with phosphate of lime. They are then distilled, and oil of lavender is obtained. The *Lavandula spica* affords an inferior product, termed oil of spike, much used by painters on porcelain, and for varnishes.

Lavender oil, or oil of lavender as it is more commonly termed, is a thin, pale yellowish liquid, with a very pleasant odour resembling the lavender flowers. It is insoluble in water, but dissolves readily in alcohol.

It is used in photo-mechanical processes, chiefly as a solvent for asphaltum, also as a perfuming agent in encaustic pastes, and a solvent of pyroxyline in the manufacture of vitrified enamels. When added to shellac varnishes, a larger quantity of the lac can be dissolved.

Lead (Symbol, Pb; atomic weight, 206·4).—A grey and very soft metal, soluble in nitric acid. It is very useful for lining wooden tanks or in making dark-room sinks. Where leaden sinks or leaden pipes are employed, however, it will be necessary to prevent acids from being thrown down. Lead forms several salts, some of which are used in photography.

Lead Acetate (Formula, $Pb(H_3C_2O_2)_2 + 3H_2O$; synonyms, *acetate of lead, sugar of lead, plumbic acid*).—Prepared by dissolving carbonate of lead in a dilute solution of acetic acid. It

is then purified and formed into white crystalline masses, with an odour resembling vinegar, and rather a sweetish taste. Ten parts of it are soluble in 25 parts of water, or 80 parts of alcohol. It gives a milky solution, which can be clarified with the addition of a little acetic acid. A dilute solution has been recommended for use as a method for eliminating the sodium hyposulphite from the film, but the advantage of its employment is rather doubtful, as a compound of lead thiosulphate would be formed in the film, a substance which blackens in the presence of sulphuretted hydrogen contained in the atmosphere.

Lead Chromate (Formula, $PbCrO_4$; synonyms, *chromate of lead*, *chrome yellow*).—Prepared by mixing dilute solutions of lead acetate and potassium chromate. It is largely used in painting as *chrome yellow*. It also serves the analyst as a source of oxygen for the analysis of organic bodies, for the reason that when heated it fuses into a brown mass, which evolves oxygen at red heat.

Lead Intensifier.—See **Intensification.**

Lead Nitrate (Formula, $Pb(NO_3)_2$; synonyms, *nitrate of lead*, *plumbic nitrate*).—Crystallises in opaque white octahedral crystals from a solution of lead, or its oxide, in dilute nitric acid. It dissolves readily in about eight times it own weight of water, hardly soluble in alcohol, and insoluble in nitric acid. Mixed with potassium ferricyanide it forms a powerful intensifier for wet plates, as the solution thus formed converts the silver image into lead ferrocyanide and silver ferrocyanide, the potassium and the nitrate combining to form potassium nitrate.

Least Circle of Aberration.—The smallest section possible to make in the cone of rays of light emergent from a lens. In practice it is the most perfect focus that it is possible for parallel rays of light to have.

Least Circle of Confusion.—See **Aberration.**

Leimtype.—A process invented by Husnik, of Prague, by which gelatine images in high relief are used for direct printing from in the ordinary letter printing-press. A thick plate of chromatised gelatine is exposed under the negative. This is then attached by means of gutta-percha to zinc or wood. The surface is then developed by means of a solvent such as a saturated solution of an alkaline bichromate. This not only dissolves those parts unacted upon by the light, but also strengthens the relief. After development, and before the fine lines and dots are injured, the plate is dried, and the lights are covered with an opaque printer's ink by means of a camel-hair brush. The plate is then exposed for a second time to the action of the light, by which it is hardened and strengthened. The plates thus produced may be used in the ordinary printing-press with letterpress, and as many as 50,000 copies may be taken. Electrotypes can also be made in the usual manner.

Length of Focus.—See **Focus.**

Lens (Lat. *lens*—a lentil; so called from the resemblance shape of a double convex lens to the seed of a lentil).—A lens is a transparent body, usually of glass, so shaped as to afford two regular opposite surfaces, both spherical, or one plane and the other spherical, constructed for the purpose of concentrating or scattering rays of light transmitted through it.

It would be a very difficult matter to determine when lenses were first made. Although their use has been traced to the Chinese moralist Confucius 748 B.C., it is possible that they were made and used many years previous to that date. A glass case in the Assyrian section of the British Museum contains a piece of rock crystal formed into the shape of a plano-convex lens 1½in. in diameter, and $\frac{9}{10}$in. thick. This was discovered in the ruin called Nimroud. It gives a focus of 4½in. According to Sir David Brewster, this lens has been designed for magnifying purposes. The date is about 700 B.C. Plutarch speaks of instruments used by Archimedes "to manifest to the eye the largeness of the sun." Euclid's treatise on "Optics" appeared about 280B.C. Other notices of lenses may be found scattered through the pages of antiquity, until the revival of science and learning in the twelfth century, when Athazen is credited with having written on the refraction of rays and the magnifying power of lenses. Vitellus, a Pole, also wrote a treatise on lenses about 1270. The first lenses of which it is possible to discover any reliable record are those invented by the Florentine Salvine, Degli Armati, who died 1317. The invention of spectacles has, however, been credited to Roger Bacon (1250), but Pliny mentions that Nero used glasses when he watched the fights of the gladiators.

Baptista Porta (1560), the inventor of the camera obscura, states: "If you know how to combine a convex and a concave glass, one of each sort, you will see far and near objects larger and clearer."

Passing over a period during which but little improvement was made in the manufacture of lenses, we come to the time of John Dolland (born 1706, died 1761). This celebrated optician was the son of a French refugee, a silk weaver at Spitalfield. His improvements in the manufacture of lenses are well known, and he it was who discovered the method of achromatising lenses by combining glasses of different dispersive powers, completely upsetting Sir Isaac Newton's statement in his "Optics" "that all refractory substances diverged the prismatic colours in a constant proportion to their mean refraction," and consequently "that refraction could not be produced without colour," and for that reason no improvement could be expected in the refractory telescope.

Many and great were the difficulties experienced in obtaining lenses homogeneous and free from striæ. The Paris Academy of Sciences offered several prizes, and subsequently a commission, consisting of Herschel, Faraday, Dolland, and Roget, were

instructed to pursue the inquiry. Knight says of the result of this commission: "The excise system of England at that time sat like a foul bird upon all the nests where glass was hatched and prevented the experiments, tying the hands of the noble quaternion of philosophers with a few yards of red tape applied by some seedy looking individual with a pen behind his ear and no speculatio in his eye." Munich carried off the palm, and later on in the year 1851 pure discs of flint glass were exhibited in London having a diameter of 29 inches, and weighing 224lbs.

In the earliest days of photography telescopic objectives were employed, but the importance of the discovery soon lead to the manufacture of special lenses for the purpose. A large number of different kinds have been constructed, the most important of which will be described later on.

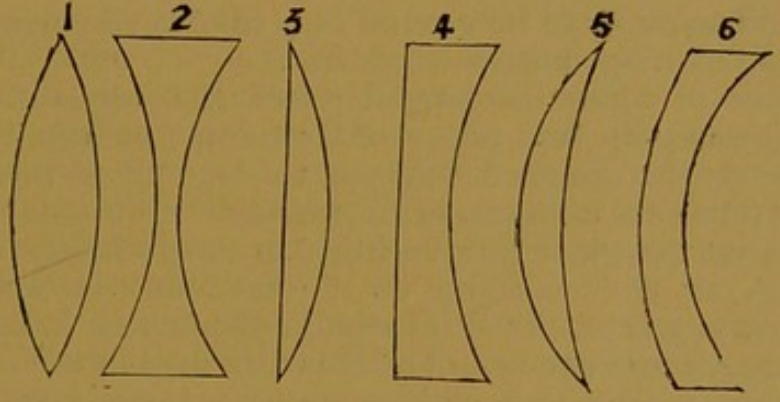

Fig. 115. Fig. 116.

The glass used for the manufacture of lenses is usually "crown" or "flint." Some account of its manufacture will be found under **Glass**. The difficulties of obtaining discs of large dimensions, perfectly free from striæ, have been partly overcome.

These discs are cast or ground with sand into something near the shape they will subsequently be formed into, and which is determined by careful calculations. These forms are here given. No 1, is a bi-convex ; No. 2, a bi-concave ; No. 3, a plano-convex ; No. 4, a plano-concave ; No. 5, a meniscus ; No. 6, a concavo-

Fig. 117.

must have the same radii of curvature which the surfaces of the lens are to have. For this purpose an arc of a circle double the diameter of the tool is drawn on a plate of copper made very flat by hammering, and followed up carefully with a file, so as to have

an exact shape.* Two of these are made, the one convex and the other concave. The convex or converging lenses are thicker in the middle than at the edges, and the concave or diverging lenses are thinner in the middle than at their edges. A double convex lens may be regarded as composed of two prisms, having their bases outwards and their edges meeting at the centre.

The tool employed for the grinding and shaping of these lenses from the roughly-shaped disc of glass is shown in fig. 117. This is cast from a wooden model, and finished in a lathe. The two gauges are thus rubbed one on the other to give them accurately the curve which they must have. These gauges are applied against the tools A and B (fig. 117) whilst they are being worked in the lathe. When the tools are thus finished they are rubbed together with emery until they touch at each part. The object of having two tools, A B, is that during the grinding the tool used loses its surface slightly, and requires to be ground in a similar way upon the other to restore it to its primitive curvature.

The piece of glass is chipped round the edges in a circular form by means of flat pliers of soft iron a little larger than the diameter the finished lens is to be. It is then attached with soft pitch to a brass plate rounded in the lathe in such a manner that the glass adapts itself to it as closely as possible. The tool A or B (according as the face of the lens is to be convex or concave) is fixed in a solid block and headed with a little moistened fine emery. The lens attached to the plate is then moved about in the tool with more or less pressure. After the emery powder has done its work, and the glass touches every part of the tool, the emery is changed, and the finest kind procurable is used to retouch the tool A (if that be the one used) with B, to preserve the correctness of its surface. The points to be observed in grinding are that the lens does not go beyond the tool, which must be somewhat large, that the emery powder be kept always moist, and that the lens be moved about in all directions and not for any length of time in one. After the emery powder, fine pumice-stone is used. The lens is then detached from the plate, reversed, and the opposite side worked in the same manner. The lens, if properly ground, should have perfectly spherical curvatures. The next process is that of polishing without altering these spherical surfaces, a by no means easy process. The following method of polishing is described by Monckhoven :—A melted mixture of equal parts of resin and pitch is passed through linen. The tool is gently heated, and the preceding mixture (somewhat cooled, so that it may have lost its previous fluidity) is spread over it in sufficient quantity to cover it to a thickness of three or four millimètres. The resinous mixture is spread in a uniform layer by means of the other tool, which, for this purpose, ought to be very cold and thoroughly clean. The first tool is then plunged into cold water to harden the resinous mixture. A little very fine rouge

* Monckhoven's "Optics."

is spread over the surface, and the lens carefully polished by proceeding in the same way as for the smoothing previously described until the operation is completed. It is necessary to take care that the glass does not get hot, and to exert a uniform pressure with the hand all over the surface of the lens, otherwise certain parts of the surface will be polished before the others, and the surface thus loses its sphericity. Lenses having convex surfaces are the easiest to work, convergent and divergent meniscus lenses the most difficult.

The ground and polished lenses have next to be centred and mounted. The centres of the two surfaces of the lens are then in the same sight line perpendicular to the circumference of the lens. If the lens is less than two inches in diameter it is attached to the latter with mastic as centrally as possible, and the latter revolved. The reflected image of a candle flame placed at some distance is then observed. If the lens is properly centred the two images produced by the two surfaces should not be displaced from each other. If improperly centred one or both of the images will describe a circle. The lens in this case requires to be moved until the centre is perfect and the images remain motionless. The margin of the lens is then ground with copper and emery, and it is ready for mounting in the brass tube either by fixing it permanently, when it is said to be set, or by fixing it into place by means of a second ring, which can be unscrewed at will.

Combination lenses are formed by cementing two or more together. This is done by slightly warming and placing a drop or two of Canada balsam upon the surface. The two lenses are then tightly pressed together, squeezing out as much as possible of the excess of balsam. When cooled they have the appearance of one piece, and can only be separated by heat. If, however, the two lenses have not a common surface, two or three small pieces of tinfoil are introduced at equal distances apart between the margins, or, if further separation is required, a brass ring is inserted between them.

Having now briefly described the manufacture of convex and concave lenses, it will now be necessary to consider the methods by which they are employed for photographic purposes.

To do this it will be well to go back a little into the theory.

When a ray of light travels through any transparent medium it preserves a straight course, provided the density of the medium remains the same ; but if the density varies, either by becoming greater or less, this ray of light is immediately *refracted* or bent out of its course, and pursues a different direction. The amount of refraction depends upon the nature of the medium and its density as compared with the one through which the ray had previously travelled. It must not be omitted to mention that this law only applies to rays of light falling upon the medium at an angle, and that deflecting power is at the surface of bodies. Fig. 118 will explain this. A ray of light falls at an angle upon the medium

denser than the air. It is refracted at the surface and pursues another straight course until it leaves the denser medium, when it is again bent, the usual law of bending towards the perpendicular

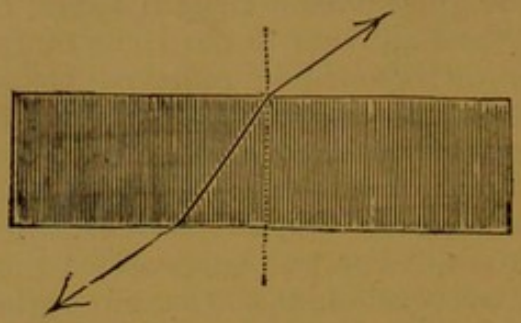

FIG. 118.

on entering, and away from it on leaving, being carried out. If the ray enters perpendicularly in the direction of the dotted lines no refraction takes place, and it passes straight through.

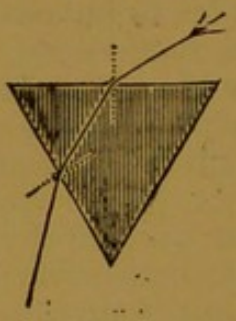

FIG. 119.

It will be clearly seen that by modifying the surfaces of the refracting media the rays of light may be diverted in almost any direction at will. A glass prism,

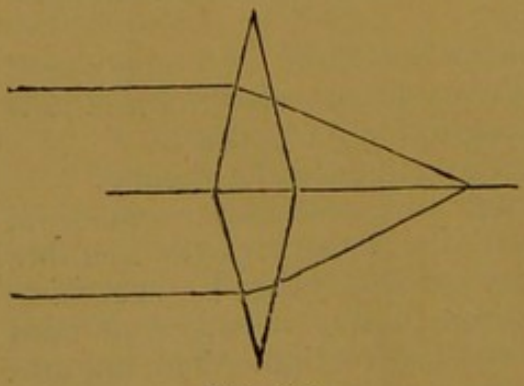

FIG. 120.

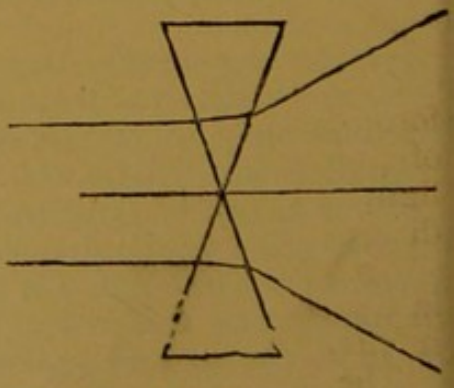

FIG. 121.

fig. 119, bends the ray of light to one side. By placing two such prisms base to base parallel rays may be made to meet at a point (see fig. 120), and conversely if they be placed together at the summits (see fig. 121) the effect will be to separate them

farther away from each other. This same effect is obtained with lenses having curved surfaces as with these prisms. The assimilation of lenses to prisms will be clearly seen on reference to figs. 122 and 123. A convergent lens may, therefore, be described as

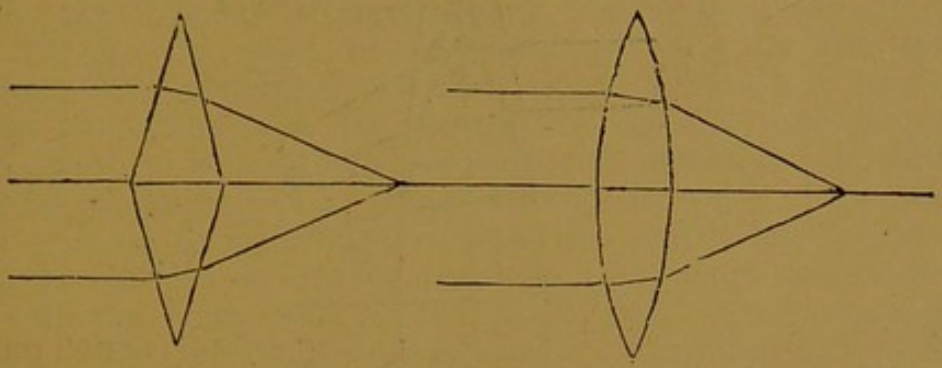

FIG. 122.

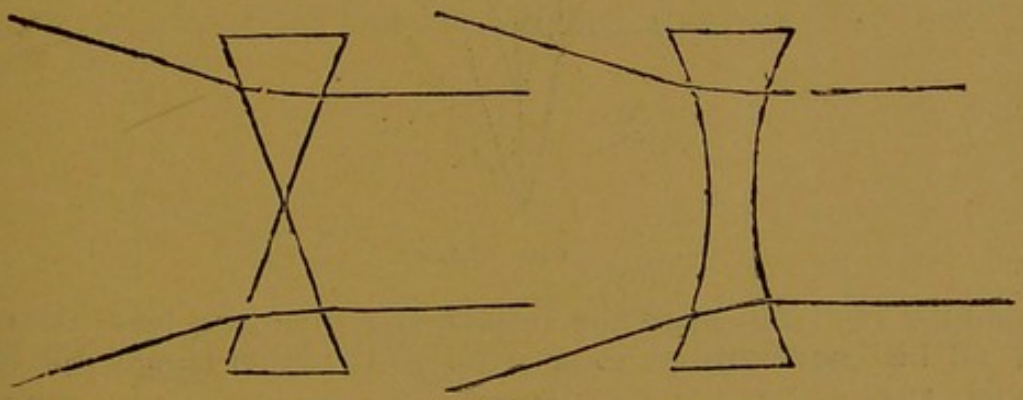

FIG. 123.

formed of two prisms united at the base, and a divergent lens as of prisms united at the points. The former causes the rays of light to converge and meet at a point, and the latter makes them diverge farther away.

To better compare the path of a luminous ray in a lens with that in a prism the surfaces of the lenses are supposed to be formed of an infinity of small plane surfaces or elements (see fig. 124).

The normal at any point is then perpendicular to the plane of the corresponding element. It is a geometrical principle that all the normals to the same spherical surface pass through its centre. Upon the above hypothesis it is always possible to conceive two plane surfaces at the points of incidence and emergence which are inclined to each other and produce the object of a prism.

Placing aside for a while the different aberrations that lenses are guilty of, we can consider the effects produced. Supposing a pencil

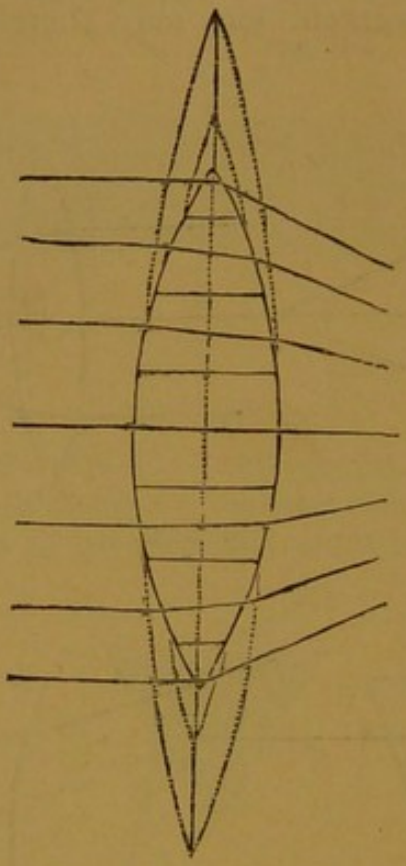

Fig. 124.

of parallel rays falls upon the surface of a diverging lens, the rays will all be concentrated to a point on the other side of the lens. See fig. 125.

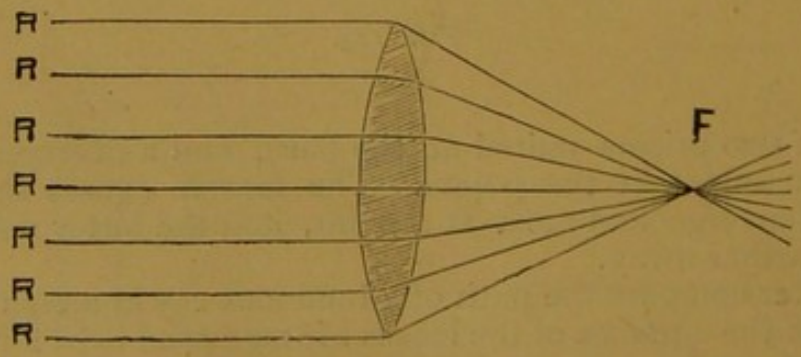

Fig. 125.

This point (F) is termed the focal point, or principal focal point, and its distance from the centre of the lens is referred to as the focal length of the objective employed. This point remains unchanged. When the rays are not parallel, but diverge from a

luminous point, that point is associated with the focus. If the luminous point be moved farther from the lens, the transmitted rays will converge to a point, and when it is twice as far from the lens as the principal focal point, the point of light produced on the other side of the lens will be at exactly the same distance from the lens. Any two such points are called conjugate foci (*q.v.*)

Now, the object of a photographic lens is to produce an image upon the ground glass of the camera, or upon the sensitive medium. The manner in which it does this will not now be so difficult to understand. It brings the rays of light proceeding from a point to a focus, and an image of the object is the result. If the object be placed at some distance in front of the lens, an image will be formed smaller than the object itself, but if the object be brought nearer to the lens the image will increase in size, and the focus will at the same time recede to a greater distance. But if brought nearer than a certain point, the lens will be what is termed "strained," and the image will become dreadfully distorted. It is for this reason that long-focus lenses are specially constructed for obtaining large images. These have usually a large diameter, but it must be remembered that the diameter or size of the lens has nothing whatever to do with the size of the image.

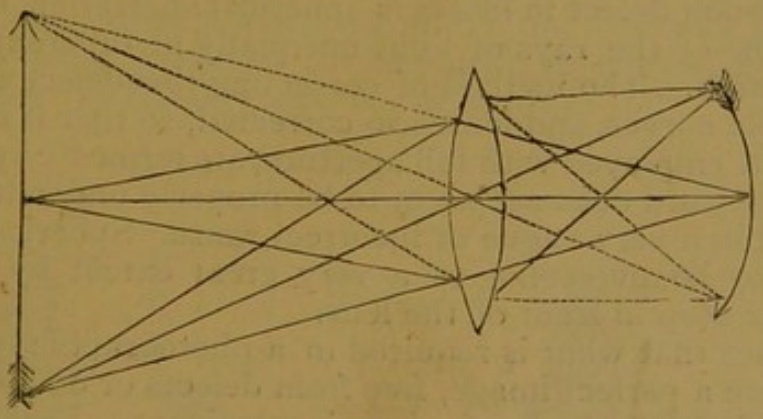

FIG. 126.

The rays of light proceeding through a converging lens from an illuminated object cross each other without interference when emerging from the other side, as seen in fig. 126, so that the image is necessarily inverted, and appears upside down on the focussing screen.

From this sketch it will also be seen that the rays which traverse the central point of the lens or the centre of the axis, as it is termed, are not bent away, but pursue a course either coincident with or parallel to the original.

Now the image produced by a lens is, unfortunately, subject to many defects, principally termed "aberrations." Under that heading these defects and the manner in which they have been partly overcome are clearly explained. It will, however, be convenient to mention them here. The principal defect, then, is termed chromatic aberration. The effect of this is that the rays of light passing through the lens become decomposed into their constituent prismatic colours, and the image on the screen is bordered by coloured fringes. At the same time the visual and chemical foci are separated. Now, for photographic purposes, it is necessary that these rays should be united, so that when a sharp image is seen on the focussing screen an equally sharp image will be produced on a sensitive plate placed on the same plane, technically known as working to focus, or having the visual and chemical foci coincident. The manner in which this defect is remedied is simple enough. Two lenses are placed together having different dispersive power, the one being of crown and the other of flint glass. Now, separately, both these lenses possess the defect of chromatic aberration, but in an opposite manner, so that the two combined completely neutralise each other, that is to say, sufficiently for photographic purposes. The absolutely perfect correction of chromatic aberration has never yet been accomplished. All lenses now manufactured for photographic purposes (except the very commonest kind) are made *achromatic*. Another common defect in lenses is spherical aberration, caused by the refraction of the rays of light unequally at different portions of their surfaces. The method of correcting this defect is by the use of suitable curves, and lenses so corrected, so that it is possible for them to be employed with full aperture, are termed "aplanatic," although this word does not seem to be properly understood, as it is often used in a very vague or incorrect sense. Spherical aberration can also be overcome to a very great extent by placing a diaphragm or stop in front of the lens.

Thus we see that what is required in a photographic lens is one that shall give a perfect image, free from defects or distortion, and having its visual and chemical foci coincident. Besides these points, there is the question of rapidity or brilliancy of the image. This is dependent chiefly upon the aperture or light gathering capacity of the lens forming the image, and the area over which the latter is spread. The amount of light gathered by the lens being proportional to its working aperture, and the area of the image being proportional to the square of the lens focus, the brilliancy of the image varies directly as the area of its working aperture, and inversely as the square of its focal length. Upon the brilliancy of the image depend the rapidity of the lens and the briefness of the exposure necessary. A certain amount of loss of light will, however, occur in all lenses, due to absorption and to reflection of the glass surfaces. Single lenses possess the advantage over all others of occasioning less loss of light from these causes.

We will now go back to the earliest days of photography, and see what has been done towards obtaining a lens answering to these requirements.

In the camera obscura of Porta a double-convex lens was always used to throw the visible image upon the glass, but when the discoveries of Daguerre, Niepce and Talbot were announced, and photography became an accomplished fact, it was discovered that this lens was exceedingly defective, and mathematicians and opticians strove to obtain one that should be more perfect, and with which the visual and actinic foci should coincide, which was not the case with the double-convex lens.

Eventually this single lens was replaced by the achromatic lens that had long been used for the telescope; but this was also very imperfect, as the requirements for photographic purposes were very different from those for telescopic. The function of an object glass of a telescope is to produce images of objects transmitted axially, or in near approximation to the axis, while a photographic lens is not only required to do this, but must also collect rays transmitted at considerable obliquity to the axis, and to project them to distances proportionally greater than the axial ones, in order to give a flat field. The rays that pass obliquely through a telescope are not used, but in the camera these oblique rays generally form by far the greater part of the image. The achromatic lens first used is shown in fig. 127. Owing, however, to the circumscribed area of definition the lens was reversed, the plane side being presented to the object, as shown in fig. 128, the arrow indicating the direction of the light.

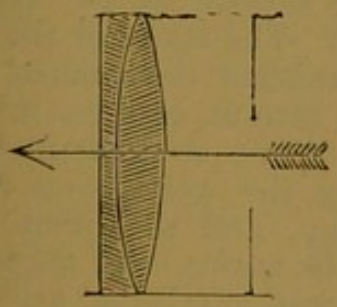

FIG. 127.

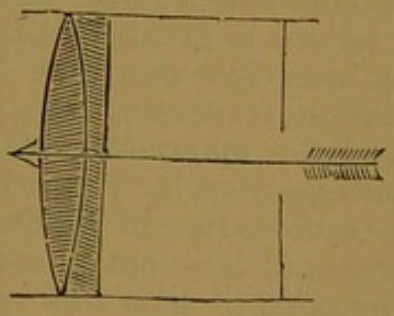

FIG. 128.

Butattempts were then made to secure a wider aperture, so that greater rapidity would result. A larger and flatter field was also considered desirable.

About the year 1840 Wollaston's meniscus fig. 129, became to be recognised as a means of securing an extended field,

and later on in the same year Chevalier, a Parisian optician, made many further improvements in its illumination by combining two achromatic lenses.

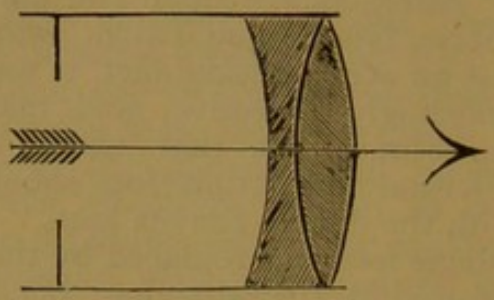

FIG. 129.

In the following year, however, the greatest discovery in photographic appliances was made by Professor Petzval, of Vienna, and Voightländer constructed under his directions the Petzval portrait lens. According to J. Traill Taylor, the late Voightländer, a year after Daguerre's discovery, when calling upon Professor Von Ettinghausen, was asked by that gentleman whether he could determine the refracting and dispersive powers of different descriptions of crown and flint glass, as Professor Petzval, who was at that time filling the mathematical chair in the Vienna University, had made the calculation of a photographic lens which could not be executed in consequence of the quality of the glass to be employed not being then in existence. Voightländer, intimating his abitity to do this, was requested to call immediately upon Professor Petzval, and was given a letter of introduction to that gentleman, accompanied by the observation that by furnishing the means to execute this lens he would render great service to the world, and secure a great reputation for himself. The result of the ensuing interview was that Voightländer furnished the desired information respecting the qualities of the various glasses, which formed the foundation of the calculation of two combinations of lenses executed by Voightländer, one being the well-known portrait combination in use to the present day, and the other the orthoscopic lens not introduced to the public notice until 1857.

The portrait lens was issued about the year 1841—fig. 130 will serve to show its construction.

The converging lenses are of crown and the divergent lenses of flint glass. The front combination consists of a double-convex crown glass lens cemented to a double concave of flint glass, and the back combination is a flint glass concavo-convex separated from a double-convex crown glass lens by a brass ring. The negative refractive power of the flint glass concavo-convex lens is sufficiently strong as to balance the positive aberration of the whole combination. A number of modifications of this lens have been introduced, but are all constructed on the same principle.

The focal lengths of the posterior and anterior combinations are as three to five, and the combinations are separated a distance about equal to half the equivalent focus of the lens itself. The chief feature about this lens is its great rapidity, obtained by shortening the focal length and using the full aperture without a diaphragm.

The year 1858 saw several improvements in photographic optics. Grubb introduced his patent aplanatic* lenses. In these he obtains

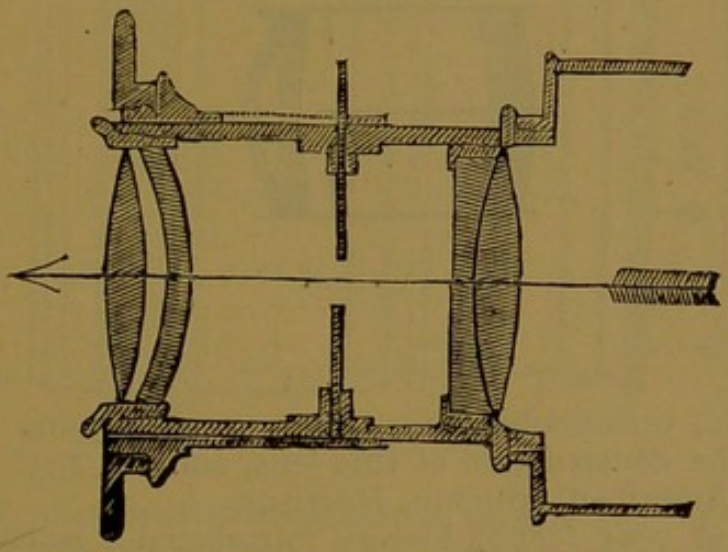

FIG. 130.

a deeper separation curve between the components of the single lens making the crown lens a meniscus, and placing it in front instead of behind the flint. The effect of this deeper separating curve, Grubb claimed, was that the spherical aberration was nearly corrected, and consequently one was enabled to use a much larger diaphragm than previously possible. Fig. 131 is a sketch of thi ens.

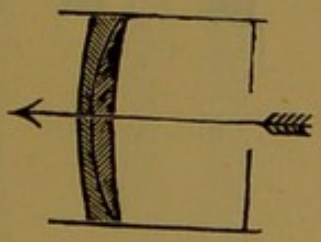

FIG. 131.

In the same year Petzval introduced his new landscape lens It was made under his directions by Dietzler, of Vienna, some dis-

* These terms *aplanatic* and *aplanatism* are somewhat misapplied and cannot, strictly speaking be applied to photographic lenses. They were originally employed by a Dr. Blair in 1791 to lenses free from spherical aberration. It is now popularly applied to any lens that will give sharp central definition when working with full aperture. This, however, even an imperfectly corrected lens will do if its diameter be sufficiently reduced.

agreement having taken place between Petzval and Voightländer since they had united their efforts to produce the portrait lens. The fame of the first Petzval lens secured a warm and welcome reception for this new one, and it was instantly copied by opticians in all countries and sold under various high-sounding names, such

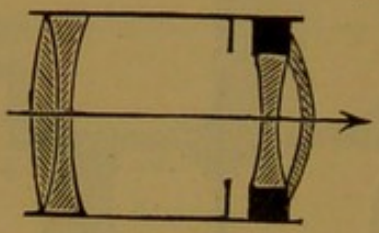

FIG. 132.

as caloscopic, orthoscopic, etc. The accompanying sketch, fig. 132, shows the construction of this lens, and fig. 133* a modification by the American optician, Harrison.

In the next year (1860) Deway introduced a *multum in parvo* lens, having in the one instrument three view and three portrait

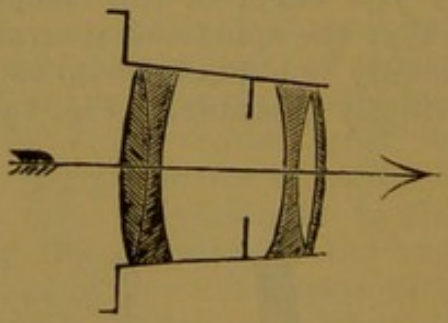

FIG. 133.

lenses, the changes being made by bayonet joints. This method has also been adopted by several other opticians. Probably the most complete is the area system invented by George Smith, of the Sciopticon Co.

Wray has also constructed a series of three single landscape lenses fitting into one mount, which he terms casket lenses. Fig. 134 represents a casket lens actual size for 5 × 4 plates. It is

* From Chapman Jones's "Introduction to the Science of Photography."—Iliffe & Son.

shown with the sliding body fully drawn out, this being correct for the 10in. focus lens. The dotted lines show it when closed for use with the 5in. lens, and for the 7½in. it is drawn out to a position midway between the two, and thus locked by a partial turn.

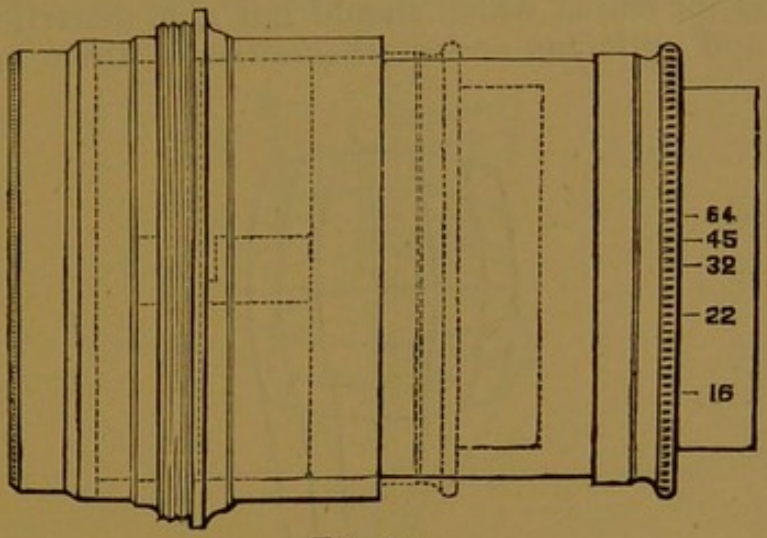

FIG. 134.

In this year also Sutton took out a patent for his panoramic water lens,* specially constructed for making panoramic views on long curved plates.

Then came the celebrated triplet lens of Dallmeyer, which was a great improvement, as it then became possible to make pictures free from distortion (see fig. 135).

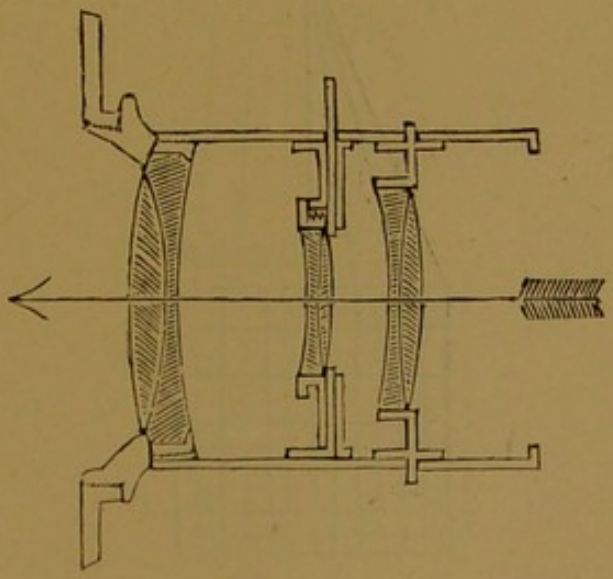

FIG. 135.

It consists of a slightly meniscus achromatic, with its convex side turned towards the object, a little behind it is a nearly plane

* See *Fluid Lens.*

meniscus concave achromatic, and a large lens of the same form as the front is placed at the back end. If the central combination be removed, the focal length of the whole lens becomes reduced, and its angular aperture, previously f/15, is then sufficiently large for portrait work.

The need for lenses which should not give distortion was now apparent, and opticians and mathematicians strove hard to pro-

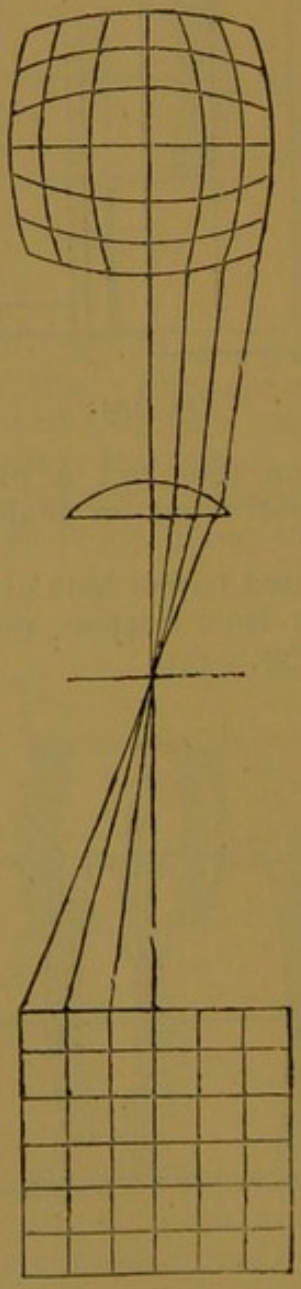

FIG. 136]

duce the required effect. Distortion may be shown in a simple manner by the appearance of a square grating after refraction,

with a single lens having the diaphragm placed in front of it, and the field flat. By fig. 136 it will be seen that when the refractory angle is greatest, viz., the farther from the axis the pencils become more refracted towards it than they are as they approach it, the axis itself suffering no displacement. The pencils of rays, it will be seen, converge towards the axis, and

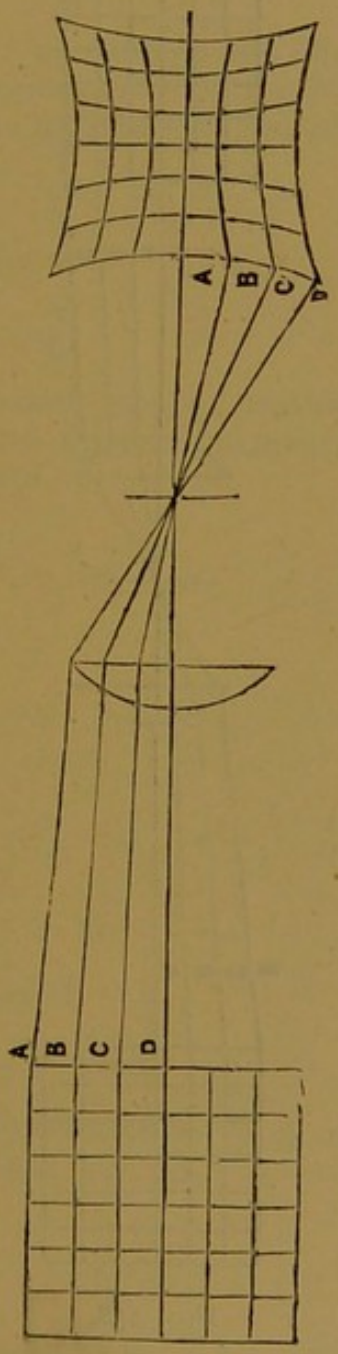

FIG. 137.

give what is known as "barrel-shape" distortion. The opposite, or pin-cushion distortion is seen, if the diaphragm be placed behind the lens, as in fig. 137; a divergence from the axis will take place,

becoming more and more marked as the refracting angles become greater towards the edge of the lens.

Of the two evils the least is chosen, and the diaphragm is usually placed in front of single lenses.

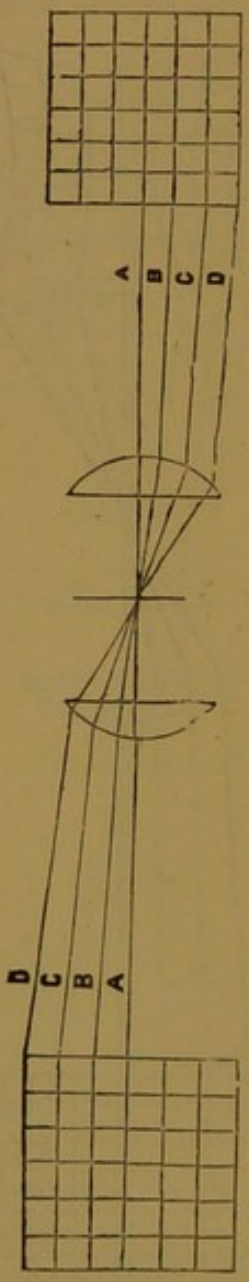

FIG. 138.

In fig. 138, however, we see how this distortion can be remedied by two lenses, having the diaphragm in the centre, this being one of the principles upon which the rapid rectilinear and non-distorting lenses are made.

The conditions for aplanatism by combination with another lens are thus given by Mr. T. R. Dallmeyer :—

In the first approximation we have

$$\frac{1}{v_1} = \frac{1}{f_1} - \frac{1}{u},$$

$$\frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{v_1} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{1}{u},$$

so that if the lenses are in contact the effect is the same as one lens equal to the *algebraical sum* of the *powers* of each. If the second lens were negative, for example, we should get

$$\frac{1}{v_2} = \frac{1}{f_1} - \frac{1}{f_2} - \frac{1}{u};$$

and with any number of lenses

$$\frac{1}{v_n} = \frac{1}{f_1} + \frac{1}{f_2} + \ldots + \frac{1}{fu} - \frac{1}{u}$$

We have found a second approximation for a single lens showing the aberration, and for our purpose here this may be put under more convenient form.

Since

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f},$$

let

$$\frac{1}{u} = \frac{1}{2f}(1 + a), \qquad \frac{1}{v} = \frac{1}{2f}(1 - a),$$

and

$$\frac{1}{v} + \frac{1}{s} = \frac{1}{\mu - 1}\frac{1}{f};$$

$$\frac{1}{r} = \frac{1}{2}\frac{1}{(\mu-1)f}(1 + x), \qquad \frac{1}{s} = \frac{1}{2(\mu - 1)f}(1 - x),$$

If we then find the values of

$$\left\{\frac{1}{r} + \frac{1}{u}\right\}^2 \text{ and } \left\{\frac{1}{s} + \frac{1}{v}\right\}^2$$

we obtain the second approximation in a more convenient form after the necessary reductions, viz. :—

We have the first lens

$$\frac{1}{v_1} = \frac{1}{f} - \frac{1}{u} + \frac{1}{\mu(\mu - 1)}\left\{a^2 + \frac{\mu^3}{\mu - 1}\right\}\frac{y_2}{8f^3}$$

$$\left\{\frac{\mu + 2}{\mu - 1}x^2 + 4(\mu + 1)ax + (3\mu + 2)(\mu - 1)\right.$$

This may be written

$$\frac{1}{v^1} = \frac{1}{f^1} - \frac{1}{u} + w_1 y_2,$$

and on passing to the second lens

$$\frac{1}{v_2} - \frac{1}{f} - \frac{1}{u} + w_2 y_2 = \frac{1}{f^1} + \frac{1}{f^2} - \frac{1}{u} + (w_1 + w_2) y_2,$$

and in general

$$\frac{1}{v^2} = \frac{1}{f^1} + \frac{1}{f^2} + \frac{1}{f_3} + \ldots \frac{1}{f^n} - \frac{1}{u} + (w_1 + w_2 + \ldots w_n) y^2$$

The object, then, for aplanatism is to make

$$\boxed{\quad} \; w = 0$$

Now this can always be done by assuming a definite ratio between the radii of one lens, and finding the ratio between the radii of the second that shall destroy the first aberration.

Now, if we call r_1 s_1 the radii of the first lens, and r_2 s_2 the radii of the second lens, and take a form of aplanatic combinations such as the rapid rectilinear, in which both front and back combinations are identical with cemented and identical contacts, here s_1 and r_2 are identical except in sign, and if the glasses chosen are suited, there is only one form for the best correction for

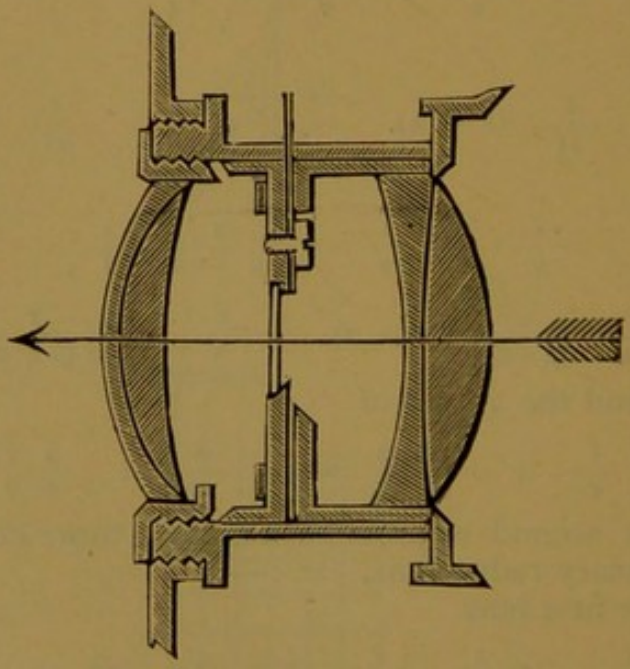

Fig. 139

spherical aberration. The ratio of the powers is constant, and, therefore, by a proper substitution in the above equations this construction becomes a simple matter. The question evolves itself into a simple quadratic, one root of which is imaginary. If both

be imaginary, the glasses are unsuitable for the purpose. In all doublets, the diaphragm being placed between the two combinations, the distortion of one is cured by the other.

In the same year (1860) Harrison patented his globe lens (see **Globe Lens**), which had a very wide angle, but gave a flare owing to its globular form. It is also guilty of spherical aberration. Among the many non-distorting lenses that were introduced about this time must be mentioned Ross's doublet lens, or "actinic doublets," as they are called. Fig. 139 shows the manner in which the lenses are fixed.

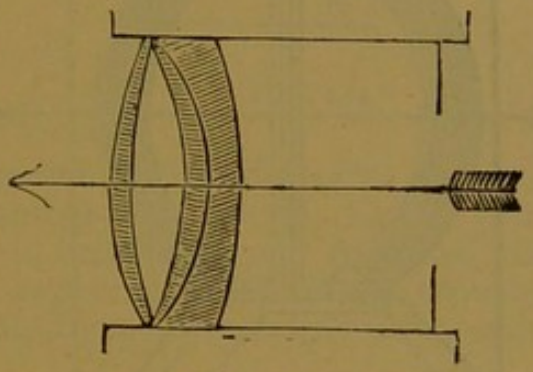

Fig. 140.

It is composed of two achromatised meniscuses, each of which can be separately used as a single lens. This was a great improvement upon the globe lens, as it is almost entirely free from spherical aberration and distortion. These lenses were manufactured in three series, *i.e.*, rapid, medium, and wide angle.

In the year 1864, Dallmeyer made a considerable modification in his single landscape lens introduced four years previous. A sketch of this modified arrangement is shown in fig. 140.

In the following year (1865), Steinheil introduced his peroscopic lens. This was a non-achromatised symmetrical doublet, the

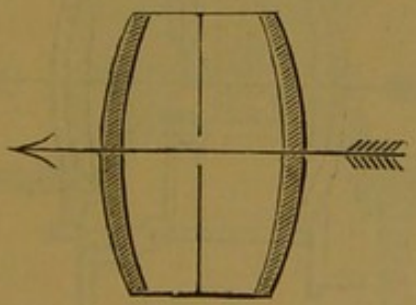

Fig. 141.

arrangement of which is shown in fig. 141. The introduction of this lens, however, can hardly be considered a step forward, as neither lens was corrected for chromatic aberration, and consequently it was necessary to shift the camera to the chemical focus after focussing on the ground glass. The distance towards the lens that

the focal plane is required to be moved is always the same fraction of the focal length, *i.e.*, $\frac{975}{1000}$. The inventor stated that focussing was unnecessary for the reason that near and distant objects were

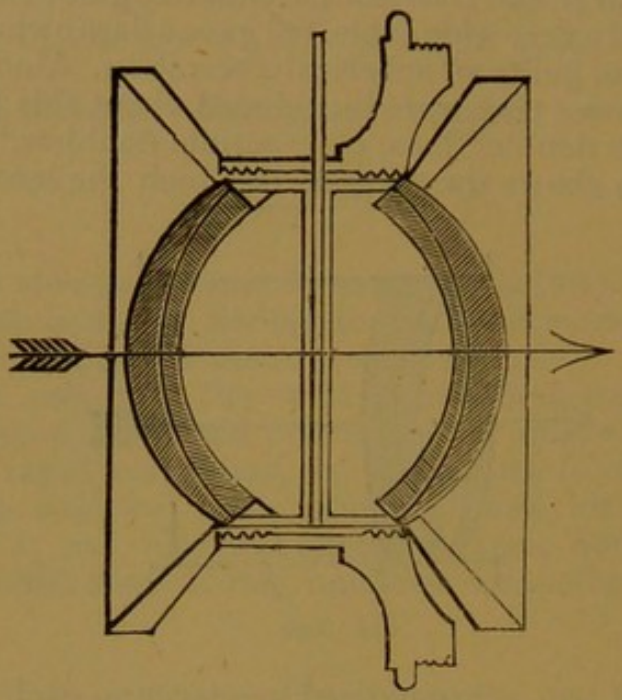

FIG. 142.

equally clear, and consequently the slide holder could be adjusted permanently. This statement, however, is rather misleading. The lens included an angle of 90°, and was considered an advan-

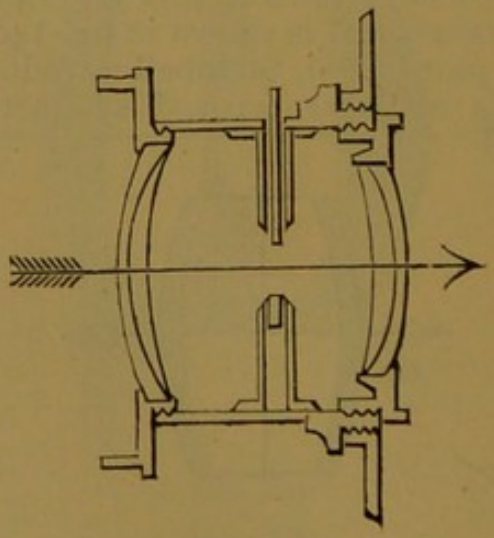

FIG. 143.

tage over the globe lens, that its diameter was only about one quarter for the same field.

Busch, of Ruthenow, also introduced a lens which he termed the pantoscope, shown in fig. 142.

This lens is a cross between the globe lens and the peroscope. It is not aplanatic, and only works with a very small aperture, f/30 or f/40.

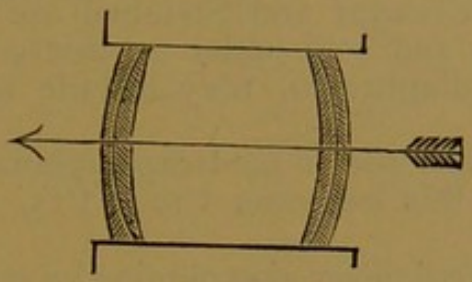

FIG. 144.

Passing on we arrive at the year 1866, a very important one in the history of photographic lenses, for in this year Dallmeyer introduced his rapid rectilinear and Steinheil his aplanatic lenses. Both these lenses appeared almost simultaneously, Dallmeyer's lens being preceded only by a few weeks by his wide-angle rectilinear

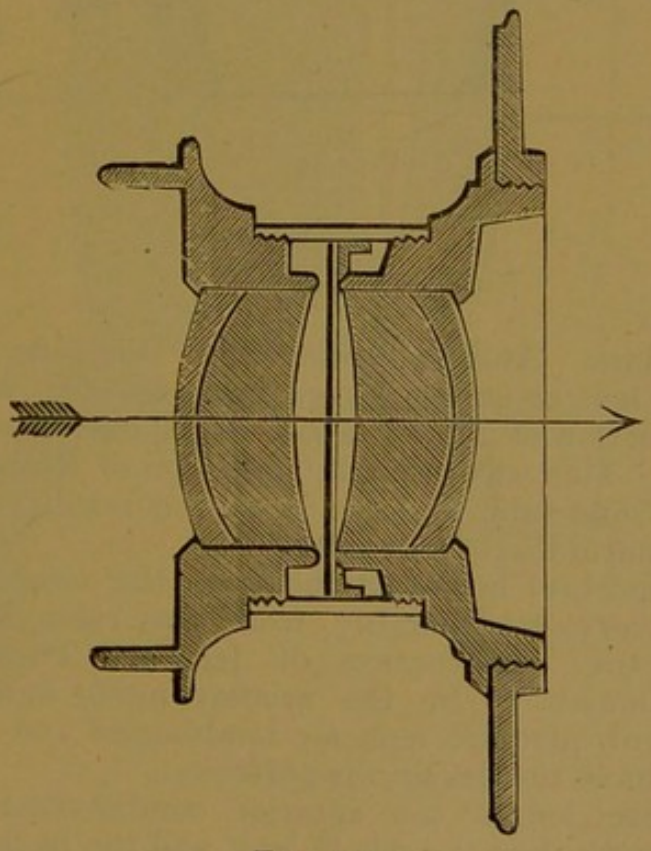

FIG. 145.

doublet depicted in fig. 143. This lens worked at f/13 to f/17 and has its back combination smaller than the front. By this means its reflecting power is diminished, and any tendency to flare reduced.

The aplanat of Steinheil is shown in fig. 144. The similarity of of the two lenses is at once seen. Steinheil, however, constructed his of two kinds of flint glass, a light and a dense kind. Both lenses were achromatic.

These lenses of Dallmeyer and Steinheil are now very extensively manufactured, and sold under a variety of fancy names; used with a small diaphragm, they include an angle of considerable extent.

Steinheil also constructed a landscape aplanat, fig. 145. The working aperture of this lens was f/12 to f/15, and the angle of view above 95°.

In this same year Dallmeyer also obtained a patent for a modification of the Petzval portrait lens (fig. 146). In this the flint glass lens of the back combination was placed behind instead of in front

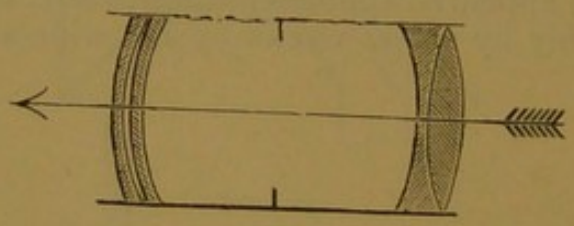

Fig. 146

of the crown glass. Another point about this lens was that the back flint glass lens could be moved very slightly backwards and cause the production of a definite and calculable amount of spherical aberration. This was termed "diffusion of focus," and much softer portraits are said to have been the result. This is now understood as naturalistic focussing.

The next important introductions were the lenses of Steinheil who departed very considerably from the rules laid down by opticians for the construction of lenses. These he called "anti-planatic lenses." In the accompanying figure (No. 147) we have the anti-planatic lens for landscapes and groups; and in fig. 148, we have the design for portraits.

In both these lenses the anterior combination possesses a shorter focal length than the whole lens, and the back combination is diverging. Both combinations give considerable spherical aberration, but are so arranged that the extent of each is equal in an opposite direction, so that two combined neutralise each other and produce a corrected whole. The working aperture of the view lens is f/6 and of the portrait lens f/3.

Fig. 149 is a sketch of the Euryscope lens of Messrs. Perkin, Son and Rayment; although cheap this lens is exceptionally free from aberration, either spherical or chromatic, and distortion. It also gives a very flat field.

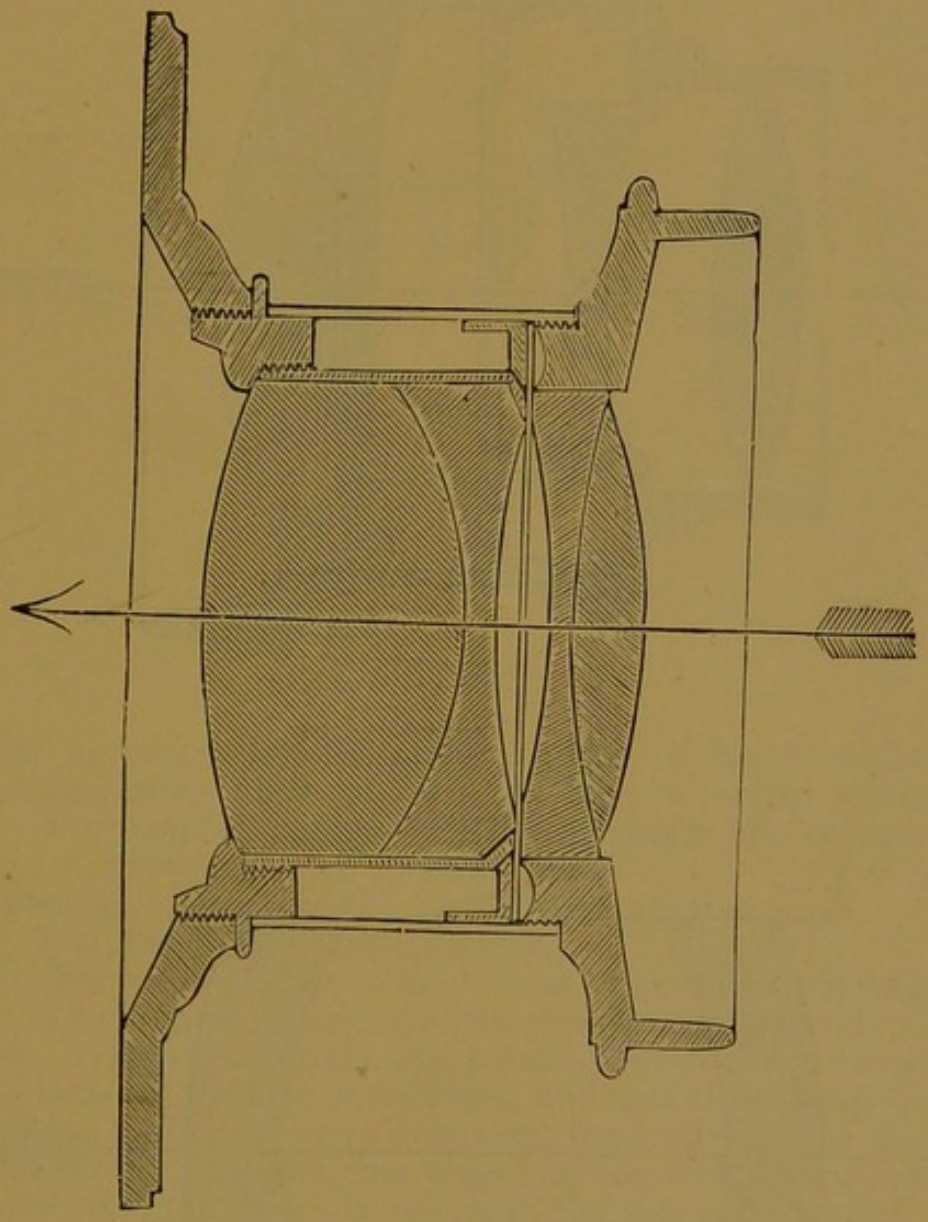

Fig. 147.

In the year 1888 Dallmeyer introduced a rectilinear or non-distorting lens, working with a very large aperture and free from distortion and astigmatism, and giving a very flat field. This lens is depicted in fig. 150.

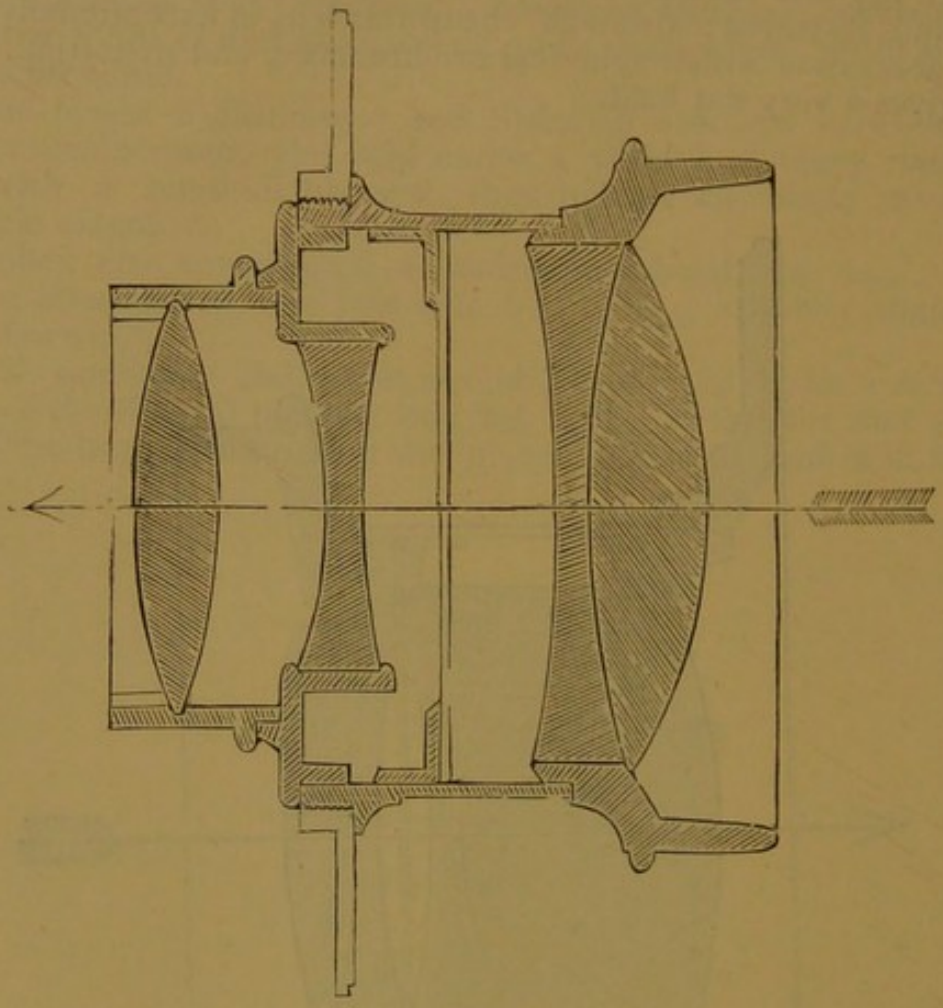

FIG. 148.

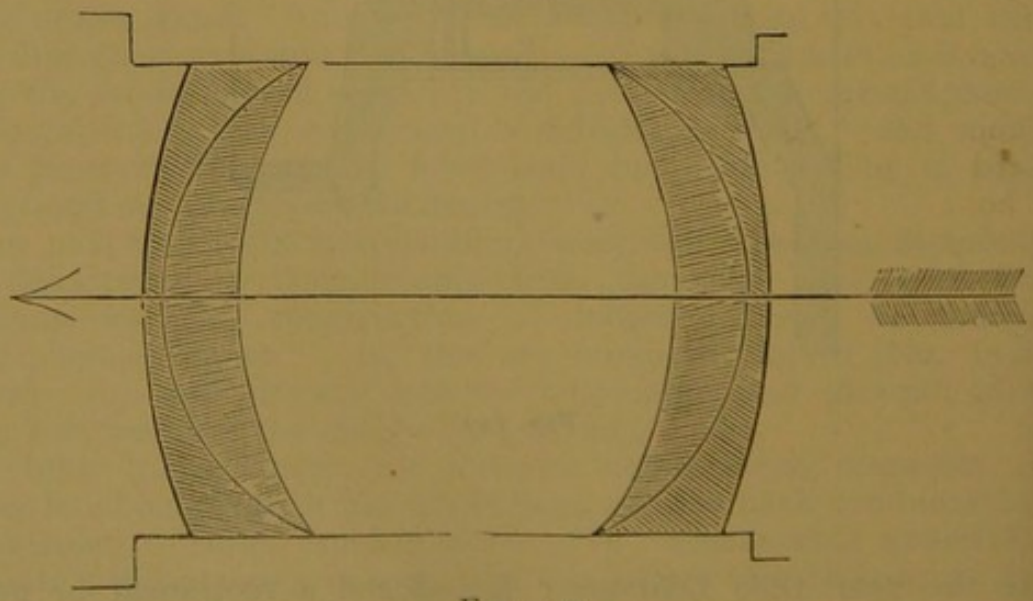

FIG. 149.

Having thus endeavoured to give a description of the various forms of lenses, we will next consider the points in choosing lenses for various classes of work.

The lens is undoubtedly the most important instrument in the hands of the photographer, and upon its careful choice rests his future success. So much commercial deception now exists, that the only reliable method of ensuring the procural of first-class lenses is to obtain them from well-known makers. No one lens can be perfectly adapted for all purposes ; it therefore

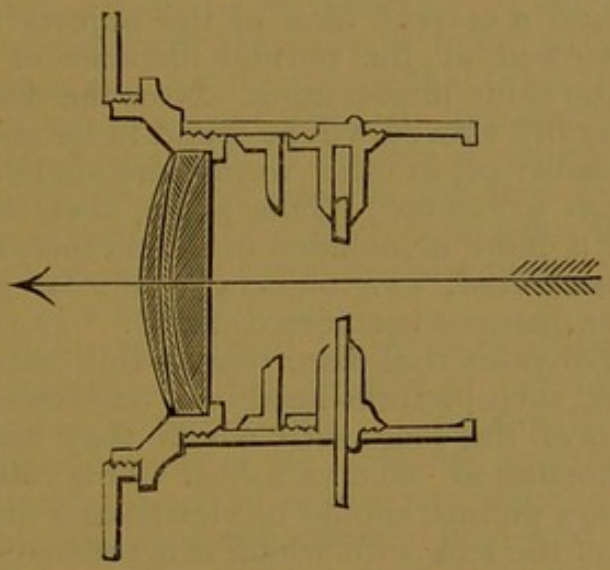

Fig. 150.

becomes necessary for the photographer, if he is desirous of attempting various kinds of work, to have a varied selection of lenses. For simplification we will divide lenses into two principal classes, *i.e.*, view lenses and portrait lenses.

In choosing a view lens the first considerations are :—

1st. The size of the picture required.

2nd. The angle of view or amount of subject to be included.

3rd. The kind of picture, viz., whether landscape, architectural, or both. With regard to the first point—the size of the image. The relation between the size of an object and that of its image depends simply upon their respective distances from the optical centre of the lens. If, for example, the object is ten feet distant, and its image one foot, the image is one tenth the size of its object. And as the distance of an image depends upon both the distance of the object and the focus of the lens employed, it is evident that with an object at fixed distance the size of its image is proportional to the focus of the lens.

The second point, the angle of the view to be included in the picture, depends upon the relation of its size to the focal length of the lens, that is to say, the shorter the focus the larger wi l be the angle, and *vice-versa*. Referring to the proper angle for new lenses, Dallmeyer, in his "Choice and Use of Photographic Lenses," says that "the human eye itself is a miniature photo-

graphic camera, inasmuch as the several rays proceeding from objects, upon entering the eye, are refracted by its lens, and thence proceed to form a perfect image or picture on the smooth screen of nerve called the *retina;* and that it is by this picture that the mind is enabled to judge of the dimensions, brightness, colour, &c., of external objects. The angular extent of the picture formed upon the retina does not exceed 60° without some movement of the eye or head. Hence for a photograph to convey to the mind a correct idea of the objects represented, it should, when viewed at the normal distance of from 12 to 15 inches, excite the same impressions. Now the distance at which a picture is generally viewed will be found to be about equal to its base, or longest side; or, in other words, the angle it subtends for vision will be from 50° to 60°. This angle, therefore, should not be exceeded, for if more is included in the picture, the perspective will appear exaggerated, *i.e.*, objects in the foreground will be too large, and the distance becomes dwarfed.

"To render it obvious that distortion of this nature is really no fault of the lens, such pictures need only be viewed at a distance equal to the focus of the lens with which they are taken, when all apparent distortion at once vanishes. This rule holds good in all cases, *i.e.*, every picture should be viewed at a distance equal to the focal length of the lens with which it is taken. Thus a 12 x 10 picture taken with a 7-inch focus wide-angle rectilinear lens should be looked at, not at 12 or 15 inches, but at 7 inches distance from the eye."

From this it will be seen that wide-angle lenses can only be used in landscape photography when absolute truth of delineation is to be disregarded for the sake of beauty. In photographing architectural subjects in confined situations, a wide-angle lens is often an absolute necessity, but it should only be used in such cases.

The best form of landscape lens is undoubtedly the "single combination," for the reason that this lens possesses only two reflecting surfaces; the most brilliant images are the result, and great rapidity of exposure is therefore possible.

The only objection to the single lens is its distortion, which only becomes apparent, however, when photographing objects containing straight lines, such as in buildings, etc., the same becoming slightly barrel shaped. To avoid this as much as possible, the building should be placed as near to the centre of the picture as possible. It should be noted that in the various kinds of single combination new lenses now manufactured, other conditions being equal, the smaller its diameter the better the lens.

With regard to the focal length this should not be greater than the base-line of the picture, that is to say, for a 10 x 12in. plate a 12in .focus lens, or a little longer, will be found most suitable.

For architectural subjects it is, of course, necessary that a rectilinear lens be chosen, preferably one with a moderate angle. The rapid rectilinear is the most popular lens, owing to its freedom

from distortion, and to its property of working with a larger aperture than any other kind of double lens. For photographing objects in confined situations the wide-angle rectilinear will be necessary, but, as already stated, should only be used when circumstances compel it.

In the selection of portrait lenses other considerations have to be made, the principal being the length of the studio, and consequently the distance from the lens, that the subject can be placed. This is usually considered to be between 12 and 24 feet. In less than 12 feet the image will generally be found wanting in definition and correct perspective, for the reason that the lens will possess too short a focus. Carte-de-visite portraits are generally taken with lenses of such focal length as to require a distance of between 14 to 20 feet. For this distance between the lens and the sitter, the equivalent focus should be about double the base-line of the plate—for instance, for a quarter or carte-de-visite plate, $3\frac{1}{4} \times 4\frac{1}{4}$, the focal length would be $4\frac{1}{4} \times 2 = 8\frac{1}{2}$ inches.

An essential point in portrait lenses is rapidity of action, as in photographing babies or other restless or nervous sitters only a very brief exposure is permissible. The rapidity of the lens is governed by the diameter of its working aperture and its focal length. Quick-acting portrait lenses can only be used, however, with considerable sacrifice of flatness of field and depth of definition. An example of this may be seen if we have two lenses of equal focal length both properly corrected for spherical aberration. Let one have a diameter of two inches and the other of four inches; the latter will be four times more rapid than the former, but will possess only half the depth of focus. These rapid portrait lenses will only be found to give good results if used for small sized images; for large pictures slower acting lenses giving greater depth of focus are required.

If for an amateur requiring a good all-round lens with which he can make landscapes, architecture groups, portraits, instantaneous views, etc., the double combination rapid rectilinear is undoubtedly the most suitable—it will, of course, be understood, however, that the different classes of work can never be so well executed as with separate lenses suitably and specially constructed for each kind of work.

The rapid rectilinear will also be found very useful for copying purposes, and also for enlarging and reducing.

The various aberrations that lenses are guilty of has already been explained under **Aberration**. The methods of testing for these defects have already been described. If, however, a lens be purchased from a good maker, such as Dallmeyer, Ross, Taylor, Taylor & Hobson, Wray, or any other well-known manufacturer, very little fear need be entertained as to its suffering from any serious defect.

Lens Screen or Hood.—An arrangement fitted on to the front of the lens to screen off as much as possible of the side light and

prevent all rays, save those emanating from the objects to be photographed, from striking the lens or the inner parts of the mount. Nearly every lens is fitted with a hood in front which serves as a light screen. If required to be larger, however, an extemporised conical tube of blackened cardboard can be readily constructed. Another form of hood, termed a sky shade, was formerly used, but is rarely seen nowadays.

Leptographic Paper.—A kind of collodio-chloride paper introduced on the Continent about the year 1866.

Level.—An instrument for indicating a horizontal line or the horizontal position of a surface. The simplest form is the spirit level as used by carpenters and others. In this is a glass tube, hermetically sealed at both ends, contains spirits of wine which does not freeze, and a small air bubble. When the air bubble is in the centre of the tube the instrument is in a horizontal position. Instead of a tube a small round disc is sometimes used. When the bubble is in the centre it shows a level position every way, thus obviating the necessity of shifting the instrument in different directions. A small spirit level of this description is often attached to the camera to facilitate its erection in a horizontal attitude.

Levelling Stand.—An instrument constructed to support a glass plate in a horizontal position, so that liquids poured on it can be made to spread evenly over without overflowing. It is usually constructed in the form of a tripod, with three adjusting screws, with which the operation of levelling is accomplished.

Licht-druck.—A photo-mechanical process, largely worked in Germany, and known in this country as Albertype, Collotype, etc.

Lifter.—See **Plate Lifter.**

Light.—Light has been defined as the mechanical effect produced upon the extension of the optic nerve, which forms the sensitive surface of the retina. We do not know what it is, or why it makes objects visible and appear of different colours, or why it produces chemical changes in various substances. Although the causes remain a mystery we know the effects, and a study of these is of the highest importance to the photographer. In the limited space at our disposal it will only be possible to deal with the most important points, but the study of reliable works on the subject is strongly recommended.

Two leading hypotheses regarding the nature of light have been put forward. The first was known as the emission or corpuscular theory. This theory of the propagation of light, although sup-

ported by the names of Newton, Laplace, and Bist, has been abandoned, and the second, or undulating theory, has taken its place. This latter assumes the existence of an extremely subtle elastic medium, filling all the space of the universe, termed the "luminiferous ether," the undulations of which constitute light, and, when they impinge upon the retina, produce vision. These undulations will be more clearly understood by the following experiment:—In a still pond throw a stone; waves are produced in circles or rings, which proceed from the spot where the stone struck the water, widen out, and as they extend become gradually less and less, until they finally disappear. If several little stones be thrown in at different parts of the pond, each will have its own system of undulating waves. These, although intersecting each other in the most complicated manner possible, will not be found to interfere with each other at all, and although a confused mass of circles appears, yet on close examination every circle will be found to widen out regularly from its own centre, without the slightest interference from the countless other circles. Another feature of this remarkable undulating motion is that the water itself appears to proceed outwards from the central point. But this, however, does not happen, as can be proved by throwing a few pieces of paper on to the water, when they will dance up and down upon the little waves without moving from the spot. Correctly speaking, the paper at any point moves in an elliptic orbit, each particle moves in a similar orbit to its predecessor; but a little later this movement being communicated further and further, and thus what we term the "wave" is propagated.

In precisely the same manner light spreads in undulations from a luminous body through the ether. The undulating movement is termed a ray of light, and we perceive it as soon as it reaches our eye. Recent microscopical researches have shown that the retina of the eye is studded with very fine rods, and although not yet clearly understood, it is supposed that this is the true method of vision. The wave of light strikes these rods, and the optical image, or the retina, is transformed to consciousness in the brain.*

Several methods of calculating the velocity with which light is transmitted are known, this is stated to be about 186,000 miles per second. It will be seen, therefore, that the time occupied in traversing terrestrial distances is too small to be appreciable, unless by specially constructed apparatus. It is interesting to note that the nearest fixed star being probably about 200,000 times farther away from this earth than the sun, it becomes visible to us now by the light which left it rather more than three years ago. Taking into consideration the high velocity of light, some slight idea can be gathered from this of the vastness of the universe.

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*See Wright's "Light and Experimental Optics."

In any homogeneous medium light moves in straight lines until obstructed or deviated from its course by some body. All bodies are either transparent, translucent, or opaque. Transparent or diaphanous bodies are those through which light passes easily; translucent bodies are those through which light passes less easily, being partially reflected; and opaque bodies are those through which light cannot pass at all.

When light falls upon the surface of a body part of it is reflected. If the surface of the body be smooth and polished the eye, if placed to receive the reflected rays, will generally observe an image of the illuminant, and the body may be termed a mirror. If, however, the same be not smooth, the light falling upon it is scattered in all directions, so that the surface itself becomes visible; while a portion of the light is reflected a part enters to a certain depth, or, in other words, is absorbed. A ray of white light is, we know, composed of all the colours of the spectrum. Certain bodies have the property of absorbing some of these colours and reflecting others, and so we get the phenomena of colour. For instance, a body which absorbs all the primary colours but blue will appear blue, one that absorbs all the colours and reflects none will appear black, and one that absorbs none will appear white.

If light falls almost vertically on to a glass surface very little of it is reflected, but as the angle of incidence is increased the greater becomes the proportion of light reflected. The law of reflection was known to Archimedes, it is that the incident and reflected rays make equal angles with a perpendicular to the surface, and lie in the same plane with it, thus the angle of incidence is equal to the angle of reflection. (See **Reflection.**)

When a ray of light passes from one transparent medium to another, unless perpendicular to the surfaces of both, it is bent aside or refracted at that point where it enters the new medium. This refraction of a ray of light, when passing from one medium, such as air, into another such as water, is subject to a particular law. This law of refraction, which was known as far back as the 17th century, is this—whatever be the obliquity of a ray passing from one medium to another, the sines of the angles made by the incident and refracted rays, with the perpendicular to the refracting surface are in constant ratio. The power of refraction is termed the index of refraction, and differs for every different substance, but remains always the same for one particular substance. Refraction only occurs at the surface of transparent media. (See **Refraction.**) The mathematical applications of reflection and refraction is termed optics. A ray of light, which is refracted through a medium, having parallel surfaces, will have the same direction on leaving as on entering, and if traversing two media having parallel surfaces, but differing in their refractive indices it will emerge in a direction parallel to the incident ray. Newton discovered that red light is not refracted so much as blue

light in passing from one medium to another If a ray of light be refracted by means of a prism, it is separated into a number of different coloured rays ; these rays may be thrown upon a screen, and will produce a band of colours termed the spectrum. These coloured rays may be passed through another prism, and will combine to form a ray of white light again.

Young showed* that two rays of light may destroy each other's effects and produce darkness. He applied this discovery to the explanation of many natural phenomena, such as the colours in mother-of-pearl on soap bubbles, etc. When a ray of light enters Iceland spar it divides into two rays, which travel in different directions, and possess peculiar properties not exhibited by ordinary rays of light, and are said to be polarised. These polarised rays cannot be made to interfere or destroy each other, but either may be divided into two interfering rays.

Newton, in his experiments with solar light, discovered that the blue and green rays of the spectrum very slightly affect the thermometer, the yellow rays somewhat more, while the extreme red rays possess great heating properties, and, further, when the thermometer was passed beyond the red into the space where no luminous rays existed, the maximum heating effect was produced.

In photography we find that the red and yellow rays havethe least amount of chemical effect upon sensitive substances, while the blue and violet rays exercise a rapid chemical action.

Before concluding these remarks on light, it will be important to photographers to consider the important part that light plays in the formation of the image. If the lens be removed from the camera, and a piece of tin-foil placed over the opening, an experiment may be made thus. In the tinfoil make a small pin-hole. Immediately we have an inverted image on the ground glass screen of the object in front. Why ? Because every straight ray proceeding from the object marks its colour on the screen, and the sum of all these rays will therefore be an image of the object. Now, as these rays all cross each other at the hole, the image must necessarily be inverted. If a dozen pin-holes be made we get a dozen images, if a thousand, a thousand, and so on. The images will, of course, overlap each other more and more. Although the image produced by a pin-hole possesses perfect depth of definition and freedom from distortion, except that produced by the image being thrown on to a plain screen, yet photographically it is of little use, owing to the impossibility of obtaining sharpness of definition and sufficient brilliancy of illumination. The pin-hole is therefore replaced by a lens. The manner in which these are constructed and the choice will be found under **lens.** (See also **Pinhole Photography, Latent image,** etc.)

Light Fog.—See **Fog.**

*See Blackie's "Modern Cyclopædia."

Lightning Photographs.—Very successful photographs of lightning discharges have been made, showing the peculiar irregular course taken by the electric fluid, so unlike the conventional zig-zag of the artist. No special apparatus is required, the photographs being made at night, the lightning exposing itself. The camera is merely placed in a suitable position, a plate inserted, and the lens uncapped to wait for a discharge. Notwithstanding the fact that scientists tell us that the lightning flash takes place in an incredibly small portion of a second, yet if the camera be moved during the visible duration of the flash a blurred image will be obtained. It should therefore be kept perfectly steady.

Lignin.—Synonymous with **Cellulose** *(q.v.)*

Lime, Chloride (Formula doubtful, general y written CaCl.OCl; synonyms, *Chlorinated lime*, *calx chlorata*, and *bleaching powder*). —Prepared by passing chlorine gas into leaden or stone boxes, in which a quantity of moist slaked lime has been spread out on shelves. The lime absorbs nearly half its weight of chlorine, forming a white powder having a peculiar smell. The temperature during the process of manufacture is not allowed to get higher than 77° F. This is ensured by acting on the fresh lime with chlorine diluted by air.

Its uses in photography are based upon the fact that the chlorine which it contains is in an easily available form, and may be liberated by any acid. It is also used in the preparation of zinc hypochlorite (used as a hypo-eliminator), and in toning. It decomposes by keeping, and old or moist samples should, therefore, be rejected.

Lime Light.—See **Oxyhydrogen Light.**

Lime Wash.—Many photographers coat the glass roof of the studio with a wash of lime, which has for its purpose the softening of the light, and keeping the chamber cool. A wash for this purpose must be made to resist the action of rain, which can be simply done by mixing the lime with buttermilk instead of water. Whitewash made with size, and containing half a pint of boiled linseed oil to every ten gallons of water, is very good for the purpose.

Instead of lime, however, sulphate of baryta can be used. This is soaked in water for a day, and then add one part of fresh glue size and one part of boiling water. One drachm of sodium bichromate is then added to each quart. When mixed to the consistency required, it may be applied to the roof with a large whitewash brush. The slight yellowish appearance at first observable will soon wash out.

Linseed Oil.—The oil obtained from the seeds of the flax,

either by pressing when cold, or by heating to about 200° Fahr. It is of a pale to dark yellow colour, with a sp. gr. of about 0·93. It is largely used in the manufacture of printing inks, &c.

Lip or Mouth Glue.—A convenient portable cement of considerable adhesiveness. Four ozs. of the very best glue and one oz. of isinglass are soaked in water until quite soft. The water is then poured off, and one oz. of brown sugar added. The whole is melted stirred well together, and allowed to evaporate until quite thick. It is then poured on to a flat bottom dish, preferably placed on ice, to prevent the glue sticking. When quite solid it is cut up into cakes. This glue only requires wetting with the tongue to be very useful for various purposes.

Liquid Glue.—See **Glue.**

Liquid Ammonia.—See **Ammonia.**

Litharge (From Gr., *lethos*—a stone, and *arguros*—silver).—Protoxide of lead, PbO. A heavy, yellow powder, usually obtained by oxidation of the metal in a current of air.

Litharge is much used as a dryer in painting. Dark-red coloured is called litharge of gold, and the paler-coloured variety, litharge of silver.

Sutton, in his "Dictionary of Photography," says: "Water which has been filtered through litharge increases the energy of the developer which is dissolved in it, but this should be used immediately, for it will not keep. There is also danger of its producing fog upon the plate."

Lithium (Symbol, Li.; atomic weight, = 7).—A comparatively rare metal, chiefly obtained from the minerals *lepidolite* or *lithia mica*, which contains silicate of alumina and potassium and lithium fluorides, and from *petalite*, containing silicate of soda, lithia, and alumina. In a hot spring in the Clifford mines, in Cornwall, the water contains 26 grains of lithium chloride per gallon.

Lithium is the lightest solid body known, having a density of only 0·5936.

Lithium Bromide (Formula, LiBr; molecular weight, = 87).—Prepared by direct combination of lithium and bromine. It is very soluble in water and alcohol, and is sometimes used in the preparation of bromide emulsions.

Lithium Chloride (Formula, LiCl; molecular weight, = 42·5).—Occurs in mineral springs. It may be prepared by dissolving lithium in hydrochloric acid. It is one of the most deliquescent substances known.

Lithium Iodide (Formula, LiI ; molecular weight, = 134).—Prepared by the combination of lithium and iodine. It is very soluble in both water and alcohol.

Lithography.—See **Photo-lithography.**

Litho-photogravure.—A photo-mechanical printing process, invented by Carl Eckstein, of Hague. A lithographic stone is polished with oxalic acid and water, and then covered by means of a roller very evenly with a diluted asphaltum solution, prepared by boiling asphaltum five parts, white wax six parts, and stearine six parts, and adding to this two parts of soda solution, dissolving the whole after cooling in turpentine oil, filtering, and keeping in well-stoppered bottles. The thin film is then scratched with a diamond in very fine lines, ruled with a machine from about the $\frac{1}{26}$th of an inch apart, while the stone is evenly covered with them. An etching liquid is next poured over the stone, consisting of one-sixth part of pure nitric acid, six parts of alcohol of 36°, and 350 parts of distilled water. After half a minute the stone is rapidly washed, dried, oiled, the asphaltum washed off with turpentine, and then inked up ; it is then ready for the transfer, which is then applied, and the subsequent operation resembles the ordinary process of photo-lithography.

Litmus or **Lacmus.**—A blue vegetable colouring matter procured from the *Roccella tinctoria* and other species of lichens by fermentation with potash. It is obtained commercially as small cakes like chalk.

Litmus Paper.—Unsized paper steeped in tincture of litmus, and made up in small books. The blue colour of the paper is changed to red by an acid, and again becomes blue when mixed with an alkali. This property is very useful in chemical operations to test the alkalinity or acidity of a solution. According to Dr. Otto Foerster* commercial litmus of bes. quality is first extracted from ordinary alcohol in the cold, then digested with water, the solution filtered and evaporated. This is a combination of the processes proposed by Wartha and Mohr. The residue is again dissolved in water, the solution filtered, and the filtrate precipitated with absolute alcohol mixed with a little glacial acetic acid. The precipitate is collected upon a filter and washed with alcohol. This causes a violet fluorescent colouring matter to remain in solution. The remaining residue is once more dissolved in water, and the precipitation, filtration, and washing repeated. At this stage a red colouring matter, which has a violet tint in an alkaline liquid, remains in solution. After once again repeating this process only a small

* "Zeitschrift für anal chem, 1889."

amount of the last-named colouring matter remains in solution. The precipitate upon the filter is then dried, being repeatedly moistened during the drying with alcohol for the purpose of expelling the acetic acid. The precipitate is then again dissolved in water, and the solution filtered. Finally, the colouring matter is precipitated with alcohol, rendered faintly alkaline with ammonia, then collected upon a filter, washed with pure alcohol, and dried.

Liver of Sulphur.—See **Potassium Sulphide.**

Long Focus Camera.—(See **Camera.**)

Luminiferous Ether.—A hypothetical medium of extreme tenacity and elasticity supposed to be diffused throughout all space, as well as among the molecules of which solid bodies are composed, and to be the medium of transmission of light, heat, etc.

Luminous Paint.—A phosphorescent luminous paint, consisting of 100 parts by weight of carbonate and phosphate of calcium, obtained by calcining sea shells* mixed well up, 100 parts of pure lime and 25 parts of calcined sea salt, both measured by weight. Half the amount of the whole weight of sulphur is then incorporated by sublimation, and from five to eight per cent. of mono-sulphide of calcium or barium.

Balmain's luminous paint is a phosphorescent substance incorporated with a colourless varnish. The following directions for the manufacture of a luminous paint were recently given by a correspondent in *Photography*:—"This substance is a calcium sulphide, and is easily prepared by cleaning thick oyster shells and then burning them until they are red-hot; when cool, roughly pound them and pick up all the black and dark pieces. When fairly clear, pound fine and place a layer of about half-inch thick in a suitably sized fireclay crucible, and then a layer of same thickness of flour of sulphur, then another of oyster shell ash, then sulphur, and so on until the crucible is filled to within one and a half inches of the top. Fill this space up with well-worked clay, and allow it to dry in a warm place; when dry, place the crucible and contents in the fire, and when a low blood red, endeavour to keep it at that for at least 60 minutes. Two hours would be better if the clay luting is done well. Allow it to cool slowly and then turn out the contents and pound to a powder. This will give you a very bright blue luminous paint. If wanted for use as a water-colour, by the addition of gum senegal dissolved in water, or if for outside use, copal gum dissolved in turps and one-fifth the bulk of poppy oil added. The poppy oil is to prevent it cracking. If it is to be applied to iron, the iron *must* be painted first with an oxide of iron paint, or the luminous paint will soon lose its luminosity."

* Those of the genus *Tridacna* are most suitable.

Luminous Photographs.—The late W. B. Woodbury used to make what he termed luminous photographs by exposing a piece of cardboard, coated over with a luminous paint, under a glass positive. The effect in the dark was very striking, a brilliant phosphorescent picture being the result.

Lunar Caustic.—See **Silver Nitrate.**

Machinery, Photographing.—To obtain a good photograph of a machine it is usually painted with a paint, which dries with a dull surface. This is composed of the following:—

Dry white lead	5 pounds.
Lamp-black	2 to 5 ounces.
Gold size	1 pint.
Turpentine	1½ pints.

The quantity of lamp-black added is varied to suit the machine or lighting. This paint is applied in the ordinary manner, and after photographing it may be removed with a rag soaked in turpentine. The object of its use is principally to avoid high reflections and consequent halation.

Macro-Photography.—A term sometimes used to denote the enlargement of the negative.

Magdala Red.—See **Naphthalene Red.**

Magic Lantern.—See **Optical Lantern.**

Magic Photographs.—A process for making these was first pointed out by Sir John Herschel. Prints on albuminised paper were first made and fixed without any toning. They are then washed thoroughly and immersed in a saturated solution of perchloride of mercury. The action of this solution is to bleach the image until it becomes of the same colour as its paper support. It then becomes invisible, and is washed and dried. By simply laying a piece of damped blotting paper, previously soaked in saturated solution of hyposulphite of soda, the image will instantly re-appear, far brighter than before. It can then be washed, and a fairly permanent image obtained. These invisible images may also be developed by ammonia or by tobacco smoke. Some years ago a little novelty was brought out in Paris. It consisted of a cigar, or cigarette tube, having a hollow chamber, through which the smoke passed. Small pieces of paper, on which were invisible images, manufactured as above, were then placed in the smoke chamber, and after smoking a cigar or cigarette, the picture, fully developed, was removed. Owing to the nature of these Parisian studies, however, many of them were better had they remained in the latent state.

Magilp or **Megilp.**—A gelatinous compound used by artists for thinning oil colours and for glazing delicate tints on finished paintings. It is made by mixing linseed oil and mastic varnish together, the proportions varying according to the work. It is thinned with turpentine.

Magnesic Chloride (Formula, $MgCl_2$).—Occurs in sea water, or may be prepared by dissolving magnesia in hydrochloric acid. It is a white, crystalline powder, with a sharp, bitter taste, soluble both in alcohol and water.

Magnesic Sulphate (Formula, $MgSO_4 7H_2O$; molecular weight, = 246; synonym, *Epsom salts*).—Found in sea water and in many natural springs. It is, however, usually manufactured in large quantities by dissolving magnesian limestone in dilute sulphuric acid, and filtering from the insoluble calcio sulphate. It is soluble in water, and has a nauseous, bitter taste. It has been recommended as a preventative of frilling in the gelatine process.

Magnesium (Symbol, Mg.; atomic weight, = 24).—The metallic base of magnesia. It occurs in large quantities as dolomite or mountain limestone. It may be obtained by decomposing magnesium chloride and potassium. The metal is of a white colour like silver, it is very malleable and fuses at a red heat. It is sold commonly in the form of wire ribbon and powder.

Magnesium Flashlight. — A flashlight produced by suddenly igniting magnesium powder. Under **Flashlight** is described an instrument for producing flashes.

Magnesium Light.—An artificial light produced by burning magnesium wire or ribbon on a suitably constructed apparatus. The magnesium light is very rich in chemical rays, and is for this reason often employed in photography, in making exposures at night or in dark places.

Magnifier.—A convex piece of glass or a lens having the property of magnifying. A magnifying glass will often be found useful in obtaining sharp definition of the image upon the focussing screen. Mounted for this purpose it is usually termed a focusser (*q.v.*)

Malic Acid (Formula $C_2H_3.OH(CO_2H_2)$; synonyms, *hydroxy-succinic acid*).—This was discovered by Scheele about the year 1785. It is very widely diffused throughout the whole vegetable kingdom, and may be found in abundance in nearly all garden fruit and plants. It is chiefly extracted from the juice of the unripe berries of the mountain ash. Malic acid appears commercially as colourless, shining needles, these are odourless, with a sour taste

and soluble in alcohol. It yields neutral and acid salts. It is sometimes used in photography as a preservative of silver nitrate. Sensitive albuminised paper, floated on a weak solution of malic acid, will keep for a great length of time.

Manganese Binoxide (Formula, MnO_2; molecular weight, 86; synonyms, *manganic dioxide*, *black oxide of manganese*).—A neutral substance occurring in nature as the ore of manganese, a black crystalline powder. It is made up into cakes, and used for the production of oxygen for the limelight.

Marbled Prints.—A defect in printing, caused by the use of a too weak sensitising solution, or to the paper having been floated for too short a period. It may also arise from imperfect albuminising. The prints appear peculiar, unevenly marked, somewhat resembling the appearance of marble.

Marine Glue.—A useful composition for mending various substances, and for cementing pieces of glass together to make glass baths. It can be made as follows:—Digest from 2 to 4 parts of indiarubber, cut up into small pieces, in 40 parts of benzole, and cause them to dissolve by the application of heat and occasional agitation. The solution thus formed should have the consistency of thick cream. Next add 80 parts of powdered shellac, and melt the mixture on a slow fire, constantly stirring. When melted and thoroughly mixed it is poured out on to metal plates to allow it to cool in sheets. When required for use it is melted at about 250° in an iron pot, and with a brush it is applied to the surfaces to be joined. As soon as it has become hard it is moistened with benzole and the pieces pressed well into contact.

Marsh Gas.—A name given to light carburetted hydrogen (CH_4).

Masking.—A device often adopted in printing from imperfect negatives. In many the sky prints too deeply. A mask cut to the outline of the sky is laid on the negative, the edge slightly raised from the surface. This will give a graduated sky. Parts of the negative that print too deeply may be improved by pasting small pieces of tissue paper to the reverse side of the negative. (See also **Printing**).

Masks and Discs.—Pieces of opaque paper used in printing. Out of the paper various shaped openings are stamped. The piece thus cut out is called a disc, and the margin remaining the mask. If the opaque mask be placed between the negative and the sensitive paper, the picture will naturally be of the same form as the opening from whence the disc was cut out, the remaining parts of the paper being white. Prints may be finished in this manner, and,

with some subjects, have a very neat appearance. Or they may be further altered by laying the disc over the printed part and colouring the margin by exposure to the light, either to a light shade or to a deep black colour.

Mastic.—A resinous oxidation drawn from the *Pistacia lentiscus*. It contains about 90 per cent. of a resin, readily soluble in alcohol, used for the manufacture of varnishes. Large quantities comes from the Levant in the shape of drops or tears of a yellowish-white colour. It is insoluble in water, but soluble to the extent of about 90 per cent. in alcohol, ether, chloroform, oil of turpentine, and benzole. The residue is a viscid and difficultly soluble resin. (See **Varnishes**).

Matt Paper Prints.—Prints made upon a matt surface paper present a very artistic appearance.

The paper is first coated with

Water..	20 oz.
Simeon's gelatine	160 gr.
White sugar	60 ,,
Ammonium chloride	50 ,,

After the gelatine is well soaked it is dissolved in a warm water bath, and all the other ingredients and about one drachm of barium sulphate added. Stir the solution well up, and add about 6 grains of chrome alum. The whole is then filtered through flannel or chamois leather, and poured into a large flat dish standing in warm water. Immerse the paper in the solution for about five minutes, and then hang up by clips to dry. Several sheets of paper may be immersed at the same time if kept from clinging to each other; air bubbles must also be avoided.

To sensitise, it is floated on the following bath for about a minute or a minute-and-a-half:—

Water..	10 oz.
Silver nitrate	500 gr.

Dissolve and add to five ounces of it strong liquid ammonia until the precipitate at first formed is dissolved. Then add the remaining silver solution and filter.

When sensitising, the paper is hung up to dry in a warm, yellow light room. Any toning bath may be used, those giving black tones are most suitable. The prints must be well washed before and after both the toning and fixing operations.

Very pretty engraving-like effects may be produced by this process if the prints be made on large pieces of paper with a wide margin made by printing under a black mask.

Matt Surface.—A dead or dull surface unpolished by burnishing or by any other means. In an artistic point of view the matt surface presented by a platinotype is far superior to the

brilliant image of a highly polished picture, although for some subjects the latter method is preferable. Gelatine prints, such as bromide or celerotype, may be made to present a matt surface by squeegeeing when in a wet state to a piece of ground glass and removing when dry.

Matt Varnish.—See **Varnish.**

Maximum Thermometer.—A thermometer arranged to indicate the highest temperature attained during the day.

Mealiness.—A defect sometimes observable in silver printing. The surface of the print presents a peculiar mottled appearance. This is generally due to the sensitising bath being too weak.

Measles.—A defect in silver printing. If the prints be held up to the light, opaque and semi-opaque blotches will be observed. These are caused by imperfect fixation by the insoluble hypo-sulphite of silver. If the prints be preserved, these spots will shortly become yellow, due to the formation of silver sulphide. They then present much the same appearance as the human ailment from whence the name is taken.

Measurer, View.—An instrument devised by M. Vidal for measuring the length, breadth, and width of the image reflected on the sensitive plate without the aid of a focussing glass. An instrument similar to that depicted in fig. 151.

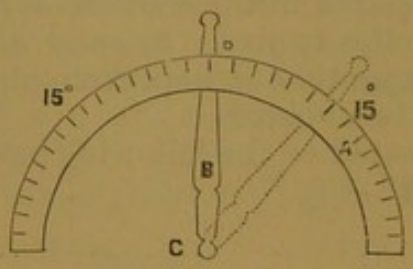

FIG. 151.

A is a brass semi-circle divided into degrees, B the alidade and C the pivot on which the alidade is fixed. The angle of the lens is first noted; supposing this to be 30°, the alidade or hand is moved to the right until it lies upon the 15° of the semi-circle. Now, in looking along it, the operator can easily see what he takes in on the right side of the camera. The alidade is then moved to the left until it lies on the 15°. What will be reproduced upon the sensitised plate can thus be easily seen. In order to find out whether or not too much sky is included, another similar instrument is placed on the side of the camera. (See also **View Finder.**)

Measures.—See **Weights and Measures.**

Measuring Glasses.—Glass vessels used for measuring liquids. In purchasing these it is important to assure oneself of the legibility of the figures with which the glasses are graduated.

In measuring liquids in graduated glasses mistakes may often occur, owing to the fact that the surface of the liquid is not a level plane but has a meniscus curvature, the liquid being drawn up the sides of the glass by capillary attraction. Another point to be observed is that the glass be held perfectly upright; a slight error in this respect will often make a very great difference in the final results.

Narrow, deep, cylindrical vessels give more accurate measurement than conical ones, and are much to be preferred when accuracy is desirable.

Megascope (Gr. *megas*—large, and *skopeo*—to see).—An optical instrument for exhibiting bodies on a large scale.

Meisenbach Process.—A very beautiful process of photo engraving. It is described as follows:—A positive transparency is made of the object, and a transparent plate is hatched or stippled in parallel lines. The two plates are then joined face to face, and a negative made in the usual manner. The negative thus obtained has the appearance of being broken up into minute dots. In order to cross-hatch and break the lines of the shading the stippled plate may be shifted once or twice during the production of the negative. From the negative thus obtained the image may be transferred to zinc, or a lithographic transfer may be made in the usual manner, and the plate subsequently heated with acid to form a block in relief. (See **Photo-engraving**).

Considerable importance is attached to the shifting of the stippled plate, this being specially sought to be protected by the patent.

Other details of the process have been published, but there is no doubt that the correct *modus operandi* is kept a secret by the patentees.

Melainotype, or Melanotype (Gr. *melanos*—black, and *tupos*—type).—A positive process of American origin, and the name of which is derived from the black colour of the material which supports the picture. Thin sheets of iron are coated on both sides, with a black Japan varnish. One side is very smooth and highly polished. When collodionised, sensitised, and in every way treated as in the collodion positive process on glass these plates give very fair results, and possess the advantage over glass plates, that they are not so easily fragile. This process is almost synonymous with Ferrotype.

Melting Point.—See **Fusion.**

Meniscus (Gr. *meniskos*—a little moon).—A lens convex on one side and concave on the other. The concave side has a curve of greater radius than the convex side, the lens is consequently thicker in the centre than anywhere else. (See **Lens.**)

Menstruum.—Any fluid or sublitised substance which dissolves a solid—a solvent.

Mercuric Chloride (Formula, $HgCl_2$; molecular weight, 271; synonyms, *perchloride of mercury*, *bichloride of mercury*, *sublimate*, *corrosive sublimate*, *muriate of quicksilver.*)—A white, heavy compound, which can be prepared by heating mercury in an excess of chlorine. Commercially, it is usually manufactured by sublimation, from a mixture of mercuric sulphate and common salt. It takes the form of heavy, colourless, prismatic crystals, sometimes sold in a powdered state. Solubility about 1 in 16 parts of cold water, and about 3 of hot water. It is also soluble in alcohol and ether. It is more soluble in the presence of ammonium chloride. It melts at 510°F. When dissolved in water, it is liable to become decomposed, but the addition of a soluble chloride will effectually prevent this.

Mercuric chloride is a powerful poison. It is readily absorbed by the skin, and being very injurious to it, contact should be avoided as much as possible.

It is used in photography chiefly for intensification (*q.v.*)

Mercurous chloride (Formula HgC; molecular weight, 235·5; synonyms, *subchloride of mercury*, *calomel*, *chloride of mercury*).—A yellowish, white powder, insoluble in water, alcohol and ether. The bleached image in mecurial intensification is composed of chloride of silver and mercurous chloride. On the application of ammonia it is immediately changed to black mercurous ammonium chloride, thus—

$$2HgCl + 2NH_4OH = NH_2Hg_2Cl + NH_4Cl + 2H_2O.$$

If sodium sulphite be used, however, the mercurous chloride is reduced to black metallic mercury,

$$2HgCl + Na_2SO_3 + H_2O = Hg. + Na_2SO_4 + 2HC.$$

Mercury (Symbol, Hg.; atomic weight, 200).—A silvery white metallic liquid, which solidifies at 39° F. It is found native in various parts, but is chiefly obtained by roasting the ore cinnabar (an impure sulphide), which is obtained from China, Spain, America, and other countries. It has a specific gravity of 13·5.

Mercury was formerly used in the daggerreotype process to develop the image. It is due to the accidental discovery of the action of mercury on the exposed plate that Daguerre first succeeded in obtaining light images.

Mercury Perchloride.—See **Mercuric Chloride.**

Mercury Sub-chloride.—See **Mercurous Chloride.**

Meta-bisulphite of Potash.—See **Potassium Meta-bisulphite.**

Metagelatine.—Gelatine, if heated and then allowed to cool, and this process repeated several times, will cease to gelatinise on cooling, and will remain in a fluid state. It is then termed metagelatine. It was formerly used as a preservative in the collodion process. It dries to a hard transparent film upon collodion. If used as a preservative a little gold syrup must be added.

Metallic Spots.—Small black spots which make their appearance in albuminised and other papers when sensitised with silver. These spots, due to small peices of metal embedded in the paper, are usually quite imperceptible until the silver solution is applied, when a combination takes place, and the spot appears quite black. This metal dust sometimes gets into the paper when it is rolled between metal rollers. The purest photographic paper now manufactured is rolled between very hard paper-pulp cylinders.

Metal Slides.—Dark slides made of sheet metal. They are very light and strong, and offer considerable safety against extraneous exposure.

Meterological Photography.—Photography has already become an invaluable aid to the meteorologist in the preservation of accurate records, or of extraordinary phenomena. According to the latest statistics the following are the principle observatories at home and abroad where photographic-recording meteorological and magnetical apparatus is in action at the present date.

Great Britain and Ireland.—Aberdeen, Falmouth, Glasgow, Greenwich, Kew, Oxford, Stoneyhurst, Valentia. *Colonial:* Adelaide, Bombay, Hong Kong, Mauritius, Melbourne, Sydney, Toronto. *Foreign:* Batavia, Brussels, Coimbra, San Fenando, Lisbon, Lyons, Madrid, Nantes, Nice, Paris, Perpignan, St. Petersburg, Utrecht, Vienna, Washington, Wilhelmshaven, Zi-Ka-Wei.

The instruments now employed at Kew Observatory, in which photography plays an important part, are thus given by Whipple.

1. Beckley's modification of the Jordan-Ronalds Carograph.
2. Beckley and Stewart's modification of the Brooke-Airy thermograph.
3. Welsh and Beckley's improved Guass-Brooke magnetographs.
   a. The declination magnetometer.
   b. Bifilar or horizontal force magnetometer.
   c. Balance or vertical force magnetometer.

4. Stokes's form of Campbell's sunshine recorder.
5. Jordan's form of sunshine recorder.
6. Whipple's modified Abney's photo-nephograph.

According to the same writer the waxed sensitised paper previously used has almost entirely been discarded in favour of argento-bromide gelatine paper.

In Jordan's sunshine recorder the cyanotype process is employed. A strip of this paper is fitted into a brass box, and the light of the sun passes through a fine slit in the box and falls upon it. After exposure the paper is developed and fixed in clean cold water (see **Cyanotype**), and we obtain a blue trace on the paper, the intensity of which roughly indicates the amount of solar influence upon this earth. A pair of these boxes, semi-cylindrical in form, are fixed back to back upon a frame which is directed to a position parallel to the equator of the station.

An instrument worthy of note here is the photo-nephograph, or system of cloud cameras. By means of this, instantaneous photographs of a cloud can be made from two or three stations simultaneously, the stations being situated at a distance of between half-a-mile to three miles from each other.

The photographs thus obtained are used for determining the position of the clouds above the earth's surface, and from this information regarding the higher air currents can be obtained. The direction and motion of the latter can be determined at heights far exceeding those at which anemometers could be placed.

At Kew, according to Whipple, two cameras are fitted to theodolites erected on stands, half-a-mile apart, but electrically connected by a buried telegraph wire. Each camera is fitted with an adjustable instantaneous shutter, which can be liberated by an electric current at the will of the operator directing, who first points his camera in the direction of the cloud selected to be photographed, and after having instructed the operator at the other station by means of a telephone, as to the direction of his camera, he releases both shutters at the same instant.

Very slow gelatine plates are used, prepared after Capt. Abney's formula.

Methylated Alcohol.—See **Alcohol.**

Methylated Ether.—See **Ether.**

Methylated Spirit.—See **Alcohol.**

Metre (Fr. *mètre*).—A French measure of length equal to 39·3707898 inches, or about 3·2809 feet. The standard of linear measure being the ten millionth part of the distance between the Equator and the North Pole as determined by actual measurement of an arc of the meridian. (See **Metric System.**)

Metric System.—The system adopted by the French Convention in 1795, but which is gradually coming into use in this and other countries. The theory of the system is that the metre is a 10,000,000th of a quadrant of the earth through Paris, the litre is a cube of $\frac{1}{10}$th metre, the gramme is $\frac{1}{1000}$th of the litre filled with water at 4°C.

The names of the graduations below the unit are formed from the Latin, and those above the unit are formed from the Greek, the unit being one.

Myria	10,000
Kilo	1,000
Hecto	100
Deka	10
	1
Deci	0.1
Centi	0·01
Milli	0.001

The Greek for multiples and the Latin for fractions.

Measures of Length.

Myriametre	10,000 metres	6·2137 miles
Kilometre	1,000 ,,	·62137 mile
Hectometre.....	100 ,,	328 feet and 1 inch
Dekametre	10 ,,	393·7 inches
Metre	1 metre	39·37 ,,
Decimetre	0·1·1 ,,	3·937 ,,
Centimetre	0·01 ,,	·3937 inch
Millimetre	0·001 ,,	·0394 ,,

1 inch = 2·539954 centimetres
1 foot = 3 0479449 decimetres
1 yard = 0·91438348 metre
1 mile = 1·6093149 kilometre

Measures of Surface.

Hectare .... 10000 sq. metres .... 11550 sq. inches = 1·1960 sq. yds.
Are ..... 100 ,, ,, ... 119·60 sq. yds.
Centiare .... 1 sq. metre .... 11960·33 ,, ,, = 2·471 acres.

1 square inch = 6·4513669 square centimetres.
1 square foot = 9·2899683 ,, decimetres.
1 square yard = 0·83609715 ,, metre.
1 acre = 0 40467102 hectare.

Measures of Volume.

Kilolitre or stere	1000 litres	1 cubic metre
Hectolitre	100 ,,	0·1 ,, ,,
Dekalitre	10 ,,	10 cubic decimetres
Litre	1 litre	1 ,, ,,
Decilitre	0·1 ,,	0·1 ,, ,,
Centilitre	0·01 ,,	10 cubic centimetres
Millilitre	0·001 ,,	1 ,, ,,

Also equivalent to

61028·	cubic inches
6102 8	,, ,,
610 28	,, ,,
61 028	,, ,,
6·1028	,, ,,
·61028	,, ,,
·061028	,, ,,

Gals.	*Pints.*	*Oz.*	*Dr.*	*Minims.*
220	0	16	6	40
22	0	1	4	49
2	1	12	1	16·9
0	1	15	1	43·69
0	0	3	4	10·36
			2	49
			0	16·9

Weights.

Millier or tonneau	1000000	grammes	2204·6	lbs. Avdp
Quintal	100000	,,	220 46	,, ,,
Myriagramme	10000	,,	22·046	,, ,,
Kilogramme or kilo	1000	,,	2·2046	,, ,,
Hectogramme	100	,,	3 215	oz. troy
Dekagramme	10	,,	0·3215	,, ,,
Gramme	1	gramme	15·43234	grains
Decigramme	0·1	,,	1·543234	,,
Centigramme	0·01	,,	0·1543234	,,
Milligramme	0·001	,,	0·01543234	,,

1 grain = 0·06479895 gramme.
1 lb. avoirdupois = 0·45359265 kilogramme.
1 oz. troy = 31·103496 grammes.
1 cwt. = 50·80237689 kilometres.

The unit of area is a square whose side is 10 metres. It is called an are, and is equal to 100 square metres, or about two acres. The unit for the measure of volumes is a cube whose edge is $\frac{1}{10}$ of the metre, that is, a cube whose edge is 3·937 inches. It is called a litre or liter, and is the $\frac{1}{1000}$ part of a cubic metre.

The unit of weight is the gramme, which is the weight of one cubic centimetre of pure rain-water weighed in a vacuum at a temperature of 39·2° Fah., which is about the temperature of maximum density. In practice the term cubic centimetre, written in abbreviated form c.c., is used instead of millilitre, and cubic metre instead of kilolitre.

Tables for the Conversion of Grammes (or Cubic Centimetres) into Ounces and Grains.

Conversion of Grams into Grains.

Grammes.	Grains.
1	15.432
2	30,864
3	46,296
4	61,728
5	77,160
6	92.592
7	108 024
8	123.466
9	138,898

Conversion of Grains into Grams.

Grains.	Grammes.
1	.0648
2	.1296
3	.1944
4	.2592
5	.3240
6	.3888
7	.4536
8	.5184
9	.5832

CONVERSION OF GRAMMES INTO TROY OUNCES.

Grammes.	Troy Ounces.
1	.03215
2	.06430
3	.09645
4	.12860
5	.16075
6	.19290
7	.22505
8	.25720
9	.28935

CONVERSION OF GRAMMES INTO AVOIRDUPOIS OUNCES.

Grammes.	Avoirdupois Ounces.
1	.03527
2	.07054
3	.10581
4	.14108
5	.17635
6	.21162
7	.24689
8	.28216
9	.31743

The above tables render the conversion of the weights in question a matter of great ease, the error introduced in the last decimal place being trivial.

The use of the tables will be best illustrated by an example. Supposing that it is desired to find the equivalent in grains of 281·61 grams, we proceed by breaking up this number into the following series of constituent parts, and finding the grain-equivalent of each part from the table:—

Portions of original number.	Equivalents in grains.
200	3086·4
80	1234·66
1	15·432
·60	9·2592
·01	·15432
	4345 90552

The required quantity is 4345·9 grains. The numbers taken from the table will, in most cases, require a change as regards the position of the decimal point; thus, to find the value of 200 grams, one refers to the table, and finds 30·864 given as the equivalent, and a mere shifting of the decimal point two places towards the right multiplies this by 100, or gives the required number. In a similar manner, by shifting the decimal place of 123·466 one place to the right we obtain the value in grains of 80 grams; while the number 154·32 is taken from the table without alteration as the equivalent of 1 gram. For ·60 the table number must have its point shifted on to the left, making it 9·2592 instead of 92·592; and finally, the value of ·01 is obtained by shifting the point of 15·432 two places to the left.

Mica.—A mineral of a foliated structure, consisting of thin flexible laminæ or scales, having a shining, pearly, and almost metallic lustre. It enters into the composition of the crystalline rocks. Owing to its peculiar transparency and flexibility it has often been used in place of glass, especially in places where it is subjected to great heat, which has no immediate effect upon it; for instance, in the windows of stoves and lanterns, in chimneys for lamps, as a substitute for glass in silvered reflectors, which are exposed to great heat.

Various attempts have been made to use it as a substitute for glass in photography, but these have been unsuccessful, owing to its peculiar property of splitting up into fine sheets, some of which are not more than the $\frac{1}{500,000}$ part of an inch thick.

Dark-room lamps having chimneys of mica, coloured with a suitable red varnish, will be found very serviceable, and can be carried about with safety without fear of cracking.

Micro-photography.—The production or reproduction of positives in a very minute size, requiring the aid of a microscope or powerful magnifying glass to examine them. This term is often erroneously confounded with photo-micrography—the product of photographic images of microscopic objects.

Micro-photographs were at one time exceedingly popular, and are still sold at seaside and other holiday resorts, usually fixed behind a small magnifying glass in some fancy article such as a penholder or a paper-knife. The collodion process is generally employed in their manufacture. An apparatus that will be found cheap and convenient is the following, a description of which is given in Sutton's "Dictionary of Photography." It was devised by Mr. Hislop, and consists of a rigid mahogany board of about three and a half feet long and six inches wide. At one end there are two uprights, between which a miniature camera fitted with a one inch microscopical objective, can be raised up or down so as to place the centre of the lens opposite the centre of the negative whatever may be its size. The object glass is screwed to a brass tube projecting from the camera towards the negative, the tube being fitted with stops of different sizes. A micrometer head for fine adjustment of the lens is also necessary, because microscopic objectives are only corrected for visual rays. In focussing, the best glass is one coated with collodion, sensitised and washed. The sharpest visual image must be found with a powerful magnifying glass, and the chemical focus ascertained by repeated trials. When once found, it will be the same in every case, provided the negative is placed at the same distance from the objective. The negative itself is placed in a frame, at any required distance, on the long mahogany board, but its plane must be perpendicular to the axis of the tube holding the negative. Illumination may be either natural or artificial, but must, of course, pass through the negative.

The collodion used for making the sensitive plates must be absolutely free from structure, or the images will have a disagreeable reticulated appearance when examined under the microscope. For the same reason a pyro developer should be used, instead of the protosulphate of iron, as the former gives a much finer silver deposit.

Another process that may be employed is the collodio-albumen.

Middle Distance.—The central position of a landscape, also called *middle-ground*.

Military Photography.—Photography was employed for military purposes as far back as 1854, when, during the Crimean war two army officers were specially instructed for the purpose in the wet and dry collodion processes. The results obtained are said to have been so satisfactory as to lead to the establishment of a photographic school at the Royal Engineers' establishment at Chatham, where enlisted men are now taught the principal branches of photography.

The introduction of the gelatine dry plate process has caused photography to be of great assistance for military purposes. Officers reconnoitring carry with them light cameras, with which they make views to accompany the report of the reconnaissance.

The plan of making photographs during their work has already been successfully adopted by engineers so as to convey to those in command accurate information regarding the progress made.

During the Franco-Prussian war homing pigeons were used for the conveyance of letters from the besieged city of Paris. This could hardly have been accomplished without the aid of photography. The messages were all photographed on the collodion films, which were afterwards stripped from the glass. Each film contained not less than 8,000 words, and about twenty or thirty of these were fitted in a small quill tied to the tail feathers of the pigeons. The weight of the whole was less than 15 grains, and did not at all impede the bird in its flight. When these messages were received they were, of course, so small as to be perfectly illegible, but when thrown on to a screen by means of a magic lantern, they could be read with ease.

Photographs were made from captive balloons during the United States rebellion, which showed not only the disposition of the troops, but also the topographical features of the surrounding country. MM. Tissandier and P. Nadar have both been successful in making photographs from a balloon.

The late W. B. Woodbury constructed and patented a balloon camera specially adapted for war purposes. A small balloon only was necessary to carry the camera, which was operated by the officer on *terra firmâ* by means of an electric current passing through the rope that held the balloon captive. By this means photographs could be made showing the positions and movements

of the enemy without risk of life, which was the case when men ascended with the balloon, which was necessarily large, and offered a good target for the enemy.

At the Engineers' School of Photography at Chatham, photographs are made of the various articles furnished for field use, and also all experimental structures, whether in the shape of shields, guns, small arms, wagons, rockets, &c. "The results of firing experimentally against plates of different thicknesses are reproduced and preserved; instructional pictures showing the methods of making guns of different descriptions, and the positions taken up by individual gunners on the issue of the various orders are taken; photographs exhibiting the regulation mode of wearing accoutrements; the precise manner in which the harness of horses is adjusted; the method of packing wagons, and fitting service saddles; the mode in which military tents and equipage are set up, as well as the preparation of pictures of newly-adopted stores and implements are among the duties fulfilled at the department."

There is no doubt that should a great war break out, photography would play a very important part.

Milk Glass.—A semi-translucent glass used in graduated measures and other instruments to contain the scale in order to render it more legible.

Millimetre (Fr., from Lat. *mille* = a thousand, and Fr. *métre*—a metre.)—A French lineal measure, equal to the thousandth part of a metre, or the ·03937 of an inch.

Minim.—See **Weights and Measures.**

Minimum Thermometer.—A thermometer so constructed as to register the lowest temperature during a day or any given interval of time.

Mirror (Lat., *miror*—to behold).—Literally, any glass or polished substance which forms images by the reflection of the rays of light. Mirrors are mentioned in the book of Job (chap. xxxvii., verse 18). Those of the ancient Egyptians were of bronze, several of which are preserved in the British Museum. Mirrors of polished metal are now termed *specula*. The date of the invention of glass mirrors is not known with certainty. From the account of Pliny, it would seem that they had been formerly made at the celebrated glass-houses of Sidon.

Mirrors are either plane, concave, or convex. Plane mirrors represent objects of their natural size, concave mirrors, or those having a hollow surface, collect the rays, reflecting them to a focus in front of the mirror, and consequently enlarge the image of the object. Convex mirrors disperse the rays, and therefore diminish the size of the image of the object. In photography, mirrors are

chiefly used for reflecting light (see **Reflector**) and for reversing (see **Mirror, Reversing.**)

Mirror, Reversing.—A plane mirror arranged at an angle of 45°, and placed close to the lens. The image in this mirror is then photographed, and a reversed image is obtained. (See **Reversed Negative.**) The mirror used for this purpose must be perfectly flat, or the image will be distorted. Ordinary looking-glass will not answer the purpose, as its reflecting surface is at the back, and we get a fairly reflected image from the glass surface as well. (See **Reflection.**)

Mirror Silvering.—The following recipes may be found useful by those desiring to re-silver mirrors or reflectors :—

Martin's Recipe for Glass.

A.

Nitrate of silver	175 grains
Distilled water	10 ounces

B.

Ammonium Nitrate	262 grains
Distilled water	10 ounces

C.

Pure caustic potash	437·5 grains
Distilled water	10 ounces

D.

Pure sugar candy	219 grains
Distilled water	5 ounces

Dissolve and add

Tartaric acid	50 grains

Boil in a flask for ten minutes, and when cool add

Alcohol	1 ounce.
Distilled water to make	10 ounces.

For use, mix together equal parts of A and B and also equal parts of C and D in another flask, then mix the two solutions in the silvering vessel and suspend the mirror face downwards.

H. J. Burton's.

Solution 1.

Nitrate of silver	25 grains.
Distilled water	1 ounce.

Solution 2.

Potash (pure)	25 grains.
Distilled water	1 ounce.

SOLUTION A.

Solution 1 }	
Solution 2 }	equal parts.
Ammonia	to just dissolve the precipitate.
Solution 1	to just cause a discoloration.

SOLUTION B.

Loaf sugar	2700 grains.
Distilled water	20 ounces.
Nitric acid	2 drachms.
Alcohol strong	10 ounces.
Distilled water to make	80 ,,

For use—

Solution A	1 ounce.
Solution B	1 drachm.

Solution A is subject to slow decomposition; Solution B, on the contrary, improves by keeping.

Metal to be silvered must be previously well cleaned with dilute acid, to remove all dirt or grease, then well washed and the following applied with a piece of flannel—

Silver nitrate	55 grains.
Liquor ammonia	60 ,,
Sodium hyposulphite	100 ,,
Prepared chalk	100 ,,
Distilled water	1,000 ,,

Or this—

Silver nitrate	60 grains.
Cream of tartar	120 ,,
Salt	110 ,,
Potassium cyanide	65 ,,

Made up into a paste with chalk and water, and applied with a soft rag.

Moist Collodion Process.—About the year 1854,* Messrs. Spiller and Crookes proposed to keep the collodion moist by the use of a deliquescent salt, *i.e.*, some substance possessing a strong affinity for water and would absorb moisture from the air. The substances experimented with were the nitrates of lime, magnesia, and zinc. The glass plate collodionised and sensitised in the usual manner was immersed in a solution of zinc nitrate and silver nitrate for five minutes. After draining for half-an-hour on blotting paper the plates were ready for use.† Owing to the hygroscope nature of the salt, the plates remain moist, and could be used a week or so after preparation. Nitrate of magnesia was found preferable to zinc nitrate. The plates could also be kept after exposure, but it became necessary to again dip them into the silver bath previous to development.

* See *Philosophical Magazine*, May, 1854. † Harrison's *History of Photography*.

Molecular Weight.—The weight of the smallest particle of a compound that can exist. It is found by adding together the weights of all the atoms of the several elements which have united to form the molecules of the compound body.

Molecule.—The smallest quantity of an element, or of an element or compound which is capable of separate existence, or which can exist in the free or uncombined state.

Monochromatic (Gr. *monos*—single, and *chroma*—colour). —Consisting of one colour only.

Monochromatic Lamp.—A lamp emitting rays of one refrangibility only. By introducing into a colourless spirit or gas flame a tuft of asbestos, saturated with chloride of lithium, sodium or thallium, a red, yellow, or green-coloured light can be produced.

Monocular Vision (Gr. *monos*—alone, and Lat. *oculus*—an eye).—Light with one eye only.

Moonlight Photography.—With gelatine dry plates of extreme sensitiveness it is possible to make photographs by moonlight, only a very long exposure is required.

Mottling.—This defect was at one time usually caused by inequality in the gelatine film, but at the present date dry plates are made all but perfect, and the cause must be looked for elsewhere. In most cases it proceeds from stagnation of the developer.

Mountant.—The substance used for attaching prints to the mount or other permanent support. In the selection of a suitable mountant, it is necessary to avoid any that show any trace of acidity. It should be as simple and as free from foreign matter as possible, otherwise it is likely to have a detrimental effect upon the image, causing it to fade away. Among the many substances used for this purpose, owing to their adhesive properties, may be mentioned flour or starch paste, arrowroot, albumen, indiarubber solution, dextrine, gum, gelatine, glue.

Flour Paste.—Ordinary household flour makes an excellent paste, but is rather liable to acidity. The following recipe for a paste that will not sour is given in "Spon's Receipts":—Dissolve four teaspoonfuls of alum in one gallon of water; when cold, stir in as much flour as will give it the consistency of thick cream, beat smooth, add one teaspoonful of pulverised resin, and 20 drops of oil of cloves, pour the whole into two quarts of boiling water, stirring thoroughly until it is cooked, pour into a glazed earthen vessel, and when cold cover the top with oiled silk, and put in a cool place. When needed for use, take out a portion and soften with warm

water. This will be found very convenient for use at times when only a small quantity of paste is required.

The ordinary method of making a flour paste is to just pour boiling water on to a small quantity previously made into a paste with cold water.

Starch Mountant.—Starch, although much employed as a mountant, should be carefully used. Unless quite pure and fresh it is very dangerous, as it is very likely to become acid and destroy the print upon which it is laid.

It is best prepared by triturating starch with cold water in a mortar, so that it shall be perfectly free from lumps. Boiling water is then poured on slowly, constantly stirring the while until the paste is formed, which will be seen by its increased transparency. The addition of a little alum to the water with which it is prepared will render the paste more permanent. The proportions would be as follows :—Powdered starch two ounces, mixed with two ounces of water, and about 18 ounces of boiling water poured on into which has been dissolved, about 50 grains of powdered alum, and 12 drops of carbolic acid.

Another formula is: Starch, 2 ozs.; white glue, 1 oz.; acetic acid, ½ oz., and a few drops of oil of cloves. The glue is first soaked in cold water, melted, and boiled, and while boiling the starch mixed with cold water is added.

Arrowroot Mountant.—This is made by dissolving with the aid of a gentle heat—

Arrowroot	300 grains
Gelat ne	300 ,,
Distilled water	6 ounces

When cool add—

Methylated spirit	5 drachms
Carbolic acid	6 or 8 drops

Albumen has been recommended as a mounting medium. The method of preparing a solution will be found given in the directions for preparing albuminised paper.

Gum is a very adhesive medium. A pale-coloured gum arabic is used. Take about four ounces, and dissolve it in about eight ounces of distilled water. If the gum has a dirty appearance it should be previously washed in a little cold water to remove all impurities. When dissolved in the distilled water it can be kept in well-filled bottles tightly corked. If required to be kept for any length of time the addition of a small quantity of salicylic acid will act as a preservative. It will then keep for fourteen or fifteen days. If hot water be used to dissolve quickly its keeping properties are considerably lessened.

Dextrine Mountant.—Formula :—

White dextrine (pure)	1 ounce
Boiling distilled water	3 ,,
Methylated spirit	½ ,,

Pour the boiling water on the dextrine and dissolve. Then add the spirit, and strain through fine muslin or calico.

Indiarubber Solution has been often recommended as a mountant, the only drawback to its employment is its liability to become dry and crumbly, causing the picture to leave its support. The method of its production is to dissolve pure masticated rubber in about forty times its weight of chloroform or benzole.

Gelatine and Alcohol Mountant.—This is a very favourite one with amateurs, owing to its simplicity and cleanliness. The method of preparing it is to soak about one ounce of gelatine in ten ounces of water. When it is thoroughly swollen it is melted by gradual heat in a water vessel, and about four ounces of methylated alcohol slowly added, well stirring the solution during the addition. If required to be kept for any length of time, a few drops of a carbolic acid solution must be added as a preservative.

Mounting.—The operation of adhering the print to a suitable support. Although photographs may be attached to wood, glass, or many other substances, cardboard is the one generally used. The art of mounting only comes by practice. The materials that are required are a suitable cardboard mount and a good mountant. Under the respective headings will be found some information with regard to the selection of these. The prints are first trimmed to size. It is important that they be cut evenly and in proper proportion, as nothing has a worse appearance than a badly-cut picture. The mount employed should be of a colour and size to suit the picture with regard to its dimensions, to allow of a sufficient margin. The back of the print having been brushed over with the mountant, it is laid very carefully on to the mount, exactly in the centre. It is then pressed gently down into perfect even contact with a soft handkerchief, and afterwards rolled or burnished.

Gelatino-chloride prints which have been glazed by the talced glass process are much more difficult to mount than ordinary albuminised prints. The following remarks by the author* may be found useful.

Gelatine is peculiarly susceptible to moisture, and this, in the case of gelatine prints, where the surface has a high polish, is plainly seen. If we take a piece of dampened paper and lay our glossy print upon it, face upwards, we shall see that this gloss gradually fades away until the surface of the print has become quite dull. Now this effect we have to avoid in mounting gelatine prints. If we simply paste a starch or other similar mountant on to the back, in the same manner as with an albumen print, we lose the polish at once—before, in fact, we have time to attach it to the mount. The more liquid the mountant the stronger its action upon the gelatine film. We will first, then, consider what course to adopt to mount the prints as they are taken off the glass. If we employ a gelatine mountant with as little water as possible it is

* The "Camera Magazine," 1890.

evident that we stand less chance of spoiling the surface of the print. Take, then, 1 oz. of hard gelatine and soak it in water; squeeze all the water out of it possible, and dissolve. When dissolved, add 4 oz. of methylated spirit. If a large quantity be made, sufficient for some time, a small amount of carbolic acid should be added to prevent putrefaction. This mountant should be placed in small bottles, and when required, a bottle of it should be placed in a little warm water until the contents are dissolved. With a stiff brush it should be rapidly applied to the back of the print, and the latter immediately adjusted to the mount, smoothed down with a soft, clean rag, and the whole laid away, face upwards, to the air to dry. On no account should these prints be laid one on another when mounting, as they will be liable to stick confused together in a heap.

Another way is one that is adopted by a great many amateurs, who treat the edges only of the print to the mounting solution. The same mountant may be used, but with a small brush; it is laid on round the edge of the print in a rim not more than the sixteenth of an inch. It is then attached to the mount. Instead of gelatine, a solution of indiarubber dissolved in benzole may be used, but this adherent is not a stable one. The indiarubber becomes hard after a time and crumbles away, and allows the print and the mount to become detached.

If the method of mounting round the edges be adopted, it should be done directly the picture leaves the glass, as after a little while the print contracts and gives a tight surface. If this be impossible the prints should be removed to a cool damp room or cellar for a few minutes previous to mounting. Gelatine contracts and expands in a very remarkable manner; a very good hygroscope can, in fact, be made out of a piece of gelatine carbon tissue. It is therefore necessary to avoid mounting the prints by the edges only if in a dry state, as when moist the print contracts and buckles up at those parts not held to the mount by the solution. Another method I must mention, and that is the mounting of these prints behind cut-out mounts. Of course, here we can get the surface as perfect as possible, as no visible portion of the print is treated with the mountant. I think prints mounted in this manner show up a great deal better than by any other way.

We now come to the second *modus operandi*, in which the prints are, before mounting, treated to a support, protective backing, or whatever else you like to call it. When on the glass, and before they are perfectly dry, a piece of thickish waterproof paper is pasted on to the back. A waterproof paper can be obtained at nearly every stationer's; this is usually white one side and coated with a black waterproof substance on the other. Cut this paper for the different prints about one-eighth of an inch each way smaller than the print itself. Apply the mounting solution to the white side, and adhere it firmly to the backs of the prints when on the

glass. When dry, the prints, with their waterproof support, will leave the glass together, and they can be mounted with safety with almost any material, as the waterproof coating effectually prevents the damp affecting the gloss. This method of backing is also convenient for prints not to be mounted, as it strengthens them for handling.

If properly done, and the right sort of paper be employed, prints mounted in this manner should not lose a bit of the beauty—vulgar beauty, if you like—of their gloss.

Another method of mounting, which I have purposely left to the last, being the most difficult, is the following. Here we move the prints on to the mount while upon the glass, and strip off together.

The prints, when removed from the water, are squeegeed on to pieces of glass, a little larger only than themselves. When nearly dry, the back is pasted over carefully, and the picture and glass laid on the mount. Of course the print must have been trimmed to proper size before squeegeeing on to the glass. When thorougly dry the print and mount should leave the glass. If there is any difficulty about this, a sharp knife should be inserted between the print and the glass, to give it a start. It is for this reason that the glass must not be much larger than the print.

Some operators prefer to first damp the cardboard before applying the print, so as to cause it to expand to the same degree as the latter. (See also **Mount** and **Mountants.**) For special instructions for mounting stereoscopic prints see **Stereoscopic Photographs.**

Mucilage.—A term generally applied to various adhesive solutions of gums, dextrine, &c. Chemically it is the gum of seeds and roots, and is obtained by steeping these in hot water, when a thick jelly is obtained. The soluble mucilage may be obtained from linseed by the action of acidulated water on it, and by precipitating the mucilage from a concentrated solution of alcohol.

Muriate of Ammonia.—See **Ammonium Chloride.**

Muriatic Acid.—See **Hydrochloric acid.**

Naphtha.—A term applied to the liquid hydrocarbons issuing from the earth in certain parts, and to most of the inflammable liquids produced by the dry distillation of organic substances.

Mineral Naphtha, or petroleum oil, is a complicated mixture of hydrocarbons. It is very inflammable. It does not mix with water, but will impart to that fluid its peculiar taste and smell. It mixes with alcohol and oils. It is used as a solvent for india-rubber, sulphur, phosphorus, camphor, iodine, and most of the resins, wax, fats, etc. It is also employed for illuminating purposes, and for the preparation of a superior lamp black.

Coal Naphtha consists largely of commercial benzole and its

homologues ; it is extensively used as a solvent of caoutchouc, and also of resins for the manufacture of varnishes.

Wood Naphtha is a name given to impure methylic alcohol. (See **Alcohol.**)

Naples Yellow (Synonyn, Neapolitan yellow).—An exceedingly permanent orange-yellow pigment, prepared by fusing for two hours at a moderate heat, a mixture of chemically pure antimonia-tartrate of potash, lead nitrate and sodium chloride. On cooling, the fused mass is immersed in water, when the salts dissolve out, leaving the pigment in the form of a fine yellow colour. It is much used in oil painting.

Naphthalene (Formula, $C_{10}H_8$; synonyms, *naphthalin*, *naphthaline*).—A frequent product of the dry distillation of organic substances. When quite pure, it consists of brilliant white scaly crystals, very friable, smelling strongly of coal gas, and melting at a temperature of 79°C to a liquid as clear as water. It boils at 216°, and burns when inflamed with a highly luminous, but smoky flame. It is insoluble in cold and almost insoluble in boiling water, dissolves readily in alcohol, ether, chloroform, carbon disulphide, benzene, and fatty and essential oils. It also dissolves in acetic and oxalic acid.

Naphthalene unites directly with chlorine and bromine, forming a number of substitution products.

It is employed in the preparation of phthalic anhydride.

Naphthaline Blue.—A blue dye obtained by treating naphthylamine with mercuric nitrate.

Naphthaline Red (Synonym, *magdala red.*)—A very beautiful red dye, prepared from naphthaline by the elimination of three molecules of hydrogen from three molecules of the base $3C_{,10}H_9—3H_2 = C_{30}H_{21}, N_3$ = azo-dinaphthylamine. This, combined with hydrochloric acid, forms the magdala red of commerce. It is a dark brown, somewhat crystalline, powder, possessing a tinctural power equal to fuchsine, but surpassing it.

Naphthylamine (Formula, $C_{10}H_9N$; synonyms, *Naphthalidam' Naphthalamine*, *Naphthalidine*).—An organic base prepared from naphthaline. It crystallises in nearly colourless silky needles, having a most disgusting odour. It is insoluble in water, but soluble in alcohol and ether. Its derivatives and products of decomposition are exceedingly numerous and complicated.

Naphthyl Carbamide (Formula, $C_{11}H_{10}N_2O$).—Obtained by saturating an ethereal solution of naphthylamine with cyanic acid gas and recrystallising from hot alcohol. It forms flat, shining, flexible crystals, insoluble in water, slightly soluble in alcohol, and very soluble in ether.

Narrow Angle.—See **Wide Angle.**

Natural Colour Photography.—See **Heliochromy.**

Naturalistic.—The dictionary meaning of this term is — in accordance with nature. The term has recently been applied to photographs made slightly out of focus. This was first advocated by Sir W. J. Newton, a miniature painter, about the year 1856. Later on in the year 1874 Dallmeyer constructed a lens specially for this object; by its means the focus of the lens could be diffused by slightly altering the position of the lenses. The latest advocate of so-called Naturalistic Photography is Dr. P. H. Emerson, who has warmly defended it against a storm of deriders. In his work, written on the subject, he says—"The principal object in the picture must be fairly sharp, just as sharp as the eye sees it; but everything else and all other planes of the picture must be subdued, so that the resulting print shall give an impression to the eye as nearly identical as possible to the impression given by the natural scene. But, at the same time, it must be distinctly understood that "fuzziness" must not be carried to the length of destroying the structure of any object, otherwise it becomes noticeable, and by attracting the eye detracts from the general harmony, and is then just as harmful as excessive sharpness would be. Experience has shown that it is always necessary to throw the principal object slightly (often only just perceptibly) out of focus to obtain a natural appearance, except when there is much moisture in the air, as on a heavy mist-laden grey day, when we found that the principal object (out of doors) may be focussed quite sharply, and yet appear natural, for the mist scattering the light softens the contours of all objects. Nothing in Nature has a hard outline, but everything is seen against something else, and its outlines fade gently into that something else, often so subtilely, that you cannot quite distinguish where one ends and the other begins. In this mingled decision and indecision, this lost and found, lies all the charm and mystery of Nature. This is what the artist seeks, and what the photographer, as a rule, strenuously avoids."*

Neatsfoot Oil.—An oil obtained from the feet of neat cattle.

Nebulæ, Photographing.—Very little has as yet been done in this direction, Barnard's Photographs of the Nebulæ of Andromeda are full of interest, as are also the wonderfully fine pictures of the Merope Nebula, and that of the great Nebula in Orion taken by Messrs. Henry, Roberts, Common, and also by Pickering, at the Harvard College Observatory.

Negative.—The term applied to the image of an object or objects, and in which the lights and shades are reversed. A negative is usually made by direct action of the light on the camera. The image shining upon the sensitive dry plate causes

*Since this was written, Dr. Emerson has published a pamphlet renouncing his theory and all he had written upon it.

parts to become darkened when subsequently treated with the developer. The lightest parts of the image cause the densest deposits, so that it will be seen that the image is darkest in those portions which are the lightest in the image itself. Negatives can also be made by printing from a positive.

Negatives are usually made upon glass by the gelatino-bromide (dry plate) or collodion processes, principally the former. Various other supports for the sensitive film have been used. (See **Film Negative Process. Stripping Films. Paper Negatives.**)

A perfect negative is one in which all the gradations or light and shade are correctly and harmoniously rendered. It should be thin and perfectly clear. In some parts of the deepest shadows the glass should be almost clear, while in certain parts of the high lights the film should be almost perfectly opaque. Between these two extremes there should exist as many gradations of tone as possible. If only a few semi-tones are present in the negative, positives made from it will be either weak or hard according to the difference in the opacity of the film in the lights and shadows.

The brilliancy of the negative is dependent upon the correctness of the exposure and subsequent development. If under-exposed, the high lights usually appear black and the shadow perfectly clear without detail, and the gradation of tone between these is, to a great extent, absent. The resulting positives will be hard pictures with masses of black and white without any detail or semi-tones.

If over-exposed, the plate appears too much of the same tint, the shadows appear fogged, the high lights are too light, and the half-tones are almost entirely lost. A positive from such a negative would be too light in the shadows, and too dark in the lights. An over-exposed plate can sometimes be remedied in developing, so that it possesses better printing qualities.

Negative Bath.—A solution of silver nitrate in distilled water used for the purpose of exciting or sensitising collodion plates for making negatives by the wet collodion process (*q.v.*).

Negative, Enlarging.—The crudest and least recommendable method of enlarging a gelatine negative is to simply soak it in water containing about one-twelfth of its volume of strong liquid ammonia. In two or three hours the film will be found to have frilled from the plate, and extended to a considerable extent. If the film is a thick one, the enlargement may be as much as two diameters; but if it is not sufficiently distended, small quantities of hot water should be added to the bath. The loose distended film floating in the bath is then caught upon a large piece of glass. It can, of course, be reversed, if required. This method of enlarging a negative is, however, a very uncertain one, and can only be used with great danger of destroying the negative itself.

The two commonest methods of enlarging negatives are first the production of a positive transparency by contact from the negative

and an enlargement made from this; and second an enlarged transparency is made from the small negative, and the large negative made from this by contact. There are plenty of advocates of both methods, but the majority of advantages are probably in the method of producing the enlargement direct from the negative—that is to say, making a large transparency, and printing the negative by contact. In this manner the defects of the positive are not enlarged, and it will be found much easier to eliminate defects on a large than on a small transparency. The large transparency * offers particular facilities for producing one or many enlarged negatives by a printing-out process, as, for instance, on albuminised silver paper after Valentine Blanchard's method. Excellent results can thus be obtained, the sensitive paper is exposed somewhat longer than it would be for a positive print, then washed, fixed, dried and waxed. No toning is necessary, and such paper negatives appear on the whole to be more stable than ordinary toned prints. If necessary, new negatives can easily be made, and each negative is as exact a reproduction of the first as possible. The various methods of making a transparency are given under that heading.

The negative or transparency to be enlarged must be illuminated equally all over. It will then only be necessary to expose a large plate in the camera to obtain the desired result. Those, however, who do not possess a large camera must enlarge on a dry plate, in just the same way as on bromide or other enlarging paper. The image is thrown by the optical lantern on to the easel, or screen, and focussed. A slight alteration must then be made in this to allow for the thickness of the plate, which is then fixed into position and exposed.

Negative Numberer.—An arrangement for numbering negatives. The most ingenious form is that devised by Kruse, of Berlin, and which is thus described:—A small benzine light (or candle) is placed in a metal lantern, so constructed both with regard to the admission of light and the letting out of smoke that no white light can escape. On the outside of this box in the right hand corner, there is a grove cut, into which the unnumbered exposed plate is inserted. This slit is covered by three small hoops of thin copper sheathing placed together. Two of these hoops or bands have on them the numbers 00 up to 99, the third one has from 0 to 9. These numbers are cut out like stencil plates, so that by a judicious turning of the bands the numbers 00000 up to 99999 can be seen on looking through the slit. The turning of both these bands, which, numbered from 00 to 99, form the last four figures, is caused by moving a button up or down, by which means the bands referred to are wound off from one small wooden cylinder on to another, whilst the band bearing the numbers 0 to 9, which indicate the ten thousandths of the number,

* See Chapman Jones's "Science and Practice of Photography."

is changed by every movement of the band from 10 to 10 thousand numbers. In using the instrument the light is shut off by means of a red glass, brought to view from within when looking for the controlling number, the undeveloped plate is inserted in the before-mentioned slit, and then by a sudden turn the red disc is drawn away. The exposure for the number is thereby completed, and the latter appears in the development black upon a bright ground. The apparatus may also be used for printing names, titles, or dates on the negative.

Negative, Reproducing.—A negative is generally reproduced by first making a positive by contact, and afterwards a negative or number of negatives from this. For this purpose gelatino-chloride or gelatino-bromide plates may be used. Very fine results can be made by the carbon process. By judicious management the reproduced negative may be made an improvement on the original, that is to say, defects in the former may be remedied or counterbalanced in the latter. In exposing glass under glass as in this case, it is necessary that absolute contact takes place. Special printing frames have been devised for this purpose.

For methods of producing reversed negatives see **Reversed Negative.** The usual method is through the medium of a transparency. If the dusting-on process is used, however, this will not be necessary.

Negative Varnish.—See **Varnish.**

Neomonoscope.—An instrument for magnifying photographs invented about the year 1862.

Nephograph (Gr. *nephos*, a cloud; and *grapho*, to draw).—An instrument arranged for the photographing of clouds. It is used at some of the principal meteorological stations and described under **Meteorological Photography** (*q.v.*).

Nessler's Solution.—A test for ammonium salts. It is prepared by dissolving sixty grains of potassium iodide in three drachms of distilled water. This is then boiled with successively added quantities of mercuric iodide until some of the latter remains undissolved. This liquid is then diluted with three ounces of distilled water filtered. The filtrate is mixed with 120 grains of caustic potash, dissolved in half an ounce of water, and the whole filtered again.

With this solution the presence of the minutest quantity of ammonia can be detected, as it gives a brownish precipitate or colour according to the amount of ammonia present.

Another method of preparing this solution is thus given by Professor Wanklyn. Mercuric chloride in powder, 35 grammes; iodide of potassium, 90 grammes; water, 1¾ litres; heat gently

till dissolved (say twenty minutes) in a large basin. Then add of stick caustic potash 320 grammes and 50c.c. of saturated solution of mercuric chloride. This will be ready for use in two hours, and gives maximum colour in three minutes.

This test is so delicate as to be capable of detecting one part of ammonia in ten million parts of water.

Neutral (Lat. *neuter*—neither).—This term is used in chemistry to denote that a substance is neither acid nor alkaline. It is chiefly applied to compounds of an acid and a base, in which the one has been fully saturated with an equivalent of the other. A neutral compound neither turns red litmus paper blue, or blue litmus paper red.

Neutral Salts.—Salts which exhibit neither acid nor alkaline properties.

Neutral Tint.—A dull grayish hue, having the character of none of the brilliant colours, such as red, yellow, blue, &c.

A factitious gray pigment used in water colours. It is composed of blue, red, and yellow, in various proportions.

Newton's Rings.—Rings of colour concentrically arranged, when a very thin lamina of anything transparent is subjected to the action of the light.

Nickel (Symbol Ni; atomic weight, 58·7).—A tetrad metallic element found in combination with arsenic in the copper-coloured mineral arsenide of nickel. It is a silver white, malleable, and ductile metal.

Nickel Plating.—A method of coating various metal goods with nickel. A dilute solution of pure zinc chloride is first made, and to this is added a solution of nickel sulphate until the liquid is distinctly green. The whole is then raised to boiling point. The article to be plated is first thoroughly cleaned, and then placed for about thirty minutes in the boiling liquid. The nickel will then deposit itself on the metal, and after washing and drying can be well polished. Another method is to employ a battery as in electro-plating.

Nickel Sulphate (Formula, $NiSO_4 + 7OH_2$).—A salt of nickel formed by dissolving the carbonate in sulphuric acid. It takes the form of green prismatic crystals, soluble in water. It is used for nickel plating (*q.v.*).

Nicol's Prism.—An instrument for polarising light named after the inventor. It is formed from a rhombohedron of Iceland spar thrice as long as its diameter. This is bisected in the plane,

which passes through the obtuse angle. The new faces, being polished, are cemented together again by Canada balsam. A ray of common light, entering the Nicol prism at one end, is divided into two opposite polarised rays, the ordinary and extraordinary. When these rays meet the Canada balsam cement, the ordinary ray undergoes total reflection from this surface, and is sent out of the field at the side, whilst the extraordinary ray passes through alone. The emergent ray is therefore polarised in one direction only.

Niepce's Process, or **Niepceotype.**—One of the earliest photographic processes discovered by Niepce. He found that bitumen became insoluble by the action of the light. A metal plate, coated over with a thin film of bitumen (dissolved oil of lavender), was exposed to the image in the camera obscura, and the bitumen became insoluble in proportion to the intensity of the light by which the various parts of the image were produced. This effect is, we know, due to the oxidation and hardening of the resinous substance. After removal from the camera the exposed plate is steeped in a mixture of oil of lavender and petroleum; the soluble portions remaining are dissolved away. The shadows of the image are thus represented by bare portions of the metal plate, the insoluble resin remaining representing the lights and high-lights. It will be clear that to get the best effect the polished metal representing the shadows should be darkened. For this purpose Niepce employed iodine and various other chemicals. Niepce, in a statement made in the year 1829, thus described his process:—"The discovery which I have made, and to which I give the name of 'heliography,' consists in producing spontaneously by the action of light, with gradations of tints from black to white, the images received by the camera obscura. Light acts chemically upon bodies. It is absorbed, it combines with them, and communicates to them new properties. Thus it augments the natural consistency of some of these bodies; it solidifies them even, and renders them more or less insoluble according to the duration or intensity of its action. The substance which has succeeded best with me is asphaltum dissolved in oil of lavender. A tablet of plated silver is to be highly polished, on which a thin coating of the varnish is to be applied with a light roll of soft skin. The plate, when dry, may be immediately submitted to the action of light in the focus of the camera. But, even after having been thus exposed a length of time sufficient for receiving the impressions of external objects, nothing is apparent to show that these impressions exist. The forms of the future picture remain still invisible. The next operation, then, is to disengage the shrouded imagery, and this is accomplished by a solvent, consisting of one part by volume of essential oil of lavender and ten of oil of white petroleum. Into this liquid the exposed tablet is plunged, and the operator, observing it by reflected light,

begins to perceive the images of the objects to which it had been exposed gradually unfolding their forms. The plate is then lifted out, allowed to drain, and well washed with water." Niepce further adds, "It were, however, to be desired that by blackening the metal plate we obtain all the gradations of tone from black to white. The substance which I now employ for this purpose is iodine, which possesses the property of evaporating at the ordinary temperature."

Nitrate of Baryta.—See **Barium Nitrate.**

Nitrate of Cellulose.—See **Pyroxyline.**

Nitrate of Silver.—See **Silver Nitrate.**

Nitrate of Strontium.—See **Strontium Nitrate.**

Nitrates.—Combinations of nitric acid with bases. For the most part they crystallise readily; they are all soluble in water, and are generally neutral to test paper. The tests for nitrates are as follows:— *

Solid nitrates, heated with copper and strong sulphuric acid, liberate red fumes. Liquids containing nitrates give the following reactions. Treated with an equal volume of strong sulphuric acid and allowed to cool, and then mixed with a freshly prepared and clear solution of ferrous sulphate carefully added so as to float on the top, a brown ring will be observed at the junction of the two liquids.

If mixed with a little strong sulphuric acid, and then added to solid brucine, a red solution is produced.

Nitre.—A name applied sometimes to potassium nitrate and sometimes to sodium nitrate; more frequently to the latter, however, the former being especially distinguished as saltpetre.

Nitric Acid (Formula, HNO_3; molecular weight, 63; synonym, *aqua fortis*).—A heavy, colourless liquid prepared by the action of strong sulphuric acid upon potassium or sodium nitrate. The strongest obtainable possesses a specific gravity of about 1·5, but a large proportion of what is now sold as nitric acid contains often as much as from 40 to 50 per cent. of water.

It is very easily decomposed, giving off fumes when exposed to the air. Mixed with about four times its volume of hydrochloric acid it forms *aqua regia*, which possesses the property of dissolving gold and platinum.

Nitric acid acts upon the majority of the inferior metals, and their hydrates or corbonates, producing nitrates. It also acts upon

* "Materia Photographica," by C. J. Leaper. Ilifle & Son.

silver and upon various forms of cellulose, such as cotton-wool, paper, &c., its action being the same as with the metals. Cotton-wool acted upon by nitric acid forms gun cotton or pyroxyline, which is in reality a nitrate of cellulose, or a mixture of cel ulose nitrates.

Nitric acid has a very sharp, penetrating and obnoxious odour somewhat resembling hydrochloric acid. It is very poisonous, and has a most powerful corrosive action. Commercial samples sometimes contain traces of hydrochloric acid. For many purposes, for instance in the preparation of silver nitrate, it must be entirely free from this acid. The presence of hydrochloric acid can easily be detected by dropping into a test tube containing some of it a few drops of a silver nitrate solution. If any be present it will combine with the silver to form chloride of silver, and the whole will become turbid.

Nitrites.—The salts of nitrous acid. If solid nitrites be warmed with dilute hydrochloric acid brownish red fumes will be yielded. Liquids containing them give a white precipitate with silver nitrate, and a brown or black colouration with ferrous sulphate.

Nitro-benzene (Formula, $C_6H_5NO_2$; synonym, *nitro-benzol*).—A heavy, oily liquid prepared by gradually adding benzene to cold fuming nitric acid so long as it dissolves, and precipitating with water. It possesses a strong almond-like odour, is insoluble in water, but soluble in alcohol and ether. It is largely employed in the preparation of aniline and its derivatives.

Nitro-cellulose.—See **Pyroxyline.**

Nitrogen (Gr. *nitron*—natron, potassa, or soda, and *gennao* to produce; symbol, N; atomic weight, = 14).—A pentad metallic element forming four-fifths of the atmosphere, and entering into a great variety of combinations. It is generally procured from the atmosphere by burning a piece of phosphorus under a bell jar standing over water. The phosphorus unites with the oxygen, forming phosphoric acid, which is readily soluble in water, leaving the nitrogen behind. There are various other ways of obtaining it.

Nitrogen is colourless and without taste or odour. It is incombustible, and does not support respiration; it is not poisonous, but kills from the absence of oxygen. Its action on the atmosphere is chiefly as a diluent to moderate the activity of the oxygen. It has recently been liquefied by the aid of cold and high pressure.

Nitrogen Iodide (formula NHI_2) can be prepared by dissolving iodine in a mixture of hydrochloric with a little nitric acid, with the aid of heat, and adding ammonia, which decomposes the ICl in solution, and gives a black precipitate of the iodide of nitrogen.*

* Bloxham's "Chemistry."

Nitrogen iodide is a black powder, exploding with a loud report, even if touched with a feather.

It decomposes by the aid of light, and has been recommended as a means of comparing light intensities by its decomposition. Two vessels, with glass bottoms, are placed side to side, being of equal size. Iodine and ammonia solutions are placed in each, forming the iodide of nitrogen, which remains unaltered so long as it is in the dark. The two lights to be compared shine by means of a mirror, each into one of the vessels. The amount of nitrogen-gas given off each is collected in a tube above in ammonia water, and the relative height shows the relative activity set up by the light. Precautions have to be taken to avoid effects of heat.

Nitro-hydrochloric Acid.—More commonly known as *aqua regia*. A mechanical mixture of one part of nitric acid with about four times its volume of hydrochloric acid. It has the property of dissolving gold and platinum, the active agent being the chlorine liberated from the hydrochloric acid by the oxygen of the nitric acid, thus—

$$O + 2HCl = H_2O + Cl^2$$

It is used for the purpose of dissolving gold in the preparation of gold perchloride, much used in photography for toning purposes.

Nitrous Acid.—See **Nitrous Anhydride.**

Nitrous Anhydride (Formula, N_2O_3; synonyms, *nitrous acid*, *nitrogen trioxide*, *anhydrous nitrous acid*).—Prepared by mixing four volumes of nitric oxide with one volume of oxygen, and exposing to a temperature of $-17°$. It condenses to a thin green liquid, its vapour being orange red. It is decomposed by water into nitric acid and nitric oxide.

Noble Metals.—A term applied to the metals gold, silver, platinum, osmium, rhodium, irridium and mercury. These can be separated from oxygen by heat alone.

Nomenclature, Photographic.—The nomenclature of the various photographic inventions and processes seems to have been carried out without the slightest regard to law or order. The most absurd and meaningless words have been adopted, and which are in many cases liable to lead the student astray.

At an international photographic congress held in Paris in 1890 the following rules were laid down as a basis for a system of rational nomenclature*:—

1. The expression *photo* shall be employed to the exclusion of the word *helio* to indicate processes due to the action of light from any source whatever, and not alone to the action of solar light.

* *Photographic News*, Feb. 21, 1890.

The expression *helio* is exclusively reserved to indicate those processes only in which solar light is used.

2. The expressions *positives* and *negatives* are reserved to indicate respectively the images in which the effects of light and shade resemble those of nature, or in which those effects are reversed.

3. In that which concerns *photographs* obtained solely by the chemical action of light, the name of *phototypes* will distinguish those produced directly by the use of the camera. The name *photo-copies* will be given to the reproductions of these by a new photographic operation by means of a sensitive surface acted upon by light.

The name *photo-calques* (photo-sketches ?) will be given to reproductions made in the same way from non-photographic original designs.

4. Photo-mechanical prints, or *phototirages*, which may also be called *photo-prints*, will be differentiated by the following appellations :—

To designate these different processes, an insertion will be made between the two radicals which form the word *photography*, and which will indicate the principal characteristics of the particular process.

According to this rule the word *photo-collography* will indicate reproductions in various inks by processes in which colloids (gelatine, albumen, bitumen, and so on) are spread upon various supports, and rendered fit for inking by the action of light.

The word *photo-plastography* will be employed to indicate processes in which a plastic substance changes its form because of the action of light, and returns to a thickness suitable for a coloured gelatinous ink.

The word *photo-glyptography* will be used for processes of engraving in intaglio by photography.

The word *photo-typography* will be employed for photographic processes of engraving in relief for use in the type-high letter printing press.

The word *photo-chromography* will be applied to printing processes for the reproduction of photographic images of several colours.

5. More extended designations of photographic processes or operations may be applied, so far as the French language is concerned, by introducing generic words preceding the necessary indications of the nature of the processes or operations.

For instance, the preposition *à* or *par* (by), according to the case, will precede the words indicating the nature of the sensitive substance employed, or that of the mode of operation ; and the preposition *upon* precede the words indicating the nature of the support of the preparations. The names of the inventors, if they have to be used, can be placed at the end.

Examples. — *Photographs.* — 1. Positive phototype ; iodide of silver on a metallic plate (Daguerre's process). 2. Positive phototype ; collodion on a metallic plate (Ad. Martin's process).

3. Negative photo-type, collodio-bromide of silver on glass. 4. Positive photo-copy, gelatino-chloride of silver on paper. 5. Positive photo-copy, in mixed colours (Poitevin's process). 6. Negative photo-sketch, ferro-prussiate blue paper (Motileff's process). 7. Positive photo-sketch, gallate of iron. *Photo prints.*— 8. Photo-collography, bichromated gelatine on ground glass. 9. *Photo-plastography*, coloured gelatinous inks (Woodbury's process). 10. Photo-glyptography, by bitumen of Judea on steel (Niecpe's process). 11. Photo-typography, by bitumen of Judea on zinc.

6. For the designation of the divers applications of photography to especial purposes, are reserved several compound words, obtained by prefacing the word photography with radicals indicating by abbreviation the particular applications.

EXAMPLES:—Chromo-photography, the photographic production of successive images taken at accurately measured intervals of time. Micro-photography, the photography of microscopic objects. Helio-photography, the photography of the solar surface. Spectro-photography, the photography of the spectra given by luminous sources. Urano-photography, the photography of celestial spaces. Chromo-photography, the direct obtaining of the reproduction of colours by photography.

Non-actinic. (Lat. *non*—not, and Eng. actinic.)—Applied in photography to rays of light which have comparatively no action upon sensitive substances. These rays are chiefly in the yellow and red ends of the spectrum. Light passing through red or yellow glass, paper, or other media, has no effect upon sensitive photographic material, unless of long exposure; it is therefore employed to enable the operator to perform the various operations that are necessary in the development of the image, etc. In photographing a landscape or coloured objects it is obvious that the yellow and red portions will have but little effect, and appear in the finished print as black parts, although they may appear somewhat bright to the eye. This defect in photography has been partially overcome in the orthochromatic process (*q.v.*)

Non-actinic Media.—Media for the transmission of non-actinic rays of light. The colour of this depends greatly upon the nature and sensibility of the material to be handled. It varies from a deep ruby to a pale orange. Abney recommends bookbinder's red cloth combined with stained red glass. It should be noted that ruby glass by itself will rarely be found sufficient, since a certain amount of blue light is apt to permeate it.

Many advocates have been found for a paper treated with lead chromate, and termed canary medium. For developing ordinary plates two thicknesses of this substance will be found sufficient. There is, however, an orange paper which will be found useful, as it retards more of the green rays.

It is well to note that if a plate be first exposed to white light and afterwards to red, a reversing action will occasionally take

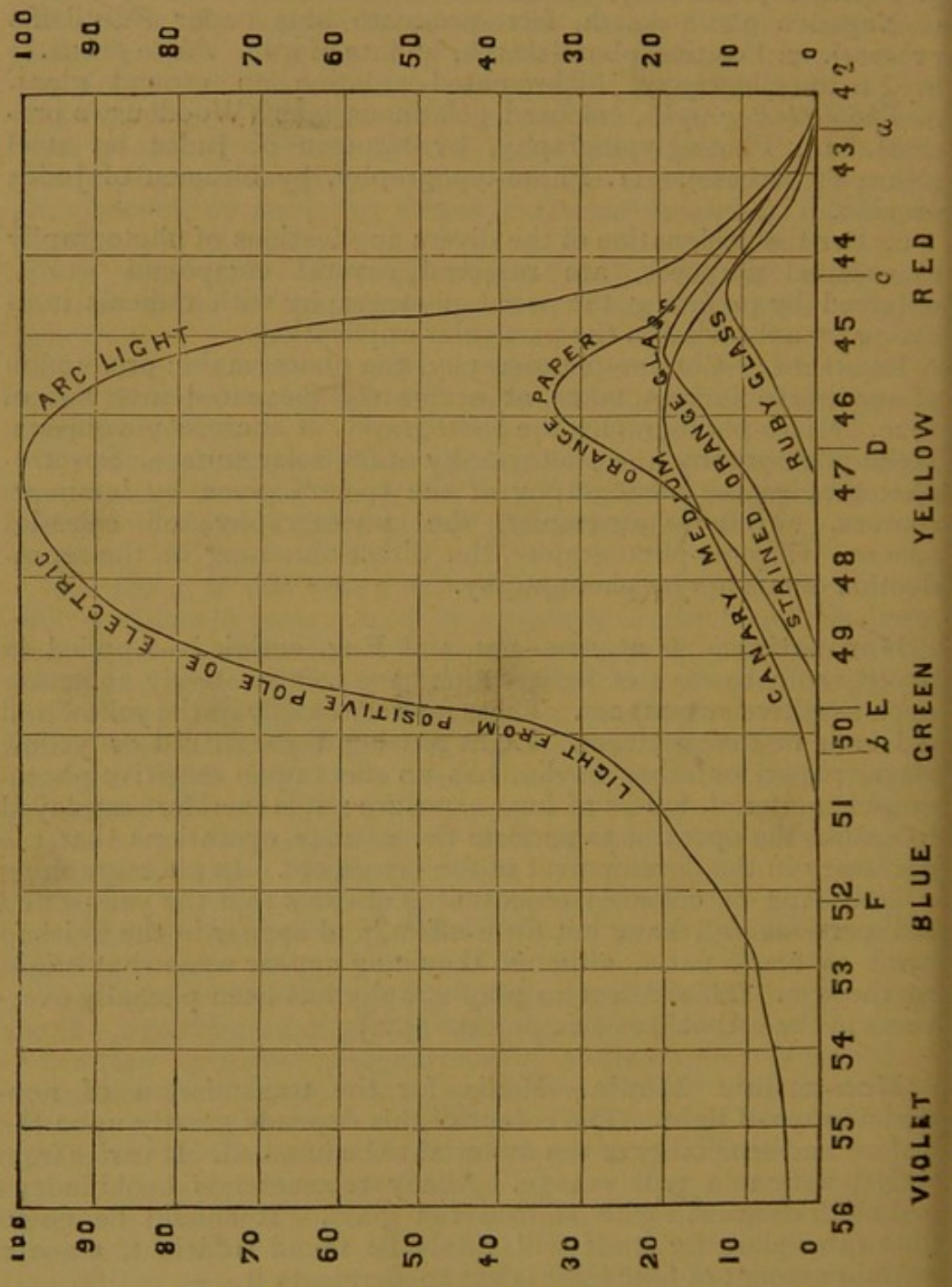

FIG. 152.

place, the image eventually disappearing. It is, therefore, necessary to avoid handling the exposed plate in the red light as much as possible until commencement of development.

The value of the light coming through stained, red, and ruby glass, orange paper, and canary medium will be seen on reference to fig. 152.

Spectroscopic tests recently made have shown that few of the commercial so-called "non-actinic" glasses are as safe as could be desired. Vogel suggests that the ruby glass so difficult to obtain should be replaced by coloured gelatine films. His method of manufacturing these is as follows:—1 gramme of aurantia is dissolved by aid of heat in 100 c.c. of distilled water. Unless the whole of the aurantia dissolves, a few drops of ammonia should be added. 20 grammes of gelatine are also dissolved in 100 c.c. of water. 25 c.c. of the aurantia solution are taken and mixed with 25 c.c. of the gelatine solution, and the mixture filtered through flannel. With this solution levelled glass plates are coated. These plates absorb the blue rays only, and are therefore only suitable for use in developing wet collodion or low sensitive gelatine emulsion plates or paper, as they allow the yellow, green, and red rays to pass through freely. For development of highly sensitive plates rhodamine should be used, as a concentrated solution of it absorbs yellow, green and violet completely, whilst blue and red light pass through freely. 8 grammes of rhodamine are dissolved in 250 c.c. of water, and 20 grammes of gelatine in 100 c.c. of water. 25 c.c. of the gelatine solution are then mixed with 30 c.c. of the rhodamine solution, and the mixture filtered. If we combine a glass plate coated with this solution with one made with aurantia as previously described, we get a perfect non-actinic medium, permitting only red light to pass through. The two plates when dry are fixed together, film to film. If, previous to coating the glass plates, they had been rubbed over with French chalk and then provided with a substratum of collodion, the films could be stripped from the glass when dry, and used for dark room lamps, etc.

Non-reversing Slide.—A camera slide, so contrived that collodionised glass plates may be exposed in it with the back of the plate next the lens, and the film next to the back shutter.

Notation, Chemical.—The written language of chemistry. The system now used belongs exclusively to modern times, although in all ages signs of some kind or other seem to have been employed to represent the various kinds of substances. (See **Chemistry.**)

Obernetter Paper.—A gelatino-citro-chloride of silver printing-out paper, similar to Celerotype, Aristotype, etc. (See **Gelatino-chloride of Silver Process.**)

A suitable toning bath for Obernetter paper is the following :—

Ammonium sulphocyanide	140 grs.
Sodium phosphate	140 ,,
Sodium tungstate	100 ,,
Water	24 ozs.

Dissolve, and place some scraps of sensitised paper, spoiled prints (untoned), etc., in the bottle, and allow it to stand for about 24 hours. Filter and then add :

Gold terchloride	15 grs.
Water	4 ozs.

Examine during toning by transmitted light, and tone to a rich purple brown.

Fixing is accomplished with one part of hypo in ten of water. After well washing they are hung up to dry, or squeegeed on to talced glass.

Obernetter's Process.—A photo engraving process known in Germany as Lichtkupferdruck. A positive is first produced on a film of gelatino-bromide of silver very rich in the silver salt. The silver of the developed and fixed image is then converted into silver chloride by the action of a mixture of perchloride of iron and chromic acid. The film is then stripped and laid on the surface of a copperplate. Under the influence of a voltaic current, the silver chloride becomes decomposed, and the chlorine unites with the copper and etches it to a greater or less degree, according to the depth of deposit of silver chloride. As a result a grained intaglio plate of great delicacy is obtained. This is inked and printed from in the same manner as an ordinary etching.

Object Glass.—The glass placed next to the object in a telescope or microscope is termed the object glass. In good instruments this is usually composed of two or more lenses cemented together, one being of flint glass, and the other or others of crown glass.

Objective.—A lens or combination of lenses used in the telescope, microscope, or photograph camera.

Obscure Rays.—Invisible rays above and below those of the visible spectrum. (See **Spectrum.**)

Oil.—The term oil is generally applied to all neutral fatty substances which are liquid at ordinary temperatures. They may be divided into two great classes,* fixed oils and essential oils.

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* Rodwell's "Dictionary of Science."

FIXED OILS.

Drying.	*Non-drying.*	*Non-drying.*
Linseed oil.	Almond oil.	Earth-nut oil.
Poppy oil.	Beech-nut oil.	Oil of mustard,
Sunflower oil.	Castor oil.	Rape seed oil.
Walnut oil.	Cotton seed oil.	Sesame oil.
Tobacco seed oil.	Colza oil.	Olive oil.
Cress seed oil.		

ESSENTIAL OILS.

Oil of anise.	Oil of cloves.	Oil of nutmeg.
Oil of bergamot.	Oil of lavender.	Oil of orange peel.
Cajeput oil.	Oil of lemon.	Oil of peppermint.
Oil of carraway.	Oil of mint.	Oil of rose.
Oil of cassia.	Oil of myrrh.	Oil of thyme.
Oil of cedar.	Oil of neroli.	Oil of turpentine.

Oils are inflammable either at the ordinary temperature or when heated. The fixed oils are not volatile without decomposition. Some of them oxidise when exposed to the air, and dry to a caoutchouc-like substance. The essential oils are of a peculiar pungent odour, distil without decomposition, and are very inflammable.

Oil Colouring.—Photographs may be coloured in oils if first coated with japanner's quick gold size. The following excellent instructions for tinting in oils are given by a correspondent in *Photography** :—"For tinting pictures in oil the following colours will be required: White, Naples-yellow, yellow ochre, raw sienna, burnt sienna, mars orange, light red, vermilion, pink madder, crimson lake, Indian red, raw umber, burnt umber, terra verte, emerald green, ultramarine, Prussian blue, ivory black, and whatever other colours the particular draperies and background may require. Payne's grey is also useful. Use sufficient megilp to render the colours thin and transparent, and lay the colours on with as little disturbance as possible to secure their purity. Commence by carrying a warm tint of light red and burnt umber over the darkest shadows; use white, terra verte and Indian red for the lighter shadows, white and terra verte for blending the high lights. The following are the best combinations for various complexions: White, Naples-yellow, and vermilion; the same, with an addition of light red, white and pink madder, with a little vermilion for the

* March 6th, 1890.

tint on cheek. If these colours are mixed in small quantities those most suitable for the model can be easily selected. The shadows may be glazed over with a mixture of white, light red, and emerald green, or white, Indian red, ultramarine, and raw umber, the complexion of the person indicating the choice. The high lights should be touched in with white and Naples-yellow graduating into the local colour. Strengthen the nostrils and the lines of the eyelids, and that separating the lips with Indian red. Carry a line of brown or indigo as may be required round the iris of the eye, put in the local tint, the reflected light and the pupil, remembering the part of the eye called white is really greyish, more or less light, according to the position of the eyes and length of eyelashes. The eyebrows and hair should be glazed with a suitable brown, keeping the former soft, transparent, and hairlike, and the divisions of the hair well but not too strongly defined, and the hair transparent where it meets the brow. The high lights of the hair will be bluish, being colder by contrast as the hair is dark or fair. Use Payne's grey mixed with shadow tints to blend the hair and face. Black dresses or coats should be glazed with a warm transparent black, into which strengthen the lights with tints of black and white mixed, and deepen the shadows with Vandyke brown and a little lake. Should the hands require painting they should be done with the same tint as face, with the addition of a rosy tinge on the knuckles and tips of fingers, and the divisions strengthened with a warm shadow tint. All draperies may be done as in case of black with such colours as the fabric may require, remembering always where the lights are cold the shadows must be warm. For lace or linen use white and blue black, white, black, and burnt umber, with white for the lights. For gold ornaments use yellow ochre or Naples-yellow, yellow ochre and raw umber, and burnt sienna and raw umber."

Oiled Negatives.—Negatives made upon paper used as a substitute for glass are usually oiled or otherwise treated to render them more translucent, and consequently to print with greater rapidity. Oiled negatives require to be kept in oiled or waxed paper. (See **Paper Negatives** and **Translucent.**)

Oiled Paper.—Paper treated with oil. (See **Translucent.**) A paper of this kind is often useful for photographic purposes—for instance, where an air-proof packing is required. Oiled-paper negatives should be kept in oiled or waxed paper.

Oil of Spike.—A volatile oil obtained by distilling the leaves and stalks of the lavender. It is not so agreeable as lavender oil (*q.v.*), is specifically heavier, and deposits a large quantity of camphor.

It is used in the manufacture of encaustic paste, varnishes, etc. (See **Lavender Oil**).

Oil of Vitriol.—See **Sulphuric Acid.**

Oil Paintings, Photographing.—The photographing of oil paintings was formerly beset with difficulties owing to the incorrect relation of the photograph to the colours, that is to say, a light yellow on a dark blue ground would appear in the photograph in the opposite to what is apparent to the eye. This defect has been considerably overcome by the use of the orthochromatic process.

The oil painting should be well lighted, and a slow and thickly coated plate used. For method of orthochromatising the plate, see **Orthochromatic Photography.**

Olive Oil.—A non-drying oil extracted from the fruit of the olive. It has a pale yellow colour, with a mild agreeable taste. It solidifies between 0° and 10°.

Opal.—This term is applied to pictures made upon opal glass by various processes. Opal plates coated with a gelatino chloride or gelatino-bromide emulsion are now largely manufactured, and sold ready for use. These are exposed behind the negative, and developed in the ordinary manner. Pictures upon opal glass can also be produced by the powder or dusting on process, and by the carbon or Woodbury printing methods. See **Opalotype.**

Opal Glass is made by fusing one of the oxides of tin or zinc with the metal. It is sold for photographic purposes in two different states, *i.e.*, "plain" and "smoothed," the former possessing the natural polished surface of the glass, and the latter being very finely ground. The latter is more generally employed, owing to the softer effect given to the picture, and also to the difficulty in obtaining even pieces of the polished kind.

Flashed opal is made by laying a thin veneer of the opal glass on to a greater thickness of clear glass.

Opaline.—This is a name given to prints mounted in optical contact with a piece of clear bevelled glass. In this manner they possess somewhat the appearance of a picture upon opal glass. The prints should, if possible, be vignetted, so as to leave a white margin all round the edge of the glass. The method of mounting them in optical contact is the following:—After toning, fixing, and washing, the pictures are dried between blotting boards placed under pressure. Soak about two ounces of soluble gelatine in cold water until soft, then add sufficient boiling water to make a rather thick solution. When the gelatine is thoroughly dissolved, filter it through muslin into a clean glass or porcelain dish standing in a hot water bath, the temperature of the solution to be kept at about 100° F. Have the bevelled-edged glasses perfectly clean and near at hand. Immerse a print in the gelatine, and when soaked lift it out and lay it quickly on the glass, and at once firmly squeegee it.

When dry, the print is trimmed with a sharp knife to the exact size of the glass on which it is mounted. A piece of leatherette paper can be pasted on to the back to give a better finish.

Opalotype.—A term applied to pictures made upon opal glass. The simplest method of producing them is upon opal glass, coated with a gelatino-chloride or gelatino-bromide emulsion. Either polished or ground opal may be used; the latter gives very artistic matt pictures. These plates are exposed under the negative, they are then soaked in water for a few minutes, and then developed with a ferrous oxalate, eikonogen or hydroquinone developer. They are then cleared and fixed. In warm weather an alum bath should be used.

Another method is to coat opal plates with a gelatino-chloride printing-out emulsion, and then print out, tone, and fix, as with gelatino-chloride paper.

A common method of producing these pictures is with a collodio-chloride emulsion, made up according to the following formulæ:—

Sol. 1.

Silver nitrate	15 grains.
Methylated alcohol	14 drachms.

Dissolve by slightly warming.

Sol. 2.

Strontium chloride	15 grains.
Methylated alcohol	14 drachms.

Sol. 3.

Citric acid	15 grains.
Methylated alcohol	14 drachms.

Sol. 4.

Pyroxyline	31 grains.
Methylated alcohol	14 drachms.
„ ether	14 „

To prepare the emulsion, 150 minims of No. 2 are added to the same quantity of No. 3; 28 drachms of No. 4 are then added. Mix up well together, then add very slowly 75 minims of No. 1, stirring the whole up while the addition is being made.

The plates are first treated either over the whole or the edges only with albumen or indiarubber solution, and after coating with the collodion are allowed to become thoroughly dry. These plates are then printed upon, toned, and fixed as with albumen paper. Special printing frames have been devised to enable the operator to examine the opal during the process of the printing operation. (See **Printing Frame.**)

Opaque (Lat. *opacus*—shady).—Bodies are said to be opaque when they are impervious to rays of light. No body is, however, absolutely opaque, as when reduced to sufficiently thin laminæ they always transmit a portion of the light which strikes them.

Optical Axis.—See **Principal Axis.**

Optical Centre.—Every lens possesses a certain point, situated on its principal axis, termed the optical centre. At this point every incident ray which passes through it does not undergo deviation, but pursues a path parallel to its original course.

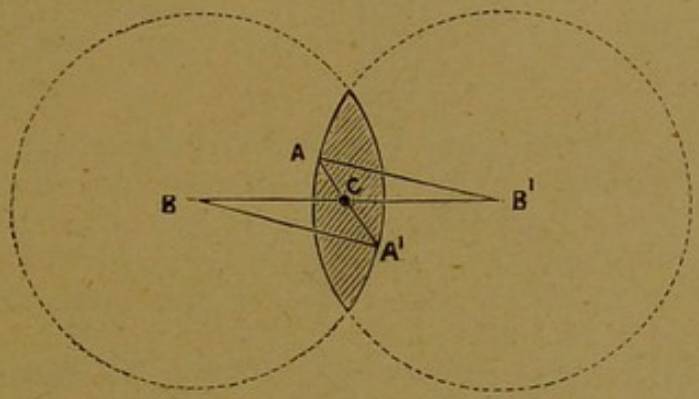

FIG. 153.

Only single lenses have perfectly true optical centres in an achromatic combination; its position may be ascertained approximately by considering it as a single lens.

In order to obtain the optical centre of a single lens, first draw a line B C B′ (fig. 153). This to represent the principal axis. From the centres of curvature B B′ next draw two radii B′ A and B A′ parallel to each other, but oblique to the central axis B B′. Next join their extremities A A′ and the point C where this line cuts the principal axis is the optical centre. To obtain the optical centre of a meniscus lens, prolong the line A A′ to the point where it meets the principal axis, and this will be the optical centre. In plano-convex and plano-concave lenses it is found by the intersection of the spherical surfaces of the principal axis. The optical centre of a plano-convex lens is on the convex surface, and of a plano-concave on the concave surface. If the lens be a meniscus or a concavo-convex, it will be outside the lens altogether, and its distance from the two surfaces will differ in proportion as their radii of curvature differ. The point C (figs. 154 and 155) shows the position more clearly of the optical centre of a plano-convex and a meniscus. Another method of finding the optical centre of the lens is the following:—

Let *r* be the radius of the front surface of a lens, *s* the radius of the back surface, and *t* the thickness of the lens, then the distance

of the optical centre, measured along the axis of the lens from the centre of the face of the front surface, is equal to $\frac{rt}{s-r}$

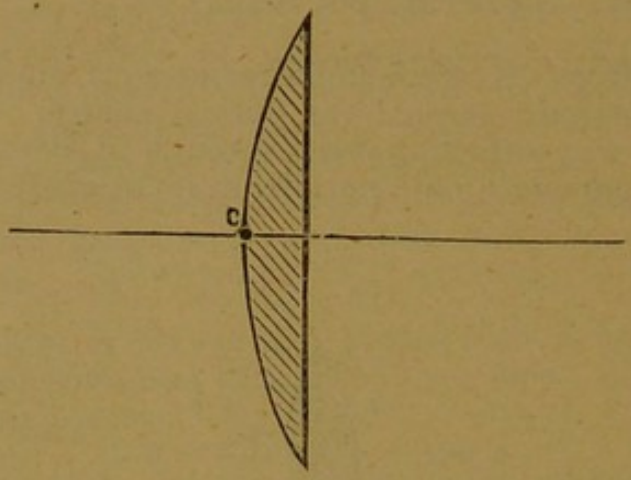

Fig. 154.

By giving to *r* and *s* the proper algebraical sign and a given magnitude, the position of the optical centre of any lens may be easily found.

Optical Contact.—A photograph is said to be mounted in optical contact when it is so firmly attached to a piece of glass that no intervening air is perceptible. For method of mounting prints in optical contact see **Opalines.**

Optical Instruments, Preserving.—All optical instruments, if required to be kept in good working order, should be carefully preserved from light and moisture, which have a peculiarly ruinous

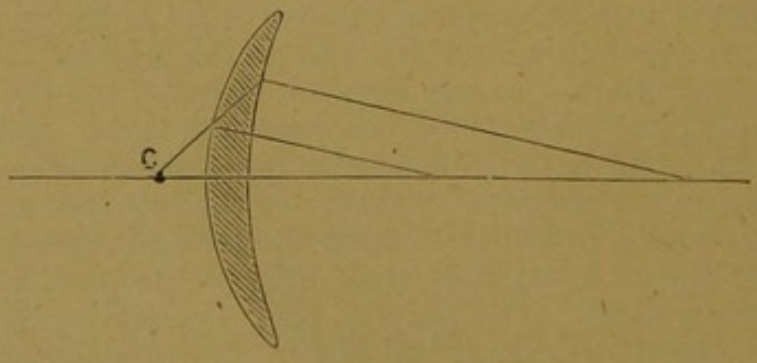

Fig. 155.

effect upon the glass. Lenses, when not required for use, should be kept in small chamois leather bags made to fit. If the brass-work of the lens becomes scratched and dirty, it may be carefully

cleaned, polished, and relacquered. The lenses should be removed carefully, noting their position to avoid error in resetting, and the old lacquer removed with a rag dipped in methylated spirit. The brasswork is then polished with a piece of fine emery cloth, the rubbing of the cloth being done in one direction only. After sufficient polish has been obtained, a small quantity of a lacquer is poured into a saucer or egg-cup. This lacquer is composed of—

Seed lac	12 ounces
Copal	4 ,,
Dragon's blood	80 grains
Extract of red sanderswood	50 ,,
Saffron	70 ,,
Pounded glass	½ pound
Spirits of wine	2 quarts

A fine flat camel-hairbrush is the most suitable instrument for lacquering. The article is first warmed to a gentle heat, and the lacquer applied with the brush in one direction only, if possible. It will sometimes be convenient to hold the article by a piece of wire fitted into some hole in it. It should not be heated to more than about 200° Fahr. The principal points in lacquering are to keep the brush clean, and charged with as little of the solution as possible. The brasswork must also be quite clean, and not made too hot. Another lacquer, somewhat simpler to that already given, can be made by dissolving ½lb. of the best pale shellac in one gallon of methylated spirit, and filtering. Yellow tints may be given to it by the addition of saffron or gamboge, or, if a redder colour is required, annatto or dragon's blood should be added.

The inside of the lens mounts may be re-blackened by applying this lacquer in the same manner, the solution having been previously mixed with finely triturated lampblack. Only one or two coats should be given, or its surface will become glossy, and it is obvious that this is to be avoided.

Optical Glass.—Glass specially manufactured for the construction of photographic lenses. This is usually crown or flint. Patents have been recently taken out by Drs. Abbe and D. Rudolph, of Jena, for the manufacture of a new glass for lens making. This new Jena glass, as it is called, has not yet been placed on the market, but lenses have already been made of it by English as well as foreign opticians. Messrs. Swift and Son have manufactured a lens of Jena glass which has an angular aperture so great that it can be used for portrait work even in a badly-lighted room, its full aperture being f/4. It has an equivalent focus of 4½ inches, and is fitted with an Iris diaphragm. Wray has also manufactured a lens of this kind of glass with an

Iris diaphragm, extending from f/8 to f/64. A lens which covers a quarter-plate with ease with full aperture will cover an $8\frac{1}{2}\times6\frac{1}{2}$ plate with the diaphragm contracted. (See under **Glass.**)

Optical Lantern.—An apparatus employed for projecting magnified images upon a white screen. The rays emanating from an artificial source of light are collected together and passed through a transparent positive picture, which by the divergence of the rays through a lens is thrown brilliantly illuminated and magnified on a screen. The practical requirements in an optical lantern are first a light-tight box or case containing the illuminant, a lens or condenser to concentrate the light and throw the rays evenly and uniformly through the transparent slide, and a lens for magnifying theimage. If an oil lamp be used a silvered reflector will also be necessary. A large variety of lanterns are now manufactured.

The Illuminant.—The cheapest form is the ordinary colza or sperm oil lantern. Paraffin oil is now generally used, burnt with a combination of from two to five wicks. This is usually accomplished by placing the long wicks parallel with or sloping towards each other, so that by a proper regulation of the ventilator the flames are made to converge and unite in one brilliant light.*

The limelight occupies the highest place. There are four different systems, *i.e.*—(1) the oxycalcium or spirit jet; (2) the blow-through; (3) the mixed; (4) the ether-oxygen light. All these depend for their illuminating qualities or the incandescence of a cake of lime by the impact upon its surface of a jet of oxygen passed through or mixed with a hydrogen or other flame to maintain combustion, because oxygen alone will not maintain a flame.†

The limelight was first discovered about the year 1826 by Lieut. Drummond, R.E., but the modern methods of construction differ considerably.‡

The best limes to be obtained are of the kind known as "hard" or Nottingham limes.

For all these four systems of limelight, the manufacture of oxygen is necessary. This will be found treated upon under **Oxygen** (*q.v.*) It can now be purchased ready made in almost every town in strong steel cylinders. The oxycalcium or spirit jet requires spirits of wine as the flame maintainer, a reservoir containing spirit being attached to the jet in such a manner as to keep up a constant supply of spirit in a small lamp placed in front of the lime support. The spirit lamp is first lit, and then the oxygen turned on and is thrown by the jet through the spirit flame on to the lime, which it lights up with extreme brilliance.

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* The Indispensable Handbook of the Optical Lantern.—Iliffe & Son. † The Indispensable Handbook to the Optical Lantern.—Iliffe & Son. ‡ The Book of the Lantern, by T. C. Hepworth.

The blow-through or safety is similar in its action to the oxy-calcium, except that instead of the spirit lamp the flame of a jet of hydrogen is used. This is the most commonly used form of lime jet. If properly constructed it should illuminate a picture at least 15 feet in diameter. The hydrogen gas can be supplied from the nearest household source by means of an indiarubber tube. It is carried to a point just in front of the lime, and the oxygen tube is carried out in front of it and brought round at an angle so as to cross the lines of flame and blow the oxygen through the hydrogen flame as it emerges from the nozzle. This system is a perfectly safe one. The others are all attended with more or less danger. It must be remembered that hydrogen and oxygen when mixed together form an explosive vapour of enormous power. In the safety jet, there is absolutely no danger of explosion, for the reason that no mixture of the gases takes place until they meet the lime cylinder.

The third system is the oxyhydrogen or mixed jet. This gives a light of very powerful intensity. In it the gases are mixed together in a small channel below the nozzle, and they come out together on to the lime. In the hands of an inexperienced person, this method would be a very dangerous one, for if the pressure on the gas bag were to be removed for even a single instant, the mixed gas or flame would be sucked back into the bag, and a tremendous explosion would be the result. To prevent this disaster, safety valves have been used.

The ether-oxygen or ethoxo limelight is similar to the last, except that vapour of sulphuric ether is used in place of the ordinary hydrogen gas. It gives a very beautiful light, but has several drawbacks, danger of explosion being one, so that it is but very little used.

The Condenser.—The object of the condenser is to collect as much of the light as possible, and pass it uniformly through the transparency. There are two principal forms—one consists of a pair of plano-convex lenses, mounted, with the curved surfaces nearly touching, and the other consists of a double convex lens associated with a meniscus, the concave side of the latter being next the radiant point.

The Lens, or objective, is required to receive the rays of light passing from the condenser through the picture, and to magnify and project them on to the screen. It should have a flat field and be free from distortion. Further, it should be achromatic.

In using the optical lantern the following hints will be found useful.* Wipe the front and condensing lenses with a piece of soft silk free from every particle of dust. Thoroughly dry new wick before putting it into the lamp; let the wick be saturated with oil before lighting. The best paraffin oil gives the brightest

* From "Hints when Using the Optical Lantern," by Perken, Son and Rayment.

light. Diener's A1 safety oil, and Strange's A1 crystal oil, also the Vaseline Company's Luxor, are specially recommended. The best quality wick is indispensable to brilliant illumination. Cheap wicks and cheap oils are false economies, and answerable for very many failures and disappointments when exhibiting the lantern. A large and strong pair of scissors should be used to trim the wicks, or preferably the "Optimus" patent wick trimmer, as a perfectly straight and even edge to the cotton is necessary to the avoidance of an uneven flame and smoke. Cut off the protruding corners to allow the flame to draw evenly upwards. Light the lamp with wax vestas or tapers. The heads of matches or charred paper are liable to fall into the air passages between the wick tubes, so impeding complete combustion. When lighting the lamp, do not turn the wicks high immediately, but raise them little by little at intervals of a few minutes. This system, besides improving the flame, gradually warms the condensing and front lenses; if suddenly heated they are likely to crack. Cold air being allowed to blow on a heated condenser will also certainly cause unequal contraction, *i.e.*, a cracked glass. The oil reservoir and other exterior parts of the lamp should be wiped *perfectly* dry, otherwise the oil about them will vapourise and fill the apartment with a most unpleasant odour. The wick should be trimmed prior to each exhibition, and when not burning should be turned one-eighth of an inch below the top of wick tubes, so that they may be permeated with oil. A plentiful supply of pure air is an imperative necessity to perfect combustion or perfect illumination. In crowded rooms, opening a window or door will greatly improve the light of the lamp; insufficiency of air ensures a bad light and an unsatisfactory exhibition. Like ourselves, the lamp gives its best results when it enjoys pure air, clean surroundings, and pure food (oil).

With regard to the size of the disc produced by the lantern, the following remarks and table from the *Optical Magic Lantern Journal* will be found of very great use:—

When one is called upon to give a lantern entertainment in a hall or room the following questions will be uppermost in the mind of the operator:—1. What size of disc can be obtained with a lens of a certain focus? 2. How far distant from the screen must the lantern be placed in order to get a disc of a certain size with a given lens of ascertained focus? Doubtless many more questions will arise, but these mentioned will be of the most importance. It is a "rule of thumb" practice for an operator to wheel his apparatus up and down a room in order to find the desired position from which to officiate, and the minds of any spectators will not be confirmed in the idea that the exhibitor thoroughly understands his business. How very much more simple and satisfactory is it to reason thus before starting for the place of entertainment:—"A screen of —— feet diameter is required, so if I bring a lens of —— focus the lantern must be —— feet from the screen;" the length of

the room being, of course, taken into consideration, in order to ascertain that it is possible to erect the lantern at the desired distance. This having been ascertained beforehand, all that is required is to take an objective of the desired focus, and measure off the necessary space between the screen and the place where the lantern should be set.

Supposing we are called upon to operate the lantern in a hall twenty-five feet in length, we first ascertain the size of disc desired, which we will suppose to be ten feet. With an objective having a focus of six inches, how far from the screen must the lantern be placed in order to produce a ten-foot disc ?

Here is the rule by which it can be ascertained :—

Let A = focus of objective.
,, B = diameter of slide.
,, C = ,, disc.
,, D = distance between the lantern and screen.

Multiply the diameter of the circle required (C) by the focus of the lens (A) and divide by the diameter of the slide (B).

$$\frac{C \times A}{B} = D = \frac{10 \times 6}{3} = 20 \text{ feet.}$$

It is thus seen that in order to produce a ten-foot disc with a six-inch objective the lantern must be placed twenty feet from the screen.

On the other hand, we may possess several lenses of different foci, and it is necessary that the screen and the lantern must occupy certain positions which we will suppose to be just twenty feet apart, and that the diameter of the disc must be ten feet. How are we to ascertain whether we must use a lens of four, five, six, seven, or other number of inches in focus ?

Multiply the distance between the lantern and the screen (D) by the size of opening of slide (B), and divide by the size of disc (C)

$$\frac{D \times B}{C} = A, \text{ focus of lens} = \frac{20 \times 3}{10} = 6\text{-inch focus.}$$

Again : We have a lens of six-inch focus, and intend that twenty feet shall intervene between the lantern and the screen, and wish to know what size of disc can be produced. In order to calculate this it is necessary that we multiply the distance between the lantern and the screen (D) by the size of slide opening (B), and divide by the focus of the lens used (A), which gives us

$$\frac{D \times B}{A} = C \text{ size of disc} = \frac{20 \times 3}{6} = 10 \text{ feet diameter of disc.}$$

The following Ready Reference Table has been computed by the foregoing rule, and by a glance it will show the relations between lantern and disc with object-glasses of every focus from 4 inches to 15 inches.

Ready Reference Table.

Distance between Lantern and Screen.	Focus of Lens. 4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.	12 in.	13 in.	14 in.	15 in.
	Diameter of Disc.											
	ft. in.	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*	*ft. in.*
10 feet	7 6	6 0	5 0	4 3	3 9	3 4	3 0	2 9	2 6	2 4	2 2	2 0
11 ,, ...	8 3	6 7	5 6	4 9	4 2	3 8	3 4	3 0	2 9	2 6	2 4	2 2
12 ,, ...	9 0	7 2	6 0	5 2	4 6	4 0	3 7	3 3	3 0	2 9	2 7	2 5
13 ,, ...	9 9	7 10	6 6	5 7	4 11	4 4	3 11	3 7	3 3	3 0	2 9	2 7
14 ,, ...	10 6	8 5	7 0	6 0	5 3	4 8	4 2	3 10	3 7	3 3	3 0	2 9
15 ,, ...	11 3	9 0	7 6	6 5	5 8	5 0	4 6	4 1	3 9	3 6	3 3	3 0
20 ,, ...	15 0	12 0	10 0	8 7	7 6	6 8	6 0	5 6	5 0	4 7	4 3	4 0
25 ,, ...	18 9	15 0	12 6	10 9	9 4	8 4	7 6	6 10	6 3	5 9	5 4	5 0
30 ,, ...	22 6	18 0	15 0	12 10	11 3	10 0	9 0	8 2	7 6	6 11	6 5	6 0
35 ,, ...	26 3	21 0	17 6	15 0	13 1	11 8	10 6	9 6	8 9	8 1	7 6	7 0
40 ,, ...	30 0	24 0	20 0	17 2	15 0	13 4	12 0	10 10	10 0	9 2	8 6	8 0
45 ,, ...	33 9	27 0	22 6	19 3	16 10	15 0	13 6	12 3	11 3	10 4	9 8	9 0
50 ,, ...	37 6	30 0	25 0	21 5	18 9	16 8	15 0	13 8	12 6	11 6	10 9	10 0

Examples.—An 8-inch focus lens, at a distance of 35 feet, will give a disc of 13 feet 1 inch. To produce a disc of 12 feet, with a lens of 10 inches focus, the lantern and screen must be separated by 40 feet. To produce a disc of 15 feet at a distance of 45 feet, will require a lens of 9 inches focus.

Opticians' Cement.—A cement used by opticians for fixing lenses, prisms, &c., to chucks, holders, &c., while they are being ground. It is made of pitch 10 parts, wood ashes 1 part, and 1 part more or less of tallow, according to the temperature of the season.

Optics was defined by Sir David Brewster as that branch of knowledge which treats of the properties of light and vision as performed by the human eye. The modern divisions of this science may be stated to be as follows:—(1) Light and its sources; (2) transmission, velocity, and intensity of light; (3) reflection and mirrors; (4) single refraction and lenses; (5) dispersion and achromatism; (6) optical instruments; (7) the eye as an optical instrument; (8) phosphorescence and fluorescence, and (9) double refraction interference and polarisation.

Light and its Sources.—Light is the agent which by its action on the retina excites in us the sensation of vision. Various hypothesis have been made as to the origin of light, the two most important being the emission or corpuscular theory and the undulating theory. These will be found more clearly defined under the heading **Light** (*q.v.*).

Transmission, Velocity and Intensity of Light.—*Luminous* bodies are those which emit light such as the sun, and ignited bodies such as a candle. *Transparent* or diaphanousbodies are those which readily transmit light. *Translucent* bodies transmit light but partially, as objects cannot be seen through them as in the case with transparent bodies. *Opaque* bodies do not transmit light.*

It is a well-known fact that light always travels in straight lines, and cannot turn a corner. The term *ray of light* is used to indicate the straight line along which light progresses. If the luminous body be central, rays of light are emitted from all its points and in all directions. A collection of rays emitted from a luminous point, and

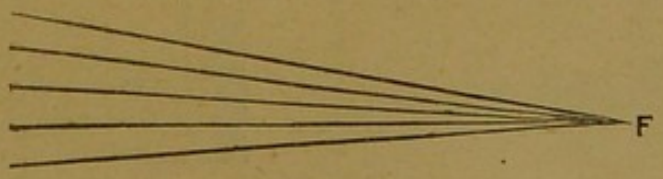

Fig. 156.

circumferentially so limited in their passage as to form a conical outline, is called a *diverging pencil of rays*, the apex of the cone from which they proceed being termed the *focus* of the pencil. See fig. 156.

* No body can be said to be absolutely opaque, as all are more or less translucent when cut or formed into sufficiently thin sheets.

If the rays proceed from so distant a point that any divergency is inappreciable, the rays are termed *parallel rays*. See fig. 157.

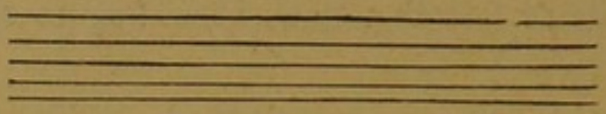

Fig. 157.

When, however, they are made to converge to a common point they are described as a *converging pencil of rays*, and the point at which they meet is termed the focus. See fig. 158.

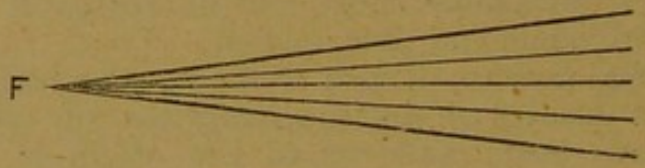

Fig. 158.

Every luminous body emits divergent rectilinear rays from all its points and in all directions. As light travels in straight lines it will be easily understood that if any opaque body be interposed between the source of light and the eye it will prevent it from being seen. The light cannot penetrate into the space behind it, and this space is termed the shadow.

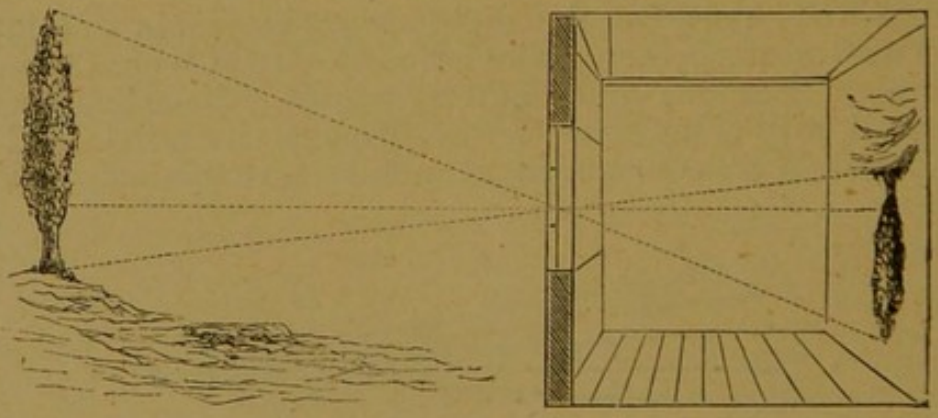

Fig. 159.

If a small aperture be made in an opaque substance, such as, for instance, a piece of tinfoil, and luminous rays made to pass through this aperture into a dark chamber and thrown on to a screen, they will form images of the external objects. See fig. 159.

These images are always inverted owing to the fact that the luminous rays proceeding from the external objects cross one another on their passage, as shown in the diagram.

Light moves at a velocity of about 190,000 miles in a second. M. Foucalt constructed an apparatus for measuring the velocity of light based on the use of the rotating mirror adopted by Wheatstone in measuring electricity. With this arrangement he calculated the speed to be 185,157 miles per second. The intensity of illumination of given surface is subject to the two following optical laws :—

I.—*The intensity of illumination on a given surface is inversely as the square of its distance from the source of light.*

II.—*The intensity of illumination which is received obliquely is proportional to the cosine of the angle which the luminous rays make with the normal to the illuminated surface.*

The first law is one that should be carefully noted by the photographer on exposing sensitive material to the action of light rays.

Reflection and Refraction.—When a ray of light meets a polished surface it is reflected according to the two following laws :—

I.—*The angle of reflection is equal to the angle of incidence.*

II.—*The incident and the reflected ray are both in the same plane, which is perpendicular to the reflecting surface.*

All the phenomena of reflection of rays of light from polished surfaces, whether plane or curved, take place in accordance with these two laws. If the polished surface be a plane, or have a regular curvature, the reflected rays of light produce images of the objects from which the rays have proceeded. If the surface be roughened, reflection will still be produced, but the rays are irregularly dispersed, and no images are produced. By the term reflecting surfaces is usually meant polished surfaces, but even when a ray of light meets a perfectly polished surface only some of it is reflected. A portion of it is absorbed by the medium forming the substance of the polished surface, another part is diffused, and another is transmitted, if the medium be transparent.

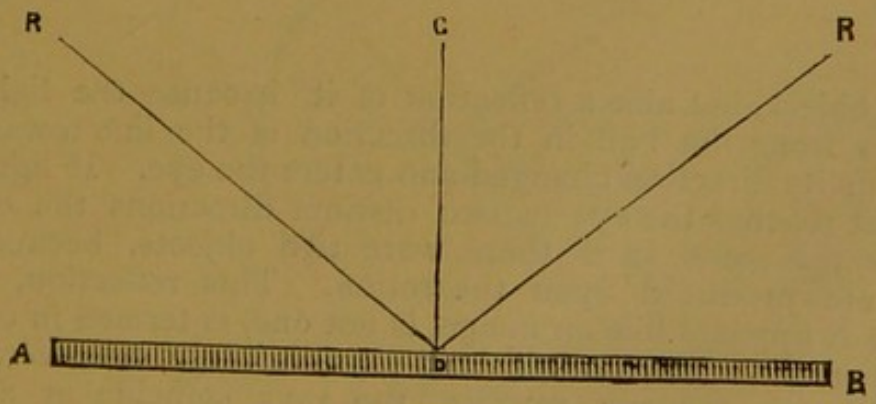

FIG. 160.

Let A B (fig. 160) be a plane reflecting surface, and R D a ray of light incident upon it, the ray will be reflected in the direction

D R′ in the same plane as the incident ray, the plane being perpendicular to the reflecting surface, and making with that surface an angle R′ D B equal to the angle R D A. The normal C D is the straight line perpendicular to the surface A B, which makes the incident ray R D and the reflected ray R′ D equal angles.

Bodies having polished surfaces are termed mirrors, and show by reflection images of objects presented to them. The place at which objects appear is their *image*. The quantity of light reflected from the surface of a mirror depends firstly upon the degree of perfection of its polish; secondly, on the colour of its surface; and thirdly, upon the incidence of the luminous rays which strike it. Mirrors are divided, according to their form, into the following :—*Plane*, *concave*, *spherical*, *parabolic*, *conical*, *&c.*

The commonest example of the plane mirror is the ordinary looking-glass. Its effect is shown in fig. 161. The eye not only

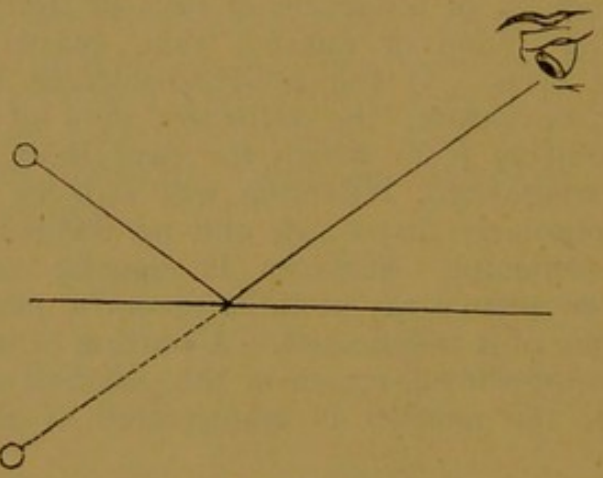

Fig. 161.

sees the object, but also a reflection of it, because the light that emanates from the ball in the direction of the line towards the mirror has its direction changed and enters the eye. If light from the object reaches the eye in two distinct directions the effect is precisely the same as if there were two objects, because two images are produced upon the retina. This reflection, which, although it appears like an image, is not one, is termed in optics a *virtual image*. When the reflected rays converge, however, as is the case with concave mirrors, the rays coincide at a point in front of the mirror on the same side as the object. They then form an image termed a *real image* that can be received on a screen.

Polished metal mirrors give only one image; glass mirrors give several, however. If a candle be placed near a looking-glass, and its reflection received obliquely, a feeble image is first seen in front of the principal and distinct one. Behind this several other images are observed, the intensities of which gradually diminish as they disappear. This phenomenon is due to the fact of the looking-glass possessing two reflecting surfaces.

Oblique rays are partly reflected from the front surface of the glass which gives the faint image first mentioned, in addition to the principal image reflected from the back surface. The other images are produced by the light from the back, or prepared surface, being reflected back again from the front surface of the glass, and so going backwards and forwards, producing numbers of images which naturally get fainter and fainter. The passage of the ray is more clearly shown in fig. 162. The thick line indicates the passage of the light ray, and the dotted lines show the reflections producing the false images.

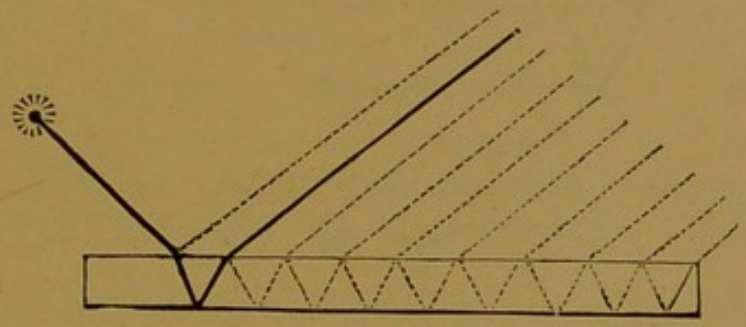

FIG. 162.

It is for the above reason that glass mirrors cannot be used for many purposes. For instance, in the making of reversed negatives, metal mirrors will be found preferable.

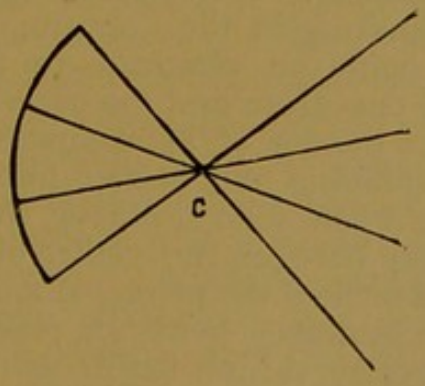

FIG. 163.

We have already pointed out that, besides plane mirrors, there are several other kinds; those now frequently used are the spherical and parabolic reflectors.

A concave mirror causes the pencils of light that impinge upon it to converge. As the law that the angles of incidence and reflection are equal applies to all reflecting surfaces, it will not be difficult to trace upon paper the effect of any mirror upon the direction of any ray of light. In figs. 163, 164, and 165,* the arcs that stand for curved mirrors are struck from the points marked C, and this point is called, in each case, the *centre of curvature* of the mirror.

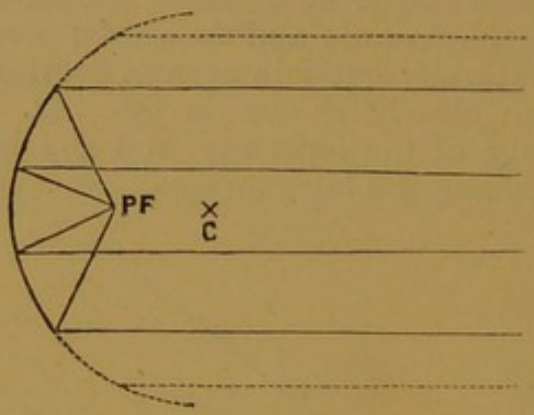

Fig. 164.

If a luminous point be placed in the centre of curvature of the mirror (c. fig. 163) the rays emanating from it travel in the direction of the radii of the sphere of which the mirror is a part, and those rays that impinge upon the mirror are reflected back along their original paths to the luminous point, and add their effect to the light emanating in the opposite direction. If, however, the luminous point be removed to a position half-way between the centre of curvature and the surface of the mirror, the light reflected forms a bundle of approximately parallel rays as shown in fig. 164 excluding the dotted lines, and conversely if parallel rays impinge upon such a mirror, they are brought to a point or focus half-way between the centre of curvature and the mirror. This point is termed the principal focus P.F. In fig. 165 we see at once that a luminous point B, placed farther from the mirror than its centre of curvature, has its light that impinges upon the mirror brought to an approximate focus at a point between the principal focus and the centre of curvature A. Conversely, a luminous point placed at A, would have its light concentrated at B, these two points, or any two points similarly related to each other,

* Chapman Jones's "Science and Practice of Photography."

being termed *conjugate foci*. The dotted lines in fig. 165 serve to show that if the curve of the mirrors were continued the concentration at the principal focus is not even approximate. This ack of focussing power is termed *spherical aberration by reflection* to distinguish it from the spherical aberration by refraction, which occurs in the case of lenses.

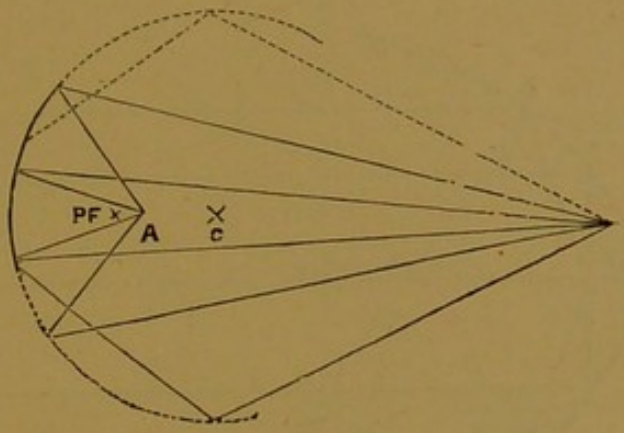

FIG. 165.

Parabolic mirrors are concave mirrors, whose surface is generated by the revolution of the arc cf a parabola, A B about its axis A A.

In spherical mirrors the rays parallel to the axis converge only approximately to the principal focus. Parabolic reflectors are free from this defect. It is a property of a parabola that the right line F B, drawn from the focus F to any point B of the curve, and the line B C parallel to the axis A A′, make equal angles with the tangent D D′ at this point. Hence all rays parallel to the axis after reflection meet in the focus of the mirror F, and conversely when a source of light is placed in the focus the rays incident on the mirror are reflected exactly parallel to the axis. The light thus reflected tends to maintain its intensity even at a great distance*

The use of mirrors of different kinds for photographic purposes is large. In the early days of the Daguerreotype a camera was constructed having a concave mirror instead of a lens. Owing to many drawbacks, however, this method was not found to be an advantage over the lens. In stellar photography, however, the mirror possesses several advantages over the lens. It can be made larger at less expense, gives a much brighter image, and is entirely free from chromatic aberration. Heliostats are adjustable mirrors, which receive their movements from clockwork in such a manner that the solar rays reflected remain motionless in a given direction.

* Ganot's Physics.

Convex mirrors do not possess real images; they are, therefore, of comparatively no use in photography.

Single refraction and lenses.—A ray of light proceeds in a straight line so long as the medium through which it is travelling is of

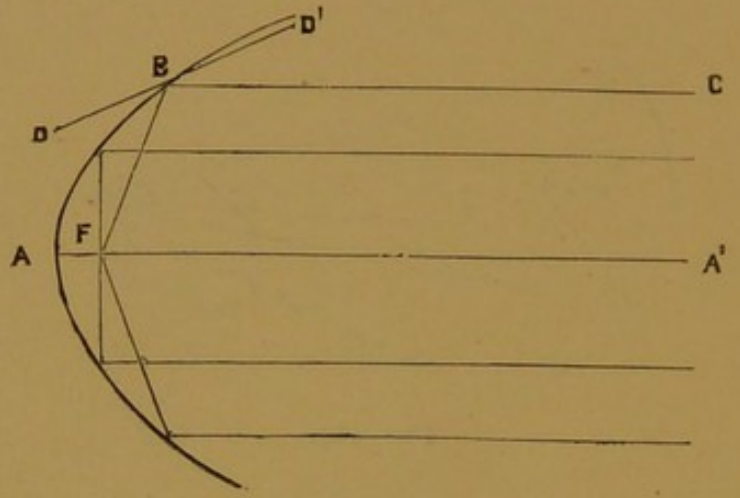

FIG. 166.

uniform density. If, however, it passes *obliquely* from one medium to another of a denser kind, it is *refracted towards* a line drawn perpendicularly to the surface of this medium at the poin of incidence; conversely on passing obliquely from a denser into a rarer medium it is *refracted from* the line. If the ray passes perpendicularly from one surface to another it continues its course in a straight line. Refraction is more clearly shown in fig. 167. The incident ray R C is refracted in the direction C R' by passing obliquely from air into water. The path of the light in the denser medium forms a smaller angle with the perpendicular A B than it does in the rarer medium. The line D E is the sine of the angle of incidence, and the line G F the sine of the angle of refraction. Analysis has shown that the direction of refraction depends on the relative velocity of light in the two media. The laws of single refraction are :—(1.) Whatever the obliquity of the incident ray the ratio which the sine of the incident angle bears to the sine of the angle of refraction is constant for the same two media, but varies with different media. (2) The incident and the refracted ray are in the same plane, which is perpendicular to the surface separating the two media.

The proportion between the lines D E and G F, when the media concerned are air and water, is approximately as 4 to 3.

These proportions, indicated as fractions, are the refractive indices, *i.e.*, $\frac{4}{3}$, or 1·33. If, however, the media are considered in an inverse order, that is to say, if the light passes from water to air, the index of refraction is consequently reversed, it would then be $\frac{3}{4}$. See also **Refraction.**

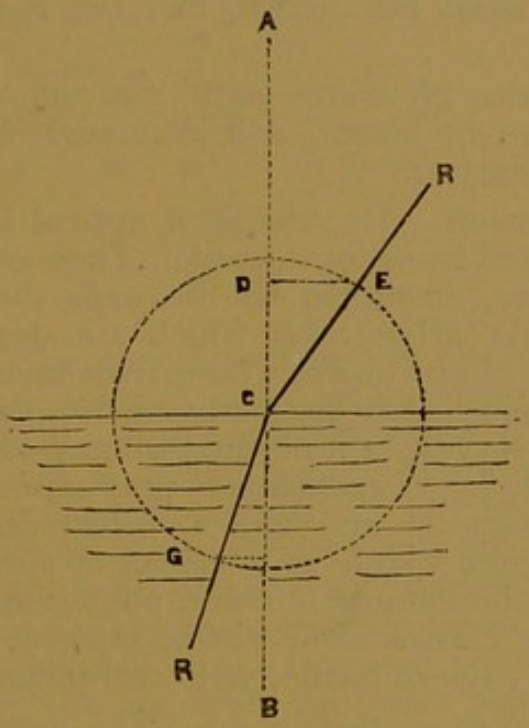

Fig. 167.

Lenses are transparent media, which, from the curvature of their surfaces, have the property of causing the luminous rays which traverse them to either converge or diverge. According to their curvature they are either spherical, cylindrical, elliptical, or parabolic. Those used in optics are exclusively spherical. They are usually made of crown glass and of flint glass. These two glasses possess different refractive indices. Combination lenses of the two glasses are made. For detailed information regarding lenses, see under **Lens.**

Dispersion and Achromatism.—To avoid confusion we have, on explaining the phenomenon of refraction, avoided mention of the phenomenon known as *dispersion.* When white light passes from one medium to another it is decomposed into several kinds of light. An experiment proving this can easily be made by boring a small hole in the shutter of a darkened room, to allow of a pencil of the sun's rays to pass through. This pencil will give you a round and colourless image of the sun. If, now, a flint glass prism be interposed in its path, the beam on emerging from it is refracted

and produces on a screen a vertical band, rounded at the ends, coloured in all the tints of the rainbow. This is termed the solar spectrum, and contains an infinity of different tints all imperceptably merging into each other. For the sake of simplicity however, it is customary to distinguish seven principal colours, these are, violet, indigo, blue, green, yellow, orange, and red. This is the order in which they are arranged in the spectrum, the violet being the most refrangible, and the red the least so. See also **Spectrum.**

This separation of white light into its component colours sometimes occurs in lenses, and is termed *chromatic aberration.* See under **Aberration.**

Optical Instruments.—By the term optical instrument is meant any combination of lenses or mirrors. They are divided by Gamot into three classes, according to the ends they are intended to answer, viz.:—(1) *Microscopes* which are designed to obtain a magnified image of any object whose real dimensions are too small to admit of its being seen distinctly by the naked eye. (2) *Telescopes* by which very distant objects, whether terrestial or celestial, may be observed. (3) Instruments to project on a screen a magnified or diminished image of any object, which can thereby be either depicted or rendered visible to a crowd of spectators, such as the camera lucida, the camera obscura, photographic apparatus, etc. The two former classes yield virtual images; the last, with the exception of the camera lucida, yield real images.

The Eye as an Optical Instrument.—The structure of the eye may be considered as a camera obscura, of which the pupil is the aperture, the crystalline the condensing lens, and the retina the screen upon which the image is formed. See **Vision.**

Phosphorescence and Fluorescence.—See under these headings.

Double Refraction, Interference and Polarisation.—A large number of crystalline bodies possess the property of double refraction, in virtue of which a single incident ray, in passing through any one of them, is divided into two, or undergoes what is termed *bifurcation.* An object, therefore, viewed through one of these crystals appears double. Iceland spar, or crystallised carbonate of calcium, possesses this property in a most remarkable degree. The term *interference* is given to the reciprocal action which two rays of light exert upon each other when emitted from two neighbouring sources, and caused to meet each other under a very different angle. If two similar waves start from the same place, at the same time, they increase each other's intensity, and the result is a wave of double light; but if one wave is half an undulation in advance of the other, the crest of one occupies the position of the hollow of the other, and the result is a dead level. If the intervals of starting are less than half a wave length, the result is a series of smaller waves, the magnitude

of which depends upon the distance which one wave has in advance of the other. The interference of the waves of light may be produced in many ways by diffraction, or by reflection, from thin films, such as soap bubbles, or from minute particles.*

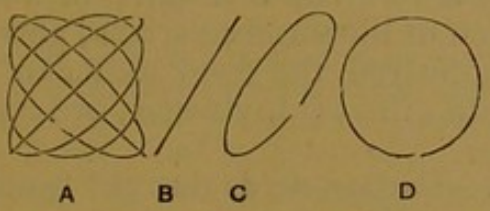

Fig. 168.

Polarisation of light is the state into which the ethereal undulations which cause the sensation of light are brought under certain conditions. These undulations are perpendicular to the line of transmission of the wave, as in a stretched cord, but in a ray of common light appear to take place successively in all directions, in the manner shown in diagram A, fig. 168 (but with the transitions far more gradual), the vibrations successively passing through rectilinear, elliptical, and circular phases with inconceivable rapidity. If now the vibrations become or are rendered stable in any form of orbit, the light is in the condition known as polarised, and the state is one of plane, elliptical or circular polarisation, according as the orbit resembles B, C, or D. The most familiar and simple form is that of plane polarisation. This may be produced in various ways, the apparatus producing such modifications being termed a polariser. When produced, however, the effects can only be perceived by examining them through another piece of apparatus called the analyser. The two, combined with the necessary adjustments, form a polariscope, of which there are many forms.

Optigraph (Gr. *optimai*—to see, and *graph*).—A form of camera used for the purpose of copying landscapes. The rays from the object to be drawn are reflected from a plane mirror through the object glass of the instrument to a speculum, and thence through an eye-glass to the eye. Between the eye and the speculum is a piece of parallel-faced glass with a small dot in its centre, exactly in the focus of the eye-glass. By moving the pencil, the dot seen in the field of the telescope is passed over the outlines of the object, which are at the same time traced on the paper by the pencil.†

* See Hunter's "Encyclopædic Dictionary." † Rodwell's "Dictionary of Science."

Orange Light.—A non-actinic light used in photography when handling sensitive materials. A very good temporary orange light can be produced by simply surrounding a candle with a piece of orange-coloured gelatine, and suspending a piece of red paper above to receive the top light. A good orange-coloured material may be made by dyeing with a solution of equal parts of annotta and pearlash, or by a bath of one part of annotta dissolved in a lye of one part each of lime and pearlash, and two parts of soda. If a redder shade is desired, the dyed stuff can be passed through water acidulated with citic acid, vinegar, or lemon-juice.

Organic Acids.—Carbon acids derived from hydro-carbon.

Organic Bases.—The alkaloids of vegetable and animal origin and the derivatives of ammonia produced by the destructive distillation of complex organic matter, and those formed chemically by the substitution of hydrogen of ammonia by organic radicals.

Organic Chemistry.—The chemistry of the carbon compounds in which the hydrogen or nitrogen of the substance is directly united with carbon. The marvellous discoveries of the last few years have made it impossible to state where organic chemistry ends and inorganic chemistry begins. In general terms, however, it may be stated that inorganic chemistry treats of the metals, or of the metals in combination with one or more of the non-metallic bodies.

Organic Radical.—A group of atoms containing one or more atoms of carbon, of which one or more bonds are unsatisfied. It can be a monad, dyad, or tryad, according to the number of monad atoms necessary to complete its active atomicity.

Organic Substance.—A substance or body having organs in action, and consequently life. The category includes animals and plants.

Oroheliograph (Gr. *oros*—a mountain, and Eng. heliograph).—An instrument invented by M. Noë, and described in a memoir to the Photographic Society of France. It consists of a camera, the sensitive plate forming the inner horizontal floor, and the lens looking up perpendicularly to the sky. Over the lens is placed a silvered mirror, half-globe shaped, completely circular on its plain and parabolic through its vertical section. The result is that an image of all surrounding objects reflected from this half-ball shaped mirror is received by the lens and transmitted thereby to the sensitive plate underneath with its surface forming a right angle with the axis of the lens and circular mirror. By this means a circular panoramic view of the horizon is obtained as seen from the station the oroheliograph occupies.

Orthochromatic Collodion Emulsion.—A collodion emulsion rendered orthochromatic by the addition of so-called colour-sensitisers, the effect of which is to produce photographic negatives more correct with regard to the colour gradations as apparent to the eye. Dr. J. M. Eder's formula is as follows:—

The emulsion is prepared with—

A.—15 grammes crystallised nitrate of silver dissolved in 12 c.c. water, and then 90 c.c. alcohol of 95% is added; the whole is then mixed with 150 c.c. of 4% raw collodion.

B.—15 grammes pure crystallised calcium bromide are dissolved at a gentle heat in 75 c.c. of an alcoholic solution of (1·800) eosine, and then added to 150 c.c. of 4% raw collodion.

In the dark room the collodion A, containing the bromide, is to be gradually added, well shaking the whole time, to the collodion containing the silver, until only about 5 or 10 c.c. of the bromide and collodion remain. The emulsion is then tested for an excess of silver nitrate. This is done by pouring a small quantity of the collodion on to a glass plate, and, when stiff, let fall a drop of potassium dichromate solution upon it. If a large excess of nitrate of silver be present, a deep coloured spot of silver chromate will be produced. A further quantity of the plain collodion is then added, and the test repeated. When the drop of dichromate solution gives only a pale orange-reddish spot the emulsion is fit for use.

This collodion emulsion only works well when a slight excess of silver nitrate is present, inducing the formation of eosine of silver. If no excess be present, the emulsion will be very insensitive, while, on the other hand, if the excess be too great, the film is much more sensitive, but is liable to produce dirty and foggy images. The emulsion may be used at once, but the results are better if it be kept for twelve or twenty-four hours. The plates are coated in the usual manner, and dipped in a vessel of spring water, until the water ceases to be repelled at any part of the surface. It is best to expose while still wet; when dry they are much less sensitive. The time required for exposure is about half that necessary for wet collodion plates with the iron developer. Most paintings or coloured objects may be photographed without the interposition of a yellow screen. A harsh blue may be softened down by using a screen of collodion stained with aurantia. The following will be found a serviceable developer:—

A

Water	100 parts.
Sodium sulphite	10 ,,
Potassium bromide	3 ,,
Citric acid	1 ,,
Pyrogallic acid	2½ ,,

B

Ammonia	1 part.
Water	6 parts.

Before use mix 100 c.c. of water, 10 c.c. of A, and 10 c.c. of B solutions.

Orthochromatic or Isochromatic Photography.—Synonymous terms applied to a process of obtaining photographic images of objects in, or nearly in their true respective tone values. Ordinary gelatine plates do not, as is well-known, represent objects in their true relative degrees of light and shade as apparent to the eye, for the reason that they are most sensitive to the blue and violet rays, less sensitive to the green, and very slightly sensitive to yellow, orange, and red, whereas the eye is most sensitive to yellow and least sensitive to blue and violet. Those rays, which produce the greatest effect on the eye, have therefore the least action on the photographic plate and *vice versa*.

As an obvious consequence of this defect, blue and violet objects appear much too bright in a photograph, while green, yellow, and red appear too dark. Thus, if we were to make a photograph of a yellow cross on a blue ground it would appear in the photograph as shown in fig. 169,

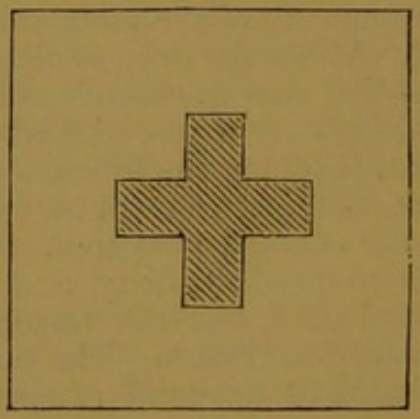

Fig. 169.

whereas if an artist were making a picture in black and white he would represent it as in fig. 170, that is to say the yellow cross would appear lighter than the blue ground, but in the photographic image it would be darker.

Fig. 171 is a table of curves taken from Professor Bothamley's paper on this subject. The curves represent the intensity of action, they rise to represent a large effect, and fall to show a diminution. The vertical lines stand for the Fraunhofer lines, and are lettered accordingly. Number 1 curve shows the visibility of the spectrum. Number 2, the effect produced by exposure and development of an ordinary gelatine bromide plate; and number 3, the result when it is prepared with a sensitiser composed of an ammoniacal solution of rose bengal.

The effect of this defect in photography will be at once apparent. Untrue images of coloured objects are obtained, the foliage in landscapes appears too dark, the blue sky or water reflecting it, too bright. The atmosphere intervening between the camera and

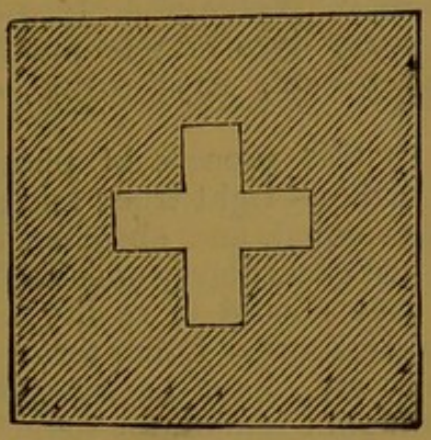

FIG. 170

objects afar off causes a bright haze, destroying all the detail in the distance. In portraiture the effect is quite as destructive, the tints of the flesh appear too heavy, sun-freckles or any other slightly yellowish mark, perhaps almost imperceptible to the eye, appear glaringly prominent as black spots or patches.

As far back as 1865, it was noticed that lenses which were of a slight yellowish tint, produced perhaps by long exposure to light, gave photographic representations of coloured objects in better relation. This led to the discovery that the interposition of

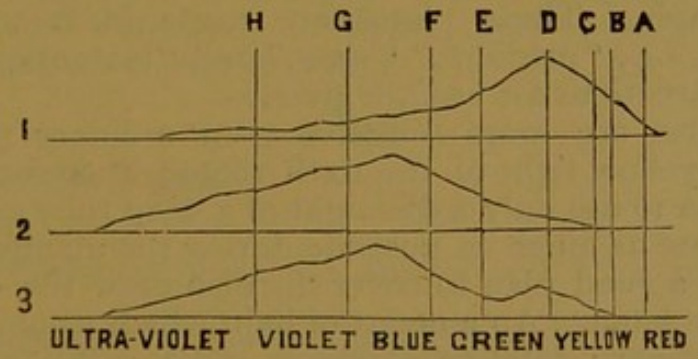

FIG 171.

a yellow transparent screen between the object and the plate, either before or behind the lens, would, by cutting off the greater portion of the blue and violet rays, and giving the green, yellow, and orange rays more time for action, produce images with nearly the same luminosity that the colours in the objects appear to the eye.

In 1873 Vogel* found that by treating certain plates with certain coal-tar dyes it was possible to make them sensitive to the less refrangible rays, namely, the green, yellow, orange, and red. Later on Waterhouse recommended eosine for the purpose, and a large number of dyes were afterwards found out to be serviceable for this purpose by many able scientists such as Vogel, Waterhouse, Tailfer, Eder, Bothamley, Wellington, Ives, Abney, Schumann, and others. Among these dyes may be mentioned the following: Eosine, cyanine, rose benzol, Erythrosine, chlorophyll, rosaniline, and azaline.

The names given to this process of photography are *Orthochromatic* from Greek orthos—right true; and chroma—colour, and *Isochromatic* from Isos—equal, and chroma—colour. Both these terms, it will be seen, are exceedingly unsuitable, and liable to mislead the student, as they should in reality be applied to photographs in true or natural colours. Other terms such as orthophotic, orthoactinic, paractinic, etc., have been suggested, but the term orthochromatic will no doubt remain for some time to come.

Orthochromatic or Isochromatic Plates.—Photographic plates prepared with a dye, either added to the emulsion previous to coating the glass, or applied in solution to the ordinary gelatino bromide dry plate. By this means better and truer colour gradation is obtained.

These plates may be obtained commercially, the best manufacture in this country being "Edwards' Isochromatic plates." These improved plates are equally adapted for landscapes and for general work in the studio. They will keep equally as well as ordinary gelatine plates, they are quite easy to work, and owing to their coloured sensitiveness, give better gradation and a more truthful representation of natural objects in the light and shade of the photograph. These plates are made in three degrees of sensitiveness, *i.e.*, "medium," "slow," and "instantaneous." The following instructions for use are given:—

These plates are more sensitive than ordinary plates to the usual red or yellow light of the dark room; therefore great care must be taken to use only a dull light of a deep ruby colour, and to shield the plate as much as possible during the manipulations. It will be found a good plan to cover the dish until the development is nearly completed. An amount of light which would be perfectly safe with ordinary gelatine plates, is quite sufficient with these colour-sensitive films to cause fog and spoil the negative.

Exposure.—These plates are extremely sensitive to ordinary daylight, and require very short exposure in the camera. If artificial light be used, such as gaslight, their relative sensitiveness will be found many times greater than the most rapid gelatine plates of the ordinary kind.

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* Die Photographie farbiger Gegenstände in denrichtigen Tonverhältnissen.

For photographing coloured objects, such as oil paintings by daylight, it is sometimes advisable, in order to obtain to their fullest extent the isochromatic qualities of the plate, to use a colour screen of yellow glass behind the lens, and proportionately increase the exposure. For ordinary purposes no screen is required. (See **Orthochromatic Screen.**)

Development.—Any good formula for developer may be used. For pyro development the following is recommended :—

THE STOCK SOLUTIONS FOR DEVELOPING.

No. 1.

Pyrogallic acid	1 oz.
Citric acid	40 grs.
Water	7½ oz.

No. 2.

Bromide of potassium	120 grs.
Distilled water	7 oz.
Strong ammonia, 880	1 oz.

The above will keep good, if well corked, for months.

To make the developer, add one part of No 1. to nineteen parts of water, and in another bottle mix one part of No. 2 with nineteen parts water. The dilute solutions should be made fresh every day.

When required to develop a plate, mix equal parts of these two solutions just before use ; place the exposed plate face up in a shallow dish or tray, and pour the mixture steadily over the plate, avoiding air bubbles ; rock the dish gently, taking care to keep the plate well covered with the solutions. Do *not* hurry the development, but allow the plate to remain in the solution *after all the details are visible*, until the required density is obtained. With these plates and the above developer there is no danger of fog, except from light or over-exposure.

FIXING.

Hyposulphite of soda	4 oz.
Water	16 oz.

Immerse the negative in the above, which should be freshly mixed.

Clearing Solution.—After fixing, rinse under the tap, then flood the plate or immerse for one minute in the following solution :—

Alum	1 oz.
Sulphuric acid	¼ oz.
Sulphate of iron	3 oz,
Water	20 oz.

Wash well and dry as usual.

Negatives on these plates develop without difficulty to full printing density. If found too intense they may be further

reduced by allowing them to remain a longer time in the clearing solution.

Considerable advantage is to be obtained by using these plates both for portrait and landscape photography. In the latter the improvement is at once seen, not only in the corrected rendering of the detail in the foliage and foreground, but also in the general effect of correct light and shade with an atmosphere that would be ruinous in ordinary photography, wholly obliterating the distant background.

Orthochromatic or Isochromatic Process.—A process of obtaining photographic images of coloured objects in true relative tone values. To obtain this, by counteracting the opposite effect that colours have upon the photographic plate to that upon the retina of the eye certain dyes are used.

The facts are these*, that when certain fugitive dyes absorb in a part of the spectrum to which the silver salt is insensitive, or only slightly sensitive, the rays absorbed produce an action on the silver salt in contact with it, either producing sensitiveness or increasing the sensitiveness. If the silver salt combines with the dye the action is readily explained by the ordinary theory, whilst if it does not the dye itself appears to undergo alteration, and to become, as it were, a developer, reducing a small portion of silver salt, on which subsequent development takes place.

The dyes generally used in practice are those known as erythrosine rose bengal, or eosine, usually with an alkali as ammonia. There are two methods of applying the dye to the plate. It may be added to the gelatine emulsion before coating, and orthochromatic or isochromatic plates then prepared are sold commercially, or the plate may be laid in a bath of the dye.

In working with orthochromatised plates every precaution must be taken to prevent fog, as it should be remembered that these plates are sensitive to the yellow or red light. The very deepest ruby should be used, and the plates covered up as often as possible.

A plate should be chosen with an emulsion containing little or no iodide.† This is first bathed for two minutes in a solution of—

Liquor ammonia	1 part.
Water	100 ,,

Then without any previous washing it is immersed in—

Dye (eosine ‡ or erythrosine)	1 part.
Water	10,000 ,,
Ammonia	100 ,,

* Abney's "Instruction in Photography."

† Burton and Pringle's "Processes of Pure Photography."

‡ It must be mentioned that a patent was secured by Messrs. Tailfer and Clayton in 1883 for the preparation of orthochromatic plates by means of an ammoniacal solution of eosine, and that a firm (Edwards & Co.) hold the rights for their manufacture in this country.

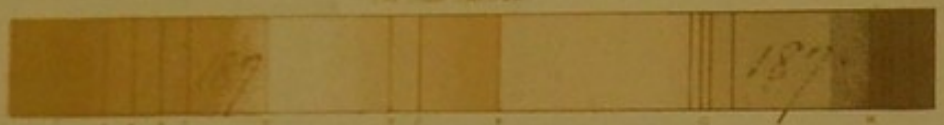


Fig. III.

Fig. II.

Fig. IV.

Colour as related to idea of Distance.

Fig. V.

Effect in Colours of Apposition

Fig. VI.

Mixture of Colours by Apposition.

Fig. VII.

Indifference of Related Colours in contact

The Primary, Secondary, and Tertiary Colours

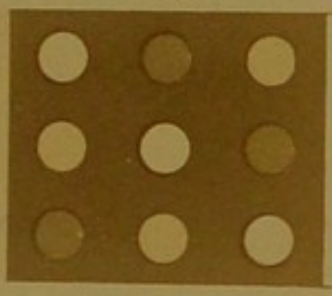
Fig. VIII.

Effect of Black and White in separating Colours.

Fig. IX.

Effect of a Green Ground in Colours.

Fig. X.



Effect of a Black Ground in Colours.

Fig. XI.

Effect of a White Ground in Colours.

A convenient way of making up these very dilute solutions is to first make an aqueous solution of the dye, as, for instance—

Erythrosine or eosine††	1 part.
Water	1,000 ,,

This is kept for a considerable time in the dark.

The ammonia solution may be a 10 per cent. one. Then take—

Dye solution (as above)	1 part.
Ammonia (10 per cent.)	1 ,,
Water	8 ,,

Ives's process of orthochromatic photography is as follows:—

In four ounces of absolute alcohol dissolve one grain of erythrosine or cyanine, soak the gelatino bromide plate in this for a minute, allow it to dry, and wash for a short time in a stream of running water. Dry and use. No alkali is necessary. Cyanine renders the plates so sensitive to red, however, that all subsequent operations must be done as far as possible in total darkness.

Captain Abney recently found that colour sensitiveness can be given to a plate by coating it with either varnish or collodion in which various sensitive dyes are dissolved. If erythrosine is to be used, varnish is stained to such an extent that when flowed over the film it shows a very light stain of dye. After exposure the plate is soaked in two or three changes of methylated spirit to remove the varnish, and after washing, development takes place in the ordinary manner. Any slight trace of varnish that may be seen, at once disappears if the plate be varnished as is usually done. If collodion be used the film must be first softened by alcohol to which a little ether has been added. After washing, development may proceed. Dyes which are not soluble in water can be made effective on gelatine plates by this method, and are certainly useful.* Ives's has also introduced a similar process, using chlorophyll as the sensitiser.

The following are some of the best known methods of rendering gelatino-bromide dry plates orthochromatic by bathing:—

SCHUMANN'S CYANINE BATH.

Distilled water	200 parts.
Alcohol	10 ,,
Ammonia	4 ,,
Alcoholic solution of cyanine 1 in 500	10 ,,

MALLMANN AND SCOLI ERYTHROSINE BATH.

Water	200 parts.
Ammonia	2 ,,

Soak the plate for two minutes.

†† It must be noted that there are a great variety of eosines on the market, some of which are very inferior as colour sensitisers. Erythrosine is much safer. Pure erythrosine should exhibit no fluorescence.

*Abney.

COLOUR BATH.

Erythrosine solution, 1 in 1,000	25 parts.
Ammonia	4 ,,
Water	175 ,,

The plate must not remain longer than one and a quarter minutes.

CHINOLINE BATH.

Alcohol	500 parts.
Chinoline red	1 ,,

To which are added 50 parts of a solution of

Alcohol	500 ,,
Chinoline blue (cyanine)	1 ,,

OBERNETTER'S METHOD WITH NITRATE OF SILVER.

Distilled water	480 parts.
Silver nitrate	1·25 ,,
Ammonium carbonate	5 ,,
Erythrosine solution (1 in 500)	35 ,,
Liquid ammonia	4 ,,

Bathe the plate for about 3 minutes in

Ammonia	2 ,,
Water	200 ,,

And, without washing, flow the sensitising solution twice over the plate and dry in the dark cupboard.

Orthochromatic Screen.—All orthochromatic plates prepared by any of the methods at present known still remain far too sensitive to the blue and violet rays. It therefore becomes necessary to interpose between the object and the plate a yellow transparent screen which has the power of cutting off a certain portion of the blue and violet rays, and leaves the less refrangible with a relative degree of intensity and chemical actinicity more correctly corresponding with the relative action of the eye. Refering to the use and abuse of the orthochromatic screen, Professor Bothamley, who is an acknowledged authority on this subject, says:* "It is obvious that any variation in the tint or thickness of the screen will effect the proportion of blue and violet cut off, and hence will determine the relative activities of the various rays after they have passed through it. From an optical point of view, it is desirable to keep the screen as thin as possible, but the depth of tint of the screen admits of very considerable variation. As the depth of tint of the screen increases, the proportion of blue and violet cut off increases proportionally, and the relative action of the less refrangible rays on the plate, or, in other words, the relative brightness with which green, yellow, orange, and red objects are rendered increases at the same. It is obvious, therefore, that it is easy to make a screen so intense that far too large a proportion of blue and violet is cut off; blue and violet objects will then be too dark, and green, yellow, and orange objects too light. In other words, the resulting photograph will be as incorrect in one direction as the ordinary

* Photographic Convention, 1889.

photograph is in the other. In landscape work a screen too deep in tint causes loss of atmosphere, and with erythrosine plates under these conditions the grass and all other yellowish-green objects come out much too light. For landscapes the proper tint of screen is pale lemon-yellow; for paintings and similar subjects the depth of screen required is usually greater, and is determined by circumstances.

"The great advantage of the screen in landscape work is that it prevents the failure, or, at any rate, want of complete success, which often results from the presence of a slight blue haze. The details in the distance, which so greatly increase the beauty of many landscapes, are rendered much more satisfactorily, and the more correct values obtained produce a roundness of the foliage, a transparency in the water, and a separation of the various planes of the picture which is rarely, if ever, attained in any other way. This kind of effect is easily seen by looking at any ordinary view with the naked eye and then through a piece of yellow glass; the increased roundness of the objects and the separation of the planes is very striking.

"It has been claimed as an advantage for commercial orthochromatic plates that they can be used without a screen, which, of course, is true, but the results obtained are not such as to lead anyone to be enthusiastic about them. It seems as if an attempt were to be made to set up as the ideal of orthochromatic photography a plate which requires no screen. Given that the plate corresponded in sensitiveness with the human eye, that ideal would be realised, but we are some distance from realisation at present, so far as gelatine plates are concerned. Moreover, it seems that the use of a screen, with the possibility of varying it to suit the work in hand, or the result which it is desired to obtain, places in the hands of the artistic photographer a power which he would be unwise to cast aside."

Carbutt, in his instructions for using his orthochromatic plates, recommends the following method of preparing a suitable colour-screen:—

"Extract the colouring matter from one ounce powdered turmeric in eight ounces alcohol by digestion and frequent shaking for a couple of days, then allow to settle. To two ounces sulphuric ether add 20 grains negative cotton and two ounces tincture of turmeric; shake until dissolved, and allow to settle; then coat the piece of thin plate glass, and, when dry, cement another piece of same clear glass over it with Canada balsam; allow to set for a day or two. The object of using the cemented glasses is that there will be less disturbance of the image caused than when a single glass is used. The colour screen can be used either in front or at the back of lens, or placed next the diaphragm, and should be in position when focussing, and when not in use preserved in a box from the light, otherwise the colour will soon bleach out.

"A very effective colour-screen and diaphragm combined can be made by dusting the surface of a piece of glass with French chalk, removing the surplus with camel-hairbrush, flow with the turmeric collodion, and allow to dry. Cut from a thin black card a pattern of the diaphragm to be used, smear a thin coat of gum on one side, and lay it down on the collodionised glass, rub down to insure contact, place between leaves of a book until dry, then remove card diaphragm from the glass and with it the colour-screen."

Professor Vogel recommends the following:—

Collodionise a thin plate with

Normal collodion 1¾%	100 parts
Aurantia	0·4 „

For landscape work 0·2 to 0·3 of aurantia will be found sufficient. The plate thus prepared can be placed either before or behind the lens.

Orthographic (Gr. *orthos*—right, and *grapho*—to draw).—A name given to a certain class of photographic lenses.

Orthoscopic (Gr. *orthos*—straight, upright, and *skopeo* to see).—A name given to a certain class of photographic lenses.

Osmium (Gr. *osme*—coloured; symbol, Os.; atomic weight, 199·2).—A tetrad metallic element discovered by Tennant in 1804. Osmium forms three chlorides—osmious chloride $OsCl_2$, osmi-oso-osmic chloride $OsCl_3$, and osmic chloride $OsCl_4$—which are all produced by the action of chlorine gas on osmium.

Osmosis.—A peculiar phenomenon noticeable in mixing dissimilar substances through a porous diaphragm (see **Dialyser**) due to the attraction which the liquids have for each other. If, for instance, water and alcohol be separated by a permeable medium the water passes into the alcohol, but only a small quantity of the alcohol will have passed into the water. If a colloidal substance is placed on one side, and water on the other, only the latter passes through.

Ounce (Lat. *uncia*—an ounce).—A unit of weight. In troy weight the ounce is the twelfth part of a pound, and contains twenty pennyweights of twenty-four grains. In avoirdupois weight the ounce is the sixteenth part of a pound, and is equivalent to 437½ grains troy.

Oval (Lat. *ovum*—an egg).—Having the shape or figure of the outline of an egg. Elliptical.

Ovalbumen.—A term applied to albumen obtained from eggs in contradistinction to that known as seralbumen, or the albumen of the blood.

Over Development.—Over development is caused by the developing solution having been too strongly concentrated, or to its action having been allowed to continue for too long a period. To judge correctly the exact time to remove the plate from the developer is one of the chief difficulties to be surmounted in learning the art of developing. Allowance must always be made for considerable loss in intensity in the fixing operation, so that the usual error made by the beginner is in under—rather than over—developing. The amount of density lost in the fixing bath depends partly upon the quality of the developer and partly upon the strength of the hyposulphite solution used. The usual method of treating over-developed negatives is to reduce their intensity by means of a reducing agent. See **Reducing.**

Over-developed negatives may, according to Herr Jandaurek, be restored as follows :—A stock solution is made of 10 grammes of sulphate of copper (blue vitriol) and 30 grammes of common salt in 120 c.c. distilled water. To every part of the stock solution add ten parts of water. Lay the washed negative in this diluted solution, gently rocking it for several minutes, until both by looking down upon it and looking through it its surface appears to be covered with a dense white precipitate. Take out the negative, rinse it well with water, and then lay it in a diluted solution of liquid ammonia, about 6 to 10 of water to one part of ammonia, until the negative is sufficiently reduced. The rapidity of the reduction depends upon the strength of the ammonia, which should always be added fresh.

Over Exposure.—A term applied if the exposure of the sensitive surface be prolonged farther than is required to impress it with all the detail, even in the darkest parts. The effect produced is seen in developing when the image rapidly makes its appearance, and before sufficient density can be obtained it appears fogged. The resulting negative is exceedingly thin, generally full of detail, but wanting in contrast and brilliancy. By very careful manipulation in development the effects of over-exposure can be partly corrected.

Considerable over-exposure produces solarisation and reversal of the image (*q.v.*)

Oxalate Developer.—See **Developer.**

Oxalate of Iron.—See **Ferrous Oxalate.**

Oxalate of Potash.—See **Potassium Oxalate.**

Oxalic Acid (Formula, $H_2C_2O_4 \times 2H_2O$; molecular weight, 126).—A white crystalline body frequently found in plants, and which may be produced by the oxidation of sugar and other organic substances, or by acting on starch, sugar, or cellulose with nitric acid, or fusion with caustic alkali.

It is produced commercially by fusing sawdust with a mixture of soda and potash to a temperature of 204° C., decomposing the oxalate with lime, and the lime salt with sulphuric acid, and afterwards recrystallising. It takes the form of colourless transparent prisms soluble in eight parts of water at 15° C, and in its own weight of boiling water. It forms a powerfully acid solution it unites with bases forming neutral and acid salts, and is highly poisonous.

Oxalic acid sometimes contains traces of sulphuric acid. This may be detected by the addition of barium nitrate, and afterwards hydrochloric acid in excess. If sulphuric acid be present a portion of the precipitate will remain undissolved. It is employed in the preparation of ferric oxalate.

Oxalic Ether (Formula, $C_2 O_4 (C_2 H_5)_2$).—Neutral oxalate of ethyl prepared by the distillation of a mixture of four parts binoxolate of potash, five parts oil of vitriol, and four parts of strong alcohol. The distillate is then washed in water. It forms a colourless oily liquid, with an agreeable aromatic odour, and a specific gravity of 1·09 It is only slightly soluble in water.

Oxgall (also known as *oxbile*).—The fresh bile of the ox purified and evaporated to the necessary consistency. It is used in painting with water colours, and is especially serviceable in causing the colours to adhere to the surface of albumen paper photographs. It is soluble in water and methylated spirit. The surface of the print should be rubbed over with a small quantity of an oxgall solution previous to applying the colours.

Oxidation.—The chemical change which causes the formation of oxides, and which is brought about by the action of oxygen acids, water, or free oxygen.

Oxide (Gr. *oxus*—sharp, acid).—The product of the combination of oxygen, with a metal or metalloid. When substances are burnt, they are not lost, but have simply changed into new bodies by combination with the oxygen of the air. If it be a metal the product is an "oxide" or "base" which, if soluble in water, has the property the reverse of acid.

Oxide of Silver.—See **Silver Oxide.**

Oxyacid.—Acids which contain oxygen, such as sulphuric acid, which has for its formula H_2SO_4.

Oxycalcium Light.—See **Oxyhydrogen Light.**

Oxyether.—A mixture of oxygen and ether. This is used in a form of oxyhydrogen light for the lantern.

Oxygen (Symbol, O; atomic weight, 16).—The most abundant element. It is present in the air we breathe, it forms $\frac{8}{9}$ths (by weight) of water, and is present, to a great extent, in the solid part of the earth.

Oxygen can only be obtained from something that contains it. For this purpose chlorate of potassium is the most convenient, as by merely applying heat it separates into potassium chloride and oxygen, thus—

$$KClO_3 = KCl + 3O$$

One molecule of the salt yielding three atoms of oxygen gas.

In the preparation of oxygen for commercial purposes, the potassium chlorate with about half its weight of black oxide of manganese is used.

The action of the manganese is not properly understood, but the evolution of the oxygen is rendered considerably more rapid even with a much lower temperature.

Oxygenate.—To unite or combine with oxygen.

Oxygenated Water.—Water containing peroxide of hydrogen in solution.

Oxygenous.—Pertaining to or derived from oxygen.

Oxyhydrogen.—A mixture of oxygen and hydrogen used in the limelight for the optical lantern.

Oxymel Process.—An early process for keeping the collodion moist. Oxymel is a mixture of vinegar and honey, and collodion plates coated over with it were found to retain their good qualities several hours. The exposure was, however, considerably increased.

Ozone (Gr. *ozo*—to smell).—This is usually considered to be oxygen in an allotropic condition. It is nearly always present in the air, apparently as the result of electrical action. It can be produced by passing electric sparks into dry air, and also by placing sticks of clean phosphorus in a bottle of oxygen, and half covering them with water. It possesses a peculiar slightly metallic odour, and appears to possess all the properties of oxygen in an enhanced degree. It liberates iodine from potassium iodide. Schönbein, who discovered and named it, employed this re-action for detecting it in the atmosphere.

Packfong (Chinese).—A Chinese alloy known as white copper. It is composed of copper 40·4, zinc 25·4, and nickel 31·6. It is used sometimes for making mirrors or reflectors.

Packing Plates.—In packing sensitive dry plates every precaution must be taken in protecting them from the light and from mechanical injury and chemical change. Very many methods are employed ; probably the use of grooved boxes, or strips of cardboard folded so as to prevent the sensitive surfaces of the plates from touching, are the methods most generally adopted. A good plan is to take a long strip of perfectly pure tissue paper, and so fold it that it lies between every plate. By thus alternating the plates and paper the fear of breakage is reduced to *nil*. It is, however, absolutely essential that the paper be chemically pure. Gelatino-bromide films rapidly absorb impurities from materials in which they are wrapped, a chemical change is produced, and on developing a black mark is visible usually round the edges of the plate. The more rapid the dry plate the more sensitive it is to these changes.

When travelling abroad it is very difficult sometimes to restrain Custom House officials from opening and examining packages of dry plates, more especially if the tourist's knowledge of the language of the country is imperfect. In order to prevent this, therefore, the following tables have been compiled, and will be found to fairly cover the ground.

English.—Photographic dry plates sensitive to light. Open only in a dark-room or by a red light.

French.—Plaques séches photographiques. A ouvrir seulement avec eclairage couleur rubis. *Or*, Plaques photographiques sensibles. Tout detruites par l'exposition à la lumière. Prendre garde de n'ouvrir la boîte que dans une chambre parfaitement obscure.

German.—Photographische trockenplatten. Sehr lichtempfindlich. Werden ganz verdorben, wenn dem Lichte ausgesetzt. Müssen nur in absolut dunkelm Zimmer oder bei rothem Lichte geöffnet werden.

Italian.—Teme la luce. Lustre da seccare fotografiche. Da aprire solamente con illuminazione colore di rubino.

Spanish.—Las placas fotograficas sensitivas que se inutilizan si se las expone al abrirlas, à la luz del dia, se pueden abrir sin inconvenientes en una habitacion enteramente oscura ó iluminada por luz roja.

Swedish.—Fotografiska plätar ma icke oppenas utom vid rodt Ljus. *Or*, Ljuskäushga fotografiska plätar, blivfa förstörda om de uttsättas för ljus. Fas derföre ej öppuas utom i ett absolut mörkt rum.

Norwegian.—Fotografiske plader maa ikke aabnes udem ved rodt Lys.

Portugese.—Nao podem ser expostas á luz porque se enutilisam; podendo só ser abertas em camara, ou com.

Pad.—A soft piece of felt used to place between the sensitive paper lying on the negative and the back of the printing frame to prevent breakage of the negative, and to ensure even and uniform contact between the sensitised paper and the negative film.

Painting Photographs. — Photographs may be painted over either with oil or water colours. With the latter the silver print should be previously washed over with a solution of oxgall. The colours will then adhere more firmly. See **Coloured Photographs, Oil Painting, &c.**

Palladium (Symbol, Pd ; atomic weight, 105·7).—A tetrad metallic element usually found associated with gold and platinum, chiefly in South America. It is separated from the gold by fusing the alloy with silver* and boiling it with nitric acid, which leaves the gold undissolved. The silver is precipitated from the solution as chloride by adding sodium chloride, and metallic zinc is placed in the liquid which precipitates the palladium, lead, and copper as a black powder. This is dissolved in nitric acid, and the solution mixed with an excess of ammonia, which precipitates the lead oxide, leaving the copper and palladium in solution. On adding hydrochloric acid in slight excess a yellow precipitate of palladamine hydrochlorate is obtained, which when heated leaves metallic palladium.

Palladium has a sp. gr. of 11·5. It resembles platinum in malleability and ductility, but is more fusible, less dense, and has a more silvery appearance. The chloride has occasionally been recommended for toning.

Palladium Toning.—Palladous chloride is used for this purpose. It may be obtained in crystals or in solution ; the bath is made up of

1 grain palladous chloride.
20 grains sodium sulphite.
10 oz. water.

A silver print is first made upon plain salted paper. This is washed with clear water containing a little common salt, and afterwards in pure water. The print is then brushed over with the palladium solution as above. Some operators recommend that the solution be made slightly acid by the addition of a few drops of nitric acid. The picture is then fixed in hypo containing a few drops of ammonia added until the solution smells slightly of it. Each lot of prints should be fixed in a fresh bath. The results obtained are very similar to those toned with platinum. For rough surface paper the black tone is very effective, the prints much resembling Indian ink drawings. Palladous chloride is very expensive, but the quantity used is small.

* Bloxham's "Chemistry."

Palladous Chloride (Formula, $PdCl_2$).—Prepared by acting on palladium with aqua regia and evaporating. The brown hydrated crystals obtained, if heated to redness, lose chlorine, leaving metallic palladium. In this respect it much resembles platinum as well as in the formation of double salts with the alkaline metals. It is used in the palladium toning process.

Panel.—The style of a professional photograph, usually about 4 x 8½ inches.

Panel Lens.—A lens constructed for making panel photographs. It has usually a diameter of about 3¼ to 4 inches, and a focal length of between 16 and 20 inches, the sitter being placed at from 14 to 16 feet from it.

Panoramic Camera (Gr. *pan*—all, everything, and *horama*—a view).—A camera specially constructed as to enable photographs embodying a very large angle of view to be taken, usually upon a curved surface. The first camera of this kind was constructed by Mr. Martens, of Paris, in the year 1847, for cylindrica Daguerreotype plates. Then followed the camera of Sutton.* A cylindrical glass was employed, and the negative paper bent so as to press against it. Cylindrical collodion plates were also used, but this, of course, necessitated the use of curved printing frames. These plates were, of course, curved in the form corresponding to the rotation of the camera around the axis situated exactly below the centre of the lens. If flat plates had been used it will be obvious that the upper horizontal lines of the image would be curved in an upward direction, and the lower ones in a downward. After Sutton's patent came the improvement of Dr. Liesegang, by which it was transformed into a simple rotating camera, A stout tripod carries a large polished table, fitted to which is a pivot or axis upon which the camera turns. This pivot is so adjusted as to fall into the same plane as the optical centre of the lens. These cameras are made in two sizes for plates 19 by 9 and 23 by 11 inches. In front of the plate inside the camera a flexible band is fitted which has a narrow vertical slit through which only the middle rays of light pass. This slit is about a quarter of an inch wide, but widened out a little where the near foreground falls in order to secure a longer exposure for that portion of the picture, and thus impart greater uniformity to the tone of the negative. The two motions of the instrument, viz., that of the camera on its axis and the motion of the dark slide, supported on wheels, from right to left, are performed by an ingenious arrangement of horizontal cords and pulleys. After focussing, the operator has only to turn a handle to take in the wide scope of the horizon or a group

*See Sutton's "Dictionary of Photography."

arranged in a semi-circle around the instrument. Any lens may be used provided its focus is in range with the length of the camera. See also **Panoramic Photography, Cylindrograph.**

Panoramic Lens.—A lens constructed for making panoramic views. The first of this kind was invented and patented by Sutton in 1858. It was intended for photographing views, including an angle of 90 degrees or more upon spherical bowls or cylindrical glasses. See **Fluid Lens.**

Panoramic Photography.—In making panoramic views a panoramic camera is usually employed. This is described under that heading. Panoramic views may also be made with an ordinary camera by taking two or three views and joining them together. For this purpose the screw of the tripod must be slightly loosened, so that the camera turns round easily. When the first view is made, objects on the extreme right hand side of the glass are noted, and the camera turned round on the screw until these objects appear on the extreme left. The second view is then made, and so on. In mounting the prints from the different negatives the greatest care must be taken to make the joints neatly, and to have the prints cut so that the images join together properly. When any difficulty is experienced in this it will be found a better plan to mount the pictures about a quarter to half an inch apart. This method is not quite so effective, but appears considerably better than a badly joined view.

It will be obvious that with all panoramic views the laws of perspective are violated to a considerable extent, and that an absolutely correct representation of the view is not given. In Sutton's camera curved plates were used, and prints made from these curved negatives were viewed flat. To obtain correct representation it would be necessary to view them curved in the same manner.

Pantascopic Camera.—An instrument invented by J. R. Johnson for taking panoramic views, including an angular extent up to 360° upon a flat plate with a common lens by means of mechanism or clockwork.

Paper (Lat. *papyrus*—papyrus, an Egyptian reed, from which paper was made).—A material made in thin sheets from a pulp of rags, esparto grass, straw, wood, and many other fibres. Over 500 different substances have been used for manufacture of paper; rags and esparto grass form the best materials, however.

A large number of different kinds of papers are now manufactured in this country. For most photographic purposes it is advisable to use perfectly pure paper. The best known are those manufactured at Rives and at Saxe; these papers have a very even body, and are quite free from chemical impurities.

Metal dust in paper will not be visible until the same be sensitised with silver nitrate, when black spots will directly appear.

The quality of the paper has also a considerable effect upon the subsequent permanency of the photographic images made upon it. Many kinds contain a large quantity of sodium hyposulphite used as an antichlor. This should be carefully tested for.

The following tables of sizes of the different printing and writing papers will be found of use :—*

Printing Papers.

Description.	Broadside.	Long Folio.	Long Thirds.	Long Fourths.	Broad Folio.	Broad Thirds.
D'ble Super Royal	41 × 27½	41 × 13¾	41 × 9⅛	41 × 6⅞	27½ × 20½	27½ × 13⅜
Do. Royal	40 × 25	40 × 12½	40 × 8⅓	40 × 6¼	25 × 20	25 × 13⅓
Do. Demy	35 × 22½	35 × 11¼	35 × 7½	35 × 5⅝	22½ × 17½	22½ × 11⅔
Imperial	30 × 22	30 × 11	30 × 7⅓	30 × 5½	22 × 15	22 × 10
Double Crown ..	30 × 20	30 × 10	30 × 6⅔	30 × 5	20 × 15	20 × 10
Super Royal	28½ × 21½	28½ × 10¾	28½ × 7 1/6	28½ × 5⅜	21½ × 14¼	21½ × 9½
Double Foolscap	27 × 17	27 × 8½	27 × 5⅔	27 × 4¼	17 × 13½	17 × 9
Royal	25 × 20	25 × 10	25 × 6⅔	25 × 5	20 × 12½	20 × 8⅓
Medium	24 × 19	24 × 9½	24 × 6⅓	24 × 4¾	19 × 12	19 × 8
Demy	22½ × 18	22½ × 9	22½ × 6	22½ × 4½	18 × 11⅛	18 × 7 5/12
Crown	20 × 15	20 × 7½	20 × 5	20 × 3¾	15 × 10	15 × 6⅔
Foolscap	17 × 13½	17 × 6¾	17 × 4½	17 × 3⅜	13½ × 8½	13½ × 5⅔

Writing Papers.

Description.	Broadside.	Long Folio.	Long Thirds.	Long Fourths.	Broad Folio.	Broad Thirds.
Imperial	30 × 22	30 × 11	30 × 7⅓	30 × 5½	22 × 15	22 × 10
Su.RoyalH.M.B.L.	27 × 19¼	27 × 9⅝	27 × 6 5/12	27 × 4 1/16	19¼ × 13½	19¼ × 9
Royal H.M.B.L.	24¼ × 19½	24¼ × 9¾	24¼ × 6½	24¼ × 4⅞	19½ × 12⅛	19½ × 8 1/12
Do H.M.	24 × 19½	24 × 9¾	24 × 6½	24 × 4⅞	19½ × 12	19½ × 8
Medium H.M.B.L.	22 × 17¼	22 × 8⅝	22 × 5¾	22 × 4 5/16	17¼ × 11	17¼ × 7⅓
Do. M.M.B.L	22½ × 17¾	22½ × 8⅞	22½ × 5 11/12	22½ × 4 7/16	17¾ × 11¼	17¾ × 7½
Demy H M.B.L....	20 × 15¾	20 × 7⅞	20 × 5¼	20 × 3 15/16	15¾ × 10	15¾ × 6⅔
Do. M.M.B.L....	20¼ × 15½	20¼ × 7¾	20¼ × 5⅛	20¼ × 3 13/16	15½ × 10⅛	15½ × 6¾
D'ble F'lscapM M.	27 × 17	27 × 8½	27 × 5⅔	27 × 4¼	17 × 13½	17 × 9
FoolscapH.M.B.L.	17 × 13½	17 × 6¾	17 × 4½	17 × 3⅜	13½ × 8½	13½ × 5⅔
Do. M.M.....	16½ × 13¼	16½ × 6⅝	16½ × 4 5/12	16½ × 3 5/16	13¼ × 8¼	13¼ × 5½

The various photographically prepared papers will be found under their respective headings.

Paper, Albuminised.—See **Albuminised Paper.**

Paper, Baryta.—Paper coated with Baryta chalk and gelatine with a little tinting matter added. It is used for coating with gelatino-chloride emulsion, as the chalk substratum keeps the gelatine film on the surface of the paper. It is chiefly used, however, for making high-class prints by the Collotype process.

* These tables were drawn up under the direction of Colonel H. R. Thuillier, R.E., by Colonel J. Waterhouse, assisted by others, for the Survey of India Department.

Paper, Blotting.—A thick, bibulous, unsized paper, much used in photography for absorbing superfluous moisture from prints, plates, &c. It is essential that for many purposes a chemically pure kind be used. This is best obtained from a good dealer in photographic materials. Ordinary blotting paper usually contains a large quantity of hypo used as an antichlor.

After silver prints are washed they are usually placed between sheets or boards of blotting paper to dry. The paper should not be used too often, as it eventually becomes impregnated with fixing

Printing Papers.

Long Quarto.	Broad Quarto.	Long Octavo.	Common Octavo.	Long 12mo.	Common 12mo.	16mo.	32mo.
27½ × 10¼	20½ × 13¾	20½ × 6⅞	13¾ × 10¼	13¾ × 6⅝	13⅜ × 6⅞	10¼ × 6⅞	6⅞ × 5⅛
25 × 10	20 × 12½	20 × 6¼	12½ × 10	12½ × 6⅜	13⅛ × 6¼	10 × 6¼	6¼ × 5
22½ × 8¾	17½ × 11¼	17½ × 5⅝	11¼ × 8¾	11¼ × 5⅝	11⅜ × 5⅝	8¾ × 5⅝	5⅝ × 4⅜
22 × 7½	15 × 11	15 × 5½	11 × 7½	11 × 5	10 × 5½	7½ × 5½	5½ × 3¾
20 × 7½	15 × 10	15 × 5	10 × 7½	10 × 5	10 × 5	7½ × 5	5 × 3¾
21½ × 7⅛	14¼ × 10¾	14¼ × 5⅜	10¾ × 7⅛	10¾ × 4¾	9½ × 5⅜	7⅛ × 5⅜	5⅜ × 3 9/16
17 × 6¾	13½ × 8½	13½ × 4¼	8½ × 6¾	8½ × 4½	9 × 4¼	6¾ × 4¼	4¼ × 3⅜
20 × 6¼	12½ × 10	12½ × 5	10 × 6¼	10 × 4⅛	8⅓ × 5	6¼ × 5	5 × 3⅛
19 × 6	12 × 9½	12 × 4¾	9½ × 6	9½ × 4	8 × 4¾	6 × 4¾	4¾ × 3
18 × 5 9/16	11⅛ × 9	11⅛ × 4½	9 × 5 9/16	9 × 3 17/24	7 5/12 × 4½	5 9/16 × 4½	4½ × 2 25/32
15 × 5	10 × 7½	10 × 3¾	7½ × 5	7½ × 3⅓	6⅔ × 3¾	5 × 3¾	3¾ × 2½
13½ × 4¼	8½ × 6¾	8½ × 3⅜	6¾ × 4¼	6¾ × 2⅝	5⅓ × 3⅜	4¼ × 3⅜	3⅜ × 2⅛

Writing Papers.

Long Quarto.	Broad Quarto.	Long Octavo.	Common Octavo.	Long 12mo.	Common 12mo.	16mo.	32mo.
22 × 7½	15 × 11	15 × 5½	11 × 7½	11 × 5	10 × 5½	7½ × 5½	5½ × 3¾
19¼ × 6¾	13½ × 9⅝	13½ × 4 13/16	9⅝ × 6¾	9⅝ × 4½	9 × 4 13/16	6⅜ × 4 13/16	4 13/16 × 3⅜
19⅛ × 6 1/16	12⅛ × 9¾	12⅛ × 4⅞	9¾ × 6 1/16	9¾ × 4 1/24	8 1/12 × 4⅞	6 1/16 × 4⅞	4⅞ × 3 1/32
19½ × 6	12 × 9¾	12 × 4⅞	9¾ × 6	9¾ × 4	8 × 4⅞	6 × 4⅞	4⅞ × 3
17¼ × 5½	11 × 8⅝	11 × 4 5/16	8⅝ × 5½	8⅝ × 3⅔	7⅓ × 4 5/16	5½ × 4 5/16	4 5/16 × 2¾
17⅜ × 5⅝	11¼ × 8⅞	11¼ × 4 7/16	8⅞ × 5⅝	8⅞ × 3¾	7½ × 4 7/16	5⅝ × 4 7/16	4 7/16 × 2 13/16
15¾ × 5	10 × 7⅞	10 × 3 15/16	7⅞ × 5	7⅞ × 3⅓	6⅔ × 3 15/16	5 × 3 15/16	3 15/16 × 2½
15½ × 5 1/16	10⅛ × 7¾	10⅛ × 3⅞	7¾ × 5 1/16	7¾ × 3⅜	6¾ × 3⅞	5 1/16 × 3⅞	3⅞ × 2 17/32
17 × 6¾	13½ × 8½	13½ × 4¼	8½ × 6¾	8½ × 4¼	9 × 4¼	6¾ × 4¼	4¼ × 3⅜
13½ × 4¼	8½ × 6¾	8½ × 3⅜	6¾ × 4¼	6¾ × 2⅝	5⅔ × 3⅜	4¼ × 3⅜	3⅜ × 2⅛
13¼ × 4⅛	8¼ × 6⅝	8¼ × 3 5/16	6⅝ × 4⅛	6⅝ × 2¾	5½ × 3 5/16	4⅛ × 3 5/16	3 5/16 × 2 1/16

salt, which is likely to be very detrimental to the subsequent permanency of the pictures.

Paper Clip.—A clasp for holding and hanging up paper. They are made of metal, wood and glass.

Paper, Filtering.—See **Filtering Paper.**

Paper, Matt.—A paper having a matt or dead surface. When salted and sensitised it gives very artistic prints. See **Matt-surface Paper.**

Paper Negative.—A negative made upon a paper support in the place of the glass plate usually used. The advantages of paper over glass are at once apparent. For tourists the reduction in the weight is naturally a great advantage; and, further, it is more easily stowed away—a hundred negatives can be placed away in a single book. It is usually used in a roll-holder or roller slide *(q.v.)*, the various exposures being made on a long band of the sensitive paper. The emulsion used for preparing the paper is similar to that employed in the manufacture of dry plates. The drawbacks to the use of paper instead of glass as a support are, first, its opacity in requiring longer time to print the positives; *secondly, the reproduction of the grain of the paper in the positive.

Paper, Non-actinic.—See **Non-actinic Medium.**

Paper, Oiled.—Prepared by brushing sheets of paper over with boiled oil, and suspending them till dry.

Paper, Sensitised.—See **Sensitised Paper.**

Paper Size.—Writing papers are usually sized with gelatine prepared from tanners' and parchment makers' clippings. Plate paper that is intended to receive impressions in colours is sized with a clear solution of isinglass. For printing papers a compound of alum and resin dissolved in a solution of soda, and combined with potato starch, is usually used. This is mixed with the paper pulp. Starch is also used either as a paste or as a clear solution.

Papier Mache (Fr.)—A material composed chiefly of paper. The common varieties are prepared by pulping any kind of mixture of different kinds of paper into a homogeneous mass of a doughy consistence. The pulp is rolled into thick sheets, and afterwards pressed in a mould to the shape required. The surface can then be painted with oil or size colours, or varnished. It is used in photography for making dishes or baths. For this purpose it is very useful, owing to its lightness and toughness.

Papyrotint Process.—A photo-lithographic process invented by Husband. It is a modification of Captain Abney's improved method of papyrotype. It is specially suitable for the reproduction of subjects in half-tone. The advantage it possesses over other methods are that a transfer can be taken in greasy ink, for transfer to stone or zinc, direct from the negative, the requisite grain being simply obtained by a chemical change. The method is as follows:—Any good surface paper is first floated on a bath of

Gelatine (Nelson's flake)	8	ounces
Glycerine	1½	,,
Sodium chloride	2	,,
Water	50	,,

* Various methods are employed to render the paper translucent. See under Translucent

The solution must not be over-heated, and must be free from bubbles. The paper after floating is dried at a temperature of 60°F., and will keep for years. It is sensitised on

Potassium dichromate	1 ounce.
Sodium chloride	½ ,,
Ferricyanide of potassium	100 grains.
Water	30 ounces.

The paper is dried in the dark room, temperature about 70° F. When dry it is exposed under the negative in an ordinary printing frame. Sunlight is preferable. The image will appear on the transfer paper, and when of a dark fawn colour on a yellow ground it is sufficiently printed. It is then laid in a bath of cold water for about ten minutes until the soluble gelatine has absorbed its full quantity of water. It is then removed, placed on a flat plate, and all superfluous moisture removed with a piece of blotting paper.

The action of the light has been to render the parts to which it has penetrated through the negative partly insoluble, and at the same time granulated. A hard transfer ink is now composed of—

White virgin wax	½ ounce.
Stearine	½ ,,
Common resin	½ ,,

These are melted together in a crucible over a small gas jet, and to them are added four ounces of chalk printing ink, and the mixture reduced to the consistency of cream with spirits of turpentine. A soft sponge is saturated with this mixture and rubbed gently over the exposed paper (in this stage the nature of the grain can be best seen). An ordinary letterpress roller charged with a little ink from the inking slab is then passed over the transfer, causing the ink to adhere firmly to the parts affected by the light, and removing it from the parts unacted upon. The transfer is next put into a weak bath of tannin and bichromate of potash for a few minutes, and when taken out the surplus solution should be carefully dried between clean sheets of blotting paper. The transfer is hung up to dry, and when thoroughly dry the whole of the still sensitive surface should be exposed to light for about two minutes. A weak solution of oxalic acid (about 1 in 100) should be used for dampening the transfer, and this applied to the back with a soft sponge. After it has been damped three or four times it is carefully removed and placed between clean sheets of blotting paper. A cold polished stone is then set in the press, and after everything is ready the transfer is placed on the stone and pulled through twice. The stone or scraper is reversed, and the transfer is again twice pulled through. A moderate pressure and a hard backing sheet should be used, care being taken not to increase the pressure after the first pull through. The transfer is taken from the stone without damping, when it will be found that

the ink has left the paper clean. Gum up the stone in the usual way, but if possible let the transfer remain a few hours before rolling up. Do not wash it out with turpentine, and use middle varnish to thin down the ink.

Papyrotype or **Papyrography** (Gr. *papuros*—papryus, and *grapho*—to write).—A method of printing from paper or pasteboard covered over with a calcareous substance. A modification of photo-lithography, paper being used as a support in place of the stone.

Papyroxyline.—A kind of pyroxylin made from paper. See **Pyroxylin.**

Parabola.—In conic sections, a plane curve of such a form that if from any point in the curve one straight line be drawn to a given fixed point, the other perpendicular to a straight line given in position, these two lines will always be equal to one another.

Parabolic Lens.—A lens ground to a parabolic surface would be entirely free from spherical aberration. It could only be ground, however, with very great difficulty, so that these lenses are no longer made, spherical aberration being nearly wholly overcome by other means.

Parabolic Reflector.—See **Optics.**

Paraffin (Lat. *parum*—little, and *affinus*—akin).—A solid, fatty substance occurring along with liquid oils in petroleum, and in the native state in coal and bituminous strata. It is a white, solid, translucent substance, without taste or smell. It takes its name from the fact that it is acted on with great difficulty by other substances.

Paraffin Oil.—See **Petroleum.**

Parcel Camera.—A detective instantaneous camera made in the form of an ordinary brown paper parcel to avoid detection.

Parchment Paper can be made by immersing ordinary unsized paper in sulphuric acid, diluted with about half its volume of water. After a few moments it is withdrawn, and will be found to have assumed a new appearance, resembling animal parchment, and its strength is quite doubled. After immersion in the acid, it is washed in water, and in diluted ammonia, and again in water.

Partition.—Partitions in cameras are usually constructed of thin wood, or tin blackened over with a dull black varnish. They require to be fitted in stereoscopic cameras to prevent the two

views from overlapping. They are also used—but rarely—when a subject is required to be taken upon which it is hardly worth while expending a large plate, to protect the remaining half from the light during the exposure.

Paste.—A good flour paste may be made by working a little flour with cold water, and then pouring boiling water on it. An arrowroot paste may be made as follows: Thoroughly mix 600 grains of the best Bermuda arrowroot with 375 grains of cold water in a capsule. Next add 10½ ounces of water and 60 grains of gelatine in fine shreds. Boil for about five minutes, constantly stirring until the liquid becomes clear. Allow it to get cold, and then stir in two ounces of alcohol and about five to six drops of pure carbolic acid. This paste should be kept in well corked bottles. See also **Mountant.**

Paste Encaustic.—See **Encaustic Paste.**

Pastel Portrait.—A photograph, usually an enlargement, worked over with chalk colours prepared by mixing fine pipeclay, gum, water, and the required pigment.

Patent (Lat. *patens*, from *pateo*—to be open).—A grant from the Crown by letters patent of the exclusive right of making, using, and selling some invention. The following may be patented:—Any new art; manufacture; composition of matter; new combination of two or more known things producing an advantageous result, or any new chemical or other process, or improvement on existing processes or manufactures.

An invention to be patented must be novel and also useful. With regard to novelty this is the point where many patents come to grief, for it is safe to say that of the hundreds of patents taken out annually at least 75 per cent. could be proved to be invalid for the want of novelty. For if it can be shown that other persons have used or published the invention previous to the date of the patent it will fall to the ground, even if the patentee was an independent inventor, deriving his ideas from no one but himself. Suppose, for instance, A, in London, patents an invention the result of his patient study and energies, and it subsequently appears that B, in some other part of the kingdom, had been previously using the same thing openly in his workshops, A's patent is perfectly valueless.

With regard to the utility of an invention many disagree. Comparatively few inventions have been refused a patent for the want of utility. A patent to be good must be separated as far as possible from anything of the kind previously known.

The following rules relating to patents should be noted.*

* "Handbook of Patent Law," by W. P. Thompson, C.E.

Two substantially distinct inventions cannot legally be combined in one patent.

A patent once granted cannot be objected to at law on the ground of its covering more than one invention.

A patent gives the owner sole right for 14 years (subject to his paying the taxes at the end of the fourth and subsequent years) of making, selling, or importing the article, or process patented in the United Kingdom of Great Britain, Ireland, and the Isle of Man, and the adjacent seas.

A patentee may, on certain conditions, be ordered by the Board of Trade to grant licences on reasonable terms to others to enable them to work the invention.

If two persons independently claim to have invented the same thing, the one who first makes his claim is, in default of conclusive evidence to the contrary, held to be the inventor.

A patent may include subject matter of another expired patent, but the inventor cannot, of course, work what is included in the previous patent without a licence from the patentee thereof.

A new application of a known thing can be patented, provided it be not analogous to any existing application thereof, or a similar material has not already been so applied.

The new combination of two known means to effect an improved result can be patented.

When an invention is the joint production of two minds it should be patented in their joint names, for should it be proved that the patentee obtained a material part of the invention claimed from another individual, the patent will be invalid.

Two or more individuals obtaining a patent in their joint names, or joint owners in a patent without a special agreement, are not partners, but each has an equal and co-extensive right to work the patent to his own individual advantage.

A patent can be seized by a sheriff, and in case of bankruptcy of owner it forms part of the estate, and can be sold for the benefit of the creditors.

In taking out a patent two methods may be adopted, either a provisional specification may be obtained or a complete one.

In taking out a provisional specification protection commences from the day when the application has been favourably deposited. The specification need only describe the nature of the invention, and the inventor has nine months left him to work out the details and decide what to claim. The cost of this is £1, but if obtained through an agent the whole charge will vary from three to four guineas. This usually includes the agent's fees for searching through previous patents of similar things.

In a complete specification protection commences from the day when the application has been formally accepted. The specification must describe the invention completely, and state exactly what points are claimed as new.

The cost of complete specification through an agent is usually from ten to twenty guineas. It is most advisable to take out a provisional protection.

Forms for the application of a patent may be obtained at the chief post offices, but it is always advisable to obtain the patent through an agent, who, for his fee of two or three guineas, will search for previous inventions, and give you every advice and assistance.

Patent Plate.—See **Glass.**

Pearlash.—A crude potassium carbonate obtained from the ashes of plants by dissolving the calcined mass in water, decanting the clear solution, and evaporating it to dryness in flat iron pans. By constant stirring towards the end of the process the pearlash is obtained in a semi-granular state. It is very impure, containing variable quantities of potassic silicate, sulphate, chloride, etc.

Pellets Process.—A process of printing with salts of iron, giving blue lines on a white ground. The most recently given formula is the following:—

Gum arabic	385 grains.
Sodium chloride	46 ,,
Tartaric acid	62 ,,
Perchloride of iron	123 ,,
Water	3½ ounces.

Well-sized smooth paper is evenly coated with this mixture, dried in the dark, and exposed beneath the negative. The image is developed in a saturated solution of ferrocyanide of potassium, and fixed in a 1 in 20 solution of hydrochloric acid.

Pellicle (Lat. *pellicula*—a little skin).—A thin skin or film. Photographically it is applied to a coating of an emulsion when the solvents have evaporated. Many attempts have been made to use gelatine or collodion pellicles without the necessity of the glass support. See **Film.**

Pencil of Light.—A term applied to rays of light diverging from or converging to a point. If the point is taken at an infinite distance the rays are then usually regarded as parallel, the amount of divergence or convergence being so small, and the pencil then becomes a beam of rays.

Pencils.—Pencils are used in photography chiefly in retouching negatives; for this purpose H to HHHHHH pencils are the most suitable. See **Retouching.**

The following recipes* for preparing pencils for wr'ting on glass, porcelain, metal, etc., may be found useful.

Black.

Finest lampblack	10 parts.
White wax	40 ,,
Tallow	10 ,,

White.

Kremser white	40 parts.
White wax	20 ,,
Tallow	10 ,,

Light Blue.

Prussian blue	10 parts.
White wax	20 ,,
Tallow	10 ,,

Dark Blue.

Prussian blue	15 parts.
White wax	5 ,,
Tallow	10 ,,

Yellow.

Chrome yellow	10 parts.
White wax	20 ,,
Tallow	10 ,,

The colour is mixed with the body of wax and tallow while warm, triturated, exposed to air for drying, so that the mass can be pressed by means of a hydraulic press into round pencils in the same way as lead pencils are formed. The pencils are dried after pressing by exposing them to the air until they have the proper consistence, and are then glued into wood.

Pendulum.—A simple pendulum is a heavy particle suspended by a fine thread from a fixed point about which it oscillates without friction. No simple pendulum can of course exist. All made by man are compound, in which there gravitate, not a particle, but a heavy body called a bob, and the laws of friction must also be considered.

The time of vibration of a pendulum is directly as the square root of its length, and inversely as the square root of the accelerating force of gravity. The length of the arc through which it vibrates does not affect the result.

The knowledge of the construction of a seconds pendulum, will sometimes be useful in timing exposures when a chronometer is not handy. All that is required is to get the exact length. This differs in direct proportion to the force of gravity at the place. In London (lat. of Greenwich Observatory 51° 28′ N.) at the sea level the exact measure required is 39·13983in.

Penny Photograph.—A photograph obtained for one penny. Machines have recently been constructed with which, if a coin of the value of one penny is placed in a slot, the machinery is set in motion, and a ferrotype plate exposed, developed, fixed and dried. The construction of these machines is given under **Automatic Machines.**

Perchloride of Gold.—See **Gold Trichloride.**

Perforated Base-board.—In many makes of cameras the base-board, instead of being solid, has a large round hole cut in the centre, or is constructed as a framework only. These are termed perforated base-boards, and by their use the lens need not be removed from the camera when folding it up, as it falls through the hole in the base-board, and is always in a position ready for use. Much time is, of course, saved by this arrangement; it is only necessary to see that the base-board still remains firm and rigid.

Perforating Glass.—To make a hole in glass, an ordinary well-tempered steel drill is the best tool. The drill must be kept moistened with turpentine in which some camphor has been dissolved, or with diluted sulphuric acid.

Periscopic Lens.—See **Lens.**

Permanency.—The question of the permanency of photographic images is one that has been much discussed. It is a well-known fact that silver prints made thirty or forty years ago have almost entirely faded away. Here and there prints will be found of that age in quite good condition, the reason lying, in all probability, in the method of manufacture adopted. It is pretty generally known that hypo remaining in the picture will soon cause it to fade. To thoroughly eliminate this, several so-called hypo eliminators have been recommended. These should never be used, for while removing the hypo from the film they leave another composition which is more likely to cause the print to fade than the hypo salt itself. Good washing is the only true eliminator. This must be thorough, and not too long. Too prolonged washing tends to decompose the prints, and will cause them to fade more rapidly. The larger the quantity of gold used in the toning process, the longer will be the lasting qualities of the prints. This should be borne in mind by those economical workers who endeavour to make a tube of gold tone a large number of sheets. Another cause of fading is due to impurities in the mount and the mountant. Unmounted prints placed between sheets of chemically pure paper will last considerably longer than mounted ones. Good quality mounts and a pure, simple paste should be used.

Silver prints are probably the least permanent of any photographic pictures. Gelatino-chloride of silver papers (Celerotype, Aristotype, etc.) are much more permanent than albuminised paper. Bromide and platinotype prints are also considered as permanent.

The most permanent are undoubtedly the pictures produced by the carbon or Woodbury process. In these the images are composed simply of gelatine and lampblack, two permanent substances.

Permanent Support.—See **Carbon Process.**

Permanganate of Potash.—See **Potassium Permanganate.**

Pernitrate of Iron.—See **Ferric Nitrate.**

Peroxide of Hydrogen.—See **Hydrogen Peroxide.**

Persulphate of Iron.—See **Ferric Sulphate.**

Petroleum (Lat. *petra*—a rock, and *oleum*—oil; synonyms, *earth oil*, *mineral oil*, *paraffin oil*, etc.)—A term applied to a variety of inflammable liquids found in different parts of the earth. A light petroleum oil is much used for illuminating purposes. Many optical lanterns are constructed for burning petroleum. The whiteness of the light obtained may be increased considerably by dissolving a little camphor in the oil (about one ounce to the pint) before lighting.

Phantasmograph.—A name given to an apparatus for printing lantern slides. It consists of a long box, at one end of which the quarter-plate negative and the lantern plate in contact with it are placed. The hinged door at the other end of the box admits the light for exposure. By this means all side or extraneous light is excluded.

Phenol Penthalein (Formula, $C_{20}H_{14}O_4$; synonym, *dihydroxy diphenylphthalide*).—A substance employed in an alcoholic solution as a test for organic acids. No alteration takes place with these, but if alkali be present its colour is changed to a reddish purple. This test, however, cannot be relied on in the presence of ether, ammonia, or carbon dioxide. It is insoluble in water.

Phosphate.—A salt of phosphoric acid. The principal are phosphate of ammonia, copper, iron, lead, calcium and soda.

Phosphorescence. — The property possessed by many substances of emitting light under certain conditions.

Phosphorescent Photographs. — See **Luminous Photographs.**

Phosphoretted Hydrogen (Synonym, hydrogen phosphide).—Obtained in three forms—gaseous, liquid and solid. The gaseous phosphide (H_3P) is prepared by heating hydrated phosphorus acid in a small retort. It has a disagreeable odour, is slightly soluble in water, and burns with a brilliant flame.

Liquid phosphide (H_2P) is obtained in small quantities whe calcium phosphide is treated with water. The gas evolved in passed through a tube surrounded by a freezing mixture, which condenses this compound as a colourless and highly refractive liquid. In contact with air it inflames instantly. Solid phosphide is HP_2 formed by the action of light on liquid phosphide.

Phosphorus (Gr. *phosphoros*—bringing or giving light; symbol, P; atomic weight, 31).—A non-metallic element found in the unstratified rocks, the soil, the organism of plants, and the bodies of animals. It is insoluble in water, but soluble in ether, chloroform, benzine, turpentine, and other oils and carbon bisulphide. It can be prepared artificially from bone ash or other phosphates by treatment with two-thirds of their weight of sulphuric acid and water and sublimation with charcoal and sand. It has but little interest photographically. It is sold in sticks, which must be kept in bottles filled with water.

Photo (*Phos*—genitive, *photos*—light).—Pertaining to or relating to light.

Also used as an abbreviated term for photograph.

Photo Aquatints.—A process for printing pictures from intaglio copperplates. The process is said to be much simpler than photogravure, which it much resembles.

Photo Caustics.—A name given to photo-lithographs produced in half-tone by means of a Meisenbach ruled negative.

Photochromy (*Photo* and Gr. *chroma*—colour).—Photography in colours. See **Heliochromy.**

Photo-chemical Action.—See **Photographic Chemistry.**

Photo-Collographic Process.—A simplified collotype process. See **Warneke's Process.**

Photo Collotype.—See **Collotype.**

Photo Crayon Process.—A process introduced by Sarony about the year 1870. It consisted in making a photographic transparency on glass, which was afterwards backed up with paper, on which a number of lines, hatchings, or stippling were lithographed, giving the portrait the appearance of a crayon work.

A similar process adopted by Henderson is the following:—A piece of course ground glass is laid over a portrait, and the glass worked on with a lead pencil or crayon all round, and, if necessary, over the lower part of the figure. The ground glass when viewed by transmitted light will then represent beautiful broken up granular markings. A thin negative is then made from this ground glass by transmitted light, reduced or enlarged as required. This negative to be superimposed with the negative to be enlarged or reproduced which, when developed, will contain all the worked up effects on the ground glass.

Photo Electricity.—The generation of electromotive forces and currents by the action of light on various metallic plates having their surfaces prepared by special processes. The most recent experiments in this direction have been made by Professor G. M. Minchin.* He uses two kinds of cells. One of them consists of a glass tube three or four inches long, in which is some pure methyl alcohol from oil of wintergreen, covering the two plates; platinum wires, sealed into the tube by heat, pass through the glass to the plates. The smaller plate is of absolutely clean, pure tin, a quarter of an inch long, a sixteenth of an inch broad. The larger and sensitive plate is one inch long and one-eighth of an inch broad. This one also is of perfectly pure tin, for any impurity, especially any trace of copper, promotes failure in the results. The plate is first cleaned with sodic hydrate, and afterwards with dilute hydrochloric or hydrofluoric acid; then it is laid upon a horizontal arm of porcelain so bent at the other end that, on raising from below a dish containing liquid, the said liquor covers the plate. By this method the second plate, or the one which has to be covered with a sensitive film, is immersed in the following solution:—

Distilled water	500 c.c.
Nitric acid	3 ,,
Nitrate of ammonia	15 grammes

The plate is left in the liquid about four minutes, and becomes covered uniformly with a whitish deposit. The solution is then removed by lowering the dish, and the under surface of the horizontal porcelain support is dried with blotting paper. This dried under surface is then uniformly heated with a spirit flame moved about underneath until the liquid above has evaporated; the surface of the tin plate will then present a dirty slate colour. As the heating is continued, a point is reached at which a dark shadow passes over the whole surface of the plate; if the heating be now stopped, a sensitive plate is produced, but not one of the maximum sensitiveness Upon continuing the heat the surface will change into a perfectly white one, and the heating should be

* "Photographic News," January 23rd, 1891.

continued until the thin vapour or smoke which is given off ceases to appear, and until the smell of nitrous acid entirely disappears. Care must be taken not to melt the tin in this process, and when the treatment is complete, the plate should be plunged into methyl alcohol from pure oil of winter-green. A fine platinum wire has first to be fixed to the top of the plate, either by means of a solder with a low melting point, or by passing a wire through a little hole at the top of the plate and then bending the end of the wire back over the top edge; the latter plan is found to give sufficiently good contact for practical purposes. The clean, plain tin plate is sealed to the bottom of the tube by means of its platinum wire; after the methyl alcohol and the other plate are inserted, the upper part of the tube, with the wire from the second plate passing through it, is sealed by heat. All this may be done in daylight. The complete cell has to be left from two to five hours in the dark before it will exhibit its maximum powers.

The tin plate thus rendered sensitive, and mounted in a cell as described, when exposed to good diffused daylight will exert an electromotive force—E.M.F. in electricians' language—of half a volt or more, as exhibited by means of the quadrant electrometer, and it will yield a steady stream of electricity for three or four hours, after which the E.M.F. falls off.

Supposing an exposure not to have been too long, the cell will gradually recover itself in the dark; if it be not exposed for more than ten minutes or so at a time it will recover itself in the dark; one of the cells which has been used only in the latter manner has been so employed by Professor Minchin for four years.

Photo electricity is yet in its infancy, but there are many who believe that it has a great future before it. Among the many possibilities are mentioned* a scientific comparison of the relative values of two different lights, the solution of the problem of telephotography, or seeing at a distance, also the question of utilising the energy of the solar rays for performing useful work by means of photo-electric batteries.

Photo Electrotype.—A very large number of processes come under this heading. They all consist substantially in first exposing a sheet of chromatised gelatine under a negative. If half-tone effects are to be produced, grained or lined negatives must be used. The effect of the light shining through the negative is to render some parts insoluble and incapable of absorbing water. After exposure the gelatine is either soaked in water, to swell the remaining soluble parts, or it is treated with a warm water bath or an acetic acid to wash them right away, leaving the insoluble parts to form an image in relief. From these, moulds in wax or plaster are made, from which a copper relief block for typographic printing is made by the electrotype process.

* Professor Minchin at the Physical Society.

Photo Engraving.—The earliest process of engraving with the aid of photography was the bitumen process of Niepce. This was, in fact, the earliest process of obtaining permanent images by the action of light. Niepce discovered that certain varnishes became insoluble by the action of light; he covered metal plates with asphaltum or bitumen of Judea, and exposed them to the image in the camera obscura. After the exposure the plates were treated with a solvent, when the unexposed parts were dissolved away, leaving the insoluble negative image of bitumen on the metal plate. To convert this into a positive one, the plate was treated with iodine vapour, which attacked those parts of the metal unprotected by the bituminous image, which was then cleared away with a powerful solvent. By applying an acid to the bituminous images on metal the bare parts are eaten away, and by this means engraved plates were obtained. See **Niepceotype.**

Bolas, the eminent authority upon photo-mechanical processes, thus describes the *modus operandi* for producing photo-engraved plates by the bitumen process:—"Bitumen or asphalt dissolves readily in benzole, and the solution runs freely through a paper filter. The solution should not be quite as thick as collodion. A carefully-cleaned copperplate, such as the engravers use, is clamped down on to a turn-table. The next step is to flood the plate with bitumen solution, and then to make the table revolve quickly. When it has revolved a few seconds the film will be dry. No other method gives such a uniform and compact film of bitumen as this. After coating it is well to put the plate aside for twelve hours, in order that the film may become harder. It is then necessary to dust it over with French chalk to remove stickiness, and after this it is placed behind a transparency and exposed to light. The time of the exposure may vary from 20 minutes to two days.

When a plate has had the requisite exposure, the next matter is to dissolve away that portion of the bitumen which has not been made insoluble by the action of light. Now, benzole is generally too energetic a solvent for the purpose, and oil of turpentine is often not sufficiently active; but by mixing these together you can get any degree of solvent power which you may require. The workman commences by flooding the plate with oil of turpentine, and if this has not sufficient action he pours it off and adds a little benzole; this begins to produce an effect, and enables him to judge as to the amount of benzole which he may safely add to the oil of turpentine. When he has added this quantity, and has washed away all the soluble bitumen from the plate, it is next thoroughly rinsed with water to remove the oil of turpentine. The plate is next placed in nitric acid, so as to etch the lines where the metal is bare.

Plates from which much printing is to be done are ordinarily covered with a thin film of iron, by the electrolytic method, and as

the film of iron is extremely thin, it does not in any way interfere with the printing qualities of the plates. When the surface of a plate begins to wear a little, and the impressions show signs of deterioration, the film of iron is dissolved off by means of dilute sulphuric acid, leaving the copperplate as good as ever. The film of iron, although so thin as not to injure the printing qualities of the plate, is nevertheless sufficiently thick to protect the copper from injury in printing. The plate having been freed from the first worn-out film of iron, is once more coated with a layer of iron, and is again ready for use. When the second film of iron is nearly worn away, and the printer approaches near to the true surface of the copperplate, the iron is again dissolved away, and a new coating of iron is put on. According to this system, one really prints rather from a cast of the plate than from the original plate, and new casts are made as required.

Another method of producing photo-engraved plates from lined subjects is by means of photo-lithographic transfer, the process being similar to photo-lithography, except that a metal plate is used instead of the stones.

Major de la Nöe's process of photo-engraving, which he terms typogravure, is really an intaglio process, although the printing is similar to ordinary zincography. A prepared zinc plate is coated with a film of sensitive bitumen as already described, and the exposure made under a tracing or a transparency, and the plate afterwards developed in the usual way. The plate is then etched with dilute nitric acid until the depth of about $\frac{1}{250}$th of an inch is reached. The plate is then dried and again coated over with bitumen. The ground is next polished off with a stick of charcoal, leaving the bitumen on the lines, after which the plate is gummed and printed from as in zincography.

Klie's process is the following: A copperplate is dusted over with powdered asphalt, and the plate heated until the particles of asphalt just adhere to the plate. A negative carbon process is then transferred to the copperplate, and the latter is then etched with a strong solution of perchloride of iron. By diluting the solution its action increases; water is consequently gradually added until the solution etches through the thicker parts, until only the high lights remain unetched.

A simple method of photo-engraving line subjects, much practised on the Continent, is the following: A copperplate is first coated over with a film of bichromated albumen and exposed under a negative; the plate is then washed with cold water, and etched with an alcoholic solution of ferric chloride.

The following details will be sufficient to enable the method to be carried into practice* One hundred cubic centimetres of albumen are mixed with a solution of two and a half grammes of bichromate of ammonia, in fifty cubic centimetres of water, and,

* T. C. Bolas on "Photo-mechanical Printing."

after having been well beaten, the mixture is filtered. A carefully cleaned plate of copper is now coated with the mixture, and after the excess has been well drained off, the plate is dried at a very gentle heat, it being retained in a horizontal position meanwhile. The exposure required is by no means a long one, half a minute in moderate sunshine being sufficient in ordinary cases; but this must, of course, be learned by experience. Instead of developing (washing away the unaltered albumen) in plain water, it is better to use a weak solution of aniline red or magenta dye, as under these circumstances the ground becomes tinted, and the progress of the development can be watched. When the plate has been dried, nothing now remains but to varnish the back and edges with an ordinary black varnish, such as the so-called Brunswick black, and to etch. The etching bath is made by dissolving one part of perchloride of iron in five of alcohol, and ten minutes is generally sufficient time for etching to the required depth.

Major Waterhouse succeeded in perfecting a process of photo-engraving with intaglio plates, his method being a modification of a process previously introduced by Geymet. The process is based upon the reticulation of a Woodbury relief.

A Woodbury relief (see **Woodburytype**) is first developed upon a plate of silvered copper. The relief need not be quite so high as required for the Woodburytype process; ordinary carbon tissue may be used. When the relief has been developed and washed it is immersed in a solution of potassium dichromate, drained and dusted over with very fine sand previously waxed by heating in an iron pot, and stirring up with a small quantity of wax. The waxed sand is now allowed to remain on the film until quite dry. When dry it is brushed off, and it will be found to have granulated or pitted the gelatine image, the pits being deepest in the thicker parts. The next process is to blacklead the plate, and make a cast in the electrotype bath. This electrotype is used as the printing plate.

Obernetter's "Lichtkupferdruck" is another process. A gelatino-bromide image is made in a film of emulsion rich in silver. This is converted into silver chloride by immersing in a solution of weak potassium dichromate acidified with hydrochloric acid. This silver chloride film is laid on to a copperplate. The chloride of silver becomes decomposed, uniting with the copper and etching it, all the details being reproduced as an intaglio. To assist the action the copperplate is connected to the positive wire of a battery, the negative wire being connected to a carbon plate placed behind the film picture. If the latter be moistened with weak salt and water the etching of the plate proceeds very rapidly.

Photo-etching.—See **Photo-engraving.**

Photo Filigrane.—A process invented and patented by Woodbury. It is briefly a method of producing designs or photographs

on paper and other similar materials by pressure, with a photographic relief.

A gelatine relief is first made with carbon tissue specially prepared for this purpose. This has a much thicker coating of gelatine. After sensitising with potassium dichromate, it is exposed under a positive as in the Stannotype process. After transferring to the support, developing and drying, a hard gelatine relief is obtained. This is laid on to a sheet of paper and the two passed together through a rolling press, the relief being well rolled into the paper. The result is that the paper body is pressed thinner in some parts than others, the thin parts appearing much lighter. On holding the paper up to the light, a photographic image is seen. The relief can be used a large number of times. By this process many novelties can be produced. Portraits can be pressed into visiting cards, writing paper, etc., designs of all kinds made. It being somewhat similar to the watermark in the bank-notes, it could be used for that purpose, saving considerable expense, and with just as sure results, with much less likelihood of forgery. The process has for some reason or other been abandoned commercially.

Photo-galvanographic Process.—A photo-mechanical process now no longer used, although many of the present secret processes are based upon it. Pretsch's photo-galvanographic process may thus be briefly described. A glass plate was first coated over with gelatine containing potassium dichromate or silver salt and other chemicals. When dry it was exposed under a transparency. After printing it was immersed in cold water to dissolve out the unaltered chromium salt and to cause those parts protected from the light to swell up in proportion to the protection which had been afforded by the transparency. Further, the raised portions were rough and reticulated, the reticulation being coarse or fine in proportion as the different parts had been protected. The high lights did not, of course, swell at all, and had no grain. The plate thus produced was, of course, an exact reverse of what is required for printing. All that was then necessary was to take an electrotype cast from this relief to obtain the printing plate.

Pretsch produced plates of this description about the year 1868. The Fox-Talbot process was contemporary with Pretsch and somewhat similar.

Neither process was a commercial success, probably owing to its not being in a sufficiently perfect state to render it independent of the help of the engraver for retouching the plates.

Photogastroscope.—An arrangement for photographing the inside of the stomach. Fig. 172 illustrates the apparatus. At the end is attached a small electric light which lights up the cavity. An image is transmitted through the lens tube to the camera by means of mirrors. The arrangement has also a fine tube, through which air is forced to inflate the stomach. Water is also made to circulate round the electric light.

Photogene (Gr. *photos*—light, and *gennao*—to produce).—The generation of a more or less continued impression or picture on the retina, and the delay in the obliteration of it.

This name was also applied by Gaudin to "any sensitive compound containing iodide of silver with excess of free nitrate."

FIG. 172.

Photogenic Drawing.—An early photographic process described by Fox-Talbot in the year 1839. He used paper impregnated with common salt, and sensitised with nitrate of silver. He also substituted potassium bromide for the common salt to get the sensitive surface. Both negatives and positives were made on this paper. Common salt was used as a fixing agent, until the superior action of sodium hyposulphite was discovered by Herschel.

Photogeny (Gr. *photos*—light, and *gennao*—to produce).—The same as photography.

Photographic Chemicals.—A list of the most important chemicals used in the various photographic operations will be found under **Formulæ.** Their solubility will be found under the heading **Solubility.**

It is very essential in most photographic processes that the chemicals be perfectly free from impurities, as by the presence of

small quantities of foreign matter the success of a process is often ruined entirely. The following list* of the impurities occasionally found in the various chemicals, and the means of testing same, will be found useful :—

Substance.	Impurities Possibly Present.	Tests.
Ammonia	Carbonic acid.	Renders lime-water milky.
	Dissolved solid matter	Residue left on evaporation.
	Chlorides.	After acidulating with nitric acid, it gives a precipitate with silver nitrate, which, after washing, is readily soluble in ammonia, and re-precipitated by nitric acid.
	Sulphates.	After acidulating with nitric acid, it gives a precipitate with barium nitrate.
	Lime.	A white precipitate with oxalate of ammonium.
	Lead is often present, derived from the action upon flint glass bottles.	Black precipitate with sulphuretted hydrogen.
Nitric Acid	Traces of sulphuric acid.	After dilution it gives a precipitate with barium nitrate.
	Chlorides.	After dilution it gives a precipitate with silver nitrate.
	Peroxide of nitrogen.	The acid is yellow.
	Iodine may be present if the acid be prepared from sodium nitrate.	After dilution and cooling it gives a blue colour with starch paste or mucilage.
Hydrochloric Acid	Free chlorine.	Liberates iodine from solution of potassium iodide. See also chlorides, nitric acid.
	Sulphuric acid.	As above for nitric acid.
	Perchloride of iron.	Yellow colour. Brown precipitate with ammonia added till it smells slightly.
Hydrochloric Acid	Arsenic.	Marsh's test.
	Some yellow samples contain no iron, but an organic salt, and give an alkaline ash on ignition of the residue after evaporation.	Reinsh's test; a small piece of copper foil becomes coated on boiling in dilute acid.
Sulphuric Acid	Bisulphate of potassium.	Residue on evaporation.
	Sulphate of lead.	Milkiness on dilution. May be completely freed from lead by diluting with three or four times as much water, and allowing to settle.
	When sold as pure, it invariably contains a trace of iron. Common acid is also liable to contain arsenic, selenium, thallium, and many other substances.	No easy test can be given, as the substances are so numerous; some of them volatile, and most require separation from the acid before detection.
	Organic matter, as a piece of straw in a carboy of acid.	Gives a brown colour to the acid.
Acetic Acid	Water.	Does not solidify when cooled to 17° C. (53° F.)
	Sulphurous and hydrochloric acids.	White precipitate with silver nitrate.
	Aldehyde, or volatile tarry matter.	Blackens in the light after adding silver nitrate.
	Organic sulphuric acid.	Smell of garlic.
Citric Acid	Tartaric acid.	Strong solution of potassium acetate added to a strong solution of the acid will deposit white crystalline bitartrate.
Pyrogallic Acid	Metagallic acid.	Black residue insoluble in water.
Silver Nitrate	Free nitric acid.	Reddens litmus paper (neutral silver nitrate does not affect litmus).
Potassium Carbonate	Chlorides and sulphates.	Same as for ammonia.
Potassium Iodide	Potassium carbonate.	A strong solution is alkaline to test paper.
	Sulphates and chlorides.	Same as for ammonia.
	Potassium iodate.	A pretty strong solution becomes yellow from liberation of iodine on addition of dilute sulphuric acid, or, better, a strong solution of citric acid.

* Compiled by G. M. Jones for the "American Annual of Photography."

Photographic Chemistry.—The number of chemical changes that take place in photographic operations is so great that it will only be possible to mention the most important. The process that is now almost universally adopted is the gelatino-bromide dry plate process. This has taken the place of a large number of processes and improvements starting with the Daguerreotype process. In this method of obtaining photographic images a sensitive plate was prepared by exposing a silvered tablet to the action of vapour of iodine, which combines with the metallic silver to form silver iodide, thus—

$$Ag_2 + I_2 = 2AgI.$$

Subsequently bromine vapour was used with iodine. On exposing the plate thus prepared in the camera a latent image was formed, which was made to appear by the vapour of mercury. Sodium hyposulphite was afterwards discovered as a fixing agent.

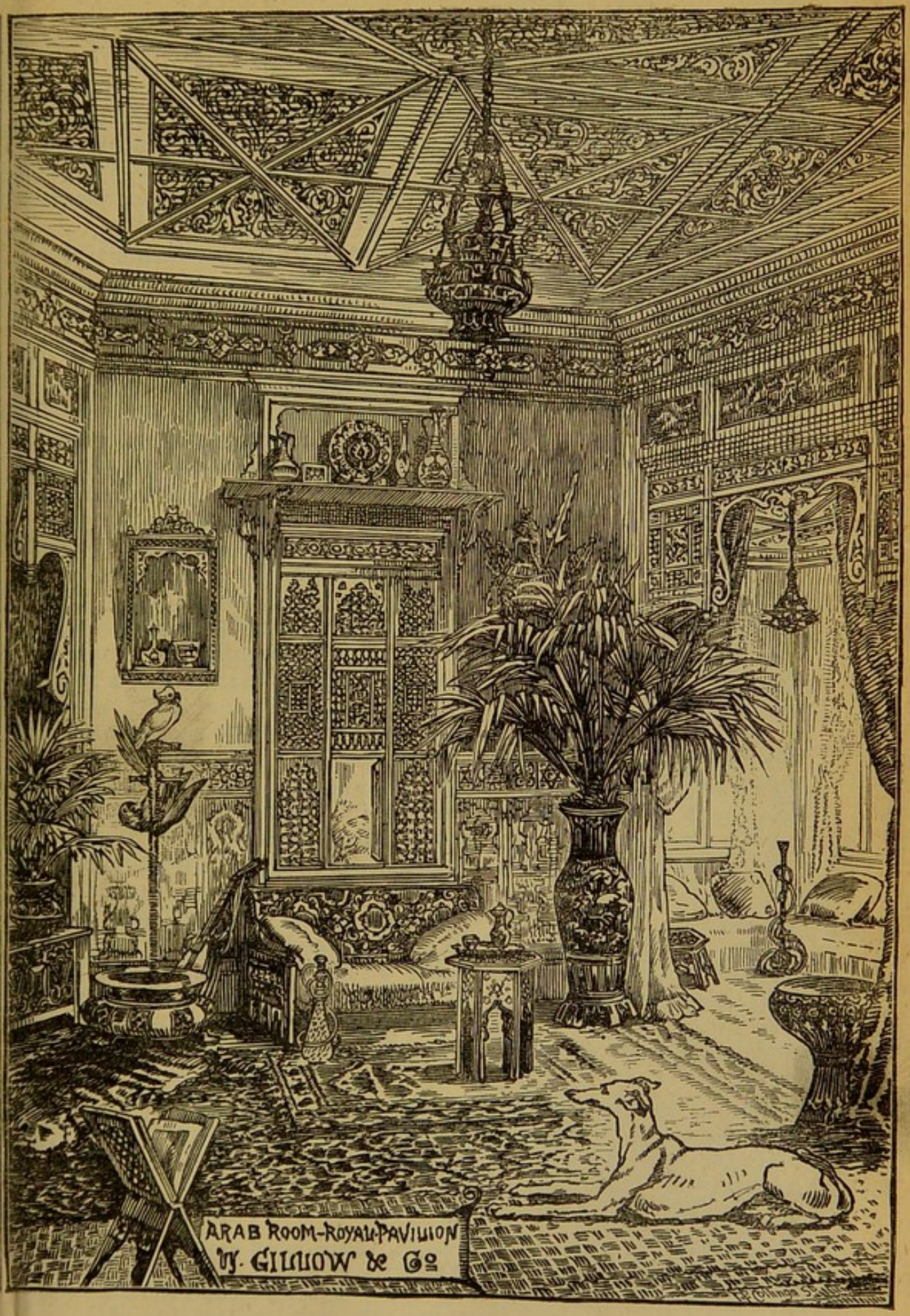
After the Daguerreotype came the calotype or Talbotype process, named after the inventor, Fox-Talbot. In this paper was used as the support for the image. It was prepared by first floating on a solution of silver iodide, and then washing slightly. When required for use this paper was excited with gallic acid and aceto-nitrate of silver brushed over it. It was then exposed in the camera, and afterwards developed with the same substances.

Then came the collodion process of Scott Archer, still employed for special work, as in photo-mechanical printing. In this process glass plates were first coated with collodion (a solution of gun-cotton dissolved in ether and alcohol) containing an iodide salt,* and then sensitised by immersion in a bath containing a silver nitrate solution. The iodide combining with the silver formed silver iodide, thus — $AgNO_3 + CdI = AgI + CdNO_3$. The sensitised plates, after exposure to the image in the camera, were developed with pyrogallic acid with either acetic or citric acids. The negatives thus obtained were fixed with potassium cyanide or sodium hypo-sulphite.

We now come to the modern *dry* plate process, so called to distinguish it from the collodion process, in which the plates were exposed in the *wet* state. The material which forms the sensitive surface of the plate is silver bromide, in some cases mixed with chloride and iodide, and held in position by a gelatine.

Silver bromide is a heavy, almost insoluble, white precipitate, obtained by adding a solution of potassium or ammonium bromide to one of silver nitrate. The white flakes of silver bromide thus formed fall to the bottom of the vessel, and in this form the compound is practically useless for photographic purposes. If, how-

* Cadmium iodide was usually employed.


ARAB ROOM-ROYAL PAVILION
W. GILLOW & Co

ever, a fluid of a viscous nature is used, the silver bromide will not fall to the bottom, but remain in suspension, and in this form is termed an emulsion, which can be used for coating plates or paper. The usual method is to dissolve a quantity of gelatine in warm water, and mix with it the ammonium bromide. The silver nitrate is then gradually added, and a white silver bromide of emulsion is produced. The change is thus represented—

$$AgNO_3 + (NH_4)\,Br = AgBr + (NH_4)\,NO_3.$$

Now, it must be noted that silver bromide is sensitive to the action of light, so that the addition above described in making the emulsion must, of course, be performed in a non-actinic light.

When the bromide is added to the silver, a certain quantity will combine with it, and no more. A simple calculation tells us that according to the equation 119 parts by weight of potassium bromide will combine with 170 parts by weight of silver nitrate.*

The sensitiveness of the emulsion is increased by boiling it. This has the effect of converting the insensitive very fine reddish silver bromide into a very sensitive coarse blue substance.

We have shown that in mixing the bromide with the silver, silver bromide and ammonium nitrate are formed. The next process is to wash the latter soluble compound from the emulsion. This is done by breaking the gelatine emulsion up into small shreds and well washing in several changes of water; besides the potassium or ammonium nitrate, any soluble bromide is also washed away, leaving the insoluble sensitive silver bromide in the gelatine. It is then remelted, and glass plates coated with it and dried are termed gelatine dry plates.

These dry plates are, when required, placed in the camera and exposed to the image formed by the lens. The effect of this is that a *latent* or invisible image is impressed on the film of the plate, which may be afterwards rendered visible by development. What is the change that occurs to produce this effect? Chemists and scientists are as yet divided upon the subject.

The theory that till recently has met with general acceptance, and which Captain Abney gives in his work, is that the silver bromide is reduced by light to sub-bromide (Ag_2Br). The formation of this sub-bromide depends, of course, on the active rays from different parts of the object.

Another theory is that electricity is sufficient to account for the formation of the latent image.†

C. J. Leaper says‡ that the weight of indirect evidence (necessarily indirect from the difficulties surrounding the problem to be solved) seems to point to the formation by light of silver oxybromide $Ag_2O.2AgBr$. It is well-known that bromine is evolved during exposure,§ and on the assumption that oxygen is at

* In practice, however, a larger quantity of bromide is taken than the equation represents because it prevents the silver nitrate from combining with the gelatine, and for other reasons.

† "The Chemistry of Photography," by J. C. Wiggin.

‡ "The Chemistry of a Dry-plate."

§ If dry-plates be exposed to the light, a distinct smell of bromine can be detected.

the same time absorbed, we may express the change by the following equatation :—

$$4AgBr+O=Ag_2O.2AgBr+Br.$$

Carey Lea, in America, has recently published his investigations in what he terms the "photo-salts of silver," which he has prepared, and which he states are producible from the haloid salts of silver (the chloride, bromide and iodide) by the action of light, as well as by purely chemical means, his photo-bromide consisting of silver sub-bromide in combination with silver bromide, the sub-bromide forming but a small portion of the whole. This photo-bromide is insoluble in strong nitric acid, whilst the sub-bromide itself is very soluble in it, and this theory receives strong confirmation in other ways; it appears to be the one most probably correct.*

The latent image produced, we have next to consider the action of the developing agent. All developers are energetic oxygen absorbers, it being upon this property that their power of developing is based. The commonest developer is the pyrogallic acid.

Pyrogallic acid is an erroneous term for what is not an acid at all, but more correctly pyrogallol—its chemical name is trihydroxybenzene. It is a powerful and greedy absorber of oxygen. It is only active as an alkaline medium. Combined with ammonia, its action on the silver sub-bromide is to reduce the silver to the metallic state, ammonium bromide being formed thus—

$$C_6H_4(OH)_3+2Ag_2Br+2(NH_4)OH$$
$$=2NH_4Br+2Ag_2+H_2O+(C_6H_4OH_3+O)$$

When ammonium bromide is used with this developer as a restrainer, its action appears to consist in diminishing the amount of silver sub-bromide capable of being dissolved by the ammonia. If strong ammonia is used more silver bromide is dissolved. If strong pyro solution is used a more rapid reduction of the bromide will take place, resulting eventually in fog.

Another developer largely employed is the ferrous oxalate, composed of ferrous sulphate, mixed with potassic oxalate, forming ferrous oxalate and potassic sulphate, the ferrous oxalate being dissolved by the excess of potassic oxalate.

$$K_2C_2O_4+FeSO_4=FeC_2O_4+K_2SO_4.$$

This also acts as a powerful reducing agent, becoming oxidised to ferric salt.

$$6FeC_2O_4+6Ag_2Br=6Ag_2+Fe_2Br_6+2Fe_2(C_2O_4)_3.$$

Hydroquinone or paradihydroxybenzene is another favourite developing agent. It is closely allied to pyro, its formula being $C^6H_4(OH)_2$. On development it becomes oxidised to quinone.

$$C_6H_4(OH)_2+O=C_6H_4O_2+H_2O.$$

Besides the various reducing agents used as developers the alkalies—ammonia potash and soda and their carbonates—are used

* J. C. Wiggin.

as accelerators. Ammonia is most energetic, but is liable to produce stains.

The latent image having been developed and become visible, the next operation is to fix the image, or, in other words, to make it permanent by dissolving out the silver bromide unacted upon by the light. If this were not done it will be obvious that the image would be reduced on exposure to the light. The fixing salt usually employed is sodium hyposulphite. Potassium cyanide, common salt, ammonia, and other salts can also be employed. Hyposulphite of soda, or, as it is more correctly termed, sodium thiosulphate, is considered to be sodium sulphate Na_2SO_4, in which one atom of oxygen has been replaced by sulphur.

$$Na_2S_2O_3.$$

The action of this salt upon the photographic film is one of double decomposition.

$$Na_2S_2O_3 + 2AgBr = 2NaBr + Ag_2S_2O_3.$$

The silver hyposulphite formed combines with excess of hypo forming the soluble double salt.

$$Ag_2S_2O_3, 2Na_2SO_3.$$

If the hypo is not in excess another double salt is formed.

$$Ag_2S_2O_3, Na_2O_3.$$

This salt is almost insoluble, and is with difficulty eliminated from the film. The importance of having plenty of hypo in the bath will be at once obvious.

After fixing, the plate is thoroughly well washed to eliminate all soluble matter. A clearing bath of acid and alum is sometimes applied. Before this application, however, it is absolutely necessary that all the hyposulphite be thoroughly eliminated from the film, otherwise it will be decomposed, the following reaction taking place :—

$$Na_2S_2O_3 + 2HCl = H_2O + SO_2 + 2NaCl$$

If the negative image be too thin for the subsequent manipulation, it is intensified. This is accomplished either by increasing the deposit of silver, or by partial substitution of another metal for it. The chemistry of intensification is given under **Intensification** (*q.v.*)

If, on the contrary, the negative image is too dense for the subsequent process, it is reduced by the application of a solution of potassium ferricyanide and hypo. The action that takes place here is in all probability the reduction of the ferricyanide ($K_6Fe_2Cy_{12}$) to ferrocyanide (K_4FeCy_6); the oxygen formed, combining with the silver of the image, would, as silver oxide (Ag_2O), be removed by the hypo.

The negative completed, we have next to consider the methods of making the positive print. The most generally employed method is that known as albuminised paper printing. Ordinary paper is coated over with albumen containing ammonium chloride.

When dry this is floated face downwards on a solution of silver nitrate. The re-action that takes place is usually described thus—

$$AgNO_3 + (NH_4Cl). = AgCl + NH_4NO_3$$

In addition to the silver chloride formed, free silver nitrate is also present. Further, a combination of the silver with the albumen also takes place, forming albuminate of silver. The principle of the process is this—silver chloride, if exposed to the light, in contact with organic matter, is darkened to sub-chloride.

$$2AgCl = Ag_2Cl + Cl.$$

Chlorine is liberated, which, if silver nitrate be present, combines with its silver, forming silver chloride again and free nitric acid.

The silver albuminate present is reddened on exposure to the light to a sub-oxide (Ag_4O). This when acted upon by the hypo is converted into metallic silver and silver oxide, which is to a great extent dissolved. The hypo also removes the silver sub-chloride, leaving a certain amount of metallic silver from it.

Positive prints upon albuminised paper have usually a disagreeable colour. For this reason toning is resorted to. It consists essentially in the deposition of gold or other metal upon the silver of the print. The free nitrate of silver is first removed from the paper by washing, otherwise gold nitrate and silver chloride would be formed by double decomposition. The toning bath usually consists of a gold chloride solution, and any salt in which a fixed alkali is combined with a weak acid. Acetates and alkaline carbonates are capable of precipitating gold from neutral solution in the presence of organic matters. With the acetate bath the following represents the change that takes place :—

$$2AuCl_3 + NaC_2H_3O_2 = Au_2 + NaC_2Cl_3O_2 + 3HCl.$$

Phosphate, biborate, bicarbonate, and many other salts of sodium and potassium may be used, the action being similar in each case, *i.e.*, to deposit the gold on the silver particles of the print.

Besides gold, other metals as uranium, platinum, etc., may be used.

In printing with gelatino-chloride papers the chemical action is somewhat similar, except that a quantity of a citrate is added to the film, forming a compound of silver citrate, and doing away with the free nitrate. Further, gelatine is the vehicle used for holding the sensitive salt in suspension, so that the silver albuminate is not formed. Prints upon gelatino-chloride paper are considered to be more permanent than those made upon albuminised paper.

In fixing prints the chemical change is very similar to that which takes place in fixing the dry plate, and which has already been described. The soluble double salts are formed. Owing to the decomposing action of acids upon hypo it is advisable that the fixing bath be kept alkaline.

It is very important that after fixing, the hyposulphite of sodium be thoroughly dissolved from the film. Potassium sulphocyanide

may also be used as a fixing agent. It is not superior to hypo, however, and is a violent poison.

The chemical action of bromide paper is the same as with bromide plates. The same kind of emulsion is usually employed, it being spread on to paper instead of glass.

Alpha paper is similar to bromide paper, except that a chloride is used instead of a bromide, chloride of silver being formed*

In platinum printing the salts of platinum are reduced, that is to say, the metal is set free by ferrous salts, and ferric salts when exposed to light become reduced to ferrous

The reactions that may be stated to take place are thus represented—

$$Fe_23C_2O_4 = 2FeC_2O_4 + 2CO_2.$$

$$3K_2PtCl_4 + 6Fe_2C_2O_4 = Fe_2Cl_6 + 2Fe_23C_2O_4 + 6KCl + 3Pt.$$

$$Fe_23C_2O_4 + 3K_2C_2O_4 = 2Fe^{iii}K_33C_2O_4.$$

The carbon process, and the basis of the majority of the photo-mechanical processes, depends upon the sensitiveness of the dichromates to light. In the carbon process the paper is first coated with a solution of pigmented gelatine. This is floated on a solution of potassium or ammonium dichromate. In presence of gelatine these dichromates become reduced by the action of the light, a portion of their oxygen combines with the gelatine, causing it to become quite insoluble. Thus—

$$2K_2Cr_2O_7 = 2K_2CrO_4 + CrO_3 + O_3.$$

When hot water is applied the portions unacted upon by the light which remain soluble are washed away, leaving the image in pigmented gelatine.

Photoglyphic Engraving.—A process of photo-etching invented by Fox Talbot. A metal plate was coated with gelatine, sensitised with potassium dichromate, and exposed to light under a negative. It was then dusted with finely powdered copal and warmed until this melted. When cold it was covered with a suitable etching fluid which soaked through the portions of the film unacted upon by light, and attacked the plate underneath.

Photoglyphy (Gr. *Photos*—light and *glupho*—to engrave).—See **Photo-engraving.**

Photoglyptie.—The French name given to the Woodburytype process.

Photogram (Gr. *photos*—light, and *gramma*—a letter or drawing).—A photographic image, a photograph.

Photograph.—A representation or picture of an object obtained by means of photography.—For the law of copyright in photography, see **Copyright.**

*A small quantity of a bromide is also used generally.

Photographer.—One who takes a picture or likeness by means of photography. Many attempts have been made of late to draw a clear distinction between an amateur and a professional photographer. Correctly speaking, an amateur is one who follows the occupation merely for love, and without any attempt at making profit by means of same, while a professional is dependent either partly or wholly upon the art for his means of livelihood. Many are of the opinion that directly an amateur photographer sells or receives any money for his work, he ceases to be an amateur and becomes a professional. The question then raised is this: If an amateur accept money for his work to partly recompense him for his expenses in connection therewith, can he no longer be considered an amateur? Provided he does not rely upon photography at all for his income, he should be classed as an amateur. —See **Amateur.**

Photographic Copyright.—See **Copyright.**

Photographic Gun.—A small instantaneous camera used in the same way as an ordinary gun. It possesses a rapid lens with an instantaneous shutter fitted into the barrel, with an arrangement for focussing. A cylinder contains 18 plates 1½in. diameter, which are brought one after the other into position.

Photographic Optics.—See **Optics, Lens, etc., etc.**

Photographist.—A photographer.

Photography (Gr. *photos*—light, and *grapho*—to draw).—Many attempts have been made to trace the art of photography. A lens has been found in the ruins of Nineveh, a city destroyed a thousand years before Christ. Some authorities assert that this must have been used only as an ornament by the women of the time, although it seems hardly possible that they should not have discovered the fact that images of objects could be obtained with it. The following is a slight resumé of the progress of photography, although the art itself cannot be said to have been discovered till the Daguerreotype process.

1556. Fabricius published a book on metals in which is noted that chloride of silver, or *luna cornea*, as it was then termed, darkened on exposure to the light.

1590. The camera obscura was invented by the Italian philosopher, Baptista Porta.

1727. J. H. Schulze obtained copies of writing in sunshine upon surfaces prepared with a mixture of a nitrate of silver solution with chalk.

1770. Scheele showed that violet light was most active in changing silver chloride. His results were confirmed by Senebier

who wrote that, in fifteen seconds the violet rays blackened silver chloride as much as the red rays did in twenty minutes.

1774. Scheele discovered the cause of the darkening of silver chloride exposed to the light. He proved the effect upon it was to decompose it and cause it to give up some or all of its chloride. He proved this by exposing it to light under water.

1795. Lord Brougham suggested in a communication to the Royal Society* the possibility of obtaining pictures upon ivory, rubbed with silver nitrate and exposed to the camera.

1802. Thos. Wedgwood (fourth son of the great potter) and Humphrey Davey read a paper at the Royal Institution on copying paintings done on glass, and making profiles by means of silver nitrate. Davy discovered that chloride was more sensitive to light than nitrate of silver, and that white leather was superior to paper. These experimenters afterwards abandoned their researches for want of something that would fix the impressions thus obtained, and prevent them from further darkening when exposed to light.

1810. Seebeck is stated to have observed that when the solar spectrum was projected upon moist chloride of silver, a faint impression of the natural colours was produced.

1812. Iodine was discovered by Courtois.

1813. About this time Joseph Nicéphore de Nièpce commenced his experiments, which resulted in the discovery of the bitumen process of photography. He coated metal plates with asphaltum or bitumen of Judea, and exposed them in the camera for several hours. The parts unaffected by the light remained soluble, and were dissolved away with oil of lavender.

1819. Sir John Herschel drew attention to the hyposulphites and the solvent power of the akaline hyposulphites upon chloride of silver.

1824. Daguerre commences his experiments on similar lines to Nièpce.

1826. Bromine was discovered by Balard. Daguerre became acquainted with Nièpce.

1827. Nièpce was refused a hearing at the Royal Society because he would not reveal the details of the process.

1829. Nièpce and Daguerre entered into a partnership, which was continued after the death of Nièpce, his son, Isidore, taking the place of his father.

1833. Nièpce, the elder, died. Daguerre continued his work. His experiments in using iodine to stain the surface of the silver plates led to the invention of the Daguerreotype process.

1834. Fox Talbot commenced his researches, and in 1839 showed several pictures stated to have been made in the camera in 1835.

1838. Daguerre attempted to form a company to work his new process, the Daguerreotype. The Parisian public was perfectly in-

*This does not appear in the published paper; Lord Brougham stated that he did make the suggestion but it was eliminated from the published report by the secretary.

credulous, and the shares were not taken up. He then explained his process to the eminent French astronomer and physicist, Arago. On the latter's recommendation to the French Government, Daguerre was awarded a life pension of 6,000 francs and Isidere Nièpce one of 4,000 francs per annum, on condition that the invention was published to the world.

1839. Notwithstanding this, a patent was taken out by Daguerre in this country, in this year, five days before it was publicly announced at Paris.

In the same year Fox Talbot described his method of "Photogenic drawing." He soaked paper in a weak solution of common salt, and then brushed one side twice over with silver nitrate. Both negatives and positives were produced. The images were fixed with common salt.

Herschel pointed out the superiority of sodium hyposulphite as a fixing agent.

J. B. Reade used an infusion of nutgalls to render silver nitrate on paper more sensitive to light.

Mungo Ponton discovered the peculiar properties possessed by potassium bichromate. He found that if paper be soaked in a solution of potassium bichromate and dried it was changed by the action of light, the chromium compound produced being insoluble.

1841. Fox Talbot patented his calotype process, which was afterwards disputed by J. B. Reade on the grounds of his previous discovery. In Talbot's process iodide of silver was used on paper. This, when required for use, was brushed over with a gallo-nitrate of silver solution. The image after exposure was hardly visible but required to be developed. This was accomplished by brushing the paper over with more of the solution.

In this year Petzval invented his famous portrait lens, which was constructed by Voightlander, and Claudet patented the use of coloured media for illuminating the dark room, which was previously quite dark.

1842. Herschel described his methods of printing with salts of iron.

1844. Robert Hunt recommended ferrous-sulphate as a developing agent.

1848. Niepce de St. Victor introduced the albumen process. Glass was coated with albumen containing potassium iodide and sensitised in a silver nitrate bath.

1849 A Frenchman, Gustave le Gray, suggested the use of collodion for photographic purposes.

1851 Scott Archer introduced the collodion process.

1852 Fox Talbot invented a process of steel engraving by the action of light. This he termed photoglyphy or photoglyphic engraving.

1854 Messrs. Spiller and Crookes introduced a moist collodion process.

1855 A French scientist, Dr. Taupenot, published his col odion albumen dry plate process, which found much favour.

1861 Major Russell published his Tannin process.

1864 Sayce and Bolton published an account of a collodion emulsion process.

In 1871 Dr. R. L. Maddox used gelatine in place of collodion, and from this sprung the present process of photographing with gelatine dry plates. It was not, however, until many years later that the advantages of gelatine over collodion were fully recognised.

This may be considered as a brief summary of the principal events that led up to the now almost universally employed dry-plate process. The wet-collodion process, however, is still worked in many establishments for special work where rapidity is not essential, and where brilliancy and depth of contrast are desirable.

The manufacture of a new collodion dry-plate by Dr. Hill Norris will also take place shortly.

For complete account of the history of photography, see W. J. Harrison's "History of Photography."

Photography, Applications of.—The introduction of the modern dry-plate process, and consequently the reduction of the time of exposure to fractions of a second, has caused photography to be of great and wonderful assistance to nearly all the modern arts and sciences. Perhaps the science that has mostly benefited has been astronomy.

Astronomy.—This may be easily explained. The sensitiveness of the eye is very limited. A star placed at such a distance that with the most powerful telescope we possess it is still imperceptible will always remain invisible, but with the photographic camera it is different. By greatly prolonging the exposure, this tiny invisible ray of light slowly but surely acts upon the sensitive plate, and after a sufficient length of time (it may require hours) it reveals its image. When we glance up at the heavens on a starry night we see some thousands of stars visible to the naked eye; with the assistance of a powerful telescope we see thousands more, but by exposing a photographic dry plate for some length of time we become aware of the existence of many hundreds more of these heavenly bodies, more appearing the longer the plate is exposed. The chemical plate possesses two principal advantages over the eye. First it is sensitive to rays utterly powerless to produce any visual effect, and next it can accumulate impressions almost indefinitely, it being possible to photograph objects so faint as to be perfectly hidden from our vision. By this means only may we eventually learn whether a blank space in the sky truly represents the end of the stellar universe, or whether farther and farther still worlds shine beyond veiled in the obscurity of immeasurable distance. Photographs of the stars were made as early as 1850 by Whipple, of Boston, and since then many thousands have been made of every region of the heavens. A complete chart is now being undertaken. For this purpose about 14,000 plates will have to be exposed from all parts of the earth, and these

plates will be so arranged that when correctly placed they will form a complete map.

Some idea of the increased astronomical knowledge that has been gained by the aid of photography may be had from the fact that in Cygnus 170 stars had been carefully mapped out by the old laborious process. A photograph made recently revealed the existence of over 7,000 stars. With regard to lunar and solar photography our astronomers have not been behind. A solar daguerreotype was made at Paris as early as 1845. In 1857 De la Rue was commissioned by the Royal Society to construct an instrument specially for photographing the sun at Kew Observatory. This instrument was used to make solar pictures or photographic record of the solar condition, and was continued for over fourteen years. For some time it has been believed that the spots on the sun have a regulating effect upon this earth. Dr. Zeyer, of Prague, claims that by means of photographs of these solar spots he is able to predict by more than twenty-four hours the approach of tempests, hurricanes, earthquakes, etc. The transit of Venus, comets, nebulæ, eclipses, etc, have all received the attention of the camera. See Astronomical Photography.

Medicine.—The physician is gradually recognising the claims of photography to his attention. He is now able to photograph the eye by a flash of light so that the pupil being previously in the dark, is dilated to its utmost, and has no time to contract before the deed is done and the image permanently recorded. Cameras are now being constructed for photographing the interior of the abdomen.* Valuable photographs, too, have been made of peculiar diseases, natural phenomena, etc., which cannot but be of great use to the medical student.

In *Chemistry*, photography has been of service in registering the belted zones of the spectrum, and making images of these bands, parts of which are invisible to the eye, and by this means not only can we obtain some information regarding the constitution of stars and nebulæ, but also some idea respecting the relative motions of these bodies and our earth.

Military Photography.—The science of warfare has also been aided by the art of photography. Balloons and kites are now constructed capable of carrying a camera with which photographs can be made of the surrounding country, the position of the enemy, strength of their fortifications, etc.

For mapping and surveying this arrangement would also be of great use.

In *Meteorology* photography assists by giving permanent records of the dark nimbus and the bright rolling cumulus clouds. The lightning flash is clearly shown as it really is. Further, it helps the meteorologist by registering for him the rising and falling of the barometer and thermometer.

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* See Photogastroscope.

In *Microscopy* we are able to photograph the disease bearing generations of bacteria vibrio and schizomycetes, and to throw these photographs upon a screen so that the image of the little flea assumes the proportions of the gigantic elephant.

Indeed, the uses of photography are many. It has been used to send letters from besieged cities to anxious friends and relatives outside. It has served to photograph the action of the torpedo in throwing up the water, and to give truthful records of the field of battle. It helps the clever engineer by multiplying his plans and by giving him evidence of work done above or below the ground determining the depths of the sea, and the direction of currents. It serves to keep in the hands of justice the image of the villainous murderer, or the avaricious forger. It detects the spurious banknote, and assists the expert in his tests of hand-writing. No traveller's equipment is complete nowadays unless it contains a set of photographic apparatus, enabling him to bring back from his travels pictures of the curious things that he has seen, and the picturesque places that he has visited.

These are a few among the many things which photography does for mankind. Every year shows some fresh use for it, and it is difficult to say where it will end, if end it well.

Photography in Colours.—See **Heliochromy.**

Photogravure.—A very beautiful photo-mechanical printing process, giving soft and most artistic results. The principles of the process were first suggested to a French firm by Woodbury, the inventor of the Woodburytype, and the process was eventually worked by them with great success. There are now several different photogravure processes worked by different firms. The details of these processes are, however, kept a close secret.

The following process is not by any means a difficult one. The first operation is to prepare from the negative a transparency with special carbon tissue for that purpose, developed on a prepared glass plate. Like all other photographic processes a good negative is necessary; it should have plenty of detail, and strong without being hard. From this negative a carbon transparency is made upon glass,* and when quite dry it is placed on the retouching desk and carefully worked up. To do this properly it requires the work of an artist, who can, by touching up the details, make an artistic picture from the photograph. It is an acknowledged fact that the majority of the magnificent photogravures that are sold have required weeks, and in some cases even months, of the artists' retouching work improving the light and shade.

The next operation is the preparation of the copperplate, which is to form the intaglio block from which the prints are

* For instructions see Transparency.

made. The dimensions of the plate should be one or two inches wider each way than the size of the picture to be printed. It should be well polished, and have the edges bevelled slightly. The copperplate is now thoroughly polished, and freed from scratches by dusting over a little very fine emery powder, moistening it with a little mixture of vegetable naphtha and turpentine, and well rubbing with a piece of soft flannel or lint. When it has become bright, the emery powder is removed, and a little whitening, moistened with the turpentine and naphtha mixture, applied. With a clean piece of flannel or lint the plate is given the final polish. All traces of emery or whitening are then carefully removed.

The next process is the laying the etching ground upon the plate. For this purpose we require an apparatus similar to that shown in fig. 173.

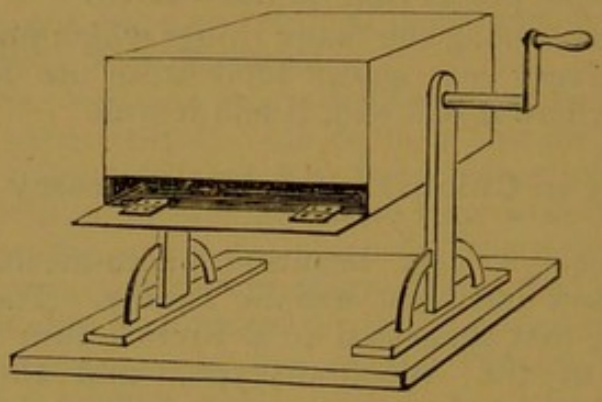

Fig. 173.

It consists of a box of suitable dimensions, fitted on two pivots and with a handle, enabling it to be revolved. A small opening at the bottom fitted with a door is made in front. In the bottom of the box a number of nails are driven to rest the plates upon.

The method of using this apparatus is as follows: About a pint of equal parts of very finely powdered resin and asphaltum are put into the box, the door closed, and the apparatus revolved very rapidly. The effect of this can be imagined, the resin and asphaltum dust fill the air in the box. A few seconds are allowed for the coarser particle to subside, and the door is then opened and the plate inserted and allowed to remain there for about 15 or 20 minutes. It is then removed and will be found to be covered with very fine asphaltum-resin dust. It must be very carefully handled, as the slightest draught or a heavy breath would displace the dust and spoil the effect. Directly it is removed from the box it is laid upon a heating apparatus with a temperature of about 150° F., where it remains just until the dust is melted sufficiently to adhere

to the copper. A very great deal of the subsequent effect depends upon careful manipulation at this point. If insufficiently heated the dust will not melt and adhere to the plate, and if over heated the resin and asphaltum will form a homogeneous film instead of what is required, *i.e.*, a collection of fine dust particles through the interstices of which the etching fluid can penetrate.

The copperplates prepared in this manner can be preserved for any length of time. It is well, therefore, to prepare a number at a time and store carefully away for future use.

This method of laying the ground is probably the one most generally employed. There are several other methods, however. One is by means of an air brush, a solution of the asphalt and resin being blown on to the plate in the form of a spray.

The following two methods are also given in Wilkinson's work on Photogravure.

The ground is laid by first coating the polished plate with a five per cent. solution of camphor in methylated chloroform and a five per cent. solution of white resin in benzole mixed together. When dry the plate is laid on the heating apparatus until the camphor ceases to smell and the resin begins. It is then cooled and the ground is ready.

The other method is to oil the copperplate with olive oil ; then to dust over with flower of sulphur and allow to remain a few hours, when a slight tint will be etched all over the plate more or less deep in proportion to the time given. These plates must be cleaned with ammonia before the next stage.

Bay salt	2 parts
Ammonium chloride	1 part
Verdigris	1 ,,

ground into a fine powder, mixed with syrup of honey, also gives a good grain,* and may be used after etching to vary the tint.

We have now the retouched transparency and the prepared copperplate. The transparency is placed in a printing frame, a mask with an opening the size of the picture required laid over it, and a piece of ordinary carbon tissue placed over this, so that the image comes exactly in the centre. The frame is then closed up and exposed to the light.

The exposure is regulated by an actinometer (see **Carbon Printing**), as the image is not visible till development.

When sufficiently printed, it is removed from the printing frame and laid in a dish of clean cold water. On immersion in the water the tissue will curl up, and afterwards return to a flat state. It is then removed and squeegeed down on to the prepared copperplate ; a few pieces of paper and a heavy weight are then laid over it to press it well down for a few minutes. It is then immersed in warm water about 90° to 100°F. until the paper back becomes loosened and can be readily removed. The temperature of the

* "Photogravure," by W. T. Wilkinson.

water is then slightly increased, and the plate laid within until the soluble gelatine is all washed away. The temperature must be raised to about 105°, or if the print is over exposed it will require to be about 110° or 115°. When only the insoluble image on pigmented gelatine remains, the plate is rinsed under a tap and placed in a rack to dry; when quite dry the margin of the copper-plate is carefully covered with a black varnish, and the plate laid in the etching solution, which consists of—

Saturated solution of perchloride of iron in methylated spirit	5 ounces
Water	10 ,,

The effect must be very carefully watched. Directly the whole of the protected copperplate beneath the carbon image is discoloured by the action of the etching fluid the plate is removed, well washed, and the carbon image wholly removed with a brush dipped in a strong solution of sodium carbonate. The etching process occupies a few minutes only, and therefore requires close attention. The discolouring action of the perchloride of iron is carefully followed, first in the shadows, next in the half-tones, and lastly in the high lights. It should be noted that in the carbon image or "resist," as it is termed, the high lights are opaque, and the shadows transparent. When the action of the etching fluid has reached the lights it must be immediately stopped in the manner described.

The action of the fluid is not to deeply etch the plate, but merely to roughen it sufficient to hold the ink when printing. Its strength depends upon the quality of the image. A strongly-concentrated solution works slower than a diluted one, so that it is preferable to commence with a moderately strong bath and dilute until the plate is properly etched.

The image and the varnish removed, the next operation is to polish the margin with fine emery cloth, the edges of the picture being protected with a straight-edge. The plate is then ready for the printing press.

An ordinary copperplate press will be required, fitted with two blankets, a thick one next the rollers, and a thin one underneath.

In printing from photogravure plates the ink must be strong in colour and in oil. It is applied to the plate with a dabber made of soft cloth or flannel, rolled up about four or five inches long and one inch in diameter. The paper used for printing on should be a good quality of plate-paper. Every sheet must be wetted over with a wet sponge and stacked for a few hours under pressure.

The plate is first cleaned with a mixture of turpentine and naphtha and wiped quite dry. It is then laid on the heating apparatus and warmed until the hand can no longer stand the heat. A little is then put on the dabber, and worked well on the inky slab. The plate is then dabbed all over, and the ink worked well into the engraving with a piece of coarse French muslin warmed,

the ink is carefully removed from the margins and whites, and a piece of fine muslin is then warmed, and made into a cushion sufficiently large enough to lay on the palm of the right hand; with this the plate is lightly wiped until ink is apparently left in the depths of the picture only. If the ink is cold it adheres firmly to the plate, hence the necessity of warming the muslin. After properly wiping, the margin of the plate is cleaned with a piece of rag dipped in turpentine. The plate is then laid in the press, and the print made.

To pull off good prints from a photogravure plate requires a considerable amount of practice. The plate can, if necessary, be further improved by working the high lights with a burnishing tool and strengthening the shadows with a roulette.

If a number of prints are to be made from one plate it will be necessary to face it with steel. The method given by Wilkinson is the following: The plate is thoroughly cleaned with whitening, moistened with turpentine and naphtha, and polished with a soft cloth. A small portion of the plate is scraped clean, and a piece of copper wire soldered to it. The steeling solution is placed in a wooden cell, the positive and negative poles from a Léclanche battery ending in copper rods the whole length of the cell. The solution is composed of—

Warm water	20 ounces.
Ammonium chloride	3 ,,
Iron sulphate and ammonia	4 ,,

When dissolved, filter, and let it stand in the cell 24 hours before use. The copperplate is hung upon the rod connected with the negative pole* of the battery, the positive pole being attached to a plate of pure steel about the same size or a little larger than the copperplate. When the two plates are in position the current is turned on. Three to five minutes suffice to complete the operation of covering the copperplate with a fine thin film of steel. The plate is removed, thoroughly washed and cleaned with whitening and turpentine and naphtha solution. The copper wire is unsoldered and the back scraped flat.

Prints should be dried separately, then slightly damped and laid between sheets of tissue paper, and placed under pressure till dry again.

If a title or name is required to be printed on to the plate, the whole must be coated with a thin film of bitumen varnish. The letters are then made with an etching needle, which must go right through the varnish, and the title written backwards of course. It is then immersed in the etching solution for a few minutes, the varnish removed, and the plate is ready for the printing press.

There is another process of photogravure, the details of which are kept a profound secret. In this the translation of photographic half-tones into the corresponding grain required for printing is said

*In a Léclanche cell the zinc is the positive and the carbon the negative.

to be effected by the aid of a substance which crystallises when exposed to the light, the size of the crystals depending upon the amount of light received. Such a substance exposed under a negative will give a surface the grain of which will exactly correspond with the lights and shades of the picture, and from which an electrotype can be made for printing purposes.

Photo-heliograph. — An instrument used in astronomical photography (*q.v.*)

Photo-lithography.—It will perhaps be as well, before describing the process of photo-lithography, to give some outline of the theory of ordinary lithography. This was invented by Senefelder, who was the first to discover the remarkable properties of the Solenhofen limestone. It is said that, for want of paper and ink to write to his mother, he casually used the surface of this stone instead of paper, using a mixture of soap wax and soot for ink, having the intention of copying on to paper at a convenient opportunity. When about to efface the writing the thought struck him, why not etch the stone with an acid. He tried this, and was delighted with the result he obtained. From this he built up the whole process of lithography.

The action of the acid is to etch away a very thin layer of the unprotected stone, while the writing remains intact, but naturally left a little in relief. In addition to this effect of the acid it forms upon the surface of the stone, where attacked, nitrate of calcium, which possesses the property of resisting and refusing the fatty ink upon the surface of the roller.

Lithographic stones are prepared by cutting into slabs and grinding and polishing the surfaces. The chalk with which the drawing is made on the stone is composed of soap, wax, tallow, and shellac, with finest lampblack added for colour. These ingredients undergo a change, and form with the stone a very stable chemical compound. The fatty acids (oleic and margaric acid) are set free from the soap and tallow by the nitric acid, and combine in the nascent state with the lime to form oleomargarate of lime. This compound adheres firmly to the stone, and by applying turpentine the image may be apparently completely removed from the stone. It is not, however, for if the ink roller be again applied the very finest details will be found to have remained intact, and make their appearance by the ink adhering to the oleomargarate of lime, and refusing to adhere to the stone, which, by the etching process, has become wet with nitrate of calcium.

This is then the theory of lithography simple. In photo-lithography we substitute a photographic image for the artist's drawing.

Bitumen Process.—The very earliest process was discovered by Niepce even before the discovery of photography itself, This process was based upon the peculiar property possessed

by asphalt or bitumen of becoming insoluble in either benzine or turpentine if exposed for some time to the action of light, these agents readily dissolving it if unexposed. The lithographic stone, poured over with a solution of asphalt dissolved in turpentine in the dark-room, is dried and exposed under a reversed negative to the action of sunlight for several days. By means of turpentine or benzine the unexposed parts can then be dissolved away, leaving an asphalt image of the exposed parts, which can be inked in and etched in the ordinary manner. Owing to the perfection attained by the transfer method now generally employed, this process is not much used. The method of obtaining the image in asphalt is, however, generally adopted for heliographic engraving or etching on copper or steel plates.

Direct Photo-lithography.—The bitumen process may be said to be a direct process. Another is the following:—

The polished stone is spread over with a solution of gum arabic and potassium dichromate. It is then dried in the dark and exposed under the negative. After this the stone is well washed and rolled in with ink. There are one or two other methods of directly printing the image upon the stone; none, however, have come into practical use, or superseded the photo transferred from paper.

Transfer Method of Photo-lithography.—In this a sheet of paper is coated with gum, albumen or gelatine containing potassium dichromate or ammonia. It is then exposed to light under a negative, and after exposure is uniformly coated with printers' ink. This inked paper is then immersed in warm water, and the surface gently rubbed with a soft brush, which removes the ink from the parts not acted upon by the light. Where the light has rendered the colloid substance insoluble, it retains its hold of the ink. The image in printers' ink is now called a photo-lithographic transfer.

Success in photo-lithography depends to a considerable degree upon the quality of the negative and of the paper used for making the transfer.

The old wet collodion process is the most suitable for the production of the negative, as great density and contrast are essential. To produce a perfect negative for this purpose requires a great deal of practice. Not only must every line in the copy be faithfully reproduced in the negative as clear glass and the white ground have considerable opacity, but the utmost sharpness possible of every dot and line is also necessary. If gelatine plates be used they should be very thickly coated. Professor Burton recommends the following emulsion for dry plates, especially for photo-mechanical line negatives:—

I.

Ammonium bromide	1,000 grains.
Potassium iodide	80 ,,
Gelatine	320 ounces.
Water	40 ,,

II.

Silver nitrate (in crystals)	1,600 grains.

III.

Hard gelatine	1,200 ,,

No. 1 is raised to a temperature of about 120°F., and No. 2 added (dry) stirring continuously. No. 3 is then added, also in a dry state. When the whole is melted the emulsion is precipitated with alcohol and washed, or it may be allowed to set and then washed.

The paper used in making the transfer should be smooth, well sized, and with plenty of body. In this country that known as bank post paper is generally employed. Professor Husnik's process for preparing it is as follows* :—One part of finest gelatine is swelled and then dissolved in 24 parts of water, a solution of chrome alum, 1 in 100 of water, is then added, and the solution while still warm is poured into a large zinc dish heated to 34°R. by means of a petroleum or spirit lamp. The scum is first removed from the surface of the solution, and the paper floated, one sheet at a time, and hung up to dry. The sheet is floated on the gelatine solution a second time, and again suspended, this time by the diagonally opposite corner to the one by which it was previously hung. A solution of white of egg one part, water two parts, is next prepared, and the paper floated on it. After again subjecting to the drying process it is ready for sensitising. This is done with a bath of—

Water	14 parts
Potassium dichromate	1 ,,
Methylated spirit	4 ,,

with sufficient ammonia to turn the reddish solution to a bright yellow one. After floating it is dried by hanging up in the dark.

Another method of preparing a gelatine transfer paper employed in the Military Institute in Vienna is thus described.† A sheet of well-sized paper is laid in a dish of water to soak, and when quite limp it is drained and placed on a glass plate made perfectly level. All air bubbles and superfluous moisture are removed by means of blotting paper and a squeegee. The edges of the paper are then turned up about 2 c.m. all round, and a warm solution of gelatine (1 in 30) poured on. In a few minutes the gelatine will have become quite set, and the sheets are laid on wire netting to dry, the operation requiring usually about two days. A day previous to using, the gelatine paper is sensitised by immersing in a cold bath of potassium dichromate and water (1 in 15). On removing from this bath it is allowed to drain, and the gelatine side placed on a glass plate. The back is then dried with blotting paper and

* See "Collotype and Photo-lithography," by D. J. Schnauss, translated by E. C. Middleton

† "Photographisches Correspondenz."

all air bubbles removed. These operations and the drying afterwards must be done in a non-actinic light. To prevent the sheets when dry from adhering either partly or wholly to the plate, it is advisable to wax the glass or apply to its surface a weak solution of oxgall.*

In the Calcutta Government Photograph Office a new method of preparing the photo lithographic transfer process has been introduced, arrowroot being used instead of gelatine. Bank post paper is coated in the usual way with two coatings of the following mixtures :—

Arrowroot	140 parts.
Potassium dichromate	70 ,,
Water	3,500 ,,

After exposure to light the prints are coated with transfer ink in the press as usual, the transfer ink used being composed of—

Hard re-transfer ink (plate to stone)	100 parts.
Lithographic chalk ink	100 ,,
Palm oil	7 ,,

After inking, the prints are washed off with hot water, hotter than is required for gelatine transfers.

When transfer paper is not prepared in large quantities, ordinary commercial gelatine paper, or the double transfer paper used in the carbon process, may be used if prepared by floating on a bath of albumen (beaten to a froth and allowed to stand) 50 parts, water 50 parts, and potassium dichronate or ammonia 7 parts. On this the paper is floated for a few (about five) minutes. The solution will not keep.

All sensitised transfer papers should be used as soon after sensitising as possible. As soon as dry it is exposed under the negative for a few minutes in sunlight when possible. The image appears of a brownish-grey colour on a yellow ground, and may be examined by a non-actinic light. When all the detail is visible it is removed from the frame.

The room in which the operations of sensitising, drying, inking up, etc., are carried on, must be lighted by windows covered with golden fabric or by gas or lamplight.

After exposure, the transfer is then inked up. A little photo-transfer ink is mixed with turpentine, and the glue roller charged with it until the whole sheet is uniformly covered with ink. It is then placed in a dish of cold water, and allowed to soak for some minutes (about a quarter of an hour will usually suffice). It is then laid on a smooth slab, and carefully rubbed with a pad of wet lint until the whole of the loose ink is washed away. The photo-litho transfer may also be put down in the same manner on a zinc plate, and then treated in the same manner as the stone. The

* A more reliable method of imparting to the surface of the paper a high gloss is to squeegee it down upon a ferrotype plate, the surface of which requires no preparation, and the risk of sticking is *nil*.—E. C. Middleton.

effect of this is that the printer's ink becomes removed from all those parts unexposed to the action of the light, and an image in fatty ink is obtained on the gelatinised paper. From this the superfluous moisture is removed with blotting paper, and the print, ink face downwards, is laid on a clean and slightly warmed lithographic stone. Both are then passed through the press, and the transfer adheres firmly to the stone, but by moistening the paper with a sponge it becomes easily removable. When stripped from it, the fatty ink will adhere to the surface of the stone, leaving a perfect reversed image on it. The stone is then gummed and etched in the ordinary manner employed in the process of lithography.

Photo-litho-transfers.—See **Photo-lithography.**

Photo-mechanical Processes.—The term photo-mechanical is applied to all processes in which the action of light upon chemical substances becomes the means of preparing printing surfaces from which many impressions can be made without any further assistance of light.

The first photo-mechanical process known was that invented by Nicephone Niepce about 1827, when he discovered the peculiar sensitiveness of asphaltum to light. He coated metallic plates with a solution of this substance, and exposed them in the camera to the image. Those parts acted upon by the light became insoluble, while the remaining portions were dissolved away with oil of lavender. By this means a reversed picture of bitumen was obtained on the metal plate. By next applying an etching acid the parts of the metal unprotected by the bitumen image were eaten into, and after clearing away the image a printing plate was obtained.

Many photo-mechanical processes are based upon this property of asphaltum, but many more upon the sensibility of dichromatised gelatine, albumen, and gum arabic, and their peculiar properties. These substances are used to produce the design, either flat for etching or direct printing, or in relief for moulding electrotypes, stereotypes, etc.

For some time the chief difficulty that was encountered was in the correct rendering of the half tones. This was eventually overcome by breaking up the image into lines, dots, or stipples.

Photo-mechanical printing processes may be divided under two different heads, *i.e.*, those in which the image is moulded in pigmented gelatine, and those in which the picture is printed with the ordinary fatty printing inks. To the first class belong the Woodburytype and Stannotype processes.

The *Woodburytype* was the invention of W. B. Woodbury. In this a sheet of bichromatised gelatine is first exposed under the negative, and afterwards washed in warm water, which removes the soluble parts, leaving the image in relief. When the

gelatine relief is dry it is exceedingly hard, and is pressed by means of hydraulic pressure into a sheet of lead. By this means an intaglio mould is formed. This is placed in a specially constructed press, having a heavy and perfectly true lid. A little warm gelatine solution, containing any desired pigment, is poured on to the intaglio mould, a piece of prepared paper laid on top of it, and the heavy lid brought down. This squeezes the excess of coloured gelatine, allowing only that to remain which lies in the mould. This sets, and at the same time adheres to the paper support, which, when removed, has attached to it the gelatinous image. This is dried and hardened with chrome alum. If glass be used instead of the paper very beautiful transparencies can be made. See **Woodburytype.**

The *Stannotype* process is a modification of the Woodburytype by the same inventor. In this tinfoil, properly backed by electrotyping or by other means, is substituted for the lead plate, thus doing away with the necessity of employing expensive machinery.

A very large number of processes come under the second classification, *i e.*, those which are printed in ordinary printer's ink. These, however, may be again divided into the following :—(1) Processes in which the image is printed from a gelatine surface. (2) Processes in which the picture is printed from stone. (3) Processes in which the image is printed from a metallic surface in relief. And (4) processes in which the image is printed from an intaglio metal plate.

Among the processes in which the picture is printed from a gelatine surface the chief are Collotype or Albertype, Artotype, Chromo-collotype, Indotint, Leimtype, and Heliotype.

In the *Collotype* process, a sheet of thick plate-glass is first coated with a film of albumen and gelatine, to which a dichromate has been added. This is then laid on a piece of black cloth exposed to light, washed and dried, and the plate is then coated with dichromatised gelatine, exposed under a reversed negative, soaked in water to remove all soluble chromium salt, hardened with alum, and finally dried. By this means a scarcely visible image in gelatine is the result, those parts which have been exposed to the light being insoluble and repellant for water, the remaining parts retaining their absorbing properties. The plate is fastened to the bed of an ordinary lithographic press, the printing being very similar. A wet sponge is used to moisten the absorbing parts of the gelatine (the whites in the picture), and an ink roller inks the image part. A sheet of paper is laid over it, and, after pressure is applied, the ink is transferred to the paper. Prints may also be made upon cotton and silk fabrics.

The *Artotype* process is very similar to the Collotype, a slight improvement being made by Obernetter. A mixture of soluble glass and albumen was used for the foundation film, thus avoiding the necessity of first exposing to the light. In all other respects the process is similar to the Collotype.

Chromo-collotypes are produced with a number of Collotype plates, using differently coloured inks. The negative to be reproduced is first blocked with opaque varnish in all parts except those required to be reproduced in a certain colour. From this a collotype plate is made to be used with that coloured ink. The varnish is then removed and the negative blocked for another colour, and so on. In printing, the paper is passed through with the different plates until all the colours have been printed on it, forming a complete many-coloured image. Instead of blocking out the negatives they are sometimes made by photographing the object through different coloured screens, which have the effect of shutting off or absorbing some colours and allowing others to pass through undisturbed to the sensitive photographic film.

The *Indotint* process was invented by Roche, of New York. A copper plate is used, roughened by exposure to the sand-blast, causing the sensitive film to firmly adhere. The film is also roughened by the addition of alcohol to the dichromatised gelatine. After exposure the unaltered dichromate is removed by washing, and the plate dried.

Leimtype. This process was invented by Husnik, of Prague. He takes a thick plate of chromatised gelatine and exposes it under a negative. This is then attached to gutta-percha, zinc, or wood as a foundation. The image is next developed with a solvent such as a saturated solution of alkaline dichromate. This has the double effect of dissolving the unexposed parts, and deepening and strengthening the relief. The high lights are protected, and the relief again exposed to the light, after which it is again developed to deepen the whites and further strengthen the image. Plates thus produced can be used in the ordinary printing machine with the letterpress. Electrotypes can also be made from these plates when a very large number of copies are required.

The *Heliotype* process is closely allied to the Collotype. The most important difference is that the gelatine film containing the image is hardened with chromic alum, and detached from its support. It thus forms a thin sheet or "skin," as it is termed, which can be laid on to a zinc plate, or attached to the cylinder of a printing machine. Further, it can be easily preserved for printing from on future occasions when desired.

In our next class, *i.e.*, those processes in which the image is printed from stone, we have to mention the following: Photo-lithography, Ink-photo process, and the Photo-caustic process.

In *Photo-lithography* an image is either made upon the stone direct, or first upon specially prepared paper, and afterwards transferred to the stone. The transfer process is the one most general. A full description of the process will be found under **Photo-lithography.**

The *Ink-photo* process is a method of photo-lithography in half-tone. The process was invented by Sprague, of London, the details being kept a secret.

Photo-caustic is the name given to photo-lithographic images in half-tones by means of a Meisenbach veiled negative.

With regard to those processes of typographic or block printing, where the image is printed from a metallic surface in relief, they may be conveniently divided into two divisions, *i.e.*, the swelled gelatine processes and photo-etchings. Under the first we have the photo-electrotype, photo-engraving, and Mosstype processes. There are a very large number of photo-electrotype processes, differing in minor details. The process may be briefly described as follows:—A sheet of chromatised gelatine is exposed under a negative. Parts are thus rendered insoluble and incapable of absorbing water, the remaining portions, protected by the image of the negative, being soluble and capable of absorbing cold water. After exposure the gelatine is immersed in cold water, when the absorbing parts swell up, or else the soluble parts are removed with warm water, acetic acid, or other solvent. The next process is the making of moulds in wax, or plates from the gelatine image; and from these copper blocks can easily be made for typographic printing by the electrotype process. If half tones are to be represented the negative must be broken up into lines, dots, or stipple.

The term *Photo-engraving* is applied to processes of making metal relief blocks. The manipulation is somewhat similar to that just described. A full description will be found under **Photo-engraving.**

The *Mosstype* process is a photo-engraving process, differing slightly in detail from that described. This is first made in a composition of asphaltum, sulphuretted resin, and caoutchouc, and from these a second mould or plaster is made, from which a casting is made in type metal to form the printing block.

Among the photo-etching processes are photo-zincography, zincotype, typogravure, and chromo-typogravure.

The term *Photo-zincography* is one that is applied to many differently detailed processes in which designs in adhesive transfer ink are transferred to zinc plates in the same manner as transferred to stone in photo-lithography. An etching agent is then applied which eats into the zinc at the unprotected parts, producing the design on the zinc in low relief. See **Photo-zincography.**

In *Zincotypes* the zinc is first coated with bitumen or bichromated gelatine or albumen, and exposed under the negative. The image is then developed. If the bitumen process is employed, oil of turpentine is used as the solvent, but in the other method the albumen is first coated with printers' ink, and then developed by gently rubbing in cold water with a tuft of cotton wool. The unprotected parts of the zinc are then washed away.

For producing these blocks in half-tones a variety of methods are employed of breaking up the negative image.

The *Typogravure* process is a method of obtaining half-tone pictures from copper relief plates, worked by Messrs. Boussod, Valadon and Co., at Asnieres, near Paris. The details of the

process have never been published. Chromo-typogravures are produced by the same means, a number of different plates being used with different coloured inks to form the many-coloured image.

In the last class, *i.e.*, those processes in which the picture is printed from an intaglio copperplate, we have photogravure, Goupil-gravure, and photo-aquatint. The idea of producing copper intaglio plates by means of photography was first worked out by Nièpce; many others followed. About 1870 or '71 Woodbury suggested to Goupil and Co. a method of photogravure which was taken up and worked by that firm with great success. A gelatine relief was made in the same manner as for the Woodbury-type process, except that a fine gritty powder was added to the gelatine to give the necessary grain. From this relief a mould and an electrotype are made. Other processes are described under **Photogravure.**

The *Goupil-gravure* process is a method of making *facsimiles* of water colour drawings. The plate is carefully inked in by hand with the different coloured printing inks, and the picture printed by one impression. The plate is cleaned and again inked for the next picture. This method of printing is, of course, very costly, as skilled artists have to be employed for colouring the plates. The results, however, are truly fine, and in some cases hardly distinguishable from the original water-colour drawing.

By the *Photo-aquatint* process images are made from intaglio copperplates in a similar manner to photogravure. It is chiefly used for the reproduction of portraits taken direct from life.

This sketch of the different photo-mechanical printing processes is necessarily very incomplete. Correct information regarding these is very difficult to obtain; all firms working the processes naturally keep the details as close a secret as possible. More detailed descriptions of the most important are given in their respective places.

Photometer (*Photos*—light, and *metron*—measure).—A contrivance for calculating the intensity of light. See **Actinometer.**

Photometry.—The process of measuring the relative amount or intensity of light emitted by different sources.

Photo-mezzotype.—A photo-mechanical printing process similar to Collotype.

Photo-micrography.—The science of photographing microscopic objects. Considerable strides have been made in this within the last few years, and the aid given to the microscopist is incalculable. Hitherto skilled artists were required to draw what was visible to the eye. This was in most cases a difficult matter, as the structure of nature's works is so intricate and delicate that magnified objects could rarely be reproduced by hand with fidelity.

By means of photography, however, we get faithful images of the objects in a few seconds.

In practice we require three essential things. These are: A camera, a microscope, and a lamp. Many arrangements have been devised for photographing microscopic objects. The simplest is a small camera made to fit on to the upper end of an ordinary microscope in place of the eye-piece. Fig. 174 illustrates a more perfect form of photo-micrographic camera known as the "Optimus;" *c* is the camera, *m* the microscope body, *k* a fine

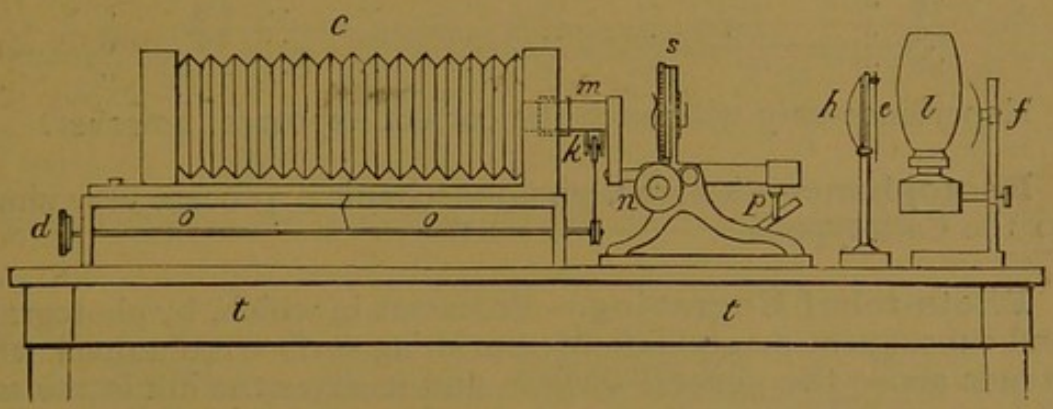

FIG. 174.

adjustment geared to grooved wheel on the focussing rod *o o*. This rod has a milled head *d*, *n* coarse adjustment of microscope, *s* stage, *p* mirror, *h* condenser furnished with diaphragm *e*, *b* lamp, *f* reflector, *t t* table.

The microscope used should be a firmly-built solid monocular with a fine adjustment. The light used must be accurately centred, otherwise one side of the object will be dark and fuzzy. The tube of the microscope should be coated with a dead-black varnish or lined with dull black paper.

The light can be an ordinary microscope lamp burning best paraffin oil containing a little camphor dissolved in it to increase the brilliancy of the illumination.

Another indispensible adjunct is a substage condenser fitted with a revolving series of stops.

Before attempting to focus, the lamp should be allowed to burn for ten minutes, so that the whole instrument may become thoroughly warmed throughout, otherwise the expansion will alter the focus very considerably. Great care must be taken in focussing the object as sharply as possible. Charters White recommends the removal of the ordinary glass focussing screen, replacing it by a plain glass, having some fine lines drawn across it with a writing diamond, these lines being placed next the objective. The focussing glass is then set until these lines are sharply defined. These lines will closely approximate to the plane of the emulsion

on the sensitive plate, therefore if the details of the object are in focus with the lines on the focussing screen, the probability will be in favour of a sharp image on the negative.

With regard to the exposure. This varies in proportion to the magnifying power of the objective used, and the colour of the object itself. The times in the following table (by Walmsley) may be considered as approximate, but variable with the colour and general character of the object to be photographed.

1½	inch	objective	..	..	..	..	..	3·45 seconds.
⅔	,,	,,	..	..	..	..	..	7·90 ,,
1/10	,,	,,	..	..	..	..	..	½·3 ,,
1/5	,,	,,	..	..	..	..	..	2·7 ,,
1/10	,,	,,	..	..	..	..	..	4·10 ,,

Experience only will teach the correct exposure, however.

Photophane.—A secret photo-mechanical process very similar to the Collotype.

Photo-relief Engraving.—Processes in which, by photography and subsequent manipulations, a printing surface is obtained, which stands above the general surface, and receives the ink in the same manner as type or woodcuts come under this heading. The Woodbury process is often termed a photo-relief one, although here the image itself is in relief, the printing block being an intaglio plate.

Photo Reliefs.—Images in relief produced by photography, and largely employed in photo-mechanical printing processes. The simplest method of making a relief is based on the peculiar property of dichromatised gelatine to become insoluble when acted upon by light. If we take a glass or a sheet of paper coated with a thick film of dichromatised gelatine and expose it beneath a negative, those parts situated beneath the transparent parts of the negative image lose their solubility, while the parts not affected retain it. The remaining parts or half-tones of the negative allow it to be affected in different degrees, according to the amount of their transparency. If the exposed gelatine film be laid in cold water, only the soluble or unaffected parts will swell up, the insoluble portions remaining the same. By this means we get a true relief. From this a casting may be made, and electrotype printing blocks produced.

If the exposed film be laid in hot water, however, we have already explained that the unaffected parts will dissolve away. In fig. 175 we are able to see in a clear manner the action that takes place. A represents a negative, portions being opaque, others transparent, and parts varying in opacity; these are the half-tones; B is the dichromatised gelatine film after exposure under the negative, the dark parts representing the action of the light in rendering the gelatine insoluble. If this be placed in cold water the unexposed portions will swell up above the others, as shown in

C. If, however, it be laid in warm water the soluble parts will then dissolve, and the relief will then have the appearance of D. It will be noted that here the half-tones are lost ; they have no

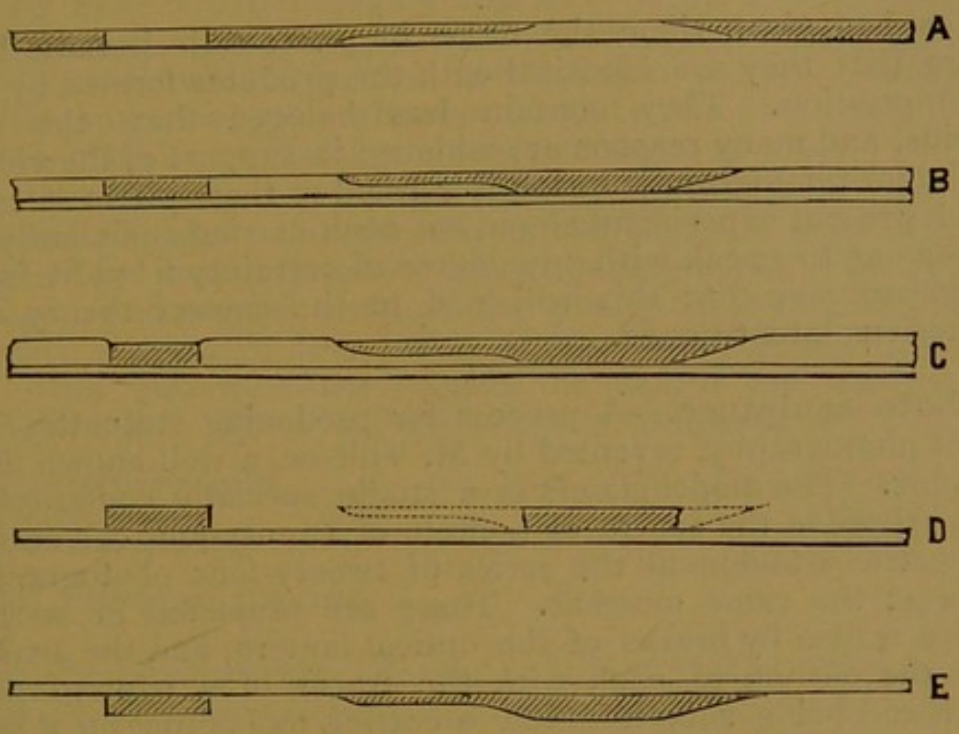

FIG. 175.

support, and consequently are easily detached and torn away, as shown by the dotted lines. To prevent this, however, a new support is given to the gelatine, or the film may be coated on a collodion or other transparent film, and exposed on the reverse side under the negative. We then get a result as shown in D.

If we compare C with E we shall see that by the two processes, *i.e.*, the application of cold and hot water, we get two opposite kinds of reliefs; in the first the unexposed parts stand out in relief, but in the latter case it is those which have been exposed to the light.

If a gelatine relief be pressed into lead, any number of images on pigmented gelatine can be made from the mould thus produced. This is the basis of the Woodburytype process. For other photo-mechanical half-tone processes the image must be broken up into a fine grain. This is sometimes done by putting the gelatine relief into fine sand. For detailed instructions in relief making see **Woodburytype.**

Photo-salts.—A term applied by Carey Lea to the coloured haloids obtained by him in his researches in the photo-chemistry of the silver haloids. These photo-salts, described by him under the names of photo-chloride, photo-bromide and photo-iodide, are produced by reactions such as would tend to give rise to the formation of sub-salts (supposing these to exist) in admixture with the normal haloids. *

Lea has given them the name of photo-salts because he considers that they are identical with the products formed by photo-decomposition. They contain less halogen than the normal haloids, and many reasons are adduced in support of the view that the latent photographic image is formed of these photo-salts. Up to the present experiments have not been carried sufficiently far to enable one to speak with any degree of certainty; but it is not at all improbable that this will lead to the correct theory of the mysterious latent image.

Photo-sculpture.—A process for producing statuettes by the aid of photography, invented by M. Villème, a well-known French sculptor. The model stands in a studio specially constructed for the purpose in the centre of a circle of twenty-four cameras. By an electric attachment the series of twenty-four photographs are made at the same moment. These are projected in succession upon a screen by means of the optical lantern, and the artist goes over the outline of each with the traces of a pantograph, the pencil end being substituted by a cutting tool acting on a lump of modelling clay mounted upon a regulating turn-table. After each photograph is traced the clay is turned through 15°. When it has completely revolved, and all twenty-four photographs gone over, the clay is removed and finished by hand.

Photo-spectroscopy.—See **Spectrum.**

Phototint.—A photo-mechanical printing process similar to Collotype.

Phototype.—This name was formerly given to a secret process of carbon printing invented by M. Joubert. It is now applied to a method of Collotype or Albertype printing and to blocks produced by any photo-typographic process.

Photo-typography.—A general term employed in photography to a large number of processes in which printing surfaces are made by the aid of light.

Photo-zinco Engraving.—See **Photo-zincography.**

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* See Meldola's "Chemistry of Photography."

Photo-zincography.—A process very similar in detail to Photo-lithography (*q.v.*) Instead of the stone, however, the image is transferred to a zinc plate. The method of making the transfer has already been described under the heading just referred to.

Zinc plates for this purpose can be purchased ready for use. They should be about 10 B.W. gauge. The first operation is to grain them with a zinc muller and fine sand. Brassfounders' moulding sand sifted through a fine sieve is the best for use. A little of it is laid on the plate, placed on a flat surface, and water poured on. The zinc muller is then worked slowly round and round until the entire surface appears after washing of a dull grey colour. All scratches must be carefully ground out and grit avoided.

This operation should be performed immediately before the plate is required for use. The transfer of the image is similar to the operation described in the photo-lithographic process. The transfer is damped and passed through the press, the zinc plate being previously screwed on to a block of hard wood planed perfectly true. After removal of the transfer the plate is well washed and fanned until dry. The etching solution is composed of—

Decoction of galls.	1 quart
Gum water	3 quarts
Phosphoric acid	3 ounces

See also **Photo-engraving.**

Phthalic Anhydride (Formula, $C_6H_4(CO_2H_2)$. Prepared by oxidising napthalene tetrachloride with nitric acid. It is sometimes used in the manufacture of eosine and of phenol phthalein.

Picric Acid (Formula, $C_6H_2(NO_2)_3OH$); synonym, *carbazotic acid*).—Prepared by the action of nitric acid on phenol. It takes the form of yellow plates or prisms, sparingly soluble in cold water, but more easily on heating, giving it a bright yellow colour; alcohol dissolves it readily. It has been used as a ray sensitiser in the orthochromatic process. It is sometimes used as a test for potassium, as its potassium salt is very slightly soluble in cold water.

Pigeon Post.—See **Military Photography.**

Pigment.—A colouring material.

Pigment Printing.—This is a term sometimes applied to the carbon or autotype process, because the image consists entirely of a pigment held in gelatine. The tissue can be obtained with various pigments, the chief are standard brown, engraving black, sepia, and red chalk. The first gives the ordinary photographic tone, the second is used for copies of drawings, engravings, etc., in black and white, and the sepia is suitable for reproducing sepia

drawings, or for portraits on canvas to form the basis of oil-painting, while the red chalk gives the tone of a red chalk drawing, or a print in Bartolozzi red. Other colours can, of course, be obtained incorporated with the gelatine, the resulting image being, of course, in that colour.

Pinhole Photography.—It is a well-known fact that, although the lens is the most important part of the photographic apparatus, pictures can be made entirely without its use. Very passable negatives can be made by means of a small hole in a rectangular light-tight box and a plate fixed at the other end, or the lens can be moved from the camera front and a piece of tin-foil in which a small hole has been made can be substituted. It is usually stated that no focussing is required—the larger the plate the wider the angle, and the greater the distance the larger the image—but according to Professor Pickering 12 inches is the maximum distance for sharp work. He found that the shorter the distance the better the definition, and, further, that the size of the hole is regulated by the distance. At 12 inches the best results are obtainable with a hole $\frac{3}{100}$in. in diameter. If it be made any smaller than this the image will suffer by diffraction, and if any larger it also becomes blurred and indistinct. A general rule may be laid down that with short foci the aperture should in no case exceed $\frac{1}{50}$in., nor be less than $\frac{1}{100}$in. The hole itself requires to be very carefully made to get the best effects. There must be no burr. This must be removed. A very simple method of avoiding its formation is to burn the hole in a piece of black paper with a red-hot needle. [*ap. p. 21*]

Pinholes.—Tiny transparent spots visible in the negative.

In the collodion process they are caused by the silver solution, which is added to the developer, dissolving out the iodide from the film. Unless the preservative be well filtered the same defect may also occur.

In the gelatine dry-plate process, pinholes may be due to tiny air-bubbles in the emulsion, or from dust in the dark slide settling on the plate previous to exposure. In the former case the pinhole will be represented by clear glass, and in the latter by transparent emulsion. To prevent air-bubbles in the emulsion, it should be allowed to settle for some time, and the top skimmed off before using.

Before laying the plates in the dark slide they should be dusted over with a broad camel-hairbrush. Abney further recommends rubbing the interior of the dark slide with a minute trace of glycerine, which acts as a trap for the dust and prevents it from settling on to the plate.

Pins.—Pins are used in photography for hanging up papers to dry, or for pinning the corners to a board. For pinning up silver

sensitised papers pins silver plated or coated with enamel should be used, otherwise the metal when in contact with the silver chloride will cause it to turn black at those parts.

Pint.—A measure of capacity for liquids = 34·65925 cubic inches. It is equivalent to 20 ounces liquid measure, and is the eighth part of a gallon.

Pipeclay.—Formerly used instead of kaolin for decolourising old nitrate baths.

Pipette.—A little instrument for measuring liquids in drops. A simple method of constructing one is to take a glass tube about ten inches long and about three-eighths of an inch in diameter. This is heated in the middle with a spirit lamp, constantly turning it round to prevent uneven expansion. When quite soft it is pulled apart suddenly, the separated parts being drawn out into very fine points. Break off one of these points and a tube with a fine aperture is obtained; the further the glass is broken away the larger the aperture. It now only remains to fit on to the other end a piece of indiarubber tubing and close the end up with a cork; the apparatus is then complete, and has the appearance of fig. 176

Fig. 176.

Pitch, Jew's.—The same as asphaltum (*q.v.*)

Pizzighelli's Process.—See **Platinotype.**

Plain Paper, Printing on.—Plain paper may be printed on and made to yield very artistic results. For this purpose we require a good class of paper, such as Saxe or Rives. This is sized with gelatine or albumen. A very good formula is the following:—

Albumen	1 ounce.
Water	16 ounces.

This is placed in a strong bottle with some pieces of broken glass, and well shaken up until all the flocculent matter is cut up. It is then strained through muslin, and ten grains of ammonium chloride added to each ounce of the solution. This solution is then filtered again and placed in a shallow dish somewhat larger than the paper to be prepared. A strip of blotting paper or board, a little longer than the width of the dish, is then drawn edge-

ways along the solution, just touching it so as to skim off air-bells, dust and foreign particles floating on the surface. A sheet of the paper is next immersed in the solution for about a minute, when it is withdrawn quickly and hung up to dry. When it is perfectly dry it is floated on the solution for about two minutes. With most papers there is a right and a wrong side, so that this must be detected before laying on the solution. Paper prepared in this manner can be kept any length of time.

The sensitising bath is made up of—

Water	10 ounces
Silver nitrate	500 grains
Sat. sol. sodium carbonate	10 to 15 drops

The sodium carbonate solution is added until a slight precipitate is formed. Give the bottle and its contents a good shaking, and after allowing it to settle it will be ready for use. If it is clear it can be decanted into the dish ready to receive it.

Those accustomed to silvering albumen paper will not find any difficulty in the next operation, that of sensitising. The paper is gently laid on the surface of the solution in such a manner as to prevent the formation of air-bubbles, and also to prevent the solution from coming on to the back of the paper. Gently raise each corner of the paper separately, and examine for air-bells; these can be removed with a glass rod on the clean tip of the little finger dipped in the solution, and the paper returned to its position. After about three minutes it is removed and hung up to dry. The silver bath must be kept at the correct strength, and will require to be renewed from time to time with nitrate of silver; it must also be kept neutral, which it will do so long as there remains an excess of silver carbonate.

Printing is done in the ordinary way under a negative in the printing frame. To get very deep effects the paper can be fumed for about fifteen minutes with ammonia. Print rather deeper than required for the finished print to allow for the reduction in density that takes place in the subsequent toning and fixing operations.

The toning process is accomplished with any toning bath. The most suitable, however, are those which give black engraving like tones.

The following bath gives very good sepia tones :—

Make up the following stock solution—

Gold trichloride	15 grains.
Water	8 ounces.

For use take about an ounce of this and add sufficient of a saturated solution of sodium bicarbonate to completely neutralise. Add to this 50 ounces of clear water and about a quarter of an ounce of common salt, shake up well, and the toning bath is ready. Tone the prints to a deep purple, and fix in a 1 in 8 solution of sodium hyposulphite for about fifteen minutes. Well wash and dry between

blotting boards. Prints of this description should be mounted on large mounts to give plenty of margin round the picture.

Very pretty effects may be obtained by printing under a mask, so as to give a broad white margin, which may, if desired, be afterwards tinted by laying a disc over the print and exposing the margin to the light until the required tint is obtained. With some subjects very good effects are made by allowing the margin to get quite black. With most papers small black spots are often visible after sensitising, due to fine pieces of metal imbedded in the paper pulp. These can usually be removed with a sharp-pointed penknife.

Plane, Perspective.—The surface upon which the objects are delineated on the picture drawn, also termed the plane of projection or the plane of the picture.

When the plane of the picture is parallel to the side of the principal object in the picture it is termed *parallel* perspective.

When the plane of the picture is supposed to be at an angle to the side of the principal object in the picture, as, for instance, a building, it is termed oblique perspective.

Plano-Concave Lens.—A lens having one side concave, and the other side plane. It causes parallel rays to diverge.

Plano-Convex Lens.—A lens having one side convex and the other side plane. It causes parallel rays to converge to a point termed the focus.

Plano-Conical.—Plane on one side, and conical on the other.

Plano-Orbicular.—Plane on one side and spherical on the other.

Plaster of Paris (Synonym, *gypsum*).—Sulphate of calcium, sold as a white powder, almost insoluble in water. If mixed with a small quantity to form a paste, it gradually thickens and afterwards solidifies to a hard mass of hydrated sulphate. Owing to this property it is largely used for making casts or moulds. It is also very useful for mending leaks or repairing broken articles. It should be kept in air-tight stoppered jars.

Plate.—In optics this term is applied to transparent media bounded by parallel surface. The term is generally used in photography to denote the support for the sensitive medium, as Daguerreotype-plate, collodion-plate, dry-plate, ferrotype-plate, etc.

Plate Box.—A box arranged for the reception of photographic plates. Two sides are grooved with an equal number of grooves; into these the two ends of the plate slide, and are thus prevented from injuring each other by contact.

Plate Carrier.—A loose blackened wood frame, fitting the interior of the dark slide to enable smaller size plates to be exposed than the camera was constructed for.

Plate-cleaning Solution.—A solution for cleaning glass plates previous to being coated with photographic substances, such as collodion or gelatine emulsions. The best known is the following :—

Spirits of wine	100 parts.
Tripoli powder sufficient to make a cream-like fluid.	
Ammonium hydrate..	2 parts.

Alkalis possess the property of converting greasy into saponaceous matter, and alcohol will dissolve both soap and grease. Both are therefore employed as detergents. Another very effective detergent is a solution of potassium dichromate and sulphuric acid.

Plate-coating Machine.—A machine for coating dry plates. See **Dry Plates.**

Plate Glass.—See under **Glass.**

Plate Holder.—A contrivance used to hold plates during manipulation. They were principally used in the wet-collodion process when cleaning and coating the plate. See also **Pneumatic Holder.**

Plate Lifter.—A contrivance for lifting the plate without using the fingers. This is sometimes of great use when the plate is required to be lifted out from chemical solutions which have an injurious effect upon the skin. It also preserves the gelatine film from mechanical injury.

Plate Paper.—A heavy bibulous paper used for taking impressions of engravings, photo-engravings, etc.

Plate Rack.—A rack arranged to receive glass or other plates, which fits into grooves in such a position that all superfluous solution drains off from one corner ; as they are kept slightly apart from each other, a current of air passing between will soon dry them.

Plate Rocker.—An arrangement for rocking the dish containing the plate in the developing solution and keeping the latter constantly flowing backwards and forwards on the negative. (See fig. 47.)

Plate Sheath.—See **Sheath.**

Plate-sunk Mount.—Mounts having a centre portion pressed or sunken in. They are very effective for platinotype, bromide or plain paper prints.

Platinic Chloride (Formula, $PtCl_4$; molecular weight, 340; synonyms, *perchloride of platinum*, *platinum bichloride*).—Obtained by dissolving metallic platinum in aqua regia. It takes the form of reddish-brown masses very deliquescent and easily soluble in water, giving a deep brownish orange solution.

Platinotype Process.—A process of positive printing from the negative, giving pictures of remarkable softness and artistic quality. As far back as 1832 Sir J. Herschel gave an account of his experiments on the action of light upon salts of platinum. Later on in 1844 Hunt pointed out the fact that if a piece of paper be dipped in a solution of platino-cyanide of potassium, and hung up to dry in the sun, no change was perceptible; but if after a short exposure it be treated with mercurous nitrate, a weak positive image was produced.

The first practicable platinum printing process was, however, invented and patented by Mr. Willis, of the Platinotype Co., who reserve the right to grant licences for working the process, and who supply all the necessary materials and the paper ready sensitised. Other processes are hereafter described, however, which may be worked by anyone.

The principles of the process may be briefly stated as follows:—Paper is coated with a mixture of potassium chloroplatinite and ferric oxalate. The ferric oxalate is sensitive to light, becoming converted into ferrous oxalate; we therefore get a faint greyish orange-coloured image of ferrous oxalate. Now, ferrous oxalate possesses the power when in solution of reducing potassium chloroplatinite to metallic platinum. It, therefore, only becomes necessary to dissolve the ferrous oxalate in a suitable liquid, when the potassium chloroplatinite will be reduced to the metallic state as metallic platinum.

A solution of potassium oxalate possesses this requisite power of dissolving the ferrous oxalate. The paper prepared with the chloroplatinite of potash having an image on it of ferrous oxalate is, therefore, floated on this solution, and a picture consisting of finely divided metallic platinum is the result obtained. It then only becomes necessary to dissolve away the remaining iron salts by any suitable acid. The following reactions (according to Berkely) takes place:—

$$Fe_2(C_2O_4)_3 = 2FeC_2O_4 + 2Co_2$$

$$6Fe(C_2O_4) + 3K_2PtCl_4 = 2Fe(C_2O_4)_3 + Fe_2Cl_6 + 6KCl + 3Pt.$$

Metallic platinum being one of the most stable substances known, it is probable that prints by this process are absolutely permanent.

Preparation of the Paper.—The paper is first treated with a size to prevent the sensitising solution from sinking too deeply into it. A good stout paper is required of even texture and pure in colour.

150 grains of moderately hard gelatine are dissolved in 30 ounces of water, and 45 grains of alum, together with seven ounces of pure

methylated spirit, are added. This is then filtered into a conveniently large dish, and the sheets passed through it one by one and hung up to dry. When dry it may be passed through a second time and dried. If arrowroot be used as the sizing, browner tones are obtained in the finished prints.

Coating the Paper.—The next operation is the coating of the paper with the sensitive solution. This should be done in a darkened room, care being taken that the sensitised paper be exposed for the shortest possible time. Lamplight, owing to its yellow colour, is not suitable, as the coated parts cannot be easily distinguished from the uncoated.

Captain Pizzighelli and Baron Hubl in their work on the subject* give the following methods of preparing the paper, the variations being made to suit the different class of negatives. These two solutions are prepared—

No. 1.

Ferric oxalate	120 grains.
Water	1 ounce.
Oxalic acid	8 grains.

No. 2.

No. 1 solution	1 ounce.
Chlorate of potassium	2 grains.

Considerable care must be taken that both these two solutions are protected from actinic light, otherwise the ferric salt will be speedily reduced to the ferrous salt.†

The sensitising solution is prepared as follows :—

Platinum chloroplatinite solution (80 grains to one ounce of water)	24 drachms.
No. 1 solution	22 ,,
Distilled water	4 ,,

This should give very soft and deep black prints. If greater brilliancy is required the following is recommended :—

Chloro-platinite solution	24 drachms.
Solution No. 1.	18 ,,
,, No. 2.	4 ,,
Distilled water	4 ,,

The next solution is recommended when results corresponding to silver images are required.

Chloro-platinite solution	24 drachms.
Solution No. 1.	14 ,,
,, No. 2.	8 ,,
Distilled water	4 ,,

* "Platinotype," by Captain Pizzighelli and Baron A. Hubl, translated by J. F. Iselin, and edited by Captain W. de W. Abney, R.E., F.R.S.

†This can be detected by taking a few drops on a glass plate and mixing with it a drop of a olution of ferricyanide of potassium. If any blue colouration takes place there has been a reduc- on, and consequently the solution is unfit for use.

For very weak negatives, reproductions of engravings, etc., use—

Chloro-platinite solution	24	drachms.
No. 2.	22	,,
Distilled water	4	,,

The addition of the No. 2 or chlorate or potash solution increases the contrast, as it reduces a portion of the platinite into a platinic salt. It will be obvious, therefore, that by a judicious use of it brilliant prints may be obtained even from weak negatives. If the pictures possess no black shadows, as, for instance, in the reproduction of pencil drawings the above mixtures may be diluted with half or even equal volumes of water. Distilled water should always be used.

Just before using, sufficient quantity of one of the mixtures given is prepared in a measuring glass for the size of the sheet of paper to be coated. For a sheet of paper 24 x 18, about 2 ozs. of the solution will be required. It is applied to the surface of the paper by means of a pad of cotton wool enclosed in a piece of soft flannel. The paper must be kept flat upon a level surface. A simple method is to stretch a long piece across a table, the ends overlapping, and having attached to them American clips tied to a kitchen poker, or

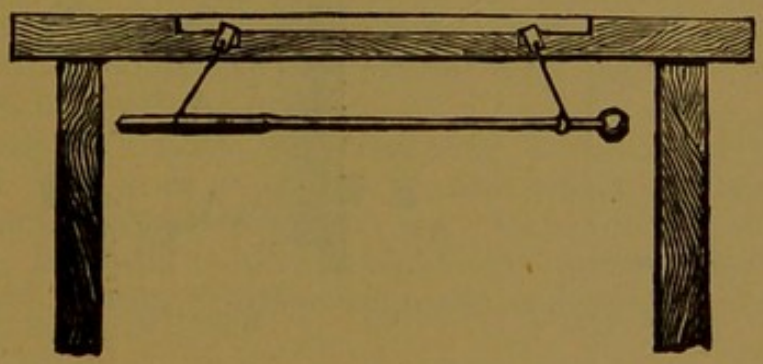

Fig. 177.

other suitable weight, as shown in fig. 177. This will keep it taut, even as it expands with the application of the wet solution. The sensitising solution is poured on and immediately spread over with the dapper, until the coating is as even as possible.

Drying the Paper.—Considerable care must be exercised in this, as much of the subsequent success is dependent upon the operation.

Directly the sheet is coated it is hung up by its corners, until all the moisture on the surface has entirely disappeared. It is then immediately dried before a fire or stove. When perfectly dry the lemon colour of its surface will have changed to an orange-yellow. It should be dried perfectly without scorching, as this would produce fogged prints. It is of the utmost importance that not less than five, nor more than ten, minutes should elapse between

the coating and the drying operations. If it becomes dried too soon the image will probably wash away in the developer, and if not dried quickly enough the picture will be flat and sunken in. In very warm weather the surface moisture will sometimes disappear in less than five minutes. In this case the walls and floor must be sprinkled with water or the paper placed in a dampened cupboard.

Keeping the Paper.—When thoroughly dry the sheets of sensitive paper, and also the prints, are preserved in chloride of calcium boxes. Figs. 178 and 179 will serve to show the construction of these boxes.

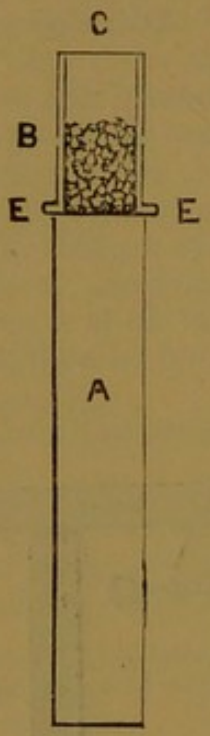

FIG. 178.

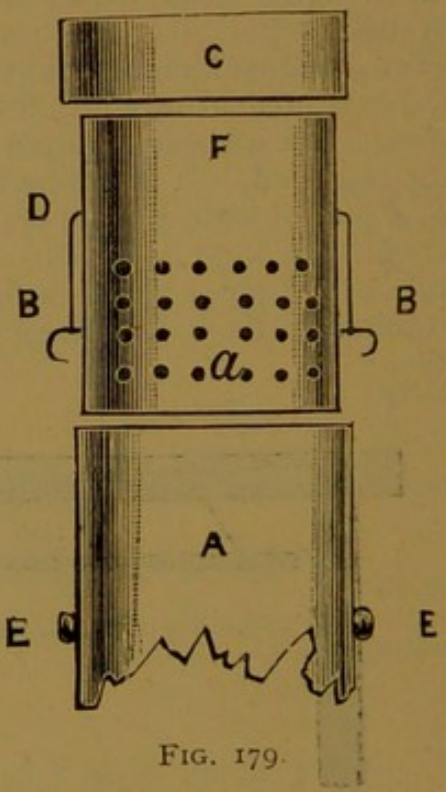

FIG. 179.

A is the compartment containing the paper. The cover B is divided into two parts, the lower part F which is placed on the top of the box consists of a cylinder. G perforated with holes which slide into the box A, and serves to hold some lumps of dry calcium chloride wrapped up in calico or double fold of muslin. The upper part C serves to close up the top of the cylinder G. An elastic band EE slips over the slots, and keeps them perfectly air tight. The calcium must be examined from time to time, if moist it must be changed for a fresh supply.* To secure the most brilliant results the sensitised paper before, during, and after exposure, must be kept as dry as possible. The effect of damp is a want of vigour, muddy tones, and impaired purity of the whites.

*Damp calcium chloride can be easily deprived of its moisture by heating in an iron vessel. It can then be used over again.

The following instructions for platinotype printing are given by Platinotype Co. :—

Printing.—Place the paper in the printing frame beneath the negative, and between it and the pad insert a sheet of thin vulcanised indiarubber, as it is of the first importance that the pads in contact with the paper be quite dry.

The correct exposure (about one-third of that required with silver-printing) is ascertained by inspection of the paper in a rather weak white light in the usual manner. A little experience will enable the exposure to be determined very accurately. The sensitised surface before exposure to light is of a lemon-yellow colour. During exposure, the parts affected by light become of a pale greyish-brown colour, and, sometimes of an orange tint under those parts of the negative which present clear glass or nearly so. As a general rule all parts of the picture except the highest lights should be visible when the exposure is complete. When examining the prints in the printing-frames, care should be taken not to expose them unduly to light ; for the degradation of the whites of the paper due to *slight* action of light is *not visible until after development.* Damp paper gives a less visible image than dry paper, hence it may easily be over-exposed. Remove prints to a calcium tube as soon as exposure is complete, unless they are to be at once developed.

Development.—Development should be conducted in a feeble white light, similiar to that used when cutting up the paper, or by gaslight. It may take place immediately after the print is exposed, or, at the end of the day's printing.

The developer is made by dissolving 1 lb. of the oxalate of potash in 54 ounces of water. Use hot water for making the solution, of which a large quantity may be made up ; it will keep indefinitely. It is well to have at hand some unused solution, since, in the event of inferior prints being made, a new bath may at once be tried.

The solution is conveniently contained in a flat-bottomed dish of enamelled iron, heated by a small spirit lamp or bunsen burner for the smallest dish, or for the larger dishes a paraffin stove. Troughs for large prints are fitted with a tube gas-burner.

The developing tray recommended by Pizzighelli and Hübl is shown in Fig. 180. A is an enamelled iron vessel containing the oxalate solution ; *a* its cover of zinc plate ; B is another hollow vessel, with a double wall of zinc plate, which acts as a water bath ; C is a gas or spirit lamp. The vessel B is filled with hot water through a little hole let into the upper side, and the hot solution of oxalate is then poured into the tray A ; it can readily be kept at the required temperature by means of the lamp underneath.

The development is effected by *floating the printed surface* of the paper for five or six seconds upon the "developing solution." To avoid air-bubbles : lay one edge of the print upon the solution near the right-hand end of the dish ; then, with a sliding motion

towards the left, lower the print, with an even movement, without stoppage, until it is entirely in contact with the liquid, where it must remain until *complete* action has taken place.

A good plan is to place the prints, after removal from the printing frames, in a calcium tube with their printed surfaces outwards, and, therefore, convex. In a short time the prints will receive and retain this curvature sufficiently for the developing operation. To develop, take the print in the right hand (its

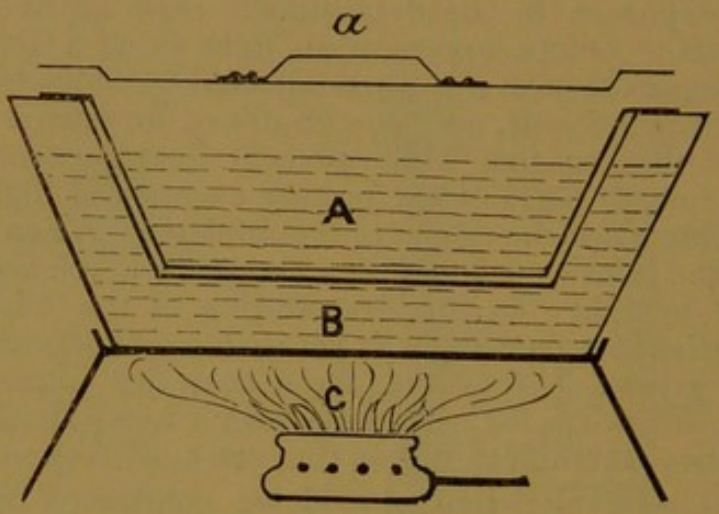

FIG. 180.

printed surface being downwards), lay the left-hand edge on the developer, and then slowly and continuously lower the right hand until the whole print is floating. The great point is to well preserve, and if possible increase, the curvature of the paper as it nears the liquid.

A temperature of about 140° Fahr. may be considered the standard temperature for the developer, though higher and lower temperatures may be used on occasion. To test the temperature, a cheap clinical thermometer must be used. The bottom of the developing-dish should be covered with the developing-solution to the depth of *at least* one-half of an inch.

After the prints have been developed, put the solution, without filtering, into a bottle for future use; it should not be exposed to a strong light. When next developing the solution will be found to be *nearly clear, but, of course, tinted by previous use.* If this clear solution be not sufficient for use, add to it some of the fresh solution of the potassic oxalate. It is a safe plan always to *keep the "bath-solution" up to its original bulk* by this means. A little suspended matter in the bath is not of any consequence.

Sometimes when a *large number* of prints (or *large prints* upon *small bulk* of solution) are developed at *one operation*, the bath will become so loaded with chemicals derived from the paper that it will no longer give good prints. Such a solution must at once be

replaced by a new one. When working on a somewhat large scale it is especially necessary to watch for any change in the quality of the prints; and in case of a doubt a new bath should be tried.

Very large prints may be developed without any difficulty in a trough, by being *slowly and continuously pulled through* the solution contained therein.

Clearing and Washing.—To clear the developed prints: these must be washed in a series of baths (not less than three) of a weak solution of hydrochloric acid. This solution is made by mixing one part of hydrochloric acid with 60 parts of water. The specific gravity of the acid should be not less than 1·16; if lower, more acid should be used. The acid should be colourless. Or citric acid, in the proportion of 1 ounce to 20 ounces of water, may be used. This softens the paper in less degree than does the hydrochloric acid. *A white opalescence of the bath shows necessity for more acid.*

As soon as the print has been removed from the developing dish it must be *immersed face downwards* in the first bath of this acid, contained in a porcelain dish, in which it should remain about five minutes; meanwhile, other prints follow until all are developed. The prints must then be removed to a second acid bath for about ten minutes; afterwards to the third bath for about fifteen minutes. While the prints remain in these acid baths they should be moved so that the solution has free access to their surfaces, but care should be taken not to abrade them by undue friction. It is impossible to affect the image *per se* by leaving the prints for a long time in the acid baths, but such treatment continued for an hour or more tends to make the paper soft and porous and to damage its surface.

The prints should not communicate to the last acid bath the slightest tinge of colour. If the bath, after the prints have been washed in it, does not remain as colourless as water when a depth of fully two inches is viewed in full daylight, the prints should be treated to yet another acid bath. The last acid bath must not in any case have been used for a previous batch of prints; after use it may form the first acid bath for the next batch, but it is better to replace all the baths by fresh ones The object of this washing in dilute acid is to remove all traces of iron salts from the paper before it is passed into the plain water. The prints must not be placed in plain water on leaving the developer, because insoluble salts will be precipitated on the print. After the prints have passed through the acid baths they should be well washed in two or three changes of water during about a quarter of an hour. It is sometimes advisable to add a pinch of washing soda to the second washing water to neutralise any acid present in the print.

Drying and Mounting.—After washing the prints are dried in the ordinary way. Any mountant can be used that does not show through the print. Gelatine alone is not suitable except for thick

paper. Thick cold starch, or starch and gelatine, are the best mountants.

Platinum prints appear somewhat more brilliant and lighter when wet than when dry, therefore, if it has a correct appearance as regards to tone, while wet, it will be too dark when finished. Prints on smooth paper may be hot-pressed, which gives them a slight sheen and brings up the dark parts. They may also be retouched with colours or chalk, their smooth, heavy surface serving well for this purpose.

The following list of defects and their remedies is given by Captain Pizzighelli and Baron Hübl:—

1.—The pictures are vigorous, but more or less fogged.

(*A*) *cause:* The paper was affected by light either in sensitising or printing.

To prevent it sensitise only under a weak light, and dry either in complete darkness or by lamplight. When examining the course of the copying operation be careful to avoid too strong a light in arranging the frame.

(*B*) *cause:* Too high a temperature in drying.

It should never exceed 40° C.

(*C*) *cause:* Spoiled ferric solution.

The ferric solution is best preserved from the influence of light by being kept in a hyalite flask. If you are not confident as to your solution, you must assure yourself before using it by testing with red prussiate of potash that it is free from ferrite. Should it only contain a trace of ferrite it can be made fit for use again by carefully adding red prussiate of potash. In order to try this, mix a few cubic centimetres of the normal ferric chlorate solution with every 100 cubic centimetres of the iron solution, and ascertain by actual experiment on paper whether the restoration is complete.

(*D*) *cause:* Too long exposure in the printing frame.

The time of copying should be shortened, and if the picture is not yet developed use a cold developer.

2.—The prints appear too weak under the developer.

(*A*) *cause:* Paper which has become damp.

The paper should always be kept in the calcium chloride boxes, even after being printed, if not immediately developed. Paper once spoiled cannot be made good again.

(*B*) *cause:* The paper is too old.

Paper can generally be kept in good condition for, at least, six or eight weeks, and sometimes even more; but after that time a gradual change appears to take place, even though it be kept in the dark, and not only weak, but also fogged pictures are the result. As neither time nor trouble are required for sensitising the paper, we recommend only to make at once as much as may be necessary for use during three or four weeks.

(*C*) *cause:* Weak negatives.

Use more chlorate of potash in the sensitising solution.

3.—The prints come out vigorous in developing, bu become weak after being dried.

Paper not sufficiently sized, for which reason the image sinks into its substance. When this is the case employ stronger solutions of gelatine or arrowroot.

(*A*) *cause :* Drying has been too slow.

The drying process should not take longer than ten minutes ; if this is exceeded the sensitising solution sinks too deeply into the paper.

4. The whites of the prints have, after drying, a more or less yellowish tinge.

(*A*) *cause :* The sensitising solution in the developer is not sufficiently acid. Attention should be paid to the instructions on this point in the previous divisions of the subject.

(*B*) *cause :* Insufficient immersion in hydrochloric acid.

The solution of hydrochloric acid must be changed two or three times, until the last change no longer turns yellow at the end of ten minutes.

(*C*) *cause :* Paper blued with ultramarine, which, when treated with hydrochloric acid, turns yellow.

Before using the paper you must be certain that its colour does not suffer from contact with a hot solution of oxalate, and from treatment with hydrochloric acid.

5. The prints come out hard.

(*A*) *cause :* Exposure too short.

(*B*) *cause :* Too much in the sensitising solution. Remedy obvious.

6. Spots and streaks.

Causes : Dirty brushes ; touching the paper with wet fingers; dirty glass plates ; vessels not kept clean, etc.

7. Black spots.

(*A*) *cause :* Particles of metal embedded in the substance of the paper, causing a reduction of the platinum.

(*B*) *cause :* May be due to insoluble impurities in the chloroplatinite of potassium. These spots have a black nucleus, with an extension like the tail of a comet, of lighter colour.

In such a case filter the sensitising solution.

Platinotype prints may be made upon many other materials besides paper. Linen or other fabrics are treated in the same manner as paper. To keep smooth it should be stretched on a suitable frame after the second coating of the gelatine sizing solution. To print on wood it should be planed perfectly smooth and then coated with the gelatine solution. Thin sheets should be kept between two boards to prevent them from warping.

Sepia Platinotype Paper.—This is a special paper prepared by the Platinotype Co. for giving sepia-toned pictures. It is believed that this result is obtained by the use of a salt of mercury with the platinum. With a few exceptions all the operations are similar to the ordinary kind of platinotype paper. The following special instructions are given :—

The sepia paper is more easily affected by faint light, and therefore increased care must be taken during the printing operation.

To develop, add to each ounce of the potassic oxalate solution one or two drachms of a special solution supplied for the purpose, and proceed as described for ordinary platinotype paper. The temperature should not exceed 150° to 160° Fahrenheit. The developing bath should be kept in the dark, and must on no account be used for black prints. Discolouration of the white of the image is due to one of the following causes—(1) Want of sufficient "special solution" in the developer; (2) too much exposure of the developing solution to light; (3) use of a dish in which the enamel is cracked so as to expose the iron; (4) paper kept too long; (5) exposure of prints to too much light while clearing. The prints are cleared with an acid bath of one part of hydrochloric acid (sp.gr. 1·16) to 60 parts of water. As the sepia prints, unlike the black ones, may be affected by light when in the acid bath, the lights being stained and degraded, the prints at this stage should be manipulated in a very weak light. The prints are damaged by being left long in the acid baths. The subsequent operations are the same as for the other kind of paper. Dishes used for sepia prints must not afterwards be used for developing black toned prints. Black and sepia prints must not be washed together in the same dish.

Cold-bath Process.—A new method of platinotype printing introduced by Mr. Willis. The novel feature about this is that the platinum salt is used in the developing solution instead of in the paper. The following notes concerning it are given by the inventor.

Paper is coated with ferric oxalate and a small quantity of mercury salt, then exposed to the light, and afterwards developed on a cold solution containing potassic oxalate and potassic chloroplatinite. The solution of ferric oxalate employed is the same as that used in the present process, both as to the strength and acidity. In each ounce of this ferric salt is dissolved from 1 to 1¼ grains of a salt of mercury, preferably the chloride. It is then dried perfectly, exposed to the action of light beneath a negative, and then developed on a cold solution containing from 30 to 120 grains of oxalate of potash, and from 5 to 15 grains of potassic chloroplatinite. The development proceeds sufficiently slowly to allow of its being watched and stopped by immersion of the print in the acid clearing bath as soon as the desired strength of the

deposit has been attained. The following are the instructions given for working the paper as supplied by the Platinotye Company:—

General Treatment of the Paper.—The presence of moisture in the paper, either during its exposure to light, or afterwards and before development, is important. Excessive moisture is neither desirable nor useful. In England the moisture absorbed from the air of a cold room in winter during fifteen minutes is usually sufficient; or, in summer, about the same time in a dampish room. Sufficient moisture will be present when the paper has lost its *crispness*, but if allowed to become *limp* the moisture will be excessive. The best results are usually obtained when the paper has been damped, before its exposure to light. But for reasons explained in the next section, beginners will find it better to expose in the dry state. If damped before exposure, such damping should not long precede the printing.

Prints made by exposure to light of paper in a damp state, or, made on dry paper and afterwards damped, will, if developed within an hour of such exposure, give the maximum of vigour, by delaying the development for some hours, the prints in the meantime being stored in a drawer, wooden box, or other suitable receptacle, so that they will retain most of their moisture, then, on development, an increase of half-tone and increased warmth of colour will be obtained. The modifications in the results to be secured in this way can be only roughly indicated; the experience of the printer will very soon prevent mistakes.

But should it be necessary to delay development of prints for one or two days, they must be dried (not scorched) before a fire, soon after they are removed from the frames, and then stored in a calcium tube until wanted for development.

As during printing operations no necessity exists for keeping paper dry, it is very advisable, on account of the ease of manipulation, to employ drawers, or flat wooden or paper boxes, one to hold unexposed paper and another to receive exposed prints. The hinged paper boxes made for holding music answer very well for the smaller sizes. This method of working from non-metallic boxes also avoids the risk of spots due to metallic dust, which is always produced during the opening and closing of a calcium tube of tin or zinc.

Exposure to Light.—This is effected in a printing-frame in the usual manner. When exposed to light behind a negative, the lemon colour of the paper receives an image of a greyish tone. Some negatives, however, present such strong contrasts that the deep shadows on the print are carried beyond the grey stage and become of an orange-yellow; this state of the image is usually termed "solarisation."

The exposure is somewhat less than that required with the old process—perhaps about one-third less. The progress of the

printing is observed by opening the frame in the usual manner, but care should be taken to prevent undue access of strong light. As a general rule all details observable on the exposed print are developable, and the converse of this is also pretty generally true, namely, that no details are developable which are not also visible before development. But here it should be observed that the action of light on skies is not often clearly seen unless the rebate of the negative has been previously rendered opaque by painting with opaque varnish, so that the tint of the sky may be compared with the original colour of the paper which is preserved by the opacity of the "rebate." It is important to remember that if paper be exposed in a damp state the visibility of the image is less than if exposed in a dry state; the image is weaker in appearance and less of the detail in the high lights is seen. On this account beginners will find it easier to expose dry, and damp the prints afterwards. This paper is undoubtedly easier to expose correctly than paper made for the former processes, and no one should experience any difficulty after a small amount of practice has been gone through.

Development.—The developing agents are numerous, and a great variety of formulæ is possible. The best results are, however, obtained with mixtures of oxalates and bi-phosphates. The following is a good formula :—

A.

Oxalate of potash	30 grains
Bi-phosphate of potash	30 grains

Dissolved and made up with water to 1 oz.

B.

Platinum salt	30 grains
Water	1 ounce

For use add one part of B to three parts of A, although a great many variations may be made in the proportions to which these two solutions are mixed to form the developer, and by these variations different effects are produced.

The mixed developer keeps in good condition for some hours after mixing, but it afterwards slowly deteriorates, and in order to secure due economy in the use of the developer, it is important to mix no more at a time than is sufficient for the prints to be developed. In developing a very large batch, perhaps the best way is to mix the whole quantity necessary, but to put into the developing-dish only sufficient to render the floating of the prints an easy matter, and then to add the remainder by degrees, as may be found necessary.

In order to develop, pour sufficient of the developer into a porcelain tray to well cover the bottom, and then float the print, with its printed surface downwards, upon the solution; after the lapse of two or three seconds it may be lifted from the solution and held in the hand. A few seconds after the print has thus been removed from the developer, it should be again similarly floated and raised; and these operations may require to be repeated, but this will depend on the strength of the print or subject.

The object of re-floating the print is thus explained. When a print is first raised from the developer, the liquid adhering to its surface contains only a small quantity of platinum salt (the developer being weak in this ingredient), and the amount of salt so taken up is usually insufficient to supply the necessary quantity of platinum pigment to the shadows and darker parts of the print; by re-floating, a fresh supply of this pigment-forming liquid is supplied, and the number of floatings required is determined by the strength of the light impression.

After the print has been twice floated it should be held in the hand, face upwards, and the progress of development carefully watched. When the half-tones have sufficiently appeared, and have become free from the granulation usually visible in the first stages of development, and the shadows also are sufficiently strong, the print should be at once immersed in the acid clearing bath. In some cases it takes a full minute to complete a development, but the moment selected for arresting it is to be decided by the taste and judgment of the operator. During the progress of the development it may sometimes be noticed that the shadows are slightly rusty in colour, and appear to hang back. This indicates the necessity of another floatation on the developer. Or, instead of re-floating, some of the solution may be applied to the shadows by means of a large camel-hair pencil.

A useful development, and one securing economy to small workers, is by means of a broad camel-hairbrush, but it requires a little practice. The brush must be well wetted and the strokes given with fair rapidity. It is usually better to begin at the edge of a print and to let each succeeding stroke *overlap* the previous one, then, as soon as the print is covered, repeat the operation with strokes at right angles to the first series so as to render the coating as even as possible. The brush should be dipped in the developer before each stroke, or, at any rate, before every second one. And before beginning another print the brush should be washed in the developer in order to detach any salt which it may have derived from the previous print.

In using the floating method, air-bells are sometimes formed on the surface of the print, but this only rarely happens when the surface is developed in its moist state. If any should appear on the print, after its first floating, they are best removed by again

laying the print on the solution and then smartly sliding the print over the surface of the liquid.

A good method of floating is to lay one end or edge of the print upon the solution near the right-hand end of the dish; then, with a sliding motion towards the left, lower the print with an even movement, until it is entirely in contact with the liquid.

In order to avoid scum-marks on the prints it is very important to rock the developing dish between the development of each print. The rocking should be so managed that the developer is driven, in a wave, against the side of the dish, so that the surface scum may be broken up and sunk in the liquid.

Pizzighelli's Printing-out Platinotype Process.—A remarkable advance in platinum printing processes, introduced by Captain Pizzighelli, by which means the print is directly produced upon the platinum paper in the printing frame. The principles upon which the process is based are the following: (1.) By adding thickening materials to the sensitising solution, the latter is prevented from penetrating the substance of the paper. (2.) If one of the substances used as a "developer" is added directly to the sensitising solution, a reduction of the platinum salt takes place in the printing frame itself under the influence of the moisture of the air. The advantages of this process will be at once apparent. The previous preparation of the paper is dispensed with, and the progress of the printing can be watched, and, further, the developing process is also done away with.

Preparing the Paper.—The sort of paper to be selected is unsized photographic, smooth or rough, as supplied from Rives or Saxe or by Steinbach.

Solutions of gum arabic and arrowroot have been found the best substances for holding the sensitised liquid. These are prepared as follows:—

No. 1—Gum Arabic Solution.

Gum arabic (finest white lumps)	50 grammes
Distilled water	100 cubic centimetres.

No. 2—Arrowroot Solution.

Arrowroot	2 grammes.
Distilled water	150 cubic centimetres.

The arrowroot is kneaded into a paste with a little of the water, and the remainder added whilst boiling, the temperature to be kept up for some minutes. The gum arabic solution is said to give the best effects.

No. 3.—Ammonium Ferric Oxalate Solution.

Ferric oxalate	20 grammes.
Oxalic acid	0·5 ,,
Ammonium oxalate	18 to 20 ,,
Distilled water	150 c.c.m.

No. 4—Sodium Ferric Oxalate Solution.

Ferric oxalate	20 grammes.
Oxalic acid	0·5 ,,
Sodium oxalate	50 to 60 ,,
Distilled water	150 c.c.m.

The precise amount of sodium or ammonium oxalate necessary is determined by the colour of the solution as the addition is slowly made. By formation of corresponding double salts the brownish grey colour it at first assumes will change to a beautiful emerald green, and on a further addition of the salt it begins to get somewhat darker. Immediately this is observed the saturation is complete, and no more must be added. It should be mentioned that the addition of the sodium or ammonium oxalate should be made in the dark room. The mixture is then shaken up and filtered.

No. 5.—Sensitising Solution.

Chloroplatinite of potassium solution (1 in 6) ..	24 c.c.m.
No. 1 solution	22 ,,
No. 3 solution	23 ,,

Or this—

Chloroplatinite of potash solution (1 in 6) ..	24 c.c.m.
No. 1 solution	22 ,,
No. 4 solution	23 ,,

Or the following—

No. 6.—Sensitising Solution.

Chloroplatinite of potash	3 grammes.
Sodium oxalate	3 ,,
Ferric oxalate	4 ,,
Oxalic acid	0·6 ,,
Gum arabic	4 ,,
Distilled water	50 c.c.m.

No. 5 gives bluish black tones, and No. 6 is suitable when a more brownish colour is desired. The mixture is well stirred up, filtered through muslin, and preserved from non-actinic light. The coating, drying and storing of the paper are precisely the same as already described for the ordinary platinotype paper. About ninety minims of the liquid will be required for a piece of paper 10 × 8 inches.

Printing.—There are two or three methods of printing. By the first the action of the light is continued until all the image has appeared of the same depth of tone as required for the finished print. By the second method the printing is carried out until the image is all quite visible as a whole, although the most delicate detail in the half-tones still remain wanting. The print is then removed from the printing frame and simply kept in the dark room. After a time, varying from half-an-hour to three or four hours, the print will be found to have com-

pleted itself, for the reason that the reduction of the platinum salts once started continues in the dark. Or, instead of laying aside to complete itself, the print may in this state be developed over with a cold solution made up as follows :—

Saturated solution of sodium carbonate ..	5 c.c.
Distilled water	100 c.c.m.

until all the finest details which are wanting have appeared. A third method of printing is to continue only as long as with the ordinary platinotype paper, that is to say, until the deepest shadows are distinctly visible. The image can then be developed with any of the ordinary platinotype developing solutions.

The prints (by whichever of the methods given above they are obtained) are placed in a dilute acid bath made up with—

Hydrocholic acid	1 c.c.m.
Water	80 ,,

and allowed to remain there until the yellow colour of the paper has disappeared. They are then washed for from ten minutes to a quarter of an hour in several changes of clean water.

Platinous Chloride (Formula, $PtCl_2$; synonym, *protochloride of platinum*).—Prepared by heating platinic chloride to 450°F. and above, until it becomes insoluble in water. It forms a dingy green powder, also insoluble in nitric and sulphuric acids. It dissolves, however, in hot hydrochloric acid and in a solution of platinic chloride, yielding in the former a bright red, and in the latter a very dark reddish brown solution. It dissolves in caustic potash, all the platinum being thrown down as platinum black on the addition of alcohol. It forms double salts with metallic chlorides.

Platinum (Symbol, Pt ; atomic weight, 197·4).—Platinum belongs to the group of noble metals in which gold, iridium, palladium, etc., are included. It is a white metal much resembling silver in appearance. It takes its name from *plata*, Spanish for silver. It possesses a specific gravity of 21·5, and usually occurs in the free state. It is obtained chiefly in Mexico, Brazil, and Siberia, and from copper ore found in the Alps. In a fine state of division it is absolutely black. Its chief properties are its exceptional stability, which is superior to gold, and its non-oxidation at any temperature. It cannot be attacked by any single *acid, and only slightly by a few alkaline substances.

Platinum is now considered to be tetratomic, or, in other words, its atom requires four atoms of any univalent element to form the molecule. Formerly it was considered to be divalent, and the term bichloride of platinum is still applied to what is in reality the tetrachloride.

*Aqua regia (a mixture of nitric and hydrochloric acids) will dissolve it slowly.

Platinum is now extensively used in photography in the different platinotype processes and in platinum toning.

Platinum Chlorides.—Platinum forms two chlorides, platinic chloride and platinous chloride (*q.v.*)

Platinum Cyanide.—The cyanides of platinum have not been prepared in a pure state, but the salts known as platino-cyanides exceed the ferro-cyanides in the force with which they retain the platinum distinguished by the ordinary tests for it.*

Platinum Perchloride.—See **Platinum Tetrachloride.**

Platinum Process.—See **Platinotype.**

Platinum Tetrachloride (Formula, $PtCl_4$; synonyms, *platinum perchloride, platinum bichloride, and platinic chloride*).—A salt prepared from metallic platinum by heating with aqua regia and eva porating. It occurs in small brownish-red masses, which, if pur^{e}, dissolve readily in water, forming a deep orange or brownish-orange solution. According to Pizzighelli the chloride of platinum sold by dealers in fifteen grain tubes is really chloroplatinic acid $PtCl_4 2HCl$. It is a fact that it certainly possesses a large percentage of free hydrochloric acid. It is used chiefly in platinum toning.

Platinum Toning.—As is generally known the chief substance used in photography for toning the photolgraphic image to an agreeable colour is gold. The chemical simi arity between gold and platinum led to experiments being made with the latter metal to replace the former. The first published formula for a platinum toning process was given in "La Lumière" (Feb., 1856) by a Frenchman, M. de Carranza. He employed an acidulated solution, 1 in 2,000 of platinic chloride. This was followed by a number of other formulæ, among which must be mentioned those of Mr. Burnett.†

The most modern and most successful method of toning with platinum has, however, been devised by Lyonel Clark, C.E., who in the year 1890 published a book upon the subject.‡ His method is described in this as follows:—

The print upon the albuminised or upon plain salted paper is made in the usual way, that is to say, just slightly over-printed, as for gold toning. A negative that will give a good gold toned print will give a good platinum one. Matt surface paper requires stronger negatives than albumen paper. The general rule is that the pluckier the negative the richer the blacks or browns obtained. A weak negative will never give a good result.

* Bloxham's "Chemistry," page 624.

† See *British Journal of Photography*, 1858, 1859.

‡ "Platinum Toning," by Lyonel Clark, C.E.

The prints when removed from the frames may be stored away until required. They are first washed in two or three changes of water until all milkiness has disappeared.

The toning bath for black or brown tones is prepared as follows :—

STOCK SOLUTION.

Potassium chloro-platinite	60 grains
Distilled water up to	2 fluid ounces

TONING BATH.

Stock solution as above	1 fluid drachm
Ordinary water up to	2 fluid ounces
Nitric acid	1 or 2 drops

In winter it is preferable to use warm water to bring the temperature to about 80°F. It must not, however, be over-heated yellow half-tones will be the result.

It is very essential that the true chloro-platinite of potassium be used. For method of manufacture see **Potassium Chloro-platinite.**

With a bath, as given above, the toning commences instantly the print touches the liquid. It is, therefore, preferable to tone the prints singly. The two ounces of solution will be sufficient to tone several 12in. × 10in. prints. Clark thus describes his method of working :—" For holding the toning bath I employ one of the plate glass bottomed dishes as generally used for the development of bromide papers. I usually turn it upside down, so as to have the sides as low as possible, and attach three ordinary levelling screws to the upper edge, which now becomes the lower one, and with these and the aid of an ordinary spirit level I adjust the dish. By this means the toning solution is spread over a large area on a thin but uniform layer, two ounces being, according to my experience, sufficient to cover a dish measuring 18in. × 15in. I then take the wet proof and holding it by opposite corners, one in each hand, place one corner on to the surface of the liquid with the left hand first, and then lowering the right hand allow the print to gradually float on to the liquid in this manner, pushing in front any bubbles that may have been formed on the surface. The print may be lifted off the toning bath as often as is thought desirable, and examined by transmitted light, and if any redness is to be seen in the deep shadows replace it on the bath. When all redness has disappeared the toning is complete. The print is then lifted slowly by one end off the liquid to allow as much as possible of the liquid on its surface to run back again in to the bath."

The print is then plunged into a bath containing water made slightly alkaline by carbonate of potash or soda. The use of the bath is to destroy any acid in the print carried over from the toning bath which would decompose the hyposulphite fixing bath. If only a small quantity of prints are toned the hyposulphite solution

itself can be rendered alkaline, and the prints placed in it direct from the toning bath.

To get the required tone the process must be stopped at the right time. The bath given is, however, so rapid that but little control can be had over the toning. When this is desired the following bath is recommended:—

Stock solution	1 fluid drachm.
Water up to	8 fluid ounces.
Nitric acid	2 to 3 drops.

With this bath the prints may be toned as with gold solution, that is to say, immersed in the bath and moved about until the required tone is obtained, when they are removed to the weak alkaline water.

The fixing bath is the ordinary sodium hyposulphite one, with a strength of about 1 in 5 of water. A few drops of ammonia are added until it smells slightly of it. If the parts have been toned to the full extent, that is to say, to a rich black or a brown-black, they should not undergo any change in colour when immersed in the fixing bath, unless it be very strong, and they are allowed to remain in it a long time. If they have only been partially toned, however, a general change in colour will be the result.

After fixing for about ten minutes, the prints are thoroughly well washed and dried.

Alpha paper may be toned most successfully with the following :—

Solution 1.

Oxalate of potash	5 ounces.
Monopotassic orthophosphate	3 ,,
Water	50 ,,

Solution 2.

Potassium chloroplatinite	60 grains.
Water	2 ounces.

Take three parts of No. 1, one part of No. 2, and two parts of water.

The above bath may also be used for toning gelatino chloride printing-out papers.

Professor Burton recommends immersing the prints before toning in a solution of common salt instead of the preliminary wash, and to add the salt directly to the toning bath, and the prints placed in directly without previous treatment.

Plumbago.—See **Graphite.**

Plumb Indicator.—In photgraphing buildings, etc., where we have a number of vertical lines, it is absolutely necessary that the sensitive surface be perfectly upright. For this purpose an

arrangement termed a "plumb indicator" is sometimes used. It consists of a swinging pointer, attached to a plate (see fig. 181), which can be screwed to the swing back of the camera.

This device shows at a glance when the plate is vertical.

Pneumatic Holder.—A very useful little contrivance used for holding glass or other smooth plates. An elastic indiarubber ball, being exhausted of air by squeezing it, adheres firmly to the back of the plate, and can be used as a handle, allowing the plate to be coated with solution over the whole surface.

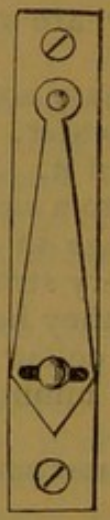

FIG. 181.

Pneumatic Shutter.—A shutter worked by means of a small indiarubber ball at the end of a tubing of the same material. By squeezing the ball, the compressed air suffices to release the shutter. The tubing can be of considerable length, allowing the operator to stand some distance from the camera. Indeed, by this means he may include himself in a group, and take his own portrait unassisted.

Poisons.—A number of the chemicals used in the various photographic operations are poisonous either when taken internally or if absorbed through the skin or through cuts or abrasions in it. The following table of the effects and antidotes and remedies has, therefore, been compiled. In every suspicious case of poisoning a medical man should be at once sent for, the remedies given being applied pending his arrival. No time should be lost, vomiting should be caused at once by tickling the throat with a feather or by thrusting the fingers down as far as possible. Three or four teaspoonsful of mustard in a tumbler of warm water usually acts as an emetic. If it does not act in fifteen minutes repeat it:—

Table of Poisons, with their Effects and Remedies.

Poison.	Effects.	Antidote and Remedy.
1. Acetic acid.	Corrosion of windpipe, odour in breath, great pain in abdomen, perhaps convulsions, collapse and death.	Large draughts of soap and water to be taken at once. The stomach pump *not* to be used. Magnesia, chalk and water, lime water, or whitewash and water may also be given.
2. Carbolic acid.	Taste and odour of tar in the mouth, inside marked with whitened or black scars, dangerous fainting and collapse.	As much sweet oil and glycerine as possible, and endeavour to promote vomiting by drinking warm water, milk, or barley water. No food to be taken till inflammation has ceased.
3. Sulphuric acid. Nitric acid. Hydrochloric acid. Phosphoric acid. Fluoric acid. Tartaric acid.	Hot burning pains in the throat and stomach, lips burnt and shriveled up, excessive thirst, drink increasing the pain.	Mix at once chalk and water or soap and water. No time must be lost. If none of these be handy, break down the plaster from the walls and ceiling; make into a thin paste, and give a wineglassful every two minutes, vomiting to be encouraged by drinking warm water.
4. Oxalic acid. Potassium oxalate.	Hot burning sensation, vomiting, cramp, numbness, great thirst, very dangerous. One drachm smallest fatal dose known.	Give lime in any form or chalk and water, but not alkalis or their carbonates; scrape the chalk or plaster from the wall, and give as in No. 3.
5. Alcohol.	Drunkenness, coma, death.	Stomach pump or emetic of mustard in water; keep patient continually awake and on the move by pinching, shaking, and walking him about.
Ammonia.	Burning sensation in mouth, throat, chest, and stomach; lips and tongue swollen, suffocation. Inhaling ammonia will cause violent irritation of the larynx.	Vinegar, freely diluted with water. Acetic or any other acid diluted with large quantity of water; lemon or orange juice may be given. If unable to swallow, inhalation of acetic acid or vinegar from saturated pocket handkerchief.
7. Barium.	Irritation with colic.	A thimbleful of Epsom or Glauber's salts dissolved in water every few minutes. Any sulphate.
8. Benzine.	Vapour acts as a narcotic; noises in the head, convulsive tremblings, convulsions, difficulty in breathing.	Brandy, liquor ammonia (half a drachm in plenty of water), frequently repeated; inhalation of ammonia, alternate hot and cold douche.
9. Bromine.	Acrid taste, tightness about the throat.	Stomach pump, egg-albumen, milk.
10. Copper chloride or sulphate.	Metallic taste in mouth, constriction in throat, griping pains in abdomen, headache, giddiness, coma, death.	Milk and eggs, barley water or arrowroot, given freely, or stomach pump or emetic of warm water and mustard.
11. Gold perchloride.	Caustic and corrosive.	Emetics.
12. Ether.	Stupefaction.	Loosen everything about chest, open doors and windows for fresh air alternate cold and warm douche.
13. Iodine.	Pain and heat in throat and stomach, with vomiting; giddiness, convulsions, death.	Stomach pump or emetic of mustard and water; egg albumen and water, or arrowroot and gruel, given freely.
14. Lead acetate.	Dryness in throat, metallic taste, great thirst, cramp in abdomen, cold sweats, convulsions. The sub-acetate is a still stronger poison.	Sulphate of soda or magnesia, or very dilute sulphuric acid. Stomach pump, or emetic of mustard and water.
15. Mercuric chloride.	Acrid taste, burning in the throat and stomach, nausea, lips and mouth white and swollen. Three grains smallest fatal dose known.	White of 12 or 15 eggs beaten up in a quart of water. One wineglassful every two minutes, or milk and barley water in large draughts to ease the vomiting.

Table of Poisons—(*continued*).

Poison.	Effects.	Antidote and Remedy.
16. Potassium bichromate.	Powerful poison. Acute pains in abdomen, violent vomiting, pupils dilated.	Stomach pump or emetic, carbonate of magnesia or chalk in milk, or white of egg in milk or water. Barley water or thick gruel. Warmth to extremities and stimulants given freely.
	Applied to slight abrasions of the skin produces sores and ulcers.	Bathe in warm water and in dilute ammonia, and afterwards poultice.
17. Potassium cyanide.	Severe burning pain in stomach, foaming at mouth, insensibility, convulsions, stiffness of jaws and body, death.	Stomach pump or emetic. Large draughts of sulphate of iron and water at once. Ammonia or smelling salts. Inhalation of ammonia.
	Applied to wounds and abrasions of the skin a smarting sensation is felt.	Sulphate of iron should be applied immediately.
18. Potassium ferrocyanide. Potassium ferricyanide.	Insensibility, gasping, spasmodic action of jaws.	Strong coffee. Dash cold water over face. Give ammonia or use smelling salts.
19. Pyrogallol.	Acute burning pain in stomach.	Emetics. Milk and white of eggs.
20. Silver nitrate.	Powerful irritant, contraction of throat sometimes, whilst flaky matter vomited turns black on exposure to air.	Copious draughts of common salt and water. Emetics of mustard or sulphate of zinc (20 grs. in water). White of egg, barley water, arrowroot, etc.
21. Zinc, salts of.	Corrosion of lips, vomiting, dilations of pupils, paralysis, coma, death.	Carbonate of soda or potash dissolved in warm water, or common washing soda well diluted. Milk and eggs freely. Tannic acid or strong tea.
2. Potassium nitrate.	Severe burning pains in abdomen, nausea, partial paralysis, convulsions, collapse.	Stomach pump or emetic. White of egg and water. Olive oil or linseed tea. Patient to be wrapped in hot blankets and limbs kept warm.
23. Potash caustic.	Heat and burning in the throat, extending to the stomach.	Give copious draughts of water containing vinegar, acetic acid, citric acid, or lemon or orange juice.

Polarised Light.—See *Polarisation* under Optics.

Porcelain Paper.—A paper having a prepared surface resembling finely-ground porcelain, and upon which very effective silver prints may be made, as the preparation, although without gloss, serves to keep the image on the surface.

The following instructions for its manufacture have been published.* Any sheet of a good quality of Saxe, Rives, or other photographic paper is coated with a warm solution of gelatine, holding in suspension sulphate of barytes or finely-powdered kaolin. After raising the paper from this emulsion it is suspended in the air until dry, when it is immersed in a solution of alum, tannin or any other substance by which gelatine is rendered insoluble. The body of the paper is thus imbued with the gelatine, and its surface has a fine texture, the pores being all filled up.

When the paper is to be used it is salted by floating it upon a bath of chloride of ammonium and water, about four grains to the ounce of water. In this state it will keep well for many months.

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It is sensitised by being floated upon a bath of ammonio-nitrate of silver. An ounce of the nitrate is dissolved in sixteen ounces of water, and strong ammonia added drop by drop, with constant stirring, until the dark precipitate at first thrown down is just redissolved. Although the way here described is that by which singularly fine specimens have been prepared, yet results indistinguishable from these may be produced by sensitising on a plain nitrate of silver solution, provided that after the paper is dry it is well fumed over ammonia, by which a great degree of richness is imparted to the tone.

After removal from the printing frame the proofs are washed first in plain water and afterwards in water containing a little chloride of sodium, say a grain to the ounce. Then follow toning and fixing, the prints acquiring a fine purple in the gold bath. On removal from the hyposulphite of soda it is recommended to wash the prints in three changes of warm water, followed by a prolonged immersion in cold water.

Porcelain Picture.—Very effective photograph pictures can be made upon porcelain by the collodio-chloride emulsion process (*q.v.*), or by the burnt-in enamel method. Chloride plates are now supplied with a milky or semi-translucent glass as the support, and much resemble porcelain when finished.

Porosity.—A term used to denote the fact that in all matter the constituent particles are not completely contiguous to one another, but separated by intervening spaces or pores. The opposite term to density.

Porotype.—A German method of copying engravings, depending on the fact that those parts of the print occupied by the ink are non-porous. A gas which acts upon a certain chemical agent, and either bleaches or discolours it, is permitted to penetrate a copper-plate engraving, or wood-cut where possible, and coming into contact with suitably prepared paper alters it, a copy of the engraving being thus produced.

Portable Apparatus.—A term given to light, compact photograph apparatus, suitable for tourists or out-door photography.

Portrait Lens.—See **Lens.**

Portrait Studio.—See **Studio.**

Portraiture.—Portrait photography is one of the most difficult branches of the art, and requires considerable experience and artistic culture. Amateur photographers, as a rule, fail in their attempt at this class of work owing to want of experience, and also to want of suitable appliances. Although by judicious manage-

ment fairly good portraits can be made in the open air, or in a well-lighted room, yet the best results are only obtainable in a properly-constructed portrait studio. The advantage of the glass house or studio lies, not only in the fact that a large quantity of light is admitted, but principally in the additional arrangement by means of which the quality and quantity of the light can be regulated and adjusted at the will of the operator. An artist could not easily depict a round ball without suitable shading. A portrait taken in the open usually has this defect, namely the lighting is the same all over the face, causing it to appear flat and pasty in the picture. In the studio, however, the light is thrown more on some portions of the face than on others, so as to give a delicate shading and roundness to the image.

Considerable artistic skill and ability is required in posing the sitter in a natural and pleasing position. There are few photographs in which the sitter does not appear to be aware that he is being photographed, and a most constrained and unnatural effect is the result.

Fairly good portraits may often be made in a well lighted room having large windows preferably facing the N.N.W. or N.E. To avoid too black and white results, a reflector or white screen should be used to light up the side of sitter away from the window.

With regard to the lens most suitable for portrait work, this will be found treated upon under **Lens**.

Rapid plates are the best for this purpose, as the shorter the exposure the less chance the sitter has to move. For very restless subjects a head-rest should be used, but only when absolutely necessary.

Avoid elaborate backgrounds and accessories. With a plain or graduated background the best effects are obtainable. If accessories or scenic backgrounds are to be used they should be in harmony with the subject. No further information upon the subject of lighting and posing can be given, experience and natural ability are required. Several books (notably those by H. P. Robinson) have been published on the subject which the student would do well to follow.

Artificial light is now been employed in portrait photography. Electric light, magnesium light, flashlight and gaslight have all been employed. Electric light is perhaps the most suitable, although the most difficult and expensive to obtain.

The light is usually fixed in the centre of a large parabolic reflector, and thus thrown down on the sitter ; various other reflectors are used to light up the darker parts and prevent too great contrasts. The sitter's eyes must be carefully guarded from the light, otherwise an unnatural expression will be given.

Positive.—The image of an object in which the lights and shades are represented as seen in nature. It is the opposite to a negative.

Positives may be obtained directly in the camera, or from the negative, by a great variety of processes.

In the Daguerreotype and ferrotype processes the images made in the camera appear as positives owing to the dark colour of the support.

If a dry plate be exposed for some length of time more than required to produce a negative, a reversal of the image takes place and a positive is the result, usually very defective, however.

Colonel Waterhouse has recently discovered a most important method of obtaining direct photographic positives upon ordinary silver bromide dry-plates. By the addition of minute quantities of certain derivatives of carbamide (urea) to the developer, a reversed action is obtained, and a positive produced instead of a negative. The process has not as yet been perfected, although, from the results of experiments, there is no doubt that it is only matter of time and careful study.

Potash.—A term applied to the hydrate of potash KHO, but also used to denote potassium oxide, and formerly also carbonate of potash.

Caustic potash is obtained by adding slaked lime to a boiling solution of the potassium carbonate in not less than 12 parts of water, when calcium carbonate is deposited at the bottom of the vessel, leaving potassium hydrate in the clear solution. It is then evaporated, the potassium hydrate remaining as a clear oily liquid, which in cooling solidifies to a white mass. This is the fused potash of commerce. It is generally, however, cast into cylindrical shaped sticks for greater convenience in using. It is very deliquescent, absorbing carbon dioxide from the air. It should therefore be preserved in well-stoppered bottles.

Potassio-ferric Oxalate (Formula, $Fe_2(C_2O_4)_3 \cdot 3K_2C_2O_4$) Occurs in tabular green crystals, which gradually turn brown on exposure to light. It crystallises out of used-up ferrous oxalate developers, and mixed with potassium oxalate forms old platinotype hot bath developers. It is employed in some of the blue or cyanotype printing processes owing to its property of decomposing by the action of light.

Potassio-ferrous Oxalate (Formula, $FeC_2O_4,K_2C_2O_4$).—A reddish-orange coloured liquid obtained by mixing together solutions of ferrous-sulphate and potassium oxalate, and contains potassio-ferrous-oxalate mixed with potassium sulphate. It is a powerful deoxidising agent, and is for this reason used as a developer in the dry-plate process. See **Ferrous Oxalate.**

Potassium (Symbol, K; atomic weight, 39·1).—A monad metallic element discovered by Davy. It is widely diffused through the vegetable, mineral or animal kingdoms. It is usually

present combined with inorganic or organic acids, and when its organic salts are burnt they are resolved into carbonate, from which all the other salts of potassium can be prepared. It is the lightest of all metals save lithium, having a sp. gr. of ·865. It has a light bluish colour; at 0°C. it is brittle and crystalline, at 15°C. it can be cut without difficulty with a knife, at 62·5°C. it is fluid, and at red heat it distils, yielding a fine green vapour. If thrown upon water the metal decomposes it with great violence, hydrate of potassium being formed, while the hydrogen gas, which escapes immediately, takes fire, burning with a red colour. To preserve it in the metallic state it must be immersed in rock oil.

To detect potassium salts, moisten with a drop of hydrochloric acid, and hold on a platinum wire in a Bunsen flame. It colours it violet. Solutions containing potassium give the following reactions: A yellow crystalline precipitate with platinic chloride or with picric acid if the solution be sufficiently strong; a white gelatinous precipitate with silico fluoric acid.

Potassium Aluminium Sulphate (Formula, $Al_2K_2(SO_4)_4 12H_2O$; synonym, *potash alum*).—Found native in Italy and in the South of France. It occurs in transparent irregular crystals, or in a finely-powdered state, soluble in ten times its own weight of cold water. It possesses the property of hardening and rendering gelatine insoluble, and is for this reason much employed in photography. See **Alum.**

Potassium Antimoniate (Formula, $2KSoO_3.5H_2O$). — A granular powder soluble in warm water, employed as a test for sodium, with which it forms a heavy crystalline precipitate of sodium antimoniate, very sparingly soluble in water. The solution for this purpose must be either neutral or alkaline, as acids will decompose it.

Potassium Bicarbonate (Formula, $KHCO_3$; synonym, *hydro-potassium carbonate*).—Often sold as potassium carbonate. It is, however, far less soluble in water, and less alkaline.

Potassium Bichromate.—See **Potassium Dichromate.**

Potassium Bromide (Formula, KBr; molecular weight, 119; synonym, *bromide of potash*).—Prepared in white cubical crystals by the action of bromine on potassium. The usual method of manufacture is by acting on bromide of iron with carbonate of potash, or by adding bromine to caustic potash and heating the product or mixture of potassium bromide and bromate of potash to a red heat until the oxygen is driven off from the latter salt. It crystallises in anhydrous cubes, which are very soluble in water (100 in 75), sparingly soluble in alcohol. It is used in photography in the manufacture of bromide emulsions not containing alcohol.

Its reaction upon silver nitrate is thus expressed, $AgNO_3 + KBr = KNO_3 + AgBr$, potassium nitrate and silver bromide being formed. It is also used as a restrainer in the so-called alkaline developing process.

Potassium Carbonate (Formula, $K\ CO_3$; molecular weight, 136; synonyms, *sub-carbonate of potash*, *pearlash*, *salt of tartar*, *salt of wormwood*, *potash*).—When the ashes of plants are treated with water the salts of potassium are dissolved, those of calcium and magnesium being left. On separating the aqueous solution, and evaporating it to a certain point, much of the potassium sulphate is deposited, it being less soluble. The carbonate remains in the solution, which is evaporated to dryness, when the carbonate is left mixed with potassium chloride and some sulphate. This is largely imported into this country and sold as *potashes*. After undergoing a slight purification process it is sold under the name of pearlash, but is far from being the pure carbonate of potash. A somewhat pure carbonate can be obtained quite free from sulphate, and containing but a trace of chloride.

Potassium carbonate is deliquescent and very soluble in water, but insoluble in alcohol. It is used in photography in developing, and also in the preparation of other potassium salts. It has also been used to free alcohol from the water contained in it.

Potassium Chlorate (Formula, $KClO_3$; synonym, *chlorate of potassium*).—Forms tabular crystals very soluble in boiling, and moderately soluble in cold water. It is used in the platinotype process for increasing the depth of contrast. This it accomplishes by converting a portion of the potassium chloro-platinite into potassium chloro-platinate; this latter is then unacted upon by the ferrous oxalate.

Potassium Chloride (Formula, KCl).—Occurs native as sylvite, and is also obtained from sea-water, and from the refuse of the manufacture of sugar from beetroot. It crystallises in cubes, s very soluble in water, and almost insoluble in alcohol.

Potassium Chloro-platinite (Formula, K_2PtCl_4).—Takes the form of reddish deliquescent crystals, very soluble in water, but slightly in alcohol. It should dissolve in water without any residue and give a neutral solution. Messrs. Pizzighelli and Hübl in their work on the platinotype process give the following instructions for its manufacture:—"Take 50 grammes of platinum chloride (chloroplatinic acid), dissolve in 100 c.c. of pure water, and filter if necessary; then heat to 100°C. in a water bath, and pass through it a strong stream of washed sulphurous acid gas. After a while the yellow liquid will begin to assume the characteristic red colour of the platinous chloride. The liquid has then to be tested from time to time to watch its progress. A little

is taken on the end of a glass rod and mixed with a little ammonium chloride on a watch glass; the presence of any unreduced or platinic chloride is shown by the formation of an insoluble yellow precipitate of chloroplatinate of ammonia. The quantity of this precipitate that is formed should be noted, as one can judge from this of the amount of reduction that is going on. When the precipitate begins to form but slightly, the stream of gas should be checked so as to have the operation well under control, and as soon as the liquid ceases to give a precipitate the gas stopped completely. The reason for this is that if allowed to continue the gas would commence to attack the platinous chloride formed, and further convert it to a platinous sulphide, a salt not reducible by ferrous salts. On the other hand, if the action be stopped too soon, platinic chloride will be left, and in the further operations would be thrown down as an insoluble salt. Hence care is necessary in the above operations.

"The solution that is obtained consists of a mixture of platinous chloride, sulphuric, and hydrochloric acids. To convert this into the double salt it should, after cooling, be poured into a porcelain basin, and a hot solution containing 25 grammes of chloride of potassium in 50 c.c. of water well mixed with it by stirring. The chloroplatinite then separates in the form of a crystalline powder. It is allowed to settle twenty-four hours; the crystalline deposit is collected on a filter, the mother liquor being drained off; it is then washed with a little water, and then a little alcohol, until the last washing gives no acid reaction.

"The powder is now spread out on filtering paper and left to dry in a dark room, as the salt when moistened with alcohol is reduced by the action of light. Salt thus prepared is perfectly pure and can be used at once. 74 or 75 grammes of the double salt should be obtained from each 100 grammes of platinic chloride, this being about 93 per cent. of the theoretical quantity. No effort need be made to obtain from the mother liquor a still further quantity of potassium chloroplatinite."

Potassium chloro-platinite is employed in photography in the platinotype process, owing to the fact that ferrous oxalate reduces it to metallic platinum. The action is thus expressed—

$$6FeC_2O_4 + 3K_2PtCl_4 = 2Fe_2(C_2O_4)_3 + Fe_2Cl_6 + 6KCl + 3Pt.$$

Potassium Citrate (Formula, $K_3H_5C_6O_7$; synonym, *citrate of potash*).—A white semi-crystalline salt, very deliquescent, soluble in alcohol and insoluble in water. It is used as a restrainer in alkaline development, as a preservative of ready sensitised paper, and is generally added to gelatino-citro-chloride emulsions.

Potassium Cyanide (Formula, KCN; molecular weight, 65; synonyms, *cyanide*, *cyanide of potash*).—Prepared by fusing in an iron crucible a mixture of eight parts of well-dried potassium ferrocyanide with three parts of potassium carbonate.

When effervescence has ceased, and the iron which separates has settled down, the clear liquid is poured off on to slabs. On cooling it solidifies, and is broken up into the irregular masses met with in commerce.

The purest form, however, is made by passing vapour of hydrocyanic acid into a solution of potash in absolute alcohol, when the cyanide is deposited in small octahedral crystals.

Commercial potassium cyanide contains about 60 per cent. of cyanide, the rest being cyanate and carbonate. These impurities only serve to lessen its strength and have no injurious effect.

It is extremely deliquescent, it being soluble in its own weight of water. It is insoluble in alcohol. It is one of the most dangerous of poisons. If treated with an acid it gives off hydrocyanide, or prussic acid gas, which, when inhaled, causes insensibility, and has been known to cause death. It should, therefore, be used under all circumstances with extreme caution.

It has several uses in photography, principally as a fixing agent in the wet collodion process, on account of its property of dissolving silver chloride and iodide. It cannot conveniently be used as a fixing agent for dry plates, owing to its disintegrating action upon gelatine. It is not, however, superior to hyposulphite of soda, and is very dangerous. It is further employed for reducing the density of negatives.

Potassium Dichromate (Formula, $K_2Cr_2O_7$; molecular weight, 293; synonyms, *bichromate of potash*, *potassium anhydrochromate*, *red chromate of potash*, *acid chromate of potash*).—The chrome iron ore is first heated to redness and thrown into water; it can then be easily ground to a fine powder, which is mixed with potassium carbonate and a little chalk added. This is strongly heated in a current of air, constantly stirring the mass. On afterwards heating the mass with water a yellow solution of potassium chromate is obtained, which is then drawn off from the insoluble residues and mixed with a slight excess of nitric acid. The solution when evaporated deposits beautiful red tabular crystals of potassium dichromate. It is soluble in about ten parts of water or alcohol at 60° F.

Potassium dichromate is of great commercial importance. In photography it is also largely employed. It has been discovered that when in contact with gelatine or other organic matter it is decomposed by light, and renders the gelatine or other organic soluble body insoluble, and incapable of absorbing water.* This important property is the foundation of a very large number of photo-mechanical printing processes, and also of several other processes, such as the carbon process, powder process, etc. It is stated that papers prepared with potassium dichromate and silver

*According to Dr. Eder, the insoluble gelatine is an unstable compound of unaltered gelatine and chromous chromate, potassium chromate being simultaneously formed.

nitrate have given images varying in colour from red to green and blue.

Potassium dichromate is not a true acid salt, for it contains no hydrogen. It is sometimes termed anhydro-chromate, and written $K_2 Cr O_4 . Cr O_3$

Potassium Trichromate (Formula, $K O.3CrO_3$) has been obtained in red crystals by the addition of nitric acid to the dichromate.

Potassium Ferridcyanide (Formula, $K_4Fe_2 (C_6N_6)_2$; molecular weight, 658; synonyms, *potassium ferricyanide*, *red prussiate of potash*).—Prepared by the action of chlorine gas upon potassium ferrocyanide. The gas is passed into the solution of ferrocyanide until a little of the solution tested with ferric-chloride no longer gives a blue precipitate. The resulting solution is then crystallised. Potassium ferricyanide takes the form of deep red crystals, soluble in water but sparingly in alcohol. It is used in reducing the density of gelatine negatives and in the cyanotype printing process.

Potassium Ferrocyanide (Formula, $KFeC_6N_6 3H_2O$; molecular weight, 422; synonym, *yellow prussiate of potash*).—Prepared by heating nitrogenous matter, such as hoofs, horns, etc., with pearlash and iron filings, the resulting mass being dissolved in water and evaporated. It crystallises in large yellow powdered pyramids soluble in twice the weight of boiling, and four times the weight of cold water. It is insoluble in alcohol. An aqueous solution turns a dark yellow if exposed for any length of time to the air, oxygen being absorbed, and small quantities of potassium ferricyanide produced. It is non-poisonous alone, but acids will change it into a very violent poison. The addition of a small quantity to the carbonate developer has been recommended by Professor Newton. According to E. J. Wall, it has an almost unique effect on the negative, preventing fog, and giving a clear black image, and brilliant and sparkling negative.

Potassium Fluoride (Formula, KF).—Prepared by neutralising hydrogen fluoride with potassium carbonate. Formerly used in photography in the iodising solution for waxed papers. It corrodes glass, and must therefore be kept in a gutta-percha or platinum vessel.

Potassium Iodide (Formula, KI; molecular weight, 166; synonym, *iodide of potash*).—Prepared by adding small quantities of iodide to a solution of potash until it has a slightly brownish colour. This is then evaporated to dryness, and the residue mixed with one-tenth of its weight of powdered charcoal, and thrown into a red-hot iron crucible, and fused to decompose any iodate of potash that may be formed. The mass obtained is dissolved in hot water, filtered, evaporated until a thin film makes its appear-

ance on the surface, and set aside to crystallise. It crystallises both in cubes and prisms, which are anhydrous and extremely soluble in water and slightly in alcohol.

Commercial iodide of potassium often contains carbonate, sulphate and iodate as impurities. It can be purified by re-crystallising it from spirit, or by dissolving in alcohol of ·805, as in this the impurities mentioned are insoluble.

Iodide of potassium was formerly much used for iodising papers for the calotype and waxed paper processes, and also for collodion. For the latter, however, it is much inferior to the other iodide. Its chief use at present is in the manufacture of some kinds of gelatine emulsions to form silver iodide. Its action may be stated thus—

$$KI + AgNO_3 = AgI + KNO_3$$

Potassium Metabisulphite (Formula, $K_2S_2O_5$; synonym, *metabisulphite of potash*).—Obtained in clear transparent crystals, having an odour of sulphur dioxide. It is soluble in three times its weight of water, but insoluble in alcohol. If treated with an excess of hydrochloric acid it should give but a very faint precipitate with barium chloride.

It has recently been recommended for the same purpose as served by sodium sulphite, *i.e.*, as a preservative of solutions of pyrogallol, quinol, eikonogen, etc.

Potassium Nitrate (Formula, KNO_3; molecular weight, 101; synonyms, *nitrate of potash*, *nitre*, *saltpetre*).—Found in the soil of India and other hot countries during the dry season. It can also be made artificially by decomposing sodium nitrate with potassium chloride. It occurs either in white crystalline masses or prismatic needles soluble in about half its weight of boiling, and in four times its weight of cold water. If quite pure it should not be precipitated either by silver nitrate or barium nitrate, proving the absence of both chlorides and sulphates.

Potassium nitrate is used in photography for the manufacture of nitric acid and of pyroxylin; for the latter purpose it should be as pure as possible, and entirely free from any chlorides.

Potassium Nitrite.—(Formula, KNO_2; molecular weight, 85).—Prepared by fusing potassium nitrate in a fireclay crucible and heating to redness, when oxygen is given off, and it slowly becomes converted into potassium nitrite. It is a very deliquescent

Potassium Oxalate.—(Formula, $K_2C_2O_4$; molecular weight, 164; synonym, *neutral oxalate of potash*).—Prepared by neutralising oxalic acid with caustic potash or potassium carbonate. Obtained in white crystalline masses or in powder. As it is always used in the liquid state, the following simple method for preparing it in that form will be found useful: Dissolve 26 ounces

of potassium carbonate in 60 ounces of water, and very slowly add about 18 or 19 ounces of oxalic acid till, after boiling, the solution is neutral to test paper. Filter and add water until the whole measures 128 ounces, when a 25% solution is then obtained.

Potassium oxalate is soluble in about three parts its weight of water. It sometimes contains sodium oxalate, which may be detected by moistening a little of the salt with strong sulphuric acid, evaporating in an open dish to complete dryness, then gently igniting until fumes cease to be evolved, and again moistening the cold residue with hydrochloric acid. By dipping a platinum wire in the mixture and holding it in a flame of a Bunsen burner, the colourless flame will turn yellow if sodium be present.

C. J. Leaper, F.C.S., in his "Materia Photographica," says:—"Care should be taken in purchasing this oxalate from druggists that potassium binoxalate or salt of sorrel (KHC_2O_4) is not substituted for it. This may be distinguished from potassium oxalate by its inferior insolubility (1 in 40). In the event of a mistake having been made, salt of sorrel can be converted into the photographically useful oxalate by neutralising it with potassium carbonate, thus:—$2KHC_2O_4 + K_2CO_3 = 2K_2C_2O_4 + H_2O + CO_2$."

Potassium oxalate is much used in photography as a solvent of ferrous oxalate for use as a developer for silver bromide and silver chloride plates and papers, and also as a developer in the platinotype process.

Potassium Oxide.—Potassium forms three oxides—(1) Protoxide, K_2O; (2) dioxide, K_2O_2; and (3) tetroxide K_2O_4.

Potassium Permanganate (Formula, $KMnO_4$; molecular weight, 158; synonym, *permanganate of potash*).—Prepared by mixing together four parts of finely powdered manganese dioxide and $3\frac{1}{2}$ parts of potassium chlorate and five parts potassium hydrate dissolved in a little water. The pasty mass formed is dried and heated to dull redness in an earthen crucible. The potassium chlorate gives the oxygen required. The cold mass is afterwards treated with cold water, when the potassium manganate is dissolved, forming a dark green solution. This is diluted with water, and a stream of carbonic acid gas passed through it until no further change of colour is observable. The precipitated manganese dioxide is permitted to settle, and the clear red solution decanted and evaporated to a small bulk. On cooling, it deposits prismatic crystals of permanganate, which are red by transmitted light, but reflect a dark green colour. The potassium carbonate remains in the solution.

Permanaganate of potash is soluble in 16 times its weight of cold water, but insoluble in alcohol. It is used in photography for intensifying wet plate collodion negatives, the silver image being first converted into silver iodide. It is further employed as a test

for hypo, and to improve old wet collodion silver baths by oxidising the organic matter in them. It is also a remarkable disinfectant, and, sold under the name of "Condy's Fluid," is largely used for deodorising solid or liquid substances.

Potassium Sulphide (Formula, K_2S_3; synonyms, *potassium trisulphide*, *sulphide of potash*, *liver of sulphur*).—A liver-coloured, deliquescent, amorphous mass, soluble in water, obtained by heating together sulphur and carbonate of potash. It is used in photography to precipitate black silver sulphide from old fixing solutions. The latter must not contain any alum, however, otherwise it would be precipitated with the silver sulphide.

Potassium Sulphocyanide (Formula, KCNS; molecular weight 97; synonyms, *potassium thiocyanate*, *potassium sulphocyanate*, *sulphocyanide of potash*).—Forms colourless crystals easily soluble in water and alcohol. It is used in the toning processes, and has been recommended as a developer in the carbon process owing to its property of dissolving gelatine. It is a highly poisonous salt, and should be used with extreme caution.

Powder Process, also known as the "dusting on" process.—A method of producing photographic images in any colour upon paper, glass, metal, or other supports. The principle of the process is this: An organic tacky substance is sensitised with potassium dichromate, and exposed under a reversed positive to the action of light. All those parts acted upon become hard, the stickiness disappearing according to the strength of the light action, while those parts protected by the darker parts of the positive retain their adhesiveness. If a coloured powder be dusted over it will be understood that it will adhere to the sticky parts only, forming a visible image, the same being a reproduction of the positive printed from. The process is very useful for the production of lantern slides and transparencies, or for the reproduction of negatives. Any of the following formulæ may be employed for the manufacture of the organic substance:—

SOLUTION A.

Gum arabic	25	grammes
Grape sugar	50	,,
Purified honey	15	,,
Alcohol 40°	15	c.c.
Water	60	,,

SOLUTION B.

Saturated solution of ammonium dichromate.

Two solutions to be mixed together before using in proportions 15 A, 25 B, 50 water.

WOODBURY'S FORMULA.

Gum arabic	60	grains
Glucose	45	,,
Glycerine	10	minims
Potassium dichromate	30	grains
Distilled water	2	oz.

OBERNETTER PROCESS.

Dextrine	60 grains
White sugar	75 ,,
Ammonium dichromate	30 ,,
Glycerine	2 to 8 minims
Distilled water	3 oz.

The gum is first dissolved and the remainder of the ingredients added. It may be necessary to warm the solution in a hot water bath to dissolve it. It is then filtered through flannel or clean muslin, and preserved for use in well-stoppered bottles. With this solution clear glass plates are coated and dried by a gentle heat over a small spirit lamp. The plate while still warm is exposed under a reversed positive* for from two to five minutes in sunlight, and from 10 to 20 minutes in diffused light. The image is then but slightly visible. On removing from the printing frame the plate is laid in the air (protected from light) for a few minutes to absorb a little moisture from it. The next process is the "dusting on." If the image is required to be black, fine Siberian graphite is spread over it with a soft flat brush. This will adhere to the parts unaffected by light, giving an image of the positive. Any coloured fine powder may be used, giving images in various colours. When fully developed the excess of powder is dusted off and the film coated with collodion. After this it is well washed to remove the unaltered gum and dichromate salt. The film may, if desired, be detached from the plate and used for enamels, ivory, wood, textile fabrics, opals, etc.

By the above process it will be seen that to obtain a positive we require a positive. Mr. G. W. Wood has recently patented a method of producing positives from negatives by this method. The principle of the process consists in using a black or dark coloured material, such as ebonite, vulcanite, ferrotype plates, or glass coated with a black or dark coloured varnish as the support or ground, and dusting on a suitable lustrous substance, such as white gold or other light-coloured bronze powders or aluminium, magnesium, zinc, tin, silver, or other suitable metal or alloy reduced to powder.

It is obvious that if the ground be dark and the bronze powder be light we get the opposite effect to that obtained with a light ground or support and a dark coloured powder. By this means we are therefore able to get a positive (viewed by reflected light only) from a negative.

Precipitation.—Solid matter thrown down from a state of solution by the action of heat, light or chemical reagent, is termed a precipitate.

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* Reversed as regards right and left.

Prescription (Lat. *præscriptionem*).—A medical recipe. The following explanation of the different signs used in writing prescriptions may often be found useful :—

Quantity.	*Sign.*	*Quantity.*	*Sign.*
½ grain ..	½ gr.	1 drachm ..	ʒi or ʒj.
1 grain ..	gr. j or gr. i.	1½ drachm ..	ʒiss.
1½ grain ..	gr. iss.	2 drachms ..	ʒii or ʒij.
2 grains ..	gr. ii or gr. ij.	3 drachms ..	ʒiii or ʒiij.
2½ grains ..	gr. iiss.	3½ drachms ..	ʒiiiss.
4 grains ..	gr. iv.	7½ drachms ..	ʒviiss.
8 grains ..	gr. viii or gr. viij.	½ ounce ..	℥ss.
½ scruple ..	℈ss.	1 ounce ..	℥i or ℥j.
1 scruple ..	℈i or ℈j.	1½ ounce ..	℥iss.
1½ scruple ..	℈iss.	½ pint. ..	Oss.
2 scruple ..	℈ii or ℈ij.	1 pint. ..	O.

Preservative.—An erroneous term applied in the dry-collodion process to substances used to give density and transparency to the negative and to cause the film to adhere. The principal requirements in a preservative are thus stated by Abney :—First, it must be an iodine or bromine absorbent, for without this quality the film manifestly might be insensitive; secondly, it must be capable of filling up the minutest pores of the collodion, so that on re-wetting after drying it may give access to the developing solution ; and thirdly, it must act as a protective varnish against the atmospheric influences.

The action of the preservative is chiefly to absorb the iodine and bromine liberated by the action of light from the silver iodide and bromide present in the film.

The following are a few of the best known preservative solutions :—

No. 1.

Tannin, pure	10 to 15 grains.
Water (distilled)	1 ounce.

No. 2.

Gum arabic	90 grains.
Sugar candy	20 ,,
Water (distilled)	5½ ounces.

No. 3.

Coffee (Mocha)	½ ounce.
White sugar	90 grains.
Distilled water (boiling)	5½ ounces.

No. 4—Sol. A.

Gum arabic	20 grains.
Sugar candy	5 ,,
Water	6 drachms.

Sol. B.

Gallic acid	3 grains.
Water	2 drachms.

Sol. B is prepared by heat, and mixed with sol. A. (See also **Collodion Process, Dry.**)

Preservative for Sensitised Paper.—It is well known that albumen paper, sensitised with silver, will not keep for any length of time. Various preservatives have been recommended to improve this. The commonest consists of an addition of citric acid to the silver bath. The sensitising bath then reads :—

Silver nitrate	60 grains
Citric acid	25 ,,
Water	1 ounce.

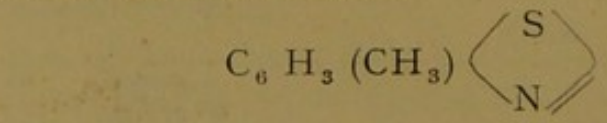
Paper thus prepared will keep for months. Debenham advocates the addition of 10 drops of pure perchloric acid to each fluid ounce of the silver bath instead of the citric acid. Commercial sensitised paper is usually silvered with an ordinary bath, and the paper afterwards floated on a preservative solution of—

Citric acid	1 oz.
Tartaric acid	1 oz.
Water	30 ozs.

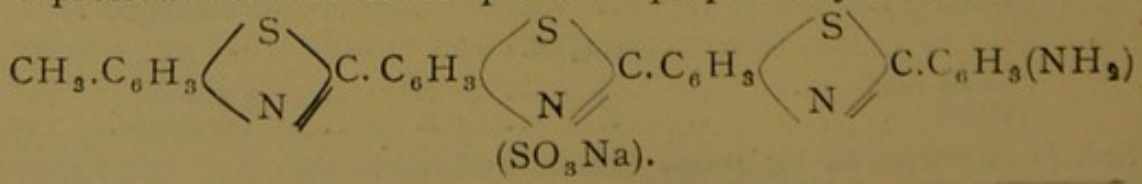
Pressure Frame.—A printing frame adapted for printing from the negative on paper, glass and other substances, so called because the back portion is so arranged that it presses the paper and other material well into contact with the negative. If this is not the case the image will appear blurred in parts, and will be likely to shift during the printing operations.

Primuline Process.—A recent process invented by Messrs. Green, Cross and Bevan. It is better known, however, as the "Diazotype process." The following description of it is partly taken from a lecture given by the inventors* :—

This process in reality consists of a new application of a group of coloured compounds, of which the dyestuff known as primuline is the typical representative. Primuline is the sodium sulphonate of a complex amido base, which is obtained by heating para-toluidine with sulphur. Its formation is preceded by that of dehydrothiotoluidine, a body which appears to be an amido-benzenyl-amidothiocresol.



and primuline base appears to result from a further condensation of this compound, and to differ from it in the same way that dehydrothiotoluidine itself differs from para-toluidine. This view is expressed in the fomula for primuline proposed by Gattermann.



* From the "Journal of the Society of Chemical Industry," 29th November, 1890.

Homologues of primuline closely similar to it in properties are similarly obtained from metaxylidine and pseudo-cumidine.

The special photographic application of this group of colouring matters to be described depends firstly upon the sensitiveness to light of their diazo-derivatives, this sensitiveness being increased in a very remarkable degree by combination with the complex colloids which constitute the textile fabrics. The actual photographic agent is the diazo-primuline, in which form the image is produced, and the development of the image consists in its conversion into any of the colouring matters obtainable by combination with phenols and amines. It will be obvious that the images produced will be positives.

In printing upon textile fabrics the material is first dyed with a hot solution of primuline, to which some common salt may be added. About fifteen to thirty grains of primuline are added to about a gallon of hot water. In this solution the fabric acquires a primrose-yellow colour. It is then washed in cold water, and afterwards diazotised by immersion for about half a minute in a cold solution of sodium nitrite ¼ per cent., which has been sharply acidified with hydrochloric, sulphuric or other acid. The material is now washed in cold water and stretched out on a level white surface, and exposed to light beneath the object of which it is required to produce a positive reproduction. It is, of course, possible to print from ordinary photographic positives or from natural objects or from any painted, printed or photographed design or picture upon any sufficiently transparent material. Either sunlight or an artificial light of sufficient intensity may be employed, the time of exposure, of course, varying with the intensity of the light. In printing by daylight it varies from half a minute in bright sunshine to half an hour or so in very dull weather.

When the decomposition of the diazo compound in the high lights of the picture is complete (which can easily be ascertained by means of a test slip exposed simultaneously, and touched with a solution of β-naphthol, at intervals) these portions will be found to have changed from an orange to a pale yellow. The material is now either passed into the developing bath at once or is kept in the dark until it is convenient to develop the image. The developing bath consists of a weak solution (about ¼ per cent.) of a suitable phenol or amine, depending upon the colour in which the design is to be produced. The following phenols and amines, amongst others, have been found to give good results :—

For Red, an alkaline solution of β-naphthol.

For Maroon, an alkaline solution of β-naphthol disulphonic acid.

For Yellow, an alkaline solution of phenol.

For Orange, an alkaline solution of resorcin.

For Brown, a slightly alkaline solution of pyrogallol, or a solution of phenylenediamine-hydrochloride.

For Purple, a solution of α-naphthylamine-hydrochloride.

For Blue, a slightly acid solution of amido-β-naphthol- -sulphonate of sodium (eikonogen).

If the design is required to be produced in two or more colours the respective developers suitably thickened with starch, if necessary, may be applied locally by means of a pad or brush. After development, which with cotton is complete in less than half a minute, the material is washed, and the picture requires no further fixing. In the case of the purple and blue developers it is necessary to wash the material finally in a very weak solution of tartaric acid. It is sometimes advantageous to heat for a few seconds in a hot soap bath.

Velveteen, linen, silk, wool, and other fabrics may be treated in the same manner except that in the case of wool and silk a longer exposure to light is necessary, and the immersion in the nitrite and developing baths must also be more prolonged. The maroon and blue developers are not suitable for silk and wool.

Architectural and engineering drawings can be copied with clearness and accuracy upon paper or calico which has been dyed with primuline diazotised and dried. The diazo-paper for this purpose can be kept in the dark for some time without undergoing decomposition. The copy is developed by brushing over the surface a solution of β-naphthol or α-naphthylamine.

Transparent photographic pictures can be produced upon glass by coating it with a film of gelatine containing primuline, then diazotising with nitrous acid, printing, say, from a carbon or a silver positive, and developing as before. In all the above applications the primuline may be replaced by its higher homologues already mentioned, and for producing designs upon silk dehydrothiotoluidine sulphonic acid, and its homologues may be employed, which are equally sensitive to light.

The above-described process is probably the first which has been devised in which derivatives of the aromatic hydro-carbons are employed for the production of a *positive* image capable of development in colour.

A process was recently invented and patented by A. Feer,* based upon the fact that when the diazo compounds are treated with an alkaline bisulphite they are converted into the diazo-sulphonates.† These compounds are sensitive to light, the action of which is to set free the diazo group from its combination, but they do not react with phenols and amines as do the diazo compounds. The mixture of a diazo sulphonate with the latter is unattended by any colour reaction, but on exposure to light, the diazo group being set free in presence of a phenol, the development of an azo colour takes place *pari passu*. The photographic surface is a mixture of a diazo-sulphonate with the alkali compound of a phenol applied to any suitable material. On exposure to light under a transparency development of colour takes place in proportion to the quantity of light transmitted, giving,

* German patent No. 53,455/ga.

† "Photography in Aniline Colours," by A. G. Green, C. F. Cross, and E. J. Bevan.

therefore, a reversed reproduction or negative picture. When printed the unattacked mixture is dissolved away by copious washing, leaving the picture already developed in the azo colour permanently fixed upon the fabric or material.

It will be seen that this latter process is in point of simplicity inferior to the primuline process, nor are the results superior. The primuline process can be adapted to a very large number of uses. No technical knowledge is required. The description of the process already given will be found sufficient. Most delicate pictures can be printed upon all kinds of materials, either from photographic positives or from natural subjects, such as fern leaves, &c. It also bids fair to supersede the old blue process for the reproduction of maps, drawings, etc. The images obtained will resist the action of hot soap and water. They are also exceedingly fast to light.

Principal Axis.—The right line which joins the centres of curvature of the spherical surfaces of a lens. If one surface be plane, however, the principal axis will pass through the centre of curvature of the spherical and perpendicular to the plane surface.

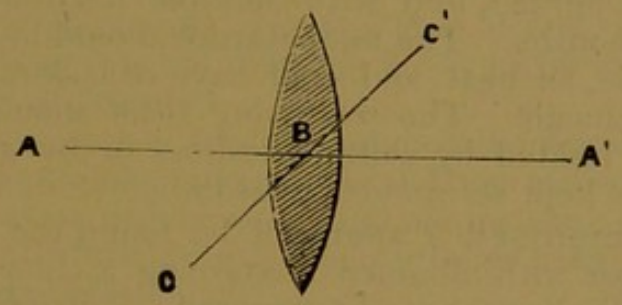


Fig. 182.

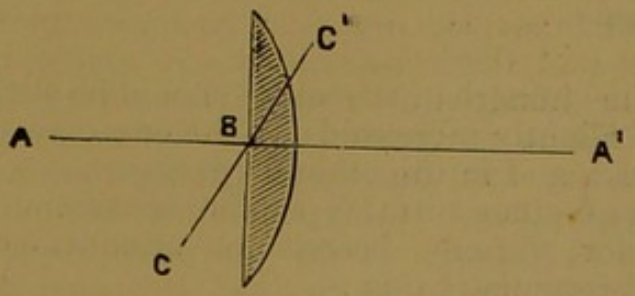


Fig. 183.

In figs. 182 and 183, A A′ are the centres of curvature, or, in other words, the points from which the axis of the circles forming spherical surfaces are calculated. A B A′ is the principal axis A straight line passing through the optical centre and making an angle with the principal axis is termed the secondary axis C C′.

Principal Focus.—See **Focus.**

Print Hanger.—A small contrivance for hanging up prints that cannot be dried between blotting boards.

Printer's Indicator.—A small brass instrument that can be attached to printing frames. It contains two dials with figures, and two movable hands; one hand indicates the number of prints required from the negative, and the other the number already printed.

Printing.—This term is applied to a very large variety of methods of obtaining positive pictures from the negative on to paper, glass, wood fabrics, and other suitable materials. The principal process of positive printing is that known as the albumenised paper process, and it is that method which will be treated upon here. The other methods of printing upon bromide, platinotype, gelatino-chloride, and other papers, as well as upon glass, wood, silks, etc., are all treated upon under their respective headings.

The Printing Room.—This should be as large as possible, well ventilated, well lighted, and with suitable heating arrangements for the winter months. The temperature should be kept as nearly even as possible, as heat and cold have considerable effect upon paper and chemicals. The *sensitising room* should also be well ventilated and lighted by yellow windows or by gaslight. Both rooms should be kept scrupulously clean.

Under **Albumenised Paper** will be found the method of preparing the paper with albumen containing a chloride. This can be, and is, usually bought ready prepared. The next process is to sensitise it by floating on a bath of silver nitrate. The usual bath is made up as follows:—*

Silver nitrate	40 grains
Water	1 ounce

In summer the strength of the silver should be slightly decreased, and in winter slightly increased; in the one case 35 grains to the ounce being used, and in the other 45 grains.

The addition of other nitrates to the sensitising bath is often recommended for various brands of albumenised paper. commonly used formula is this :—

Silver nitrate	40 grains
Ammonium nitrate	20 ,,
Water	1 ounce

To this a few drops of ammonia are added till the solution is slightly alkaline. To the same bath the addition of five grains of lead nitrate has also been recommended.

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* See **Silver Bath.**

On this bath the paper is floated for from forty to eighty seconds in the summer, and from seventy to 120 seconds in the winter, and afterwards hung up to dry. For further details of the sensitising manipulations see under **Sensitising.**

The Drying Room should be kept quite clean, and heated with a small stove, over which should be hung a rack fitted with wooden clips to suspend the paper. Drying the paper spontaneously is undoubtedly a mistake, as the silver then sinks into the paper, and the brilliancy of the surface is lost.

Fuming.—Before printing many operators subject the sensitive paper to the fumes of ammonia. By this means much richer and finer tones are obtained. The paper is placed in a box having a false bottom perforated with holes, and beneath which is laid a tray containing strong liquor ammonia. It is very necessary that the fumes be equally distributed on the paper to avoid patchy and unequal prints. In damp weather it may be found advisable to slightly dry the paper before fuming.

Cutting the Paper.—This is best done with an ivory paper-cutter. Many operators cut the print to the exact size required for the finished print. This is not advisable, however, as the subsequent operations will very often destroy or mar the edges, and much loss is sustained in consequence. Never try to secure too many prints from one sheet of paper, but allow of a comfortable margin above the size of the print required.

The Negative.—Before attempting to make prints from a negative it should be carefully studied, and the best method of treatment thought out. Thin negatives should be printed in a soft, weak light. A piece of white tissue paper stretched over the frame will secure the required effect.

Weak, flat negatives should never be printed from unless necessary. They can sometimes be improved by coating the back with a varnish tinged with iodine. The varnish is then scraped away behind those parts required to print deeper, and those parts required to print lighter may be treated with the pencil or Indian ink. Another method is to paste a piece of tissue paper behind and work upon it with the pencil. A strong bath should be used in sensitising, and the time of fuming doubled. By printing under green glass greater contrast is obtained. See **Green Glass.**

Dense negatives with strong lights and black shadows, with little gradation between the two extremes, should be printed in a very strong light, preferably sunlight. It is also advisable at times to slightly expose the paper to light to soften the glaring high-lights.

Broken negatives should be carefully put together, and a piece of unsalted paper glued firmly to the glass side. When dry the paper will contract slightly and draw the parts closely together. In printing, the frame is laid on a board, kept revolving by means of a meat-jack or other contrivance, so that the light does not

come from one side only. The paper can be made translucent by any of the known methods.

Filling the Frames.—There are two methods of laying in the negative; it can either be placed directly in the frame, or made to rest on a thick piece of plate glass previously inserted. This glass must be kept thoroughly clean on both sides. The negative must also be dusted on the film side and well cleaned at the back; all pieces of emulsion and other foreign matter carefully removed.

The description and illustration of the printing frame is given under that heading.

Every care must be taken to guard against breakage of the negative. This can easily be effected by many ways—by dropping carelessly in the frame, warpage of the wooden frame, unequal padding or backing, improper placement of the backboard, pieces of grit or other substances between the negative and the glass plate.

After placing the negative in the frame the sensitised paper is laid on it in the required place. This can be ascertained by holding the negative and paper up to the light while adjusting the latter in position.

Behind the paper pads of blotting-paper or felt cloth are placed to ensure even contact of the paper with the negative. This should not be too thick or uneven. The backboard is then inserted, and should fit properly, and the pressure given by means of the springs or wedges should be perfectly even all over; not too strong, or the glass may break, but sufficient to hold the paper firmly into place and prevent it slipping when examining.

The cutting of the paper, filling the frames, and the examination of prints should all be carried on in a weak or yellow light.

Except in exceptional cases, as, for instance, with dense negatives, the exposure should be made in a bright light, but not sunlight. Care must be taken to protect the frame from shadows, stray lights, or reflections.

After a little time the frame should be carried into the weak or yellow light, and the print examined by turning back half the backboard and carefully lifting up the sensitised paper. This operation is repeated at intervals until the print is finished. In examining prints never expose them to direct light, or the purity of the lights will be ruined.

The colour of the print should be darker than required for the finished picture to allow for the loss which takes place in the subsequent operations. Experience alone will guide the operator in judging the right time to remove the print from the printing frame, as, to a certain extent, it depends upon the kind of toning bath used, some reducing the colour of the image more than others.

Vignetting, *Combination Printing*, &c., will be found under those headings.

Printing Frame.—A frame in which the sensitive surface of the paper is pressed into close contact with the face of the negative while it is being exposed to the light.

The ordinary printing frame consists of a wooden box-shaped frame, having a hinged lid to allow of the examination of the picture during the printing process. (See fig. 184.) In choosing a

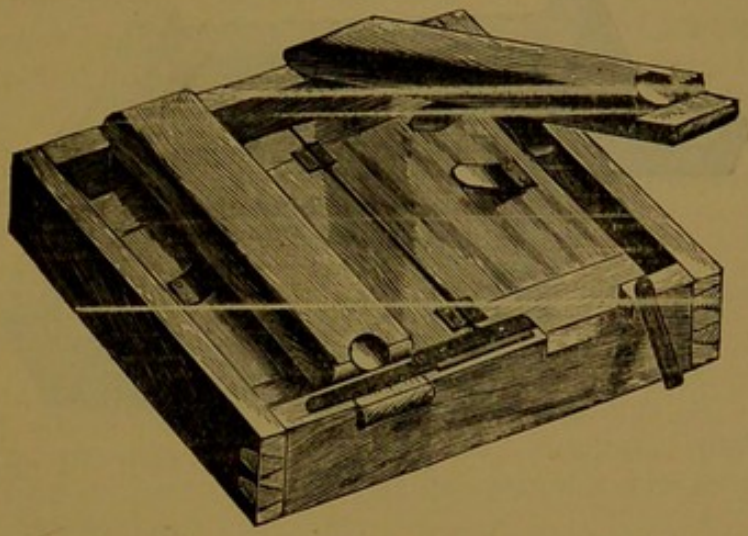

Fig. 184.

frame the points to be observed are—First, that it is carefully made and perfectly square and true, otherwise the negative is liable to get broken when the pressure is put on. Secondly, the back should be hinged perfectly level, the joint allowing of no light to pass through. Lastly, it should be so arranged that there is no fear of the print or the negative shifting during any of the operations.

Durnford's frame is a very light and handy contrivance; it consists of a hinged backboard only, the negative being kept into position by springs.

In printing out upon glass or opals a specially constructed frame is required. A clever contrivance is that devised by Cowan. It is a frame made specially for the printing out opal, which is required to be examined during the progress of printing without fear of movement. It is also provided with a simple means of adjustment to allow for the various thicknesses of opal plates and negatives without fear of breakage. For the printing of transparencies, provision is made for the inspection of same during printing through the opal. The frames are supplied with opaque masks, square and oval, to which the negatives are attached, and these are held in position in the frame by means of a hinged bar of wood and brass spring. The mask also serves to prevent the deep printing of the margins of the negative, which take up so much

gold in toning. To attach the negative to the mask use a daub of the wax compound at the corners, and then lay on it the opal plate; and on its four corners at back also daub the wax. The hinged back is then shut down, and the composition causes the opal to adhere to the back of the frame; thus it can be lifted to allow of examination during printing.

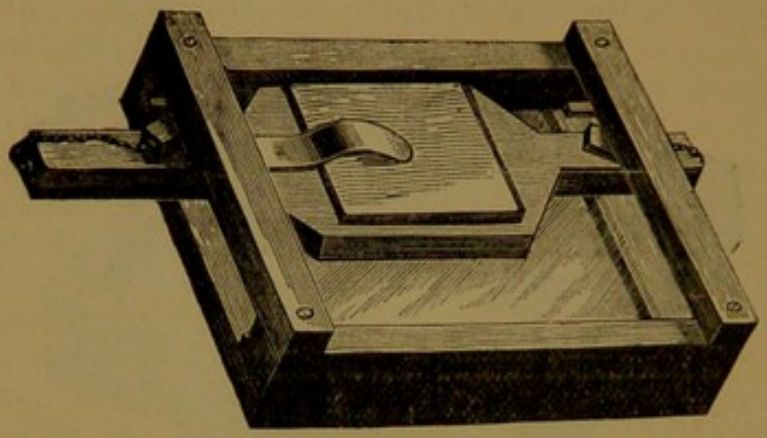

Fig. 185.

For printing lantern slides from large negatives by contact, a frame constructed by Messrs. Adams & Co. is probably the simplest and handiest form. Fig. 185 will show the plan adopted, whereby any part of the negative can be printed from, and not only any part but any angle. Two other advantages are, no risk of breaking the negative, and by means of wedges many slides may be made exactly the same as each other.

Printing In.—A term used in combination printing when clouds, figures, etc., are afterwards added or printed in, the spaces for their insertion having been previously masked out.

Printing Ink.—A compound of linseed oil and lamp or ivory black. The oil is boiled, the lamp black and other ingredients added, and the compound ground. There are a great variety of recipes.

Printing Out.—A term applied in photographic printing to those processes on which the image is entirely produced by the action of light in contradistinction to other processes in which the image is either invisible or but slightly visible, and is afterwards completed by development.

Printing Room.—See Printing.

Prints, Colouring.—See Photographs, Painting.

Print.—A positive image obtained either directly or indirectly from a photographic negative, as silve-rprint, Woodbury-print, etc.

Print Trimmer.—See **Knife.**

Print Washer.—See **Washing.**

Prism (Lat. *prisma*).—Any transparent medium comprised between plane faces usually inclined to each other. The prism generally used for optical experiments is a right triangular one o glass, the principal section of which is a triangle. It is used to refract and disperse light. If a ray of white light be passed through it is resolved into its component colours (see **Spectrum**). A prism is also used in photography for producing reversed negatives (see **Reversed Negative**).

Prismatic Colours.—The colours into which a ray of light is decomposed by passing through a prism.

Process Blocks.—Printing blocks obtained by the aid of photographic processes. The following excellent instructions for the production of half-tone or nature process blocks are given by Mr. W. T. Wilkinson* :—

"For the production of half-tone process blocks the most important accessory is the ruled sheet from which the framed screen is made. This ruled sheet is a print made from a steel or copper plate ruled by a special machine with from 100 to 120 lines to the inch. These plates should not be less than 15 inches square, and are preferably 24 inches square, but these large sizes are very difficult and costly to procure; still, if the process has to be worked, the cost must be faced. The ruled sheet, with every line perfect, is carefully mounted upon a sheet of smooth cardboard, and from it a number of negatives are made of varying sizes, the cross-line being obtained by a double exposure, turning the ruled sheet half round between the two exposures. These negatives must be perfect throughout, and carefully intensified so as to have the maximum of density with perfectly clear lines. They must be *absolutely sharp* from centre to edge, consequently a rectilinear lens must be used, and a very steady camera; single or portrait lenses or light out-door cameras cannot give the requisite class of result. The wet-collodion process or Mawson's photo-mechanical dry plates may be used, but to use the ordinary dry plates of commerce will be only waste of time and material. These negatives, once obtained, must be carefully varnished, and as carefully preserved, as from them the screens are made by contact printing in the camera. The screens are not intensified, but are developed up to the various degrees of density required to suit any picture to be reproduced.

*Photography, January 1st, 1891.

"The grained negative is made in two ways. First, by copying a print, placing the screen in front of the sensitive plate during exposure in the camera, and using a reversing mirror behind the lens to get a reversed negative. Second, is to use a transparency with the screen in contact therewith in the enlarging camera, the reversal of the negative being obtained by putting the transparency in its holder with the film next the lens (for a carbon), and away from the lens when a contact dry-plate transparency is used. The screen may be used in contact with or close to the sensitive plate, instead of in contact with the transparency, and in dull weather this plan is the best, as when the screen is in contact with the transparency a smaller stop must be used to get the lines sharp than is necessary when the screen is close to the sensitive plate. The grained negative must not be intensified, or the lines and half-tones will be blocked up.

"The negative obtained, a print from it is made upon zinc, very highly polished with fine emery, followed by stick charcoal, then coated in a whirler with prepared bitumen dissolved in benzole or in chloroform. The film must be very thin, and spread perfectly even. With the benzole a whirler is absolutely necessary, as it is impossible to get an even film without it, but when chloroform is used a whirler may be dispensed with, as the solvent evaporates so rapidly that after wasting a few shillings worth of chloroform sufficient dexterity may be attained to coat a plate evenly without the whirler.

"The prepared bitumen is obtained by washing the ordinary asphaltum of commerce in from four to six changes of methylated ether, then drying the residue, half an ounce of which, dissolved in 20 ounces of benzole or chloroform, will give a coat of the requisite density. The bitumen solution must be filtered each time it is used, and as the solvents are very volatile, fresh must be constantly added to keep the solution at its normal strength.

"The exposure should be made to direct sunlight in a printing frame, fitted with screw pressure, so that absolute contact is got between negative and zinc plate. The exposure will be from thirty minutes to three hours, and can only be accurately got at by practice and observation.

"To develop the image, when the solvent used is benzole immerse the plate in a dish of turpentine and rock gently till the operation is complete, but when chloroform is the solvent the plate is held in the hand and flooded with the turpentine, when the image at once flashes out. Wash under the tap, then blot off the water, and if the image is clear from bitumen in the half-tones and dots, the plate is at once put into a mixture of nitric acid and water, the mixture tasting just like good vinegar does. If the whole of the bitumen is not dissolved from the half-tones and dots, more turpentine must be applied, either all over or locally, but do not rub the image, as until washed it is not strong enough to stand

any rubbing. When benzole is used as the solvent for the prepared bitumen the development takes from ten to thirty minutes, and within certain bounds the risk of over exposure is very slight, as the development is then only a matter of time in the turpentine bath. When the development is complete the plate is treated as above.

"The weak solution of nitric acid and water above mentioned is the first etching bath, and the plate is allowed to remain in from five to fifteen minutes, rocking the dish all the time. It is then removed, well washed under the tap, and blotted dry with clean blotting paper. Smear it over with a solution of gum arabic, and let it dry spontaneously, then moisten the gum with a damp sponge, and roll up with a colour roller, or an indiarubber, charged with good litho printing ink, rolling carefully and patiently, occasionally damping the surface to prevent the ink smearing the whites, until the bitumen is covered with ink. Dust with very finely powdered ordinary asphaltum, rubbing the powder in with a clean, soft brush; wash off the superfluous powder, then put the plate into a stronger bath of nitric acid and water, and etch for fifteen minutes. The whole of the ink is now removed with turpentine, followed by washing under the tap, then with another immersion in the acid water for about a minute, again wash, then dab dry with a soft cloth.

"The plate is now inked up with a type roller and stiff ink, and an impression pulled, which impression serves as the guide for the finishing etchings.

"Roll up the plate with stiff litho ink, getting a good film of ink on; now take a good sable brush and a little ink mixed to working constituency with turpentine, and, after carefully consulting the print, paint over all those portions of the image that are of the right tone, leaving only those portions bare that print too flat. Then rebite the plate, clean off the resist, and again prove, and, if necessary, re-ink with the roller, then paint out and rebite. Instead of stopping out the image, strong acid water may be painted on the inked-up image with a brush upon those parts it is desired to etch so as to print lighter, but the first method is the safer. The whole process, as written, seems very complicated, but it is not so in practice."

Proof Spirit.—A mixture of about equal parts of distilled water and absolute alcohol. It is defined by the Act 58 Geo. III., c. 28, to be "such as shall, at a temperature of 51° of Fahrenheit's thermometer, weigh exactly $\frac{12}{13}$ parts of an equal measure of distilled water."

Its specific gravity = ·9198 at 15°C., and it contains 49¼ per cent. by weight of absolute alcohol.

Proto-nitrate of Iron.—See **Ferrous Nitrate.**

Prussian Blue.—Ferrocyanide of iron. In the cyanotype process the image is formed in Prussian blue.

Prussiate of Potash.—The red prussiate of potash is ferricyanide, and the yellow prussiate of potash is ferrocyanide of potassium.

Prussic Acid.—Hydrocyanic acid.

Psyctic Photography.—See **Spirit Photography.**

Pumice Stone.—A very porous rock of extreme lightness, chiefly exported from the Lipari Isles. It is a very useful substance. In the form of a powder it is used for polishing metals, woodwork, and for cleaning glass. It is also useful in removing stains from the fingers.

Putrefaction (Lat. *putrefactus*, from *putrefacio*, to make putrid).—The apparently spontaneous decomposition of organic substances, especially those rich in nitrogen. It may be prevented (1) by keeping the substance in a vacuum; (2) by freeing from moisture and keeping perfectly dry; (3) by keeping in an atmosphere a few degrees below 0°C.; (4) by heating to boiling point and hemetically sealing; (5) by the use of antiseptics. According to Pasteur putrefaction only takes place when a substance comes in contact with living germs.

Pyro.—An abbreviated term for "Pyrogallol," or, as it is also termed, "Pyrogallic acid."

Pyro-ammonia Developer.—See **Developer.**

Pyro and Glycerine Developer.—Edwards's formula is given under **Developer** as a pyrogallic developer for Isochromatic plates.

Pyrocatechin (Formula, $C_6H_4(OH)_2$; synonyms, *oxyphenic acid*, *pyromorintannic acid*).—Obtained by the dry distillation of catechu extracted from the inner bark wood of the *Acacia catechu*, and also from *Kino*, another similar extract. The leaves of the Virginia creeper contain pyrocatechin. It is also obtained by fusing potassium phenol-sulphonate with potash, and is present in crude pyroligneous acid, distilled from wood.

Pyrocatechin crystallises in quadratic prisms soluble in water, alcohol, and ether. They fuse at 102° C., and boil at 245° C. In presence of alkalies it absorbs oxygen from the air, and becomes brown. Nitric acid oxidises it to oxalic acid. It is a reducing agent, and for this reason has been recommended as a developer for dry plates.

The first investigator was M. Benoist, who published his formula in *La Nature* as follows:—

SOLUTION A.

Distilled water	½ litre.
Sodium sulphite	34 grammes.
Pyrocatechin	8 ,,

SOLUTION B.

Distilled water	½ litre.
Washing soda	75 grammes.

Dr. Arnold's formula is as follows:—

SOLUTION A.

Pure pyrocatechin	1 gramme.
Water	100 c.c.m.

SOLUTION B.

Sodium carbonate	20 grammes.
Water	100 c.c.m.

To develop a 10 × 8 plate take 1 c.c. of A solution and from five to ten c.c. of B in about 70 c.c. of water. For instantaneous drop-shutter work, more of solution A must be used.

Dr. Eder speaks highly of this developer, but notifies the importance of obtaining pure pyrocatechin. His formula is—

SOLUTION A.

Pyrocatechin	1 part.
Sodium sulphite	4 parts.
Water	40 ,,

SOLUTION B.

Caustic potash	4 parts.
Water	40 ,,

For use, mix one volume of A with two volumes of B.

The advantages claimed for this developing agent are—freedom from fog, non-actinicity of solution, simplicity in preparation, high energy at low temperature, and a negative colour that facilitates printing. According to Dr. Arnold, the plates lose their sensitiveness to light as soon as they are immersed in the developing solution, and may be developed at a distance of twenty inches from a gas flame, or in weak daylight. Further, the solution does not stain the fingers.

Pyrogallic Acid.—A common but erroneous term for pyrogallol, which is not actually an acid. See **Pyrogallol.**

Pyrogallic Developer.—Development with pyrogallol, or pyrogallic acid, as it is erroneously termed, in a solution with an alkali, is more general than with any other agent. One of the chief advantages with this form of developer is the power the operator

possesses of varying it to suit the requirements of the subject. Greater latitude of exposure is also possible with this developer than with any other. Pyrogallol is usually kept in the solid state, preventing decomposition, but if required in solution it can be dissolved in a solution of sodium sulphite, slightly acidified with citric acid, and of such strength that the solution contains ten per cent. of pyrogallol. The darkening of the solution is thus prevented, as the sodium sulphite suffers oxidation instead of the pyrogallic acid.

Strong liquid ammonia, sp. gr. ·880, is mixed with nine times its bulk of water, so that every ten minims contains one minim of the ammonia. The potassium or ammonium bromide should also be made up as a ten per cent. solution. Sodium carbonate, if used, should be purchased in the dry state, and made up in a ten per cent. solution. Potassium carbonate should also be purchased dry, and can be made up into solution as strong as 50 per cent. if required. In making up these solutions the water must not be measured out but added to the solid until the solution measures ten times the weight of the solid used.

Sodium sulphite is usually made up as a twenty per cent. solution.

The pyro developer can be made up after hundreds of different formulæ. Every maker of plates usually recommends a certain one, and it is generally advisable to give this a trial for that kind of plate. These formulæ vary very considerably; for instance, one manufacturer of plates recommends

Pyro	Potassium bromide	Ammonia
6	¾	5

and another

Pyro	Potassium bromide	Ammonia
3	7	12

The following is a table of the largest and smallest quantities of chemicals admitted to the pyro developer:—

	Largest.	Smallest.
Pyro per ounce ..	.. 10 grains ..	.. 1 1·4 grains.
Sodium sulphite ..	.. 80 ,, ..	.. 5 ,,
Sodium carbonate..	.. 40 ,, ..	.. 1 1 5 ,,
Potassium carbonate	.. 21 22·10 ..	.. 5 ,,

For various formulæ for pyrogallic development, see **Developer.**

Pyrogallol (Lit. derived from gallic acid and heat. Formula, $C_6H_3(HO)_3$; molecular weight, 126; synonyms, *trihydroxybenzene*, *pyrogallic acid*, *pyrogallin*, *pyro*).—A trihydroxybenzene derived from gallic acid by destructive distillation, carbon dioxide being given off as one of the products of decomposition, thus:

$$C_6H_2(OH)_3.CO_2H = C_6H_3(OH_3) + CO_2$$

It is prepared as follows: Gallic acid dried at 100°C. is mixed with three times its weight of powdered pumice stone to equalise the heat, and distilled in a retort, through which a slow stream of

CO_2 is passed, the retort being heated by an oil-bath to between 210° and 220°C. A solution of pyrogallol, for use as a developer for photographic purposes, can readily be prepared by heating 10 grammes of gallic acid with 30 c.c. of glycerine to 195°C., so long as carbon dioxide is evolved. It is then made up with water to one litre. Of course, by this method the pyrogallol is obtained mixed with glycerine.

Pyrogallol crystallises in fine needles felted together in light white tufts. It fuses at 115°C., and boils at 210°C. It is very soluble in water (1 in 2½ parts) and in alcohol and ether. Metagallic acid is sometimes present in samples of pyro, which have consequently a slightly brownish colour, and leave a residue when dissolved in water.

If the solution be mixed with an alkali it absorbs oxygen from the air, turning brownish black, and forming carbonates, acetates, and other products, a small quantity of carbon dioxide being evolved. It is a most powerful deoxidiser and reducing agent. Its action upon the silver salts causes it to be most extensively used as a developing agent. The reducing power of an alkaline solution of pyrogallol is in fact so great that it cannot be used alone, as the whole plate would be reduced, and we should get what is termed "fog." For this reason, therefore, a restrainer is added. The best for this purpose is a soluble bromide such as that of potassium.

Owing to the rapid oxidising properties of pyrogallol solution it is very difficult to preserve. All of the following substances have been recommended for the purpose:—Formic acid, glycerine and alcohol, potassium metabisulphite, sodium sulphite, and citric acid.

Pyroligneous Acid.—An impure form of acetic acid obtained by the destructive distillation of wood.

Pyro-stains.—Pyro-stains may be removed from the fingers by washing in a ten per cent. solution of oxalic acid or sulphuric acid diluted with water in the proportion 1 to 20, or a mixture of bleaching lime and citric acid.

Pyro Tablets.—Pyrogallol is sold in this form for the convenience of tourists. The pyro is compressed into tablets or cakes, each of which is scored into twenty-five 4-grain divisions, which may be easily separated.

Pyroxylic Spirit.—See **Alcohol Methylic.**

Pyroxylin or **Pyroxyline** (Formula, $C_6H_8(NO_2)_2.O_5$; molecular weight, 252; synonyms, *dinitro cellulose*, *gun-cotton*).—This name is applied to a series of compounds obtained by acting on vegetable fibres with nitric and sulphuric acids. They are all more or less explosive, and are all what are termed substitution

compounds, being derived from the vegetable fibre by the substitution of atoms of NO_2 for an equal number of atoms of H in the fibre. The pyroxylin with which we have to deal with here is that known as the soluble kind, sometimes termed collodion wool, as is used in the manufacture of collodion for photographic purposes.

It can be purchased ready for use, and it is advisable to obtain it in this form, as its manufacture is attended with considerable danger.

The following directions are taken from Hardwich's "Photographic Chemistry" for preparing pyroxyline:—

The most important part is the composition of the nitro-sulphuric acid in which the pyroxyline is prepared, as the slightest variation in the quantity of water, in the relative proportions of the two constituent acids, or in the temperature at the time of putting in the cotton, will affect the result.

Sulphuric acid sp. gr. 1 854 at 60° F.	.. ..	18 fluid ounces.
Nitric acid sp. gr. 1.45 at 60° F.	.. ..	6 ,,
Distilled water..	..	4½ ,,

The water is poured into a dish, and the nitric and sulphuric acids added in the order written.

The mixture is then well stirred, and the temperature, which will have considerably increased on addition of the sulphuric acid, must be allowed to sink to 150° Fah., and at this temperature it must be kept by means of a water-bath. The wool is first immersed in a strong solution of sodium or potassium carbonate to free it from the natural oil contained in it, and then well washed in clean water until the latter shows no trace of alkalinity or the salt used. It is then dried. The wool prepared in this manner should be weighed out in balls of about thirty grains each, and these are immersed one by one into the acid mixture, and well stirred in it, so that each ball becomes thoroughly saturated with the acids. They are then left for ten minutes and removed and washed in a running stream of water for twenty-four hours, or until they give no acid reaction when tested with litmus. They are then dried in the sun or on a water bath. When dry they form the collodion wool of commerce, and should be entirely soluble in a mixture of equal parts of alcohol and ether. They should also be inflammable. The nitric is the only acid that acts upon the cotton wool, the sulphuric merely increases the rapidity of its action.

Pyroxyline can be made from many varieties of cellulose. Cotton, straw, pith, flax, linen, calico, have all been used, giving more or less different results. However, cotton wool is the substance generally employed.

Pyroxyline is insoluble in water, alcohol, or ether alone, but is soluble in a mixture of the two latter, forming collodion.

Hardwich says that the temperature of the nitro-sulphuric acid at the time of immersing the cotton invariably affects the photo-

graphic properties of pyroxyline. At high temperatures a portion of the film is converted into a substance which has a bitter taste, and turns brown when treated with alkalies. This substance is believed to be nitro-glucose, formed by the action of strong nitric acid upon grape sugar; the grape sugar itself being produced by the cellulose by contact with the warm and diluted sulphuric acid. Its presence in the collodion tends to diminish the sensitiveness of the film to weak rays of light, but increases the rapidity and intensity of the development in negative images.

Pyroxyline is liable to decomposition, a partial liberation of oxides of nitrogen apparently taking place, forming, in some cases, red fumes within the bottle. It can be kept perfectly, however, if the following precautions are taken: First, it should be thoroughly washed and thoroughly dried; and, secondly, it should be kept in a well-ventilated vessel—a thin cotton bag, in which it can be loosely stowed away is a good receptacle. It is dangerous to press it too tight in a stoppered bottle. Light, heat and moisture are all agents facilitating decomposition, it should therefore be kept in a dark, dry and cool place.

Papyroxyline.—Liesegang was probably the first to introduce this substance for collodion making. It is a kind of pyroxyline made from paper instead of from cotton wool. The following is a good formula for washed emulsion processes:—

Nitric acid sp. g. 1·45	2 fluid ounces.
Sulphuric acid sp. g. 1·845	3 ,,
White blotting paper	145 grains.

The temperature should be about 100° Fahr., and the time of immersion about half-an-hour.

Qualitative Analysis.—See **Analysis.**

Quantitative Analysis.—See **Analysis.**

Quart (Lat. *quarta*—the fourth part).—The fourth part of a gallon; two pints, or 69·3185 cubic inches.

Quarter-plate.—The size of dry plate, $3\frac{1}{4}$ by $4\frac{1}{4}$ inches.

Quinol.—The same as **Hydroquinone** (*q.v.*)

Quinol Developer.—See **Hydroquinone.**

Quinolin, Red (Formula, $C_{26}H_{19}N_2Cl$).—Occurs either in the form of a deep crimson powder or in reddish-brown prisms. It is only slightly soluble in water, but soluble in alcohol, forming a solution having a reddish-yellow fluorescence. It occurs mixed with cyanin blue in commercial azalin, used in orthochromatic work.*

* C. J. Leaper.

Rack and Pinion.—A contrivance for producing a limited rectilinear motion from a circular one. A toothed wheel or pinion rotating about its own axis is caused to work in a straight or toothed bar. This contrivance is often attached to the focussing arrangement of the camera. By simply turning a screw or small handle the distance between the lens and the focussing screen can be adjusted at will.

Racks.—Contrivances, usually of wood or metal, used for drying or draining plates. Those made to fold up are the most convenient for use.

Radical (Lat. *radicis*—a root).—The basis of a compound. Gerhardt's definition is, "the proportion in which certain elements or groups of elements may be substituted for others, or may be transferred from one body to another in the act of double decomposition."

Radical Compound. — In organic chemistry a compound radical is a group of elements which, in the various changes and decompositions which a substance undergoes, remains unaffected, and acts as if it were an element. Cyanogen, ethyl, etc , are compound radicals.

Rain Water.—See **Water.**

Rapidity.—The rapidity of a lens is dependent upon the relation the focus bears to the working aperture. The rapidity of the photographic dry plate is usually known by its sensitometer number, but this is often very misleading, however. The rapidity is obtained by heating the bromide emulsion for some time or by the ammonia process.

Rapid Lens.—Any lens allowing a large quantity of light rays to pass through upon the sensitive plate. The rapidity of a lens is dependent upon the relation the focus bears to the size of working aperture. Depth of focus and definition are opposed to rapidity, and, therefore, any arrangement tending to increase the depth and definition can only be made at the expense of rapidity. It is generally understood that the rapidity of all lenses is equal with the same ratio size diaphragm. Although this system holds good with single lenses, through which the same amount of light is always admitted through the same size aperture of diaphragm, yet with combinations of two lenses, a certain distance apart, as in rapid rectilinear, etc., this cannot be said to be quite correct. Here the ratio of the focus to the actual aperture no longer regulates the rapidity. The available aperture (A) is in this case given by the equation $A = \frac{fa}{f-d}$, f being the focal length, a the actual aperture of the diaphragm, and d the distance between the centre

of the diaphragm and the nodal point of emission of the back combination.

Rapid Rectilinear.—A rapid lens corrected for aberration, and giving straight lines when photographing buildings or other similar objects.

Ray (Lat. *radius*—a ray).—A line of light proceeding from a radiant point or a point of reflection. A collection of rays is termed a pencil. An incident ray entering a doubly refracting crystal is resolved into two; termed from their properties an ordinary and an extra-ordinary ray.

The term ray is also applied to one of the component elements of light, as the violet rays of the spectrum, or the luminous actinic or heat rays.

Visual Ray.—In perspective, a straight line drawn through the eye.

Reaction.—A chemical term applied to the change or effect produced by bringing two or more elements or compounds together, whereby one or more new bodies are formed.

Ready-sensitised Paper.—Albumenised paper can be purchased ready sensitised. It keeps for about four to six months. Although now made of very good quality, the results obtained upon it are never so good as upon paper freshly sensitised without the addition of the preservative necessary with commercial sensitised paper. Ready-sensitised paper can be purchased either in sheets or in cut sizes. The sizes of the sheets are as follows: 18 x 22¾, 20½ x 24½, 22 x 36, 26 x 40, 27 x 42. The paper should be carefully protected from light and from moisture. Packets of cut sizes are better kept under heavy pressure. This not only keeps the paper flat, but also forces out the air from between the sheets and retards its discolouring action.

Reagent.—A term in chemistry applied to any substance employed to bring about a chemical reaction or change in another element or compound, with the view, generally, of either detecting its presence or effecting its separation from other substances.

Real Image.—See **Optics.**

Ream.—A quantity of paper of any dimensions containing twenty quires of twenty-four sheets, or 480 sheets in all. It is a common practice to count 500 sheets in a ream.

Reaumur Scale.—See **Thermometer.**

Recovery of Waste.—See **Residues.**

Re-crystallise.—To crystallise again or anew.

Rectification.—The concentration of a volatile substance by distillation, as when spirits of wine is prepared from a dilute solution of alcohol by repeated distillation.

Rectified Spirit.—Alcohol, with sixteen per cent. of water. Sp. gr. 0·838; strength, 56 over proof.

Rectigraph (Lat. *rectus*—right, and *grapho*—to draw).—A name given to a class of corrected lenses.

Rectilinear (Lat. *rectus*—right, and *linear*—a line).—A term applied to lenses which have been corrected for aberration as much as possible, so that in photographing architectural subjects the lines appear perfectly straight in the image.

Re-development.—A process formerly adopted with wet collodion. It is in reality intensification of the image, and has been recommended for bromide plates and paper. The negative or print, after thorough washing, is bleached in a solution of cupric or mecuric chloride, and then re-developed with ferrous oxalate or hydroquinone. For bromide paper dilute ferrous citrate developer acts well.

Red Fog.—See under **Fog.**

Red Light.—See **Non-actinic Media.**

Red Prints.—Red prints may be obtained by the following process:—

Citric acid	100 grains.
Ammonium chloride	100 ,,
Gelatine	10 ,,
Water	10 ounces.

Dissolve the citric acid in a small portion of water, and exactly neutralise with sodium carbonate. Float the paper on this bath for one or two minutes, and sensitise upon a fifty-grain nitrate of silver solution. Fix in fresh hypo without toning.

Red Prussiate of Potash.—See **Potassium Ferridcyanide.**

Reducing.—When a negative has been over-developed, and becomes too dense, it requires a considerable time printing the positive images. In order to save this it can be reduced. It also happens very often that the plate is under-exposed, and in forcing out the details in the shadows the high-lights become too dense. Here reduction is also advisable sometimes. The action of the

solution, however, begins on the outer surface of the film, and works its way through, consequently, unless the solution be made very weak, it will in all probability dissolve away the shadow details before accomplishing the required reduction of the darker parts of the negative.

With ferrous-oxalate developer reduction in density can often be accomplished by immersing the developed negative in the hypo bath without previously washing. If this has not a sufficient effect a mixture of one part of the ferrous oxalate developing solution and one part of the fixing solution acts as a powerful reducer. Clearing solutions usually have a slight reducing action upon the negative. A method often practised, although by no means advisable, consists in bleaching the image in a saturated solution of mercuric chloride. Usually, however, the change in colour from black to white causes too great a diminution in opacity, and, further, the bleached image will usually change when exposed to the light in printing.

There are a number of formulæ for reducing the image by dissolving it partially away. Among these may be mentioned the following :—

FARMER'S REDUCING SOLUTION.

Sat. sol. potassium ferridcyanide	1 part.
Sodium hyposulphite solution (1 in 5)	10 ,,

BELITSKI'S REDUCER FOR GELATINE PLATES.

Water	7 ounces.
Potassium ferric oxalate	2½ drachms.
Crystallised neutral sodium sulphite	2 ,,
Powdered oxalic acid	30 to 45 grains.
Sodium hyposulphite	1½ ounces.

The solution should be made up with the ingredients added in the same order as written. It is then filtered and kept in well-corked bottles in subdued light, the influence of light being to reduce the ferric salt to ferrous.

BARTLETT'S REDUCER.

Perchloride of iron	30 grains.
Citric acid	60 ,,
Water	1 pint.

DICHROMATE REDUCER.

Potassium dichromate	20 grains.
Hydrochloric acid	10 minims.
Water	1 ounce.

EDER'S REDUCER.

SOLUTION 1.

Ferric chloride	1 part.
Water	8 ,,

SOLUTION 2.

Potassium oxalate	2 parts.
Water	8 ,,

Equal parts of each solution are mixed before using, and a small quantity of the mixture added to a strong solution of hypo. The plate is then immersed, or the solution applied locally, and the image rapidly weakens. The chemical action of the reducer is to convert the silver of the image into oxalate of silver, which is immediately dissolved by the sodium hyposulphite.

Local reduction is a term applied to the reduction of certain portions of the negative only. This is done when the film is quite dry by rubbing it with a soft pad moistened with alcohol until the density is reduced as required. The pad is usually composed of a tuft of cotton-wool or a piece of wash-leather, flannel, etc. For sharply-defined outlines, a pointed stick of soft wood is used steeped in alcohol.

The above remarks all apply to the reduction of gelatino-bromide dry plates. Prints upon bromide paper may also be treated in the same manner.

Prints upon albumenised paper which have been over-printed can be reduced by immersion in a solution of cupric chloride, or before toning, by using platinic chloride in place of the gold salt.

Cyanotype or ferro-prussiate prints can be reduced by immersion in a weak solution of ammonia, and afterwards into a weak solution of hydrochloric acid.

Reduction *(in size).*—The operation of producing transparencies or prints from negatives of large dimensions. The opposite to enlarging. The negative to be reduced is inserted in the same position as for enlarging. The lens, however, is turned towards the negative and the image focussed on the ground glass screen. The distances will be found on reference to the table of conjugate foci on page 167. In reducing, the greater distance must, of course, be between the lens and the negative, and the lesser between the lens and the sensitive film.

Reducing Agents.—In chemistry this term is applied to bodies which have an action the inverse of oxidation, such as nascent hydrogen from sodium amalgam, zinc, etc.

The term is also applied in photography to those agents usually termed developers, which, by their reducing action upon the exposed silver salts, cause the latent image to become visible.

The same term is also given to certain compounds or solutions of compounds which will reduce the opacity of an over-dense negative.

Reflecting Camera.—A camera made in the form of a camera obscura, so that the image upon the ground glass appears the right way up. A mirror inside at an angle with the lens produces an image on the ground glass at the top. When ready for exposure the mirror is lifted up, making the interior light-tight. The dark slide forms the back of the camera, and is always in position ready for use.

Reflection.—See under **Optics.**

Reflectors.—See under **Optics.**

Reflectors, Silvering.—See **Mirror, Silvering.**

Refraction (Lat. *refractus*).—The bending or deflection of a ray of light (including heat and all other forms of radiant energy) which takes place whenever the ray passes at any other angle than a right angle from the surface of one medium into another medium of different density. This optical density by no means coincides with comparative specific gravity, *e.g.*, turpentine is optically denser than water, but floats on the top of it. It is a retarding influence, and accordingly when the ray enters the denser medium at right angles, though not

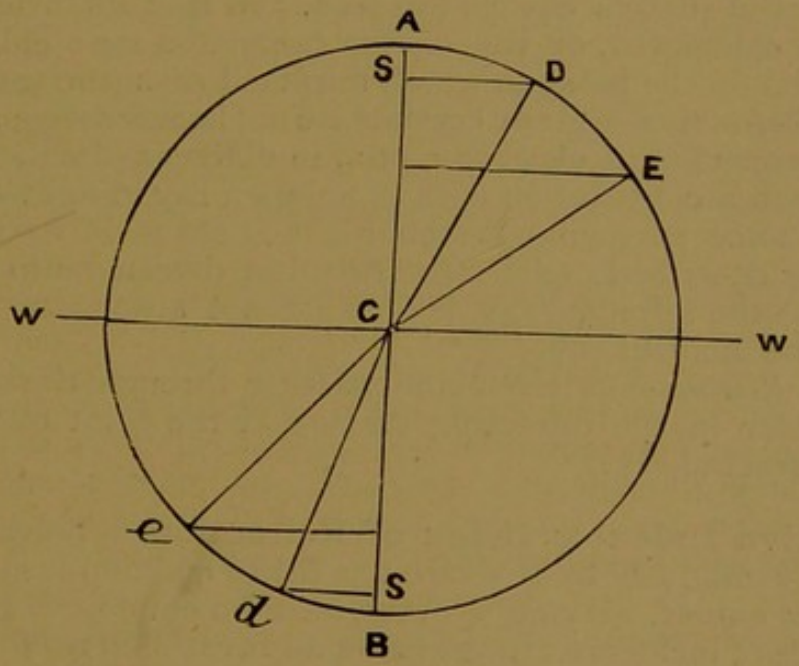

FIG. 186.

refracted, it is retarded in a certain proportion, traversing a less distance in a given time. Rays at other angles, it can be shown by analysis, must be bent aside according to a law discovered by Snell, about A.D. 1620. Let W W fig. 186) represent the refracting surface of the denser medium—for example, water; and draw A B perpendicular to that surface. Describe a circle round the point C where the perpendicular cuts the surface. Now let a ray, D C, enter the surface at C, at some angle A C D with the perpendicular, and suppose it is found by experiment that the refracted ray takes the direction C d. In the first place, the refracted ray will be found to be in the same plane as the incident ray. In the second place, if the medium below W W be the denser, the refracted ray will be bent towards the perpendicular, and the reverse in the contrary case,

so that a ray, d c, incident in water, would be refracted as C D, further away from the perpendicular on emergence into air. But thirdly, the refracted course of every other ray can now be calculated according to the following law. Draw D S and d s normal to the perpendicular, then the lines D S and d s will represent, geometrically, the sines of the arcs A D and d B, and if the radius C A be unity, the numbers expressing S D and d s will be the sines of the angles. The sine S D will have a certain ratio to the sine d s. And now if any other incident ray (E C) be taken, its sine found in the same way will be found to bear the same ratio to the sine of the refracted ray. This ratio of the sines is therefore invariable for all incidences for the same homogeneous substance. Such ratio is called its refractive index, and it will be readily seen how the index of any substance, as some kind of optical glass, being once found by simple experiment, the course of every refracted ray incident at any angle on the curved surface can be foreseen, and thus its focus or other properties calculated, or the curves calculated for a given focus, which is simply the point to which refracted rays converge.*

Double Refraction.—Many crystals are not homogeneous, but have different properties of elasticity, etc., in different directions. The effect of such a constitution is that, unless a ray of light enters the crystal in some particular directions, it is not merely refracted in the manner described under refraction, but diverted into two rays. In this case the refracted ray or rays are not always in the same plane as the incident ray.

Plane of Refraction is the plane passing through the normal or perpendicular to the refracting surface at the point of incidence and the refracted ray.

Refractive Index or **Index of Refraction.**—When a ray of light passes obliquely from a rare to a dense medium it is refracted to a certain extent, varying with the medium employed, as the sine of the angle of incidence always bears an invariable ratio to that of the angle of refraction, for the same ray and the same medium. This ratio is termed the refractive index of that medium.

The following table gives the refractive indices of a few well-known substances:—

Gas.	Index of refraction.
Air	1·000294
Oxygen	1·000272
Hydrogen	1·000138
Liquid.	Index of refraction for mean yellow ray
Linseed oil	1·485
Oil of turpentine	1·457
Alcohol	1·372
Ether	1·358
Water	1·336
Glycerine	1·470

* Hunter's "Encyclopædia."

Solid.	Index of refraction for mean yellow ray.
Diamond	2·47 – 2·75
Sulphur	2·115
Flint glass	1·575
Rock crystal	1·547
Canada balsam	1·532
Crown glass	1·525 – 1·534
Plate glass	1·514
Iceland spar	1·654
Ice	1·315

Refrangibility (*Re* and *frango*—to bend).—The property which rays of light possess of being bent out of a straight line when they pass from one medium to another of different density.

Re-gilding.—Photographic picture frames may be re-gilt after the following method given in "Spon's Workshop Recipes":—Wash the frame well with a sponge and clean water, and when dry give it two coats of water-gold size mixed with some warm thin size from dry hide or parchment. When dry rub over with fine sand-paper, and it is then ready for gilding with the gold leaf. After a couple of days it can be finished with an agate burnisher.

Register.—The register of a camera is the correspondence in position between the focussing screen and the surface of the sensitive plate or film afterwards introduced. This, especially where lenses of large aperture are used, should be very carefully tested. The most effective method of doing this is by focussing a distant object, such as a signboard with shapely defined letters on it, using the full aperture of a rapid lens. A focussing glass should be employed if the operator does not possess good eyesight. The focussing screen is then removed, and each side of the different double dark slides is brought into position, having a piece of ground glass fitted where the dry plate is usually placed. The wo slides are then withdrawn, and the image examined. If erfectly sharp the register is correct. Another method is to xpose a plate and examine for sharpness, but this is also a test for hromatic aberration in the lens.

Registering Copyright.—See **Copyright.**

Relief (Lat. *relevo*—to lift up).—A photo relief is an image in which certain portions stand out higher than others. In the carbon and Woodburytype prints the image is in relief, although very slightly. The simplest method of making a relief is described under **Woodburytype.** A relief may be obtained on an ordinary fairly thickly-coated gelatine dry plate. Give a rather full exposure, and develop with—

A.—Potassium hydrate stick	180 grains.
Sodium sulphite	180 grains.
Water	3 ounces.
B.—Pyro	48 grains.
Water	8 ounces.
C.—Potassium bromide	60 grains.
Water	1 ounce.

Six drachms of B are mixed with two drachms of A, and the plate immersed until all the detail is produced. Ten drops of C are then added, and development continued until sufficient density is obtained. After development, the plate is well washed and immersed in a 10 per cent. solution of chrome-alum, warmed to about 30 to 40° C., gently brushing it while in the solution with a soft brush. By this means a negative in relief can be made.

Rembrandt Effect.—This name is given to a style of portraiture in which the shaded side of the sitter is portrayed with light more or less behind the head, and intended to resemble the great works of the celebrated artist of that name.

Removal of Film.—The gelatine films may be removed from the glass plate by immersing them in a weak solution of hydrochloric acid. The films from old and useless negatives are best soaked for some time in cold, and afterwards in hot water. They are then well rubbed with whitening. Wall recommends rubbing them with a paste composed of pumice-stone powder and glacial acetic acid.

Repeating Back.—A form of single dark slides so arranged that two separate negatives may be made upon one plate. There are many forms of studio cameras with repeating backs, enabling the operator to take two cabinet or c.-de-v. pictures upon one plate. Repeating backs are also used for single stereoscopic cameras, with one lens only, the two negatives being made upon the one plate, the lens having been moved about two inches previous to making the second exposure.

Residues.—The recovery of the unused gold, silver and platinum used in photography is now practised by all who use large quantities.

Silver Residues.—It is well known that only about three per cent. of the silver used in sensitising albumen paper remains in the finished prints; although it is not possible to recover the whole of the remaining 97 per cent., yet by careful practice about 80 per cent. should be saved. The following table, showing where the different losses take place, has been carefully compiled by M.M. Davanne and Girard:—

	Silver per cent.
Draining papers	1·028
First and second washing waters..	52·860
Hypo bath	32·100
Washing water of fixed proofs	4·110
Cuttings and clippings	4·570
Remaining on proofs	3·100
Loss	2·232
	100·000

It will be observable that the greater portion of the silver is to be found in the first washing waters and in the hypo bath—nearly 85 per cent., so that it will well repay one to save these if only a fair portion of the silver can be extracted.

Residues may be divided into three classes, *i.e.* :—

1. Clipping cuttings, spoilt paper and prints.
2. Washing water used previous to fixing.
3. Old hypo baths.

Unless large quantities of paper are used, the first class can be entirely abandoned if the unreduced silver is fixed out from the spoilt prints, etc. If they are saved, however, they should be stored away until a good quantity is obtained. They are then made into a pile, and burnt by setting fire to the top of the pile and allowing it to descend. The ashes are then collected and sent to the refiners, or, instead of burning, the paper may be beaten up to a pulp, with dilute sulphuric acid and strips of metallic zinc or copper placed in the mixture. Metallic silver is precipitated, and the zinc or copper is dissolved.

With regard to the second class of residues, the first and second washing waters only should be saved in a large tank or tub, and hydrochloric acid or common salt added, and the liquid allowed to settle. When the top is quite clear, the silver chloride will have settled to the bottom, and the liquid decanted or syphoned off. When a fairly good portion of the silver chloride is obtained, it should be collected, dried, and sent to the refiners.

The third class, *i.e.*, the old hypo bath, cannot, of course, be subjected to the same treatment, as the silver chloride is soluble in them, and would not precipitate. To reduce the silver from the fixing baths, the old solutions are kept separately in a tub or earthenware vessel, and some sulphuretted potash (liver of sulphur) added, which throws down the silver as a black deposit of sulphate Ag_2S. In this state it should be sent to the refiners. It can be reduced to metallic silver by roasting to free it from the sulphur, and fusing. There are serious drawbacks to this process, however. The stench is abominable and injurious, and if free sulphur be left in, explosions are likely to occur when the mass is fused.

Davanne's method of recovering the silver from old hypo baths consists simply in immersing a plate of copper in the hypo bath, and letting it stand for about four days. The silver becomes gradually deposited upon the copperplate, whilst the copper is

dissolved in the liquid. The copperplates are generally stood up on ends against the sides of the tub, and are occasionally brushed with a stiff brush. The metallic silver will then settle gradually to the bottom, and when a sufficient quantity has accumulated it is filtered and washed. The filtrate, consisting of metallic silver and a little copper, can easily be converted into silver nitrate, slightly blue owing to the copper. If only a small portion of copper be present it will have no injurious effect; if a large quantity is detected, it can be thrown down as an oxide in the form of a black powder. The silver oxide should be added until the blue colour has disappeared.

Instead of sending the residues to the refiners they can be all mixed together with nitrate of potash and charcoal and fused in a crucible.

The silver bromide from old waste emulsion can be recovered by first melting and then adding a small quantity of hydrochloric acid, and boiling for a few minutes. The gelatine is thus destroyed, and is poured off, the precipitated silver bromide is then collected, and can be placed among the other residues.

Platinum Residues.—Platinum is now largely used in photography, in the different platinotype processes and in platinum toning, and is a sufficiently valuable metal to repay the worker to save what he can of it.

The following remarks, concerning the recovery of platinum residues, are given in Lyonel Clark's book on platinum toning:—"The old toning baths, and the washing water the prints are passed through after toning, are especially rich in the metal, and these liquids should be poured into any bottle, and an ounce or so of the ordinary ferrous oxalate developing solution added. The bottle should be stood aside, and the platinum will be found to be rapidly thrown down in the metallic state. The major portion of the liquid is decanted off, and the residue filtered and dried, and can be sent to the refiners at once, or it can be converted into platinum chloride for subsequent conversion into chloroplatinite of potassium. In case any iron should be present, it is best to treat the filtrate with a fairly strong solution of sulphuric acid; this will dissolve out any iron in the form of the sulphate without injuring the platinum; the residue should be washed and dried and dissolved in aqua regia (nitric acid one part, hydrochloric acid four parts), with gentle warming. As little aqua regia as possible should be used, only just sufficient to dissolve the platinum, as it has subsequently all to be evaporated off. The dissolution of the platinum should be conducted out of doors, or in a well-ventilated room, as the nitrous oxide fumes given off are most unpleasant, and rapidly rust iron or steel objects. The residue left after evaporation is chloroplatinic acid, and can be weighed, and at once used for the production of the chloroplatinite of potassium.

Gold Residues.—To obtain the gold from old toning baths, add sulphate of iron either in crystals or in solution. This will precipitate the gold in a black powder, which is well washed and dried, and then dissolved in nitro-muriatic acid, when a solution of gold chloride will be the result. This can be evaporated to dryness, dissolved in distilled water, and again evaporated to remove all traces of acid. Another way is to reduce the black powder in a crucible, but an enormous heat is required.

Resin Process.—See **Cooper's Process.**

Resins.—A widely-distributed class of vegetable substances frequently obtained by making incisions in the bark of trees.

Most of the resins are soluble in anhydrous alcohol, and many in ether, sulphide of carbon, and oils; soften or melt at a moderate heat, and at a higher temperature burn with a smoky luminous flame.

Many of the resins are employed in the manufacture of varnishes for photographic and other purposes.

Restoring Daguerreotypes.—Old and faded Daguerreotypes can be restored by cleaning and immersing in a dilute solution of cyanide of potassium.

Restoring Negatives.—Negatives which have been intensified with mercury are very apt to fade and lose their brilliancy. This can be restored by soaking the negative in water for about five minutes, and then immersing in the following solution:—

Schlippe's salt	10 grains.
Water	1 ounce.

until sufficient vigour has been restored.

Restoring Prints.—Prints when kept some time previous to toning will often turn yellow or brown, and become completely discoloured. They may, however, be restored by placing immediately before toning in a two per cent. solution of strong ammonia. After toning they are washed in a bath of similar strength, and, further, about one part of ammonia is added to the fixing solution. With this treatment the whites of the prints should be completely restored.

Finished prints which fade by the action of light or by other influences can never be satisfactorily restored.

Restrainer.—Any substance employed in order to lessen energy in the reducing or developing action of the chemical solutions upon the exposed film. If a plate has been over exposed and it is immersed in an ordinary developer the effect would be that the image would flash up rapidly, allowing the operator no control over its density,

and when finished it would have a very unsatisfactory appearance, owing to the absence of detail in the high lights and other defects.

The simplest restrainer is water added to the developing solution, which naturally weakens its action upon the film. Another method is to tan or harden the film with tannin or chrome alum, for instance, causing the gelatine to be less permeable to the developer.

The soluble bromides and the citrates of potash soda and ammonia are all used as restraining or retarding agents. The following formulæ for restrainers are from Wall's "Dictionary of Photography."

The restraining power of the bromides of ammonium, potassium and sodium bear the following proportions to each other :—

Bromide of ammonium 98 parts are equal to 119 parts of potassium bromide and equal to 103 parts of sodium bromide. Ammonium bromide is consequently the strongest, and potassium bromide the weakest, while the sodium salt ranks between the two.

The citrates of potassium, sodium and ammonium have apparently quite a different action, for while the bromides prevent to a certain extent the excessive deposit on the high-lights, and permit the detail to make its appearance, the citrates, on the other hand, appear to prevent the detail from making its appearance, and permit the density to be obtained.

To make these restrainers the bromides are simply dissolved in water as follows :—

Ammonium bromide	98 grains
Distilled water to make	980 minims

of solution, each drachm of which will then contain six grains of bromide of ammonium.

Potassium bromide	119 grains
Distilled water to make	980 minims

of solution, each drachm of which will contain $7\frac{3}{7}$grs. of bromide of potassium, equal in restraining power to six grains of ammonium bromide.

Sodium bromide..	103 grains
Distilled water to make	980 minims

of solution, each drachm of which will contain $6\frac{1}{3}$ grains of sodium bromide, equal in restraining power to six grains of ammonium bromide, or to $7\frac{3}{7}$ grains of potassium bromide.

Potassium Citrate Restrainer.

Citric acid	720 grains
Potassium bicarbonate*	944 "
Distilled water to make	$2\frac{1}{2}$ ozs.

of solution.

* Or potassium carbonate 884 grains.

AMMONIUM CITRATE RESTRAINER.

Citric acid	720 grains.
Liq. ammonia ·880	630 minims.
Distilled water to make	2½ ozs.

of solution.

SODIUM CITRATE RESTRAINER.

Citric acid	720 grains
Sodium bicarbonate*	884 ,,
Distilled water to make	2½ ounces

of solution.

These solutions will keep for an indefinite period, and can be diluted by adding five parts of water. The advantage of these last three restrainers is that when a negative shows plenty of detail, but refuses to gain in density, the addition of a little of one of the dilute solutions may be made, and the plate left for hours, if necessary, till the required density is obtained, without the slightest sign of fog.†

In the collodion process, the action of the developer is usually restrained by the addition of some thickening substance, such as sugar, gelatine, etc. The collodial restrainer introduced by Carey Lea has found considerable favour among photographers.* It is prepared by first soaking an ounce of French glue in one and a half ounces of water, to which one drachm of sulphuric acid has been added. When it has swollen up thoroughly, the water is boiled until the glue is dissolved. Another half an ounce of distilled water is then added, and the boiling continued a couple of hours. Eighty grains of granulated zinc are next added, and the boiling again continued for another hour and a half. The solution is then allowed to settle, and the clear fluid decanted off. To every three ounces of a fifteen grain solution of iron used in the developer one minim of this solution is added.

Retarding Agents.—See **Restrainer.**

Reticulation (Lat. *reticulum*—a little net).—An effect sometimes observable on the collodion film when dry, and much resembling the pattern of crape. It is usually due to the solvents used in the manufacture of the collodion not having been sufficiently anhydrous, or it may be due to faulty pyroxyline.

Retouching.—The art of retouching does not consist as is often supposed in making bad negatives into good, but in the perfection of good negatives. Under-exposed or over-exposed negatives will never give good results, however skilful the retoucher.

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* Or sodium carbonate (crystalised) 1,440 grains.

† E. J. Wall.

* Capt. W. de W. Abney.

In landscape photography retouching should rarely be resorted to except in bringing up flat high lights, etc.

In portrait photography, however, retouching is almost an absolute necessity, as it is almost an impossibility to obtain truthful and satisfactory portraits by photographic means alone. We are well aware that one of the principal drawbacks in photography is its failure to represent colours in the same relative value as seen by the eye. In portrait photography this defect is apparent to a considerable degree. For instance, fair complexioned sitters possessed of ruddy faces come out dark, freckles appear as prominent black spots, pimples blotches, wrinkles and facial lines often appear so exaggerated as to be positively objectionable, and to alter the appearance of the sitter to a considerable extent.

The object of retouching is, briefly, to remove these effects by the judicious use of a sharply-pointed lead pencil, without, however, destroying the likeness to the sitter, which many retouchers are apt to do.

For this purpose a retouching desk or easel is required, upon which the negative can rest firmly, and is lighted up with a reflector placed behind, so that the image can be properly seen by the worker.

The negative to be retouched is first varnished, and, when dry, the parts to be treated are dusted over with a little finely-powdered cuttle-fish. This is gently rubbed with the finger until the film has a rough appearance when viewed under a magnifying glass. Instead of this a retouching medium or matt varnish can be used.

The pencils used are usually very hard, Hardtmuth's or Faber's; HHH to HHHHHH are most suitable. The pencil should be sharpened into a long fine point, and then kept in order by occasionally rubbing on a piece of fine emery paper.

The transparent portions of the negative which give too dark a complexion on the positive can be filled up by careful stippling or interweaving pencil lines until they are brought into harmony with the surrounding parts. Pimples, freckles, blotches, etc., are thus removed, and the wrinkles and exaggerated lines softened down. This is what is termed smoothing the face.

The next operation is the most important one, however, and calls for the skill and considerable artistic knowledge of the retoucher. It is termed "modelling the face," and consists in bringing the high lights, semi-tones and deep shadows into harmony with each other in accordance with the artistic laws governing light and shade.

The art of retouching is one that requires to be learnt under the guide of a competent teacher. The principal thing is to know, on examining an untouched negative, what to do, and what not to do. Many make the great mistake of over-retouching, removing all individuality from the portrait.

On the subject of retouching H. P. Robinson says :— *

"A very little unskilful retouching will remove the texture of the flesh and leave that of stone ; will remove the expression of a living face, and leave that of a mask ; whilst the same amount of retouching applied with knowledge and intelligence would have retained the texture of flesh, removing only the temporary and accidental blemishes, and the exaggerations of photography, which interfered with truth and beauty, would have given fuller effect to a fine expression or subdued a suspicion of frowning or weariness by delicate touches applied in the right place. . . . . To know when to leave off should be the aim of the retoucher."

Retouching Desk.—A desk or easel used in retouching the negative. There are many forms in the market. They all more or less consist of two frames and a lid. The bottom frame resting on the table holds a movable mirror, used to reflect the light to the underside of the negative ; to the front of this frame is hinged another frame, containing a piece of ground glass, on which the negative to be retouched rests, and which opens to an angle of about 30 to 45 degrees. On the side farthest from the retoucher is hinged a light lid of wood, opening to nearly a right angle with the frame, on which the negative is retouched. This serves to shade the extraneous light from the eyes of the sitter, and can be supplemented with curtains on each side.

Instead of the mirror and ground glass, a sheet of white paper will often answer quite as well. A sheet of brown or black paper, with a small hole cut in it, can be placed over the negative to shut out all light except where the retoucher is working. This effectually prevents an excessive glare to the eyes, and gives greater brilliancy to that portion of the negative being worked on.

Retouching Medium.—A kind of matt varnish rubbed or coated on the negative previous to retouching. It gives a biting surface for the pencil to work on. Two formulæ are—

No. 1.

Gum dammar	10 grains
Canada balsam	5 ,,
Turpentine	1 ounce.

No. 2.

Shellac	75 grains
Mastic	75 ,,
Sandarac	126 grains
Ether	3 ounces

Dissolve, and add

Benzole	4 drachms.

* "The Studio, and what to do in it."

Reversal of the Image.—This is a term applied to the phenomenon resulting in a reversal of the image; those parts which should appear light becoming dark, and *vice versâ*. Complete reversal of the image would result in a perfect positive instead of a negative.

If a photographic dry plate be exposed for a considerable length of time to the image, solarisation takes place, resulting in a complete or partial reversal of the image. The addition of some of the thio-carbamides to the developer will result in a positive being obtained instead of a negative as usual.

The author has obtained some fairly good positives by underexposing the plate, and developing with the ferrous oxalate developer as far as possible. A small quantity of fixing solution (sodium hyposulphite) is then added to the developer, and the developed negative immersed in it. In a short time the reversal of the image will be complete, and a positive is obtained.

Reverse Action of Light.—See **Solarisation.**

Reversed Negatives.—Negatives with the image reversed in position as regards right and left. In photo-mechanical printing this is a necessity, otherwise the prints finally obtained would be incorrect, the right side being to the left, and *vice versâ*. Reversed negatives can be made in several different ways. These can be divided into three different classes: First, reverse negatives

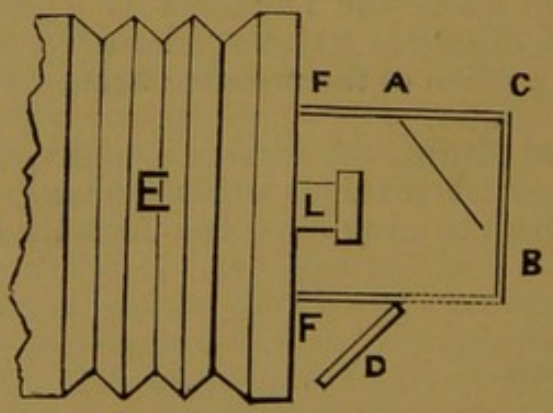

Fig. 187.

obtained direct in the camera; second, negatives reversed by removing and reversing the film of the negative; third, by reproduction from other negatives.

The simplest method under the first class is to photograph the image upon the plate reversed in the camera. To do this the back of the dry plate must be thoroughly clean, and also one should be selected having a perfect glass support, free from bubbles or other

defects. The dry plate is then inserted in the dark slide, film side down, or the opposite to the usual way. A little care must be taken that the spring used for keeping the plate into position has no injurious effect upon the film. After focussing, the back or front of the camera is moved so that the distance between the lens and the screen is increased exactly the thickness of the dry plate.

The next method of making reversed negatives direct in the camera is by means of a silvered reflector. Metal or glass silvered on the external surface should be used. The accompanying sketch (fig. 187) will show how it is arranged :—E is the camera, L the lens, A C B D is the section of a hood fitted round the lens and attached to the camera, A B is a mirror, as described, fitted at an angle of 45° with the axis of the lens, and so arranged that the centre of the mirror is its continuation, D is a small door which can be opened and shut at will. The camera is turned sideways towards the object, and a little consideration will serve to show that the image obtained on the focussing screen and upon the plate will be reversed.

In the third method of the first class a right-angle prism is used fitted on to the lens. (See fig. 188.)

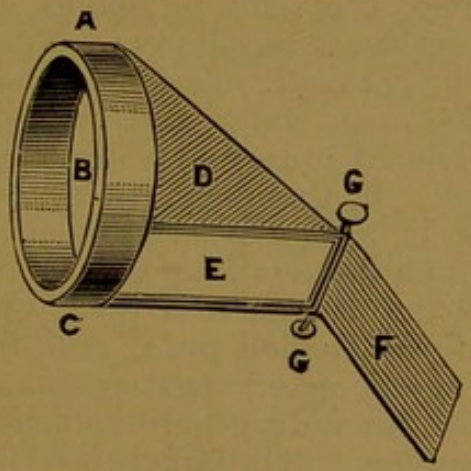

FIG. 188.

A C is a flange that fits on to the lens, taking the place of the cap. B E is a right-angled glass prism, whose breadth is equal to or greater than the diameter of the front glass of the lens. All the surfaces are enclosed in a brass mounting except B E, care being taken that the surface enclosing the right angle is not in contact with the surface of the glass. E is a shutter for exposure, F F screws for clamping E. The camera is turned sideways to the object, and the image undergoes total reflection by the prism, giving a reversed negative.

Of the second class, *i.e.*, negatives reversed by reversing the film, the most convenient method is the following: The negative

is made in the ordinary way upon a gelatino-bromide plate. It is then washed and dried and coated with a solution of indiarubber dissolved in benzole, and when this coating is dry it is flowed over with transfer collodion, composed of—

Methylated spirit (·805)	2 ounces
Methylated ether (·730)	1 ounce
Pyroxyline	24 grains
Castor oil	24 minims

When this is dry, the negative treated in this manner is immersed in—

Water	50 ounces
Hydrofluoric acid	½ ounce

The film should next be cut round the edges with a penknife and stripped away gently, and floated off into a bath of clear water to wash. A glass plate is then coated with a warm solution of gelatine (about five grains to the ounce), and the film floated on to it in the reverse position—that is to say, with the collodionised side downwards—with a soft squeegee it is pressed into contact with the glass, and then set aside to dry.

The best class of processes for producing reversed negatives is by reproduction. There are several methods. The powder process is very often employed; this will be found described under that heading. Bolas's method is as follows:—A dry plate is soaked for five minutes in a four per cent. solution of potassium dichromate, rinsed once or twice with water, and then dipped into a bath of equal parts of methylated spirit and water, the superfluous mixture blotted off and dried. All these operations must be conducted in the dark-room. It is then exposed, under the negative to be reversed, to sunlight for three or four minutes, when a faint delicate image will be seen impressed; it is then washed and developed with ferrous oxalate or akaline pyro, and fixed and washed as usual. The result is a reversed negative image.

Now that sensitive bromide negative films are made so perfect, there is no doubt that they will be largely used in obtaining negatives required to be reversed, as they can be printed from either side with the same effect.

Reversing Back.—A very useful arrangement in many modern cameras. It is well known that the different sizes of photographic pictures are always longer one way than another. In landscape photography one is often confronted with the difficulty of deciding whether the picture would have the best appearance vertical or horizontal. In the case of photographing high buildings, too, it is often difficult to tell whether they would be all included on a horizontally-arranged plate. In the common forms of camera, without the reversing back, it is necessary to unscrew the camera from the baseboard or tripod, alter its position from horizontal to vertical, or *vice-versâ*, and re-adjust. This operation naturally

involves considerable time and trouble. With the reversing back, however, the camera is made square instead of oblong, and that portion of the back which holds the focussing screen, and the grooves in which the dark slide fits, is so constructed as to be readily detached. It can then be turned round from one position to the other, and sprung into place in the space of a few seconds only. Although with this arrangement the camera is somewhat bulkier and slightly heavier, yet these drawbacks are fully balanced by the additional convenience it affords.

Revolver Camera.—A small instantaneous camera made in the form of a revolver.

Revolving Background.—A circular graduated disc revolving on a pivot attached to a stand. It is used in portrait photography, placed behind the sitter, and revolved until the correct light and shade effect is obtained.

Rising and Moving Front.—A movement now arranged in nearly every camera. It consists in constructing that portion of the front of the camera to which the lens is attached in such a manner that it can be raised, lowered, or moved to either side, and by means of clamp screws adjusted in any position. This movement is especially useful in making pictures of architectural subjects; by shifting the position of the lens a picture is often obtained difficult or undesirable to get in any other way.

Rive Paper.—A very fine class of paper manufactured at Rive-de-Gier, or simply Rive, a town of France in the department of the Loire. It is of a very fine and even texture, and is largely used for photographic purposes.

Rocker.—An arrangement for keeping the dish rocked during the progress of development. See fig. 47.

Roller Slide.—See **Roll Holder.**

Roller Squeegee.—A wooden revolving roller attached to a handle and coated with indiarubber. It is used for mounting prints, or for squeegeeing gelatine prints upon glass. For the latter purpose, however, the straight edge squeegee is preferable. They are also made with two rollers.

Roll Holder or **Roller Slide.**—An arrangement for holding a continuous band of paper or other flexible substance, coated with a sensitive emulsion, in the camera during exposure. The first roller slide was introduced by Mr. A. Melhuish, about the year 1861, and was used for making paper negatives.

In the usual roller slide the film is unwound from one spool in equal lengths corresponding to the size of the plate for which the holder is designed, and after it has received the exposure it is again wound on to another roller termed the clamping reel. In this manner a large number of exposures can be made upon a long band of paper or film, and this is then cut up, and each picture developed.

It is exceedingly compact and very light. When a perfect flexible film has been discovered, the advantage over glass plates will be incalculable.

The best form of roller slide is that known as the Eastman-Walker roll-holder. It is constructed in three parts, a body consisting of four sides, together with the top and bottom. These latter are held to the body and together by two simple springs which pass down the ends, and by a mere pressure of the finger the roll-holder can be taken apart instantly, and its contents got at in all directions. Inside the body are fitted four rollers, two being small and permanent, and merely form runners for the film to pass over in its passage between the spool-holders. The other two are large rollers, fitted to attachments screwed into the sides of the frame. They are easily removable, and one fits on to an attachment provided with a brake, which serves as an automatic tension, keeping the film stretched flat and smooth, and prevents it being too freely unwound. There is also an audible and visible indicator, enabling the operator to be perfectly assured, both by sight and sound, that each exposure has been correctly wound off, and a new length placed into position ready for the next exposure. The film is also marked with an automatic perforator, so that no error can be made in cutting up the paper previous to development.

This roll-holder, although occupying the space of three double dark slides, contains sufficient material to make 50 or more exposures.

It can be easily adjusted to any ordinary camera, care being taken that the position of the film coincides with the plane of the focussing screen.

Rolling Press.—A contrivance for flattening and giving a finished surface to photographic prints, either mounted or unmounted. They are made either with two polished steel rollers, between which the print passes, or with a roller and a polished steel plate. The steel plate upon which the cards are laid is often so arranged that it can, if necessary, be heated with a gas or spirit lamp. By this means the cards are given a uniform and highly finished surface, similar to that obtained by burnishing. The pressure of the roller upon the steel plate should be perfectly even and under the control of the operator.

Rose Tap.—A tap fitted with a rose similar to that used for ordinary garden watering-cans. The water comes out as a fine

spray from the number of holes contained in the rose. It is very useful for washing negatives and prints, as the water running direct from the tap as a heavy stream will often destroy the gelatine film or the prints.

Rotten Stone.—A mineral found in Derbyshire. It is reduced to a fine powder, and used for polishing metals, Daguerreotype plates, etc. For the latter purpose it should be sifted through fine muslin.

Rouge.—Red oxide of iron. It is used for polishing metal, glass however, etc. Daguerreotype plates should not be polished with it, as the iron clings to the silver and injures the tone of the picture.

R.R. Lens.—An abbreviated term for a rapid rectilinear lens.

Rubber Finger Stalls.—Finger stalls made of indiarubber are very useful when working with poisonous chemicals.

Rubber Stamp.—Rubber stamps are now too well known to need any description. They can be made very useful to the photographer for numbering, naming, and marking negatives. For this purpose the movable reversed type should be used. A non-actinic ink is also necessary, and the name stamped backwards upon the film. If reversed type is unobtainable, the transfer aniline ink used in the gelatine copying apparatus should be used. The name, etc., is then printed on to a piece of paper, and when dry this can be transferred to the negative while the latter is still moist.

Ruby Glass.—Ruby glass is usually obtained by the addition of sub-oxide of copper and a little gold. It is used in photography as a non-actinic medium.

Ruby Light.—See **Non-actinic Media.**

Ruby Varnish.—See **Varnish.**

Rust Spots.—Rust spots sometimes make their appearance upon lenses, and may be removed by placing the spots in contact with chlorhydric acid diluted with a little water.

Safe Edge.—In carbon printing a thin strip of black or non-actinic paper pasted round the negative on the *glass* side is termed a safe edge. If the negative be masked on the negative side so as to print white, and should there be a heavy shadow in the picture coming against this portion, it is very likely to wash up in developing. The safe edge, however, prevents this.

Sal Ammoniac.—See **Ammonium Chloride.**

Salicylic Acid (Formula, $C_7H_6O_3$; synonyms, *spinoylic acid*, *orthohydroxy-benzoic acid*).—A dibasic acid found in the flowers of the *spiræa ulmaria*, or obtained by heating sodium phenol to 180° in a stream of carbon anhydride. It has a sweetish-sour taste, is slightly soluble in cold, more so in boiling water, and very soluble in alcohol and ether. It is principally used as an antiseptic and antiputrefactive agent.

Salt, Common.—See **Sodium Chloride.**

Salted Paper.—Paper prepared with a chloride. On sensitising on a nitrate of silver bath, sensitive silver chloride is formed. Albumenised paper containing a chloride is sometimes termed salted paper, but the term is more generally applied to paper prepared for matt surface or plain paper prints.

Saltpetre.—See **Potassium Nitrate.**

Salts.—When an anhydride and a base are brought together they usually combine to form a salt, the distinctive properties of both being lost in the resulting compound.

All salts may be made to form an acid or a base, but they are not all neutral to test paper—for instance, carbonic acid is so weak an acid that it has not sufficient power to neutralise the alkalinity of the soda when it combines with it to form sodium carbonate, this being nevertheless a salt, however, as it has its acid and its base.

Salts, Haloid.—Chlorine, bromine, iodine and fluorine are four elements which compose a natural group, the members of which are connected by the similarity of their chemical properties far more closely than those of any other group of elements.* They are usually termed the halogens, from their tendency to produce salts resembling sea-salt in their composition, such salts being called haloid salts.

Sandarach (Synonym, *gum sandarach* or *sandarac*).—A gum exuding from the *Callitris quadrivalvis*, one of the *cupresseæ* growing in Barbary, where it is called the Arar tree. Sandarach usually occurs in small whitish-yellow drops. It is a brittle, inflammable, resinous substance, with an acrid aromatic taste. It is used for making varnishes.

Satin, Printing on.—Prints may be made upon satin by treating with silver chloride in the same manner as with silk (see

* Bloxham's "Chemistry."

Silk, Printing on). Images may also be made upon satin stuffs by the diazotype or primuline process. See **Primuline Process.**

Saturated Solution.—When a solid is dissolved in a liquid, the first portions added may disappear quickly enough, but as more is added solution proceeds more and more slowly, until it ceases altogether, and any more of the substance added will sink to the bottom and remain there. The solution is then said to be *saturated*. See **Solution.**

Saxe Paper.—A fine even textured paper, manufactured at Saxe, in Germany, and much used for photographic purposes.

Scarf Camera.—A small toy instantaneous camera hidden behind a scarf, the lens protruding through the latter, and made to represent a scarf pin.

Scenic Background.—See **Background.**

Schlippe's Salt (Sodium sulphantimonate; formula, $Na_3Sb\,S_4\,9H_2O$).—Obtained in fine transparent tetrahedral and very deliquescent crystals by dissolving sulphide of antimony in sodium hydrate and adding sulphur. Freely soluble in water. It is sometimes employed for the intensification of collodion negatives.

Sciagraphy (Gr. *skia*—a shadow, and *grapho*—to draw).—The act or art of correctly delineating shadows in drawing; the art of sketching or reproducing objects with correct shading.

Sciopticon.—A convenient form of oil optical lantern. It was first introduced into this country from America by Woodbury some years ago, and although it was immediately imitated by a number of manufacturers it still holds its own as the finest oil lantern.

Scratches.—To prevent the negative from being scratched it is coated over with a protective varnish, which will preserve it to some extent. Accidents will often happen, however, and the films get scratched. This can sometimes be retouched with suitable colour, or can be filled up with black or non-actinic colour, so as to print as a white line in the positive picture, which can be better worked out with suitable colour.

Screen, Focussing.—See **Focussing Screen.**

Sealing Wax.—The term wax applied to this article is a misnomer, no wax being used, but resin, which is essentially different in its properties. The best kind is made with shellac, the inferior sorts of common resin. The best red sealing wax is

made by melting 4lbs. of light coloured or bleached shellac with 1lb. of Venice turpentine and 3lbs. of Chinese vermilion. Golden sealing wax is made by using powdered yellow mica or cat gold, instead of vermilion. Ivory black is used for black wax. An inferior kind may be made by substituting common resin for the lac, red lead for the vermilion, and common turpentine for that of Venice. A common black wax for bottles can be made with 6lbs. of black resin, ½lb. beeswax, and 5½lb. lampblack.

Seed Lac.—When the lac is broken from the twigs and washed in water it breaks into small particles called *seed lac*. It is used in the manufacture of varnishes, and is more soluble in alcohol than shellac.

Sel d'Or.—See **Gold Hyposulphite.**

Self-toning Paper.—A paper prepared principally for the use of amateurs and tourists. It requires no special treatment to get an agreeable tone. The paper, after printing, is merely washed and fixed, when it takes a brown colour instead of the dirty yellow obtained with ordinary paper thus treated. Only a brown tone, however, can be obtained. After fixing and washing the prints are laid between sheets of blotting paper, and afterwards dried under a hot iron. The hotter the latter the greater brilliancy of the prints, although scorching must be avoided. The preparation is a trade secret, and the results, however, are not perfection, the labour saved is not great, and the permanency of the prints is doubtful.

Semi-opaque.—Half opaque and half transparent.

Semi-tones.—Half-tones.

Semi-transparent.—Half or imperfectly transparent.

Sensitise.—To render sensitive or capable of being readily affected by the action of light.

Sensitised Paper.—This term properly includes any kind of prepared paper sensitive to light, the action being either visible or latent and made visible by development. It is more generally applied, however, to albumenised or plain paper treated with a chloride and afterwards floated on nitrate of silver. See **Sensitising.**

Sensitised paper unless specially prepared will not keep for any length of time. That sold commercially is all prepared with acids as preservatives. The addition of 10 drops of perchloric acid to every ounce of the sensitising solution is often recommended.

Ashman's method is as follows. The paper, when surface dry, is floated on one of the following solutions properly made up and filtered :—

No. 1.

Picked white gum arabic	¾ oz.
Rochelle salts	1¼ ,,
Distilled water	20 ,,

No. 2.

Picked white gum, Arabic	¾ oz.
Tartaric acid	1¼ ,,
Distilled water	20 ,,

After the paper is dry it should be stored away in sheets of sodaic blotting paper (*q.v.*) No. 1 will preserve it for about a fortnight and No. 2 for several months.

Sensitiser.—Any substance added or applied to a photographic material to increase or alter its sensitiveness to light.

Sensitising.—The operation of causing the albumenised paper to become sensitive to light. This is done by floating the surface of the paper already prepared with albumen containing a chloride upon a solution of silver nitrate. (See **Silver Bath.**) The albumen soaks up a portion of the silver solution, which combines with the chloride and albumen to form silver chloride and silver albuminate, these compounds, being sensitive to light, darkening rapidly by its action.

The operation of sensitising must be performed either by gas-light or during the day in a room lighted with windows covered with yellow paper or fabric. The room should be kept scrupulously clean and free from dust, and be fitted up with a convenient arrangement for hanging the paper lines ; or string stretched across the room with American clips strung along them will be found very convenient. The dishes containing the sensitising solution should be conveniently larger than the sheets of paper to be sensitised. It should be placed on the table as near to the window as possible to get plenty of light to work with. Over the bath should be fitted a few American clips to hold the paper by one corner, and at such a height from the bath that the bottom corner of the sheet is nearly touching the liquid in the bath ; this prevents splashing in drawing, and also the formation of air-bubbles.

The bath is placed lengthways before the operator, and the silver solution poured in. With a thin strip of blotting paper the surface of the liquid is skimmed, removing any scum or air-bubbles.

The paper to be sensitised should neither be too hard and dry, nor too moist. In very hot and dry weather it is advisable to place the sheets in a cool damp cellar for some little time before floating.

The paper has now to be floated, prepared side downwards, upon the silver solution. This is done by first turning up a small portion of each corner of the sheet for convenience in examining and lifting it from the bath. Two diagonally opposite corners are now held with the thumb and first finger of each hand, and the sheet curved slightly inward. That part of the sheet nearest the left hand is lowered gently on to the centre of the solution, and the sheet slowly drawn on to the solution, steadily lowering the right hand, until the whole sheet is floating in contact with the solution, with the exception of the four up-turned corners.

If this method be followed no air-bells will form between the paper and the solution. After a little time the corners are gently raised and lowered again one at a time to enable the operator to examine the progress of the sensitising operation. Any air-bubbles visible should be removed before again lowering the corner on to the solution. If any of the solution should by accident get

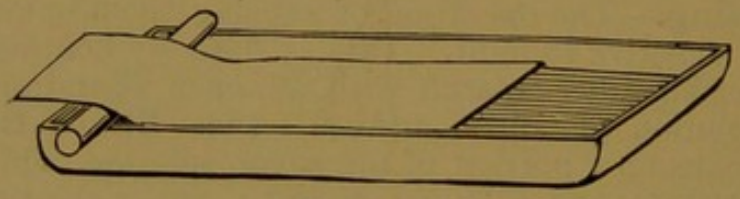

FIG. 189.

on to the back of the paper it should be blotted up at once with a piece of blotting paper. It often happens that the paper after floating will curl up, the corners and sides leaving the solution. The cause of this is that the paper is too dry; by breathing hard on to it the paper can be made to resume its position on the solution.

With regard to the correct time the paper should be allowed to remain upon this solution, this depends both upon the strength of the bath and the temperature of the solution and of the atmosphere. Further, different brands of paper often require different lengths of time for sensitising, and it is also influenced by the character of the negative and the effect to be produced in the resulting print. Many operators sensitise their paper of different degrees of strength for the various negatives from which they have to print; for instance, for weak negatives, a paper sensitised strongly. The usual time, however, may be said to vary from 40 to 70 seconds in the summer, and from 60 to 100 seconds in the winter.

The correct time for sensitising, as has already been stated, is dependent upon so many considerations that some amount of thought and experience is required by the operator to get the best class of results.

After the sheet has been allowed to remain for the required time upon the solution, it is slowly raised by two corners and drawn slowly over the edge of the dish, or preferably over a glass rod attached to one side of the dish (see fig. 189). In this manner the superfluous solution is removed from the surface of the paper. Some operators prefer to do this by laying the sheet on a piece of bibulous paper, but unless this be perfectly pure and free from anti-chlor. the method is rather risky.

The sheet is next fixed at one corner to a clip, and at the opposite or lowest corner a piece of white blotting paper is affixed to absorb the moisture (see fig. 190).

FIG. 190.

The drying of the paper is an important point. It should not be done spontaneously, as the silver solution will then sink into the paper, and the brilliancy of the prints is lost.

The sheet is first allowed to drain and become partially dry, and then finished thoroughly by heat in a drying cupboard fitted with a row of gas jets or a stove. In this the top of the sheet is attached to two clips. If it be found that the paper curls up in drying, pieces of wood the same length as the paper with a clip at each end are fixed to the lower edge of the paper to keep it straight.

The heat for drying should be diffused and sufficient to quickly dry the sensitised paper.

The following are the failures likely to be met with in sensitising albumen paper, and the causes.

The paper repels the silver solution. It is too dry.

White spots are produced if bubbles of air are allowed to remain beneath the paper when floating. The corners should be lifted up as soon as paper has settled down and the air-bells removed.

Small drops of the silver solution termed "tear drops" adhere to the sheet when hung up to dry. They should be blotted off immediately, and are caused by the paper being too dry.

The paper discolours quickly if over-sensitised.

A dull and sunken-in appearance of the image may also be caused by over-sensitising.

Bronzing of the dark shadows is also sometimes the result of over-sensitising.

Poor, weak prints are usually produced by too short sensitising. Greasiness of the paper is also produced either by insufficient sensitising or by the solution being very cold. Unpleasant foxy-reddish tones of the prints are often caused by too short floating on the sensitising bath.

The curling of the paper on the solution is caused by the paper being either too dry or the albumen film being too tough. Breathe on the back of the paper until it lays down flat again.

Stains are sure to appear if the sheet is allowed to come in contact with any unclean substance.

Dark stains on the back are produced by the silver solution running over the back.

Small dark spots or specs are caused by small metallic pieces of dust imbedded in the paper. They can sometimes be removed with the sharp point of a knife.

Inequality in the prints is due to uneven sensitising.

Sensitising Bath.—See **Silver Bath.**

Sensitometer.—An instrument for comparing the sensibility of various photographic sensitive surfaces. There are various forms, which are, however, all more or less imperfect. The reason of this is that a standard light is required perfectly uniform and reproducible at any desired place or time. A light of this description has never yet been found, nor has any means yet been devised of calculating the difference between an accepted standard and an actual light made as near to it as possible.

Warnerke's Sensitometer is the one generally employed in testing various photographic sensitive surfaces. It consists of a transparent scale of figures made by the Woodbury process, the transparency of the scale decreasing by regular degrees from 1 to 24. Under this scale the plate to be tested is exposed for a given length of time. Warnerke employs what he terms a normal light, that is, a glass pane coated with a phosphorescent

paint. Before this, two-and-a-half centimetres of magnesium wire are burned, then the whole is left undisturbed a minute, when it is placed upon the scale under which the dry plate lies. This light is considered as always uniform, but this is not so, however, as the temperature has a very marked effect upon the luminosity of the phosphorescent paint, the mere warmth of the hand increasing it. Further, this instrument possesses the drawback of being unable to register small differences.

Taylor's Sensitometer.—In this a more perfect method of graduating the light that reaches different parts of the plate from a uniform source is employed by means of a series of varying areas of a uniformly illuminated surface. The apparatus first employed by Arthur Taylor, in 1869, consists of a box containing a series of short wide tubes, each of which was open below to the sensitive surface, and closed at the upper end with a diaphragm perforated with a certain number of exactly uniform holes. The intensity of the light acting upon the sensitive surface at the bottom of any tube is proportional to the number of holes in the cover at the upper end of the tube.

Vogel's Sensitometer is an improvement upon the previous one. The scale is formed by a metal plate with holes. This plate covers a wooden block in which twenty-four cylindrical cells are drilled. Above the first cell one hole is made, above the second two, above the third three, and so on. Under these cells, the plate to be tested is exposed in a dark-slide-like contrivance, and it is obvious that the relative clearness under the different cells must be in exact proportion to the number of apertures made above the respective cells. When, therefore, two plates are exposed equally long under this instrument before an object uniformly illuminated and then developed, it may be that one plate will show the effect of light up to cell number two (with two holes), and the other up to cell number four (with four holes). With half the strength of the light the same result was obtained with the first plate as with the whole strength in the second plate, and the first plate is therefore shown to be twice as sensitive as the second.

Mucklow and Spurge's Sensitometer.—This is also similar to Taylor's, except that the diaphragms have one opening each, the openings being made of the required sizes. It is obvious that when a developable film is being tested the light must be graduated, because a uniform effect cannot be secured (the time then being in inverse ratio to the sensitiveness), as the result is not apparent until development.

Sensitive.—Capable of undergoing change by exposure to light.

Sensitiveness.—The sensitiveness of photographic substances, films, plates, paper, etc., is determined by the amount of time re-

quired for a given quantity of light to impress itself upon them either visibly or rendered visible by after development. The sensitiveness of dry plates is usually calculated by means of Warnerke's sensitometer. This method is, however, far from being perfect, and although plates are often sold with the sensitometer number marked upon the box containing them, yet this cannot be taken as a sure guide to their rapidity of action, and the numbers are often more misleading than otherwise.

The sensitiveness of dry plates can be considerably increased by immersing them for from three to five minutes in a solution of 100 parts of alcohol ·805, from one to two parts of a 1 in 15 solution of azotate of silver, and ten parts of ammonia. They are then dried and used immediately.

Sepiatype.—A platinotype process introduced by Willis, giving sepia tones. See **Platinotype.**

Shapes, Cutting.—See **Cutting Moulds.**

Sheath.—An arrangement for holding the dry plate in detective cameras so that they are protected from the light and can be conveniently changed at will. They are usually made of darkened metal.

Shellac (Synonym, *gum lac*).—A reddish-brown, fusible, brittle and inflammable substance occurring in thin sheets. Bleached lac occurs in white opaque brittle masses. These should not have a shiny appearance on the exterior, as this denotes that a change has taken place, and the substance will be found more or less insoluble.

Lacs are all soluble in alcohol, and in water containing borax, sodium carbonate, caustic soda, or ammonia. They are principally used in the manufacture of varnish. A shellac solution is not suitable for a varnish without the addition of sandarac or other suitable substance to give it the required elasticity.

If ammonia be mixed with an alcoholic solution of shellac the latter may be mixed with all proportions of water.

Shellac Mountant.—Made by dissolving one ounce of shellac in four ounces of methylated spirits, and allowing to stand for some time, when the solution will be ready for use. Another method is to dissolve the shellac in a hot solution of borax and water, but the borax is liable to spot the prints.

Shutter.—For ordinary photographic work the lens is fitted with a cap which covers its front, and which is removed when making the exposure. For many classes of work, however, a shutter is necessary; for although it is possible to make a very rapid exposure by removing and replacing the cap as quickly as possible, yet it will be understood that exposures of 100ths of a

second cannot be possibly done in this manner. The shutter is, therefore, a mechanical arrangement to effect this, and a very great variety have been constructed. They may be divided into the following classes :—

1. (a) The simple flap shutter.
   (b) The double flap.
   (c) The flap and drop.
2. The simple drop shutter.
3. The "go and return."
4. The roller blind shutter.
5. The diaphragmatic.

With regard to the first class it may be stated that they are of little service for very rapid exposures, and that they give a longer exposure to the foreground than to the sky—an arrangement of great service at times when the contrast is very great, as it often is.

The simple drop shutter, when properly constructed, is capable of giving very rapid exposures, and is for this reason very often employed. It is usually a plate of wood, metal or ebonite, which falls by gravitation in front of the lens. The centre of the falling piece has an aperture of a certain length, usually two or three times the diameter of the lens. Its rapidity can, of course, be increased by means of an elastic band or spring.

Of the "go and return" class there are two well-known forms, one of which works in the diaphragm slot and the other in front of the lens. These are more useful for prolonged exposures, but many, however, have a tendency to shake the camera when pushed to the utmost by the spring just at the critical moment when the lens is fully opened. The consequence is, of course, a blurred image.

The roller blind class includes several well-known and tried shutters. They are perfectly free from vibration. Many of them can be used both as time and instantaneous shutters.

The diaphagmatic class includes all shutters working between the lens combinations. One of the advantages is that the position of this shutter enables smaller moving parts to be used.

Shutters are usually set in motion by releasing a catch with the finger, setting the spring or weight into action. A better system, however, is that known as the pneumatic release. It consists of an indiarubber tube attached to a piston, and having at the other end a hollow indiarubber ball. By pressing the ball air is forced through the tube, causing the piston rod to release the shutter. By this means shaking the camera is entirely avoided; the exposure can be made at any distance without exciting attention, and if the tube be long enough it is possible to photograph oneself, or be included in a group of one's own taking. The requirements of a shutter are thus summed up by Chapman Jones :—"A shutter should be small, that it may not catch the wind; light, that it may not strain the lens mount or camera front; simple, that it may be easily repaired by the user, quickly fixed to or removed from the lens, and need no change whatever in either the camera or lens."

In order that the shutter may be used intelligently, it is necessary that the lengths of exposure given by it should be accurately measured. This is usually done by photographing a body, falling at a known rate, and measuring the length of the impression. A simple plan is to have a large black circular disc, having towards its edge a white clearly-defined spot. This disc is revolved at a given speed—say, one second per each revolution. An exposure is made with the shutter, and on development the length of the image is calculated—if it has moved, say, ten degrees of the circle, the exposure given by the shutter was the $\frac{1}{36}$ of a second. It is important that the image of the moving object be as near to the centre of the plate as convenient, as the edges usually get less exposure.

Another apparatus has been devised for this purpose by Addenbrooke. A sensitive plate is caused to revolve at a given speed behind a small opening made in an opaque screen, in front of which magnesium ribbon is burnt. The shutter is fixed between the light and the aperture of the screen. The proportion that the curved line of the developed image bears to the whole circle is the proportion that exists between the time of one revolution of the plate and the exposure given by the shutter. For example, if the plate makes one revolution per second, and a tenth part of a circle is produced on development, it is apparent that the duration of time the light was admitted was the one-tenth of a second.

In photographing moving objects it is useful to know the maximum amount of exposure that can be given at different distances. The following calculations of W. Groves* will enable one to do this satisfactorily :—

Let x = distance of image from lens (*i.e.*, focal length) in feet ;
y = ,, object ,, in feet ;
d = amount of movement of object permissible in feet ;
v = velocity of object transversely to axis of lens in feet.

Assuming that the amount of movement of the image on the plate permissible is $\frac{1}{100}$ inch, that is, $\frac{1}{1200}$ foot, we have

$$\frac{d}{\frac{1}{1200}} = \frac{y}{x} \qquad \therefore d = \frac{y}{1200\,x}.$$

Now, $\frac{v}{d}$ = the number of times the object traverses the permissible distance in each second.

∴ Time lens may be uncovered (speed of shutter) =

$$\frac{1}{\frac{v}{d}} \text{ sec.} = \frac{d}{v} \text{ sec.} = \frac{y}{1200\,xv} \text{ secs.}$$

Examples :—

If $x = 8''$ ($\frac{2}{3}$ foot), and y = 10 feet, and $v = 4\frac{1}{2}$ feet per sec., then

$$\text{Speed of shutter} = \frac{10}{1200 \times \frac{2}{3} \times \frac{9}{2}} = \frac{1}{360} \text{ secs.}$$

If y = 20 feet speed $= \frac{2}{360} = \frac{1}{180}$ sec.

If y = 30 feet ,, $= \frac{3}{360} = \frac{1}{120}$ sec.

* "British Journal of Photography," 1891, p. 45.

With many shutters very little effect is produced on the plate during the periods near opening and closing, and it is probable that the minimum time of exposure in such cases might be one-fourth or one-third more than the above without visible blurring.

Sidereal Photography.—See **Astronomical Photography.**

Side Swing.—An arrangement by means of which the back of the camera carrying the focussing glass and dark slide can be moved, so that one side be nearer or farther from the lens than the other. In the double swing back, besides the vertical swing explained under **Swing Back**, there is also an arrangement for its movement horizontally, so that the proper focus may be secured of any object, whether at top, bottom, or at either side of the image.

Silhouettes.—These can be made very effectively by photography to represent the old style of profile portraits cut out of black paper. One method is to place the sitter against a white translucent screen brightly illuminated from behind, giving a short exposure and strong development; or the sitter can also be placed behind and near to the screen, his shadow being photographed. A simple method of making a silhouette portrait from an ordinary side-face negative is to print a light positive on albumenised paper and carefully cut out the figure. This is then placed in the light to get quite dark, and then toned a deep black, fixed and pasted on to a white mount. To save the trouble of the last operations the cut-out portrait can be dipped in ink, or otherwise blackened. Other methods of obtaining these portraits will no doubt suggest themselves. What is required is a perfectly sharp outline of the features taken to give a correct likeness as possible. A study of the old-fashioned cut-out portraits is advisable.

Silk, Printing on.—Photographic positives can be made very effective printed upon silk, satin, or other fabrics. There are several methods of accomplishing this. A simple one is the following:—The silk best suited for the purpose is that known as Chinese silk, and this is first washed in warm water with a plentiful lather of soap, then rinse in hot water, and gradually cool until the final washing water is quite cold. Next prepare the following solutions:—

SOLUTION 1.

Tannin	4 parts.
Distilled water	100 ,,

SOLUTION 2.

Sodium chloride	4 parts.
Arrowroot	4 ,,
Acetic acid	12 ,,
Distilled water	100 ,,

The arrowroot is mixed up into a paste with a little of the distilled water, and the remainder added boiling hot, with the acid and the salt previously dissolved in it. When the solution is quite clear the tannin solution is added, and the whole allowed to get fairly cool. The silk is then immersed for about three minutes, being kept under without air in the folds, and then hung up to dry, or stretched out with pins on a flat board. The material is then sensitised by brushing over with the following solution :—

Silver nitrate	12 parts
Distilled water	100 ,,

Nitric acid, two drops to every three ounces.

Other methods of sensitising are by immersing in or floating on the silver solution. After sensitising, the material is dried by pinning on to a board to keep flat. It is then cut up as required, and printed behind the negative. Every care must be taken in printing to keep the material flat, and without wrinkles or folds. It must also be kept quite straight, otherwise the image will be distorted. Printing is carried on in the same manner as with albumenised paper. It is then washed and toned in any toning bath. The sulphocyanide gives the best action. Fix in a ten per cent. solution of hyposulphite of soda for ten minutes, wash and dry spontaneously. When just damp it is ironed out flat with a not over-heated iron. Black tones can be obtained with a platinum toning bath, or with the uranium and gold toning bath made up as follows :—

Gold chloride	1 part.
Uranium nitrate	1 ,,

Dissolved and neutralised with sodium carbonate, and then added to

Sodium chloride	16 parts.
Sodium acetate	16 ,,
Sodium phosphate	16 ,,
Distilled water	4,000 ,,

Very effective results may be made by printing with wide white margins obtained by exposing with a non-actinic mask.

Another method is the following :—

Ammonium chloride	100 grains.
Iceland moss	60 ,,
Water (boiling)	20 ounces.

When nearly cold this is filtered, and the silk immersed in it for about fifteen minutes. To sensitize immerse the silk in a 20 grain solution of silver nitrate for about sixteen minutes. The silver solution should be rather acid.

Or immerse the silk in—

Water	1 oz.
Sodium chloride	5 grs.
Gelatine	5 ,,

When dry float for thirty seconds on a 50-grain solution of silver nitrate. Dry, slightly over-print, and tone in the following bath :—

Gold chloride	4 grains.
Sodium acetate	2 drachms.
Water	29 ozs.

Keep twenty-four hours before using. Fix for twenty minutes in hypo, 4 ozs. to the pint of water.

Images in many different dyes may be made upon silk by the Diazotype process. (See **Primuline Process.**)

Instead of silk, satins and other similar fabrics can be used.

Silver (Symbol, Ag; atomic weight, 108).—A white metal which when quite pure is rather softer than gold, and not quite so soft as lead. It is the best known conductor of both heat and electricity. Its great use in photography is due to the fact that it forms compounds exceedingly sensitive to light.

In consequence of its softness all silver for the manufacture of coins and articles is mixed with copper; British coinage contains 92·5 parts of pure silver and 7·5 parts of copper. The following method of obtaining pure silver from coins is given by Wall: Place the coin, either entire or, preferably, cut up small, in a test tube, with one part of pure nitric acid and two parts of water; apply a gentle heat, and an action commences at once, orange-red fumes of nitric oxide being evolved. If after the lapse of some time the whole of the coin is not dissolved, add more nitric acid, and again apply heat. When the coin is dissolved, the solution will be seen to be of a bright blue colour, due to the copper; pure silver can be obtained from this solution by evaporating to dryness and fusing strongly the resulting mass. A little taken out and dissolved in water should give no blue colouration with solution of ammonia; or sheet copper may be placed in the acid solution, when a precipitate of pure silver will take place, which may be collected and again dissolved in nitric acid to form solution of nitrate of silver; or the precipitate may be collected and fused as above to obtain a button of silver.

Silver is soluble in nitric acid and boiling sulphuric acid, and partially in hydrochloric acid, and combines directly with chlorine, bromine and iodine.

Water at ordinary temperature, and air free from sulphuretted hydrogen, have no effect upon it, tarnishing being due to the sulphuretted hydrogen contained in the air.

Silver is principally employed in photography in the manufacture of silver nitrate (*q.v.*)

Silver Albuminate (Synonym, *albuminate of silver*). — This name is given to a white insoluble substance formed when albumen

is mixed with silver nitrate. Its composition is very uncertain. It reddens on exposure to light. It is formed when albumenised paper is sensitised in a silver nitrate solution.

Silver Ammonio-nitrate (Formula, $AgNO_3 2NH_3$; synonym, ammonio-nitrate of silver).—Can be obtained by exposing powdered silver nitrate to ammoniacal gas. Combination takes place rapidly. Solutions of ammonio-nitrate of silver are used in sensitising plain salted paper for positive printing, and also in the manufacture of gelatino-bromide of silver emulsion by the ammonia process.

Silver Bath (for paper).—In the ordinary method of making photograph positives by what is termed silver printing, paper prepared with albumen or gelatine containing a certain quantity of a soluble chloride is floated for varying lengths of time on what is termed a "silver bath." It consists of a solution of silver nitrate with or without the addition of other substances. Upon floating on this solution a certain quantity of it is absorbed by the gelatine or albumen substratum, and combines with the chloride to form silver chloride in a very fine state of division. The effect of the light upon the white surface of the silver chloride is to darken it to a violet colour. The action of the light may be stated to be quite superficial, for even if the action of the light be allowed to continue until the colour is very deep the amount of reduced silver forming it is exceedingly small. It will be obvious that an important consideration is the strength and composition of the silver bath in order to secure the best results. It will naturally be imagined by the student that the strong bath would sensitise the paper much quicker than a weaker solution, but this is not the case, however. Again, it would be natural to suppose that with a weak bath the paper would take up less silver than with a strong bath. This is also incorrect. A certain quantity of silver nitrate will combine with the chloride and organic substances used in preparing the paper no matter whether the bath be weak or strong.

A strong solution of silver has the effect of hardening the albumen surface, so that for a time there is repulsion between the paper and the bath solution ; while the weaker solution not affecting the albumen in this way is readily absorbed, and if the floating of the paper be long continued the solution will penetrate the albumen and dissolve it.*

In both these methods of floating, either for a long time on a strong bath, or for a short time upon a weak one, we obtain serious disadvantages. In the first case, although we get brilliancy in the positives, the bronzing of the shadows is with some negatives

* Heighway's "Printer's Assistant."

a serious defect; and in the second method the prints are usually very weak with a poor sunken-in appearance.

For general use, a bath of medium strength, 40 grains of silver nitrate to the fluid ounce of water, is the best, as it is suitable for most work, least likely to get out of order, and can be easily kept a required strength.

Silver baths may be divided according to their composition into three classes. *

The first class comprises such formulæ which require the use of nitrate of silver and water only. They usually differ in strength from between 40 to 60 grains of silver nitrate to the ounce of water. It should be kept slightly alkaline in reaction by the occasional addition of a few drops of ammonia or a small quantity of a strong solution of sodic carbonate. A small quantity of silver carbonate will be formed with the addition of the latter solution, but this will settle to the bottom, and tend to keep the bath clear by carrying down with it any floating organic matters.

The second class refers to the old ammonio-nitrate method formerly much used, and still largely, for the production of silver prints upon plain paper. It is prepared as follows :—The silver nitrate is first dissolved in the requisite quantity of water, two-thirds of the solution are then placed in a separate vessel, and strong ammonia added drop by drop. A precipitate of oxide of silver is at once formed, and the ammonia still added in drops until this precipitate is completely dissolved again. The remaining third of the solution is then added, when a slight precipitate will be again formed. This is removed by adding pure concentrated nitric acid very cautiously drop by drop until the precipitate is just re-dissolved, not another drop being put in after that Although this bath gives greater sensibility to the paper, and deeper prints, yet it is more likely to discolour owing to the separation of organic matter from the paper.

The third class of silver baths includes those which, in addition to the silver nitrate and alkaline nitrate, such as the ammonium, sodium or potassium salts. The action of these salts is to absorb the free chlorine, and further to prevent the paper from becoming too dry in very hot weather. There are a great variety of formulæ, one of the most generally used is—

Silver nitrate	50 grains
Ammonium nitrate	30 ,,
Water	1 ounce.

Made slightly alkaline with the addition of ammonia or sodium carbonate. A few grains of alum are also added, sometimes, for preventing blisters.

In sensitising albumen or plain salted papers upon the silver bath, they are always floated. For full instructions see **Sensitising.**

* C. L. Mitchell, M.D.

The strength of the silver baths should always be greater in the winter and less in the summer.

Never attempt to use the smallest possible amount of solution. The depth in the bath should be at least half an inch.

Considerable care and attention must be taken in the preparation and care of the silver bath. It must be remembered that each sheet of paper floated upon the solution absorbs a quantity of the silver, and unless this be replaced the bath will soon refuse to work. For strengthening the solution, a stock solution of 60 grains of silver nitrate to the ounce of distilled water. A practice adopted by some operators is to allow about 50 grains of silver nitrate for each sheet of paper, and the amount of silver corresponding to the number of sheets used is dissolved in a few drachms of distilled water and added to the bath.

With regard to the water used in making up a strengthening silver bath, there is no doubt that distilled is the best; ordinary cistern water can, however, be used if the solution be exposed in a clear glass vessel to the sun or bright daylight. It will then become quite brown owing to a precipitate formed, which will, however, fall in a few hours to the bottom of the vessel, when the clear liquid can be poured off and filtered.

The alkalinity of the bath should not be too decided. When it shows an acid reaction a few drops of a diluted solution of ammonia are added until the red litmus paper *slowly* changes to blue.

Some operators prefer to use an acid bath acidified with citric acid. This is useful when the paper is required to be kept for some days, but otherwise it is not recommendable, because the results are not so fine, the action is slower, and the bath is not so easily purified.

The usual method of determining the strength of the silver solution is by means of the hydrometer or argentometer, the latter being specially marked, showing at a glance the number of grains of silver nitrate in each ounce of the solution. With pure solutions of silver nitrate the strength can be correctly estimated, but after a time the bath becomes contaminated with soluble salts, organic matter, etc., which tend to increase the density of the solution, and to render the working of the argentometer less accurate. The principal source of contamination to the solution is from the dissolution of the albumen from the paper floated on it. This, in time, causes the bath to become yellow and then brown. This discolouration must of course be removed, otherwise the paper will be unevenly sensitised and darkened.

There are several methods of purifying the bath. A simple one is to add a little kaolin, and then shake it up well and place in glass vessel in the sun. The organic matter is carried down with the kaolin as it subsides. It is then filtered and is ready for use. Kaolin is the purest form of disintegrated felspar; it sometimes

contains chalk, which renders it unfit for decolourising acid solutions of silver citrate. It should then be treated with a weak acid and washed.

Another method of purifying the bath is by the addition of a little of a strong solution of potassium permanganate. A stock solution is made up of—

Potassium permanganate	20 grains.
Water	1 ounce.

The usual method after the paper has been all sensitised for the day is to add a few drops of this solution with a glass rod, and stirring up the bath to well mix it. The solution takes a rose tint, which gradually dies out; a few more drops are added until the rose colour does not die away. The tinted solution is then put into a clean glass bottle and exposed to sunlight until the colour disappears. It is then filtered until clear. With a few drops of the permanganate solution, the bath can be decolourising during the sensitising operations by well mixing it up. It must be used with caution, however, as evil effects can also arise from it.

Other methods consist in adding a few drops of hydrochloric acid or a pinch of common salt. Chloride of silver is instantly formed, which falls to the bottom, carrying impurities with it, or a small quantity of sodium carbonate can be added, and the bottle placed in strong sunlight.

When any of these methods fail, however, it can be restored by "boiling" the bath. The solution is poured into an enamelled iron dish placed over a lighted gas stove. If the bath is not alkaline it must be made so by the addition of ammonia solution. When thoroughly heated it will become black and turbid. When about a third of the solution has evaporated the solution is cooled and filtered. The strength of the silver is then ascertained, and distilled water added to reduce it to the required strength. Another method is to fuse the bath. The method is similar to the last one. The evaporation is continued to dryness, and the bath fused until all frothiness disappears. The heating apparatus is then removed, and the mass scooped in a lump. When sufficiently cool sufficient of a nitric acid solution 1 in 12 is added to re-dissolve the silver with the aid of heat. The bath is again evaporated to dryness, dissolved in pure distilled water, and filtered water is then added until correct strength is obtained, all organic matter having been by this means thoroughly carbonised.

It will often happen that the silver solution becomes so choked up with the soluble salts, resulting from the chemical actions which occur in sensitising, that none of the methods of purification will be advantageous. In this case it is best put away and the silver recovered at a convenient opportunity. Mr. C. L. Mitchell gives the following methods of recovering the silver from the old baths: —If the bath has been made according to the first or third class,

all that is necessary is to render the bath acid with nitric acid, and then add a strong solution of washing soda until the white precipitate of carbonate ceases to be formed. This is allowed to settle, the supernatant liquid poured off, and the precipitate washed repeatedly until the washings are free from colour, and all soluble salts have been removed. The precipitate is then drained on a filter and the moist mass filtered, and all is placed in a dish of porcelain or enamelled iron, and dilute nitric acid (1 in 10 of water) added, until effervescence ceases, and the white precipitate is nearly entirely dissolved. This solution is then filtered and evaporated, first to dryness, and then heated to calm fusion, and allowed to cool. The resulting semi-crystalline mass may be considered a pure silver nitrate. If the old silver bath, however, is prepared according to the ammonia-nitrate formula, this method will not answer, as in the presence of the ammonia salt not all the carbonate of silver can be precipitated. The best plan, therefore, is to acidify the bath as before with nitric acid, and then add salt until all the silver is precipitated as chloride. This should be well washed, collected on a filter, and dried. It may then be conver ed into pure metallic silver by fusing it in a crucible with powdered charcoal and potassium nitrate, or it may be placed in a vessel containing dilute sulphuric acid (1 in 20) and metallic zinc added. Metallic silver will be precipitated in a finely divided state, and the zinc dissolved. From this silver the nitrate can be prepared by dissolving it in dilute nitric acid, and then proceeding in the same manner as described for the silver carbonate.

It should be noted that care and cleanliness will greatly assist in preserving the silver bath in its purity as long as possible. Filter and strengthen each time after using.

Silver Bath for Plates. — See under **Collodion, Wet Process.**

Silver Bromide (Formula, AgBr.; molecular weight, 188; synonym, *bromide of silver*).—Prepared by direct union of the two elements silver and bromine, or by double decomposition between silver nitrate and any soluble bromide. In the Daguerreotype process, silver bromide is formed by the first method, and in the dry-plate process by the second, potassium or ammonium bromide being used. When silver nitrate is added to potassium bromide, the silver combines with the bromide, and the nitrate with the potassium.

Silver bromide usually occurs in a yellowish state. Stas in his researches proves it to occur in six distinctly different states. These are—(1) as white flakes, (2) as yellow flakes, (3) as a bright yellow powder, (4) as a pearly white powder, (5) as a yellowish white powder, (6) in an intense yellow melted state.

De Pitteurs classifies the photographically useful varieties of silver bromide as follows* :—

	By transmitted light.	*By reflected light.*	*Photographic occurrence.*
Semi-transparent	Orange	Slaty blue	Very fresh collodion-emulsions.
		Bluish-white	Ripened emulsion and wet collodion.
	Reddish orange	Bluish-white	Very sensitive wet collodion.
		Yellowish-white	Very old collodion-emulsions.
Almost opaque	Violet blue	Yellowish-white	Very old collodion-emulsions.
		Greenish-yellow	Fresh gelatine emulsions.
	Blue	Green or Greenish-violet	Ripened gelatine emulsions.
		Indistinct	Red-sensitive gelatine emulsions giving foggy pictures.

Silver bromide is insoluble in water, alcohol, ether, and in weak ammonia solution. Soluble in sodium hyposulphite, potassium cyanide, ammonia, and in saturated solutions of the majority of the chlorides, bromides, and iodides.

Bromide of silver is sensitive to light, darkening by a lengthy action to a dirty grey, bromine being evolved.

By very short exposures to light no visible change takes place, although a most important action in reality occurs. This action is usually stated to be a reduction to silver sub-bromide Ag_2 Br. Others consider it to be converted into an oxybromide $Ag_2O \cdot 2AgBr$, or into a photo salt† AgBr x.yAg_2Br. Whatever the precise action may be, it is a fact that it is more easily reduced by certain salts, alkaline pyro and other substances blackening it, which constitute the process of development.

Its uses in photography in the collodion and dry-plate emulsion processes are very important.

Silver Chloride (Formula, AgCl; molecular weight, 143·5; synonyms, *chloride of silver*, *argentic chloride*).—A white insoluble substance obtainable by direct union between the two elements chlorine and silver, or by double decomposition with silver nitrate with a soluble chloride. If a solution of sodium chloride or hydrochloric acid be added to a solution of silver nitrate silver chloride is immediately formed as a white precipitate.

Silver chloride also occurs as a native ore, termed, from its peculiar appearance, horn silver.

Silver chloride when exposed to actinic light changes in colour from white to purplish tints, and finally to black, but this only takes place if water, organic matter, or chlorine absorbents of some kind be present. If perfectly dry and pure no change takes places. Chloride of silver can be exposed to the light for years in a perfect vacuum without the slightest change taking place. A certain quantity of humidity is necessary

* "Materia Photographica."—C. J. Leaper.

† Carey Lea's Theory.

to form a reaction, hence in very cold weather the darkening of silver chloride paper is always slower than in warm and damp weather. By short exposure it becomes converted into what is generally considered to be sub-chloride of silver, the action being similar to that with silver bromide (*q.v.*), and can then be acted upon by reducing agents or developers, as they are termed.

Silver chloride is but slightly soluble in water, and in strong hydrochloric acid; potassium cyanide and sodium thiosulphate (hypo) dissolve it readily.

If fused silver chloride be covered with hydrochloric acid, and a piece of zinc placed upon it, it will be found entirely reduced after a few hours to a cake of metallic silver; the first portion of the silver having been reduced in contact with the zinc, and the remainder by the galvanic action set up by the contact of the two metals beneath the liquid.*

Ammonia will readily dissolve silver chloride, the solution depositing colourless crystals of the chloride when evaporated; if the ammonia solution is very strong, ammonio-chloride of silver will be formed.

Silver chloride melts at 260° Fahr., is not decomposed if heated with carbon, but can be reduced by heating in a current of nascent hydrogen.

It is largely employed in photography for printing processes, and in the manufacture of chloride and chloro-bromide emulsions.

Silver Citrate (Formula, $Ag_3C_6H_5O_7$; molecular weight, 513).—A white salt formed when a soluble citrate is added to silver nitrate. Silver citrate is capable of reduction by light, and for this reason sodium citrate is sometimes substituted for a portion of the salt in the salting bath of the albumen printing process. It reddens the colour of the print, and makes the paper less sensitive, but, according to Hardwich, it renders it more vigorous on the surface, and less liable to assume a cold inky tint in the toning bath. Citrate of silver is also formed in the gelatino-citro chloride and collodio-citro-chloride printing-out emulsion processes.

Silver Emulsion.—An emulsion containing silver, usually in the form of an iodide, bromide, or chloride, or mixtures of these held in suspension in some viscous substance, as collodion, gelatine, etc.

Silvering Solution.—See **Silver Bath.**

*Thomson and Bloxham's "Chemistry."

Silver Intensification.—See under **Intensification.**

Silver Iodide (Formula, AgI ; molecular weight, 235 ; synonym, *iodide of silver*).—Found in the mineral kingdom, but can be formed either by direct union between the two elements, silver and chlorine, or by a double decomposition with silver nitrate and a soluble iodide. If silver nitrate be in excess the precipitate is of a strong yellow colour, which darkens rapidly on exposure to light to a brown or greenish tint, but if the iodide is in excess no visible change takes place; the action of the light is then only visible by development as with chloride and bromide of silver.

Silver iodide is insoluble in water, alcohol and dilute nitric acid, and nearly insoluble in strong ammonia. It is, however, soluble in all the solvents for silver bromide.

It is used in the Daguerreotype process, collodion process and in the manufacture of dry-plate emulsions. It gives extreme sensitiveness and greater density.

Silver Nitrate (Formula, $AgNO_3$; molecular weight, 170; synonyms, *nitrate of silver*, *lunar caustic*).—Prepared by dissolving pure silver in nitric acid. Six ounces of silver are dissolved in $2\frac{1}{2}$ fluid ounces of strong nitric acid, and 10 fluid ounces of water, by the aid of gentle heat. The solution is then evaporated to dryness, and heated to 198°C. (fusing point) to expel excess of acid. Silver nitrate can also be prepared from standard silver, containing copper, in the following manner : Dissolve the metal in a moderately strong solution of nitric acid, and evaporate in a porcelain dish. A blue residue, containing the nitrate of silver and copper, will be the result. The dish is then heated until this residue has fused and become uniformly black, the blue copper nitrate being decomposed, and leaving black copper oxide at a temperature which is insufficient to decompose the silver nitrate. Care should be taken that the residue is not heated more than sufficient to decompose all the copper nitrate. To find out when this is effected, take a little on the end of a glass, and dissolve in water filtered and tested with ammonia. If any copper be present a blue colour will be produced. When satisfactory, the residue is treated with hot water, the solution filtered from the copper oxide, and evaporated to crystallisation.

For surgical purposes, the fused nitrate is moulded into thin sticks (lunar caustic), but for chemical and photographic purposes it is dissolved in water and crystallised. Silver nitrate acts as a powerful caustic, owing to the facility with which it parts with oxygen, the silver being reduced to the metallic state when in contact with organic matter. This effect is greatly increased by exposure to light. Pure silver nitrate undergoes no change when exposed to the light, but if organic matter be present a black

deposit containing finely-divided silver is produced. It is for this reason that silver baths used for sensitising collodion plates and albumenised paper readily become discoloured. They can, however, be easily purified. (See **Silver Bath.**)

Recrystallised silver nitrate should be soluble in its own weight of water, and in four times its weight of boiling alcohol, which, however, precipitates it on cooling. Zinc, iron, lead, tin, and several

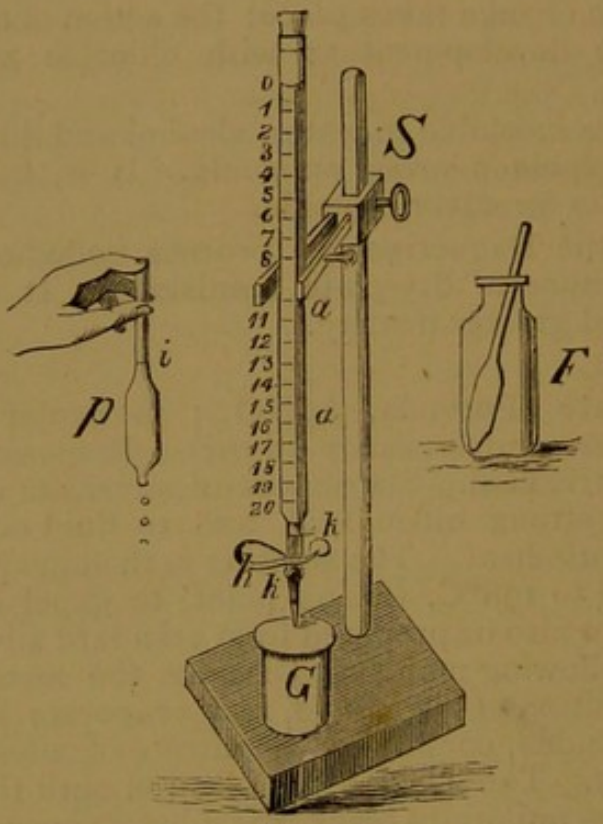

FIG. 191.

other metals precipitate metallic silver from solutions of silver nitrate. The following method of testing the purity of a commercial sample of silver nitrate is given by Clement J. Leaper:—"Dissolve it in water, completely precipitate the silver with pure hydrochloric acid, filter and evaporate the filtrate to dryness, when no residue should remain. If there should be any remain ignite it, when white fumes will indicate the presence of ammonium nitrate in the sample. If a residue remain after continued ignition, treat it with boiling water, and test the soluble portion for potassium and sodium in the usual way (*vide* tests for these salts), when positive results will indicate the presence of potassium or of sodium nitrate. The insoluble portion left after treating the residue with water is dissolved in a little nitric acid diluted with water and tested for lead with sulphuretted hydrogen, and for magnesium with ammonium hydroxide and sodium phosphate."

Silver nitrate is largely used in photography for a variety of purposes, but chiefly to form other silver salts. To prepare a pure solution of silver nitrate it is dissolved in water in a clean glass, bottled, and placed in the sun for a few hours. The solution will be rapidly darkened, and a brown precipitate will be formed. This will eventually fall to the bottom, and the clean solution may be decanted or filtered off. (See **Silver Bath.**)

To test the amount of silver nitrate in a solution, a special instrument, termed an argentometer, has been constructed. This is clearly marked with the number of grains per ounce. The following table, however, by Dawson,* will perhaps be found useful at times, when only an ordinary hydrometer is available.

Table for ascertaining from the specific gravity the amount of silver nitrate contained in one fluid ounce of any pure solution at 60° Fahrenheit.

Grs. per fl. oz.	*Sp. gr.*	*Grs. per fl. oz.*	*Sp. gr.*	*Grs. per fl. oz.*	*Sp. gr.*	*Grs. per fl. oz.*	*Sp. gr.*	*Grs. per fl. oz.*	*Sp. gr.*	*Grs. per fl. oz.*	*Sp. gr.*
10	1,021	32	1,063	54	1,105	76	1,146	98	1,187	120	1,227
11	1,023	33	1,065	55	1,106	77	1,148	99	1,189	121	1,229
12	1,025	34	1,067	56	1,108	78	1,150	100	1,191	122	1,231
13	1,027	35	1,069	57	1,110	79	1,152	101	1,193	123	1,232
14	1,029	36	1,070	58	1,112	80	1,153	102	1,194	124	1,235
15	1,031	37	1,072	59	1,114	81	1,155	103	1,196	125	1,236
16	1,032	38	1,074	60	1,116	82	1,157	104	1,198	126	1,238
17	1,034	39	1,076	61	1,118	83	1,159	105	1,200	127	1,240
18	1,036	40	1,078	62	1,120	84	1,161	106	1.202	128	1,242
19	1,038	41	1,080	63	1,122	85	1,163	107	1,204	129	1,244
20	1,040	42	1,082	64	1,123	86	1,165	108	1,205	130	1,245
21	1,042	43	1,084	65	1,125	87	1,167	109	1,207	131	1,247
22	1.044	44	1,086	66	1,127	88	1,168	110	1,209	132	1,249
23	1,046	45	1,088	67	1,129	89	1,170	111	1,211	133	1,251
24	1,048	46	1,089	68	1,131	90	1,172	112	1,213	134	1,252
25	1,050	47	1,091	69	1,133	91	1,174	113	1,215	135	1,254
26	1,051	48	1,093	70	1,135	92	1,176	114	1,216	136	1,256
27	1,053	49	1,095	71	1 137	93	1,178	115	1,218	137	1,258
28	1,055	50	1,097	72	1,138	94	1,180	116	1,220	138	1,259
29	1,057	51	1,099	73	1,140	95	1,181	117	1,222	139	1,261
30	1,059	52	1,101	74	1,142	96	1,183	118	1,224	140	1,263
31	1,061	53	1,103	75	1,144	97	1,185	119	1,226		

Correction for Temperature.—For every 10° below 60° *deduct* one grain from the number quoted in the table, and for every 10° above 60° *add* one grain to the number tabulated.

Silver Nitrite (Formula, $AgNO_2$). — A brownish powder freely soluble in water. It can be crystallised from a strong solu-

*From Hardwich's "Dictionary of Photography."

tion of silver nitrate saturated with ammonia. It is stated that a slight trace of it in the silver bath, used in the wet collodion process, increases the sensitiveness. It is, however, liable to fog the image.

Silver Oxide (Formula, Ag_2O; molecular weight, 232).—Obtained as a brown precipitate when a solution of silver nitrate is decomposed by potash. It is usually prepared by dissolving half an ounce of silver nitrate in four ounces of water, and pouring it into a bottle containing three pints and a half of lime-water. The oxide is washed by decantation. It is a powerful oxidising agent, and is used to purify silver solutions from copper.

Silver Printing.—A term given to all methods of positive printing by means of silver chloride.

Silver Stains.—See **Stains.**

Silver Sub-bromide.—A hypothetical substance formed by the action of light upon silver bromide. (See **Silver Sub-salts.**)

Silver Sub-chloride.—A hypothetical substance formed by the action of light upon silver chloride. (See **Silver Sub-salts.**)

Silver Sub-iodide.—A hypothetical substance formed by the action of light upon silver iodide. (See **Silver Sub-salts.**)

Silver Sub-salts.—Silver sub-chloride, sub-bromide, and sub-iodide, termed the sub-salts, are supposed by some to be formed when silver chloride, bromide, and iodide are exposed to the action of light. When, for instance, chloride of silver darkens by the light rays sub-chloride is supposed to be formed, thus—

$$4AgCl = 2Ag_2Cl + Cl_2$$

The sub-salt has, however, never been isolated in such a form as to correctly establish its chemical individuality.

The idea that the sub-chloride is the product of the photo-decomposition of the normal chloride was first suggested by Fische in 1814, was reiterated by Wetzlar, and has since received general acceptance.* Recent researches, however, appear to render the existence of these sub-salts extremely doubtful.

Silver Sulphide (Formula, Ag_2S; molecular weight, 242).—Occurs in residue recovery, being the resultant salt of the decomposition of silver hyposulphite in the prints. It is insoluble in water or ammonia, but soluble in nitric acid, converting it into silver sulphate and nitrate.

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* Meldola's "Chemistry of Photography."

Silver Tester.—An apparatus for testing the quantity of silver nitrate in any solution pure or impure. For ordinary purposes the argentometer or hydrometer are usually used, the specific gravity of the liquid determining the amount of silver nitrate contained in it; when working with the silver bath in photographic processes, however, it gradually gets contaminated with other soluble matter, and the hydrometer test is no longer accurate for the amount of silver nitrate alone. Another method must therefore be employed. One much used abroad is Vogel's silver tester. (See fig. 191.)

It consists of a stand *S*, a burette *a*, two pipettes *p* and *F*, and a beaker glass *G*. A solution of iodide of potassium is prepared, containing 1023.4 cubic centimetres of water and exactly 10 grammes of pure dry iodide of potassium. 100 cubic centimetres of this solution precipitate 1 gramme of nitrate of silver, so that if 1 cubic centimetre of a silver solution is measured off and tested, every cubic centimetre of the test solution used gives 1 per cent. of nitrate of silver (1,000 cubic centimetres = 2.11 pints and 1 gramme = 15.4 grains). This prepared solution is placed in the burette *a*, which is divided off into cubic centimetres, and furnished with a pinch-cock *k*. The pipette *p* is then dipped in the silver solution to be tested, filled, by drawing with the mouth at the upper end, to the mark *i*, which is an exact cubic centimetre, and the solution allowed to run into the glass *G*. Into the same glass *G* are placed 1 or 2 cubic centimetres of prepared nitric acid, using the pipette *F*. (This nitric acid contains 1 grain of protosulphate of iron to every 2 ounces of pure acid.) And finally 10 to 14 drops of a prepared starch solution are added. (This solution is made by rubbing up $\frac{1}{8}$ oz. of starch to a thin paste with distilled water, pouring it into 12$\frac{1}{2}$ ounces of boiling distilled water, and stirring for several minutes; after settling for a few hours, the clear solution is poured off, and 2$\frac{1}{2}$ ounces of pure pulverised nitrate of potassium added, when it is ready for use, and will keep undecomposed for about six weeks.) The solution in the burette *a* is then allowed, by pressing open the pinch-cock, to run into the glass *G*, until the blue colour which is produced does not disappear by shaking, but remains permanent. With a little care at the close of the testing, a single drop will be found sufficient to produce this permanent blue colour. A simple reading of the number of cubic centimetres of solution used contains $7\frac{3}{5}$ per cent., that is, 100 c.c. of solution contains $7\frac{3}{5}$ grammes silver nitrate, which is equivalent to about 35 grains to the ounce.*

Another method which, although not so accurate, is much simpler, is the following, the only articles required being an 8 oz. narrow-mouthed bottle, a graduated measuring glass, and some pure salt. The test solution is made by dissolving 55 grains of dried salt in a pint of distilled water. Pour into the 8 oz. bottle

*J. F. Magee.

half an ounce of the silver solution to be tested, and add the testing solution gradually from a clean graduate measure, so that the quantity used can be accurately determined. After each addition shake the mixture well and add until no cloudiness is produced. If it requires one ounce of this solution, the silver solution contains 10 grains of silver nitrate to the ounce, if 2 oz. it contains 20 grains, and so also for fractional parts. $3\frac{1}{8}$oz. shows $31\frac{1}{4}$ grains, and so $4\frac{1}{2}$ oz. 45 grains, etc. As every one ounce of solution used shows 10 grains of silver nitrate to the ounce, it is only necessary to multiply the number of ounces and parts of an ounce to give the required result. If the silver solution contains ammonia after measuring off half an ounce of it into the 8 oz. bottle, it should be made acid with a little pure nitric acid, and then the operation can be proceeded with in the same way as before.

Silvering Mirrors.—See **Mirrors, Silvering.**

Simpsontype Process.—The collodio-chloride printing-out process was first devised by G. Wharton Simpson, and termed Simpsontype.

Single Lens.—See **Lens.**

Single Transfer.—See **Carbon Process.**

Size.—The following list of photographic sizes may be found useful :—

SIZES OF GLASS MOUNTS, PAPER, &c.

Petite cards	.. ..	$1\frac{5}{8}$ by $3\frac{1}{8}$
One-ninth plate	.. ..	2 ,, $2\frac{1}{2}$
Lantern size	.. ..	$3\frac{1}{4}$,, $3\frac{1}{4}$
One-sixth plate	.. ..	$3\frac{3}{4}$,, $3\frac{1}{4}$
One-fourth plate	.. ..	$3\frac{1}{4}$,, $4\frac{1}{4}$
Half-plate	.. ..	$4\frac{1}{2}$,, $6\frac{1}{2}$ and $4\frac{1}{4}$ by $5\frac{1}{2}$
Half-plate (English)	..	$4\frac{3}{4}$,, $6\frac{1}{2}$
Whole plate (4 — 4)	..	$6\frac{1}{2}$,, $8\frac{1}{2}$
Extra 4 — 4	.. ..	8 ,, 10

Other sizes are expressed by inches.

SIZES OF MOUNTS.

Stereoscopic	$3\frac{1}{2}$ by 7,	4 by 7,	$4\frac{1}{4}$ by 7,	$4\frac{1}{2}$ by 7, 5 by 8
Victoria		$3\frac{1}{4}$,, 5		
Imperial		$7\frac{7}{8}$,, $9\frac{7}{8}$		
Boudoir		$5\frac{1}{4}$,, $8\frac{1}{2}$		
Panel		4 ,, $8\frac{1}{4}$		
Minette		$1\frac{1}{2}$,, $2\frac{3}{8}$		
Card		$2\frac{1}{2}$,, $4\frac{1}{8}$		
Cabinet		$4\frac{1}{4}$,, $6\frac{1}{2}$		
Promenade		$4\frac{1}{8}$,, $7\frac{1}{8}$		

Sizes of French and Italian Dry Plates with Equivalent in English inches.

French.						Italian.					
Centimetres.				*Inches.*		*Centimetres.*				*Inches.*	
6½	by 9	=	2·5	by	3·7	9	by 12	=	3·7	by	4·7
9	,, 12	=	3·7	,,	4·7	12	,, 16	=	4·7	,,	6·3
12	,, 15	=	4·7	,,	5·9	12	,, 18	=	4·7	,,	5·9
13	,, 18	=	5·1	,,	7·0	13	,, 18	=	5·1	,,	7·0
12	,, 20	=	4·7	,,	7·8	12	,, 20	=	4·7	,,	7·8
15	,, 21	=	5·9	,,	8·2	18	,, 24	=	7·0	,,	9·4
15	,, 22	=	5·9	,,	8·6	21	,, 27	=	8·2	,,	10·6
18	,, 24	=	7·0	,,	9·4	24	,, 30	=	9·4	,,	11·8
21	,, 27	=	8·2	,,	10·6	27	,, 33	=	10·6	,,	12·9
24	,, 30	=	9·4	,,	11·8	30	,, 36	=	11·8	,,	14·1
27	,, 33	=	10·6	,,	12·9	40	,, 50	=	15·7	,,	19·6
27	,, 35	=	10·6	,,	13·7	50	,, 60	=	19·6	,,	23·6
30	,, 40	=	11·8	,,	15·7						
40	,, 50	=	15·7	,,	19·6						
50	,, 60	=	19·6	,,	23·6						

Sizes of Albumen Paper.

18 × 22¾, 20½ × 24½, 22 × 36, 26 × 40, 27 × 42.

For other sizes of paper see under **Paper.**

Size.—A gelatinous solution made by boiling the skin and membranous tissues of animals to a jelly, and used in paper-making.

Skin.—A skin of gelatine made by pouring gelatine and glycerine on a glass plate, drying, and stripping. It is used in the stripping film process as a permanent support for the thin gelatine film holding the image. See **Stripping Film.**

Sky.—In landscape photography the sky is often a very important part to be studied. It requires, as a rule, very considerably less exposure than the foreground, hence the difficulty of obtaining natural skies and clouds in a negative. To do this, many methods have been recommended of giving a shorter exposure to this part of the picture; by stops having a graduated aperture or by shading a portion of the lens or the plate during exposure. The usual method, however, is to make separate cloud negatives and print them in the positive picture afterwards. See **Cloud Printing.**

Sky Diaphragm.—See **Diaphragm.**

Skylight.—See **Studio.**

Sky Negatives.—See **Cloud Negatives.**

Sky Shade.—A shade or hood fitted over the lens to prevent the bright light from the sky from shining into the lens during exposure.

Slide Carrier.—See **Plate Carrier.**

Slide, Dark.—See **Dark Slide.**

Slide, Lantern.—See **Transparency.**

Sliding Legs.—An arrangement in the camera tripod by means of which the legs can be shortened or lengthened at will. It is very useful when photographing in hilly and rocky country.

Snow Photography.—The photographing of snow scenes with natural and brilliant contrasts of black and white is not by any means an easy task. Many authorities have stated that snow scenes require sunlight, otherwise the result will be flat. Captain Abney, however, in photographing in the Alps, found that the colour values of the landscape are often more correctly rendered as the light declines. His method is to expose four or five times longer than is usually done, so that there is a reserve of power, as it were, during the actual process of development, which is as follows:—

(*a.*) Give plenty of alkali with very little pyro, and you get a feeble image; then increase the pyro, and you get density.

(*b.*) Add plenty of bromide, three or four times more than is ordinarily recommended, more particularly when there has been a very full exposure.

FORMULA.

Ammonia ten per cent. solution	40 minims.
Potassium bromide	5 grains.
Sodium sulphite sat. sol.	60 minims.
Pyro sufficient to cover the point of a small penknife.	
Water	2 ozs.

(*c.*) The image appears very, very gradually; indeed, before all the detail is apparent, a quarter of an hour elapses. When viewed by transmitted light the image will be a phantom one, and, if fixed, would be unprintable.

(*d.*) The next operation just reverses these principles; the developer is poured off, and pyro (this time a good quantity) and a little bromide are added to two ounces of water, and the necessary density is rapidly obtained, occasionally adding two or three drops of a ten per cent. solution of ammonia.

Soap.—Combinations of the alkalies, potash and soda, with fatty acids are what are usually termed soaps.

The soaps used in photography are—Castile soap (*q.v.*), used as a lubricator in burnishing; cyanogen soap, used for removing silver stains from the hands; and "Monkey" soap for cleaning glass or other materials.

Soda.—Common washing soda is an impure carbonate of soda (*q.v.*)

Soda, Bicarbonate of (Formula, $NaHCO_3$; molecular weight, 84; synonyms, *sesqui-carbonate of soda*, *acid carbonate of soda*, *hydro-sodium carbonate*).—Prepared by passing carbonic acid gas into dampened sodium carbonate. It is soluble in water and insoluble in alcohol. It is used principally for toning. It takes the form of a white powder, and should not be confounded with the carbonate. To test a solution, add a few drops of a solution of perchloride of mercury. If a red precipitate is at once formed, it is a carbonate, and if a white, becoming red on boiling, it indicates a bicarbonate.

Soda Developer.—See **Developer.**

Sodaic Blotting Paper.—Sheets of blotting paper soaked in a 1 in 20 solution of sodium carbonate and dried. Sensitised paper, if laid between sheets of this paper, and preserved from light and air, will keep for some time longer than if stored away in an ordinary manner.

Sodium Acetate (Formula, $NaC_2H_3O_2 \cdot 3H_2O$; molecular weight, 136).—A slightly alkaline salt, occurring in small transparent crystals. It can be prepared by neutralising acetic acid with sodium carbonate. It is soluble both in water and alcohol. It is used in gold toning processes, and for this purpose should be free from chloride.

A hot, super-saturated solution of this salt will retain its heat for an exceptionally long time, and is for this reason used in foot-warmers for railway carriages.

Sodium Auro-chloride (Formula, $NaCl \cdot AuCl_3 \cdot 2OH_2$).—An impure form of chloride of gold, often sold for photographic purposes.

Sodium Bichromate (Formula, Na_2Cr_2O7; synonym, *sodium dichromate*).—Now very largely substituted for potassium dichromate (*q.v.*) On the Continent sodium bichromate is used for all the different photo-mechanical printing processes in place of the potassium salt. Its principal advantages over the latter are in the price and in its greater solubility, so that an abundant addition may be made without fear of crystallisation. It dissolves in double its quantity of water, potassium salt requiring as much as ten or twelve.

Sodium Bromide (Formula, NaBr).—Occurs in small white crystals, obtained by saturating hydrobromic acid with soda. Soluble in water and alcohol. It is stated that its use in the pre-

paration of gelatine emulsions causes them to become more sensitive to the orange and yellow rays than if either potassium or ammonium bromide be used.

Sodium Carbonate (Formula, $Na_2CO_3 \cdot 10H_2O$).—Prepared by decomposing common salt with sulphuric acid, heating the resulting sulphate of sodium with chalk and small coal in a reverberating furnace, lixiviating the mass with cold or tepid water, evaporating the solution to dryness, and calcining the product with sawdust in a suitable furnace. By dissolving the soda ash formed in hot water, filtering, and allowing it to cool slowly, the carbonate is deposited in large transparent crystals, which effloresce in dry air and crumble to a white powder. When this is re-dissolved in water, filtered, and the solution carefully crystallised, it constitutes the pure sodium-carbonate used in pharmacy.

There are also a variety of impure forms of sodium-carbonate. It is, however, advisable in photographic operations to use the purest form. It is largely used for rendering solutions alkaline.

Sodium Chloride (Formula, NaCl; molecular weight, 58.5; synonyms, *chloride of sodium*, *common salt*, *salt*, *rock salt*, *etc.*)—Found abundantly in this country, principally in Cheshire, and in other countries. It also occurs dissolved in sea-water, and in small quantities in most rivers, lakes, and springs. It can be formed by the direct union of the elements.

Pure sodium chloride takes the form of minute white crystals, soluble in water, but insoluble in absolute alcohol.

It is sometimes employed in the salting of albumenised paper, and in the manufacture of gelatino-chloride and collodio-chloride emulsions.

Sodium Citrate.—There are three compounds of sodium and citric acid; of these only one is used in photography. This is the normal citrate $C_6H_5O_7K_3 + H_2O$, which takes the form of deliquescent needles. It is used as a restrainer. To prepare, neutralise a solution of citric acid with sodium carbonate, and evaporate to dryness at 212° Fahr.

Sodium Hyposulphite (Formula, $Na_2S_2O_3 + 5H_2O$; molecular weight, 248; synonyms, *sodium thiosulphate*, *hyposulphite of soda*, *hypo*).—Formed by passing sulphurous acid gas through sodium sulphide until sulphur ceases to precipitate, or by heating sodium sulphite with excess of sulphur. It takes the form of irregular crystalline masses more or less transparent. If quite pure it should not effloresce.

Sodium hyposulphite is very soluble in water and insoluble in alcohol. It does not keep very well when in the form of solution.

Its keeping properties are, however, improved by the addition of sodium carbonate till alkaline. The addition of salicylic acid has also been recommended for this purpose. It should also be noted that solutions of this salt keep better in the dark than in the light.

Commercial sodium hyposulphite should be tested for sodium sulphate, which is often contained in it. Leaper's instructions are to mix an aqueous solution of it with an excess of hydrochloric acid free from chlorine, filtering off the precipitated sulphur, and adding barium nitrate to the filtrate, when a white precipitate will occur, if sodium sulphate is present.

Hyposulphite of soda was first prepared by Chaussier, as far back as 1799. In 1869 Schutzenberger showed that the so-called "hyposulphurous acid" was really thiosulphuric acid,* from which it resulted that the salts, previously termed hyposulphites, were, in reality, *thiosulphates* † The correct name for this substance is therefore sodium thiosulphate, although the familiar name of hypo will not be easily or soon discarded.

The principal use of hyposulphite of soda in photography is as a fixing agent owing to the fact of its being a solvent of the silver haloids. This property was first discovered by Sir William Herschel about the year 1819. If a silver salt be added to sodium hyposulphite two salts are formed, thus, for instance, with silver chloride in silver printing—

$$AgCl + Na_2S_2O_3 = AgNaS_2O_3 + NaCl$$

and

$$2AgCl + 3Na_2S_2O_3 = Ag_2Na_43(S_2O_3) + 2NaCl$$

The first salt $AgNaS_2O_3$ is a double hyposulphite of silver and sodium, which is with difficulty soluble in water, but soluble in sodium hyposulphite. It is for this reason that it is important to use an excess of sodium hyposulphite, so as to completely eliminate the insoluble salt, as upon this rests, to a considerable extent, the permanency of the image. Many substances have been recommended to get rid of the excess of sodium salt (see **Eliminator, Hypo**), but these, as a rule, are as injurious as the hypo itself. After thoroughly well washing the prints in many changes of water, a test for hypo should be used. This is usually made up as follows:

Potassium permanganate	1 grain.
Potassium carbonate	10 grains.
Distilled water	20 ozs.

This will form a pinkish purple liquid, and a few drops are added to the last washing water. If hypo be present a slightly greenish colour will appear. The prints should be made to receive a further washing, and the test again applied. Another method is to make a little starch paste by boiling a little starch in distilled water, and adding thereto a few drops of an alcoholic solution of

* "Comptes Rendus," vol. lxix., p. 196.
† Harrison's "History of Photography."

iodine. A deep blue colour will be formed, due to the formation of iodide of starch. One or two drops of this deep blue liquid are added to the last washing water, and if hypo is present the blue colour will disappear. Mercuric chloride is also used as a test for hypo. A few drops of a solution of it added to the washing water will cause a cloudiness if any hypo be present.

If an acid be added to a solution of sodium hyposulphite, sulphurous acid will be evolved and sulphur deposited. It is for this reason that the fixing bath for printing should be made distinctly alkaline.

Sodium Nitrate (Formula, $NaNO_3$; molecular weight, 85). Occurs native in Chili, and sometimes termed "Chili saltpetre." It takes the form of deliquescent crystals, soluble in water and alcohol. It is sometimes added to the silver bath for albumenised paper, as it tends to keep the image on the surface of the paper. It is also recommended as an addition to developers to obtain a good chocolate colour.

Sodium Oxalate (Formula, $Na_2C_2O_4$; synonym, *oxalate of soda*).—Takes the form of fine lustrous needles; is soluble in twice its weight of boiling, and 35 times its weight of cold water. It is used in the printing-out platinotype process.

Sodium Phosphate (Formula, $HNa_2PO_4 + 12H_2O$; molecular weight, 358; synonym, *hydro-disodium phosphate*).—Prepared by neutralising phosphoric acid with an alkaline salt of soda. It is soluble in water, but insoluble in alcohol. It takes the form of prismatic crystals, which effloresce in air. It is used in the toning process.

Sodium Pyroborate.—Synonymous with **Borax** *(q.v.)*

Sodium Silicate (Synonyms, *water glass*, *soluble glass*).—A combination of soda with silica. It is usually prepared by fusing 15 parts of fine sand with eight parts of sodium carbonate and one part of powdered charcoal. It occurs in white masses, but little affected by cold water, but readily soluble in boiling water, yielding a strong alkaline liquid.

It is employed in the collotype and in other processes mixed with albumen to form a substratum for glass plates required to be coated with collodion.

Sodium Sulphite (Formula, Na_2SO_3; molecular weight, 126; synonym, *sulphite of soda*).—Prepared by passing sulphur dioxide over damp crystals of sodium carbonate, the following representing the change that takes place—

$$CO_3 + SO_2 = Na_2SO_3 + CO_2.$$

It takes the form of prismatic crystals, soluble in four times its weight of cold and twice its weight of hot water.

Much difficulty has been experienced in getting pure sodium sulphite as necessary for photographic purposes, but recently, however, manufacturers have discovered the necessity of putting this on the market, and it is now easily obtainable.

The crystals should be quite transparent and free from a powdery appearance on the outside. They should not smell of sulphur dioxide, denoting the absence of sodium bisulphite. To test samples of sodium sulphite dissolve 10 grains in a drachm of strong hydrochloric acid, free from chlorine, and dilute with half an ounce of water; add to this a few drops of a solution of barium nitrate. Only a very slight precipitate should be formed. If this is considerable, however, it denotes the presence of large quantities of sodium sulphate. Mr. J. C. Belcher, on referring to the purity of sulphites for photographic purposes, says :—"The presence of an excess of sodium carbonate in the sulphite causes great annoyance to photographers, as, by its varying amount, they are unable to make any allowance in their formula, which demands an addition of a definite amount of the former in conjunction with the latter for developing. The presence of carbonate in sulphite of sodium is easily detected. The method depends upon the fact that carbonic acid gives a beautiful red colour with an alcoholic solution of phenolphthaleïn, whilst sulphurous acid produces no action in this respect.

"If, then, we dissolve some of the sulphite above referred to containing only one or two per cent. of carbonate, add a little alcoholic phenolphthaleïn, we shall have a red colour developed due to the carbonic acid, and, on adding carefully a solution of the meta-sulphite—preferably potassium meta-sulphite, as this crystallises much more freely than the sodium salt, and is more stable—till the colour just disappears, the result is a pure solution of neutral or normal sodium (potassium) sulphite, the SO_2 radical combining with the sodium which was previously combined with the CO_2 radical. The question, therefore, of obtaining a pure solution of normal or neutral sulphite of sodium need no longer perplex photographers."

The same writer refers to the fact that sulphites oxidise more or less rapidly to sulphates, and suggests as a means of preserving that they should be kept in well-stoppered bottles, with the crystals covered with pure ether. When required for use they could be laid for a few seconds on blotting paper to dry, preparatory to dissolving.

Its use in photography is principally as a so-called preservative of pyro, as it absorbs oxygen, and is converted into sulphate, preventing the pyro from becoming discoloured.

It is also used in mercurial intensification.

In 1885 Captain Abney pointed out that sodium sulphite is an excellent fixing agent. It is, however, considerably more expensive

than hypo. It is used in the proportion of about four ounces to the pint of water. Sodium sulphite has also been recommended as an addition to the hyposulphite bath, to prevent it from discolouring negatives after it has been used for some time.

Sodium Thiosulphate.—See **Sodium Hyposulphite.**

Sodium Tungstate (Formula, $Na_2WO_4 + 2H_2O$; molecular weight, 317).—Prepared by fusing wolfram with sodium carbonate. It crystallises in orhomboidal plates, soluble in water, but insoluble in alcohol. It is principally employed in the toning process.

Solar Camera.—See under **Camera.**

Solar Enlarging.—See **Enlarging.**

Solarisation (Lat. *solaris*, from *sol*—the sun, and *isation*).—A peculiar effect produced by long exposure of a photographic sensitive film to the action of light resulting in the complete reversal of the image from a negative to a positive. The phenomenon of solarisation has been found to be of a recurrent character. Thus if a dry plate be exposed for a certain length of time a negative is obtained on development, this being the ordinary process of photography. If the exposure be considerably increased, the plate on development will be quite dark all over, showing no signs of the image. This is termed the first neutral stage. By still further prolonging the exposure the reversal of the image takes place, and a positive is obtained instead of the negative. This reversal is followed by a second neutral stage, and this is in turn succeeded by an ordinary negative as would have been first obtained, and the phenomena succeed each other again in the same order as before by continued exposure to a strong light. It has been estimated that the second negative stage requires for its production a light of 100,000 times the intensity of that required for the formation of the first negative image.*

No very satisfactory explanation has ever been given of this peculiar phenomenon. It has, however, been discovered that a preliminary exposure to white light facilitates the reversal. Further, a strong developer acts in the same manner as over-exposure, so that a solarised plate might give a negative with a weak developer, and a positive image with a strong one. Abney discovered that oxidising agents facilitate reversal, whilst reducing agents either retard it or prevent it altogether.

The effect of solarisation and reversal of the image is perfectly invisible until development.

In the old wet-collodion days, when silver iodide was used, this phenomenon was often met with; for instance, in a landscape

*Meldola.

negative, when other parts of the image were correctly exposed, the sky would appear nearly as a blank, any small deposit of silver having a red hue; later on, when bromide was added to the collodion, this occurrence was rare, but with gelatine dry plates it often makes it appearance.

Solar Spectrum.—See **Spectrum.**

Solidification.—The passage of bodies from the liquid to the solid state, or the reverse of fusion. It is accompanied by evolution of heat and in general by change of volume. Two principal laws govern the phenomenon. These are:—

(1.) Each substance solidifies at a fixed temperature if the pressure upon it be always the same; that temperature is the temperature of fusion for the body.*

(2.) From the commencement to the close of the process the temperature of the liquid remains at the fixed point.

Soluble Glass.—An impure alkaline silicate, prepared by fusing for five or six hours a mixture of quartz, sodium and potassium carbonate and powdered charcoal, pulverising the fused mass, boiling with water for three or four hours, and concentrating the solution to a sp. gr. of 1·24. It is used as a varnish and in the collotype process.

Solution.—A term applied to the product of the action, as well as to the action itself, whereby a solid or gaseous body in contact with a liquid suffers liquefaction, or to the union of one liquid with another when each is capable of taking up only a limited quantity of the other. When a liquid adheres to a solid with sufficient force to overcome its cohesion, the solid is said to undergo solution or become dissolved. By diminishing cohesion in the solid, as by reducing it to powder, solution is facilitated, in consequence of the larger extent of surface exposed to the action of the solvent. Heat also, by diminishing cohesion, favours solution. In adding the solid to the liquid, the first portions will usually disappear rather quickly, but as more is added solution proceeds slower and slower, until it ceases altogether. The solution is then said to be saturated. The solution of a solid in a liquid is usually attended with a fall in the temperature, excepting where solution is preceded by the formation of a definite chemical compound. The solution of one liquid with another occurs without change of temperature, excepting in cases in which chemical union takes place, as in the dilution of sulphuric acid with water. It does not always happen that heat increases the solvent process of a liquid. Lime, for instance, is more soluble in cold water than in hot.

Various solids dissolve in the same liquid at very different rates and in different proportions. The following will be found a fairly complete list of the solubilities of the chemicals used in photographic operations:—

*Under certain conditions this law can be departed from; water enclosed in fine capillary tubes has been lowered to a temperature of — 20°C. before solidifying.

Table of Solubilities of the Various Chemicals used in Photography.

s., soluble; v.s., very soluble; sp.s., sparingly soluble; n.s, not soluble; dec., decomposed.

Name.	One part is soluble in cold water.	One part is soluble in hot water.	Alcohol.
Alum, potash	10	8	n.s.
Alum, chrome	10	dec.	n.s.
Ammonia, gaseous	v.s.		
Ammonium bichromate	v s.	v s.	
Ammonium bromide	1·5	1	1 in 13
Ammonium carbonate	4	dec.	sp.s.
Ammonium chloride	3	1	sp.s.
Ammonium fluoride	v.s.	v.s.	sp.s.
Ammonium iodide	1	·5	s.
Ammonium nitrate	2	1	s.
Ammonium oxalate	v.s.	v.s.	1 in 2
Ammonium sulphide	v.s.	v.s.	1 in 2
Ammonium sulpho-cyanide	1	·5	s.
Barium bromide	·96	·75	s.
Barium chloride	2·18	1·5	sp s.
Barium iodide	·48	·35	v.s.
Barium nitrate	12	3	sp.s.
Barium peroxide	n.s.	n.s.	in hydrochloric acid
Boracic acid	30	3	1 in 30
Borax	12·5	2	n.s.
Cadmium bromide	1·5	1	sp.s.
Cadmium chloride	·71	·67	sp.s.
Cadmium iodide	1·5	1	1 in 2
Calcium bromide	1	·75	s.
Calcium carbonate	n.s.	n.s.	n.s.
Calcium chloride	·75	·5	1 in 10
Calcium hypochlorite	sp.s.	sp.	dec.
Calcium iodide	·75	·5	1 in 10
Carbolic acid	16·6	s.	s.
Citric acid	·75	5	10 in 15
Cobalt chloride	1	·75	s.
Copper acetate	14	·5	1 in 14
Copper bromide	1	·75	s.
Copper chloride	1	·75	v.s.
Copper nitrate	3	1	s.
Copper sulphate	3	1	n.s.
Gallic acid	100	3	1 in 8
Glycerine	s.	s.	s.
Gold perchloride	1	·75	s. and in ether.
Hydroquinone	3	s.	s. and in ether.
Hydroxylamine	v.s.	v.s.	n.s.
Iron ammonium sulphate	v.s.	dec.	s.
Iron chloride (ferric)	·75	·5	1 in 1
Iron chloride (ferrous)	2	1	1 in 1
Iron citrate	s.	s.	n.s.
Iron iodide	v.s.	v.s.	v.s.
Iron nitrate	v.s.	dec.	dec.
Iron oxalate (ferric)	s.	s.	n s.
Iron oxalate (ferrous)	s. in excess of alkaline oxalate only.		
Iron sulphate (ferrric)	s.	dec.	s.
Iron sulphate (ferrous)	1·5	1	n.s.
Lead acetate	2·5	2	1 in 12·5

Table of Solubilities of the Various Chemicals used in Photography—(*Continued.*)

Name.	One part is soluble in cold water.	One part is soluble in hot water.	Alcohol.
Lead carbonate	n.s.	sp.s.	n.s.
Lead iodide	s.	s.	n.s.
Lead nitrate	7·7	7	s.
Lead oxide	n.s.	n.s.	alkalis
Lithium bromide	·66	·5	v.s.
Lithium chloride	1·3	1	s.
Lithium iodide	·61	·5	s.
Magnesium bromide	1	·75	s.
Magnesium chloride	2	1·5	s.
Magnesium iodide	1	·75	v.s.
Magnesium sulphate	1·3	1	sp.s.
Mercuric chloride	19	3	5
Mercuric iodide	sp.s.	sp.s.	sp.s.
Mercurous chloride	n.s.	n.s.	n.s.
Mercurous iodide	n.s.	n.s.	n.s.
Mercury cyanide	8	2	1 in 20
Oxalic acid	8	1	n.s.
Platinum chloride	1	·5	s.
Potassium bicarbonate	3	2	n.s.
Potassium bichromate	10	7	n.s.
Potassium bromide	2	1	1 in 90
Potassium carbonate	·75	·5	n.s.
Potassium chlorate	16	2	n.s.
Potassium chloride	3	2	sp.s.
Potassium citrate	·6	3	n s.
Potassium cyanide	·1	·5	sp.s.
Potassium ferric sulphate	s.	s.	n s.
Potassium ferricyanide	2·5	1·2	n.s.
Potassium ferrocyanide	3	1	n.s.
Potassium fluoride	v.s.	v.s.	v.s.
Potassium hydrate	·5	·25	sp.s.
Potassium iodide	·75	·5	1 in 16.
Potassium nitrate	4	1	n.s.
Potassium oxalate	3	2	sp.s.
Potassium permanganate	16	10	n.s.
Potassium platino-chloride	10	1	s.
Potassium sulpho-cyanide	2	1	sp.s.
Pyrogallic acid	3·5	1	v.s.
Salicylic acid	760	9	v.s. and in ether.
Silver acetate	sp. s.	sp. s.	v.s. and in ether.
Silver bromide	n.s.	n.s.	n.s.
Silver carbonate	n.s.	n.s.	in H Cl and H Br.
Silver chloride	n.s.	n.s.	n.s.
Silver citrate	sp.s.	sp.s.	s. in ammonia, pot. cyanide and hypo.
Silver fluoride	v.s.	v.s.	v.s.
Silver iodide	n.s.	n.s.	s. in ammonia, pot. cyanide and hypo.
Silver nitrate	1	·5	sp.s.
Silver nitrite	300	dec.	n.s.
Silver oxalate	sp.s.	s.	n.s.
Silver oxide	n.s.	n.s.	n.s.
Silver sulphate	200	88	n.s.
Silver sulphide	n.s.	n.s.	n.s.

Table of Solubilities of the Various Chemicals used in Photography—(*Continued*).

Name.	One part is soluble in cold water.	One part is soluble in hot water.	Alcohol.
Sodium acetate	3	·66	n.s.
Sodium biborte	12·5	2	n.s.
Sodium bromide	1.25	1	1·16
Sodium bicarbonate	12	dec.	n.s.
Sodium carbonate	2	1	n.s.
Sodium chloride	2.75	2·75	n.s.
Sodium citrate	1	·5	sp.s.
Sodium hydrate	1·5	·5	sp.s.
Sodium hyposulphite	1.5	1	sp.s.
Sodium iodide	·5	·3	sp.s.
Sodium nitrate	1·36	1	1 in 7
Sodium phosphate	4	2	n.s.
Sodium sulphate	2	·4	s.
Sodium sulphide	s.	s.	sp.s.
Sodium sulphite	4	2	sp.s.
Sodium tartrate	1·75	1	n.s.
Sodium tungstate	4	2	n.s.
Strontium bromide	1	·75	sp.s.
Strontium chloride	1·8	1	sp.s.
Strontium iodide	·5	·25	s.
Strontium nitrate	5	2	sp.s.
Tannic acid	·8	·5	10 in 8.
Tartaric acid	·8	·5	1 in 5.
Tin chloride (stannic)	dec.	sp. s.	
Tin chlorde (stannous)	v.s.	v.s.	v.s.
Uranium bromide	1	·5	sp.s.
Uranium initrate	·5	·25	v.s.
Uranium oxalate	sp. s.	30	n.s.
Uranium sulphate	·5	·25	v s.
Zinc bromide	1	·5	s.
Zinc chloride	·33		s.
Zinc iodide	·33	dec.	v.s.
Zinc sulphate	·7	5	n.s.

Specific Gravity.—The relative gravity or weight of any body or substance, considered with regard to an equal bulk of some other body, which is assumed as a standard of comparison. The standard for the specific gravities of solids and liquids is pure distilled water, at a temperature of 62°F., which is reckoned unity. By comparing the weights of equal bulks of other bodies with this standard, we obtain their specific gravities. Thus the specific gravity of cast-iron is 7·21, that is, any particular mass of cast-iron will weigh 7·21 times as much as an equal bulk of water. The practical rule is, weigh the body in air, then in pure distilled water, and the weight in air, divided by the loss of weight in water, will give the specific gravity of the body. In designating the gravities of gases, the standard of unity is atmospheric air.* In order to calculate the amount of water to be added to a liquid to reduce it to a lower specific gravity, subtract the specific gravity of water from the required specific gravity, and

*Annandale's Cyclopædia.

the result will be the amount of liquid to be taken. The difference between the specific gravity of the liquid and the required specific gravity represents the amount of water. For example, suppose we have a sample of sulphuric acid having a specific gravity of 1·845, and it is required to use an acid with a specific gravity of 1·3, how much water must be added to the strong acid to obtain the weak? 1·845—1 = ·845 = the amount of strong acid; 1·845—1·3 = ·545 = the amount of water.

Thus, if we add 545 parts of water to 845 parts of strong sulphuric acid, we shall obtain an acid having a specific gravity of 1·3, or if we add 1 ounce 65 minims (fluid measure) of water to 845 parts of strong sulphuric acid, we shall obtain about 23 drachms of sulphuric acid having a specific gravity of 1·3.

Specific Heat.—A term applied to the quantity of heat required to raise equal weights of different substances through equal intervals of temperature. Water is taken as the standard substance in measuring quantities of heat.

Spectroscope.—An instrument employed in spectrum analysis. It usually consists of the following parts: (1.) A tube with a narrow slit at one end and a convex lens at the other, from which parallel rays of light proceed when light is made to pass through

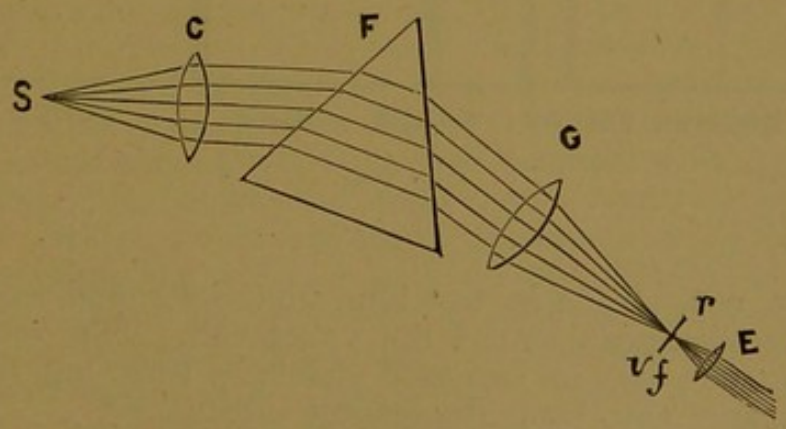

Fig. 192.

the slit, the two forming together what is termed the collomator. (2.) A prism of dense flint glass on which the rays fall after emerging from the collomator. (3.) An observing telescope so placed that the rays traverse it after emerging from the prism.

Fig. 192 gives a ground plan of the arrangement: S is the slit, C the collomating lens, P the prism, O the object glass of the telescope, and E the eye-piece. An image of the slit will be formed at *f* by rays of given refrangibility, others betweeen *f* and *v* by rays of greater refrangibility, and others between *f* and *r* by rays of lens refrangibility, thus giving a complete spectrum.

Spectrum (Lat. *spectrum*—a vision).—The stripe formed on a screen by a beam of light, as of the sun, received through a narrow slit and passed through a prism, being thus decomposed or separated into its constituent rays. This oblong stripe consists of a number of colours shading imperceptibly into one another from red at one end, through orange, yellow, green, blue, indigo, to violet at the other. (See Fig. 5.) These colours are due to the different constituents of which solar light is made up, and the stripe seen is formed by an indefinite number of images of the slit ranged in order and partially over-lapping. The analysis or decomposition of the beam is due to the different refrangibilities of the component rays, the violet being the most refrangible and the red the least. Besides the coloured rays, the spectrum contains thermal or heating rays, and chemical or actinic rays, which are not visible to the eye. The heating effect of the solar spectrum increases in going from the violet to the red, and still continues to increase for a certain distance beyond the visible spectrum at the red end, while the chemical action is very

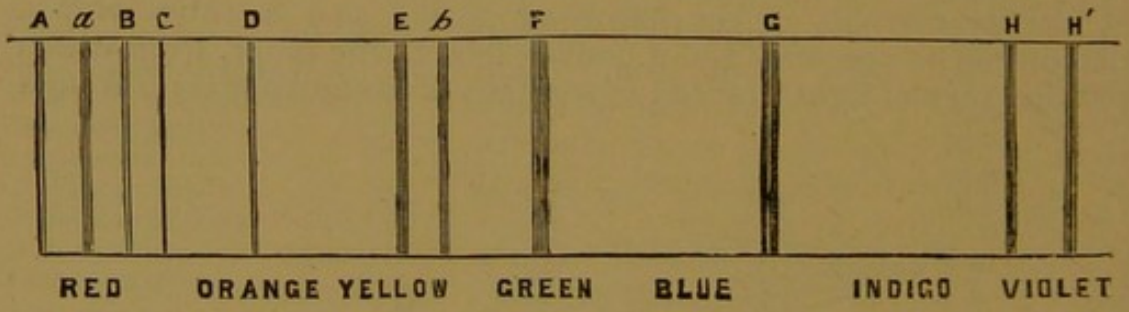

Fig. 193.

faint in the red, strong in the blue and violet, and sensible to a considerable distance beyond the violet end. The actinic rays beyond the violet may be rendered visible by throwing them upon a surface treated with some fluorescent substance.*

Besides this band of different colours, a pure solar spectrum will be found to possess a number of dark lines, which cut through it perpendicularly. These lines were first discovered by Wollaston, and were carefully studied by Frauenhofer, and called after him Frauenhofer's lines. These lines are always to be found on the same spot, and serve to indicate the exact places on the scale of colour. For instance, if we use the term blue in the spectrum, this is naturally vague and incomplete, but by indicating the line on the spectrum in which this colour is found no difficulty will arise. For this purpose Frauenhofer gave certain characteristic names to the line, which he indicated by letters. A certain line in the

* Blackie's "Modern Cyclopædia."

red he called A, another in the yellow D, and so on. As, however, these lines number some thousands it is evident that these letters will not suffice to indicate them all. Fig. 193 shows the position of the most conspicuous of these fixed lines, and the letters above them are the names by which they are known.

In order to properly understand these lines it is necessary to remember five important things. These are—*Firstly*, an incandescent solid or liquid body gives out a *continuous* spectrum ; *secondly*, an incandescent gaseous body gives out a *discontinuous* spectrum consisting of bright lines ; *thirdly*, each element, when in the state of an incandescent gas, gives out lines peculiar to itself ; *fourthly*, if the light of an incandescent solid or liquid passes through a gaseous body, certain of its rays are absorbed, and black lines in the spectrum indicate the nature of the substance which absorbed the ray ; *fifthly*, each element, when gaseous and incandescent, emits bright rays identical in colour and position on the spectrum with those which it absorbs from light transmitted through it. The spectrum of sodium, for instance, shows two bright lines which correspond in position with the double black line at D (the sodium line). Now, applying these principles to the solar spectrum, we find, from the nature and position of the rays absorbed, that its light passes through hydrogen, potassium, sodium, calcium, barium, magnesium, zinc, iron, chromium, cobalt, nickel, copper, and manganese, all in a state of gas, and constituting part of the solar envelope, whence we conclude that these bodies are present in the substance of the sun itself, from which they have been volatilised by heat. The moon and planets have spectra like that of the sun, because they shine by its reflected light, while, on the other hand, each fixed star has a spectrum peculiar to itself. It has been already stated that the incandescent vapour of each elementary substance has a characteristic spectrum, consisting of fixed lines, which never changes. Spectrum analysis, as this is called, furnishes the chemist with an exquisitely delicate test to enable him to detect the presence of minute quantities of elementary bodies. For instance, by heating any substance until it becomes gaseous and incandescent, he is able by means of the lines to read off from the spectrum the various elements present in the vapour. By this means several new elements have been discovered.*

Photography has been of very great assistance to the spectroscopist by the means it has given him of not only making rapid and correct representation of the spectrum lines, but also in showing him a number of lines of very great importance situated in the ultra-violet parts of the spectrum, and which are totally invisible to the eye. In return for this assistance, spectroscopy has been of great value to photography. In the very earlier days of photography the action of the spectrum upon substances sensitive to light was studied. Indeed, before that period, and

* From Annandale's Cyclopædia

as far back as 1777, Scheele showed that the violet rays of the spectrum had the greatest darkening action upon silver chloride.

The effect of the spectrum upon photographic sensitive surface is very different from what is apparent to the eye. For instance, yellow and green appear the clearest to us, but the photographic plate is hardly affected by them; but it receives a powerful impression from the indigo and violet rays, which appear dark to our eye, and even from rays that are quite invisible to us. Hence it is not difficult to understand that many-coloured objects are represented by photography in a false light. This has been partly remedied by the introduction of the orthochromatic process. By means of so-called dry sensitisers the plate can be made more sensitive to the yellow and red rays, and give true representations of coloured objects. (See **Orthochromatic Photography.**)

A careful study of the action of the spectrum colours enables us to discover the safest light with which we can illuminate the dark room for convenience in working. (See **Non-actinic Media.**)

Spectrum Analysis.—See **Spectrum.**

Spherical Aberration.—See under **Aberration.**

Spirit Level.—See **Level.**

Spirit Photographs.—The production of phantom-like images by means of photography, although very simple, has often been used to gull the weak-minded believer in supernatural visitants. In the old wet-collodion days photographers were often troubled with spirit images, as the glass of old negatives was used over again, and in some cases a chemical action had taken place between the old image and the glass, impressing itself upon the latter, and showing as a hazy figure in the positive of the second image made upon the plate.

The usual method of preparing spirit photographs is the following. The spirit may be prepared on the plate either before or after the exposure of the sitter. In a room made perfectly dark the draped figure to represent the spirit is posed, in a ghost-like attitude, in front of a dark background. With suitable lamp, light is thrown upon the figure. Next a fine piece of muslin gauze is placed close to the lens, which gives a cloud-like, indistinct appearance to the image. The exposure is made, and the latent image remains upon the sensitive plate, which is again used to photograph the sitter, with the result that on development the two images are made to appear at the same time, so that the sitter imagines that the spirit must have been hovering around him at the time the photograph was made. By such means a variety of effects can be made—spirits floating in the air, mysterious hands, etc.

Squeegee.—A handy contrivance, consisting of a strip of flat indiarubber set in a wooden back or handle. It is exceptionally useful for pressing the front in contact when mounting, for carbon printing, for glazing gelatine prints, &c., where an even pressure is required. The indiarubber should be neither too hard nor too soft, and it should have an even and perfectly straight edge.

Another form is that known as the roller squeegee. It consists of one or two wooden rollers, covered over with indiarubber, and set in a handle. Its purpose is the same.

Stains.—Stains are usually due to careless manipulation. Pyro stains on negatives developed with that substance can usually be removed with—

Chrome alum	1 ounce.
Citric acid	1 ,,
Water	20 ,,

This solution is also useful for clearing negatives or bromide paper developed with ferrous oxalate.

Silver stains upon negatives which sometimes make their appearance if the paper or negative be damp when printing are very difficult to remove. Remove the varnish, and apply—

A.—Ammonium sulphocyanide	½ drachm.
Water	1 ounce.
B.—Nitric acid	½ drachm.
Water	1 ounce.

A freshly-mixed solution is used for each negative. Afterwards wash well, and immerse in a saturated solution of chrome alum.

Silver stains on the hands may be removed with :—

Sodium sulphite	½ ounce.
Lime chloride	¾ ,,
Water	1 ,,

Mix up well, and apply with an old hard toothbrush.

Pyro stains on the fingers are removable by well washing with a 10 per cent. solution of oxalic acid.

To remove nitric acid stains from the hands or clothes, touch them with a solution of potassium permanganate, wash well in dilute hydrochloric acid, and again wash.

Black stains with ferrous oxalate development will sometimes occur if the plate be handled with fingers contaminated with sodium hyposulphite. There is no method of removing them. Yellow stains on prints, after fixing, are generally due to their having stuck together when in the hypo. Some of the silver hyposulphite has not been removed, and changes in the washing waters to silver sulphide, producing yellow stains. Use fresh hypo for each batch of prints.

Standard Gold.—A mixture of metal containing 11 parts of pure gold with one part of alloy, *i.e.*, 22 carats fine, with two carats of alloy.

Standard Silver.—A mixed metal containing 37 parts of pure silver and three parts of alloy.

Standard Sizes.—See **Sizes.**

Standard Spirit.—A mixture of alcohol and water having a sp. gr. of ·92 at 62° Fahr. It contains nearly equal parts of absolute alcohol and water.

Stand, Camera.—See **Camera Stand Tripod.**

Stannotype (Lat. *stannum*—tin, and Eng. *type*).—This process may be termed a simplified Woodbury process. On reference to the description of the latter, it will be found that one of the principal requirements is a costly hydraulic press, with which to form the printing mould by pressing the gelatine relief into the lead surface. The object of the stannotype process was to do away with this costly machinery, and bring the process within the reach of all. A careful consideration of the principles involved in the Woodburytype process will show that if a gelatine relief were produced from a positive instead of a negative, this relief would serve as the printing mould in the same manner as the impressed lead, were it not for one serious drawback, and that is, that being of gelatine it would be destroyed when it received the necessary wetting. This drawback was overcome by Woodbury after a long course of laborious experiments by a most simple expedient. It was simply by protecting the relief by means of a sheet of tinfoil, pressed well into contact with it.

The first thing necessary in the preparation of the relief is a positive transparency. This can be produced by any of the well-known methods, that process being most suitable which gives the greatest range of density. This transparency, it should be noted, must be reversed as regards right and left, unless the picture is one that can be printed reversed without being noticeable. The single-transfer carbon process is the one generally used, the image being intensified with potassium permanganate. Finally, the transparency should have an edging of clear glass about $\frac{1}{8}$in. in width, and the highest light should be quite clear.

The transparency having been made, the relief is next made from it, as in the Woodburytype process. This may also be done by laying a piece of moist paper upon a sheet of glass, and coating it with a gelatine solution; when set, both are detached from the glass and hung up to dry. It is afterwards sensitised in a bichromate solution and printed from with the positive. If paper be used as the support, the side farthest from the paper is, of course, brought into contact with the positive, and that side is afterwards attached to glass, either by means of an indiarubber solution, or by coating the glass with gelatine containing a little bichromate solution, and drying the film in the sunlight.

By whatever means the relief is produced, it should, after being developed, be allowed to remain upon the glass plate, which should be plate glass and rather thick.

The next operation is the protection of the relief with the tinfoil. If only a few hundred copies are required to be printed, ordinary tinfoil will do, but if a large quantity are necessary, special steel-face foil must be employed. The tinfoil must be of perfect quality, and free from pinholes. These may be detected by holding the sheet up to a strong light, and any piece containing them should be instantly rejected, as the smallest hole will allow the gelatinous ink to wet the relief beneath, and produce a white spot, if nothing more serious.

A piece of the perfect foil, a little larger than the relief, is laid on to a clean sheet of glass, and carefully flattened and rubbed out smooth with a velvet pad. Those used for brushing silk hats are very serviceable for this purpose. The relief is then prepared to receive it. The edging, which is in high relief, is first coated with a thick solution of rubber in benzine, and when this is set the whole surface is flowed with a thin solution of rubber. Burton recommends gum para, a good strength of solution being two grains to the ounce. Pure benzine will serve as a solvent, although chloroform is much preferred. When this indiarubber film has set, the tinfoil is laid carefully over it and pressed well into contact with the velvet pad, and then the plate holding the relief and foil is passed through two rubber or rubber-coated rollers. The domestic wringing machine, fitted with indiarubber rollers, serves excellently for this purpose. The rollers are separated, and the plate inserted, so that the rollers cross the centre of it. Pressure is then applied, and the plate inked backwards and forwards so that the tin face is pressed well into all the parts of the relief. The back of the glass is then cleaned, and the face surface of the now perfect printing mould carefully oiled with a little piece of flannel with a drop or two of mixture of olive and paraffin oils. The mould is then ready for printing from in the same manner as with the Woodburytype process (*q.v.*)

Stannous Chloride (Formula, $SnCl_2$; synonym, *protochloride of tin*).—Prepared by dissolving tin in hydrochloric acid. It is used with chlorine water as a test for gold, forming the so-called purple of cassius.

Starch (Formula, $C_6H_{10}O_5$; molecular weight, 162; synonym, *amylose*).—Commonly made from rice. When starch is heated with water to about 122°F., the granules begin to burst, which is completed at 158°F., when the granulose is dissolved to a viscous liquid, which becomes a jelly on cooling. In this form it is used in photography for mounting purposes. It is also used as a size for paper. It can be detected by a drop of a dilute solution of iodine, which will turn it blue.

Stellar Photography.—See **Astronomical Photography.**

Stereograph (Gr. *stereos*—solid, and *grapho*—I draw).—The representation of a solid on a plane. A stereoscopic slide.

Stereomonoscope (Gr. *stereos*—solid, *monos*—alone, and *skopeo*—to see).—An instrument with two lenses by which a stereoscopic effect can be obtained from a single picture.

Stereoscope (Gr. *stereos*—solid, and *skopeo*—to see).—If a solid object be viewed from a short distance by both eyes on whatever point they are fixed, that point will be seen the most distinctly, and other points more or less clearly. But, owing to the different positions of the two eyes, it is quite apparent that the images seen by them differ slightly from one another, and it is by the union of these two pictures that we see the object and know it to be solid. If, therefore, we draw or photograph this object first as seen by the right eye and then as seen by the left eye, and present each eye to that picture which was made from its point of view, we see the representation of the object in relief almost as we see the object itself. Fig. 194 proves this. If the two representations of a

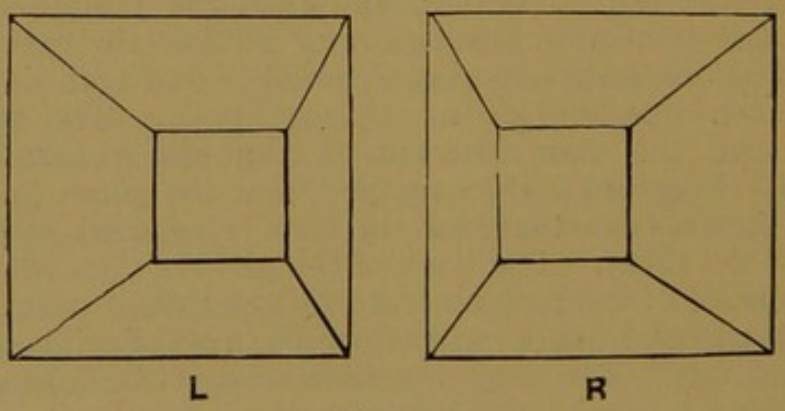

Fig. 194.

truncated pyramid, as seen by the right and left eye, be steadily looked at R with the right eye and L with the left, holding a piece of card between the fingers to separate them, we get a single picture of the object in relief. To assist the eye in combining such pairs of dissimilar pictures, mirrors and lenses have been used, such instruments being termed stereoscopes.

The first stereoscope invented by Wheatstone has been termed the reflecting stereoscope for the reason that mirrors or reflectors are used to change the apparent position of the pictures, so that they are both seen in the same direction. Two mirrors about three inches square are arranged so that their backs are at right angles to each other as shown in fig. 195. The two arrows are

reflected by the two mirrors into the right and left eye respectively, and appear as only one arrow. As, however, the picture was inverted by the mirror, it was necessary to place the drawing for the right eye on the left side, and the one for the left eye on the right side.

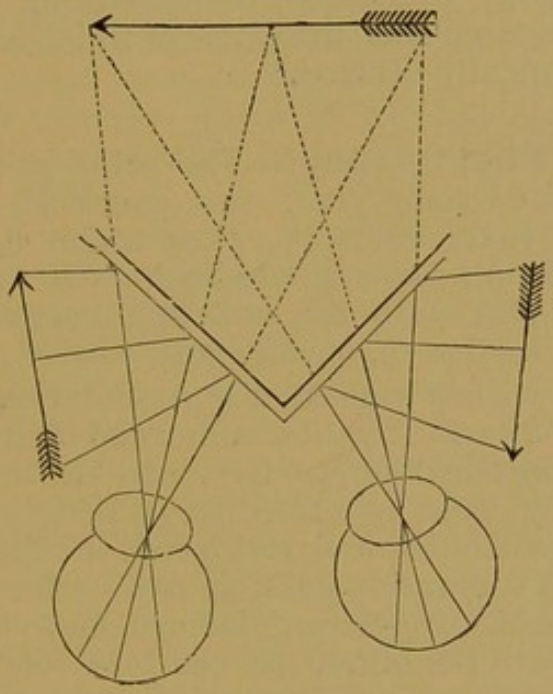

FIG. 195.

To Sir David Brewster is due the credit of the invention of the lenticular stereoscope, so called to distinguish it from Wheatstone's instrument. In Brewster's instrument another means is made use of to compel each eye to see its own picture. This is done by lenses divided in half and inverted. His method is thus described* :—

"If an object be viewed through the centre, or, more properly, along the axis, of a convex lens, it will be seen exactly in front of the eye—*i.e.*, in a line with the eye, the centre of the lens, and the actual place of the object. If now the lens be moved slightly to the left, the object will appear to advance to the right; and conversely, as the lens is moved to the right, the object is displaced in the opposite direction. Let the lens be cut in half transversely, and the two semi-circular pieces reversed as to their former position —that is, placed side by side, and so that their thin edges shall be adjacent, while the two plane edges formed by the section of the lens are kept in mutual parallelism and have their faces turned outwards towards the left and right respectively. The right eye will now look through the left half of the lens, and *vice versa*, and

* "The Stereoscope"—G. V. Blanchard.

the two pictures, each placed opposite its appropriate eye, and in the principal focus of the eye-piece, will be seen, not in their actual places, but in a position midway between the two. The subsidiary purposes served by this arrangement are, that the pictures are magnified as well as caused to coalesce, and that the equality of the magnifying power of the eye-pieces (a result by no other means certainly attainable) is secured by the fact of their being cut from the same lens, the whole of which is thus advantageously and economically utilised."

Stereoscopic Photography.—The art of stereoscopic photography was practised some years ago, and held public attention for some twenty years or more, after which it gradually died away. Many attempts have of late been made to revive it, and it is quite possible that with the new appliances and the better understanding of the theory, it will again receive much attention.

When an artist wishes to make a representation of a solid body, he adopts various means—by the shading and lighting; in architectural work by geometrical perspective, and in landscape by both these, and also by what is termed aerial perspective. Although by this means the effect is often very good, the illusion is far from being complete, as it is rarely possible to mistake the painting for the solid object itself. By closing one eye, and viewing a painting or a photograph with the other, the effect of solidity is considerably increased. When, however, we see a natural object with both eyes at once, our eyes being about two and a-half inches apart, a little consideration will make it plain that we in reality see two images from slightly different points of view. The right eye sees rather more of the right side, and the left eye rather more of the left side, yet our brain and our vision work together, so that we do not usually see objects double, but single. This is what is termed binocular vision, an effect no single painting or photograph can possibly produce.

In the production of stereoscopic photographs we endeavour as far as possible to imitate nature in her provisions for enabling us to see objects with a certain amount of roundness or solidity, and to permit us also to better realise the distances between various objects situated on different planes.

For the production of stereoscopic photographs special twin cameras are constructed. In the earliest days, however, a single camera fitted with only one lens was used. An extra baseboard was provided, upon which the camera was moved from between two and a-half to three inches to one side between the first and the second exposure. Although by this means the same effect was, and is still, often produced, yet this method has several drawbacks. For instance, objects in motion and instantaneous effects cannot be made with the single lens. The modern stereoscopic camera is fitted with two lenses side by side, their centres distant about

three inches, and their foci equal. These are generally termed twin lenses. A partition runs down the centre of the camera interior to separate the views from the two lenses, and form as it were two distinct cameras.

The usual size of a stereo plate is $6\frac{3}{4} \times 3\frac{1}{4}$ inches, but, provided the centres of the mounted prints are not more than three inches apart, the height need not be limited to $3\frac{1}{4}$ inches. Mr. J. Traill Taylor recommends for stereo work a plate 8×5 inches. Another well-known practical worker, Mr. W. I. Chadwick, considers the best size of negative plate to be $6\frac{1}{2} \times 4\frac{1}{4}$, a standard size known as double quarter being half a whole plate, and double the size of a quarter plate.

With regard to the lenses, if required for all-round work, rapid rectilinears will be found the most useful. For landscape work, without straight lines, single lenses give the best effect. They should be mounted carefully on the same horizontal plane. The question of the correct space that should be allowed between the two is a disputed one. Our eyes being about $2\frac{1}{2}$ inches apart, this is usually the correct distance to get the natural effect, but for most landscape subjects this can be increased to three inches. The greater the distance between the two lenses the greater the relief; but this effect can be carried to extremes, producing an unnatural and exaggerated effect. The lenses should be of equal foci, and with perfectly similar diaphragms for each, otherwise one picture will be more exposed than the other. Iris diaphragms are too indefinite for this purpose.

A little thoughtful consideration will show that if the two halves of the stereoscopic picture are taken on one plate, these two halves will have to be transposed if the image is required to be seen stereoscopically. They can, of course, be transposed on the plate itself by taking the right view on the left of the plate and the left on the right, but arrangements for this are rarely made now, the cameras being what are termed "binocular," consisting practically of two cameras side by side, with a division down the centre. With this camera, therefore, if we hold the negative up before us in the same position as it occupied when in the camera, we have the picture taken with the right hand lens on our right hand, and that made with the left lens on our left. But when from this negative we make our positive prints we invert this arrangement, and the right hand picture is on the left, and, therefore, to get into correct position again, the double print must be cut through the centre, and the two pictures divided and transposed. If this be not done, and the pictures viewed thus in the stereoscope, we get an opposite effect to stereoscopic, an effect which has received the name "pseudoscopic," or false sight.

Very considerable care is required in cutting and mounting stereoscopic pictures, or stereograms, as they are termed. The first thing is to determine a base line. The cutting edge is laid

down on the double print, and the knife drawn along, so that it cuts a given object in the foreground of each half at exactly the same point.* The top of the print is then trimmed parallel to this base line. The two halves are then separated and transposed. The sides of the pictures are then trimmed on the print that is to be mounted on the right-hand side, more subject on the right than we leave on the right of the left-hand picture; and on the left-hand picture we must leave more of the left side than we leave on the left of the right-hand picture. The pictures are then mounted so that their centres shall be not less than two and three-quarter inches nor more than three inches apart.

Stereoscopic pictures should be printed to full depth, and should be full of detail. Flat prints, wanting in vigour, often look best in the stereoscope.

It is an indisputable fact that stereoscopic transparencies are a long way superior to prints, therefore this portion would be very incomplete without some remarks concerning their manufacture.

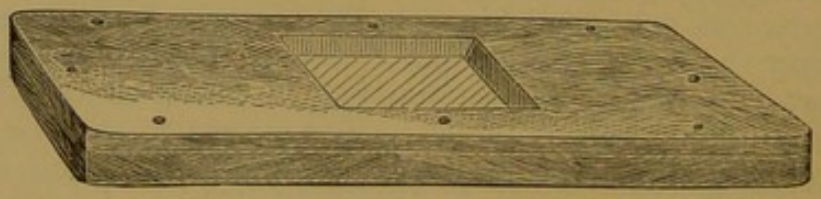

Fig. 196.

The simplest method is by contact printing. The negative may be cut and transposed, or it may be printed from in an ordinary printing frame, and the transparency cut and transposed, and bound up between two cover glasses.

The best plan, however, is by means of a special printing frame, shown in the accompanying sketches†. The principle of the frame is to print each picture separately, and at the same time to effect the necessary transposition by printing the left-hand side of the negative on the right-hand side of the transparency plate, and then to transpose the negative and plate, and print the right end of the negative on the left of the transparency plate. The working of this frame is thus given.‡ The front of the frame (fig. 196) is of solid wood, with an aperture in the centre, through which the printing is done. The frame should be 10½in. long *inside*, the aperture two inches and seven-eighths wide, and exactly in the middle. In fig. 197 the negative shown by diagonal lines has been placed in

* For this purpose it is absolutely necessary that the camera be held level when exposing the plate by means of a tripod stand; hence the failures that so often attend stereoscopic pictures made by detective or hand cameras.

† From "Chadwick's Stereoscopic Manual."

‡ W. I. Chadwick.

the frame film side up, and adjusted with its left side over the aperture. The sensitive transparency plate is shown by horizontal lines, adjusted with its right end over the negative and the aperture in the frame. The back (fig. 198) is now placed in

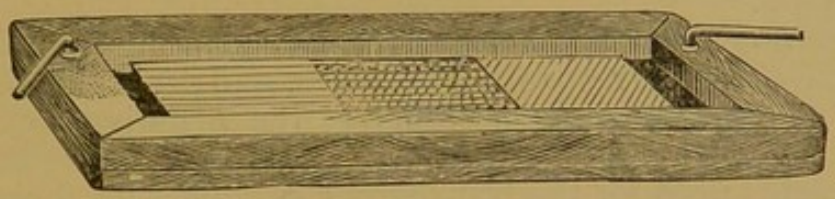

FIG. 197.

position, held by the spring and two holders shown in figs. 197 and 199. After exposure the relative position of negative and plate must be changed, as shown at fig. 199, where the right end of the negative and the left end of the transparency plate are now over

FIG. 198.

the aperture and ready for the second printing. When adjusting the negative for the first printing, as in fig. 197, observe some particular object—say the edge of a stone, or something of the kind in the foreground *that is cut by the left* side of the aperture—

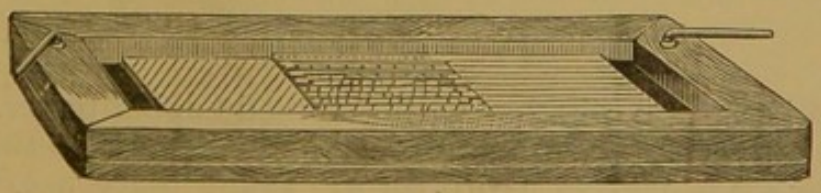

FIG 199.

and by a piece of cardboard to serve for a guide the plate is applied in such a position that the centre of it is cut by the left edge of the aperture. The back of the frame is now applied and printing performed. We now remove the sensitive plate, refresh

our memory with "the stone in the foreground," and slide the negative to the position, as in fig. 199, adjusting the particular "stone in the foreground" as for the previous printing. Apply the plate by use of the guide, which is now turned to the other end, and if made correctly it will produce the two pictures side by side, with a clean cut line between them without any space or overlapping.

In printing from large negatives the printing frame must, of course, be made correspondingly larger, and provided with suitable guides, enabling various portions of the negative to be printed from.

The plates used for the transparencies should be those specially prepared for that purpose; several excellent kinds are now in the market. When finished, the transparency is filled with a paper mask, with openings at $2\frac{3}{4}$ centres, and a cover glass. The whole

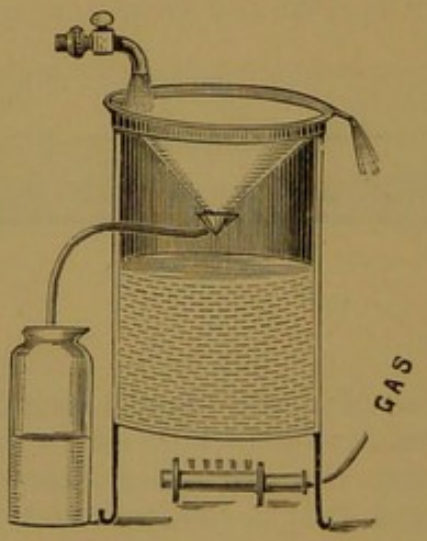

FIG. 200.

are then bound up together with gummed edging paper. To view correctly, the film side must, of course, be nearest to the observer; the cover glass acts as a protector. Some place a ground glass behind the transparency, but this should be very thin. (See also **Transparency.**)

Still.—An apparatus for distilling water or other liquids. A simple form is that shown in fig. 200. The instructions for its use are as follows: Pour ordinary tapwater into the cylinder, fix on the cone lid and place the still over a gas stove or fire; allow a gentle stream of *cold* water to pass over the conical

lid. When the water in the cylinder boils, the steam rises, settles on the under surface of cone, and, being condensed by the cold water above, drops into the funnel, and is caught on the outside by a bottle or other vessel placed for that purpose. This is the distilled water.

Stop.—A disc of blackened metal or other material having a central aperture of such a size as to allow the rays of light to pass only through that portion of the lens that it is determined to use. For this reason the stop must be placed quite close to the lens. (See **Diaphragm.**)

Stopper.—Stoppers of glass bottles are usually made to fit by grinding them in the neck of the bottle with a little fine emery powder paste. There are many chemicals used in photography which require to be kept in tightly-stoppered bottles, as corks would be gradually destroyed. One of the most annoying things with these is the liability of the stopper to stick fast in the bottle, defying all ordinary efforts of removal. The best method to remove a tight glass stopper is by tapping it gently on one side with a light wooden handle, and at the same time you hold the bottle in your other hand you press the stopper on the other side upwards. Another method is to wrap a cloth dipped in boiling water round it, and thus expand the glass, or the same effect can be had by means of a piece of string passed once or twice round the neck and drawn rapidly backwards and forwards, holding the bottle firmly the while. The following method is given by a correspondent to *Photography* :—

"Put two or three drops of paraffin oil in the recess between stopper and bottle. This will, in a short time, insinuate itself through the 'sticking' place. In the meantime, prepare two pieces of hard wood, say ash, about 9in. long by 1in. wide and $\frac{3}{4}$in. thick. Bind them at one end with a leather hinge (a bit of good thick 'upper' off an old shoe will do well), nail it very securely, and glue a strip along the inner edges, say 5in. long. You have then an instrument somewhat like a pair of crude nutcrackers. Put this on your stopper, grip it tight with the hand, give a few wriggles, and then a firm, slow turn, and your stopper is certain to give way to this persuasion. The leather lining is to soften the pressure and prevent slipping, and the length is for leverage. You can wipe the oil out of the neck before it can run into the contents of the bottle."

Prevention is always better than cure, we know ; therefore, all stoppers should be anointed with a little vaseline, which will effectually prevent sticking, and has no injurious action upon the contents.

Stripping Film.—Paper coated first with a solution of soluble gelatine, and then with a sensitive gelatine emulsion as used for

dry plates. The paper acts as a temporary support during the operations of exposure, development, fixing, and washing, after which the film is laid face downwards on a prepared sheet of glass, and the paper removed with warm water, which dissolves the soluble layer, and leaves the image-bearing film upon the glass. The temporary paper support is then replaced by a prepared sheet of gelatine called a stripping skin, and the whole stripped, when dry, from the glass. This process gives a clean, transparent flexible negative of superior printing quality, having all the advantages of glass without its fragility, and about one-fiftieth of its weight. These negatives can be printed from both sides equally well, and are therefore very suitable for the carbon and photo-mechanical processes. The process of developing and fixing is precisely the same as with a dry plate. No alum bath should, however, be used previous to stripping. The following instructions are given by the Eastman Co. for stripping their film :— While the films are washing, clean a glass plate one half-inch larger all round than the negative, and free from surface defects, and flow over it a thin layer of rubber solution, draining away all excess, and allow the surface to dry (say, for five minutes), then coat the plate with a plain collodion. The moment the collodion sets, wash well in cold water until the water runs from the surface without any appearance of greasiness, then place the collodionised plate face upwards in a dish of cold water, and bring into contact with it under water the paper negative film side downwards; grasp the plate and film by one edge with the finger and thumb, and lift the glass with the film attached slowly, allowing the water to drain from the opposite side. Lay the plate upon a table and place upon the back of the paper negative a smooth side of an indiarubber cloth (larger than the glass), and remove all surplus water by the action of a squeegee. The squeegee should be used firmly but without violence, the motion being in all directions. Remove the rubber cloth, lay the plate with the film upwards on a table, and place upon the film a double thickness of stout, clean, blotting-paper. Place a board or other flat surface over the blotting-paper, and on the board a weight of a few pounds. Proceed in like manner with all the washed films, always piling the last plate on the top of the blotting-paper covering the previous plate, and always place on top the blotting-paper, the board and the weight. In fifteen minutes the first plate will be ready to strip, but a much longer period may elapse if desired, provided the collodion varnish is not permitted to dry. The films will, however, strip perfectly after a lapse of several hours, if kept as directed.

Into a flat dish put water at about 120° to 200° Fahr., and, face upwards, in this immerse the first (or bottom) plate. Rock the dish slightly, and in a minute or two the paper will be found wholly or partly floating in the water. Remove it entirely with care Remove from the film with warm water and gentle friction with a·

soft hairbrush, or the soft part of the hand, any of the soluble gelatine that may remain attached to it. Wash well with cold water and immerse, if necessary, in the

CLEARING BATH.

Saturated solution common alum in water	20 ozs.
Acid hydrochloric	1 „

And if intensification is necessary, soak the negative in a saturated solution of corrosive sublimate, wash well, and blacken the image with a solution of 10 drops of strong ammonia to one ounce of water.

All intensified or cleared negatives should be very carefully and very thoroughly washed in running water or in frequent changes of water for not less than two hours.

In a flat dish soak one of the stripping skins in cold water (in very dry climates soak in a bath of water containing five per cent. of glycerine and a few drops of carbolic acid). Place the plate under the skin in water and bring the skin into contact with the negative. Grasp the skin by the edge with the finger and thumb and lift slowly, allowing the water to drain from the opposite side. Remove all surplus water by the gentle action of a squeegee. Set the plate aside to dry gradually, say, for four or five hours at ordinary temperature. Trim the edges of the negative with the point of a sharp knife and strip it from the glass. Adhering rubber solution may be removed from the face of the negative or the glass by a tuft of cotton-wool saturated with benzine.

It is of the utmost importance that the stripping skin should not be soaked too long—otherwise the glycerine will be entirely removed, and the finished negative will be hard and brittle ; two minutes should be amply sufficient.

The back of the dried stripping skin may be coated with collodion before the negative is removed from the glass if thought desirable, or if a varnished negative is not required, the use of the collodion varnish may be dispensed with entirely.

Solutions used in developing the films should not exceed 75° Fahr., and the hands should only touch the films at the corners while wet to prevent softening of the soluble gelatine layer which holds the film to the paper.

For photo-mechanical printing processes and carbon single transfer, the negatives may be printed from while on the glass.

Printing from stripped film negatives may be done from either side if required, but the side that was in contact with the glass at the time of transfer is the correct side. The negative should be laid (preferably) on the convex side of finely-ground glass in the printing frame, ground side next to negative. This method gives fine soft effects, and prevents mottling of the print, caused by partial contact of the negative with the glass.

Stripping Films (Collodion).—Negatives produced by the collodion process can be stripped from the glass support without much difficulty. The following is the *modus operandi:* The glass plate must be well polished and rubbed over with French chalk, and then polished again. It must not be albumenised. When the negative is dry strips of thick paper are pasted along the four sides, either with starch or a solution of gum tragacanth. It is then slightly warmed and placed on a previously levelled stand, and a warm solution of gelatine poured over it, sufficient to give a fairly thick film. This gelatine solution is made up as follows:—

Gelatine	2½ ozs.
Sugar	1½ ,,
Water	20 ,,

And is prepared by first soaking the gelatine in water until quite flabby, and then placing the vessel containing it in hot water until the gelatine is thoroughly dissolved, when it is strained through muslin and is ready for use.

In coating, a small quantity is poured over the levelled plate and spread evenly all over with a Blanchard brush or other similar contrivance. When the film is set the negative is removed and placed in a current of cold air until the film is quite dry. When thoroughly dry all that remains to be done is to run the point of a sharp penknife all round the edges underneath the paper strips, and the negative film will leave the glass plate with a brilliantly polished and flat surface.

Old collodion negatives can be stripped sometimes, but the operation is undoubtedly a risky one, as there is always considerable chance of spoiling it during the operation. If the negative be a valuable one a good positive transparency should always be made before attempting the operation.

The varnish is first removed and the paper pasted round; the plate is then levelled, coated with gelatine, dried, and stripped in the same manner as already described.

Strontium Bromide (Formula, $SrBr_2$).—Prepared by neutralising hydrobromic acid with strontium hydroxide. It crystallises in small tablets, soluble in water, and sparingly so in alcohol. It is employed in the manufacture of some collodion emulsions.

Strontium Iodide (Formula, SrI_2).—Forms yellowish-brown needles, soluble in water and alcohol. Sometimes used as an iodiser for collodion.

Studio.—The old-fashioned idea that any room with a top and side light constituted an efficient studio has long since been abandoned, and considerable attention is now paid by photographers in the construction of the studio, so as to get the best results. Locality is an important point, as the quality, not the quantity or

intensity, of the light is the important point. The usual instructions are that one part should be open to the north, another to the east, a third to the west, and the south side should be closed. In some cases, however, a side light will be impossible; care should then be taken that the inclination of the top light is towards the north. Every attempt should be made to facilitate and perfect the lighting of the model. There is more art in this than many imagine. A soft light is what is necessary.

The skylight should be perfectly rain-proof, and arranged with adjustable blinds, enabling the operator to reduce or increase the amount of light from any part.

Various other contrivances are used for arranging the light upon the sitter, such as hand screens, reflectors, curtains, screens in frames, etc.

The accessories should be carefully and cautiously chosen. The fearful and wonderful furniture never seen outside a photographer's is gradually being discarded, and the best photographers are beginning to find that the finest results are obtainable with the most simple accessories.

Studio Camera.—See **Camera.**

Studio Stand.—See **Camera Stand.**

Sub-bromide of Silver.—See **Silver Sub-bromide.**

Sub-chloride of Silver.—See **Silver Sub-chloride.**

Sub-iodide of Silver.—See **Silver Sub-iodide.**

Sublimate, Corrosive.—See **Mercuric Chloride.**

Substratum (Lat. *sub*—under, and *sterno*—to strew).—An underlying layer.

Sugar of Lead.—See **Lead Acetate.**

Sulphate of Baryta.—See **Barium Sulphate.**

Sulphate of Silver.—See **Silver Sulphate.**

Sulphite of Sodium.—See **Sodium Sulphite.**

Sulphocyanide of Ammonium.—See **Ammonium Sulphocyanide.**

Sulpho-pyrogallol.—A name given to solutions of pyro with sulphite of soda as preservative..

Sulphuretted Hydrogen (Formula, H_2S; synonym, *hydric sulphide*).—An inflammable gas having a very disagreeable smell. It is slightly soluble in water, and more so in ammonia, soda and potash. It is principally employed in photography to precipitate silver sulphide from fixing baths containing alum.

Sulphuric Acid (Formula, H_2SO_4; molecular weight, ·98; synonym, *hydric sulphate*).—Pure sulphuric acid is prepared by distilling oil of vitriol, when the impurities are left behind, and a colourless liquid is produced.

Nordhausen, or fuming sulphuric acid, is prepared by passing sulphuric acid vapour over red-hot bricks. It can be distinguished from English sulphuric acid by its fuming in the air when the bottle is open.

Sulphuric acid is a heavy, oily liquid, with a spec. gravity of 1·845. Great care must be used in handling it, as it corrodes the skin, clothes, etc. It is miscible in all proportions with water, great heat being evolved; therefore, in adding it to water, this must be done in a vessel that will not easily break by the heat.

It is employed in photography in the manufacture of pyroxyline, and for a variety of other purposes.

Table of strength of sulphuric acid at 15° C.:—

Sp. gr.	Per cent of H_2SO_4	Sp. gr.	Per cent of H_2SO_4
1·845	100	1·306	40
1·825	90	1·223	30
1·736	80	1·144	20
1·615	70	1·106	15
1·501	60	1.068	10
1·399	50	1·032	5

Sulphurous Acid (Formula, H_2SO_3; molecular weight, 82; synonym, *hydric sulphite*).—A colourless liquid prepared by deoxidising sulphuric acid with charcoal. It has a pungent sulphurous odour, and should be used fresh, as it changes to sulphuric acid. Its fumes are very poisonous. It is employed in photography as a pyro preservative, and also as an addition to the fixing bath.

Sulphur Toning.—An old method of toning silver prints. They were immersed in an acidified solution of sodium hyposulphite. The sulphur is precipitated by the action of the acid, and clings to the image, giving it a brown tone. Prints toned in this manner, however, usually have yellow whites, and are far less permanent than if toned with gold or platinum.

Supersaturated.—Saturated to excess.

Surfacing.—A method of giving a brilliant polish to positive prints. With a print the surface of which is composed of gelatine,

as, for instance, a bromide or a gelatino-chloride print, but little trouble is necessary. All that is required is to thoroughly clean a glass plate, rub it over with a little French chalk or powdered talc, and squeegee the print face downwards upon it. When dry they will leave the glass with a very highly polished surface.

Instead of a glass plate, polished ebonite or enamelled iron plates can be used.

With other prints, such as albumenised paper pictures, however, another operation is necessary. True, albumen prints can be surfaced in the same manner as the gelatine pctures, but the same high gloss is never obtained. It can, however, be given to them by first dipping the prints in a warm ten per cent. solution of gelatine, and then squeegeeing them to the glass plate. As, however, the glossy gelatine surface is easily affected by moisture, many operators prefer to coat the glass first with collodion, and then squeegee the gelatinised prints to this. A glossy collodion surface is thus obtained, less liable to become deteriorated by the influence of warmth and moisture.

Sweating.—A whitish deposit which occurs on some kinds of glass. This defect is most often found with foreign makes of glass, and is considered to be due to the formation of a salt of lead. It can be detected by the tongue, and is least found with glass which has a greenish tint when viewed at through the edge turned towards the light.

Swing Back.—A contrivance at the back of a camera which admits of an inclination of focussing screen, or dark slide, with reference to the axis of the lens. If the swing be confined to one plane it is a single swing back; if arranged to move upon both a horizontal and a vertical axis it is termed a double swing back. For the same purpose other devices have been used, such as a moving or swinging front, etc.

The swing back is useful in nearly all branches of photography. In landscape work it is useful in bringing the foreground and distance into focus at the same time. To do this it is generally necessary to employ a very small stop, which means a considerably increased exposure. By moving the top part of the swing back in an outward direction, however, it is possible to bring both planes into focus. With a double swing back objects at any part of the plate, whether at the top, bottom, or sides, can be brought into focus.

In architectural photography the swing back is exceedingly useful, although often abused. When it becomes necessary to tilt the camera to take in a large building the vertical lines will naturally all converge to the top, causing the houses to have a tumble-down appearance. By means of the swing back, however, the back of the camera can be kept perfectly horizontal, and the lines will be straight.

In portraiture the swing back is also useful in bringing all the parts of the sitter into focus, without increasing the exposure, by stopping the lens.

The theory of the swing back is this: The nearer an object' from which rays of light proceed, is to the lens, the longer will be the focus of these rays after they have passed through the lens, consequently those rays which proceed from distant objects have a shorter focus than those proceeding from a nearer point. By swinging the back of the camera it will not be difficult to see how it is possible to get both rays in focus at the same time and upon the same plane.

The simplest form of swing back is that in which the back of the camera is hinged to the baseboard. The most perfect form, however, is that in which the back, whether swung horizontally or vertically, makes its own centre the centre of movement.

Swing Front.—A makeshift way of obtaining the same end as a swing back, which it does, though in a less perfect manner. The horizontal swing to the front is of little use except with a camera fitted with conical bellows. With this it is difficult to take two pictures on one plate. If the back and front are each provided with a horizontal swing, the difficulty is removed. The swing front, *in addition to* the swing back, is often very useful.

Symbols, Chemical.—See **Elements.**

Symmetrical Lens (Gr. *symmetria*—due proportion).—A name given to a certain class of photographic lenses.

Syphon (Lat. *siphon*).—A curve tube having one branch longer than another used for transferring liquids from higher to lower levels. A convenient form of syphon can be made with a piece of indiarubber tubing bent in two, one length being longer than the other. The tube is then filled with the liquid, and the short end immersed in it, when the whole of the solution contained in the vessel can be transferred to another receptacle. It is a very useful instrument for removing the liquid from a vessel without disturbing the precipitate at the bottom. A very delicate syphon for draining off the water very slowly from a precipitate can be made with a piece of soft wool, one end dipped in the solution and the other end (which must be the longer) left hanging over the side of the vessel. The wool must first be wetted to give a start.

Talbotype Process.—See **Calotype.**

Tannic Acid (Formula, $C_{13}H_9O_7CO_2H$; synonym, *tannin*).—Extracted from gall nuts, ether being used at the same time to dissolve the colouring matter and gallic acid.

Tannic acid does not crystallise, but is left on evaporation in brownish-white shiny scales, soluble in water, but sparingly so in alcohol. Its chief uses in photography are in the dry-collodion process, and for hardening gelatine prints and films.

Tannin.—See **Tannic Acid.**

Tanning Prints.—Gelatino-chloride prints can be tanned or hardened with a dilute solution of tannic acid. It is, however, liable to cause the print to turn yellow after a little time. The best method of hardening is by means of a strong solution of chrome alum. The effect of this is to better ensure the prints leaving the glass in the glazing process, and also gives the gelatine a harder surface less sensible to atmospheric influences. See **Tannin Solution.**

Tannin Process.—An old dry-collodion process invented by Major Russell. A glass plate is first well cleaned with Tripoli powder, and then washed in clean water, and dried with a soft cloth previously warmed. One side of the plate is then coated with the following gelatine solution in the same manner as collodion :—

GELATINE SOLUTION.

Nelson's gelatine	20 grains.
Water	10 ozs.
Spirits of wine	½ oz.

Dissolve the gelatine in the water and add the spirits of wine. The solution is then filtered through fine muslin or flannel.

After coating the plate with this the superfluous gelatine is poured back into the bottle, and the plate stood up on end on a piece of blotting paper to drain and dry. When dry it is slightly warmed, and can then be packed away in a grooved box. A number of plates can thus be coated at one time, as if they are carefully packed they will keep any length of time. Care must be taken in coating that none of the gelatine solution gets on to the back of the plate. They are next coated with an old iodised collodion in the usual way, and then placed in a similar nitrate of silver bath to that used in the old wet-collodion process. In this bath the plate is allowed to remain for about five minutes, when it is taken out and well washed with plenty of water.

The tannin preservative bath is prepared as follows :—To every ounce of distilled water required in the bath add 15 grains of tannin. Filter and pour out two separate portions of about

four drachms each, one to be used for the first coating of the plate, which serves to remove the water remaining upon it after washing, and the second portion is then poured on and off the sensitised side of the plate. This operation is repeated several times, and the plate is then stood in a warm and dark room, resting upon blotting paper, and when dry it is ready for use in the camera. The time necessary for exposure usually varies between one minute on a favourable day to eight minutes in dull and dark weather.

The developing solution is made up as follows:—

SOLUTION 1.

Pyrogallol	72 grains.
Spirits of wine	1 ounce.

To be preserved in a well-stoppered bottle.

SOLUTION 2.

Silver nitrate	20 grains.
Citric acid	20 ,,
Distilled water	1 ounce.

Filter. For use, add ½ drachm of No. 1 solution to 3 ounces of distilled water, and then take about three drachms of this diluted pyro solution, and add to it from 10 to 15 minims of the silver nitrate and acid solution. Moisten the exposed plate with water, quickly and evenly applied, then pour on the developing solution, and let it flow gently to and fro over the plate. If the sky comes out quickly and strongly, but the details do not, it is a proof of under-exposure, which can sometimes be remedied by the addition of a little more pyro to the developer. If, however, the image appears to come out suddenly, the plate has no doubt been over-exposed; it is then necessary to add a few drops of solution No. 2 to the developer. After development the plate is fixed with sodium hyposulphite, well washed, dried, and varnished.

Tannin Solution.—A solution of tannic acid or tannin, as it is more commonly called, has been recommended for hardening gelatine prints and negatives. Gelatino-chloride prints, if treated with tannin, have a very hard surface, much less easily affected by moisture. In surfacing it also causes the prints to leave the glass more easily. The solution recommended is as follows:—

Water	34 ounces.
Tannin	15 grains.
Salt	155 ,,
Saturated solution of alum	3 fluid ounces.

This is filtered or decanted as soon as all the ingredients have been dissolved. The prints are laid in it for a few minutes, and then well washed.

It should be stated that prints treated with tannin are liable to become yellow after a time.

Dr. Ehrmann recommends a tannin solution for the purpose of hardening the gelatine films of dry plates during hot weather, and thus prevent the frilling which so often occurs. This solution is used in place of alum, and is made up as follows :—

Crystallised sodium sulphite	2 drachms.
Tannin	32 grains.
Water	16 ounces.
Hydrochloric acid	1 drachm.

It does not precipitate and cause the gelatine film to shrink up. The solution keeps well, and, owing to the presence of hydrochloric acid, any yellow colour formed on the plate is entirely removed by bleaching, and the result is a clear printing solution.

Tartaric Acid (Formula, $C_4H_6O_6$; molecular weight, 150).—Prepared from impure cream of tartar by precipitation with chalk and subsequent addition of sulphuric acid. It usually occurs as a fine white powder, or in prismatic crystals, soluble in water and alcohol. It is employed in photography in preserving sensitised paper, and in the manufacture of printing-out emulsions containing free nitrate of silver.

Tea Process.—An old dry-collodion emulsion process. A plate is first coated with a bromo-iodised collodion and sensitised as usual, a preliminary edging having been given to it. After thoroughly washing, the plate is immersed in an infusion of tea, prepared by pouring about ten ounces of boiling water on half-an-ounce of good black tea. After standing one hour or two it is filtered, and is then ready for use. The exposure required is about three times that of wet plates, and development should be proceeded with within twenty-four hours of exposure.

Writing of this process Captain Abney says :—"Of all dry processes the tea process is the most charming, when exposure can be given to the plates within two or three days of preparation. They can be developed with an acid iron developer or by the alkaline developer. They possess a beauty not obtainable by most processes."

Telescopic Photography.—See **Astronomical Photography.**

Temporary Dishes.—Very handy temporary dishes can be made by bending a piece of stiff paper or cardboard all round and

folding the corners so as to form a complete tray, useful for developing, etc. They can be made to last some time, and to resist the action of many chemicals if varnished with shellac or soaked in melted paraffin wax.

Tent.—In the old collodion days, when it was necessary to develop the plate immediately after exposure, a dark tent was an absolute necessity when working in the field. The advent of the dry plates has, however, changed this. Simple dark tents are, however, constructed for the convenience of tourists, enabling them to change and develop their plates when away from home. There are various designs, all having the same purpose, however.

Terchloride of Gold.—See **Gold Chloride.**

Testing Lenses.—The lens being the most important part of the photographer's outfit, it is advisable that this should be perfectly free from defects of all kinds. Lenses by well-known makers are invariably thoroughly tested before being sent out. With other kinds, however, some rough and ready means of testing it is useful. The lens should, if possible, be had on approval for a few days, and tested as follows :—

Spherical Aberration.—Fix a newspaper or something similar in front of the camera, pinning it quite flat all over. Then sharply focus the letters in the centre, and then examine those at the sides. If blurred and indistinct, spherical aberration is present.

Chromatic Aberration.—Arrange three cards with letters on, one behind and above the other, and focus for the centre. If on exposing the plate and developing the centre one does not come out the sharpest the lens is not properly corrected for chromatic aberration.

Flare.—Direct the camera to a strong light, and if a flare spot be present it will make its appearance on the focussing screen as a circular patch of light.

Curvilinear Distortion.—In the centre of the screen focus any straight upright object, and then rotate the camera till its image is brought to the edges, when it should still be perfectly straight and upright.

Flatness of Field can be detected by the same method by seeing if the image also remains perfectly sharp after the camera is rotated.

Centring of Combination.—To discover whether the combinations in a doublet lens are correctly mounted with regard to each other

hold the lens at arm's length, and some distance from a single gas or candle flame. The reflected images of the flame should be one behind the other in a straight line. It is not, of course, possible to view them all when superimposed, but by a little manœuvring it can be seen whether they gradually come together as they should.

Focal Length.—Focus for a distant object, and then measure the distance from the diaphragm to the ground glass. This gives the focal length of the lens, and should not be less than the diagonal measurement of the largest size plate it is intended to cover.

Covering Power.—Place the lens in the camera and see that with the largest diaphragm it covers the plate well even to the sides and corners.

Aperture.—A good lens should work with as large an aperture as possible. A "rapid rectilinear" should work at *f*/8, and a "landscape" at *f*/16.

The Glass.—Lenses are usually made of flint and crown glass. They should not have any perceptible colour. This may be seen by laying the combinations on a piece of white paper. Bubbles and striæ can be detected by looking through the lens. The surfaces should be well polished and free from scratches.

The Mount.—The interior of the mount and the stops should be of a dead black without any reflecting parts.

Test Paper.—Unsized paper prepared with certain substances and used for testing solutions for acidity or alkalinity.

Litmus Paper is made by steeping blotting paper into an infusion of commercial litmus. It takes a deep indigo colour, and is used for testing acids. If a solution be acid it reddens it, or if exposed to acid fumes. It can also be used for testing alkalies by dipping into a dilute solution of sulphur acid and drying it. It then takes a red colour, which is changed to blue again on immersion in any alkaline solution.

Turmeric Paper is made by steeping blotting paper in an infusion of turmeric, which gives it a yellow colour. This becomes changed to brown by the action of an alkali.

A good test paper for alkalies can, according to Sutton, be made by steeping blotting paper in a strong infusion of the petals of the red rose. The red colour of this kind of paper is changed by an alkali to green.

Test papers are usually sold made up into little narrow books. They are of great use to photographers in testing the condition of the silver bath, and for a variety of similar purposes.

Tests for Chemicals.—See **Photographic Chemicals.**

Thermometer (Gr. *thermos*—hot, and *metron*—a measure).—An instrument for measuring intensity of heat or temperature by means of expansion of a liquid or gas. Mercury is generally employed, and an ordinary thermometer consists of a spherical or cylindrical glass bulb at the end of a very fine tube, the bulb being completely filled and the tube partly filled with mercury, while the space above the mercury contains only a small quantity of mercury vapour, which offers no resistance to the expansion of the mercury. When the temperature rises the mercury expands, and consequently rises in the tube. On the other hand, a fall in the temperature is indicated by a fall of the mercury in the tube. A graduated scale is attached with two fixed points, the freezing point and the upper or boiling point of water. The distance between the two fixed points is then divided into a number of degrees, which are continued above and below the two fixed points. In the Centigrade or Celsius thermometer, used by scientists all over the world, and in general use on the Continent, the distance between the two points is divided into a hundred degrees, the freezing point being 0° and the boiling point 100°.

In the Reaumur scale the distance is divided into 80 degrees, the freezing point being 0° and the boiling point 80°.

On the Fahrenheit thermometer, which is the one most generally used in this country, the freezing point is marked 32° and the boiling point 212°, hence the zero of the scale on that part marked 0° is 32 degrees below the freezing point, and the interval between the freezing and the boiling points consists of 180 degrees. The zero point is supposed to have been fixed by Fahrenheit at the point of greatest cold he had observed.

Degrees above 0° are termed + degrees, and those below 0° are termed — degrees.

The following formulæ will serve to convert any given number of degrees of one scale into the corresponding number of one of the other scales:—

C. ÷ 5 × 9 + 32 = F.
R. ÷ 4 × 9 + 32 = F.
F. — 32 ÷ 9 × 5 = C.
F. — 32 ÷ 9 × 4 = R.
C. ÷ 5 × 4 R.
R. ÷ 4 × 5 C.

For further convenience the following table of the assimilation of the three thermometers is appended:—

Thermometric Tables,

SHOWING THE ASSIMILATION OF THE THERMOMETERS IN USE THROUGHOUT THE WORLD.

Celsius.	*Réaumur.*	*Fahrenheit.*	*Celsius.*	*Réaumur.*	*Fahrenheit.*
100	80·0	212·0	49	39·2	120·2
99	79·2	210·2	48	38·4	118·4
98	78·4	208·4	47	37·6	116·6
97	77·6	206·6	46	36·8	114·8
96	76·8	204·8	45	36·0	113·0
95	76·0	203·0	44	35·2	111·2
94	75·2	201·2	43	34·4	109·4
93	74·4	199·4	42	33·6	107·6
92	73·6	197·6	41	32·8	105·8
91	72·8	195·8	40	32·0	104·0
90	72·0	194·0	39	31·2	102·2
89	71·2	192·2	38	30·4	100·4
88	70·4	190·4	37	29·6	98·6
87	69·6	188·6	36	28·8	96·8
86	68·8	186·8	35	28·0	95·0
85	68·0	185·0	34	27·2	93·2
84	67·2	183·2	33	26·4	91·4
83	66·4	181·4	32	25·6	89·6
82	65·6	179·6	31	24·8	87·8
81	64·8	177·8	30	24·0	86·0
80	64·0	176·0	29	23·2	84·2
79	63·2	174·2	28	22·4	82·4
78	62·4	172·4	27	21·6	80·6
77	61·6	170·6	26	20·8	78·8
76	60·8	168·8	25	20·0	77·0
75	60·0	167·0	24	19·2	75·2
74	59·2	165·2	23	18·4	73·4
73	58·4	163·4	22	17·6	71·6
72	57·6	161·6	21	16·8	69·8
71	56·8	159·8	20	16·0	68·0
70	56·0	158·0	19	15·2	66·2
69	55·2	156·2	18	14·4	64·4
68	54·4	154·4	17	13·6	62·6
67	53·6	152·6	16	12·8	60·8
66	52·8	150·8	15	12·0	59·0
65	52·0	149·0	14	11·2	57·2
64	51·2	147·2	13	10·4	55·4
63	50·4	145·4	12	9·6	53·6
62	49·6	143·6	11	8·8	51·8
61	48·8	141·8	10	8·0	50·0
60	48·0	140·0	9	7·2	48·2
59	47·2	138·2	8	6·4	46·4
58	46·4	136·4	7	5·6	44·6
57	45·6	134·6	6	4·8	42·8
56	44·8	132·8	5	4·0	41·0
55	44·0	131·0	4	3·2	39·2
54	43·2	129·2	3	2·4	37·4
53	42·4	127·4	2	1·6	36·6
52	41·6	125·6	1	0·8	33·8
51	40·8	123·8	0	0·0	32·0
50	40·0	122·0			

For extreme degrees of cold mercury cannot be employed, as it freezes at about 40° below zero on the Fahrenheit scale. They can only be used for temperatures between — 40° and + 675°, as it boils at the latter point. For lower temperatures alcohol is used, as this has never been known to freeze, and for higher temperatures air thermometers are employed, in which changes of temperature are measured by the contraction of a known volume of air. Alcohol cannot be used for high temperatures, as it is soon converted into vapour.

Thiocarbamides, Reversal with.—It has recently been discovered that the addition of a thiocarbamide to the developer will produce a reversal of the image. The following remarks upon the subject are by Professor Bothamley, F.I.C.*

"Phenyl-thiocarbamide added in a small quantity to an eikonogen developer containing eikonogen five parts, sodium sulphite 10 parts, crystallised sodium carbonate eight parts, water 400 parts, gives a reversed image with a normal and even with under-exposure. Over-exposure prevents reversal, and an excess of the thiocarbamide is also injurious, the best proportions being 12 to 15 parts of a saturated aqueous solution (1 : 1,000) to 100 parts of the developer. Potassium bromide in the proportion of 0·5 to one part of a 10 per cent. solution in 100 parts of the developer aids reversal, and in some cases a small quantity of ammonia is beneficial. Good reversal is difficult to obtain with landscapes having strong contrasts, but for copying the results are more satisfactory. Before development the plate should be flooded with dilute nitric acid (5 per cent.), which is quickly washed off, and before fixing a short immersion in a two to three per cent. solution of cupric bromide gives clearer whites, but too long an immersion will weaken the lines. A bath of cupric bromide *before* development destroys the image. Potassium dichromate does not act so well as nitric acid when used as a preliminary bath or added to the developer; potassium ferricyanide, when added to the developer acts as a powerful restrainer, and its clearing effect is not so good as that of nitric acid. Phenyl-thiocarbamide gives no similar reversal with ferrous oxalate, pyro, or quinol; with the first two it acts as a restrainer, and with the last as a powerful accelerator, giving general fog. Thiosinnamine (allyl-thiocarbamide) acts less regularly but more energetically than phenyl-thiocarbamide, giving clearer whites. With eikonogen it gives the best results in presence of sulphite; with pyro containing sulphite it also gives reversal, but not with pyro in presence of much bromide; with Thomas's quinol developer it gave no reversal, but good results were obtained with a developer containing quinol, one part; sodium sulphite, two parts; crystallised sodium carbonate, 10 parts; water, 70 parts. With the eikonogen

*Photography Annual 1891.

developer the addition of about two parts of a 10 per cent solution of potassium dichromate to 500 parts of developer gives clearer results.

Thiocarbamide (sulpho-urea) itself also gives reversal with the eikonogen developer, but the results are very irregular. Neither thiocarbamide nor allyl-thiocarbamide gives good results for copying, even with the preliminary bath of nitric acid. Very few experiments with the spectrum were made, but it seems that the reversal of any particular part of the spectrum is almost entirely a question of the exposure. In some cases with phenyl-thiocarbamide and allyl-thiocarbamide the image first develops normally, but as development continues reversal takes place; in other cases the plate seems to fog all over, and the reversal is only evident after fixing.

All the thiocarbamides exert no reducing action on the haloid salts of silver in absence of an alkali, though thiocarbamide and allyl-thiocarbamide form pasty compounds with them. In presence of an alkali, partial reduction takes place even without exposure to light, and the reduction proceeds further on addition of eikonogen. Simple carbamide (urea) has a slight reducing action on precipitated silver bromide in presence of an alkali, but has no action on gelatino-bromide plates, and gives no reversal when added in any proportion to an eikonogen developer.

No reversal takes place when any of these compounds is added to the hydroxylamine developer, though thiosinnamine, like glucose, seems to prevent the evolution of gas."

Thiosulphite of Sodium.—See **Sodium Hyposulphite.**

Time Shutter.—A shutter arranged so that exposures of any length can be given to the plate.

Toning.—The process of changing the colour of the silver print or other kind of positive from an unpleasant to an agreeable colour. The colour of a silver print upon albuminised paper is usually of an offensive red, which it is very necessary to alter. The operation in toning usually consists in changing the colour by partial substitution of gold, platinum, or some other metal for the silver of the print.

It is true that if a silver print be merely fixed in an acidified fixing bath of sodium hyposulphite, an agreeable brown tone will be obtained, for the reason that the sulphur precipitated by the action of the acid would adhere to the image, but this method of sulphur toning, although practised in the earlier days, is now abandoned on account of the inferior permanency of the results.

The principal method of toning is by means of an alkaline solution of gold. Platinum is also finding much favour as a toning agent.

The accepted theory of the gold toning process is that the gold is deposited from an alkaline solution of its terchloride in a layer over the reduced silver. Gold is very easily reduced from its salts to the metallic state. When, therefore, the silver image is immersed in the solution of chloride of gold, the silver having a great attraction for the chloride, the gold parts with it willingly, and it goes over to the silver to form silver chloride and the dark sub-chloride where the silver has been reduced by the light. Now the gold having parted with its companion, naturally falls down as a precipitate of metallic gold depositing itself upon the image. The colour of the gold precipitated is regulated by the rapidity of its precipitation. A very slow precipitation gives fine particles of a reddish colour, whereas quick precipitation gives coarser particles of a bluish colour. The colour of these particles gives the colour of the image, consequently by regulating the precipitation we can get a variety of agreeable tones between the two extremes of red and blue. It will be obvious from this that the colour of the image is no guide to the amount of gold in it. It is stated upon good authority that the greater the amount of gold contained in the print, the much greater the permanency of the image; it therefore follows that it is not a good plan to be too economical with the gold salt.

It should also be remarked that the variety of colour differs very greatly with the kind of bath used with different brands of paper, and also to a certain extent with the quality of the negative.

The prints are prepared for the toning process by well washing in several changes of water to remove all soluble matter, except with toning baths containing chloride of lime and sulphocyanides, as these apparently require a free silver before any action will take place. Some operators prefer to place them after washing in a very weak solution of common salt—about a pinch to the pint. This gives the prints a redder colour, and makes the colour change in toning more obvious. A preliminary bath of sodium carbonate gives more purple tones; it is also very necessary with "preserved" ready-sensitised papers, which usually contain a large quantity of free acid, and which it is necessary to neutralise.

There are a very large variety of toning bath formulæ, many of which are given under **Toning Bath.**

After washing, the prints are placed one by one into the toning solution, which should be contained in a white porcelain dish used only for that purpose. The depth of the solution should be at least half-an-inch. Too many prints should not be toned at once, as the operator should have complete control over each one. They should be kept constantly moving, and prevented from adhering to each other.

The temperature of the toning solution should be between about 65° and 75° F., except with gelatine prints, when, of course, it must be colder, or the gelatine would perhaps dissolve. In toning the following should be noted:—Hard intense prints require

vigorous toning, and should be placed face downwards in the solution. Weak prints require gentle toning. Toning the prints with the face downwards hastens the operation; with the face upwards it retards it.

The greatest enemy of the toner is hyposulphite of soda. Every precaution must, therefore, be taken that this substance does not reach the toning bath, the toning and fixing operations being kept as separate as possible.

When the desired tone (as viewed by transmitted light) is arrived at, which should take at least ten minutes, the prints are removed. Practice only will enable the operator to know with certainty when to remove the prints from the gold bath, as this differs with the different solutions. With some the prints change to a considerable extent in the fixing bath. With regard to the correct illumination for the toning operation, some prefer to work in dull, diffused daylight, and others by gas or other artificial light. With the latter, of course, allowance has to be made for the different appearance of the colour when viewed by daylight.

Upon removal from the toning bath the prints are laid in a dish of cold water. To prevent further toning by the action of the solution in the print, a little common salt should be added.

The failures most likely to be met with in the toning process are the following:—If the prints tone too rapidly the bath is too strong in gold. Unevenness of tone will also arise from this defect. The prints will also lose a great deal of their tone in the fixing bath. Uneven toning is also the result of the bath being acid or too warm. If the prints are allowed to stick together or to the sides of the dish, patchy unevenness will also be caused, or if fresh gold solution be added while the prints are in the bath. If the prints tone too slowly it is possible that the solution is too weak in gold. Sometimes they will refuse to tone from this cause, or from the bath being contaminated with foreign impurities, or from its being too cold.

Loss of tone in fixing is an annoying defect, more often occurrent with some gold than with others, also with inferior samples of gold. This can sometimes be avoided by making the fixing bath acid with acetic acid, and then neutralising with ammonia till distinctly alkaline to test paper. If not made alkaline, however, a yellowness of the whites will be caused. This latter defect may also be caused by over-toning.

Toning Bath.—A solution used for the purpose of changing the reduced silver of the image to an agreeable colour which shall not be destroyed in the fixing bath. The following is a fairly complete list of the toning baths in daily use at the present time. With the gold toning baths it is very convenient to dissolve the contents of a 15 grain tube of gold chloride in 15 drachms of water, neutralise it with a little common chalk, and for every grain recommended in the formula use so many drachms of the solution.

1.—Acetate Bath.

Sodium acetate	75 grains.
Gold chloride	3 ,,
Water	30 ounces.

This is probably the most simple and generally used bath. It is exceedingly reliable, and gives uniform results. It works better after a few days than at first, and improves with age, being constantly replenished with a little of the stock solution. If required for immediate use hot water should be taken, and the bath used when cold. It gives with most papers brownish-purple tones. E. J. Wall prefers to keep a concentrated solution thus—

Gold chloride	15 grains.
Sodium acetate	480 ,,
Distilled water to make 7½ ounces.	

For use mix ½ oz., equal to one grain of gold to half-pint of water for every sheet toned. After use the bath can be filtered and used to dilute the next bath.

2.—Sodium Carbonate Bath.

Sodium carbonate	45 grains.
Gold chloride	3 ,,
Water	30 ounces.

A fresh solution of this bath must be made each time, about an hour before using, as it does not keep. The prints are made rather dark, and toned to a purple shade. After fixing, the image assumes a good brown colour. If the temperature of the water be raised to about 180° F., the carbonate and gold added, and the bath used in about ten to fifteen minutes, fine sepia tones are obtainable.

3.—Chloride of Lime Bath.

Chloride of lime	4 grains.
Gold chloride	3 ,,
Water	30 ounces.

About a tablespoonful of chalk is added, to neutralise acidity. This bath can be used at once if made with hot water, or if with cold an hour or so should be allowed. It gives purplish-black tones. When it gets old, a little gold chloride and chloride of lime are added.

4.—Carbonate of Lime Bath.

Gold chloride	3 grains.
Carbonate of lime	25 ,,
Distilled water	20 ounces.

The gold and chalk are thoroughly well mixed together in the water. After about an hour it is ready for use. Brownish-purple tones are obtained. The bath keeps fairly well.

5.—Bicarbonate Bath.

Gold chloride	1 grain.
Sodium bicarbonate	4 ,,
Water	8 ounces.

or

Gold chloride	3 grains.
Sodium bicarbonate	3 ,,
Common salt	6 ,,
Water	10 ounces.

These baths are ready for use, but will not keep. They give warm brown tones.

6.—Phosphate Toning Bath.

Gold chloride	1 grain.
Sodium phosphate	20 grains.
Water	8 ounces.

Should be used as soon after preparation as possible. It gives warm purple tones, but will not keep.

7.—Bicarbonate and Acetate Bath.

Gold chloride	3 grains.
Sodium bicarbonate	6 ,,
Sodium acetate	72 ,,
Distilled water	30 ounces.

The gold and bicarbonate are added to two ounces of water, and well shaken until all colour disappears. The acetate and remainder of the water are then added. Can be used in about six or eight hours after preparation.

8.—Acetate of Lime Bath.

Gold chloride	1 grain.
Acetate of lime	20 grains.
Chloride of lime	20 ,,
Common chalk	25 ,,
Tepid water	20 ounces.

The gold is well shaken up with the chalk and a little of the water and then added to the solution containing other ingredients. This bath improves by keeping.

9.—Borax Bath.

Gold chloride	1 grain.
Borax	1½ drachms.
Boiling water	24 ounces.

The borax is dissolved in the boiling water, and when cool the neutralised gold chloride is added. On no account add the borax to the gold. The bath should be prepared a few hours before using.

With regard to the keeping qualities of this bath much has been said both ways. The truth of the matter is that, although the borax solution will keep indefinitely, the gold becomes rapidly deposited; therefore, in using the bath again no saving of gold

takes place, as enough is required as would be necessary for a new bath. There are many, however, who consider an old borax bath to tone better and evener than a freshly prepared one. If required to be used again it must be kept in a dark place.

10.—Borax and Tungstate Bath.

Gold chloride	1 grain
Borax	10 grains
Sodium tungstate	40 ,,
Water	6 ounces

Very suitable for ready-sensitised paper.

11.—Acetate and Borax Bath.

Gold chloride	3 grains
Sodium acetate	30 ,,
Borax	3 ,,
Distilled water	30 ounces

Mix the gold and acetate in half the water and add the borax dissolved in the remainder. It can be used at once, keeps well, and gives brownish-black tones.

12.—Calcium-chloride Bath.

Gold chloride	15 grains
Water	5 ounces

Neutralise with lime-water, make up to fifteen ounces with water, and add two drachms of calcium chloride. This stock solution will keep for a long time for use. Dilute one ounce with ten ounces of water.

13.—Acetate Bicarbonate and Borax Bath.

Borax	330 grains
Sodium acetate	180 ,,
Sodium bicarbonate	90 ,,
Distilled water	20 ounces.

This is the stock solution. For use, take 10 drachms and mix with 10 ozs. of distilled water, containing one grain of chloride of gold. The bath should be made up about two hours before use. Old toning bath can be used instead of water for dilution. Rich brown tones can be obtained.

14.—Tungstate Bath.

Gold chloride	15 grains.
Sodium tungstate	300 ,,
Boiling distilled water	15 ounces.

When cool it can be used, and it gives fine purplish-brown tones.

15.—Citrate Toning Bath.

Gold chloride	1 grain.
Sodium carbonate	60 grains.
Citric acid	20 ,,
Distilled water	10 ounces.

After mixing, the solution is warmed till it changes colour. It is then used, as it will not keep.

16.—Sel d'Or Bath.

Gold chloride	1 grain.
Sodium hyposulphite	4 grains.
Hydrochloric acid	4 drops.
Distilled water	10 ounces.

The gold is dissolved in half the quantity of water, and added to the hypo dissolved in the other half, stirred constantly, then add the acid. The prints after toning are immersed in a soda bath, and then fixed.

17.—Sulphocyanide Toning Bath.

Gold chloride	1 grain.
Potassium sulphocyanide	12 grains.
Sodium hyposulphite	½ grain.
Distilled water	4 ounces.

Print rather deeply, and immerse in the toning bath without previous washing. Fix in fresh hypo.

Restrained Lime Bath.

Gold chloride	4 grains.
Lime chloride	4 ,,
Sodium chloride	4 ,,
Distilled water	20 ounces.

Gives black tones.

Bromide Bath.

Gold chloride	2 grains.
Sodium carbonate	30 ,,
Sodium bromide	1 grain.
Distilled water	20 ounces.

This bath should be used as soon after mixing as possible. It does not keep. Brown or chocolate-brown tones.

Toning Bath for Yellow and Faded Prints.*

Solution 1.

Distilled water	17 ounces.
Sodium tungstate	154 grains.

Solution 2.

Carbonate of lime	60 grains.
Lime chloride	15 ,,
Gold chloride	60 ,,
Distilled water	15 ounces.

Solution 2 is made up in a yellow glass bottle, thoroughly well shaken up, allowed to stand for a day, and then filtered into

* By M. Zaudaurek, of Vienna.

another yellow bottle and kept tightly stoppered. After the prints have been well washed they are placed separately in the toning solution, made up of

Solution 1	5 ounces.
,, 2	75 to 150 minims.

They should tone in about ten minutes, if quicker than this the proportion of solution 2 should be reduced. After toning, the prints are washed and fixed in—

Solution 1	10 ounces.
Sodium hyposulphite	250 grains.

In this they should remain until the yellow colour of the paper has completely disappeared. If very far gone this may take several hours. Afterwards well wash.

So far we have only considered toning solutions with gold for albumenised paper prints. Other metals, are, however, sometimes used, as the following will show :—

Platinum Toning Bath.

Platinum perchloride	15 grains.
Sodium bicarbonate	15 ,,
Distilled water	15 ounces.

Print to a considerable depth, and just previous to toning add on drop of nitric acid for every grain of platinum used.

Platinum Toning Bath

Platinum perchloride	1 grain.
Water	16 ounces.
Potassium carboate to neutralise	
Formic acid	½ to 1 drachm.

A serviceable bath for silver prints upon plain paper; it gives deep black tones.

Platinum can also be snbstituted for gold in any of the gold toning formulæ, or a mixture of the two metals can be employed.

17.—Uranium Toning Bath.

Uranium nitrate	1 grain.
Gold chloride	1 ,,
Sodium bicarbonate	20 ,,
Distilled water	10 ounces.

This bath must be made alkaline, and used immediately. Very fine purplish black tones are obtainable. Place the prints in salt and water both before and after toning.

Another bath is the following :—

Gold chloride	4 grains.
Uranium nitrate	4 ,,
Sodium chloride	60 ,,
Sodium acetate	60 ,,
Distilled water	32 ounces.

Neutralise the gold and uranium, previously dissolved in a little water, with sufficient sodium bicarbonate. Print deeply, and well wash previous to toning. Fix in

Sodium hyposulphite	2 ounces.
Sodium chloride	1 ounce.
Sodium bicarbonate	¼ ,,
Water	1 pint.

IRON, GOLD AND URANIUM BATH.

Gold chloride	1 grain.
Uranium nitrate	1 ,,
Sodium carbonate to neutralise acetate of iron solution	1 drop.
Distilled water	8 ounces.

For rich black tones; should be used as soon as the black precipitate, at first formed, is dissolved.

GOLD AND LEAD BATH.

Lead nitrate	60 grains.
Sodium chloride	80 ,,
Sodium hyposulphite	1 ounce.
Gold chloride	2 grains.
Distilled water	20 ounces.

Gives black tones. The water in which the ingredients are mixed should be warmed slightly. Fresh hyposulphite should be used for fixing.

COPPER AND GOLD BATH.

Sodium phosphate	80 grains.
Cupric chloride	1 grain.
Gold chloride	5 grains.
Water	40 ounces.

The gold should be neutralised with chalk.

Another formula is

Sulphate of copper	1 grain.
Gold chloride	1 ,,
Distilled water	10 ounces.

The prints are allowed to remain in this solution for about five minutes, and are then transferred to

Gold chloride	1 grain.
Sodium acetate	10 grains.
Sodium bicarbonate	10 ,,
Potassium chloride	2½ ,,
Distilled water	10 ounces.

The paper is preferably fumed with ammonia, and printed very dark. Purplish black tones are obtained.

OSMIUM TONING BATH.

Osmium ammonium chloride	23 grains.
Osmiate of potash	1½ ,,
Acetic acid	½ ounce.
Water	36 ounces.

This formula has been often recommended, but is rarely used, owing to the high price of the osmium salt.

Palladium Toning Bath.

Palladous chloride	1 grain.
Sodium sulphite	20 grains.
Water	10 ounces.

Plain paper silver prints are brushed over with this solution until toned. They are then fixed in hypo containing a few drops of ammonia.

Mercury Bath.

Mercury chloride	2 grains.
Tartaric acid	10 ,,
Hydrochloric acid	5 drops.
Distilled water	10 ounces.

For black tones. Permanency of results very doubtful.

To simplify the toning and fixing operations combined baths have been recommended. These, although very suitable for gelatino-chloride papers, are not likely to give very permanent results.

Combined Toning and Fixing Bath.

Water	32 ounces.
Sodium hyphosulphite	8 ,,
Ammonium sulpho cyanide	1 ounce
Sodium acetate	½ ,,

Mix well and add—

Water	8 ounces.
Gold chloride	15 grains.
Ammonium chloride	30 ,,

Add to the solution 100 grains of silver chloride, or some scraps of untoned paper, spoilt prints, etc.

For toning Alpha paper, developed with ferrous oxalate, the following combined toning bath is recommended :—

Water	10 ounces.
Sodium hyposulphite	2½ ,,
Sodium acetate	½ ounce
Ammonium sulphocyanide	¼ ,,
Gold chloride	4 grains.

A very great variety of tones can be obtained, these being principally dependent upon the amount of exposure given to the print previous to developing.

For toning ferro-prussiate papers to a sepia tone, immerse in a dilute solution of potassium hydrate until they turn an orange colour. They are then washed in water and immersed in a solution of tannin five grains to the ounce until of a dark brown colour. Again wash in water and return to the potash solution until the desired tone is arrived at. Brown tones are obtained by omitting the last bath. Blacker tones can be produced by immersing in a three per cent. solution of sodium carbonate after treating with the tannin, then washing and returning to the tannin solution. Another

method of obtaining black tones with this paper is by immersing the print in a ten per cent. solution of silver nitrate until the image disappears entirely. It is then washed for a couple of hours or so and developed with a ferrous-oxalate developer.

See also **Platinum Toning, Gelatino-citro Chloride Paper, Palladium Toning,** etc.

Tracing Paper.—A tissue paper of even body treated with oil, resin or varnish to render it transparent.

It can be made by dipping paper in a mixture of equal parts of Canada balsam and camphene and drying.

A German process consists in saturating the paper, preferably writing paper, with benzine, and before this evaporates applying a varnish as follows:—Boiled bleached linseed oil, 20 parts; lead shavings, 1; oxide of zinc, 1; Venice turpentine, ½. Mix and boil eight hours; when cool strain and add white gum copal, 5; gum sandarac ½. This varnish may be applied by dipping, or with a brush or sponge.

Tracings, Copying.—There are a great variety of processes for copying tracings, a number of which are given here. Most of these processes give a negative image from an ordinary tracing. The two following methods will, however, be found useful, by which tracings may be reversed into negatives, so as to give positive images. The first is by Liesegang, and the second was published some time ago in the "American Machinist."

First Method.—The tracing is made on paper with lithographic or autographic ink. Great care must be taken that the drawing pen does not cut through the paper.

When the tracing is dry it is stretched upon a drawing board in the usual manner. Under the tracing a sheet of blotting paper is placed. The drawing is then coated once or twice with a concentrated solution of aniline brown, by means of a wide, soft flat brush. After drying, the drawing is treated with a tuft of cotton or a sponge dipped in oil of turpentine, and rubbed over until all the lines appear in a clear white upon a dark ground.

Second Method.—The drawing is traced on paper with a solution of citrate of iron and ammonia. When dry the surface of the sheet is blackened by means of a crayon, soft pencil or plumbago powder. The sheet is then immersed in water in order to dissolve out the ferric salt, which leaves the lines white. When all are quite clear it is dried.

Tragacanth.—See **Gum Tragacanth.**

Transferrotype.—A process of transferring bromide prints to any suitable support. The paper is first coated with a soluble film of gelatine, and afterwards with an insoluble gelatine emulsion, as

used for bromide positive printing. The method of exposing, developing, clearing, fixing, &c., are the same as with the latter paper.

After the print is washed, and while still wet, it is laid face downwards upon the object to which it is desired to transfer the image. The surface may be polished or ground glass, porcelain, wood, ivory, or any substance that will stand the action of hot water, and allow the image to adhere. It must be perfectly clean, and free from grease and oil. Squeegee the wet print carefully in contact with the surface and place it under a blotter and weight to dry. When dry pour hot water upon the back of the picture until the paper blisters, then run a pin under one corner of the paper and pull it gently away. After removing the paper gently rub the surface of the picture with a tuft of cotton, moistened with warm water, and set away out of reach of dust to dry.

The paper may be stripped any time after it has been thirty minutes under the blotter, but it is safer to allow it to thoroughly dry. The proper temperature of the hot water depends upon whether the paper is dry or not. If dry it should be between 160° and 180° Fahr. If only thirty minutes have elapsed after squeegeeing down, the water should be about 110 degrees Fahr., and the temperature gradually increased by the addition of boiling water until the paper blisters. Thirty minutes is the least time that should be allowed for drying, otherwise there is danger of the picture leaving the support.

Clean dishes and clean hands are essential in the production of clean work. The faintest trace of hyposulphite of soda or pyrogallic acid is fatal to good results.

Transferrotype, Toning.—Warm tones, ranging from a rich brown to a brilliant red, may be obtained with transferrotype paper, after fixing and transferring (the image will not transfer after toning) by the following method :—

Two solutions are prepared.

SOLUTION A.

Potassium ferricyanide	100 grains.
Water	24 ounces.

SOLUTION B.

Uranium nitrate	100 grains.
Water	24 ounces.

These solutions keep separately, but must be mixed only for immediate use. Take equal parts of A and B, and immerse the image into it until the desired tone is obtained, then wash thoroughly, and then immerse for five minutes in a fresh fixing bath of

Hypo	3 ounces.
Water	16 ,,

and wash thoroughly.

Transfers.—There are several photographic processes by means of which images can be transferred to almost any support, as wood, glass, china, etc. The one most generally adopted is no doubt the single or double transfer carbon process. Liesegang introduced a very simple method of transferring prints. He coated thickly-gummed paper with a collodion printing-out emulsion. After printing upon this paper it was laid upon the final support, previously coated with a gelatine solution, and then melted. The gum substratum dissolved and the paper came away, leaving the image upon the support, which was then toned and fixed.

Another method is as follows :—A sheet of paper is first coated with a gelatine solution, and this is damped and laid on to a sheet of glass. Little larger strips of paper are then pasted all round, half on the paper and half on the glass. When dry the expansion of the paper stretches it quite firm and flat. It is then coated with a solution of collodion containing about 2 per cent. of pyroxyline and 2 per cent. of castor oil. The paper can now be levelled and coated with a collodio-chloride or a gelatino-chloride printing-out emulsion, or an ordinary bromide or chloride emulsion as used for plates, and the image printed by contact and development. If a gelatine emulsion be used it must be made to contain as much alum as permissible to render the film insoluble. To transfer it is only necessary to coat the support with a 10 per cent. solution of gelatine, and after toning and fixing the print to squeegee it on to it. By the application of a little warm water the paper support, with the underlying film of gelatine, can be washed away. (See also **Transferrotype.**)

Translucent (Lat. *transluceo* – to shine through).—Substances are said to be translucent when they allow rays of light to pass through, but so nearly opaque that objects are scarcely, if at all, visible through them.

Paper can be made translucent by several different methods. In working with paper negatives it is almost a necessity to have the paper as translucent as possible to lessen the time required in making positives, and also for the purpose of removing as far as possible the grain or texture of the paper. Of the best known method may be mentioned the following.

Prepare—

Castor oil..	5 parts
Ether	1 ,,

Place the paper negative face downwards upon a piece of glass and spread this solution thickly over it, then well warm it till the oil has thoroughly soaked through the paper, and when cool remove the superfluous oil and again warm. Should any of the oil get on to the surface it can be readily removed with a little ether.

Another method is by means of an indiarubber solution composed of—

Indiarubber solution	2 parts.
Canada balsam	2 ,,
Benzole	3 ,,

This is rubbed well into the back of the negative with a piece of cotton wool till thoroughly soaked. It is then dried.

Passing through melted paraffin wax is also recommended for making paper translucent. This must be effected at a temperature so low as to enable it to thoroughly penetrate the paper. It is better not to iron the negative, but to simply warm it, and with a piece of soft cloth to remove all the superfluous wax. Paraffin cools instantaneously, and does not soil the albuminised paper. It renders the paper perfectly free from granularity and prints out rapidly.

A process by no means easy, but which may be made successful, is the following.

Make a mixture of—

Gum dammar	20 parts.
Gum elemi	5 ,,
Benzole	100 ,,

Pour this into a flat dish and place the negatives in one after the other, and allow them to remain in it for about five minutes, and hang up to dry. Benzole must be occasionally added to the solution in consequence of its speedy evaporation. The negatives treated with this will be found very transparent and require no varnishing.

A common method of rendering paper negatives transparent is by means of vaseline. Although a special vaseline oil has been prepared for this purpose, the ordinary substance used as a pomade will answer very well. One method of applying it is to rub the vaseline thickly over the back of the negative, and then hold it near a fire so that the oil will melt and run well into the fibres of the paper. One of the drawbacks to the use of vaseline for this purpose is the necessity of always keeping the negatives treated with it between sheets of oiled paper to preserve the vaseline from evaporating when not in use for printing from.

It should be noted that before rendering a paper negative translucent it is always advisable to make a print, as with many negatives a better positive is obtained without oiling.

Transparency (Lat. *trans*—through, and *pareo*—to appear).—Lit. anything that is transparent. In art, a picture painted or photographed on transparent or semi-transparent material, such as glass, thin paper, etc., to be viewed by the natural or artificial light shining through it.

Under this heading we will give the different processes of obtaining transparencies from an ordinary negative for various purposes, such as for window transparencies, lantern slides, stereoscopic slides, and also for making fresh negatives from a negative by first making a positive transparency.

There are a very great variety of methods, the simplest being, of course, the simple exposure of an ordinary dry plate behind a negative, and development, usually with hydrokinone, eikonogen, or other method which gives a more artistic tone than the useful pyro.

A good developer, giving pleasing black tones, is the following, recommended for "Paget Prize" plates by the manufacturers, these plates being very suitable for transparencies :—

No. 1.

Hydrokinone	1 ounce.
Methylated spirit	10 ,,
Sulphurous acid	½ ,,
Potassium bromide	¼ ,,

Dissolve the hydrokinone in the spirit, and add the acid. In another vessel dissolve the potassium bromide in 3 ounces of distilled water. Mix the two solutions, and make up to 20 ounces with distilled water.

No. 2.

Caustic soda (in sticks)	1 ounce.
Sodium sulphite	5 ,,
Distilled water to make	20 ,,

One part of each of these two solutions to four parts of water. If too hard, more water should be added.

In the production of lantern slides or transparencies upon ordinary gelatino-bromide plates, the chief drawbacks are in the production of clear lights and brilliancy. A brand of plates should be chosen possessing a fairly thick coating. Authorities differ on the advisability of adding a little chloride to the emulsion for the purpose of improving the colour. Others again recommend iodide for warm tones.

With a variety of developers a number of different effects can be produced, colours of all kinds and shades to suit the taste of the worker. The ferrous oxalate developer is one that is very generally used, and gives very good cold black tones. After developing, fixing and well washing, Pringle recommends a clearing solution composed of a very strong or saturated solution in water of alum and citric acid, to each pint of which about two drachms of hydrochloric acid are added.

Mr. F. C. Beach recommends the following eikonogen developer as a suitable one for lantern slide transparencies, giving a bluish black tone similar to the palladium or platinum tone usually given to wet-plate slides. The proportions are—

Sulphite of soda	10 grains
Eikonogen	5 ,,
Carbonate of potash	2 ,,
Water	1 ounce.

This developer made up as recommended above will develop from seven to ten slides in succession. The rapidity of its action can, if desired, be retarded by adding a few drops of a ten-grains to the ounce solution of potassium bromide.

Another method of making transparencies, or lantern slides, is by means of Alpha plates. These plates are placed upon the market ready for use, one of their peculiarities being the extra-ordinary latitude of exposure. Thus, from one negative, a number of perfect slides can be obtained with different exposures of from one to three minutes, all possessing the same depth, but differing in the colour in the following order—greenish black, olive green, cold brown, brown, reddish brown, red, yellowish red. It will thus be apparent that it is possible to so arrange the exposure as to get the colour most desired or the one most suitable to the subject. Besides the colours already stated, a further variety can be obtained by toning the formula used in the combined fixing and toning bath recommended for use with the Alpha paper.

Water	10 ounces.	
Hypo	2½ ,,	(Avoirdupois.)
Acetate of soda	½ ,,	,,
Ammonium sulphocyanide	¼ ,,	,,
Gold chloride	4 grains.	

This is used instead of the ordinary fixing bath, and the slide can be toned any time after fixing. The brown developed slides give the greatest range of tone in the toning bath.

A most beautiful process for the production of transparencies is the albumen process, although the difficulty of working it has prevented its use from being more universal. A description of the process will be found in another place. (See **Albumen Process.**)

Transparencies can also be produced by means of printing-out emulsions. A formula is given under the heading treating of gelatino-citro-chloride printing processes. Instead of spreading this ~~paper~~ emulsion upon a paper support, glass can be coated with it, and transparencies produced. Of course, the printing must be carried very far to get any degree of density when viewed by transmitted light.

Other methods of producing transparencies are by means of the carbon process, the collodio-chloride process, etc., all of which will be found treated upon in the various places.

Transparent Cement.—Made by dissolving seventy-five parts of caoutchouc in sixty parts of chloroform and adding fifteen parts of mastic.

Transparent Paper.—Paper can be made transparent for copying drawings, plans, etc., by lightly rubbing it with a ball of

cotton wool saturated with pure benzine. The tracing can be made, and the benzine on evaporating leaves the paper quite opaque as before, and free from odour. For the best results, however, pure benzine should be employed.

Tray Cover.—A cover of any suitable material placed over the developing tray when treating the latent image with the developer will serve as an extra precaution against the fogging of the plate by means of a too-actinic light, or by daylight entering the dark room.

Trichloride of Gold.—See **Gold Chloride.**

Trimmer.—A little instrument consisting of a sharp-edged wheel, fitted to a convenient handle, and used for trimming prints. One of the advantages this has over the trimming knife is the ability to cut the prints either when wet or when dry. There are two forms —the rigid used for cutting prints, and another form in which the cutting wheel turns upon a swivel, and with this instrument ovals or any similar shapes can be cut.

Trimming.—The art of trimming or cutting the prints to the required size, simple as it may seem, is one that to do correctly requires no little practice. The principal requirements in a trimmed print are perfectly clean cut and parallel edges. Few things look worse than a badly-trimmed print. This is especially noticeable with views of buildings or other objects having straight lines. If the prints be not trimmed with their edges parallel to these lines the beauty of the print, if it be a good one, is entirely lost, as the houses will appear to be toppling over. In seascapes, too, how necessary it is that the edges should be trimmed parallel, and at right angles to the horizon line. It is a common, but nevertheless a bad, practice to trim the print all round parallel with the negative, but an artist would reduce his picture to any size and shape which he considered would give the best effect. This, in the majority of cases, would be very different from the standard sizes.

Tripod.—A three-legged stand for the camera when used for out-door work. The head is usually a solid piece of wood on a metal frame, upon which the baseboard should rest evenly all over its surface. This is an important point, as if the baseboard only touches a portion, or if the tripod head be too small, the camera will not be held firm, no matter how rigid the stand may be, and will vibrate at the merest touch. The tripod head is usually screwed centrally to the baseboard, but in the arrangement termed the "contained tripod head" the baseboard is fitted with a circular plate, bearing pins or holes to which the legs are attached. The advantage of this contrivance is that there is no loose screw to get lost, no tripod head to carry, and the camera is much more easily set up. The legs of the tripod stand are of

very varied construction. The simplest consists merely of a stout ash pole composed of three portions, which spread out and form the stand. The length of this being usually about five feet makes it very inconvenient for travelling, however. For this reason tripods have been constructed, the legs of which fold up into two, three, four, and even five lengths. With the last the fifth point is usually telescopic. The usual tripod leg consists of three slips of wood, one of which folds up between the other two, and when opened out is locked firmly by some arrangement for that purpose. The two-fold stand is probably the simplest form of convenient stand. It should be noted that the rigidity of the camera depends chiefly upon the width apart of the shutter frame when the leg is attached to the tripod, the stability varying as the square of the width, and also upon the thickness and depth of the material. There are also a few forms of metal telescopic stands. These are very useful when photographing on rough and hilly ground, so that one leg can be shortened without interfering with the other.

Tripod Head.—See **Tripod.**

Tripoli.—A siliceous deposit consisting of the cast-off shells of diatoms. Found in deposits of considerable thickness and extending over many miles of country. It was first imported from Tripoli, but has since been found in other places. It is largely used for polishing metals, marble, glass, etc.

Tripoli Powder.—Prepared tripoli imported from Germany, and used for polishing metals, glass, etc.

Turmeric.—The dried tubers or rhizomes of *Curcuma longa*, a native of Ceylon. The best is in small short pieces, externally yellow, internally deep orange. Unsized paper, dipped in an alcoholic solution of turmeric, is used as a test for alkalies. (See **Test Paper.**)

Turmeric Paper.—See **Test Paper.**

Tungstate of Soda.—See **Sodium Tungstate.**

Turpentine (Formula, $C_{10}H_{16}$).—An oleo-resinous substance flowing naturally or by incision from several different kinds of trees, as from the pine, larch, fir, &c.

Ordinary turpentine is usually obtained from the Scotch, or some species of fir. Venice turpentine is obtained from the larch. All the turpentines dissolve in pure alcohol, and by distillation yield oils termed spirits of turpentine.

It is much used as a solvent for varnishes.

Twin Lenses. — In stereoscopic photography a camera is usually employed fitted with two lenses side by side, their centres distant about two and a-half or three inches, and their foci exactly the same; for this reason they are often termed twin lenses.

Ultra-red Rays.—A term applied to the rays beyond the red low end of the spectrum. From these rays, which are invisible on account of the slowness of their vibrations, the greatest heating effects are obtained. (See **Spectrum.**)

Ultra-violet Rays.—A term applied to the rays beyond the violet or high end of the spectrum. The vibrations of these rays are too rapid for vision, but they possess greater chemical activity than any others.

Umbrella Tent.—A kind of collapsible dark tent for changing or developing plates. It opens out like an umbrella, but has no stick in the centre, and can be placed on a table or the ground, or hung to the bough of a tree.

Under-exposure.—Sensitive plates, films, or papers are said to be under-exposed when the action of the light has been insufficient. An under-exposed plate appears hard, the high lights developing very black, and the shadows remain clear glass. Under-exposed plates can rarely be improved. A strong developer should be used, and with the ferrous oxalate it is a common practice to add a few drops of a very dilute solution of hypo-sulphite of soda.

Undulatory Theory.—The theory of light that has been generally adopted. It pre-supposes that there exists a universal ethereal medium pervading all space of infinite elasticity. The sensation of light is supposed to be caused by rapid undulations or waves in this impenetrable ether. Sir John Herschel gives the following table of the number of waves composed within the space of an inch constituting differently coloured lights, and also the number of each which strike upon an object (the eye for instance) in one second of time :—

Colours of the Spectrum.	Number of Undulations in an Inch.	Number of Undulations in a Second.
Extreme red	37,640	458,000000,000000
Red	39,180	477,000000,000000
Orange	41,610	506,000000,000000
Yellow	44,000	535,000000,000000
Green	47,460	577,000000,000000
Blue	51,110	622,000000,000000
Indigo	54,070	658,000000,000000
Violet	57,490	699,000000,000000
Extreme violet	59,750	727,000000,000000

Uniform System.—A system of numbering diaphragms adopted by the Photographic Society of Great Britain taking f_4 as the standard, which is termed No. 1. The numbers are termed the U.S. number. (See **Diaphragm.**)

Uranium (Symbol U ; atomic weight, 180).—A valuable metal occurring as an impure oxide in pitch blende, and as carbonate in liebigite. The nitrate and the chloride are both used in photography. See **Uranyl Nitrate** and **Uranyl Chloride.**

Uranium Collodion Process.—A collodion process devised by Wortley, in which uranium was used.

The formulæ are—

Plain collodion	10 ounces.
Cadmium bromide	76 grains.
Uranium nitrate	5 drachms.
Silver nitrate	3 ,,

The manipulations necessary are precisely the same as with the ordinary collodion bromide emulsion process. The following is the preservative :—

Tannin	80 grains.
Gum arabic	48 ,,
Sugar	32 ,,
Water	8 ounces.
Gallic acid solution	4 drachms.

The gallic acid solution consists of 1 part of gallic acid in 20 parts of alcohol.

The following is used as developer :—

Water	320 minims.
Alcohol	128 ,,
Alcohol pyrogallic solution (1 in 10)	40 ,,
Ammonium carbonate solution (1 in 8)	20 ,,
Ammonium bromide solution (1 in 8)	20 ,,

The pyro, water and alcohol solutions are first left to act by themselves, and the ammonium solutions are added later. With over-exposed plates more bromide, and with under-exposed plates more pyrogallic acid, solutions are used.

Uranium Intensifier.—See under **Intensification.**

Uranium Printing.—Very pretty images can be made by this process. A variety of very pleasing terra cotta and other red colours can be obtained.

Paper is first floated for five minutes on a bath of—

Uranyl nitrate	80 grains.
Distilled water	1 ounce.

This solution should be preserved in the dark. Instead of floating the paper the solution can be applied with a broad camel-hair brush, or a pad of wool.

When dry, the paper is exposed beneath the negative in sunlight, until the principal details are visible. It is then developed with one of the following :—

1.

Distilled water	1 ounce.
Potassium ferricyanide	50 grains.

This gives a reddish brown tone.

2.

Distilled water	1 ounce.
Silver nitrate	25 grains.

Gives a dull grey image, which can be washed and toned in gold hyposulphite.

3.

Gold chloride	1 grain.
Distilled water	1 ounce.

This should be brushed over the image, and gives a purplish black. The prints after development should be washed in 1 in 80 bath of hydrochloric acid, and then thoroughly washed again.*

Uranium Toning.—See **Toning.**

Urie's Machine.—See **Automatic Printer.**

U.S.—See **Uniform System.**

Valency (Lat. *valeo*—to be worth).—See **Atomicity.**

Varnish.—A solution of resinous substances used for the purpose of forming protective coatings over the negative film, resisting the action of the air and moisture. Photographic varnishes are mostly volatile, that is to say, the solvent used can be evaporated by heat without decomposition.

A large number of formulæ for varnishes have been given from time to time. The following, however, have all been well tested, and have proved satisfactory :—

NEGATIVE VARNISH. (1.)

Sandarac resin	4 parts.
Spirits of wine	20 ,,
Chloroform	0·5 part.
Oil of lavender	3 parts.

In using this varnish, it is (after filtering) poured on to the glass plate and dried by the application of heat. It gives a perfectly colourless film, and does not crack no matter how long the negative be stored away.

---

*E. J. Wall.

Negative Varnish. (2.)

Orange shellac	2½ ounces.
Mastic	½ "
Sandraac	2½ "
Oil of turpentine	½ "
Venice turpentine	½ "
Camphor	20 grains.
Methylated spirit 66 overproof	40 ounces.

Some workers prefer the addition of 20 grains of mercuric nitrate, cupric nitrate or cupric sulphate to the above solution.

Negative Varnish. (3.)

Sandarac	2 ounces.
Venice turpentine	½ "
Oil of turpentine	1 "
Alcohol ·825	20 "

This formula has been recommended by W. K. Burton. Pure methylated spirit 66 overproof can be used instead of alcohol, the cost being reduced by nearly one half. This varnish is of a pale colour, and requires that the negative be warmed previous to coating. The film is very hard.

Negative Varnish. (4.)

Orange shellac	2 ounces.
Sandarac	2 "
Canada balsam	60 grains.
Oil of lavender	1 ounce.
Methylated spirit	16 ounces.

Like other shellac varnishes, this will require clearing to remove the wax in the lac, which is insoluble in alcohol. This is done by shaking up kaolin, or prepared chalk, with the varnish, and allowing it to settle.

Negative Varnish. (5.)

Sandarac	2 ounces.
Seed lac	1 to 1½ ounces.
Castor oil	3 drachms.
Oil of lavender	1½ drachms.
Alcohol	18 fluid ounces.

Negative Varnish. (6.)

Best white hard varnish	15 ounces.
Methylated spirit	25 "

This is a quickly-made varnish; the formula for the "white hard" will be found elsewhere. Its only objection is that it takes rather longer to dry than other varnishes. It gives a very good film, however.

Negative Varnish. (7.)

Amber	2 parts.
Copal	2 "
Mastic	1 part.
Petroleum naphtha	10 parts.
Spirits of wine	20 "

NEGATIVE VARNISH. (8.)

Button lac	8 ounces.
Sandarac..	2 ,,
Methylated spirit	2 quarts.

This is shaken at intervals for about a week and then filtered.

NEGATIVE VARNISH. (9.)

Gum sandarac	½ ounce.
Gum shellac	1 ,,
Methylated spirit	10 ounces.

The two principal gums used in the manufacture of photographic varnishes are lac and sandarac, or gum juniper, as it is termed in the trade. Lac is somewhat harder than sandarac, but it has an objectionable red colour, while sandarac is almost colourless. Lac varnish can be easily decolourised, however, by passing it through

[Not so]

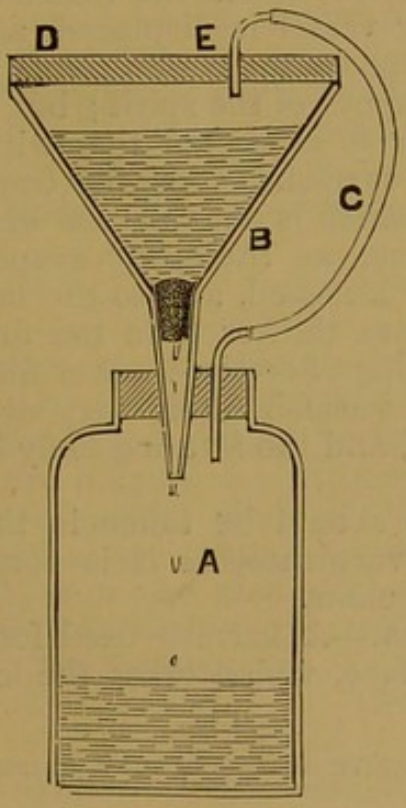

Fig. 201.

animal charcoal broken up into small pieces and freed from salts contained in it by treating it with hydrochloric acid and washing. Seed lac is preferable to stick lac, as it possesses less colour.

Owing to the viscous nature of varnishes some difficulty is usually experienced in their filtration. The length of time required for this operation allows of a considerable evaporation of the alcohol, benzole, or other solvent used. A simple apparatus for the perfect filtration of small quantities of volatile varnishes, without loss by evaporation, is given by Mr. H. C. Standage and reproduced here.

The following description of the arrangement is given :—*

"A is a large bottle, either of glass or tin. This is hermetically closed by a cork with two holes; a caoutchouc stopper is very handy in this case, or a wide bung. B is a glass funnel, the neck of which passes through one of the holes in the cork of A, while a piece of bent glass tubing, connected with a piece of indiarubber tubing C, passes through the other hole; a plug of cotton-wool—medicated wool I find the best—is put in the neck of the funnel, or else a filter paper is used. I prefer the former for both spirit and volatile varnishes. The top of the funnel is ground smooth, and a piece of mahogany made to fit accurately thereon as a cap D. A ring of rubber placed on the underside of this cap renders it air-tight. In the centre of this cap is a hole, through which passes a piece of bent-glass tubing E, which is connected with the other end of the rubber tubing C. The volatile varnish is placed in the funnel B, the cap put on, and as the varnish filters through into A, the air in the latter vessel is displaced, and, passing through C, enters E, and so keeps up the equilibrium. The air in B becomes saturated with the vapour of the spirit; but, as such vapour cannot escape when the air is saturated therewith, no more vapour is given off from the varnish; thus, the consistency of the filtered varnish is uniform, which is not the case when it is filtered in an open funnel, because, as the spirit evaporates, the proportion mixed with resin is lessened, and so the latter portion of varnish that is filtered becomes thicker than the first, due to this loss of spirit. When the plug of cotton-wool or filter-paper ceases to act well—*i.e.*, when the varnish filters very slowly—whatever is in B should be poured off, and the filtering body be replaced with fresh material."

Considerable care should be taken in the purchase of the raw materials used for varnishes, as it is very necessary that they should be free from colour.

Retouching Varnish.—A varnish used for retouching. It gives a rough, biting surface, which takes the lead of the retouching pencil.

NEGATIVE RETOUCHING VARNISH. (1.)

Sandarac	1 ounce.
Castor oil	80 grains.
Alcohol	6 ounces.

First dissolve the sandarac in the alcohol and then add the castor oil.

NEGATIVE RETOUCHING VARNISH. (2.)

Shellac	0·035 ounce.
Sandarac	0·21 ,,
Mastic	0·21 ,,
Ether	2·7 fluid drachms.

2·7 parts of pure benzole are added after the resins have dissolved in the ether.

Photographic News, June 19th, 1891.

NEGATIVE RETOUCHING VARNISH. (3.)

Sandarac	½ ounce
Canada balsam	1 drachm
Sulphuric ether	7 ounces
Benzole	3 ,,

This varnish is applied cold.

LUCKARDT'S RETOUCHING VARNISH.

Alcohol	300 parts
Sandarac	50 ,,
Camphor	5 ,,
Castor oil	10 ,,
Venice turpentine	5 ,,

Monckhoven's retouching varnish is made by placing shellac in a saturated solution of carbonate of ammonia in water. After twenty-four hours the solution is poured off, and replaced by the same quantity of water. This should be about in the proportion of 1 to 8. The fluid is boiled under constant stirring until the lac is all dissolved. The negative, which should be thoroughly dry, is coated twice with this varnish.

Cold Varnish.—A cold varnish is one that can be used without the necessity of heating the negative. These have found much favour with amateurs, who are usually more successful with them than with the other varnishes. The simplest is the following :—

Bleached shellac	3 ounces
Borax	1 ,,
Distilled water	25 ,,

One of the principal points in the manufacture of this varnish is that the shellac must be recently bleached, otherwise it will most likely be found insoluble. It should be broken up into small pieces and heated with the borax and a little water until hot, the remaining part of the water is then gradually added.

Very good cold varnishes are prepared with amyl acetate or acetone. Hydrated acetone can be used as a solvent of sandarac. Amyl acetate is used as a solvent of pyroxyline and a very good varnish is thus formed. The formula is—

Pyroxyline	15 grains.
Acetate of amyl	1½ ounces.

This is coated over the negative in the same manner as collodion. It requires from twelve to twenty-four hours to dry, but gives a very hard protective film.

Varnish for Paper Negatives, Photographs, etc.—An elastic varnish for paper negatives, photographs, etc., can be prepared as follows:—

Some clear and transparent piece of dammar are crushed into small pieces. About forty grains of this is placed into a flask and about six ounces of acetone poured over it. This is exposed to a moderate temperature for about two weeks, frequently shaking. At the expiration of this time, the clear saturated solution of dammar is poured off, and to every four parts of varnish three parts of a rather dense collodion are added, the two solutions are

mixed by agitation, and the resulting liquid is permitted to settle, when it is afterwards preserved in properly closed bottles. This varnish is applied by means of a soft beaver hairbrush in a vertical direction. When first applied, the paper appears as if covered with a thin white skin, but as soon as the varnish has become dry, it gives a clear, shiny surface. Two or three coats should be given. This varnish retains its gloss under all conditions of weather, and remains elastic, this quality adapting it admirably to the pupose of varnishing photographs, etc.

Another good varnish for protecting photographs, maps, drawings, etc.—

Mastic	1 ounce.
Sandarac	2 ,,
Powdered glass	2 ,,
Ether, methylated, ·725	5 ,,
Methylated spirit	10 ,,

The use of the glass is merely as a clearing agent. This varnish should be filtered, and can be applied by means of a spray diffuser to drawings, bromide enlargements, etc.

A good varnish or lacquer for photographs can be prepared as follows :—

Dammar	1·4 ounces.
Acetone	6·3 ,,

The resin should be nearly dissolved in about a fortnight, if the bottle (well-stoppered) is allowed to stand in a warm place. The solution should then be poured off, and applied several times with a soft brush.

Varnish to Imitate Ground Glass.—This can be made with—

Sandarac	90 grains.
Mastic	20 ,,
Ether	2 ounces.
Benzole	½ to 1½ ounces.

The amount of benzole determines the nature of the matt obtained.

Colourless Varnish.—Dissolve 2½ ounces of shellac in a pint of rectified spirits of wine, boil for a few minutes with five ounces of well-burnt and recently-heated animal charcoal. A smal portion of the solution should then be filtered, and if not colourless, more charcoal is added; when all the colour is removed, press the liquid through a piece of silk, and afterwards filter through fine blotting paper. This varnish should be used in a room at 60° Fahr. It dries in a few minutes, and is particularly suitable for prints, photographs, etc.

White Hard Varnish.—This is prepared as follows :—

Sandarac	2 lbs.
Spirits of wine	1 gallon.
Venice turpentine	18 ounces.

Fifteen parts of this, diluted with 25 parts of methylated spirit, forms a very good negative varnish.

Amber Varnish.—To make a good amber varnish, the following formula will be found a good one :—

Amber	6 lbs.
Oil of turpentine	4 gallons.
Oil of linseed	2 ,,

Dead Black Varnish.—A very useful varnish for blackening the insides of the camera, dark slides, etc., can be prepared as follows :—

Alcohol	8 ounces.
Lampblack	2 ,,
Shellac	1 ounce.

Dissolve the shellac in seven ounces of the alcohol, and mix the lampblack with the remaining ounce ; then add the two together, and the varnish is formed. (See also **Black.**)

Anti-rust Varnish.—A varnish for preventing metal instruments, etc., from rusting—

Resin	120 parts.
Sandarac	180 ,,
Gum lac	60 ,,
Essence of turpentine	120 ,,

Take the first three ingredients in a powdered condition, and digest them by means of a regular heat until melted, then add the turpentine very gradually, stirring the whole time. The mixture should be digested until dissolution, then add rectified alcohol 180 parts. Filter through fine cloth on thick, bibulous paper, and preserve in well-stoppered bottles.

Varnish for Backing Positives.—This is made with—

Spirit of turpentine	6 ounces.
Asphaltum	2 ,,
White wax	2 scruples.
Lampblack	1½ ,,

Crystal Varnish for Ferrotypes—

Dammar	25 grains.
Benzole	1 ounce.

Black Varnish—

Gum sandarac	½ ounce.
Gum shellac	1 ,,
Methylated spirit	10 ounces.
Lampblack	2 ,,

Mix the lampblack with a little of the methylated spirit, and add to the gum solution. A black varnish similar to this is sold as Bates's Black, a very useful varnish for blocking out portions of negatives, and for a variety of other purposes.

Dissolve in a warm place, and filter through flannel.

Waterproof Varnish.—A useful varnish for coating wooden or paper dishes, which will then last some time, provided alkaline substances are not used in them.

Colophony	2½ ounces.
Shellac	½ ounce.
Turpentine	9 ounces.
Yellow wax	⅛ ounce.
Methylated spirit	20 ounces.

Melt the wax in a water bath, and add the resin and lac, then the turpentine, and lastly the spirit.

Iodine Varnish.—Prepared by the addition of ½ to 1 part of iodine to 100 parts of negative varnish. It is used for coating the back of thin negatives to cause them to print slower, or it can be applied to parts only.

Varnish for Sketching Lantern Slides.—It is very often useful to have some method of writing or drawing on a piece of glass, to be used as a lantern slide. For this purpose the following varnish will be found serviceable:—

Ether	50 parts.
Sandarac	1 part.
Mastic	1 „
Benzene	10 parts.

This will give a rough surface, which can be used for drawing on. After the drawing or writing is made, it is flowed over with—

Ether	100 parts.
Sandarac	3 „
Mastic	3 „

Which produces when dry a perfectly smooth and transparent surface.

Coloured Varnishes.—Coloured varnishes may be made with the following—

Seed lac	10 parts.
Dried spirit	80 „

To which is added any of the aniline colours soluble in alcohol. By this means an excellent ruby varnish can be made for dark room windows, etc.

Varnishing.—Negatives from which a number of prints are required or which are intended to be kept for probable future use should be varnished with a protecting coating of a lac solution. Suitable varnishes for all kinds of work will be found under **Varnish.**

The negative should be varnished as soon as it is quite dry, and should be handled as little as possible previous to the operation. Touching the surface of the film makes it repellent to the varnish, and consequently it is more difficult to get an even flow over the surface.

Negatives from which extra large quantities of prints are required should be given a preliminary coating of plain collodion.

Although the operation of coating a negative with varnish may seem simple enough, yet few manage it properly without considerable practice. First of all the varnish should be quite clean, and kept free from impurities, and before putting it on the plate should be carefully wiped over with a broad camel-hair brush. Another important consideration is that the room where the coating takes place be quite free from dust, as it is astonishing how soon particles of all sorts of matter floating in the air settle on the sticky plate. The first operation is to gently warm the negative, but not by any means to make it too hot. A little of the varnish is then poured on about the right hand top corner, and with a little manœuvring this pool can be made to run over the whole of the plate, and the surplus run off into a separate bottle kept for the purpose. The plate is then rocked in front of a clear fire or a vertical gas stove. If a pneumatic holder be used the whole of the plate can be coated, but if not, the bottom left hand corner is held by the ball of the thumb, and a small corner left uncoated.

Several methods of varnishing have been recently introduced with which no heat is required.

Although a coating of varnish protects the sensitive gelatine film from the influences of moisture, yet it is no proof against rain spots or drops of water, which, if not quickly removed, will soon work their way through the varnish and destroy the film.

Varnish, Removing.—The varnish can be removed by means of a pad of cotton-wool saturated with spirits of wine or turpentine.

Vaselene, commonly called Vaseline.—A pale yellow translucent semi-solid substance, consisting of a mixture of the hydrocarbons $C_{16}H_{34}$ and $C_{20}H_{42}$, obtained by treating the undistilled portion of petroleum with superheated steam and filtering while hot through animal charcoal. It is insoluble in water, slightly soluble in alcohol, but dissolves freely in ether, chloroform, benzene, and turpentine, is miscible in all proportions with fixed and ~~valuable~~ volatile oils, melts at 35° to 40°, and commences to fume at 160°. Its density in the melted state is ·840 to ·866. Pure vaselene is not affected by air. It is used for a large variety of purposes. A little rubbed round a glass stopper will prevent it from sticking, and a layer over a corked bottle will effectually prevent the air from entering and destroying the contents. It is also used in making paper or paper negatives transparent.

Vaseline.—The popular name given to Vaselene (*q.v.*)

Vegetable Parchment.—See Parchment Paper.

Vehicle.—In order to spread the sensitive salts upon hard repelling substances, such as glass, etc., it is necessary that some substance be used wherein they may be suspended. The suspend-

ing substance is termed the "vehicle," and the ones commonly used are collodion, albumen, gelatine, etc.

Venice Turpentine.—See **Turpentine.**

Ventilation.—The ventilation of the rooms in which photographic operations are carried on is a point which should be carefully looked into. Too frequently is the dark room entirely without ventilation, and in consequence the health of the operator suffers. Many photographic sensitive materials, too, require to be stored in a properly-ventilated room. Plates, paper, &c., are often spoilt, and the cause apparently inexplicable. Usually the dealer or manufacturer suffers, when in reality the cause is due to their being stowed away on high shelves where foul air accumulates. In ventilating the dark-room care must, of course, be taken that light is not admitted at the same time. A convenient plan is to bore a number of holes (about 1in. in diameter) in the hollow of the door, and outside a piece of wood is fixed in a slanting direction as shown in fig. 45. This allows of the entrance of air without light. Another arrangement should be made somewhere high up the wall close to the ceiling where the foul air can escape, so as to have a current of fresh air passing through, carrying away the noxious gases.

Vergara Film.—See **Woodbury Film.**

Vest Camera.—A small detective camera worn under the vest, the lens protruding through a button-hole. About six round pictures of the size of half-a-crown are taken upon circular dry plates.

Victoria Size.—A size of picture 3 × 4¼ inches, size of mount 3¼ × 5 inches.

View Finder.—A little instrument used in instantaneous photography. In photographing rapidly moving objects it is necessary that some means should be employed to enable the operator to see whether or not the object will appear in its proper position on the plate. With a finder attached to the camera it is possible to see exactly when the object is in position on the plate, the shutter is instantly released, and the picture secured.

There are various kinds of finders on the market, the usual form being that of a small camera obscura.

Wall gives a method in which the focussing screen is used. When turned back over the top of the camera, it should have the lens drawn in it, as shown in fig. 202. Then when the eye is placed at A looking along AB, the object when opposite this will be in the centre of the plate, and CAD is the angle included by the lens. (See also **View Meter.**)

View Lens.—See **Lens.**

View Meter.—An instrument for readily ascertaining the amount of view that will be depicted upon the ground glass with the lens used. Thus the operator can see the view at a glance without the trouble of setting up and arranging the apparatus. In some view meters the landscape is seen through blue glass, which practically reduces the different colours to monochrome, so that the operator can get a better idea of the actinic powers of the lights and shades of the proposed view.

Vignetting.—A method of positive printing by which the margins of the picture are made to gradually fade away. This softness is produced by many different ways.

The vignette is usually made of cardboard, with a hole cut into it, of a size and shape to suit the requirements of the picture. The edge of the hole is then cut all round with teeth or slits, and then

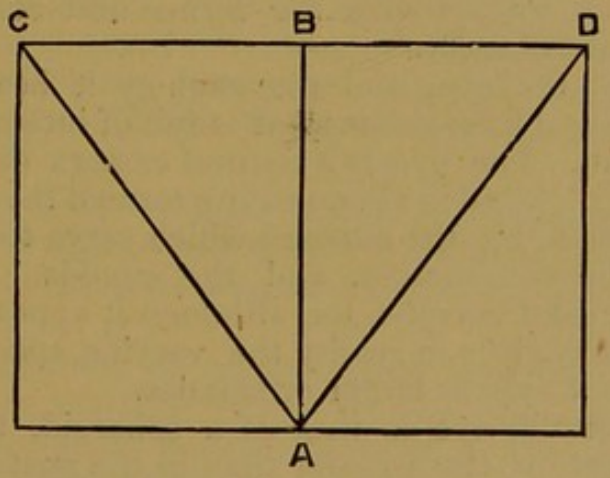

Fig. 202.

covered over with a piece of thin tissue paper to give softness to the vignetting. This is placed over the negative during the printing operation. An important point is the distance between the negative and the vignetting card. Usually this should be at least about half an inch. The greater the distance, however, the smaller should be the opening.

There are besides this a variety of vignetters, some of glass, with oval or other shaped openings, surrounded by a gradually deepening margin of a non-actinic colour, others of zinc with cut-out openings, having serrated edges, and other patent ones, which can be adjusted to any size or shape of opening.

Considerable care and thought are required in producing a successful vignette. They can afterwards, if preferred, be "greedy" by darkening the white margin.

Violet Prints.—Cyanotype "blue" prints may be toned to a dark violet colour by the following method :—

The blue prints are treated with a solution of—

Caustic potash	1 part.
Water	300 parts.

The blue colour will be decomposed, and a rusty yellowish-brown substance—ferric hydrate*—will be left on the paper. If then a solution consisting of—

Alcohol—90 %	25 parts
Water	30 ,,
Gallic acid	4 ,,

be poured over the rusty colour a fine violet black will be the result.

Virtual Image.—See **Image.**

Vision (Lat. *video*—to see).—Lit. the faculty of seeing; that power by which we perceive the forms and colour of objects through the sense of sight.

The study of the eye, and the analogy it bears to the photographic camera and lens, is one that is full of interest to the photographic student. The eye is a natural camera obscura lens and diaphragm. It is placed in a bony cavity termed the orbit, and maintained in position by the muscles which serve to move it, by the optic nerve, the conjunctiva, and the eyelids. It is about the same size with most persons, for, although it appears to differ very greatly with many, it is in reality the varying aperture of the eyelids that makes it appear larger or smaller.

The shape of the eye is that of a spheroid, the curvature of which is greater in the anterior than in the posterior part. It is composed of the following parts :—The *sclerotica*, or white of the eye, AAAA (Fig. 203), which serves for the attachment of the

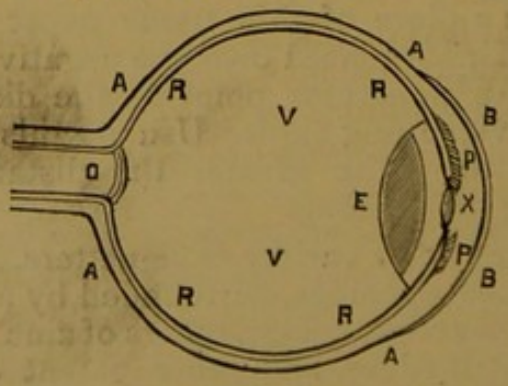

Fig. 203.

muscles ; a transparent medium in front of the eye, through which we see, termed the *cornea* BB ; a tough, velvety membane, termed

* Winkler.

the *choroid*, on the inner surface of which is a dark substance preventing internal reflection. The retina RRRR is the inmost coat of all, and is composed of layers of nerve-cells, which transmit their impressions to the brain *via* the optic nerve OO, which, communicating directly with the brain, is the immediate seat of vision,* PP is the iris of the eye. In its centre is a circular opening called the pupil X. Behind the pupil and iris is the crystalline lens E, a firm and transparent body through which the rays of light pass on their way from the pupil to the retina. It is a single, though not a simple, bi-convex lens, about half-an-inch in diameter, and with a little over half-an-inch focus. The posterior chamber V V is filled with the vitreous humour, which shapes the whole construction.

From this description of the structure of the eye its resemblance to the photographic camera will be apparent. The pupil is the aperture, the crystalline the condensing lens, and the retina the screen on which the image is formed.

The image thrown upon the retina is inverted, consequently a natural question arises, Why do we not see objects upside down? The explanation is that "the image simply causes a stimulation of the optic nerve, which produces a change on some part of the brain, and it is only of this change that we are aware, and not of the image itself."

The optic angle is the angle formed between the principal optic axes of the two eyes when they are directed towards the same object. This angle is, of course, smaller the greater the distance of the object.

The visual angle is the angle under which an object is seen. Taking the same distance, this angle increases with the size of the object, and with the same sized object it decreases as the distance increases. It is therefore evident that objects appear smaller the greater the distance they are from the eye.

A single eye sees most distinctly any point situated in its principal axis, and less distinctly other points towards which it is not directly looking, but which are still within its angle of vision. It is able to judge the direction of any such point, but unable by itself to estimate its distance. Of the distance of an object it

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* The retina is not simply a dead screen receiving and reflecting the various impressions o light which fall upon it. It is a forest of *living* nerves, which not only distinguish between the intensities and colours of the rays which touch them, but also recognise the direction in which they come. Thus the inversion of the image, as far as the sensation of the retina is concerned, does not exist. If the retina perceives the rays from the summits of objects as coming down to it, and those from the bases as *coming up*, and thus regarding *the object*, and not the (to it) invisible image formed on its own substance, this nerve screen *sees* everything in its proper position. It is a natural error to think of the eye as looking at the image formed on its own retina, but a little thought will show us that such an idea is parallel to the absurdity of hoping to see one's own face without a glass or equivalent reflection. It is then upon the sensitive screen of the retina that the light rays, collected and grouped by the eye lens, make their impression. The nerves of this organ, like those of others, have certain limits to the range of their co-existent perceptions. Thus, just as we cannot hear a whisper in the presence of the rattle of a train, or taste a delicate flavour if mingled with a bitter draught, so we cannot perceive a faint impression of light in presence of another of far greater intensity.—*Prof. Henry Morton.*

may be able to judge by loss of colour, decrease in magnitude, indistinct outline, etc.; but if the object be near, the single eye is not infalliable even with these aids. *

When both our eyes are directed upon one single point we then have a power of judging the distance of that point in comparison with that of any other point, and this power we seem to gain by the sense of the amount of effort required to cause the optical axis to converge upon one point and upon another.

Visite, Carte de.—See **Carte de Visite.**

Visual Ray.—See **Ray.**

Vitriol.—An old name for sulphuric acid (*q.v.*)

Vogel's Intensifier.—An uranium intensifier devised by Vogel. It consists of—

Uranium nitrate	1 gramme
Red prussiate of potash	1 ,,
Glacial acetic acid	20 ,,
Water	200 ,,

This has a strong intensifying action upon the plate when immersed in it. Local intensification can be accomplished with this solution by applying with a brush. The intensifier can also be removed from the whole or parts only with a dilute solution of ammonia. After intensifying, the plate is washed for about fifteen minutes. Longer washing will reduce, the water gradually dissolving the brown substances which affect the intensification.

Vulcanite.—A hard, non-elastic variety of vulcanised rubber, used for making a variety of objects, among which may be mentioned dippers, silver baths, photographic dishes, etc. It is not affected by water or any indiarubber solvents.

Sheets of polished vulcanite are often used for surfacing gelatine prints. All that is necessary with these is to thoroughly cleanse and squeegee the print firmly to the plate. When dry it will come away with a polished surface slightly inferior to that obtained with a glass plate. The risk of sticking is not so great, however, as with glass, and, further, no special preparation is required.

Vulcanised Rubber.—Caoutchouc, or indiarubber, treated with sulphur, to render it insensible to atmospheric changes; more durable and more suitable for a number of purposes.

Warnerke's Process.—A simplified collotype process, invented by M. Raymond, of Paris, and introduced in this country by

* Ganot's "Physics."

Warnerke. The printing surface employed is vegetable parchment, coated with a suitable gelatine. This is sensitised on a bichromate bath, and then squeegeed on to a talced glass. When dry, it can be stripped from the glass, and is ready for printing from, under a reversed negative, the exposure being prolonged "until the details corresponding with the most opaque parts of the negative are discernible." The time required varies, of course, with the actinicity of the light and the density of the negative. After exposure beneath the negative the parchment is removed, and the back of it exposed a second time for about five minutes in order to more firmly fix the gelatine film to the parchment and to diminish the swelling of the gelatine, and consequently the relief. The next operation is to wash the bichromate from the film in several changes of water; it is then blotted and hung up to dry. The dry film is immersed in water for about half an hour, the superfluous moisture blotted off, and the parchment stretched over a wooden frame. The apparatus for holding the parchment consists of a solid wooden board as a base, and a clamping frame. After it is stretched on the frame the wooden block, which is smaller but thicker than the frame, is placed under it, and the frame lowered. The block being thicker raises the parchment, and renders it perfectly and tightly stretched.

The gelatine surface is then covered for an hour with a solution of—

Water	10 ounces
Glycerine	24 ,,
Ammonia	1 ,,

This renders the gelatine better permeable to moisture, and causes it to repel the printing ink.

After about an hour the glycerine solution remaining on the surface is blotted off with a soft rag dapper, and it is ready for printing from.

A good collotype ink is required; this is spread evenly over the surface with a glue roller, a sheet of paper laid on it, and this backed with a piece of stout, but fine, felt, and the whole placed under a press. An ordinary letter-copying press answers the purpose. Pressure is applied and removed, and the paper will be found to have received an impression of the collographic plate. For clean margins, slips of oiled paper or cut-out masks should be laid on the printing surface before the paper is applied. After about three or four dozen impressions have been taken off, the plate is remoistened with a solution of glycerine and water.

Warnerke's Sensitometer.—See **Sensitometer.**

Washed Emulsion.—For information regarding the manufacture of washed emulsions see **Collodion Emulsion (Washed).**

The following formulæ are given in the *British Journal Almanac*:—

WASHED EMULSION (for Landscapes).

No. 1.

Ether, s.g. ·720	4	fluid ounces.
Alcohol, s.g. ·820	2¾	,,
Pyroxyline	40	grains.
Castile soap (dissolved in alcohol)	30	,,
Bromide of ammonium and cadmium	84	,,

Sensitise with one hundred grains of nitrate of silver dissolved in one ounce of boiling alcohol; and after standing ten days, add a further twenty grains of silver, dissolved as before in two drachms of alcohol.

No. 2 (Rapid).

Ether, s.g. ·720	4	fluid ounces.
Alcohol, s.g. ·820	2½	,,
Pyroxyline	40	grains.
Castile soap	30	,,
Bromide of ammonium and cadmium	56	,,

Sensitise with 125 grains of nitrate of silver, dissolved, as before, in one ounce of alcohol with the aid of heat. In twelve hours' time add thirty grains more of the double bromide of ammonium and cadmium dissolved in half an ounce of alcohol.

FOR WASHED EMULSION (for Transparencies).

Ether, s g. ·720	5	fluid ounces.
Alcohol, s.g. ·820	3	,,
Pyroxyline or papyroxyline	60	grains.
Bromide of cadmium and ammonium	100	,,
or Bromide of zinc	96	,,
Hydrochloric acid, s.g. 1·2	8	minims.

Sensitise with twenty grains of nitrate of silver to each ounce, dissolved in a minimum of water with two drachms of boiling alcohol. Allow to stand for two or three days.

N.B.—In the three last formulæ, the emulsion, after being allowed to ripen for the time stated, should be poured into a dish and allowed to become thoroughly dry. The mass of dry emulsion is then washed, to remove all the soluble salts, and is then again dried and redissolved in equal parts of ether and alcohol, at the rate of from twenty to twenty-four grains to the ounce of solvents.

Washing.—The operation of washing the negative and positive prints is performed for the purpose of totally eliminating the sodium hyposulphite and other soluble substances. Considerable importance is attached to this operation, as upon it depends, to a great extent, the permanency of the negative or positive print.

For negatives, the handiest contrivance is a light wire rack, holding about a dozen negatives, and which can be placed in a suitable zinc or porcelain vessel, through which a running stream of water can be made to flow. With an arrangement of this kind, negatives should be thoroughly washed in about an hour.

In washing prints we have also to prevent them from clinging together. Several arrangements have been contrived and placed upon the market which answer the purpose very well. The water should be emptied quite a way several times, the prints drained, and placed in a fresh supply of clean water.

To lessen the time of washing many so-called hypo eliminators have been devised, but with most of these, however, another compound is formed at least as injurious to the permanency of the print as the hypo itself.

Most authors recommend washing the prints in a running stream of water, but a little consideration will show that a number of complete changes will be far more efficacious. We can prove this by experiment. In a large basin of water empty a bottle of strong dye, and allow a stream of water to flow into the basin, and out over the sides. The time taken before the water becomes perfectly colourless will be astonishing. Now, if we simply empty the basin and fill it up again, and repeat this operation but twice, the water will contain no trace of the colouring matter. A similar effect takes place with the hypo, except that the latter being colourless it is not noticeable. The most perfect method of eliminating the hypo from prints is one which although somewhat tedious and for large numbers of prints hardly possible, yet for special work where great permanency is required it might be of great advantage. The prints are washed for a quarter of an hour or so in clean water. Another vessel containing clean water is then arranged near at hand, and each print laid on a sheet of clean glass and squeegeed back and front to remove all possible moisture. It is then placed in the fresh water, and another print treated in the same manner. When all the prints have been subjected to this treatment the water in the first vessel is then changed, and after about another quarter of an hour the prints are again squeegeed and placed in the fresh water. By repeating this operation, say, three or four times, using fresh water each time, the prints should be thoroughly well washed and all traces of hypo eliminated. By this method the length of time the prints are required to remain in the water is considerably lessened, and this is always an advantage, as with a too long immersion in water the albumen has a slight decomposing action which is fatal to permanency.

In order to test whether the hypo has been thoroughly eliminated from the prints, several methods have been devised. The simplest is the permanganate test. In a pint of distilled water one grain of permanganate and ten grains of potassium carbonate are dissolved. This will give a pink solution. A little of the water in which the prints have been last soaking is now poured into a clean white glass bottle, and to it is added four or five drops of the permanganate solution. If the water be quite pure the addition of the solution will give it a faint pink tinge, but if any trace of sodium hyposulphite be present this colour will be of a light green. After

the addition of the permanganate solution the bottle should be well shaken, allowed to stand for about ten minutes or so, and then carefully examined.

Another method commonly employed is that known as the "starch iodide test." A small piece of starch, about the size of a pea, is boiled in a quarter of an ounce of water until a clear solution is obtained. To this is then added one drop of tincture of iodine (iodine dissolved in alcohol), which will give it a dark blue colour. Two test tubes are now required. Into one is poured some of the last washing water to be tested, and into the other some plain distilled water. One drop of the test solution is now added to each tube, and both well shaken. The next point is to examine the two tubes side by side in front of a piece of white paper. Hypo will cause the blue colour to disappear, so that if the washing water does not present as blue an appearance as the other tube containing the distilled water only, it may be decided that hypo is still present.

Dr. Bannon recommended* silver nitrate as a very delicate test for hyposulphite of soda. A print should be removed from the washing apparatus, and the water drained from it into a test tube. This is then heated, and a few drops of a silver nitrate solution added to it. It is stated that even if so small a quantity as the one ten-thousandth part of hypo be present a black precipitate will be formed, while a smaller amount will produce a precipitate of a yellow colour.

Watch Camera.—A small camera which when closed has the appearance of an ordinary watch. On pressing a spring a series of about half-a-dozen tubes shoot out into position, and the camera is formed.

Water (Formula, OH_2).—A clear colourless liquid devoid of taste and smell, and possessing a neutral reaction. Pure water is tasteless and colourless, except in thick layers. It boils at 100 C. (212 Fahr.), and becomes solid at 0 C. (32 Fahr.) It is undoubtedly one of the most important substances in nature; it is also the most widely distributed, occurring in three physical states, *i.e.*, liquid, gaseous and solid. In its liquid state it forms the oceans, rivers, lakes, which occupy nearly three-fourths of the whole surface of the earth. In its solid state it forms ice and snow, existing permanently at the polar regions, and, as a vapour, is an important constituent of the aerial envelope of the earth.

Pure water is not found in nature, owing to the fact that it dissolves a portion of whatever it comes in contact with. Rain is the purest form of natural water, but contains certain gases, which it collects from the atmosphere during its descent to the earth.

Water taken from wells, springs, rivers, lakes, etc., differs very

* *Photographic Times*, 1889.

much from each other, according to the nature of the earth or rocks over which it passes, or upon which it lies. Among the various substances found dissolved in water taken from different places may be mentioned the following*:—Sodium sulphate, sodium chloride, magnesium sulphate, magnesium chloride, magnesium carbonate, calcium sulphate, calcium carbonate, sulphuretted hydrogen, potassium sulphate, potassium chloride; phosphates, bromides and iodides of calcium, aluminum, sulphate, ferrous carbonate, carbonic acid, silica, and a large variety of vegetable substances.

Water from natural sources is commonly classified as *hard* and *soft*, terms which are applied to it according to the manner in which it acts upon soap. If, for instance, we rub a piece of soap in "soft" water, such as ordinary rain water, it is not a difficult matter to speedily produce a lather, and its cleansing powers are easily made use of; but if, on the other hand, the water is what is termed "hard," spring water for instance, it will be found that the soap requires a much longer time and considerably more friction to produce the required lather. Curdy flakes will also make their appearance. The reason of this is that soap is formed of the combination of a fatty acid, with an alkali manufactured by boiling oils and fatty substances, with potash for soft soap, and with soda for hard soaps. The action of the soda is to rob from the oil or fat two acids, stearic and oleic acid, and with which it unites to form hard soap, which would be chemically termed a mixture of stearate and oleate of sodium. If we take some soapy water and add a little magnesium sulphate (Epsom salts) solution to it, curdy flakes will be produced in just the same manner as when soap is rubbed in hard water, the soap losing its properties of frothing. The magnesium sulphate has decomposed the soap, forming sodium sulphate, which remains dissolved in the water, and insoluble curdy flakes consisting of stearate and oleate of magnesium. A similar effect is produced by the hard water, the hardness being caused by the presence of different calcium and magnesium salts, all of which have a decomposing action upon the materials contained in the soap. If the hardness be caused by the presence of calcium bicarbonate, it can be got rid of by boiling, as can also most of that due to magnesium bicarbonate. The effect of boiling is to drive away the carbonic anhydride that causes these salts to become soluble, and they will be precipitated.

When spring, river, or well water is boiled in a kettle, a thick fur or incrustation is soon formed in the interior of the vessel. This is usually of a brown colour, and the harder the water the more rapid will be the deposit. The explanation is that when natural water is boiled the carbonic acid gas contained in it is expelled, and, as the calcium, magnesium, and iron carbonates are not soluble in water which does not contain carbonic acid, they

* Bloxham's "Chemistry."

are precipitated, forming a succession of those layers on the bottom and sides of the vessel in which the water is boiled. This deposit must be removed, and is very annoying in the case of steam boilers, as it is a bad conductor of heat, and in consequence a great waste of fuel is occasioned. A small marble placed in the kettle will lessen the amount of deposit upon the sides. It will be understood that when water is boiled for some time it becomes much softer, owing to the precipitation of the salts. When the hardness can be removed by boiling, it is termed "temporary hardness," but if due to such substances as sulphate of lime, which is not thrown out of solution by boiling, it is termed "permanent hardness."

The organic matter contained in water may be due to several causes. It may be dissolved from the earth, or it may be due to the decomposition of animal or vegetable substances, or from sewage or drainage which has gained access to it.

There are a number of fine analytical tests for the purity of water which are used by chemists, which are, however, far too elaborate for the ordinary photographer. The following simple tests may, however, be found useful.

1.—Pour about half a pint of water into a wide-mouthed bottle or decanter, close it with the stopper or with the palm of the hand, and shake violently up and down. If an offensive odour is then detected, the water is probably contaminated with sewage gas.

2.—Add to a little water a drop or two of dilute sulphuric acid and enough potassium permanganate (Condy's fluid) to tinge it of a faint rose colour, and cover the vessel with a glass plate or a saucer. If the pink tinge be still visible after a quarter of an hour or so, the water is probably good.

3.—Pour a little solution of silver nitrate into a carefully cleaned glass, and see that it remains transparent; then pour in some of the water. Should a strong milkiness appear, which is not cleared up on adding a little dilute nitric acid, the water probably contains much sodium chloride.

The purest form of water is obtained by distillation, that is, by first of all converting the liquid into a vapour, and then recondensing it into the liquid form again. (See **Water, Distilled**).

Water, Distilled.—Pure water obtained by distillation. The water is first filtered, and then distilled in a still *(q.v.)* The water which comes out first should be rejected, as it contains nearly all the volatile impurities, and one-tenth of the water should be left in the retort; the solid impurities are also left.

Distilled water should give no precipitate with silver nitrate, showing the absence of chlorides; nor with ammonium oxalate, showing the absence of lime; nor with barium chloride, showing the absence of sulphuric acid. A drop of potassium permanganate should give a pink tint to the water, proving the absence of organic matter.

Water Developing Plates.—These plates are prepared and sold for the conveniences of amateurs and photographic tourists. No developer is required, as the back of the plate is coated with a medium holding the necessary chemicals for the developer; when the plates are immersed in a dish of clean water, this substance at the back dissolves and forms the developing solution.

Water Glass.—See **Sodium Silicate.**

Wax.—A term originally restricted to beeswax, but now extended to various bodies possessing similar characters. Found widely diffused in the vegetable kingdom, occurring as a coating on various parts of plants.

Beeswax is the wax of bees, used by them for constructing their cells. It is a secretion elaborated within the body of the animal from the saccharine matter of honey, and extruded in plates from beneath the rings of the abdomen.

It is a yellow, tough, solid substance, insoluble in water, softening with heat, and becoming liquid below the boiling point of water. It may be bleached by exposure to the air in thin shreds. It is a mixture of several neutral bodies and fatty acids.

Chinese Wax is a secretion from a tree grown in China.

Waxed Paper.—To make, place cartridge or other paper on a hot iron and rub it with beeswax, or brush on a solution of wax and turpentine. On a large scale it is prepared by opening a quire of paper flat upon a table and rapidly ironing it with a very hot iron, against which is held a piece of wax, which, melting, runs down upon the paper and is absorbed by it. Any excess on the topmost layer readily penetrates to the lower ones*. Waxed paper is useful for wrapping up sensitive material and preserving it from the effects of moisture and air.

Waxed Paper Process.—A paper negative process in which the paper was waxed before being sensitised. The waxed paper is immersed in a solution of potassium iodide and bromide, together with sugar of milk, and after drying is treated with a solution of silver nitrate, acidified with glacial acetic acid. After exposure it is developed with—

SOLUTION 1.

Silver nitrate	5 grammes.
Glacial acetic acid	8 c.c.
Water	50 ,,

SOLUTION 2.

Saturated solution gallic acid in distilled water.

For use take equal parts of solutions 1 and 2, with 90 times the

* Spon's "Workshop Recipes."

bulk of water. If under-exposed a larger quantity of No. 1 is used and if over-exposed a little more of No. 2. Fixing takes place with the usual solution of hyposulphite of soda.

Waxing Negatives.—With paper negatives the opacity of the paper support is rather a drawback to the positive printing process. To remedy this the paper can be made more transparent. The negative, when quite dry, is laid face down on a piece of blotting paper. An iron is well warmed and cleaned on emery paper or on a clean cloth. A little piece of white wax is brought in contact with the point of the iron, on the back of the negative. The heat will melt a sufficient quantity of the wax, which can then be spread over the picture by moving the iron about in all directions. Blotting paper is next laid over the negative, and the hot iron run over the surface of it until all the superfluous wax is absorbed by the blotting paper. (See also **Translucent.**)

Weights and Measures.—The confusion existing in the English system of measurement is, without doubt, very great. All solid chemicals are sold by avoirdupois weight, while most formulæ are written in apothecaries' weight. Various suggestions have been offered to remedy this state of things. The adoption of the French metric system is, without doubt, but a matter of time. The principal tables of English weights and tables are the following :—

LIQUID MEASURE.

60 minims	= 1 fluid drachm
8 fluid drachms	= 1 fluid ounce
20 fluid ounces	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon
1 minim	= ·91 grains of water
1 fluid ounce	= 437·5 grains of water
1 pint	= 1·25 lbs. of water
1 gallon	= 10 lbs. of water

1 gallon = 8 pints = 160 ozs. = 1,280 drachms = 76·800 minims

APOTHECARIES' WEIGHT.

20 grains	= 1 scruple
3 scruples	= 1 drachm
8 drachms	= 1 ounce

1 oz. = 8 drachms = 24 scruples = 480 grains. 1 lb. = 12 ozs. = 5,760 grains

APOTHECARIES' FLUID MEASURE.

60 minims	= 1 fluid drachm
8 drachms	= 1 ounce
20 ounces	= 1 pint
8 pints	= 1 gallon

AVOIRDUPOIS WEIGHT.

16 drachms	= 1 ounce
16 ounces	= 1 lb.
Stone	= 14 lbs.
Quarter	= 28 ,,
Cental or Quintal	= 100 ,,
Hundredweight	= 112 ,,
Ton	= 20 cwt.

1 lb. = 16 ozs. = 256 drachms = 7,000 grains. 1 oz. = 437·5 grains.

Troy Weight.

24 grains	= 1 dwt.
480 ,, ...	= 20 dwts. = 1 oz.
5760 ,, ...	= 12 ozs. = 1 lb.

Cubic or Solid Measure.

Cubic foot	= 1,728 cubic inches.
Cubic yard	= 27 cubic feet.

Measures of Length.

Inch	= 72 points or 12 lines
Nail ($\frac{1}{16}$)	= 2¼ inches
Palm	= 3 ,,
Hand	= 4 ,,
Link	= 7·92 ,,
Quarter	= 9 ,,
Foot	= 12 ,,
Cubit	= 18 ,,
Yard	= 36 ,,
Pace (geometrical)	= 5 feet
Fathom	= 6 ,,
Rod, pole or perch	= 5½ yards
Chain (100 links)	= 22 ,,
Cable's length	= 120 fathoms, 720 feet
Furlong	= 40 rods, 220 yards

Mile = 8 furlongs = 80 chains = 320 rods = 1,760 yds. = 5,280 ft. = 63,360ins.

Square Measure.

Square foot = 144 square inches
Square yard = 9 feet = 1,296 inches
Square rod, pole, or perch = 30¼ yards = 272¼ feet
Square chain = 16 rods = 484 yards = 4,356 feet
Square rood = 40 rods = 1,210 yards = 10,890 feet
Square acre = 4 roods = 160 rods = 4,840 yards
Square mile = 640 acres = 2,560 roods = 6,400 chains = 102,400 rods, poles, or perches, or 3,097,600 square yards

Circular Measure.

The diameter is a straight line passing through the centre from opposite parts of the circumference, or perimeter.

The radius is half the diameter, or a straight line from the centre to the circumference.

The diameter is to the circumference about as 7 is to 22, or more nearly as 1 is to 3·1416.

The diameter × 3·1416 gives the circumference.

The radius squared × 3·1416 gives the area.

The diameter squared × 3·1416 gives the area of a sphere or globe.

One-sixth of the cube of the diameter × 3·1416 gives the solidity of a sphere.

Water.

Cubic inch = ·0361 lb.
Gallon = 10·0000 lbs.
Cubic foot = 62·3210 lbs. or 6·2321 gallons.
35·943 cubic feet (210 gallons) = 1 ton.
The gallon is = 277¼ cubic inches = 0·16 cubic feet = 10 lbs. distilled water.

Wet Collodion Process.—See **Collodion Wet Process.**

Wet Process.—Synonymous term for the wet collodion process.

Whey Process.—An old enlarging process by development. Paper is bathed for two or three minutes in—

Potassium iodide	2 grammes.
Potassium bromide	1 gramme.
Whey of milk (filtered)	100 c.c.

It is then hung up to dry, and when thoroughly dry it is sensitised with—

Silver nitrate	30 grammes.
Water	500 c.c.
Glacial acetic acid	2 to 10 grammes.

The amount of acetic acid depends upon the temperature. Exposure is made in a solar camera, the time required varying from about 15 seconds in dull light to one minute with fine.

The developer is made up as follows :—

Pyro	3 grammes.
Glacial acetic acid	150 c.c.
Water	1000 ,,
Potassium bromide	1 to 2 grammes.

The print is laid on a large glass plate, and the developing mixture poured over it.

White Ink.—The following will be found suitable for writing white letters upon the dark portions of silver prints :—

Potassium iodide	10 parts.
Water	30 ,,
Iodine	1 part.
Gum arabic	1 ,,

Chinese white can also be used for the same purpose.

White Lead.—Made by suspending rolls of thin sheet lead over malt vinegar or pyroligneous acid in closed vessels, the evaporation of the acid being kept up by the vessel being placed in a steam bath.

It forms a dense white powder, insoluble in water, but readily soluble in dilute nitric acid or acetic acid. It is largely used in painting backgrounds and for other similar purposes.

Whole Plate.—The size of dry plate, $8\frac{1}{2}$ x $6\frac{1}{2}$ inches.

Wide-angle Lens.—A term applied to certain forms of lens embracing a large amount of view. (See **Angle, Wide.**)

It should be noted that lenses are often advertised as capable of giving an angle of view of 100° and upwards. They do not do so, however, as, except in the case of certain obsolete forms of lenses, the angle included is rarely more than 80°.

In order to test the correct angle included by a lens, a large camera should be employed of such dimensions that the image given by the lens does not cover the ground glass. The smallest diaphragm is inserted, and an object in the distance focussed, and the diameter of the illuminated image measured. As it is often difficult to see the image at the edges, the following instructions given in Burton's "Photographic Optics" may be of use.

Focus the sun on the centre of the plate at some time when it is pretty near the horizon. The smallest stop is inserted, and the camera is slowly swivelled till the image of the sun disappears. The spot where it was last seen is marked, and the camera is then turned in the opposite direction, and the spot where the sun was last seen is again marked. The distance of the two marks is the diameter of the circle covered. To find the angle the following construction is made:—A line (AB) is drawn equally the focal

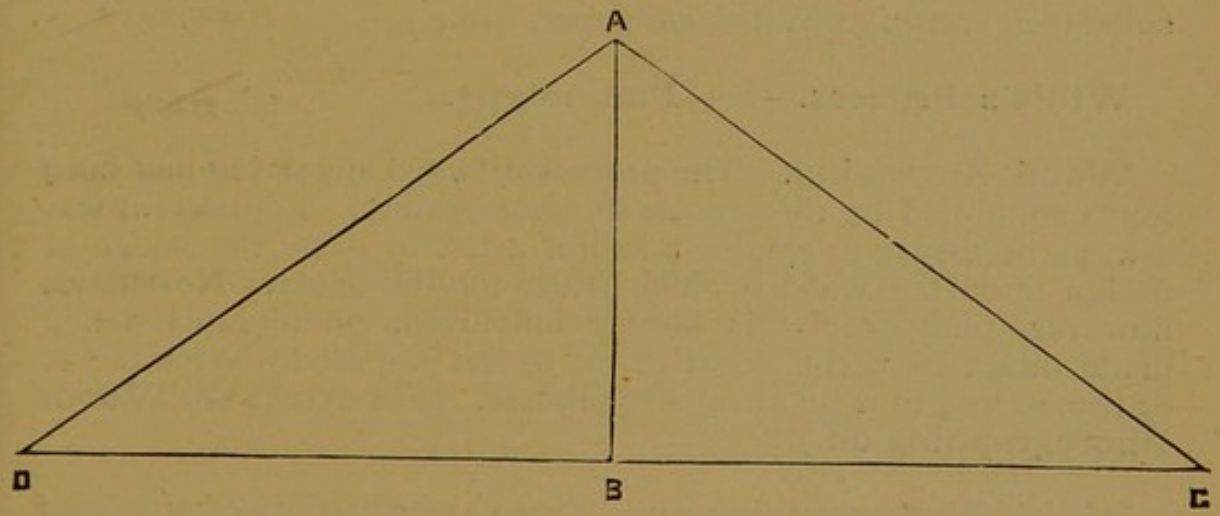

FIG. 204.

length of the lens. At B a line BD is erected perpendicular to AB. BD and BC are each made equal to the radius of the circle. AC and AD are then joined. The angle CAD is then measured with a protractor or otherwise, and is the angle of the lens, and the diagonal of the largest plate that can be used. To discover if the lens will cover any given size of plate, the circle is drawn out on the paper, and it is found by actual experiment whether or not the plate will come within it. For example, the diameter of the circle is 16in. If it is desired to find if a plate 12 x 10 inches will come within it, the plate is laid on the circle, and it is found that it just comes within it. With a large plate the corners project.

It is not advisable to try to make a lens cover too large a size of plate, as the result will be unpleasant dark corners. In fact, no little advantage is gained by using a lens for a size smaller than that for which it is intended—for instance, a 5 × 4 lens for a quarter-plate.

Willesden Paper.—A peculiar waterproof paper manufactured under a patent at Willesden. This paper, besides being waterproof, will not rot, and will resist the attack of insects or mould.

The process may be briefly described as follows:—The paper is passed through a bath containing a concentrated solution of cuprammonium hydroxide at such a rate as will permit of the pectising and gelatinising of the exterior of the fibres composing the paper without wholly disintegrating the mass. It is then dried in the ordinary way. This drying converts the film of pectised cellulose, coating each filament and fibre into an insoluble solid varnish which cements the whole together. To build up thick cards two or more reels of paper are passed simultaneously through the bath, and then pressed together and dried as a whole.

Canvas and other fabrics are also treated in this manner.

Willesden Trays.—Trays and dishes made with a waterproof substance known as Willesden paper. (*q.v.*)

Willis's Process.—See **Platinotype.**

Wood Engraving.—The process of wood engraving has been much simplified by the process of photography. Formerly it was always necessary to employ a skilful artist to draw the image or design upon the wooden block ready for the artist. Nowadays, however, photography is largely employed, photographs being made direct from the negative on to the prepared wooden block, or transferred to it by a transfer process. (For details see **Wood, Photographing on.**)

Wood, Photographing on.—There are a variety of processes for photographing upon wood, and for ordinary decorative processes any of them can be used, such as the carbon transfer process, the powder process, transferrotype, etc. But the principal object of producing images upon wood is now usually for the purpose of the engraver. Photography is now rapidly taking the place of the artist on wood. Of the many processes of photographing upon wood only a few, however, can be utilised for this purpose, as they are nearly all defective in one point, and that is that the block becomes wet during the operation. Engravers' boxwood is generally very sensitive to moisture, and to wet a block is generally to spoil it.

The two following methods are given in "Spon's Workshop Recipes":—

(1.) From a negative of the subject desired make a clear thin positive upon glass by the wet collodion process. The positive should be of the proper size on clear glass without the substratum. Tone and fix as a transparency, and lay in a dish of water containing a small percentage of sulphuric acid to loosen the film.

The film will soon become so loose that it can be easily stripped from the glass and transferred to the block. To do this safely, lay on the film a piece of wet albumenised paper a little larger than the glass, press out the bubbles and surplus water carefully, then turn back one corner of the paper, and it will come off bringing the film with it. Have the block smoothly whitened with Chinese white in gum water, and the surface slightly damp. It is now easy to transfer the film to the wood and remove the paper, when the block must be allowed to dry spontaneously.

(2.) Another way to print on wood is by a sort of photolithographic process. Coat paper with a thin uniform coat of gelatine in warm water. Dry, and float a short time on a weak solution of potassium dichromate in water. Dry again, and expose under a negative till all the details are visible. Roll the entire surface of the print with a printers' roller, charged with lithographic transfer ink thinned with spirits of turpentine. Soak the paper in a dish of tepid or warm water until the ink can be removed by rubbing gently with a soft sponge. All the ink, except the lines composing the picture, can be removed, when the print should be laid face downwards on the whitened block, and subjected to a heavy pressure in an ordinary letter press. The paper can easily be removed by wetting the back.

Besides the importance of wetting the block as little as possible, there is another very important point in this branch of the art, *i.e.*, nothing must remain on the surface which is capable of clogging up the point of the engraver's tool, nor must the chemicals used have any deleterious effect upon the wood, causing it to become friable, by which the fine delicate lines crumble and give way under their construction.

Among other processes that have been recommended for photographing upon wood for engraving purposes may be mentioned the following:—

In Ive's process thickly-salted albumen is prepared by beating up the whites of six eggs with 80 grains of ammonium chloride. It is then allowed to stand, and afterwards filtered through flannel. A little of this is poured on to the centre of the wooden block and mixed with some dry, pure white lead, the mixture is then rubbed into the wood with the ball of the hand. When quite dry it is sensitised by floating on a 60 grain solution of silver nitrate for five minutes, blotted off and placed before a fire to dry. When the block is dry and cold it is fumed for half an hour or so with ammonia, and printed rather deeply under a reversed negative. When printed the block is floated on a large dish of water for an hour or so, changing the water several times, and it is then toned and fixed by floating for half an hour on a ten per cent. solution of hypo, made strongly alkaline with sodium carbonate, and containing a little gold chloride. Finally float for three

or four hours on constantly changed water. If the wooden block is found to be very porous it should be coated two or three times with the albumen solution.

Another method* is with—

Gelatine..	45 grains.
White soap	45 „
Water	5¾ fluid oz.

Soak the gelatine in the water for five or six hours, then dissolve it with the aid of a water bath. Cut the soap into small pieces, and add to the gelatine solution, stirring the whole with a glass rod to insure a perfect mixture; then add powdered alum until the froth disappears, and strain through muslin. Cover the block with this mixture and a little zinc white, then wipe off so that a very thin film will be left, rubbing it gently so that the film may be of as even a thickness as possible. After drying apply with a wide badger-hair brush a coating of the following :—

Albumen	3¼ fluid oz.
Water	2½ „
Sal. ammonia	67½ grains.
Citric acid	19 „

Whip the albumen to a froth and allow it to settle ; to the limpid portion add the water, then the sal. ammonia, stir, and then add the citric acid. When the block is dry sensitise with a solution of—

Water	3¼ fluid oz.
Nitrate of silver	187 grains.

Pour this upon the surface of the block, spread it evenly with a glass rod, and pour off the excess. When the block is dry expose under a negative in the usual manner until it is printed the exact shade required. When printed immerse the printed surface in a very strong solution of salt for about three minutes; then wash in a stream of water for a short time, and fix it by placing it face downwards in a saturated solution of hypo. After fixing wash under a stream of water for about ten minutes; when dry it is finished and ready for the engraver.

The American process, said to be the one adopted by the splendidly-illustrated monthly magazines published in that country, is said to be as follows† :—

First make a reversed collodion transparency in the camera from the negative. A tough and horny collodion should be used. Develop with—

Pyrogallic acid	100 grains.
Citric acid	60 „
Acetic acid	2 ounces.
Water	20 „

* See Spon's "Workshop Recipes." † Wilson's *Photographic Magazine*.

and fix in hyposulphite of soda. Coat the wood with the following hot solution of gelatine :—

Gelatine	4 ounces.
Water	1 pint.

Dissolve the gelatine by placing in a vessel of warm water, and then add 4 grains of chrome alum and mix thoroughly. The wood, having been coated, is allowed to dry. The gelatine surface is then moistened with water for ten or fifteen minutes, and the transparency, still wet from the washing water, is laid down upon it and pressed lightly in contact, and allowed to dry under slight pressure. When dry, the collodion readily leaves the glass, and remains in contact with the block.

Here are some further points :—The plate is cleaned as usual, and dusted with powdered talc and polished off; it is then coated with positive collodion, sensitised and exposed as usual, fixed with cyanide of potassium, and placed in a dish of warm water. In the meantime, have your block blackened by rubbing drop black on it, or ordinary blacking, and coat and drain well with a solution of the commonest glue you can get, one ounce to twelve ounces of hot water; the common glues are the best, for they take a much longer time to set than better ones, and so you can get a much thinner coat with draining. Place your block in a vessel of water, having it immersed about three inches, then bring your photo from the dish, place it over the block and under the water. You will find by touching the edges of the film it will readily leave the glass; you can then turn it about any way under the water, and when in position, raise your block gently out of the water, bringing the film with it; if it is puckered at all, it is owing to raising too roughly, and must be placed in the water again. If satisfactory, place at an angle to drain, and dry in warm, airy place. The whole operation, from focussing to getting the block ready for drying, will not take a practised hand more than twenty minutes. The common glue will not block the tool at all if you drain the block well, and when cut all can be removed immediately with a sponge and warm water. A very good way to black the block is to hold it over a petroleum lamp with its chimney removed. The glue-water will not come off it if applied in the same manner as applying varnish to a negative, and under no circumstances be induced to use a black varnish, for it is next to impossible to do a good job, for the graver slips as if it were cutting on glass.

Harris's process does not strictly come under this heading, as an indiarubber block is used instead of wood, but it may be given here, as it is also a process intended as a help to the engraver. Hard rubber is first procured in smooth black polished sheets, about $\frac{1}{8}$in. thick. These are cut and trimmed to the size required, cleaned, and albumenised in the same manner as glass for negatives.

The rubber plate is next coated with collodion, sensitised in the silver bath, exposed in the camera, and developed in the usual way of making a negative. The whole operation is very similar to the ferrotype process, except that the image is made upon rubber instead of iron. When a clean sharp image is obtained it is fixed in cyanide and varnished with a very thin transparent varnish and dried by a gentle heat. The plate is now ready for the engraver.

Wood Spirit.—See **Methylic Alcohol.**

Woodbury Tissue.—A translucent paper coated over with a gelatino-bromide emulsion, and used for the production of negatives, transparencies, etc. This process was the last invention of "that great inventive genius," the late W. B. Woodbury, and had it not been for his death the process would, no doubt, have been brought to perfection. Paper was first rendered translucent by passing through a mixture of gum dissolved in benzole (see **Translucent**), and then coated with an ordinary gelatino-bromide emulsion. Perfect negatives were thus produced upon a material light and flexible, and sufficiently transparent as not to retard the printing operation.

Woodburytype.—A photo-mechanical process of extreme beauty standing apart from all other photo-mechanical processes, from the fact that it is the only one which faithfully reproduces the half-tones of the picture. Notwithstanding the fact that many unscrupulous persons have laid claim to the invention of this process, it is undoubtedly the outcome of the inventive genius of the late W. B. Woodbury, and to which he gave his name. No one, on reading the description of this process and its apparent simplicity, could imagine the amount of time or labour spent upon its perfection by the inventor, who has been rightly termed "The Caxton of Photography."

The Woodburytype, although much worked in this and other countries, is mostly confined to a few firms, owing, probably, to the considerable expense required in the purchase of the necessary plant. For this reason Woodbury devised a simple process, very similar, which he called the Stannotype, but owing to the usual mismanagement of a limited company formed to work it, it did not meet with the success it deserved.

The Woodburytype, or Woodbury process, is also worked to a considerable extent in France, under the name of Photoglyptie, and in Germany as Woodburydruck.

A Woodbury print consists of the same substance as a carbon print. If we examine a carbon print we shall see that the image consists of pigmented gelatine, differing in thickness in the various parts according to the different tints of the image. It is therefore apparent that the image is in relief, the dark parts being raised, and the white parts having hardly any pigmented gelatine at all.

It will not be difficult to understand that if this relief could be obtained, say, by casting the pigmented jelly in a mould, the same gradation of colour would be obtained. On further consideration it will also be apparent that, the carbon image being in relief, this might itself be used for the production of the mould. Woodbury's experiments first led him to making negative reliefs from carbon prints by electro-decomposition of copper. But this process was not satisfactory, and moulds were made in plaster, fusible metal, and all sorts of substances, until the inventor discovered the extraordinary hard properties of a gelatine relief, and that it could be pressed into lead, or even harder metals if necessary, forming the necessary mould as perfect as was possible to be obtained.

The next difficulty was that the carbon print, although possessing sufficient relief while wet, could not be pressed into the lead in that state, and when dry the amount of relief was reduced to a fraction of the amount when wet. It therefore became necessary to secure some method of obtaining a very high relief. This was eventually managed by having a very thick film of best chromated gelatine, having but a very slight amount of pigment in it, enabling the light to penetrate it the more easily.

Prof. Burton, in his excellent work on photo-mechanical printing processes, says :—"When the Woodburytype process was first worked the difficulty in getting a sufficiently high relief was much felt. At that time paper was not to be had nearly as smooth as it can now be obtained, and with a comparatively slight relief faults in the paper showed very plainly. It is now, however, possible to work with a relief in the final print of only $\frac{1}{2000}$ of an inch or even less, and as the relief of the print shrinks in drying by about ten times, this involves in the mould a relief of only about $\frac{1}{200}$ of an inch, which is one that is not difficult to get if due precautions be taken. It will be evident that it is necessary to begin upon a film at least as thick as the relief required, and that initial thickness of film being sufficient, the depth or height of relief will be greater the greater the contrast in the negative and the less the amount of pigment in the film. Indeed, the pigment may be left out altogether when a negative of only moderate density has to be worked with."

With regard to the negative most suitable for the Woodburytype processes. Like most other photo-mechanical processes, a "brilliant" negative full of contrast is essential, having at the same time all the necessary gradation between the two extremes, and also possessed of plenty of detail. The negative for the purpose is, whenever possible, made by the collodion process. Good gelatine negatives can be used, however. From a thin gelatine negative it is rare that a good Woodburytype is producible. It can sometimes be improved by making a transparency from the thin negative on a very slow bromide or a chloride plate, intensifying this and making another negative from this, the latter being also intensified if necessary.

The next consideration is the production of the gelatine relief. For this we first require to prepare the sensitive tissue. Several formulæ have been given. The following has been chosen, however, and will be found to give satisfactory results.*

Nelson's transparent sheet gelatine	3½ ounces.
Sugar	1 ounce.
Glycerine	100 grains.
Phenol	2 minims.
Indian ink	2 grains.
Ammonia (·880)	60 minims.
Bichromate of ammonia	300 grains.
Water	12 ounces.

The gelatine is first of all soaked in 10 ounces of the water, and the Indian ink dissolved in the remainder. When the gelatine is thoroughly soaked, it is melted by the aid of gentle heat, and when dissolved the sugar, glycerine, phenol, and ammonia are added. The Indian ink solution is then poured in, and finally the bichromate of ammonium is stirred in in a finely powdered state.*

*Another formula is the following :—

Nelson's gelatine	4 ounces
Sugar	¼ ,,
Glycerine	100 grains
Phenol	2 minims
Indian ink	2 grains
Potassium bichromate	200 ,,
Water	12 ounces

While this solution is being prepared, sheets of patent plate glass, somewhat larger than the size of the print required, are thoroughly well cleaned. A tuft of cotton wool dipped in powdered talc or French chalk is then rubbed over one side, and dusted off again with a fresh piece of cotton wool. The chalked side is then coated with a film of plain collodion, and placed away to dry spontaneously.

We now have the collodionised plates and the solution ready, and the next operation is to gently warm a plate, and, placing it on a level stand and carefully adjust it with a spirit level. When this is done a measured quantity of the gelatine solution, previously heated to about 130° Fahr., is poured and carefully spread all over the plate. The amount of the solution to be used is about half an ounce for each quarter plate, or about five ounces per square foot. The operation of coating can be performed in diffused daylight, as the films are not sensitive until dry, when they must be carefully protected. As soon as the film is set the plate is removed to the drying chamber. On account of the thickness of the film a special drying arrangement is used in which slightly heated air is made to circulate, firstly over the dried calcium chloride and then over the films. The effect of this is that the calcium absorbs all the water from the air, which then greedily

* From *Photographic News*, September 14th, 1883.

absorbs the water from the films. Fig. 205 shows an arrangement given in the *Photographic News*. The direction of the arrow shows the passage of the air. The calcium chloride should be well dried by heating in a shovel over a bright fire. It can be used over and over again if dried in this manner previous to use. A little thermometer should be attached to the drying box, with its bulb in the interior of the box, and the scale outside so as to be easily read without the necessity of opening the chamber. The temperature should be raised to about 80° Fahrenheit but never allowed to exceed 85°.

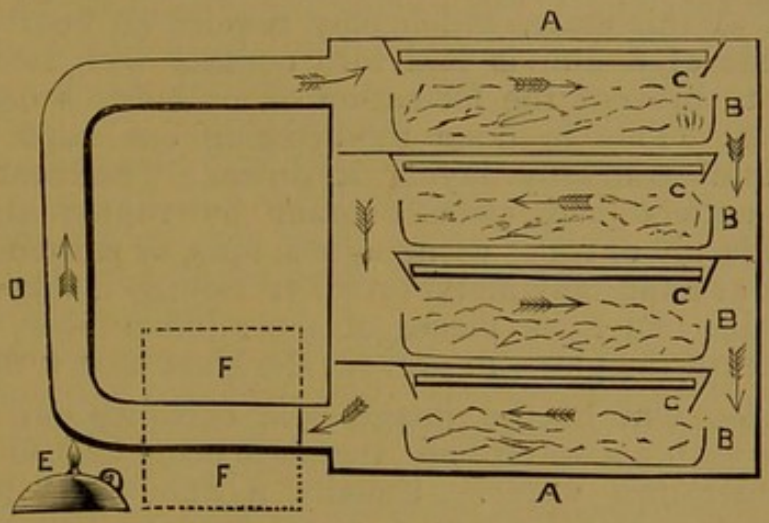

Fig. 205.

As soon as the films are quite dry they are cut all round the edges with a sharp knife and separated from the glass support. They are then carefully protected from light and moisture by wrapping in non-actinic paper and then in tinfoil. The best effects are obtained by using the films at once, or at least within two days from preparation.

Before printing from the negative it should be provided with a "safe edge," as in carbon printing. It is then placed in the printing frame, and the collodionised side of the film laid next to it. A sheet of tinfoil, or a plate of glass, is then laid over the film to protect it from moisture, and the frame carefully closed.

With regard to the exposure, an actinometer is, of course, required, as with the carbon process. The exposure is, however, somewhat longer, even after allowing for the density of the negative usually used. Printing can be carried on advantageously in full sunshine provided that the frame be kept at right angles to the direction of the sun's rays. The exposure is thus, of course, considerably lessened. When only a small amount of pigment is used in the preparation of the film the image is slightly visible; it is not, however, advisable to open the frame for the purpose of examining it, as the tissue might be attacked by moisture and thus become insoluble.

After exposure the next operation is to develop the film in the same manner as a carbon print. First of all, however, it is necessary to have some support to hold the film during the development, otherwise it would soon become unmanageable. For this purpose a sheet of glass coated with an indiarubber solution has been found most suitable. A very thick rubber solution is sold in tins. This is diluted with pure benzine until it flows similar to collodion. The glass plates are coated with this solution in the same manner as with collodion, except that as little excess is poured off as possible. The plates when coated are laid on a levelling stand until the rubber becomes tacky. When it has arrived at this state, which may require an hour or so, the collodion side of a film is laid into contact with it in such a manner as to prevent the formation of air bubbles between the two surfaces. This is done by bringing one edge into contact first and gradually laying it down. The next thing is to ensure perfect and close contact by rolling through an ordinary indiarubber roller wringing machine, or if such an instrument be not at hand, any metal or other rolling machine can be used by placing two thick pieces of sheet indiarubber, one below and one beneath the plate, to prevent the glass from breaking.

The development of the image next occupies our attention. This is done with hot water only, the plate being kept in a vertical position under the water. Usually a number of plates are developed at the same time in a metal grooved box. Development must be allowed to proceed spontaneously, and is sometimes completed in a couple of hours, or may require a day, or even longer. The temperature of the water should first be no hotter than 100° or 105° Fahr., and this should be frequently changed.

When all the bichromate salt has been dissolved out, and the water remains colourless, the temperature is gradually raised as required to perhaps as much as 150°. The plate can be removed from time to time, and the progress of development examined. If pigment was used in the film, the image will appear as a transparency, but if not, it is only possible to judge by the amount of relief in the film. In a correctly-exposed and developed relief, those portions of the film which represent the high lights should be washed away very nearly to the collodion, and at the same time dark parts forming the highest relief should still represent very nearly the whole thickness of the film, that is to say, only a small quantity of gelatine should have been dissolved away from these parts. From this it will be easily possible to judge whether the film has been exposed correctly. If over-exposed, parts of the film will retain the original surface, no gelatine having been dissolved away at all from these parts, while on the other hand, if the exposure has been too short, a large quantity of gelatine will be dissolved away, leaving a poor, weak relief. The effect of using the over-exposed relief would be the production of prints with heavy,

dark shadows, while the under-exposed relief would produce poor or sickly-looking prints. It will readily be understood, therefore, that considerable practice and skill are required in judging the correct exposure, and that a great deal depends upon this in the production of perfect prints.

As soon as the development of the film is considered complete, the plate is held under a cold water tap for a few seconds, and well rinsed all over. It is then laid in a five per cent. solution of chrome alum for about eight or ten minutes, so as to make it as hard as possible. After this the film is well washed in cold water to remove the alum, and then stood on end on a piece of blotting paper for a few minutes to get surface dry. The next operation is to lay it in a dish containing methylated spirts, and to allow it to remain in this for about an hour or so. It is then placed in a rack to dry spontaneously. As soon as the film is dry* it can be removed from the glass by inserting a penknife under one corner, and gradually and gently drawing it away. The whole or parts of the rubber will come away with it, and this is next removed with the tip of the finger, the rubber being made to come off in little rolls and balls.

The relief can now be retouched. Any little spots or marks which are raised in the relief, and which would print dark in the final image, can be removed by scraping gently with the edge of a strip of glass broken square across. A relief can often be considerably improved in this manner, although it is needless to say some skill and knowledge are required.

The relief is now ready to be used for the production of the leaden printing moulds, but it is always advisable to keep it for a few hours after stripping from the glass. The reason of this is that the relief contracts slowly for several hours after removing from the glass plate, and until it has arrived at its normal condition it is very liable to break when under pressure. Reliefs are usually stored away in albums, each relief being attached to a page by its four corners stuck through four slits in the leaf. It is thus easily removed, and, if the book be indexed, any desired relief can be quickly found at any time.

From this gelatine relief we can, at any time, produce the printing mould. All that is necessary is to press the relief down on to a sheet of lead with sufficient pressure to drive it into the metal, and thus form a perfect mould. As, however, the pressure required is very great, being nearly five tons per square inch, the machine necessary for this work is naturally very expensive, and it is this fact that has prevented the process from being more generally employed. An hydraulic press for pressing sizes up to whole plate would require to be capable of being worked up to 250 tons. This size is about the largest usually employed in this process owing to the enormous amount of pressure required. Special

*Some operators prefer to remove before it is quite dry, as otherwise there is a danger of the collodion cracking.

presses have been constructed for the Woodburytype process by Messrs. Tangye Bros., which are very compact, the length of stroke being very small. Besides the press we require a steel plate perfectly planed and scraped as a surface plate, with pieces of steel bolted all round the sides to prevent the lead from spreading out when subjected to pressure. Fig. 206 and the following description* will better serve to illustrate the matter :—"A is the

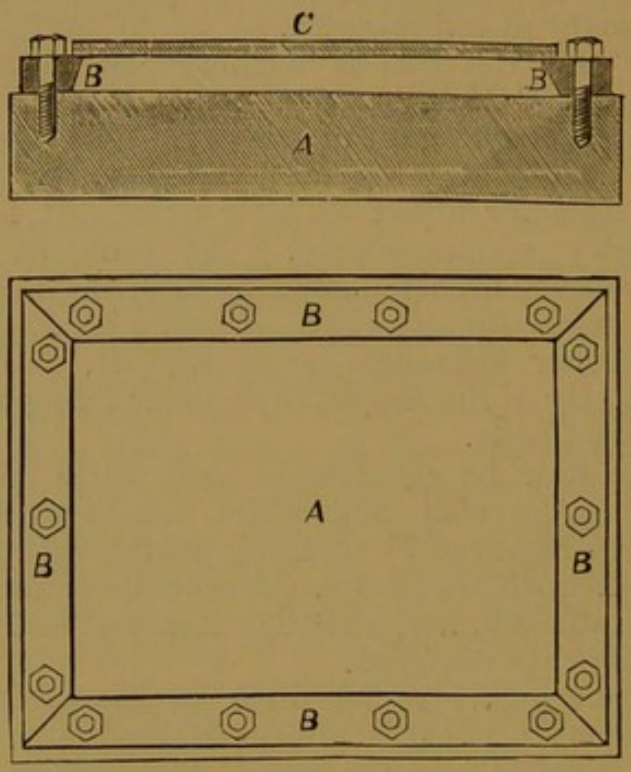

Fig. 206.

steel plate, BBBB are the steel bars, which may be $\frac{1}{2} \times \frac{3}{8}$ inch in section, slightly bevelled away at the inner edge as shown. They are fixed with set screws. C is the lead plate, polished on its lower side, and smooth on both sides. The platen of the machine is made just to fit within the bars BBBB, so that when it comes down it cuts off the edges of the lead plates. The relief is placed on the plate A, the lead plate is placed in position as shown, one or more thicknesses of millboard are placed on the top of it, the platen is brought down with full pressure, and when it has been raised, and the lead is removed, it will be found that a perfect mould has been produced, and these may be multiplied almost indefinitely."

It should be noted that the best moulds are produced when the relief is laid upon the plate collodion side downwards; but a little consideration will show that if this be done a reversed print will be produced. It is therefore always advisable to find some opportunity during the different processes to reverse the negative

* Burton's "Photo-mechanical Printing Processes."

image. If this be not possible the relief must be laid on the plate with the collodion side uppermost, and two or three moulds made and rejected. After this the moulds following will be as sharp as required.

The mould is now trimmed round the edges with a circular saw, cutting off all the superfluous lead except a margin of about half-an-inch round the picture. It has already been shown how the operator with a little strip of glass can plane away any little raised defects in the relief. Those which he cannot do, however, he can in the mould, as they are then raised, and will allow of being removed.

The operation of printing is practically the production of a number of castings from the lead mould or gelatine containing a suitable pigment. The mould is placed upon the bed of the printing-press, a little pigmented gelatine solution poured on to it, a sheet of paper laid over this, and the lid of the press is then brought down. By the application of pressure all the excess of gelatine solution is squeezed out round the edges, and only that remains which lies in the hollow parts of the mould. This sets, and at the same time adheres to the paper only (the mould being slightly greased), and a perfect casting of the mould is obtained adhering to the paper. This casting is, of course, in relief, the dark parts standing rather high, and the other shades of varying thickness, thus giving perfect gradation. When dry the amount of relief is scarcely discernible, but the different tints remain the same.

It must not be supposed that any kind of paper will do for printing upon, as it requires to be perfectly smooth and of even texture, and to be specially prepared for the purpose. A paper very suitable is that known as Rive's, which is manufactured specially for photographic purposes. A kind of varnish is made up as follows :—

Borax	4 ozs.
Sodium carbonate..	1 ,,
Water	3 pints.

This solution is heated to boiling point, and then is added—

White shellac	1 lb.

The mixture is kept boiling until all the shellac has dissolved. When quite cold, water is added to make up to its original volume. A little carmine is also added for the purpose of giving an agreeable tint to the pictures. It also has the advantage of rendering the coated side of the paper easily distinguishable. The paper is coated in a room kept warm, the temperature not being allowed to fall below 90° Fahr. The solution is first of all filtered, and then poured into a deep dish in such a manner as to avoid the formation of air-bubbles. A piece of wood is placed under the farthest end of the dish to incline it a little, and so give a greater depth of liquid at that part of the dish next the front edge of the table and

nearest to the operator. Two sheets of the paper are now placed back to back, and held by two opposite corners, keeping the edges in perfect contact with each other. With one clear sweep this double edge is immersed in the shallow end of the liquid, drawn along the solution, and brought out of it at the deep end. At first thought one would imagine that the liquid would run between the two sheets, but this is not so, however. The density of the liquid keeps them tightly together, only penetrating about the one-sixteenth of an inch all round the edges. After the sheets are brought out of the liquid they are allowed to drain a little into the dish, only care must be taken to hold the bottom edge as near to the surface of the solution as possible to avoid air-bubbles. They are then hung up to dry. When dry, the two sheets are separated from each other by cutting off a slip about one-eighth of an inch from one edge, and inserting a penknife to separate the other edges. The sheets thus separated are laid one on top of the other ready for the next operation. An emulsion of gelatine and resinous matter is prepared by dissolving one part of gum benzine in 10 parts of alcohol. This solution is filtered, and mixed with a warm solution composed of one part of gelatine, dissolved in nine parts of water, violently stirring the whole while the addition is being made. This solution is applied to the surface of the lac-coated paper, by means of a piece of soft flannel made in the form of a pad. It will be found sufficient to thoroughly moisten the surface, and set it aside to dry. When dry the prepared paper is required to have a glass-like surface given to it. This is done by passing a set of alternate sheets of paper and thin highly-polished steel plates through a powerful rolling press. After the paper has been prepared and rolled, it requires to be handled with extreme care, as any little crease will show in the finest print.

We have now considered the production of the printing mould and the paper, and must now give our attention to the printing press. What is really required is an arrangement that will press

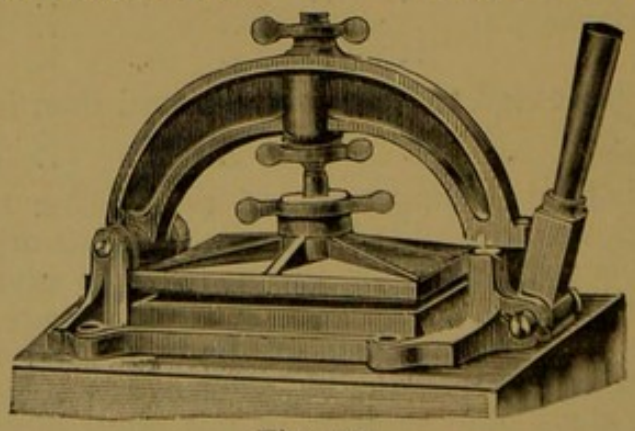

Fig. 207.

the paper perfectly flat upon the mould, and drive out all the superfluous gelatine ink. The presses used by most firms working the Woodbury process are heavy, clumsy arrangements. That

designed for the Stannotype process, and depicted in fig. 207 answers the purpose equally well. It would be as well to note here that the process of printing hereafter described, are the same in the Stannotype process as in the Woodburytype. The production of the mould by the former process is described under **Stannotype.**

With regard to the printing process, it will be seen on reference to fig. 207 that it is not unlike an ordinary copying press, except that the arch is hinged at one end and clamped at the other. By means of the three nuts the platen of the press can be adjusted to any position and held tightly. The bottom nut serves to screw up a ball-and-socket joint used to adjust the angle of the platen in case of a want of parallelism between the two faces of the mould, and the other two serve to adjust the distance between the bed of the press and the platen according to the different thicknesses of mould. The pressure is also adjusted to any desired amount, and this always repeated every time the arch is lowered.

To prepare for printing, the arch is raised and pushed back out of the way. A piece of wet cardboard is then laid on the bed of the press, and upon this the Woodbury or Stannotype mould is placed.* The three screws are now loosened and the platen brought down upon the relief. The surface of the plates consists of a thick piece of glass cemented to the ironwork, and ground perfectly true. This should lie perfectly true upon the mould. The handle which clamps the arch is then adjusted. The screw beneath the arch is now screwed up tightly to adjust the pressure. The top screw is then tightly adjusted. The bottom screw holding the ball-and-socket joint is now turned tightly. If all the screws have been properly adjusted, the platen should be so rigidly fixed to the arch that it will always come down in precisely the same position, and with the same amount of pressure.

The ink used in printing is composed simply of gelatine dissolved in water, and a little colouring matter added. The gelatine should be of a hard kind; Nelson's opaque, or Heinrich's hard emulsion gelatine both answer the purpose admirably. The proportions are about one part of gelatine in five parts of water, but in very cold weather this may be found too stiff, and a little water and more pigment added. The amount of colouring matter to be added to the gelatine solution to form the printing ink can only be satisfactorily found by experiment. Of course, any colour can be used, but, as a rule, Indian ink and a little carmine is added. The amount of colour required varies with the depth of the mould, the deeper the mould the less colour being required. The best plan is to make up the gelatine solution, add a very small quantity of colouring solution, and make a print, a few drops of colouring matter being added each time, until the best effect is

*With a Woodbury or lead mould the better plan is to soften a piece of guttapercha in hot water and press it between the platen of the press to a sheet of about a quarter of an inch and this will form a perfect bed for the leaden mould.

produced. To save trouble in grinding the colour, liquid Indian ink can be purchased. Mr. Geo. Smith, an authority on Woodburytype printing, recommends "lamp brown," obtained by collecting the smoke from the tip of the flame of a small lamp burning benzine. It gives a very rich colour, and has the advantage of permanency. He also adds a small quantity of bichloride of mercury to the ink, to prevent decomposition. The ink is usually kept in thin glass sloping necked bottles, this shape being most convenient, as the ink can be poured out with but little chance of air bubbles forming. The flask containing the ink is kept in a bath containing warm water, and to this it is returned after every time of using. The mould is first greased by rubbing it over with a piece of flannel containing a few drops of a mixture of paraffin and salad oil. The smallest quantity is sufficient; any excess must be carefully avoided. The next operation is to pour a little pool of the warm gelatine ink on to the centre of the mould. The size of the pool should be about half the diameter of the picture. A piece of the paper is next laid on this prepared side downwards, and the platen of the press brought gently down and clamped firmly with the lever handle. The excess of gelatine is thus squeezed out, and runs down the bed of the press into the trough round the bottom, from whence it can afterwards be removed and used over again. After closing the press, a few minutes are allowed to elapse for the gelatine to set. In winter or in cold weather the gelatine does not require a very long time to get stiff, but in summer it may take some time. In very hot weather it sometimes becomes necessary to work in a very cool room, or to use ice round the press to keep it cold. In works where large quantities of printing are done the presses are arranged round a circular table, which revolves round its central support. The printer stands at one place, opens one press, pours the ink on, places the paper on this, closes the press, and gives the table a slight turn until the next press comes into position before him. This is filled up and moved on, and this repeated until the press first manipulated has completed the circuit and again comes before the operator. By this time the gelatine ink has had ample time to set, and the finished print is lifted away, fresh ink and paper put on, and the press again closed, and so on. Thus no time is lost, the prints being made as fast as it is possible for the printer to work the presses.

When the first print is made it must be carefully examined to find out—first, if the press is properly adjusted, and secondly, if the ink is correctly prepared with regard to density and colour. If the margins of the print are not clear and white, either the pressure is insufficient or the gelatine is too strong. The pressure should be increased by loosening the top screw, and screwing up the one directly underneath the next more tightly than before, and then tightening up the top screw again. If no improvement takes place the ink is probably at fault, and should be diluted with water. If the

image is too light all over, more colouring matter should be added, but if it shows clear margins, and is generally too dark, too much colouring matter has been added, and more gelatine and water should be mixed with it.

As soon as the press has been properly adjusted with the requisite amount of pressure, and the ink properly mixed, printing can proceed regularly without any trouble. The oily cloth should be rubbed over the mould every two or three impressions, or oftener if the gelatine is found to stick. In removing the prints one corner is laid hold of and the print drawn slowly away. The thick edging of gelatine all round the margin is scraped away with an artist's palette knife, with the rounded end cut off straight. The ink scraped off, and all that which finds its way into the trough of the press and round the sides of the mould, is all collected and can be melted up again and filtered ready for use.

Before the prints are dried they are immersed in a three per cent. solution of chrome alum for about five minutes. The effect of this is to harden the gelatine, rendering it insoluble and less likely to be influenced by moist atmospheres. After treating with the alum bath the prints are well washed in water and permitted to dry spontaneously. When dry the brilliancy of the surface can be improved by rolling on a polished steel press, or by rubbing with an encaustic paste, or a varnish composed of—

Borax	4 ounces
Water	3 pints
Shellac	8 ounces

and dried in front of a fire.

The softness and beauty of the Woodburytype process is not equalled by any other process. For portrait work it is especially suitable. One of the drawbacks, however, is the difficulty of obtaining large, clean, white surfaces; thus, in landscapes, a sky must be printed in, or else the gelatine ink wiped away directly after printing by means of a rag dipped in warm water. For the same reason vignettes cannot be printed. For many years the difficulty of obtaining clear white margins was keenly felt, it being always necessary to mount the pictures upon a suitably stiff paper, and this in the case of book illustrations was very objectionable. Recently, however, it is pleasing to note a method has been devised by means of which the ink can be entirely removed from the margins, leaving a clear image in the centre of a piece of white paper. The method as yet remains a secret, no particulars having been divulged. Another process has also been devised, by means of which the prints are transferred to another paper, or other support. Clear margins are thus obtained, and a soft matt appearance given to the image.

It must not be omitted to be mentioned that besides the production of paper prints the Woodbury process is largely employed in the manufacture of opals, lantern slides, etc., of superb quality.

Wood Naphtha.—The neutral crude distillate obtained from the products of the destructive distillation of wood. It contains from 75 to 85 per cent. of pure wood spirit or methylic alcohol, 5 to 10 per cent. of acetone, with much smaller proportions of creosote, aldehyde, hydrocarbon oils, and other substances that are but little known. In its most rectified condition it possesses a specific gravity of ·830*

Wortley's Process.—A dry collodion process invented by Colonel Wortley, in which the following is used as a preservative :—

SOLUTION No. 1.

Salicine, saturated solution in distilled water.

SOLUTION No. 2.

Tannin	60 grains
Distilled water	1 ounce

SOLUTION No. 3.

Gallic acid	48 grains
Alcohol	1 ounce

To make the preservative take

No. 1	2 ounces
No. 2	1 ounce
No 3	½ ,,
Sugar	40 grains
Water	7 ounces

This can be used over and over again with occasional filtering. The plates are immersed in it.

Writing Ink Process.—See **Ink Process.**

Yellow Fog.—See **Fog.**

Yellow Stain.—A yellow stain is often produced upon negatives caused by insufficient fixing. This is very often difficult to remove. One method recommended by Mr. Drake is as follows:—Soak the plate for five minutes in clean water, meanwhile make a solution of iodide of potassium, twenty grains to the ounce of water, now put the plate in this solution and let it stay for ten minutes. If the stain is very old keep it in for half an hour. Now dissolve half a drachm of cyanide of potassium in one ounce of water. Take the plate and put into this, and gently rub the stains with a tuft of cotton wool (absorbent filtering cotton will do), free from grit, until they are quite gone. If the stains are very old, make the solutions stronger and soak for a longer time.

Yellow stains are also often produced by pyro-development. These can usually be removed by immersing the plate in a clearing solution composed of

Alum	4 ounces.
Citric acid	2 ,,
Water	20 ,,

* Hunter's "Encyclopædia Dictionary."

for several times. In this solution the plate should be soaked for about ten minutes in water before immersing in the above.

Yellow silver stains produced in printing from ordinary silver paper can be removed with the following :—

SOLUTION A.

Sulphocyanide of ammonium	½ drachm.
Water	1 ounce.

SOLUTION B.

Nitric acid	½ drachm.
Water	1 ounce.

For use, mix equal parts of A and B fresh for each negative, and apply to stained portions, or the negative can be immersed in the solution. After the stain has disappeared the negative should be well washed, and treated with a saturated solution of chrome alum and well washed.

Zinc (Symbol, Zn ; atomic weight, 65·5).—A metallic element never found in nature. Its chief ones are calamine or zinc carbonate, blende or zinc sulphide, and red zinc ore in which zinc oxide is associated with the oxides of iron and maganese.

Zinc Bromide (Formula, $ZnBr_2$).—Can be formed directly by igniting zinc in bromine vapour. Zinc bromide unites with the bromides of alkali metals, forming double salts like the corresponding chlorine compounds.

Zinc Chloride (Formula, $ZnCl_2$).—Prepared by dissolving zinc or zinc oxide in hydrochloric acid and evaporating. If any iron be present it can be separated by the addition of a little chlorine water to peroxidise it, and afterwards precipitated as hydrated, Fe_2O_3, by adding zinc carbonate.

It can also be prepared by distilling a mixture of zinc sulphate and sodium chloride. Zinc chloride is a nearly white translucent solid, very soluble in water, alcohol and ether. It is very deliquescent. It is very useful as an antiseptic, and, like sulphuric acid, it withdraws the elements of water from organic bodies.

Zinc Iodide (Formula, ZnI_2).—Obtained by digesting iodine with an excess of zinc and water until the colour of the iodine disappears. It separates in regular octahedral or cubo-octahedral crystals, is very deliquescent, and dissolves easily in water. When heated in contact with the air it is decomposed, iodine being evolved and zinc oxide produced.

Zincography.—See **Photo Zincography.**

W W

Zinc Oxide (Formula, ZnO).—Zinc forms but one oxide, known in commerce as zinc white or Chinese white, prepared by permitting the vapour of the metal to burn in earthern chambers through which a current of air is maintained. It is much used as a paint, and in the manufacture of glass for optical purposes.

Zinc Sulphate (Formula, $ZnSO_4 + 6H_2O$; synonym, white vitriol).—Prepared by roasting blende (zinc sulphide) at a low red heat, when it combines with the oxygen from the air to form $ZnSO_4$, which is dissolved out by water and crystallised. Its crystals are very similar in appearance to sulphate of magnesia. It has an astringent metallic taste, dissolves in two-and-half parts of cold, and in a much smaller quantity of hot water.

Zoellner's Process.—An iodide of starch process for reproducing drawings, manuscripts, etc., invented by Dr. F. Zoellner, of Berlin.*

Thin and smooth paper of a uniform texture is first to be sized with starch. If paper which was sized with starch in its manufacture is used, the operation is, of course, unnecessary. When dry the paper is sensitised with a mixture of—

Concentrated solution sesquichloride of iron	1 part.
Concentrated solution ferric oxalate	6 parts.
Distilled water	13 „

This solution may be preserved in a dark place and in a well-stoppered bottle for a long time. Floating the paper upon the solution for from 30 to 60 seconds is the best method of sensitising in this process. The prepared paper may be preserved in portfolios protected from light for over two weeks without losing its sensitiveness.

The exposure, through thin translucent originals, requires in the sun but a few minutes, and in diffused light from 15 minutes to half-an-hour.

The image after the action of the light still remains invisible, but rapidly makes its appearance with an intense blue colour, by treating it with a solution of potassium iodide in diluted albumen. The developing solution is prepared as follows : The whites of two eggs are beaten to a froth, and allowed to stand several hours, then the liquid albumen, which has collected at the bottom of the vessel, is decanted and diluted with one-third of its volume of distilled water. In this diluted solution of albumen 78 grains (troy) of iodide of potassium are dissolved.

The developing solution is applied by means of a wide varnishing brush, and before it is dry is washed off with clear water.

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* "Modern Heliographic Processes," by Ernst Leitze.

The prints may be developed as soon as they are taken out of the printing frame, or this operation may be postponed for from six to twelve hours. The developed and washed prints are dried in the open air.

Zirconium (Symbol, Zr; atomic weight, 89·6).—The metallic basis of the rare earth zirconia. Zirconia is a hard, white powder, which emits an intensely brilliant light when ignited with the oxy-hydrogen limelight. It is for this reason made into cylinders, and used instead of the lime in the oxy-hydrogen light.

THE END.

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Gelatine Chloride Paper. 2.
Harmonizing Harsh Negatives. 4.
Amidol Developer. . . 6.
Stereoscopic Photography. . 8–18.
Pinhole Photography. . . 21.

2

Gelatino-Chloride Paper [315 - a/341.]

Bicarbonate Toning Bath. - Welford.

Gold. 4 grs
Bicarbonate of Soda. 90 grs
Water . . . 6 oz.

Wash prints before toning.
Rinse after toning.
Fix in weak hypo 1 : 6 for 10 min^s.
Over print to allow for reduction.
Actual time does not change in fixing.
Judge time by transmitted strong light.
As soon as the last trace of red or brown is gone it is finished
Tones quickly & evenly. - 1½ to 3 min^s.
Gives a grey black tone, like platinotype.
Over toning is impossible.
In warm weather (above 60°) double the quantity of water & keep the tray.
Hewison says this bath works better if made with 9 oz of water.
The sulphocyanide bath with extra gold gives the same tones.
Any acid in the gold should be first neutralized with bicarbonate of soda. Welford says his bath works best with Eastmans paper, & is not so suitable for Ilford P.O.P.

Hypo Sulphocyanide Bath

Water . . . . . 16 oz
Am. Sulphocyan 30 grs
Gold Chloride 2½ grs.
Wash prints for 6 or 8 mins before toning
& for 10 mins after. Toning 5 or 6 mins.
Fixing in Hypo 3:20. for 8:10 mins.

Borax Bath

Borax 90 grs Water 20 oz Gold 2 grs. 60°.

Carbonate Bath

Soda carb. anhyd. 20 grs [or Soda cryst 574 grs]
Water 20 oz. Gold 2 grs. Will not keep.

Alum Bath 1½ oz to 20 oz
Chrome Alum ½ oz to 20 oz.

Eastman Contrast Bath

1. Hypo 20 Potash Alum 5, ~~Pot. Sulphate 2,~~
Soda sulphate 14 to 20. Water 160. oz. = 1 Gallon.
2. Gold 15 grs Lead Acet 64 grs Water 8 oz.
Add 1 of 2 to 8 of No 1.

Borax bath - Blue tones.

No 1. Borax 600 grs Water 160 oz.
No 2. Gold Chlor. 15 grs. Water 15 oz
Use 8 oz of No 1 & ½ oz of No 2.

Stolze's Acid Chrome Alum Bath.

Chrome Alum 5. Water 100
Add Ammonia drop by drop till a
permanent cloudiness is formed, &
filter. 5% = 1:20.

4.

Harmonising Harsh Negatives.

Edis's method:- Soak the plate in water till the film is soft, then immerse in

Hydrochloric Acid pure	1 part.	or 5 mins
Alum	10 "	
Bichromate of Potash	5 "	10 grs
Water	100 "	1 ℥.

till the image is bleached quite white through the film, & work thoroughly. Redevelop with ferrous oxalate with bromide added. As soon as the thin portions have developed thoroughly, & before the dense parts have become black on looking through the back, wash & fix.

Macintosh's method. Bleach in

Bichromate of Potash	10 grs
Bromide of Potassium	5 "
Water	1 ℥

Bath the plate & allow the solution to permeate the film; pour the sol. off & add to it 5 drops of nitric acid, & again flood the plate. Allow the action to proceed through the film. Bath in three changes of alum to remove the bichromate & harden the film, & wash thoroughly in water.

The operations are conducted by gas or lamplight.

Redeveloper with

Pyro . . . . . 2 grs.
Ammonia . . 2 mins
10% Bromid. if used ¼ gr
Water . . . . 1 oz

The shadow detail will first be developed, the halftones will follow, & the high lights will remain white when viewed from the back for sometime. When the lightest half tone which shows in the print from the negative is nearly but not quite blackened through, by the developer on viewing the plate from the back, the action should be stopped, the plate washed & transferred to the hypo, which will speedily dissolve out the undeveloped silver in the high lights, leaving the negative much thinner in the high lights than it originally was.

6

Amidol Developer.

Amidol 20 grs = 2% = 10 grs
Sod Sulphite 200 grs 100 grs
Water . . 1000 " [Spiller.] 1 oz.

Use dilute 1 to 8 water, or 1 to 15
" with 3 or 4 water. 5 to 20 oz 10% Pot. Br. to each oz
or Energetic, rapid, clean-gives density &
detail in short fog-develops several plates.
For instantaneous exposures can be
used undiluted.

Edis Formula = [as above, diluted 1 in 4]
Amidol 5. Sod. Sulphite 50. Water 1000.
Full printing density in 3 or 4 mins.

Sinclairs for Lantern Slides.
Amidol 80 grs Sulphite 800 grs. Water 8 oz.
For use, dilute 1 oz with 3 oz of Water, &
add dl ½ gr Pot. Brom. to each oz of developer.
Ed. B. J. P. advises the addition of
⅛ gr Pot. Brom. to each oz of developer.
Stock sol. 1. Water 3.
Amidol can be used for Bromide Paper.
Davis for Lantern Slides. Remain Plates.

Stock. Amidol 1.
Pot. Metabisulphite 6
Water 60.

Developer.
Stock ½ oz
Sod. Brom. 10% sol. 1 oz
Pot. Carb. 10% sol ¼ oz
Water to 3 oz.

Exposure Gas 1 ft = 60 s. Developed 6 m Rochester
or Water to 6 oz. Exp. 240 s " 5 m Do

Rogan (Ewart Bros)

Stock Sulphite

Sod Sulphite cryst 1/2 Water 20 oz.

To 4 oz add 8 or 10 grs Amidol Powder & a few drops of 10% sol. Pot. Brom.

Detail in 30 seconds. Density in about 3 minutes.

In Over exposure, use weak sol & extra bromide

" under " " strong " & little "

" uncertain " begin with weak developer & strengthen

Preserva. R. [Bromide Paper]

Stock. Amidol 1/2

Pot. Metabisulphite 1/2

Water 10 oz.

Developer.

Stock Sol. 16 drs

5% sol. Pot. Carb 14 "

10% sol. Pot. Brom 2½ "

Water to 20 oz.

Gives a black tone. diluted a greyer.

With Amidol avoid over exposure.

Amidol for redeveloping Bleached Bromide.

Amidol ½ gr. Sulphite 5 grs Water 1 oz.

8. Stereoscopic Photography.

See p. 670 – 674.

1. With one camera – Stationary objects.

Having levelled the camera, arranged the picture, & focused, make a mark on the ground glass corresponding to some prominent object about the centre of the picture, & expose the plate.

Move the camera to another position parallel to the former, & the same distance from the object to be taken. Let the mark and some prominent object correspond, & take a second negative, with equal exposure.

If the distance of the nearest object to be represented be 50 feet, let the two positions be 2 feet apart; if 100 feet, 4 feet apart; 150 feet, 6 feet apart, & so on.

2. With two Cameras. Objects likely to move.

Two cameras of equal foci are placed in the same relative positions so that the most prominent object occupies the same position on the ground glass of each, & the exposure is made simultaneously. At 6 feet from the nearest, distance between centres of lenses 2½ inches; if 8 ft., 3½ in. if 12 ft. 5 inches & so on.

Wheatstone allowed 1 foot of separation for every 25 ft. of distance. When there are no near objects in the view the cameras may be as much as 12 ft. apart without distortion

3. With binocular camera. - divided.
Best focal length of lenses 6 in.
Short focus exaggerates near objects, and
long focus limits the view for a small picture.
Distance of lenses apart may be for
8×5 plates, 4 in; for 6½×4½, 3¼ in;
6¾×3¼, 3½ in for near object,
to 2¾, 3, or 3¼ for more distant subjects.
Width of picture 2½ in (best) to 2⅞ in.
Height of picture may be 2¾ to 3¼ or 4 inches.
Size of mounts 7×3 7/16 :- 6 11/16 × 3¼;
It is very important in focussing that the
camera should be level from side to side,
and also vertical.
The plates should have equal exposure &
development.
Prints must be cut to the same base line.
The left hand negative prints the right
hand positive, which print should be cut with
⅛ in more view on the right hand side
& vice versa. [i.e. the print before cutting & mounting.]
The inner edges of the prints are mounted
1/16 of an inch from the centre of the card.
A somewhat shiny or burnished surface
shows up a stereo print better than a
mat surface.
A transparency shows better than an
opaque print.
A stereo print should not have any
glaring high lights. It should be well
exposed but not over developed.

In Stereograms every detail is easily distinguished; distance is charmingly rendered; the idea of solidity is better illustrated, & the style of the picture is more true to nature. Suitable views are more abundant than for large single pictures. Each picture will make a lantern slide, & with two pictures there is less risk of failure from defects in the films.

The negatives may be taken on celluloid, cut, the pictures transposed, placed film side out on glass, attached with india rubber bands, & with glass to the stereoscope adjusted to get a proper stereoscopic effect, gummed in position, & ready for printing transparencies as paper.

Prints may be printed with masks & discs, obtaining slips ready for use with the picture when finished surrounded by the black border.

Dark prints frequently make pleasing transparencies in open mounts.

Rather thin negatives, full of detail, can only be had, when using a shutter, by the use of rapid lenses and the most rapid plates.

Snow effects are caused by slow plates, slow lenses, prolonged development, & taking pictures in bright sunshine, all of which tend to give over density in the highlights & consequently "snow effect" in the finished slide.
Avoid bright sunshine. A bright diffused light is the best. Use the largest stop that the lens will cover sharply, & a very rapid plate. Keep back pyro in developing, be liberal with bromide as it permits the use of more alcali. As soon as the image appears, force up detail with liberal additions of alcali, so as to keep down contrast, & do not develop too far. A negative too thin for yielding a vigorous single print does best for stereoscopic work. See B. J. A. 1890, p 617 & 1887.
Simple Shutter. B. J. A. 1890. p 682.
Transparencies - See Chadwick's Manual.
Printed by daylight should be done in the camera. With artificial light, by contact printing. Negative may be cut & transposed, or a special printing frame may be used.
Prints made in the camera are printed through the glass & do not need to be transposed. They are mounted with the film side furthest away from the observer.
Transparencies made by contact are mounted with the film towards the observer & a cover glass in front and thin ground glass behind.

"When the scene to be depicted in relief is at such a distance as to produce no effect of solidity when viewed with both eyes, it is necessary to lengthen the base line of the angle of observation & to make two exposures at a distance - perhaps of one hundred yards. Stereoscopic views of the moon must be taken on the same principle, at the extreme of the libration, the angle representing a base line of thousands of miles."

"Single lenses are best adapted for stereoscopic cameras. The distortion is corrected by the lenses of the stereoscope. An absolutely rectilinear photograph becomes distorted when viewed through the eye pieces of the stereoscope, & such distortion increases in proportion to the magnifying power of the eye glasses When compound lenses are employed they must be absolutely identical in focus. To find the equivalent focus of two lenses when compound, multiply their foci together and divide the product by their sum less the distance at which they are mounted apart.

$$f = \frac{a \times b}{(a+b)-d}.$$

"The cost objectives for all landscapes are portrait lenses employed with a stop in the middle. They may answer for out door purposes when employed without a diaphragm, to secure transcripts of extremely rapid motion.

To get the eyes of the sitter to look straight into those of the observer, the sitter must look intently into the lens while being taken & one picture must be taken at a time - of course without any motion of the head or body being permitted.

Preparing the Negative for Printing.

Draw a horizontal line upon a large sheet of paper & upon this erect two lines 3½ inches apart. Lay the negative face down upon the paper, & placing the half to the left upon the space enclosed between the two lines, see that the precise portion of the picture desired to be seen is enclosed between the two lines. With a diamond & a rule cut off the end at the left hand mark, & then push the negative to the left until the corresponding portion of the other half is brought within the lines.

trim cut off the end that projects beyond the right hand line, and severing the two halves in the centre, reverse their positions so as to bring their opposite ends together. Lay these halves down on a plain plate of glass & bind all together with strips of gummed paper round the margin. The negative is now ready for being printed from."

"To trim the prints provide a glass cutting guide 6½ × 3½ in. with an opaque line across the centre. Lay this down upon the print in such a way that the opaque mark shall precisely cover the divisional line which shows the junction of the two pictures, & run the trimming knife around the edge.

"To print transparencies by contact, cut a mask in thin black paper, lay this evenly on the negative & fix with gummed strips. This is laid in the frame & covered with the sensitive plate face down, with a thin strip of wood at one side to press on to same. Print

To prevent over-exposure, avoid strong reflected light, give full exposure, & do not carry development to an undue length.
With intense negatives it may be of use to degrade the high lights by exposing the print for a short time to open daylight without the negative.

Trimming & Mounting Stereographs.

The first step consists in forming a perfectly straight & horizontal base line. Select a corresponding point in the immediate foreground of each print, lay a straight edge accurately against the two, and pass the cutter along the whole edge of the double print. Lay the glass shape with its bottom edge to the newly cut edge. Place the shape on the left hand picture & cut it out.
In trimming the second or right hand picture, as this printing is done alternately reversed on the mount, it will be requisite that a small portion more of the image be left at the right hand side of the picture, now to be cut, than what appears in the other; & as both halves are equal in breadth, there will be less of the image on the left hand side of this print, than on the one which was cut previously. In doing this the foreground alone must be taken into consideration

16
a If both halves are trimmed to agree
as regards the distance, the distance would
appear on the same plane as the
mount, while the middle & near objects
would appear nearer than the opening.
The distance between similar objects
in the foreground of a mounted stereograph
is less than that between like objects in
the distance. Hence clouds would have
to be further separated than distant
objects in the scene, & mounds would
have to be separated still more than
the clouds in order that their relative
effects of distance be given.
When less of the left foreground on
the left half of the pair is seen than
there is in the right half, & vice versa.
Then are the conditions perfect.
In pasting the prints on the
mounts, a small portion, say 1/16 in
should be left between them.
The centres of the component parts of
a stereoscopic picture should by
preference be 2 3/4 in & never exceed 3 in,
this when distant objects are considered.

Transparencies

When a bi-unicular negative is employed without its halves being transposed, it is necessary in the case of contact printing, that the right hand end of the negative be superposed on the left end of the positive plate, & vice versâ. A frame may be made to print the ends of two plates at the same time

In the transparency Camera a small stop should be employed.

When copying to precise dimensions, the distance between the lens & negative, and between ground glass & lens will be equal to twice the solar focus of the latter.

A thin image as regards opacity in the shadows is necessary, & yet a degree of density must be obtained exceeding that of a good transparency for the Lantern.

Warm brown tones are most pleasing.

Avoid backing a very fine transparency with ground glass.

Substitute for Flash Opal. Plain glass coated with rather thick Collodion (Dgr-13) mixed with a little finely sifted carbonate of lead. Add 4 drops of Castor oil to impart toughness, & 1 drop of Canada balsam to secure adhesion.

18. The Stereoscope

a pair of semi-lenses, or lenticular prisms are mounted with the edges towards each other or whole lenses may be used mounted at such a distance apart as to enable the eyes to see a point between the centre & the margin, the amount of separation in this case slightly exceeding the distance between the eyes.

a pair of spectacle lenses, 8 inches, will do.

The eye pieces should be achromatic - diameter of 1 3/4 inches, & focus not exceeding 6 inches. They must be mounted plane & as near to the eye, & have their centres 3 inches apart, with means of adjustment at will.

Focussing can be managed by ordinary sliding on the base board.

The eyepieces should have a hood to prevent the light from the sides impinging upon the eyepieces.

In viewing prints on paper there should be free access of light both from above & on either side.

A Partition is not necessary.

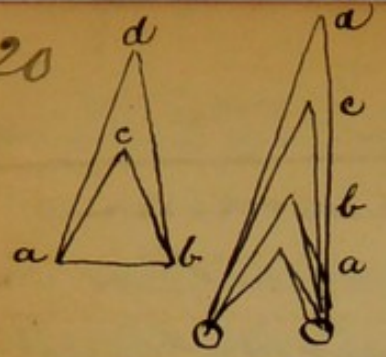
In the case of transparencies it is different. They are viewed by transmitted light alone & should have an opaque covering.

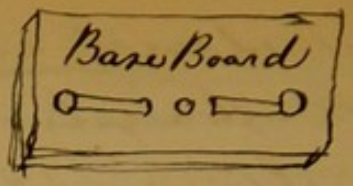
[T. Traill Dayton. B. A. 1887.]

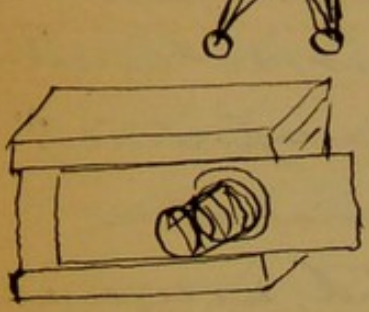
Chadwick on Mounting & Cutting the Prints

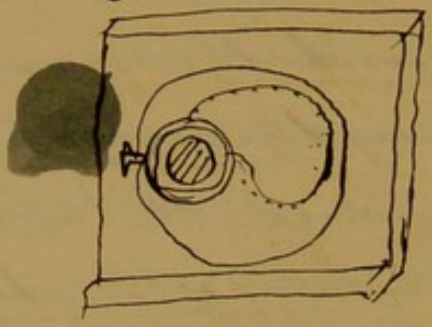
We desire to mount our pictures showing relief from the mounts, as though the picture was beyond the mount, (as though we were looking through the aperture), we require to produce the effect of a hollow; - thus, when mounted, we require to see more subject on the left hand side of the right hand picture, than is to be seen on the left hand side of the left hand picture. The prints require ~~mounting~~ cutting so that when mounted the subject in the immediate foreground of each picture is wider apart than the centre of the prints bodily.

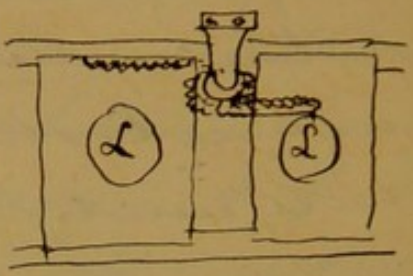
After the prints are washed & dried, before cutting, lay them face down, with the sky or upper part of the picture furthest away. Mark on the back with a lead pencil the letter R on the right hand side as the print lies face down. Turn the prints face up, & adjust a base line to the cut through exactly the same object in the foreground of each picture. Allow a little more subject, say $\frac{1}{8}$" or an inch on the right hand side of the right hand picture [cannot & to be afterwards mounted on the left] than is divided on the right side of the left picture [as it lies on the table mount].

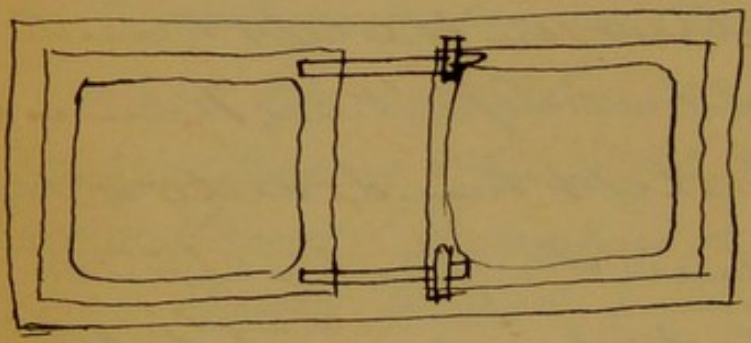


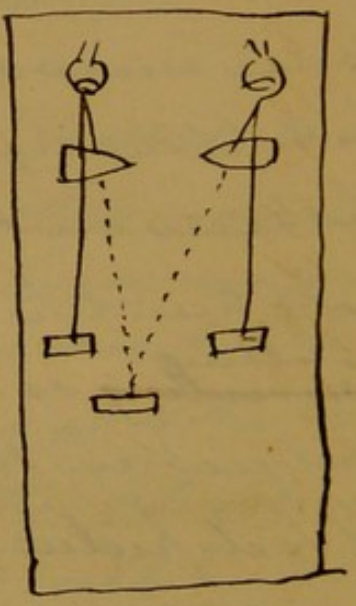


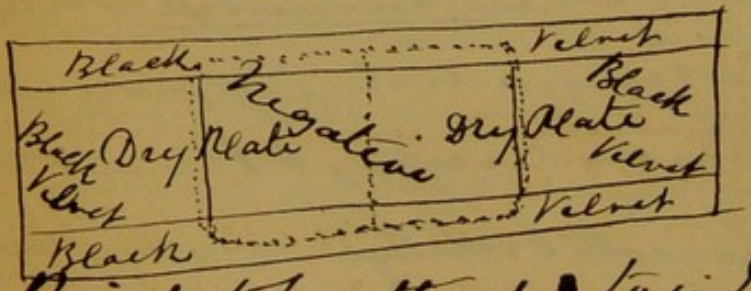












Points to be attended to in Mounting.

1. Identical base lines.
2. Each print 2½ in wide.
3. Height 3 in.
4. Trim the prints so that on the left of the right hand picture & the right side of the left hand picture a little more of the subject is seen than on the other sides of the pictures. or. The sides of the prints which come together in mounting should each show more of the subject than the outside sides - 1/16 to 1/8 in is sufficient.
5. Allow 1/16 in to 1/8 in to separate the prints
6. Trim by foreground objects, & let not more than 3 in separate them.

[Bedding Bk Oct. 93]

[Cont'd at P. 25.]

Pinhole Photography. [p. 542]

Table of Comparative Exposures.

If with a given plate, light, subject &c and a lens working at f 16, the correct exposure be one second, then, under the same circumstances the following table gives the corresponding exposure in minutes.

Distance of hole from plate	Diameter of hole in inches, 1/50	1/44	1/35	1/25
6 in.	+6 min.	4½ min		
8 "	10	+8	5	
10 "	16	13	8	
12 "	24	18	+12	6
14 "	32	24	15	8
16 "	40	32	20	10
18 "		41	26	13
20 "			32	16
24 "				+24

Exposures at various apertures equivalent to one second at f. 16.

Aperture.	f 4	f 5.6	f/8	f. 11	f 16	f/22	f 32	f 44	f/64
Seconds	1/16	1/8	1/4	1/2	1	2	4	8	16

+ = distance for best definition with each hole.

No 9 needle = 1/49 No 8 1/44 No 6 1/34 No 3 1/26 in diam.

A millimetre = .03937 or nearly 1/25 in [J. G. Lambert]

To find the diameter of pinhole that will give the best photographic definition

Multiply 0.008 by the square root of the distance between the plate & the pinhole (in inches) & the result is the best diameter of the pinhole in fractions of an inch. [Abney.]

For an angle of view of about 28°

Size of Plate.	Distance of Pinhole	Diam. of Pinhole
4¼ × 3¼	9	1/40
6½ × 4¾	13	1/40
8½ × 6½	16	1/30
10 × 8	20	1/25

[Markell]

22 For an angle of view of about 45°

Size of Plate.	Dist. of Pinhole.	Diam. of Pinhole.
4¼ × 3¼	5	1/50
6½ × 4¾	8	1/45
8½ × 6½	10	1/40
10 × 8	12	1/35
15 × 12	18	1/30

Relative approximate exposures.

Diam. in inches	1/25	1/30	1/40	1/50
Relative exposure	1	1½	2½	4

Distance in inches.	5	8	10	12	15	18	20
Relative exposure	1	2½	4	5⅓	9	13	16

Brilliantly lighted Landscape

Diam. of Pinhole.	Distance from Plate.	Exposure
1/45	8 in	5 m
1/40	10	6
1/25	20	10-12 m

N.B. Camera should be level & plate perpendicular

To find the size of the object.

Multiply the size of the image by the distance of the object from the pinhole & divide by the distance of the plate from the pinhole.

To find the distance of an object

Divide the size of the object by the size of the image & multiply by the distance of the plate from the pinhole.

To find the angle of view — See Hardman's Table.

Focal length.	6	8	10	12	15 in	18 in
Plate 4¼	38°	29°	23°	20°	16°	13°
6½	55°	43°	35°	29°	23°	20°
7½	64°	50°	41°	35°	28°	23°

To find the distance from pinhole to plate for a required angle of view.

Look out the quotient corresponding to that angle divide the base of the plate by the quotient, & the result will be the necessary distance.

[Rothamley.]

Pinhole $\frac{1}{50}$ in at 6 in. focus = f/300

16² : 300² :: 1 s : 351 s } Pinhole of $\frac{1}{50}$ = 350 times
256 : 90,000 :: " : " } exposure of f/16.

f16 .. $\frac{1}{2}$ s .. 1 s .. 2 s
f300 .. 3 m .. 6 m .. 12 m

Rev. J. Perkins Table of Exposures

For aperture of f16 and for every second:-

Diam of Pinhole.	Distance from Pinhole to Plate. 8.	10.	12.	14.	16.	18.	20. in
0.02 in	10	16	24	32	41	52	64 min
0.03 "	5	8	12	16	20	26	32 "
0.04 "	2½	4	6	8	10	13	16 "

Photomniles Exposure Table [Warmald.]

Midday - 30 times plate. Sunshine.

Jan - Nov. 2½ m
Feb. - Oct 1½ m
Mar Sept. 1 m
Apl - Aug. 55 s
May - June July 45 s
Dec. . . 3 m

[Sun obscured, &
Sky light ×2
Cloudy. ×3
Dull. ×4 or 5.]

[Plate 60 times ×½]

Pinhole Portraiture

Bright sunshiny day. Rapid Plate. 30-60 s.

Advantages of Pinhole.

1. More artistic definition than with a lens.
2. Unlimited depth of focus.
3. Perfect perspective of lines in architecture.
4. Mathematical exactness in scale for plans.
5. Angle of view can include 170°.

References. Note Bk. IV. 116. 49.
Am. Phot. Ann. 92 p. 41

24 Capt. Colson's Formula. $f = d^2 \times .00081$

Diam of Hole	Dist best def. cm	Aug tab. Aperture	U.S. No of Aperture	Exposure with U.S. No 32 lens
$\frac{3}{10}$ mm.	11.11	f 370	8335	4' 27"
$\frac{4}{10}$	19.72	f. 493	15200	8' 0"
$\frac{5}{10}$	30.86	f 617	23793	12' 24"
$\frac{6}{10}$	44.44	f 741	34317	17' 55"

mm J. R. Dallmeyer's Formula. c.m

$\frac{3}{10}$	5.21	f 174	1892	1' 1"
$\frac{4}{10}$	9.26	f 232	3346	1' 45"
$\frac{5}{10}$	14.47	f 289	5220	2' 45"
$\frac{6}{10}$	20.35	f 336	7056	3' 45"

The results of the two are barely distinguishable.

$\frac{5}{10}$ m.m. nearly corresponds to $\frac{1}{50}$ inch. B. J. P. 5 July 1895.

1 m m = .03937 inch. 1 c.m = .3937 inch.

[From P. 20.]

1. Lenses to be paired.
2. Mounted horizontally.
3. Camera to be levelled horizontally by spirit level or plumb.

Rule a glass plate with parallel lines, $\frac{1}{4}$ in apart, for cutting base line & top. Lay a line on corresponding point in each picture & cut. Allow $2\frac{3}{4}$ - 3 in. in height.

Rule over the plate with lines $\frac{1}{8}$ in apart for cutting sides. Paste a piece of paper the same thickness as the paper print across the lower part of the glass at right angles to the sides, to use as a square at the bottom of the print. Note which line runs through some prominent point in the foreground. Allow $\frac{1}{8}$ in more on the side which comes nearest the centre of mount. Mark the prints at back R & L.

Mount with a space between the prints of $\frac{1}{16}$ in.

Maximum distance between objects in the foreground $2\frac{5}{8}$ to $2\frac{7}{8}$ in.

Stereoscopic relief of prints is greatly aided by accessories - as furniture &c.

Gelatine surface is most suitable.

Rough surface paper is not suitable.

To view a transparency which has not been mounted with a ground glass back, place a sheet of white paper, or grey tinted cardboard, in front at an angle of 45° to reflect the light.

Prints may be mounted in optical contact on waste plates & backed with opaque paper.

Use 2 grains sol. of Gelatine to P. O. P.

Reversing the negative to print both views on one sheet at the same time.

Place the negative face down on a blotter & cut in two through the centre of the clear strip in the middle, leaving one half of the same on each.

Draw on the blotter three parallel straight lines. 2 7/8 in apart & about 7 in long & mark them 1, 2, 3. Through the same draw cross lines at right angles 5 in apart & mark them A & B. Place the left negative (having the half of clear strip on the left side) over the left oblong formed by lines 1 & 2, A & B, the two latter forming a guide for the edge of the plate: placing the negative so that the lines 1 & 2 will form the edge of the limited view. Cut off very accurately the strip projecting beyond the line 2. Place the right negative in its place over the oblong formed by the lines 2, 3, A. B. Carefully replace the left negative in its old place & right edge forming line 2 & cut the left edge of the right negative.

NB. The right negative must occupy exactly the same relative position over the oblong as the left did. - the

objects on the right half near the line 2 must correspond to those near the line on the left half. Holding the left half firmly in its place, the right one is slid into its proper position & the strip projecting beyond the line 2 is cut off. The two halves may be mounted on glass - carefully cleaning both negatives & plate - by placing a minute quantity of Paper glue on top & bottom of the negatives. Take care it does not spread. The inner edges of the two halves must butt together. The negative should be matted as the central line is jagged. The mats may be pasted on the folio. Allow a strip of $\frac{1}{8}$ in to cover the centre.

[Communication Am.e 1894.]

Stereoscopic views.

Limitation of foreground is not so requisite, & proximity of objects in the foreground is not objectionable as in ordinary photographs of a landscape. The apparatus should be aimed horizontally, but if a strong elevation is necessary the person who has to look at the view should incline the stereoscope. - e.g. a monument. [Anthony. Am.e 1894.]

28 Marking the negative for Printing.
With a straight edge & a knife draw a
horizontal line for the top of the picture.
covering the film.
Select the object for the middle of the
print & measure from this in each
negative 1½ in toward the middle of
the plate & draw vertical lines at right
angles to the horizontal line
In order to mark the prints for mounting
draw an oblique line across the angle
inside
Trim the print by laying the edge of
a cutting shape (3½ × 3.) on the line.
The prints are mounted with marked
& cut corners on the upper outside
This saves on marking R & L, & shows the
print by its front instead of the back.
A vertical middle is recommended as
the best. Once laying out will answer
for any number of prints: the paper
can be cut nearer to the proper size
for printing. The prints are trimmed
in mounting, so that the picture taken
with the left hand lens is mounted
on the left hand end of the print.

Anthony. Bull. 1894

45

56

61.

62

64

Time in seconds which a body takes to fall

Inches	.0	.1	.2	.3	.4	.5
0.	0.	0.023	.036	.044	.046	0.057
1	.072	.075	.079	.082	.085	.088
2	.102					
3	.125					
4	.144					
5	.161					
6	.176					
7	.190					
8	.203					
9	.216					
10	.227					

Distance in inches which a body falls in seconds

Sec	Inches
.005	.0048
.050	0.478
.100	1.930
.125	3.017
.150	4.344
.200	7.723
.250	12.067

NEW HAMPSHIRE.

Littleton—CHISWICK INN.
White Mountains—PROFILE HOUSE.
Mt. Washington—SUMMIT HOUSE.

NORTH CAROLINA.

Hot Springs—MOUNTAIN PARK HOTEL.

ONTARIO.

Muskoka, Lake Joseph—THE STANLEY HOUSE.

PENNSYLVANIA.

Dingman's Ferry—HIGH FALLS HOUSE.
Sullivan Co—HOTEL EAGLESMERE.

VIRGINIA.

Luray—LURAY INN.

GEORGIA.

Savannah—HOTEL DE SOTO.

FLORIDA.

St. Johns—MAGNOLIA HOTEL.

STANDARD FORMULÆ AND USEFUL RECIPES.

ARRANGED BY CHARLES EHRMANN.

THE WET COLLODION PROCESS.

1.—NEGATIVE COLLODION.

Ether	½ ounce
Absolute alcohol	½ ounce
Pyroxyline	5 grains
Iodide ammonium	5 grains
Bromide of cadmium	2 grains

2.—NEGATIVE COLLODION.

Plain Collodion		*Sensitizer.*	
Alcohol	5 ounces	Alcohol	5 ounces
Ether	10 ounces	Iodide ammonium	60 grains
Pyroxyline	100 grains	Iodide cadmium	30 grains
		Bromide cadmium	20 grains

After being perfectly dissolved, mix.

3.—FERROTYPE COLLODION (ESTABROOKE'S).

Iodide of ammonium	30 grains
Iodide of sodium	10 grains
Iodide of cadmium	20 grains
Bromide of cadmium	20 grains
Ether and alcohol (of each)	5 ounces

Pyroxyline, sufficient quantity, say 25 grains.

4.—COLLODION FOR THE REPRODUCTION OF LINE WORK (VOLKMER'S).

Plain Collodion.		*Sensitizer.*	
Ether	500 grams	Chloride of calcium	1.6 grams
Alcohol	400 grams	Iodide ammonium	4.7 grams
Pyroxyline	16 grams	Iodide cadmium	7 8 grams
		Absolute alcohol	100.0 grams

After being perfectly dissolved, mix.

5.—SILVER BATH FOR WET-PLATES.

Nitrate of silver	1 ounce
Distilled water	10 ounces

Iodize and acidulate with nitric acid.

6.—SILVER BATH FOR WET-PLATES (LIESEGANG'S).

Distilled water	150 c.c.m.
Nitrate of silver	10 grams

If the bath fogs add a few drops of iodine solution (1 part iodine to 10 parts alcohol).

7.—SILVER BATH FOR LINE WORK.

Water	1 litre
Nitrate of silver	100 grams

Nitric acid, c. p., a few minims, to acid reaction.

To 1 litre of bath add 20 c.c.m. of the following solution:

Iodide potassium	6 grams
Iodine	1 gram
Water	500 c.c.m.

8.—Silver Bath for Ferrotypes (Estabrooke's).

Water	64 ounces
Nitrate of silver	4 ounces
Iodide potassium	2 grains

Dissolve, sun for three or four hours, filter and acidulate.

9.—Developer for Ferrotypes, by E. P. Griswold.

Water	64 ounces
Protosulphate of iron and ammonia	4 ounces
Acetic acid, No. 8	4 ounces
Yellow rock candy	½ ounce

10.—Developer for Wet-Plates.

Sulphate of iron and ammonia	1 ounce
Acetic acid	1½ ounce
Water	16 ounces

11.—Developer for Hard Negatives (Line Work), Wet-Plates.

Water	100 c c.m.
Protosulphate of iron	5 grams
Tartaric acid	1 gram

12.—Developer for Wet-Plates (Very Intense).

Water	1000 c c.m.
Protosulphate of iron	36 grams
Sulphate of copper	12 grams
Glacial acetic acid	50 c.c.m.
Alcohol	40 c.c.m.

13.—Developer for Wet-Plates.

Protosulphate of iron	1 ounce
Acetic acid	1 ounce
Water	16 ounces

14.—Intensifier for Wet-Plates.

Saturated solution of protosulphate of iron	20 c.c.m.
Acetic acid	10 c.c.m.
Citric acid	5 grams
Water	200 grams

And silver solution to suit.

15.—Intensifier for Wet-Plates.

Pyrogallic acid	1 gram
Citric acid	3 grams
Water	80 c.c.m.

And silver solution to suit.

16.—Intensifier for Line Work, Wet-Plates.

A.—Bromide of potassium	½ ounce
Water	4 ounces
B.—Sulphate of copper	½ ounce
Water	4 ounces

Mix equal parts of A and B and pour on the film. When perfectly whitened, blacken with solution of nitrate of silver, 30 grains to the ounce.

For greater intensity, use hydrosulphate of ammonia solution, 1 part in 4 parts of water, after the bromide of copper, and thorough washing.

17.—Intensifier for Wet-Plates.

Red prussiate of potash	2 drams
Nitrate of lead	3 drams
Water	12 ounces

Immerse the fixed negative till thoroughly whitened; wash, and flood with solution of hydrosulphate of ammonia (see No. 19).

18.—Intensifier for Wet-Plates.

Water	1 litre
Red prussiate of potash	50 grams
Nitrate of uranium	50 grams
Sugar	50 grams
Sulphuric acid	30 minims

19.—To Strip Collodion Negatives.

The best way to do this is to coat the negative, when dry, with a solution of pure rubber in benzole, and afterwards with leather collodion. When perfectly dry, the edges of the negatives may be cut in, and the plate immersed in a diluted acetic acid solution 1:10. After a short time the film loosens, and may easily be detached from the plate, and turned.

20.—To Rectify a Negative Silverbath.

Dissolve one part of permanganate of potassium in hundred parts of water and add drop by drop so much of this solution to the bath impregnated with organic matter, till after vigorously shaking a slight pinkish color remains.

Sun for several hours, filter and test for neutrality. Acidify with nitric acid.

DRY COLLODION PROCESSES.

21.—Collodio-Bromide Emulsion.

Ether, sp. g.: .720	5 fluid ozs
Alcohol, sp. g.: 820	3 fluid ozs
Pyroxyline	50 grains
Bromide of cadmium and ammonium	80 grains
(or bromide of zinc	76 grains)

Sensitize by adding to each ounce 15 grains of nitrate of silver, dissolved in a few drops of water and one dram of boiling alcohol. This is suitable for slow landscape work or transparencies.

22.—Washed Emulsion.

Ether, sp. g. .720	4 fluid ozs
Alcohol, sp. g. .820	2½ fluid ozs
Pyroxyline	40 grains
Castile soap dissolved in alcohol	30 grains
Bromide of ammon. and cadmium	84 grains

Sensitize with 100 grains of nitrate of silver dissolved in 1 ounce of boiling alcohol, and after standing ten days, add 20 grains more of silver, dissolved in 2 drams of alcohol.

For greater rapidity, use ¼ oz. more alcohol, and add at first only 54 grains of the double bromide of ammonium and cadmium; sensitize with 125 grains of nitrate of silver, dissolved as before in one ounce of boiling alcohol. In twelve hours' time add 30 grains more of the double bromide of ammonium and cadmium, dissolved in half an ounce of alcohol, and wash.

23.—Washed Emulsion for Transparencies.

Ether, sp. g. .720	5 fluid ounces
Alcohol, sp. g. .820	3 fluid ounces
Pyroxyline	60 grains
Bromide of cadmium and ammonium	100 grains
(or bromide of zinc	90 grains)
Hydrochloric acid, sp. g. 1.2	8 minims

Sensitize with 20 grains of nitrate of silver to the ounce, dissolved in a minimum of water with 2 drams of boiling alcohol. Allow to stand for two or three days.

The emulsion, after being allowed to ripen, should be poured into a dish and set aside to become thoroughly dry. The mass of dry emulsion is then washed, to remove all soluble salts, and is then again dried and re-dissolved in equal parts of ether and alcohol, at the rate of from 20 to 24 grains to the ounce of the solvents.

24.—DEVELOPER FOR COLLODION EMULSION.

A.—Pyrogallol.....96 grains
Alcohol..... 1 fluid ounce

B.—Bromide of potassium.....10 grains
Water..... 1 fluid ounce

C.—Liquor ammonia, sp. g. .880..... 1 fluid dram
Water.....15 fluid drams

or,

D.—Carbonate of ammonium..... 2 grains
Water..... 1 fluid ounce

For each dram of developer take for a normal exposure 5 minims of A, 1 or 2 minims of B, and 1 or 2 minims of C, or if D be used, add the above quantities of A, B and C to 1 dram of D. When the details of the image are out, add double the quantity of B and C.

25.—INTENSIFIER FOR COLLODION EMULSION NEGATIVES.

Nitrate of silver.....60 grains
Citric acid.....30 grains
Nitric acid.....30 minims
Water..... 2 ounces

To each dram of a solution of pyrogallol, three grains to the ounce, add 2 or 3 minims of the above, and apply until sufficient density is secured.

ALBUMEN PROCESSES.

26.—GOBERT'S ALBUMEN PROCESS.

Albumen from fresh eggs..... 26 drams
Iodide of ammonium..... 15 grains
Bromide of potassium..... 4 grains
Iodine in pellets..... 4 grains

Sensitize in

Distilled water..... 4 ounces
Nitrate of silver.....155 grains
Glacial acetic acid..... 2½ drams

Albumen plates are developed with saturated solution of gallic acid with a few drops of aceto-nitrate of silver solution (1 to 30).

27.—WHIPPLE & BLACK'S ALBUMEN HONEY PROCESS.

Albumen..... 8 ounces
Honey..... 7 ounces
Iodide of potassium..... 3 drams
Bromide of potassium.....20 grains
Chloride of sodium.....10 grains
Water..... 2 ounces

Sensitize in bath of the following proportions—

Nitrate of silver..... 1 ounce
Water.....10 ounces
Acetic acid.....8 to 10 drams

For development, see above (No. 26).

GELATINE DRY-PLATE PROCESSES.

28.—W. K. BURTON'S GELATINE EMULSION.

A.—Bromide of ammonium.....260 grains
Iodide of potassium..... 20 grains
Gelatine (Nelson, No. 1)..... 80 grains
Distilled water..... 10 ounces

B.—Silver nitrate (dry).....200 grains

C.—Silver nitrate.....200 grains
Distilled water..... 1 ounce

Converted to ammonia-nitrate.

D.—Gelatine, hard (dry).....600 grains

For detailed directions for making the emulsion, see PHOTOGRAPHIC TIMES, Vol. XVII, page 285.

29.—BURBANK'S GELATINE EMULSION.

Water ..... 1 ounce
Bromide of ammonium ..... 15 to 20 grains
or,
Bromide of potassium ..... 18 to 25 grains
Nitrate of silver, proportioned to the amount of bromide ..... 25 to 30 grains
Gelatine ..... 30 to 40 grains

See Burbank's "The Photographic Negative," pages 87–109.

30.—HENDERSON'S GELATINE EMULSION BY AMMONIA METHOD.

In distilled water ..... 8½ ounces

dissolve

Bromide of ammonium ..... 308 grains
Gelatine (previously swelled) ..... 50 grains

When cold add

Water ..... 1½ ounces
Alcohol ..... 1½ ounces
Stronger ammonia ..... ½ ounce
In distilled water ..... 3½ ounces

dissolve by heat

Nitrate of silver ..... 462 grains

and add gradually to the gelatine solution. Ripening for twenty-four hours gives sensitiveness to the emulsion. Add, finally, 220 grains of swelled gelatine.

31.—GEORGE W. FOWLER'S GELATINE EMULSION.

A.—Bromide of potassium ..... 84 grains
Iodide of potassium ..... 4 grains
Muriatic acid ..... 1 drop
Gelatine ..... 36 grains
Distilled water ..... 4 ounces

B.—Nitrate silver ..... 108 grains
Distilled water ..... 2 ounces

C.—Gelatine (hard) ..... 100 grains

Water to cover, used merely to soften the gelatine.

32.—DR. J. M. EDER'S GELATINE EMULSION WITH AMMONIO-NITRATE OF SILVER.

In distilled water, 10 ounces, dissolve bromide of potassium, 370 grains; add gelatine, 617 grains, previously swelled in water. In distilled water, 10 ounces, dissolve nitrate of silver, 462 grains.

To this solution, cold, add stronger ammonia, drop by drop, until the precipitate first formed is re-dissolved. Add this gradually to the first solution, and place in a water bath at a temperature of 105 deg. Fahr., for 30 to 45 minutes. Then remove the source of heat, and allow the emulsion to cool down gradually to about 75 deg. Fahr., then pour out to set, and proceed as usual.

DEVELOPING FORMULÆ FOR GELATINE DRY-PLATES.

33.—SODA-POTASH DEVELOPER FOR GELATINE DRY-PLATES.—J. CARBUTT.

A.—Distilled or ice water ..... 10 ounces
Sulphite of soda crystals ..... 4 ounces

Dissolve and add slowly

Sulphuric acid ..... 1 dram
Pyrogallol ..... 1 ounce
Water to make up to 16 fluid ounces.

B.—Water ..... 10 ounces
Carbon. of potass., ch. pure ..... 2 ounces
Carbon. of soda, granulated ..... 2 ounces

N. B.—During summer add thirty grains of bromide of potassium to A; for portraits or instantaneous work, to four ounces of water add three

drams of A and two drams of B. More of B to be added if under-exposed, and more of A, with a few drops of a 10 per cent. solution of bromide of potassium, if over-exposed.

34.—CARBUTT'S IMPROVED DEVELOPER FOR TRANSPARENCIES.

A. Oxalate of potash..... 8 ounces
Water.....30 ounces
Citric acid.....60 grains
Citrate of ammonia solution..... 2 ounces

B. Sulphate of iron..... 4 ounces
Water.....32 ounces
Sulphuric acid.....16 drops

C. Citrate of ammonia solution.

Dissolve one ounce citric acid in five ounces distilled water, add liquor ammonia until a slip of litmus paper just loses the red color, then add water to make the whole measure eight ounces.

Developer.—Add one ounce of B to two of A, and one-half ounce of water, and three to six drops of bromide solution.

Let the development continue until the blacks look quite strong, and detail plainly showing in the high lights; wash off developer thoroughly before fixing, use fresh hypo solution, when fully cleared, wash for half hour, then immerse five minutes in the hardening solution given below; afterwards wash for half hour, then carefully go over surface with soft camel's-hair brush, or pledget of cotton, to remove any particles of dirt; place in rack to dry. Then varnish with plain collodion:

Collodion Varnish.

Alcohol..... 4 ounces
Pyroxyline.....30 to 40 grains
Sulphuric ether..... 4 ounces

When, after shaking, the cotton is dissolved, filter and flow the plain collodion over the dry transparency, the same as when using varnish; when dry, cover with matt and a crystal cover glass, and bind with binding strip.

Hardening and Clearing Solution.

Water.....36 ounces
Chrome alum..... ½ ounce
Citric acid..... ½ ounce

Three to five minutes, then wash and place in the

Fixing Solution.

Hyposulphite of soda..... 8 ounces
Water.....40 ounces

35.—SODA DEVELOPER FOR GELATINE DRY-PLATES (CARBUTT'S "ECLIPSE" FORMULA).

No. 1 Pyro Stock Solution.

A. Distilled or ice-water.....10 ounces
Sulphuric acid..... 1 dram
Sulphite of soda crystals..... 4 ounces

Then add Schering's pyro, one ounce, and water to make sixteen fluid ounces.

No. 2 Stock Soda Solution.

B. Water.....10 ounces
Sulphite of soda crystals..... 2 ounces
Carbonate of soda crystals..... 2 ounces
(or dry granular, one ounce)
Potash carbonate..... 1 ounce

Dissolve and add water to make measure sixteen fluid ounces.

For large galleries, dilute with water to proportion of ten ounces of No. 2 to seventy ounces of water to make eighty fluid ounces for winter use, testing 5 deg. Beaumé, and to 100 to 120 fluid ounces for summer testing 3½ deg. to 4 deg. Beaumé and label "Dilute Soda Solution."

No. 3 Bromide Solution.

C.—Bromide of sodium or potassium.....½ ounce
Water.....5 ounces

Developer.—Dilute sufficient of B to meet the requirement for the day's work, or the number of plates to be developed, by adding eight ounces of water to two ounces of stock B. To three ounces of dilute B, add 1½ to 2½ drams of A. The more pyro the denser the negative, and *vice versa*. One and one-half dram A to above quantity of B dilute, has been found to yield portrait negatives of perfect quality and quick printers. If restraining becomes necessary, use a few drops of No. 3. No yellowing or fogging need be apprehended, if directions are followed. After developing, wash and immerse negatives in the

Hardening and Clearing Bath.

Chrome alum.....½ ounce
Citric acid.....¼ ounce
Water.....36 ounces

for not less than two minutes, wash under tap and place in

Fixing-Bath.

Hyposulphite of soda.....8 ounces
Water.....40 ounces

The weight used in this formula is the avoirdupois ounce of 437½ grains.

36.—Manipulation of Carbutt's Flexible Films.

First lay film in water in tray for half a minute or so, then develop, fix, and wash precisely as for glass dry plates; after washing, lay for five minutes in water 25 ounces, glycerine 1 ounce, pass rapidly through clear water, then hang up by spring clip to dry.

37.—Formulæ and Directions for Working the Cramer Plate of High Sensitiveness.

Alkaline Solution.

Sulphite of sodium crystals.....6 ounces
Carbonate of sodium crystals (sal soda).....1¼ ounces
Water.....64 ounces

The alkaline solution, as well as the sulphite of sodium, must be kept in well-stoppered bottles. If old and decomposed it will cause yellow stains.

If dried or granular sulphite of sodium is used, 3 ounces will be found equal to 6 ounces crystals.

Twelve drams carbonate of sodium crystals (sal soda) are equivalent to 5 drams carbonate of sodium dried or 6 drams carbonate of potassium.

Pyro Solution.

Distilled or pure ice-water.....6 ounces
Sulphuric acid.....15 minims
Sulphite of sodium crystals.....1 dram

After this is dissolved add

Pyrogallic acid.....1 ounce

The solution should have a bright yellow color and smell like burning sulphur, owing to the liberation of sulphurous acid, which preserves the pyro.

Developer.—During cold weather use 8 ounces alkaline solution and 2 to 5 drams pyro solution; keep moderately warm (about 70 degrees Fahrenheit).

In hot weather add to 4 ounces alkaline solution, 6 ounces cold water and from 2 to 4 drams pyro solution, and keep it cool (below 60 degrees Fahrenheit).

Developer which is too warm or contains too much carbonate of soda or potassium will work foggy.

Three drams pyro solution will generally be found sufficient for 8 ounces developer to produce good intensity if the plates are not over-exposed and if the development is carried on far enough.

The developer can be used repeatedly.

When fresh it answers best for short exposures.

After having been used once or twice it will work with more contrast and clearness. Therefore it is well to add a little old developer to the new. For over-exposed plates old developer should be used, and if much over-exposed, restrain by adding to the developer a few drops of bromide solution (1 ounce bromide of potassium to 10 ounces of water).

An under-exposed plate should be treated with diluted developer, weak in pyro, for instance: 4 ounces alkaline solution, 1 dram pyro solution and 8 ounces of water; use plenty of solution, keep it cool and change it several times if the exposure has been so short as to require prolonged development.

Fixing Bath.

Hyposulphite of soda.....1 pound
Water.....1 gallon

Do not expose the plate to light before it is fixed, and leave it in the bath a few minutes longer than apparently necessary, to insure thorough fixing.

To prevent yellow staining of negatives it is of the utmost importance to renew the hypo bath as soon as the solution turns dark.

After fixing place the negative in dish containing cold alum solution. Let it remain about fifteen minutes to harden the film, then wash thoroughly.

In hot weather, when there is danger of frilling or softening of the film, use the following:

Fixing Bath for Hot Weather.

Dissolve

Hyposulphite of soda.....2 pounds
Bicarbonate of soda.....½ pound
Powdered alum.....2 pounds

in 2 gallons of water.

Allow to stand a couple of days until settled, then decant the clear solution for use. This bath will fix somewhat slower than the plain hypo bath, but will produce very clear negatives and will harden the film so thoroughly as to allow subsequent washing without the use of ice. It should be used in tropical climates.

38.—Potash Developer for Gelatine Dry-Plates (Beach's Formula).

A.—*Pyro Solution.*

Warm distilled water.....2 ounces
Sulphite of soda.....2 ounces

Dissolve, and when cold add

Sulphurous acid.....2 ounces
Pyrogallol.....½ ounce

B.—*Potash Solution.*

1.—Water.....4 ounces
Carbonate potash, c. p.....3 ounces
2.—Water.....3 ounces
Sulphite soda.....2 ounces

Combine 1 and 2 into one solution.

For a shutter exposure take three ounces water, half ounce A, and three drams B, increasing the latter to five drams if the image hangs back

For over-exposure, three ounces water, three drams A, one dram B, adding more if necessary.

39.—POTASH DEVELOPER FOR GELATINE DRY-PLATES (DR. STOLZE'S).

Modified by Dr. Eder.

A.—Water	200 c.c.m.
Carbon of potass, c. p.	90 grams
Sulphite of soda	25 grams
B.—Water	100 c.c.m.
Sulphite of soda	25 grams
Pyrogallol	12 grams

Mix 40 minims of A with 50 minims of B and 100 c.c.m. of water.

Bromide of potassium should be used only in minimal quantities, one to three minims (of a ten per cent. solution); with more, the general sensitiveness is much reduced.

An alum bath mixed with an equal volume of saturated sulphate of iron solution increases the density, and gives the plate a good printing quality.

40.—DEVELOPER WITH SULPHITE OF AMMONIUM, FOR GELATINE DRY-PLATES.

A.—Water	350 c.c.m.
Sulphite of ammon	70 grams
Pyrogallol	25 grams
B.—Water	200 c.c.m.
Bromide of ammon	8 grams
Ammonia	80 c.c.m.

Take 1 c.c.m. of each and 35 c.c.m. of water.

41.—POTASH DEVELOPER FOR "HARVARD" DRY-PLATES.

A.—Distilled water	12 ounces
Sulphite of soda (crystals)	2 ounces
Citric acid	60 grains
Bromide of ammonium	25 grains
Pyrogallic acid	1 ounce

Dissolve separately, mix in order named and filter.

B.—Distilled water	12 ounces
Sulphite of soda (crystals)	2 ounces
Carbonate of potash	4 ounces

Dissolve separately, mix and filter.

The stock solutions must be kept in well stoppered bottles, The pyro stock solution will remain clear and in good order for about a month. It should not be used after it has turned dark and muddy from age.

To develop, mix A, one dram; B, one dram; water, two ounces. For detail, add more water; for contrast, more A; for density, more of each A and B. For instantaneous or short exposures use double the quantity of water (4 oz.) to begin with, pour off when about half developed and finish with developer, full strength.

After development, and before fixing, it is well to flow the negative with a saturate solution of alum. Rinse, and fix in the following solution:

Hyposulphite of soda	1 pound
Water	2 quarts

Many prefer to add alum to the fixing solution (about one ounce to the above), to which there is no serious objection, provided, always, it is filtered occasionally.

42.—DEVELOPER FOR IVORY FILMS.

Soda Developer.

STOCK SOLUTION.

Water	10 ounces
Sulphite Soda (Crystals)	2 ounces
Sal Soda (Crystals)	2 ounces
Bromide Potassium	30 grains

For use add to 5 ounces water, 1 ounce stock solution, 12 grains pyrogallic acid.

Ammonia Developer.

STOCK SOLUTION.

Water	4 ounces
Sulphite Soda	180 grains
Bromide potassium	180 grains
Liquor Ammonia (.880)	5 drams

For use add to 6 ounces water, 1 dram stock solution and 12 grain pyrogallic acid.

Immerse in water bebore developing,

NOTE.—Remember that pyro gives the strength, and the alkali the detail ; so that more time given the less alkali is needed.

Should the film be over-exposed, add as soon as possible to the developer a few drops of 60-grain solution bromide potassium.

43,—DEVELOPER FOR ALLEN AND ROWELL'S IVORY FILMS.

A.—Sulphite of Soda, cryst	6 ounces
Carbonate of soda	2½ ounces
Water	64 ounces
B.—Water	8 ounces
Sulphuric acid	20 drops
Sulphite of soda, cryst	2 ounces
Pyrogallic acid	1 ounce

Take one ounce of A end one dram of B. Restrain with bromide of potassium.

44.—SODA-POTASH DEVELOPER FOR GELATINE DRY-PLATES (NEW YORK AMATEUR CLUB).

Ferro-cyanide potassium	1½ ounces
Carbonate of potassium	1½ ounces
Gran. carbon. of sodium	1 ounce
Cryst sulphite sodium	2 ounces
Hot distilled water	10 ounces

45.—SODA DEVELOPER IN ONE SOLUTION FOR GELATINE DRY-PLATES (EDER'S FORMULA).

Crystal sulphite of soda	5 drams
Crystal Carbonate of soda	2½ drams

Dissolve in 2 ounces of boiled distilled water, and after having cooled down add 46 grains of pyro. Keep in well stoppered bottles, and for use dilute with 5 times its bulk of water.

46.—SODA DEVELOPER FOR GELATINE DRY-PLATES (COOPER'S FORMULA).

A.—Sulphite of soda, cryst	6 ounces
Distilled water	1 quart

When dissolved, add

Pyrogallol	1 ounce
B.—Carbonate of soda, pure, cryst	4 ounces
Water	1 quart

Take equal parts of A, B, and water. Restrain with bromide of potassium one ounce to water six ounces.

47.—FERROUS-OXALATE DEVELOPER FOR GELATINE DRY-PLATES (DR. EDER'S).

A.—Neutral oxalate potassium.....200 parts
Distilled water.....800 parts

Acidulate with oxalic acid.

B.—Proto-sulphate of iron, cryst.....100 parts
Distilled water.....800 parts
Sulphuric acid..... 5 minims

C.—Bromide of potassium..... 10 parts
Distilled water.....100 parts

D.—Hyposulphite of soda..... 2 parts
Distilled water.....200 parts

Mix immediately before use three parts of A with one part of B, and develop. Restrain with a few drops of C.

For over-exposure take less of the iron solution, and add gradually in small portions, as required. To give the negative body use C.

To make soft negatives with fine details, take of

A.....2½ ounces
B..... ½ ounce
C.....4 minims
D.....6 minims

Plates giving with ordinary developer hard and glassy negatives, give with this modification very satisfactory results.

48.—HYDROCHINON DEVELOPER, CRAMER'S.

A.—Sulphite of soda.....480 grains
Phosphate of soda.....160 grains
Water..... 8 ounces

Dissolve, filter, and add

Hydrochinon.....100 grains
B.—Carbonate of soda.....480 grains
Phosphate of soda.....160 grains
Water..... 8 ounces

Mix equal parts of A and B.

49.—HYDROCHINON DEVELOPER, MÜLLER.

A.—Water.....10 ounces
Sulphite of soda, cryst..... 6 drams
Carbonate of potassium..... 6 drams

B.—Hydrochinon..... 1½ drams
Water..... 1 ounce
Alcohol..... 1 ounce

Mix one ounce of A with one dram of B.

50.—HYDROCHINON DEVELOPER, WITH LIME WATER, FOR GELATINE DRY-PLATES.

Lime water.....10 ounces
Sulphite of soda..... ½ ounce
Sugar..... ½ ounce

To three ounces of this solution add four grains of hydrochinon.

51.—"CHAUTAUQUA" DEVELOPER WITH EIKONOGEN IN TWO SOLUTIONS.

A.—Eikonogen.....128 grains
Crystalized sulphite of sodium..... ..... 1 ounce
Dissolve in warm water.... ..... 16 ounces

B—Crystallized carbonate of sodium..... 1½ ounce
Water..... 10 ounces

For normal exposures take three parts of A and one part of B. To prevent intensity add a few drops of a 10 per cent. solution of bromide of potassium.

52.—"CHAUTAUQUA" DEVELOPER WITH EIKONOGEN. (In one solution for instantaneous work.)

Eikonogen.....120 grains
Crystallized sulphite of sodium..... 1½ ounce

Dissolve in 8 ounces of hot water and add carbonate of potassium 120 grains.

For use dilute with an equal bulk of water and add a few drops of a 10 per cent. solution of bromide of potassium.

53.—"CHAUTAUQUA" DEVELOPER, WITH AMMONIA, FOR GELATINE DRY-PLATES.

A.—Bromide ammonium..... .... ½ ounce
Water..... .... 8 ounces

B.—Aqua ammonia..... 1 ounce
Water..... ..... 7 ounces

C.—Pyrogallol .. .. 1 dram
Nitric acid..... 5 minims
Water.....12 ounces

Take for correct exposure of A forty minims, of B twenty minims, of C half ounce, and two ounces of water.

54.—"CHAUTAUQUA" DEVELOPER, WITH CARBONATE OF SODA, FOR GELATINE DRY-PLATES.

A.—Dissolve three ounces of granulated sulphite of soda, and one-quarter of an ounce of meta-bisulphite of potassium in thirty-two ounces of distilled water and add one ounce of pyrogallic acid.

Keep in well stoppered bottles.

B.—Dissolve eight ounces of granulated, or sixteen ounces of crystallized carbonate of soda (common washing soda) in water enough to make a bulk of thirty-two ounces.

Mix one ounce of water with one dram of A, add a few drops of B, and increase gradually till development proceeds regularly. If necessary, restrain with 10 per cent. solution of bromide of potassium.

55.—"CHAUTAUQUA" DEVELOPER, WITH CARBONATE OF POTASSIUM, FOR GELATINE DRY-PLATES.

A.—Water.....12 ounces
Pyro.. .... 1 ounce
Sulphite of soda, granulated..... 2 ounces
Bromide potassium..... .....80 grains
Citric acid..... .....60 grains

B.—Water ..... 12 ounces
Sulphite of soda, granulated ..... 1 ounce
Carbonate of potash ..... 3 ounces

One dram of each, A and B, to one ounce of water, makes the developing solution.

56.—Ferrous Oxalate.

For bromide prints and transfers see 47.

57.—"Chautauqua" Developer, with Hydrochinon, for Gelatine Dry-Plates.

A.—Hydrochinon ..... ½ ounce
Sulphite of soda, granulated ..... 1 ounce
Meta-bisulphite of potassium ..... 30 grains
Water ..... 16 ounces

B.—Carbonate potash ..... 1½ ounce
Water ..... 16 ounces

Take equal parts for normal exposures. For over or under-exposures proceed as with pyro. Bromides do not restrain the action of hydrochinon.

58.—The Acid Fixing and Clearing Bath.

Add 2 ounces of S. P. C. Clarifier (acid bisulphite of sodium) to 1 quart of hypo solution 1 : 5.

59.—Combined Alum and Hypo Bath.

Add saturated solution of sulphite of sodium to saturated solution of alum till the white precipitate formed remains undissolved, and when the odor of sulphurous acid becomes perceptible.

Mix this solution with an equal bulk of freshly prepared hypo solution 1 : 5 and filter.

This bath will remain clear.

60.—Clearing Solution (Edward's).

Alum ..... 1 ounce
Citric acid ..... 1 ounce
Sulphite of iron ..... 3 ounces
Water ..... 20 ounces

This should be freshly mixed.

61.—Clearing Solution ("Chautauqua").

Alum ..... 1 ounce
Citric acid ..... ½ ounce
Water ..... 15 ounces

62.—Belitzki's Method to Remove the Last Traces of Hypo.

Chloride of lime ..... 20 grams
Water ..... 1 litre

Add to the milky liquid

Sulphite of zinc ..... 40 grams

dissolved in from 80 to 100 parts of water, shake well and decant:

The clear, supernatant solution of hypochlorite of zinc is kept in well-closed bottles; one part of it mixed with sixty parts of water will remove the last traces of fixing soda.

The solution remains active as long as it smells of hypochlorous acid.

63.—To Remove Hypo from Films.

A solution of bromine in water, of a light cherry color, destroys the hypo in a gelatine film.

64.—Intensifier, with Mercury and Ammonia, for Gelatine Dry-Plates.

Pour over the well-washed negative a saturated solution of mercuric chloride; do not keep it on too long, unless the negative is very thin. Wash well, and immerse in bath of

Water	10 ounces
Ammonia	10 minims

Leave the plate in this solution until the black color goes quite through the film. Wash well.

65.—Intensifier (Mercuric) with Sodium Sulphite, for Gelatine Dry-Plates.

Whiten the negative in a saturated solution of mercuric chloride, wash and blacken with a solution of sulphite of sodium 1 : 5. Wash well.

The reduction is perfect, with a positive black tone.

66.—Intensifier with Iodide of Mercury.

Dissolve 1 dram of bichloride of mercury in 17 ounces of water and 3 drams of iodide of potassium in 3 ounces of water, and pour the iodide solution into the mercury till the red precipitate formed is completely dissolved.

For use, dilute with water, flow over the negative till the proper density is reached and wash, when the deposit will turn yellow. Remove the yellow color by flowing a 5 per cent. solution of hypo over the plate, and give it the final washing.

67.—Intensifier for Gelatine Dry-Plates with Mercuric Chloride and Hydrochinon (Dr. Mallman).

After whitening in the saturated solution of mercuric chloride, as usual, treat with an old hydrochinon developer; the result is a bluish-black intensification, which is applicable to positives as well as negatives.

68.—Intensifier, with Cyanide of Silver, for Gelatine Dry-Plates.

Mr. J. E. Thompson gives the following: After fixing and washing the plate well, place it in a solution of

Bichloride of mercury	10 grains
Chloride of ammonium	10 grains
Water	1 ounce

for a few seconds, until it bleaches. Then wash and place in a bath of cyanide of silver until it blackens, made as follows:

Cyanide of potassium	2 ounces
Distilled water	48 ounces
Nitrate of silver	1 ounce
Distilled water	6 ounces

Pour the silver gradually into the cyanide, stirring with a glass rod. The quantities given are about right to form a precipitate which will redissolve afterwards. To be used when a few days old.

69.—Dr. Eder's Collodion Intensifier Modified for Gelatine Films. By E. Vogel, Jr.

The compound recommended is as follows:

Nitrate of lead	2 drams
Ferricyanide of potassium	3 drams
Water	12½ ounces
Glacial acetic acid	1 to 1½ ounces

The negative deposit assumes in this bath the well-known grayish-white color. To darken it the plate must first be washed for a reasonable time in pure water, and then treated in various ways according to the character of the negative.

For half-tone negatives the gray deposit may first be rendered blue by immersing the plates in a solution of ferric-chloride, which color gives place to a brownish-yellow when immersed in dilute ammonia.

To reproductions in lines a high density is given with permanganate of potassium, or by chromate of potassium, with ammonia cupric chloride, etc.

With permanganate a dark-brown is obtained. With bichromate of potassium and ammonia the plate turns yellowish-red, and with cupric chloride browish-red.

70.—Intensification of Gelatine Dry-Plates with Uranium.

The washed plate should be flooded with a one per cent. solution of uranium nitrate, which should be allowed to remain on the plate for about half a minute or so, and then poured back into the measure, into which a few drops of a two per cent solution of potassium ferricyanide has previously been added. The mixed solution are then poured over the plate, and if sufficient intensity is not obtained, more potassium ferricyanide may be added.

Add a few minims of glacial acetic acid.

71.—Reducer for Gelatine Dry-Plate Negatives (Farmer's).

Sat. sol. of ferricyanide of potassium	1 part
Hyposulphite of soda solution, 1.5	10 parts

72.—Reducer for Gelatine Dry-Plates (J. Bartlett's).

Perchloride of iron	30 grains
Citric acid	60 grains
Water	1 pint

73.—Reducer with Bichromate, for Gelatine Dry-Plates.

Bichromate of potassium	10 grains
Hydrochloric acid	10 minims
Water	1 ounce

74.—Belitski's Acid Ferri-Oxalate Reducer for Gelatine Plates.

Water	7 ounces
Potassium ferric oxalate	2½ drams
Crystallized neutral sulphite of sodium	2 drams
Powdered oxalic acid, from	30 to 45 grains
Hyposulphite of soda	1½ ounces

The solution must be made in this order, filtered, and be kept in tightly-closed bottles; and as under the influence of light the ferric salt is reduced to ferrous, the preparation must be kept in subdued light.

75.—To Reduce Intensity of Negatives.

Rub the parts to be reduced with a soft rag moistened with alcohol, till

the density is softened down. For sharply defined outlines use a pointed stick of soft wood dipped in alcohol.

The method may be well applied for the brightening up of flare spots and halation marks.

ORTHOCHROMATIC METHODS BY BATHING.

76.—ORTHOCHROMATIC DRY-PLATES—F. IVES' CHLOROPHYLL AND EOSINE PROCESS.

Use any good bromide collodion emulsion that contains no free nitrate of silver. Flow plate as usual, and as soon as the emulsion film sets, flow several times with strong alcoholic solution of chlorophyll from blue myrtle, or plantain leaves, then immerse in water strongly tinted with blue shade eosine, and keep in motion until smooth.

Sensitizes for all colors, including deep ruby red; a very light-yellow screen is sufficient to secure correct rendering of color-tone.

77.—ORTHOCHROMATIC DRY-PLATES—V. SCHUMANN'S CYANINE BATH.

Soak the plate in 200 c.c.m. of water and 2 to 4 c.c.m. of ammonia for two to three minutes, then immerse in

Distilled water	200 c.c.m
Alcohol	10 c.c.m
Ammonia	4 c.c.m
Alcoholic solution of cyanine, 1:500	10 c.c.m

78.—ORTHOCHROMATIC DRY-PLATES—DRS. MALLMANN AND SCOLIK'S ERYTHROSINE BATH.

Preliminary Bath.

A.—Water	200 c.c.m
Ammonia	2 c.c.m

Soak the plate for two minutes.

Color Bath.

Erythosine solution, 1.1000	25 c.c.m
Ammonia	4 c.c.m
Water	175 c.c.m

The plate should not remain longer in this bath than one and a quarter minutes. A longer time depresses the general sensitiveness.

79.—ORTHOCHROMATIC DRY-PLATES—STANDARD CHINOLINE SOLUTION—DRS. MALLMANN AND SCOLIK.

Alcohol	500 c.c.m
Chinoline red	1 gram

To which are added 50 c.c.m. of a solution of

Alcohol	500 c.c.m
Chinoline blue (cyanine)	1 gram

The above solution is identical with the liquid dye sold under the name "Azaline."

80.—ORTHOCHROMATIC DRY-PLATES, "CHAUTAUQUA" CHINOLINE BATH.

Soak the plate, the emulsion of which should contain but little iodide of silver, for 150 seconds in

Water	6 ounces
Ammonia	30 drops

And color in

Standard chinoline solution	2 drams
Water	32 ounces
Ammonia	1 dram

81.—OBERNETTER'S METHOD WITH NITRATE OF SILVER.

Distilled water	480 c.c.m.=14 ounces 1½ dram
Nitrate of silver	1.25 grams=20 grains
Ammonium carbonate	5 grams=1 dr. 11 grains
Erythrosine solution (1:500)	35 c.c. m=1¼ ounce
Aqua ammonia	4 c.c.m.=1 dr. 8 minims

Bathe the plate in the preliminary solution (see No. 78) for 150 seconds. Without washing flow the sensitizing solution over the plate twice, and dry in the dark closet.

82.—TO PREPARE YELLOW GLASS SCREENS.

Take of crushed (not powdered) curcuma root two ounces, and macerate in ten ounces of alcohol for three days. After filtering the tincture, mix with an equal bulk of ether, and add to each ounce of the mixture six grains of gun cotton.

With this collodion coat a plane parallel glass plate, which must be perfectly white, thin, and without any curvature.

VARNISHES.

83.—NEGATIVE VARNISH.

Sandarac	4 ounces
Alcohol	24 ounces
Oil of lavender	3 ounces
Chloroform	5 drams

84.—NEGATIVE VARNISH.

White hard varnish (see No. 85)	15 ounces
Alcohol	25 ounces

This will be found a good and cheap varnish if durability is not required, as it is easily rubbed up for retouching upon and easily cleaned off. Very suitable for enlarged negatives that are not to be retained.

85.—NEGATIVE VARNISH.

Tough, hard and durable.

Shellac	1½ ounces
Mastic	½ ounce
Oil of turpentine	½ ounce
Sandarac	2½ ounces
Venice turpentine	½ ounce
Camphor	20 grains
Alcohol	20 fluid ounces

86.—NEGATIVE VARNISH.

Sandarac	90 ounces
Turpentine	36 ounces
Oil of lavender	10 ounces
Alcohol	500 ounces

87.—STANDARD PHOTOGRAPHIC VARNISH.

White shellac	8 ounces
Orange shellac	4 ounces
Sandarac	1 ounce
Alcohol	60 ounces

88.—RETOUCHING MEDIUM.

Gum Damar	70 grains
Yellow resin	6 drams
Spirits of turpentine	4 ounces

89.—NEGATIVE RETOUCHING VARNISH.

Sandarac	1 ounce
Castor oil	80 grains
Alcohol	6 ounces

First dissolve the sandarac in the alcohol, and then add the oil.

90.—GROUND-GLASS VARNISH.

Sandarac	90 grains
Mastic	20 grains
Ether	2 ounces
Benzole	½ to 1½ ounces

The proportion of the benzole added determines the nature of the mat obtained.

91.—ENCAUSTIC PASTE.

Pure wax	500 parts
Gum elemi	10 parts
Benzole	200 parts
Essence of lavender	300 parts
Oil of spike	15 parts

PRINTING AND TONING ON ALBUMENIZED OR PLAIN PAPER.

92.—THE SILVER PRINTING BATH.

Silver nitrate	50 grains
Water	1 ounce

93.—MODIFIED SILVER BATH.

Silver nitrate	50 grains
Ammon. nitrate or magnesium nitrate	50 grains

To secure a neutral state of the bath a little carbonate of silver should be kept at the bottom of the stock bottle.

94.—TO MAKE SENSITIZED ALBUMEN PAPER DURABLE.

1—Sensitize in the following bath :

Nitrate of Silver	1 ounce
Citric acid	1 ounce
Alcohol	1 ounce
Water	12 ounces

or,

2.—Sensitize the paper in the usual bath, drain well, and when superficially dry float the back of the paper for 20 minutes on a solution of

Citric acid	1 ounce
Water	30 ounces

or,

3.—Sensitize as usual, drain well and wash the paper in 3 or 4 changes of water then float the back on a solution of

Nitrite of potassium	5 ounces
Water	100 ounces

When dry roll the paper up, coated side out and wrap in blotting paper soaked in the Nitrite of potash solution and dried.

95.—TONING BATH (SPAULDING'S).

Stock Solution.

Water	15 ounces
Gold chloride	15 grains

To make up a toning bath for twenty cabinet size prints, tak

Water	10 ounces
Soda bicarbonate	3 grains
Common salt	6 grains
Stock solution of gold	3 ounces

96.—THE PRICE TONING FORMULA.

Into seven and a half ounces of water dissolve fifteen grains chloride of gold and sodium, then add to it 300 grains of acetate of soda and seven drops of a saturated solution of chloride of lime.

This stock solution should be prepared at least twenty-four hours before being used. Take half ounce of it and mix with seven ounces of water.

97.—THE PHOTOGRAPHIC TIMES TONING BATH.

Into seven and a half ounces of water put seven and a half grains chloride of gold and sodium. Lable the bottle containing the mixture: *Chloride of gold solution.* Combine six ounces of water with *one ounce of French azotate*, to which add one and a half ounces of the chloride of gold solution.

98.—THE CHAUTAUQUA TONING BATH.

Dissolve fifteen grains of chloride of gold and sodium in fifteen ounces of water. Take of this solution three ounces, pour it in the toning dish, test for acidity with litmus paper, and *neutralize* with bicarbonate of soda, and add thirty grains of acetate of soda and thirty ounces of water. Prepare the solution an hour before using it.

If warm tones are wanted add a little acetic acid to the last washing water.

For this bath the sensitizing silver should be neutral, for which purpose a small portion of carbonate of silver should be kept in the silver stock bottle.

99.—CHARLES W. HEARN'S TONING BATHS.

With Sal Soda.

Distilled or ice water	64 ounces
Acid sol. of ch. of gold (4 grains to 1 ounce)	1 ounce
Saturated solution of sal soda	½ ounce

Should be prepared half hour before use.

100. *With Chloride of Lime.*

Water	40 ounces
Chloride of lime	5 grains
Chloride of gold	4 grains

If the chloride of gold is acid, it may be neutralized with carbonate of lime.

101. *With Citric Acid.*

A.—Citric acid	1 ounce
Water	20 ounces
B.—Chloride of gold	15 grains
Water	15 ounces

Stock Solution.

Take of A two and a half ounces and make slightly alkaline with saturated solution of bicarbonate of soda; of B, half ounce, and sixty-four ounces of water.

When ready to tone take sufficient of the stock solution, which should never be less than three or four days old, and add thereto one ounce of gold solution B; make alkaline with bicarbonate of soda.

102.—TONING BATH FOR ALBUMEN PRINTS (NEWCOMB'S).

Water	1 quart
Phosphate soda	80 grains
Cupric chloride	1 grain

One grain of chloride gold for each sheet of 18x22 paper.

The gold solution should be neutralized with chalk.

103. *With Bicarbonate of Soda.*

Chloride of gold sol. (1 grain to the ounce)	1 ounce
Water	16 ounces
Saturated sol. of bicarb. of soda	10 minims

Allow this bath to ripen for one hour. Should be made up fresh for every time toning.

104.—ABNEY AND ROBINSON'S TONING BATHS.

Gold trichloride	1 grain
Sodium carbonate	10 grains
Water	10 ounces

Should be used immediately after mixing. This bath gives purple and black tones.

105.

Gold trichloride	2 grains
Saturated sol. of chloride of lime	2 drops
Chalk	1 pinch
Water	16 ounces

The bath should be prepared with hot water, and be kept for one day before using it.

106.—SCHWIER'S BORAX TONING BATH.

Chloride of gold solution, 1:50	3 c.c.m
Borax solution, 1 to 10	100 c.c.m
Water	100 c.c.m

Can be used immediately.

107.—DR. LIESEGANG'S TONING BATH.—*With Tungstate of Soda.*

Boiling water	1 litre
Tungstate of soda	20 grams
Chloride of gold	1 gram

Can be used immediately after cooling.

108.—DR. LIESEGANG'S TONING BATH.—*With Phosphate of Soda.*

Water	1 litre
Phosphate of soda	15 grams
Chloride of gold	1 gram

109.—DR. LIESEGANG'S TONING BATH.—*With Carbonate of Lime (Chalk).*

Water	1 litre
Chloride of gold	1 gram
Carbonate of soda	15 grams
Chalk	5 grams

After twelve hours the bath is perfectly clear and colorless, when it is ready for use. It is very durable, and gives fine tones.

110.—TONING BATH FOR READY SENSITIZED PAPER.

A.—Water	1 litre
Chloride of gold	1 gram
B.—Water	1 litre
Borax	10 grams
Tungstate of soda	40 grams

111.—E. L. WILSON'S TONING BATH.

Water	32 fluid ounces
Acetate sodium	60 grains
Chloride sodium	60 grains
Chloride gold	4 grains
Nitrate uranium	4 grains

Neutralize the gold and uranium, previously dissolved in a little water, with sufficient bicarbonate soda. Before using, add gold to renew the bath, as necessary.

112.—DR. EDER'S DURABLE TONING BATH.

Take pure perchloride of gold, dissolve it in distilled water, neutralize the acidity with carbonate of lime (chalk) or carbonate of magnesia, and filter. Of this solution take as much as represents one grain of the chloride of gold, dissolved, dilute it with nine times its bulk of water, and tone. This solution will keep, when stored in the dark, and will produce good, dark, purple tones.

113.—Printing on Plain Paper.

Prepare the plain paper with

Ammonium chloride	60 to 80 grains
Sodium citrate	100 grains
Sodium chloride	20 to 30 grains
Gelatine	10 grains
Distilled water	10 ounces

or,

Ammonium chloride	100 grains
Gelatine	10 grains
Water	10 ounces

The gelatine is first swelled in cold water and then dissolved in hot water, and the remaining components of the formula are added. The solution is filtered, and when still warm the paper floated upon it for three minutes.

The salted paper is sensitized upon a neutral forty-five-grain silver bath.

114.—Red Prints for Photo-Engravers.

Citric acid	100 grains
Chloride of ammonium	100 grains
Gelatine	10 grains
Water	10 ounces

Dissolve the citric acid in a small portion of water, and exactly neutralize with carbonate of soda (228 grains of common washing soda are required).

Float the paper on this bath for one to two minutes, and sensitize upon a fifty-grain nitrate of silver solution. Fix in fresh hypo, without toning.

ARISTOTYPE OR CHLORIDE OF SILVER COLLODION PRINTING.

115.—Aristotype, or Chloride of Silver Collodion.

A.—Alcohol	100 c.c.m.
Nitrate of silver	8 grams
B.—Alcohol	100 c.c.m.
Chloride of strontium	2 grams
C.—Water	100 c.c.m.
Citric acid	5 grams
D.—Alcohol	100 c.c.m.
Ether	100 c.c.m.
Gun cotton	4 grams

To 100 c.c.m. collodion (D) add first, by constant agitation, 10 c.c.m. of B and 10 c.c.m. of C; finally add 5 c.c.m. of A by vigorously shaking the mixture. The resulting emulsion is allowed to settle for twenty-four hours, and is then used for coating paper.

116.—Chloride of Silver Collodion (Geldmacher's).

Solution 1.

Gun cotton	6½ drams
Ether	15 ounces
Alcohol	15 ounces
Castor oil	1 dram

Solution 2.

Nitrate of silver	5 drams 8 grains
Water	6 drams
Alcohol	1½ ounces

Dissolve in a warm water bath.

Solution 3.

Citric acid..... .....1 dram 15 grains

dissolved in

Alcohol..... 2½ ounces

and

Chloride of strontium..... .....1 dram 15 grains

dissolved in

Alcohol ..... 2½ ounces

Make the two solutions separately and mix.

After all the solutions have been made add No. 3 to No. 1, shake vigorously, and by subdued light add gradually small portions at a time the No. 2 solution by constant agitating.

After an hour ripening the collodion emulsion is ready for use.

The paper to be coated must be furnished with a substratum of sulphate of barium and gelatine.

117.—Toning Bath for Aristotypes.

A.—Sulpho-cyanide of ammonium..... 40 grams
Hyposulphite of soda..... 3 grams
Carbonate of soda..... 1 gram
Water ..... 1½ litres

B.—Chloride of gold..... 2 grams
Chalk..... teaspoonful
Water ..... 1½ litres

Mix A and B in equal parts. B must be poured into A, not *vice versa*. Or

Water ..... 1 litre
Hyposulphite of soda.....120 grams
Common salt..... 60 grams
Chloride of gold in solution..... 1 gram

118.—Liesegang's Toning Bath for Aristotypes.

A.—Water ..... 20 ounces
Sulpho cyanide of ammonium..... 1 ounce
Alum..... 1 ounce
Saturated solution of carbonate of ammonium.... 20 drops

B.—Water .....*50 ounces
Chloride of gold..... 15 grains

119.—A. Stieglitz' Toning Bath for Aristotypes.

1. Water .....32 ounces
Phosphate of soda..... 3 drams
2. Terchloride of gold.....15 grains
Water... .....16 ounces

Mix. Allow to stand for twenty-four hours.

120.—Liesegang's Combined Toning Bath.

Water..... 32 ounces
Hyposulphite of soda..... 8 ounces
Sulpho cyanide of ammonium..... 1 ounce
Acetate of soda..... ½ ounce
Saturated solution of alum..... 2 ounces

and

Water..... 8 ounces
Chloride of gold..... 15 grains
Chloride of ammonium..... 30 grains

Pour the gold solution into the hypo solution, then add thirty grains of freshly prepared chloride of silver.

121.—Dr. Stolze's Combined Toning Bath for Aristotypes.

Hyposulphite of soda..... 35
Ordinary salt..... 9
Alum..... 4
Sulpho-cyanide of ammonium..... 2
Water.....150 to 200 c. c. m.

} grams

The compound will have matured for use in four to eight days.

Decant the clear solution from the deposit formed, and filter. Immediately before use, add to above quantity, 2 c.c.m. chloride of gold solution 1:100. If the solution does not act with sufficient energy, a few c.c.m. of saturated alum solution may be added.

PRINTING ON SUBSTANCES OTHER THAN PAPER.

122.—Collodion for Porcelain Pictures.

Fennemore's Method.

A.—Negative gun cotton	60 grains
Alcohol	2 ounces
Ether	3 ounces

Dissolve 120 grains nitrate of silver in three ounces of hot alcohol, and add by constant stirring to the above collodion.

B.—Chloride of strontium	32 grains
Citric acid	24 grains

Reduce to a fine powder and dissolve in four ounces of alcohol; add

Ether	4 ounces
Gun cotton	60 grains

The two collodions are to be mixed in equal proportions.

123.

Hearn's Method.

A.—Alcohol	7 ounces
Ether	9 ounces
Gun cotton	112 grains
B.—Nitrate of silver	486 grains
Distilled water	1 ounce
C.—Chloride of calcium	128 grains
Alcohol	4 ounces
D.—Citric acid	128 grains
Alcohol	4 ounces

Decant eight ounces of A, add sixty-four drops of B in small portions, stirring up well after every addition, and four drams of C in the same way. Finally four drams of D must be added in the same manner as the calcium solution.

124.—Printing on Silk.

Boiling water	20 ounces
Chloride of ammonium	100 grains
Iceland moss	60 grains

When nearly cold, filter and immerse the silk for fifteen minutes. Sensitize for fifteen minutes in an acid 20-grain silver bath, and when dry stretch the fabric over cardboard. Print deeper than usual and tone in

Water	20 ounces
Acetate of soda	2 drams
Chloride of gold	3 grains
Common whiting	a few grains

125.—Making Silver Prints on Wood.

Gelatine	45 grains
White soap	45 grains
Water	5¼ fluid ounces

Soak the gelatine in the water for five or six hours, then dissolve it with the aid of a water bath. Cut the soap into small pieces, and add to the gelatine solution, stirring the whole with a glass rod to insure a perfect mixture, then add powdered alum until the froth disappears, and strain through muslin. Cover the block with this mixture and a little zinc white, then wipe off so that a very thin film will be left, rubbing it gently, so that

the film may be of as even a thickness as possible. After drying, apply with a wide badger's-hair brush a coating of the following:

Albumen	3¼ fluid ounces
Water	2½ fluid ounces
Sal ammonia	67½ grains
Citric acid	18¾ grains

Whip the albumen to a froth, and allow it to settle; to the limpid portion add the water, then the sal ammonia, and carefully stir with a glass rod, then add the citric acid. When the block is dry, sensitize with a solution of

Water	3¼ fluid ounces
Nitrate of silver	187½ grains

Pour this upon the surface of the block, spread it evenly with a glass rod, and pour off the excess. When the block is dry, expose it under a negative in the usual manner, until it is printed the exact shade desired. When printed, immerse the printed surface in a very strong solution of salt for about three minutes. Then wash it under a stream of water for a short time, and fix it by placing it face downward in a saturated solution of hyposulphite of soda. After fixing, wash under a stream of water for about ten minutes; when dry, it is finished, and ready for the engraver.

126.—To Transfer Photographs upon Wood for Engraving.

Float the reverse side of sensitized albumen paper for fifteen minutes upon a 4 per cent. solution of bichromate of potassium, dry well, expose to light till the picture is fairly visible, place the print upon a glass plate under water until the unacted-on bichromate is dissolved out; after removal from the water, roll in with fatty ink.

When the picture is sufficiently blackened, and nearly dry, it can be transferred upon the engraver's block by rubbing it on carefully.

PRINTING WITH THE SALTS OF IRON.

127.—Cyanotypes or Blue Prints.

A.—Citrate of iron and ammonia	1⅞ ounces
Water	8 ounces
B.—Ferricyanide of potassium	1¼ ounces
Water	8 ounces

Mix equal parts immediately before use and float the paper, Rives plain, upon it for three minutes; hang up to dry.

128.—Converting Blue Prints into Brown Prints.

Blue ferro-prussiate photographic prints may be converted into brown prints by the following process:

The positive blue print, thoroughly washed and dried, is plunged into a solution of ammonia, in which it is kept until it has nearly or entirely lost its color. (The operation lasts from two to four minutes). The print is rinsed and plunged into a bath of tannic acid, the operation being stopped as soon as the desired sharpness and tone are obtained.

This last operation requires about ten minutes. If at the end of this time the color be not dark enough, it is intensified by adding to the bath a few drops of ammonia. After a lapse of one or two minutes, rinse in abundant water.

1. Solution for preparing the sensitized paper:

Tartrate of iron and potash	15 parts
Red prussiate of potash	12 parts
Rain water	250 parts

2. Solution to remove the color of the print:

Ammonia of 23 deg. Beaumé	100 parts
Rain Water	800 parts

5. Solution to give the brown tone:

Tannic acid	10 parts
Rain water	500 parts

Dissolve and filter.

129.—TONING BLUE PRINTS.

Blue prints may be given the black tone by plunging them into a solution of four parts of potash in one hundred parts of water; then, when the blue color has entirely disappeared under the action of the potash, and a yellowish color has taken its place, they are immersed in a solution of four parts of tannin in one hundred parts of water; then washing them again we obtain prints whose tone may be assimilated to that of pale writing ink.

130.—PELLETT'S METHOD FOR MAKING BLUE LINES UPON WHITE GROUND.

The formula is composed as follows:

Gum arabic	385 grains
Sodium chloride	46 grains
Tartaric acid	62 grains
Perchloride of iron	123 grains
Water	3½ ounces

Highly sized and smooth paper is evenly coated with this mixture, dried in the dark, and exposed under a negative.

Develop with a saturated solution of ferrocyanide of potassium. Fix in a one to twenty solution of hydrochloric acid.

USEFUL RECEIPTS.

131.—TO TONE BROMIDE PRINTS WITH PLATINUM.—E. VOGEL.

Float the print on

Potassium platino chloride	15 grains
Distilled water	32 ounces
Hydrochloric acid	2½ drams

for twenty minutes, wash and remove to a fifteen per cent. solution of copper chloride. If by this operation, vigor and depth of tone is reduced, re-develop with ferrous oxalate. The method yields warm tones.

132.—TO FIND THE FOCAL LENGTH OF A LENS.—W. H. SHERMAN'S RULE.

Make two images of any object of convenient length, so that the *difference* between the images will be equal to some even part of the object, making the position of the ground glass on the base of the camera where each image is in focus. The distance between the two positions of the

ground glass thus found, will be the same part of the focal length that the difference of the two images is of the object.

Example: With two images of a foot-rule; let one image be eight inches long and the other four inches. The difference being one third the length of the object, the distance between the two positions of the ground glass will be one-third of the focal length of the lens.

133.—To Calculate the Focal Fraction of Stops for Lenses.

Divide the focal length obtained by the above method expressed in inches and hundreths, by the diameter of stop opening expressed in hundredths of an inch.

135.—Labarraque's Solution.

Chloride of lime	2 ounces
Carbonate of soda	4 ounces
Water	40 ounces

Mix the chloride of lime with thirty ounces of the water, and dissolve the carbonate of soda in the remainder. Mix, boil and filter.

136.—Eau de Javelle.

Dry chloride of lime (hypo chloride of lime)	2 ounces
Carbonate of potash	4 ounces
Water	40 ounces

Mix the chloride of lime with half of the water; dissolve the carbonate of potash in the remainder. Mix, boil and filter.

137.—A Few Remedies Against Blistering of Albumen Paper.

Do not dry the paper by excessive heat.
Avoid acidity in solutions.
Moisten the print before washing with a sponge saturated in alcohol.
Immerse the print before fixing in a weak alum bath.
Add a trace of aqua ammonia to the fixing-bath.

138.—Matt Black Varnish.

A tolerably strong solution of sandarac in alcohol, mixed with fine lamp-black, drys without gloss, becomes hard without being brittle, and may be applied with a fine brush upon almost any substance.

139.—Invisible Ink.

Chloride of cobalt	50 grains
Distilled water	1 fluid ounce
Glycerine	10 minims

Dissolve the chloride of cobalt in the distilled water, and add the glycerine.

Writing executed with this ink is invisible on paper, but on warming the writing turns blue. On exposure to damp air, it becomes invisible again.

140.—MAKING PAPER ADHERE TO METAL.

Gum tragacanth	30 grammes
Acacia gum	120 grammes
Water	500 c.c.

141.—TO PRECIPITATE GOLD FROM SPENT SULPHO-CYANIDE TONING BATHS.

Add sulphuric acid, and heat when the gold will separate.

142.—TO KEEP UNMOUNTED ALBUMEN PRINTS FLAT.

Soak them in equal parts of alcohol, glycerine and water; dry between blotting paper under slight pressure.

143.—THE STRIPPING OF AMERICAN FILMS.

From pyro-stained and presumably tanned gelatine is much facilitated by soaking the negative, after thoroughly washing, in a dilute solution of hydrochloric acid.

144.—MAGIC PHOTOGRAPHS.

Fix an albumen print in perfectly fresh hypo solution and wash well, and soak it in a solution of 1 part bichloride of mercury, ¼ of a part of chloride of ammonium in 60 parts of water, till the photograph is bleached out.

The picture will appear again when brought into contact with hypo solution, or moistened blotting paper previously prepared with the fixing soda.

145.—SOLUTION FOR MOUNTING PRINTS WITHOUT THEIR COCKLING.

Nelson's No. 1 photographic gelatine	4 ounces
Water	16 ounces
Glycerine	1 ounce
Alcohol	5 ounces

Dissolve the gelatine in the water, then add the glycerine, and lastly the alcohol.

146.—PERMANENT PASTE.

Arrowroot	10 grams
Water	100 grams

in which one gram of gelatine has been soaked, and boil. After cooling add ten grams of alcohol and a few drops of carbolic acid.

147.—LEATHER COLLODION.

2 p.c. collodion	100 parts
Castor oil	4 parts

148.—LUBRICATOR FOR HOT BURNISHING.

Cetaceum	10 grams
Castile soap	10 grams
Alcohol	1 kilogramme

149.—TO REMOVE SILVER STAINS FROM THE HANDS.

Sulphate of soda	½ ounce
Chloride of lime	½ ounce
Water	1 ounce

Mix thoroughly, and apply with an old toothbrush.

150.—GELATINE SOLUTION FOR STRIPPING PLATES. (CARBUTT'S).

Water	9 ounces
Gelatine	1 ounce
Glycerine	¼ ounce

Swell the gelatine in cold water and dissolve by the heat of a water bath and filter through muslin at a temperature of 100 to 110 deg. Fahr.; flow over the well-dusted negative, using one fluid dram of the solution to each four square inches of surface. Guide to the edges of the plate with your finger, and remove air bells with a soft-pointed paper. Allow to set in horizontal position, and when perfectly dry, detach the film from the glass. Stripped films may be kept between the leaves of a book.

Plates to be stripped are, previously to coating, prepared for that purpose.

151.—TO MAKE TRANSPARENCIES ON ALBUMEN PAPER.

Print on the back of heavily-silvered albumen paper till the picture is perfectly well printed out, by viewing the paper by transmitted light.

Tone and fix as usual, and, when dry, make the paper translucent with

Poppy oil	1 ounce
Balsam fir	¼ ounce
Spirits turpentine	½ ounce

152.—TO FROST A SKYLIGHT.

Very thin starch paste, to which unboiled starch has been added. Must be free from lumps, and be daubed on with a large bristle brush.

153.—TO KEEP THE HANDS SOFT AND WHITE.

Apply before retiring:

Glycerine	2 ounces
Bay rum	6 ounces
Oil cajeput	1 dram
Oil bergamat	1 dram

Mix well.

154.—TO REMOVE NITRIC ACID STAINS FROM HANDS OR GARMENTS.

Touch the stains with solution of permanganate of potassium; wash, rinse in dilute hydrochloride acid, and wash again.

155.—TO REMOVE YELLOW STAINS FROM BROMIDE PRINTS.

Soak for one or two hours in

Acetic acid	2 ounces
Sat. oxalate of potassium solution	4 ounces

156.—TO REMOVE PYRO STAINS FROM FINGERS.

Wash with a 10 per cent. solution of oxalic acid, or sulphuric acid, diluted with water (1 : 20).

157.—TO REMOVE YELLOW STAINS FROM PYRO-DEVELOPED NEGATIVES.

Bathe them in sulphurous acid water or in a 10 per cent. solution of sulphite of soda, to which a few drops of sulphuric acid have been added.

158.—TO REMOVE THE ODOR OF HYDROSULPHATE OF AMMONIA FROM THE DARK ROOM.

Sprinkle the floor with a solution of nitrate of lead.

159.—TO AVOID HALATION.

A quick drying coating, which is applied to the back of the plate,

consists of collodion, with which any dark red or brown pigment is mixed. Spanish brown or rouge answers well.

160.—To Recover Silver Bromide from Waste Emulsion.

Let the emulsion be melted, and then add a small quantity of hydrochloric acid, following by boiling for two or three minutes. The silver bromide precipitates, and the destroyed gelatine is then poured off. The bromide is then placed among the other residues for reduction.

161.—Toning Bath for Gelatine Lantern Slides.

Chloride of platinum	1 grain
Hydrochloric acid	1 minim
Water	32 ounces

162.—Compound for Blocking out Large Portions of a Negative.

Mix asphaltum varnish with fine lamp-black and apply with a camel's-hair brush.

Should be kept in well-stoppered bottles.

163.—Flash-light Powder for Orthochromatic Plates.

Pure metallic magnesium powder	10 grains
Nitrate of soda (finely powdered)	from 50 to 70 grains

164.—Largest and Smallest Quantities of Chemicals Admitted to the Pyro Developer.

	Largest.	Smallest.
Pyro, per ounce	10 grains	1 1-4 grains
Sulphite of soda	80 grains	5 grains
Carb. of soda	40 grains	1 1-5 grains
Carb. of potash	21 2-10 grains	5 grains

165.—Consumption of Chemicals in Silver Printing on Albumenized Paper.

Of one hundred parts of silver used in the albumen printing process will be found

In the finished print	3 per cent
In filters, blotters and cuttings	7 per cent
In the wash water before toning	50 to 55 per cent
In the fixing bath	30 to 25 per cent
In the wash water after fixing	5 per cent

Ninety per cent. of the silver used may be recovered.

One sheet of paper will take from the silver bath from thirty to forty-five grains of nitrate of silver.

One sheet of paper requires to tone one and one-half grains of gold (one decigram).

About eighty to ninety grains of hyposulphite of soda are necessary to fix one sheet of paper.

UNITED STATES WEIGHTS AND MEASURES.

ACCORDING TO EXISTING STANDARDS.

LINEAL.

	Inches.	Feet.	Yards.	Rods.	Furlong.
12 inches = 1 foot.	12				
3 feet = 1 yard.	36 =	3			
5.5 yards = rod.	198 =	16.5 =	5.5		
40 rods = 1 furlong.	7,920 =	660 =	220 =	40	
8 furlongs = 1 mile.	63,360 =	5,280 =	1,760 =	320 =	8

SURFACE—LAND.

	Ft.	Yds.	Rods.	Roods.	Acres.
144 sq. ins. = 1 sq. ft.					
9 sq. ft. = 1 sq. yd.	9 =	1			
30.25 sq. yds. = 1 sq. rod.	272.25 =	30.25 =	1		
40 sq. rods. = 1 sq. rood.	10,890 =	1,210 =	40 =	1	
4 sq. roods = 1 acre.	43,560 =	4,840 =	160 =	4 =	1
640 acres 1 sq. mile.	27,878,400 =	3,097,600 =	102,400 =	2,560 =	640

VOLUME—LIQUID.

	Gills.	Pints.	Cub. In.
4 gills = 1 pint.	8		
2 pints = 1 quart.			
4 quarts = 1 gallon	32 =	8 =	231

FLUID.

Gallon.	Pints.	Ounces.	Drams.	Minims.	Cubic Centimetres.
1 =	8 =	128 =	1,024 =	61,440 =	3,785.441
	1 =	16 =	128 =	7,680 =	473.180
		1 =	8 =	480 =	29.574
			1 =	60 =	3.697

16 ounces, or a pint, sometimes called a pound.

TROY WEIGHT.

Pound.	Ounces.	Pennyweights.	Grains.	Grams.
1 =	12 =	240 =	5,760 =	373.25
	1 =	20 =	480 =	31.10
		1 =	24 =	1.55

APOTHECARIES' WEIGHT.

lb. Pound.	℥ Ounces.	ʒ Drams.	℈ Scruples.	gr. Grains.	Grams.
1 =	12 =	96 =	288 =	5,760 =	373.25
	1 =	8 =	24 =	480 =	31.10
		1 =	3 =	60 =	3.89
			1 =	20 =	1.30
				1 =	.06
				15½. =	1.00

The pound, ounce, and grain are the same as in Troy weight.

AVOIRDUPOIS WEIGHT.

Pound.	Ounces.	Drams.	Grains (Troy).	Grams.
1 =	16 =	256 =	7,000 =	453.60
	=	16 =	437.5 =	28.35
		1 =	27.34 =	1.77

ENGLISH WEIGHTS AND MEASURES.

APOTHECARIES' WEIGHT.

SOLID MEASURE.

20 Grains = 1 Scruple = 20 Grains.
3 Scruples = 1 Dram = 60 Grains.
8 Drams = 1 Ounce = 480 Grains.
12 Ounces = 1 Pound = 5760 Grains.

FLUID.

60 Minims = 1 Fluid Dram.
8 Drams = 1 Ounce.
20 Ounces = 1 Pint.
8 Pints = 1 Gallon.

The above weights are those usually adopted in formulæ.

All Chemicals are usually sold by

AVOIRDUPOIS WEIGHT.

$27\frac{11}{32}$ Grains = 1 Dram = $27\frac{11}{32}$ Grains.
16 Drams = 1 Ounce = $437\frac{1}{2}$ Grains.
16 Ounces = 1 Pound = 7000 Grains.

Precious Metals are usually sold by

TROY WEIGHT.

24 Grains = 1 Pennyweight = 24 Grains.
20 Pennyweights = 1 Ounce = 480 Grains.
12 Ounces = 1 Pound = 5760 Grains.

NOTE.—An ounce of metallic silver contains 480 grains, but an ounce of nitrate of silver contains only $437\frac{1}{2}$ grains.

U. S. FLUID MEASURE.

Gal.		Pints.		Ounces.		Drams.		Mins.		Cub. in.		Grains.		Cub. C. M
1	=	8	=	128	=	1,024	=	61,440	=	231.	=	58,328.886	=	3,785.00
		1	=	16	=	128	=	7,680	=	28.875	=	7,291.1107	=	473.11
				1	=	8	=	480	=	1.8047	=	455.6944	=	29.57
						1	=	60	=	0.2256	=	56.9618	=	3.70

IMPERIAL BRITISH FLUID MEASURE.

Gal.		Pints.		Ounces.		Drams.		Mins.		Cub. in.		Grains.		Cub. C. M.
1	=	8	=	160	=	1,280	=	76,800	=	277.27384	=	70,000.	=	4,543.487
		1	=	20	=	160	=	9,600	=	34.65923	=	8,750.		567.936
				1	=	8	=	480	=	1.73296	=	437.5	=	28.396
						1	=	60	=	0.21662	=	54.69	=	3.549

LA PHOTOGRAPHIE DANS LES ARTS LES SCIENCES ET L'INDUSTRIE. Par Albert Londe. Paris: Gauthier Villiers et Fils, 1888, 52 pp.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES.

THE meter is a measure of length equal to 39.370 English inches, or 39.368 American inches, a standard of linear measure supposed to be the ten-millionth part of the distance from the equator to the north pole, as ascertained by actual measurement of an arc of the meridian.

This system, formed on the meter as the unit of length, has four other leading units, all connected with and dependent upon this. Hence, we have:

1. The meter, which is the unit of measures of length.
2. The are, which is the unit of surface, and is the square of the meter.
3. The litre, which is the unit of measures of capacity, and is the cube of a tenth part of the meter.
4. The stere, which is the unit of measures of solidity, having the capacity of a cubic meter.
5. The gram, which is the unit of measures of weight, and is the weight of that quantity of distilled water at its maximum density, fills the cube of a hundredth part of the meter.

Each unit has its decimal multiples and sub-multiples, that is weights and measures ten times larger, or ten times smaller, than the principal units. The prefixes denoting multiples are derived from the Greek, and are: Deka, ten; hecto, hundred; kilo, thousand; and myria, ten thousand. Those denoting sub-multiples are taken from the Latin, and are: Deci, ten; centi, hundred (like in centigram or centimeter); and mili, thousand.

The metric system has been adopted by many nations, the English excepted. In America its use has been made optional, but is legalized by Congress. All photographic formulæ received from the continent of Europe express values and quantities with metrical weights and measures. To utilize them direct without translating into the expressions of the English system, the student is advised to procure gram weights and cubic centimeter graduates, and substitute them for those denoting quantities according to the old plan.

As an assistance to those who cannot acquire these aids, we annex tables taken from the "British Almanac of Photography," which convert grams and cubic centimeters into English grains, drams, and ounces sufficiently correct for practical purposes.

METRIC FLUID MEASURES.

THE cubic centimeter, usually represented by "c.c.," is the unit of the metric measurement for liquids. It contains nearly seventeen minims of water; in reality, it contains 16·896 minims. The weight of this quantity of water is one gram. Hence it will be seen that the cubic centimeter and the gram bear to each other the same relation as our dram for solids and the dram for fluids, or as the minim and the grain. The following table will prove to be sufficiently accurate for photographic purposes:

METRIC SYSTEM OF WEIGHTS AND MEASURES.

MEASURES OF LENGTH.

Denominations and Values.		Equivalents in Use.
Myriameter	10,000 meters.	6.2137 miles.
Kilometer	1,000 meters.	.62137 mile, or 3,280 ft. 10 ins.
Hectometer	100 meters.	328. feet and 1 inch.
Dekameter	10 meters.	393.7 inches.
Meter	1 meter.	39.37 inches.
Decimeter	1-10th of a meter.	3.937 inches.
Centimeter	1-100th of a meter.	.3937 inch.
Millimeter	1-1000th of a meter.	.0394 inch.

MEASURES OF SURFACE.

Denominations and Values.		Equivalents in Use.
Hectare	10,000 square meters.	2.471 acres.
Are	100 square meters.	119.6 square yards.
Centare	1 square meter.	1,550. square inches.

MEASURES OF VOLUME.

Denominations and Values.			Equivalents in Use.	
Names.	No. of Liters.	Cubic Measures.	Dry Measure.	Wine Measure.
Kiloliter or stere	1,000	1 cubic meter.	1.308 cubic yards.	264.17 gallons.
Hectoliter	100	1-10th cubic meter.	2 bu. and 3.35 pecks.	26.417 gallons.
Dekaliter	10	10 cubic decimeters.	9.08 quarts.	2.6417 gallons.
Liter	1	1 cubic decimeter.	.908 quart.	1.0567 quarts.
Deciliter	1-10	1-10th cubic decimeter.	6.1022 cubic inches.	.845 gill.
Centiliter	1-100	10 cubic centimeters.	.6102 cubic inch.	.338 fluid oz.
Milliliter	1-1000	1 cubic centimeter.	.061 cubic inch.	.27 fl. drm.

WEIGHTS.

Denominations and Values.			Equivalents in Use.
Names.	Number of Grams.	Weight of Volume of Water at its Maximum Density.	Avoirdupois Weight.
Millier or Tonneau	1,000,000	1 cubic meter.	2204.6 pounds.
Quintal	100,000	1 hectoliter.	220.46 pounds.
Myriagram	10,000	10 liters.	22.046 pounds.
Kilogram or Kilo	1,000	1 liter.	2.2046 pounds.
Hectogram	100	1 deciliter.	3.5274 ounces.
Dekagram	10	10 cubic centimeters.	.3527 ounce.
Gram	1	1 cubic centimeter.	15.432 grains.
Decigram	1-10	1-10th of a cubic centimeter.	1.5432 grain.
Centigram	1-100	10 cubic millimeters.	.1543 grain.
Milligram	1-1000	1 cubic millimeter.	.0154 grain.

For measuring surfaces, the square dekameter is used under the term of ARE; the hectare, or 100 ares, is equal to about two acres. *The unit of capacity* is the cubic decimeter or LITER, and the series of measures is formed in the same way as in the case of the table of lengths. The cubic meter is the unit of measure for solid bodies, and is termed STERE. *The unit of weight* is the GRAMME, which is the weight of one cubic centimeter of pure water weighed in a vacuum at the temperature of 4 deg. Cent. or 39.2 deg. Fahr., which is about its temperature of maximum density. In practice, the term cubic centimeter, abbreviated c.c., is used instead of milliliter, and cubic meter instead of kiloliter.

THE CONVERSION OF FRENCH (METRIC) INTO ENGLISH MEASURE.

1	cubic centimeter	=	17	minims.						
2	cubic centimeters	=	34	"						
3	"	=	51	"						
4	"	=	68	"	or	1	dram	8	minims.	
5	"	=	85	"	"	1	"	25	"	
6	"	=	102	"	"	1	"	42	"	
7	"	=	119	"	"	1	"	59	"	
8	"	=	136	"	"	2	drams	16	"	
9	"	=	153	"	"	2	"	33	"	
10	"	=	170	"	"	2	"	50	"	
20	"	=	340	"	"	5	"	40	"	
30	"	=	510	"	"	1	ounce	0 dram	30	minims.
40	"	=	680	"	"	1	"	3 drams	20	"
50	"	=	850	"	"	1	"	6 "	10	"
60	"	=	1020	"	"	2	ounces	1 "	0	"
70	"	=	1190	"	"	2	"	3 "	50	"
80	"	=	1360	"	"	2	"	6 "	40	"
90	"	=	1530	"	"	3	"	1 "	30	"
100	"	=	1700	"	"	3	"	4 "	20	"
1000	"	=	1 litre = 34 fluid ounces nearly, or $2\frac{1}{8}$ pints.							

THE CONVERSION OF FRENCH (METRIC) INTO ENGLISH WEIGHT.

ALTHOUGH a gram is equal to 15·4346 grains, the decimal is one which can never be used by photographers; hence in the following table it is assumed to be $15\frac{2}{5}$ grains, which is the nearest approach that can be made to *practical* accuracy:

1	gram	=	$15\frac{2}{5}$	grains.					
2	grams	=	$30\frac{4}{5}$	"					
3	"	=	$46\frac{1}{5}$	"					
4	"	=	$61\frac{3}{5}$	"	..... or	1	dram	$1\frac{3}{5}$	grain.
5	"	=	77	"	..... "	1	"	17	grains.
6	"	=	$92\frac{2}{5}$	"	..... "	1	"	$32\frac{2}{5}$	"
7	"	=	$107\frac{4}{5}$	"	..... "	1	"	$47\frac{4}{5}$	"
8	"	=	$123\frac{1}{5}$	"	..... "	2	drams	$3\frac{1}{5}$	"
9	"	=	$138\frac{3}{5}$	"	..... "	2	"	$18\frac{3}{5}$	"
10	"	=	154	"	..... "	2	"	34	"
11	"	=	$169\frac{2}{5}$	"	..... "	2	"	$49\frac{2}{5}$	"
12	"	=	$184\frac{4}{5}$	"	..... "	3	"	$4\frac{4}{5}$	"
13	"	=	$200\frac{1}{5}$	"	..... "	3	"	$20\frac{1}{5}$	"
14	"	=	$215\frac{3}{5}$	"	..... "	3	"	$35\frac{3}{5}$	"
15	"	=	231	"	..... "	3	"	51	"
16	"	=	$246\frac{2}{5}$	"	..... "	4	"	$6\frac{2}{5}$	"
17	"	=	$261\frac{4}{5}$	"	..... "	4	"	$21\frac{4}{5}$	"
18	"	=	$277\frac{1}{5}$	"	..... "	4	"	$37\frac{1}{5}$	"
19	"	=	$292\frac{3}{5}$	"	..... "	4	"	$52\frac{3}{5}$	"
20	"	=	308	"	..... "	5	"	8	"
30	"	=	462	"	..... "	7	"	42	"
40	"	=	616	"	..... "	10	"	16	"
50	"	=	770	"	..... "	12	"	50	"
60	"	=	924	"	..... "	15	"	24	"
70	"	=	1078	"	..... "	17	"	58	"
80	"	=	1232	"	..... "	20	"	32	"
90	"	=	1386	"	..... "	23	"	6	"
100	"	=	1540	"	..... "	25	"	40	"
1000	"	=	1 kilogram = 32 oz., 3 dr., 40 gr.						

TABLE SHOWING THE COMPARISON OF THE READINGS OF THERMOMETERS.

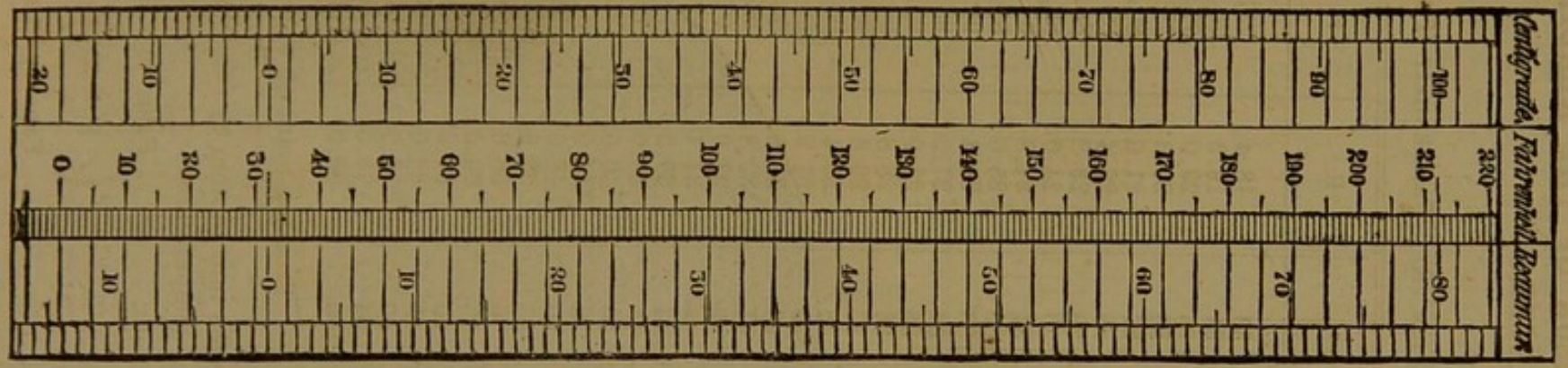
CELSIUS, OR CENTIGRADE (C). RÉAUMUR (R). FAHRENHEIT (F).

C.	R.	F.	C.	R.	F.
—30	—24.0	—22.0	23	18.4	73.4
—25	—20.0	—13.0	24	19.2	75.2
—20	—16.0	— 4.0	25	20.0	77.0
—15	—12.0	+ 5.0	26	20.8	78.8
—10	— 8.0	14.0	27	21.6	80.6
— 5	— 4 0	23.0	28	22.4	82 4
— 4	— 3.2	24.8	29	23 2	84.2
— 3	— 2.4	26.6	30	24.0	86.0
— 2	— 1.6	28.4	31	24.8	87.8
— 1	— 0.8	30.2	32	25.6	89.6
			33	26.4	91.4
Freezing point of water.			34	27.2	93.2
			35	28.0	95.0
0	0.0	32.0	36	28.8	96.8
1	0.8	33.8	37	29.6	98.6
2	1.6	35.6	38	30.4	100.4
3	2.4	37.4	39	31.2	102.2
4	3.2	39.2	40	32.0	104.0
5	4.0	41.0	41	32.8	105.8
6	4.8	42.8	42	33.6	107.6
7	5.6	44.6	43	34 4	109.4
8	6.4	46.4	44	35.2	111.2
9	7.2	48.2	45	36.0	113.0
10	8.0	50.0	50	40.0	122.0
11	8.8	51.8	55	44.0	131.0
12	9.6	53.6	60	48.0	140.0
13	10.4	55.4	65	52.0	149.0
14	11.2	57.2	70	56.0	158.0
15	12.0	59.0	75	60.0	167.0
16	12.8	60 8	80	64 0	176.0
17	13.6	62.6	85	68.0	185.0
18	14.4	64.4	90	72.0	194.0
19	15.2	66.2	95	76.0	203.0
20	16.0	68.0	100	80.0	212.0
21	16.8	69 8			
22	17.6	71 6	Boiling point of water.		

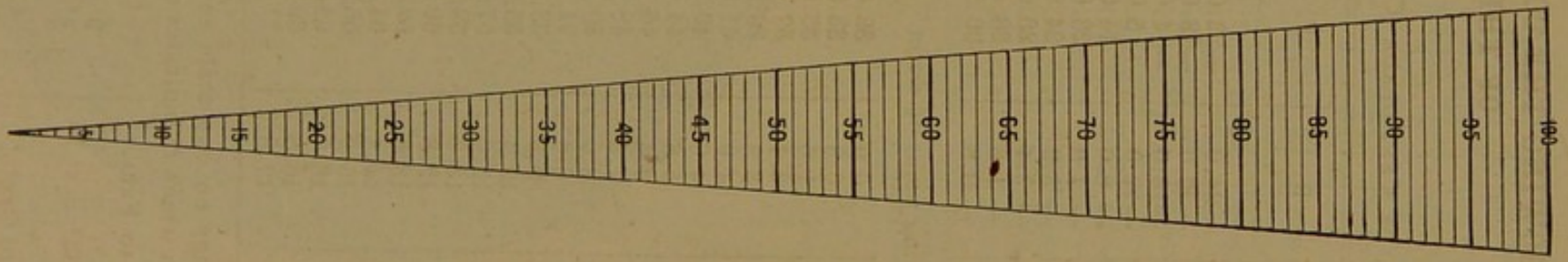
Readings on one scale can be changed into another by the following formulæ, in which $t°$ indicates degrees of temperature:

Réau. to Fahr.	Cent. to Fahr.	Fahr. to Cent.
$\frac{9}{4}t° \text{ R} + 32° = t° \text{ F}$	$\frac{9}{5}t° \text{ C} + 32° = t° \text{ F}$	$\frac{5}{9}\left(t° \text{ F} - 32°\right) = t° \text{ C}$
Réau. to Cent.	**Cent. to Réau.**	**Fahr. to Réau.**
$\frac{5}{4}t° \text{ R} = t° \text{ C}$	$\frac{4}{5}t° \text{ C} = t° \text{ R}$	$\frac{4}{9}\left(t° \text{ F} - 32\right) = t° \text{ R}$

THERMOMETER SCALES.



SCALE FOR MEASURING DIAMETERS OF STOPS FOR LENSES.

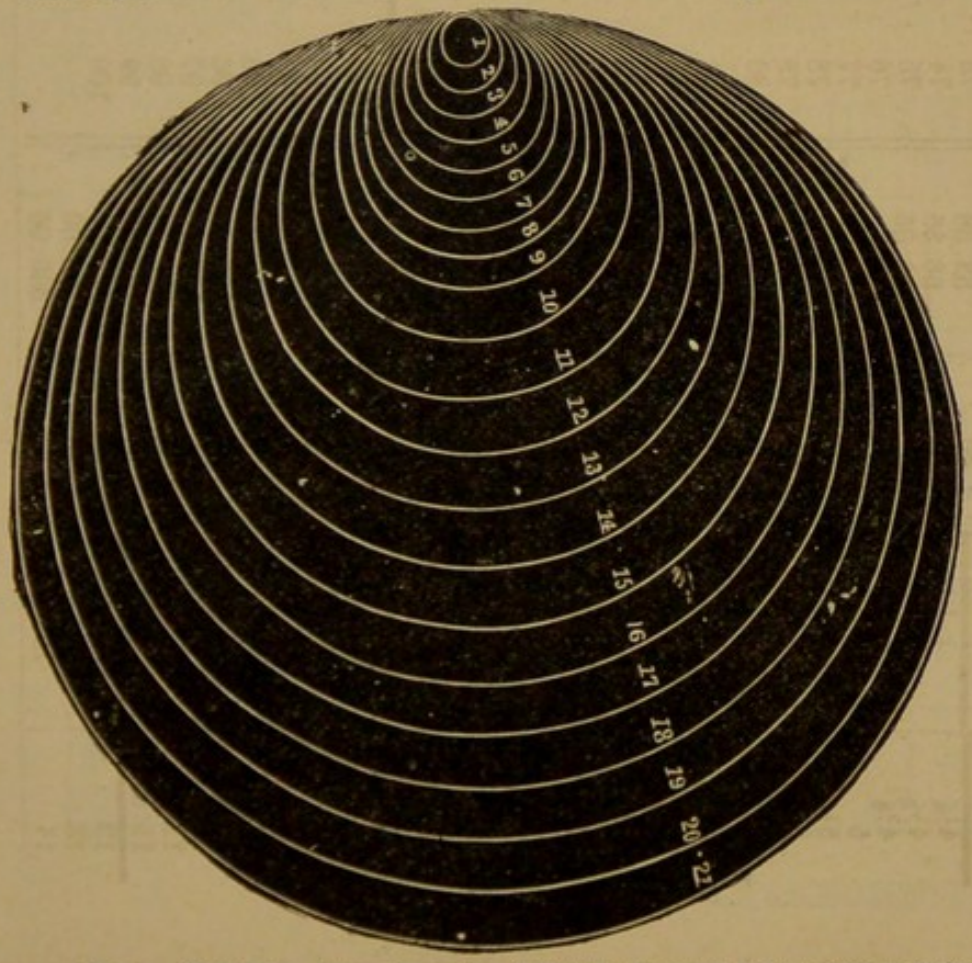


Each cross line varies in length from the adjacent one by $\frac{1}{100}$th of an inch.

To use: Lay the stop flat on this scale, and select the cross line which is of the same length as the greatest diameter of the opening; read this off, by means of the figures, which will be the measurement in $\frac{1}{100}$ths of an inch. The equivalent focal length of lens, divided by this measurement of the stop opening, will give the fraction expressing relative rapidity of lens — $\frac{f}{4}$ or whatever it may be.

THE PHOTOGRAPHIC SOCIETY'S (OF GREAT BRITAIN) STANDARD DIAPHRAGMS.

THE annexed diagram and table are intended to facilitate the calculation of the proper number with which to mark the diaphragms according to the Photographic Society of Great Britain's Uniform System, which will be found described on another page. This number it is proposed to call the "U. S." (or uniform system number). The numbered circles in the diagram represent the sizes of stops. The photographer, knowing the equivalent focus of his lens, looks along the line opposite the number which represents the circle nearest inside to his diaphragm, and when he gets to the column headed by that equivalent focus the number there found is the U. S. number to be marked on the diaphragm. For example: A lens of eight inches equivalent focus has a diaphragm in size about No. 5 on the diaphragm; running the eye along the line opposite No. 5 we find in the column under—"focus eight inches" the No. 11, which is the U. S. number required.



No. of Circle.	4 focus	5 focus	6 focus	7 focus	8 focus	9 focus	10 focus	12 focus	14 focus
1	25	39	56						
2	11	17	25	34	44	56	68		
3	6¼	10	14	19	25	31	40	56	
4	4	6¼	9	12	16	20	25	36	48
5	2⅝	4⅛	6¼	8½	11	14	17	25	34
6	2	3⅛	4½	6¼	8	10	13	18	25
7	1⅞	2⅛	3⅛	4⅜	6	8	10	14	19
8	1¼	2	2⅝	3⅜	5	6¼	8	11	15
9	1	1⅛	2⅛	3	4	5	6¼	9	12¼
10		1	1⅛	2⅛	2⅝	3⅛	4⅛	6	8½
11			1¼	1⅛	2	2⅛	3⅛	5	6
12			⅞	1⅛	1⅛	2	2⅛	3⅛	4¾
13				1	1¼	1⅝	1⅜	2⅜	4
14					1	1¼	1⅛	2⅛	3
15						1	1⅛	1⅞	2⅛
16							1	1⅛	2
17								1⅛	7⅜
18								1⅛	1⅛
19								1	1⅛
20									1⅛
21									1

NOTE.—This table, taken from the "British Almanac," has proved to be very convenient in the calculating of stop values.

'UNIFORM SYSTEM" NUMBERS FOR STOPS FROM $\frac{f}{1}$ TO $\frac{f}{100}$.

In the following table Mr. S. A. Warburton has calculated the exposure necessary with every stop from $\frac{f}{1}$ to $\frac{f}{100}$ compared with the unit stop of the "uniform system" of the Photographic Society of Great Britain. The figures which are underlined show in the first column what $\frac{f}{a}$ must be in order to increase the exposure in geometrical ratio from $\frac{f}{4}$, the intermediate numbers showing the uniform system number for any other aperture.

f	U. S. No.
1	$\frac{1}{16}$
1¼	.097
1.414	⅛
1½	.140
1¾	.191
2	¼
2¼	.316
2½	.390
2.828	½
2¾	.472
3	.562
3¼	.660
3½	.765
3¾	.878
4	1.00
4¼	1.12
4½	1.26
4¾	1.41
5	1.56
5¼	1.72
5½	1.89
5.656	2
5¾	2.06
6	2.25
6¼	2.44
6½	2.64
6¾	2.84
7	3.06
7¼	3.28
7½	3.51
7¾	3.75
8	4
8¼	4.25
8½	4.51
8¾	4.78
9	5.06
9¼	5.34
9½	5.64
9¾	5.94
10	6.25
11	7.56
11.31	8
12	9.00
13	10.56
14	12.25
15	14.06
16	16
17	18.06
18	20.25
19	22.56
20	25.00
21	27.56
22	30.25
22.62	32
23	33.06
24	36.00
25	39.06
26	42.25
27	45.56
28	49.00
29	52.56
30	56.25
31	60.06
32	64
33	68.06
34	72.25
35	76.56
36	81.00
37	85.56
38	90.25
39	95.06
40	100.00
41	105.06
42	110.25
43	115.56
44	121.00
45	126.56
45.25	128
46	132.25
47	138.06
48	144.00
49	150.06
50	156.25
51	162.56
52	169.00
53	175.56
54	182.25
55	189.06
56	196.00
57	203.06
58	210.25
59	217.56
60	225.00
61	232.56
62	240.25
63	248.06
64	256
65	264.06
66	272.25
67	280.56
68	289.00
69	297.56
70	306 25
71	315.06
72	324.00
73	333.06
74	342.25
75	351.56
76	361.00
77	370.56
78	380.25
79	390.06
80	400.00
81	410.06
82	420.25
83	430.56
84	440.00
85	451.56
86	462.25
87	473.06
88	484.00
89	495.06
90	506.25
90.50	512
91	517.56
92	529.00
93	540.56
94	552.25
95	564.06
96	576.00
97	588.06
98	600.25
99	612.56
100	625.00

EQUATIONS RELATING TO FOCI.

The following simple optical formulas and calculations, worked out by Mr. J. A. C. Branfill, will prove useful in many branches of photography, especially where several lenses of varying foci are in constant use for a variety of purposes:

p = Principal focus.
F = Greater conjugate focus.
f = Lesser conjugate focus.
r = Ratio of any dimension in original to the same dimensions in copy (in case of reduction), or *vice versa* (in case of enlargement).
a = Diameter of aperture to lens.
x = Exposure required, assuming that $x = 1$ when $a = \frac{p}{4}$.

$$p = \frac{r(F+f)}{(r+1)^2}$$

$$f = p\left(\frac{1+r}{r}\right) = \frac{F+f}{r+1}$$

$$F = p(r+1) = rf$$

$$F+f = p \times \frac{(r+1)^2}{r} = p\left(2 + r + \frac{1}{r}\right)$$

$$r = \frac{F-p}{p} = \frac{p}{f-p} = \frac{F}{f}$$

$$x = \frac{f^2}{16\,a^2}$$

N. B.—For ordinary landscape work, where r is greater than 20, x may be taken as $\frac{p^2}{16\,a^2}$

NOTE.—In case the above may not be clear to some photographers, the following rules may be better understood:

To find the principal focus of a lens (p), focus a near object in the camera, and measure the distance between it and the ground glass ($F+f$); next find the proportion which any dimension in the object bears to the same dimension on the ground glass (r). Thus, if the original dimension be four times as large as its reproduction, we say that r equals (=) 4. Multiply $F+f$ by r, and divide the product by the square of a number greater by one than r ($r+1)^2$. This rule was lately published by Mr. Debenham.

To find the lesser conjugate focus (f) (if p and r are known), multiply p by the sum of $r+1$ and divide the product by r. Or divide $F+f$ by $r+1$.

To find the greater conjugate focus (F) multiply p by $r+1$. Or multiply f by r.

To find $F+f$ (the distance which the ground glass should be from the object to be copied in order to get a given value for r) multiply p by the sum of $r + \frac{1}{r} + 2$.

To find r divide $F-p$ (the difference between F and p) by p. Or divide p by $f-p$. Or divide F by f.

To find x divide the square of f by 16 times the square of a (the diameter of aperture to lens).

For example Focus an object which is five inches high, so that it is one inch high on the ground glass; thus we know that $r = 5$. Next measure the distance between the object and the ground glass ($F+f$), which is found to be 45 inches.

Then $p = 45 \times$ (multiplied by) $5 \div$ (divided by) $6 \times 6 = 6\frac{1}{4}$ inches.
$f = 6\frac{1}{4} \times 6 \div 5 = 7\frac{1}{2}$ inches. Or $f = 45 \div 6 = 7\frac{1}{2}$ inches.
$F = 6\frac{1}{4} \times 6 = 37\frac{1}{2}$ inches. Or $F = 7\frac{1}{2} \times 5 = 37\frac{1}{2}$ inches.
$F+f = 6\frac{1}{4} \times (5 + \frac{1}{5} + 2) = 6\frac{1}{4} \times 7\frac{1}{5} = 45$ inches.
$r = (37\frac{1}{2} - 6\frac{1}{4}) \div 6\frac{1}{4} = 5$. Or $r = 6\frac{1}{4} \div (7\frac{1}{2} - 6\frac{1}{4}) = 5$.

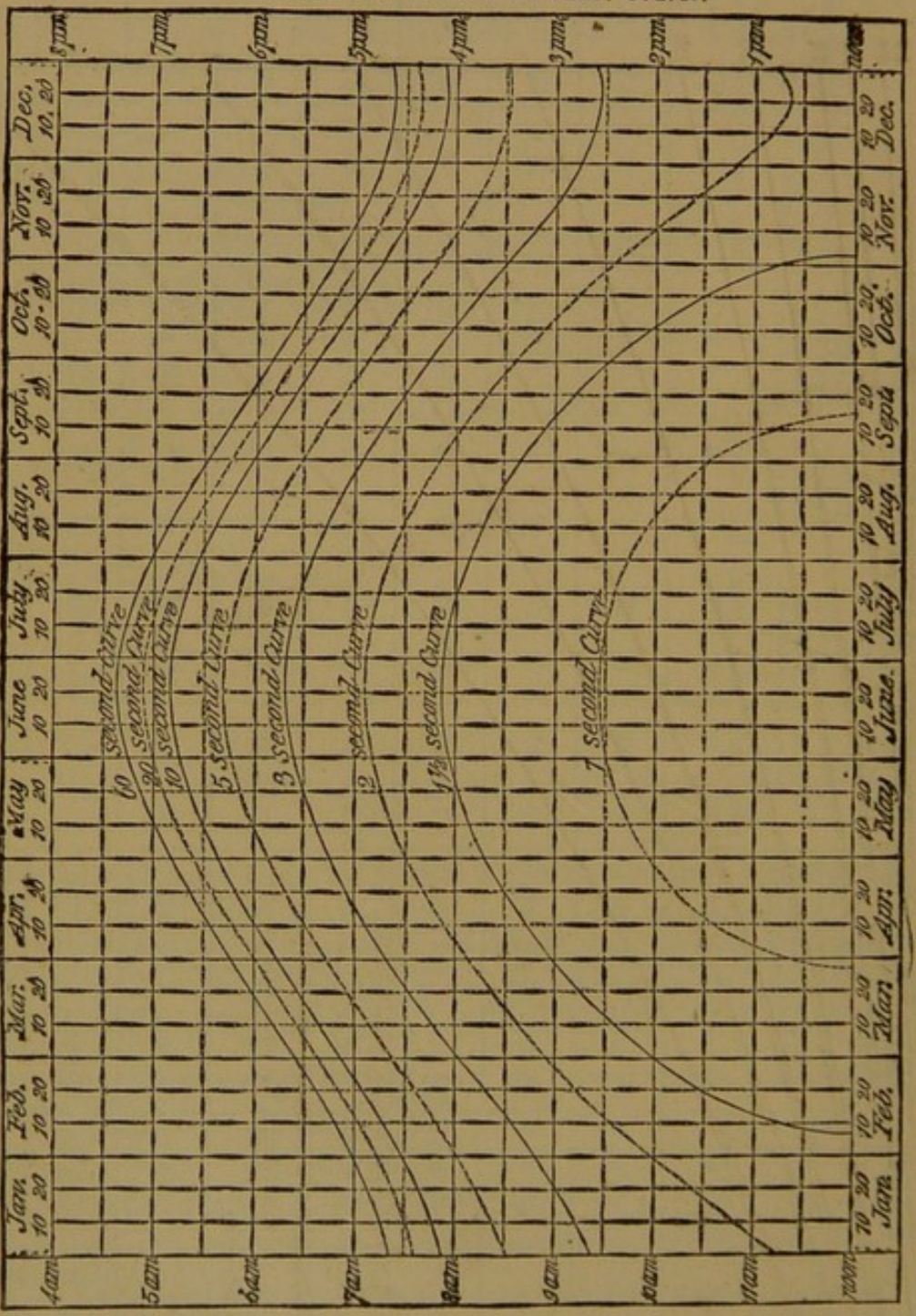
And x (the exposure required) will be $7\frac{1}{2} \times 8\frac{1}{2} \div (16 \times \frac{9}{16}) = 6\frac{1}{2}$; that is, the exposure will be $6\frac{1}{2}$ times as much as the exposure required with an aperture whose diameter equals $p \div 4$, assuming the aperture (a) to be $\frac{1}{4}$ inch diameter.

PROF. BURTON'S TABLE OF COMPARATIVE EXPOSURES.

Apertures Calculated on the Standard System of the Photographic Society.	Sea and Sky.	Open Landscape.	Landscape with heavy foliage in foreground.	Under Trees, up to		Fairly Lighted Interiors.		Badly Lighted Interiors, up to		Portraits in bright diffused Light out of doors.	Portraits in good Studio Light.		Portraits in Ordinary Room.	
				mins.	secs.	mins.	secs.	hrs.	mins.		mins.	secs.	mins.	secs.
No. 1, or $\frac{f}{4}$	$\frac{1}{100}$ sec.	$\frac{1}{50}$ sec.	$\frac{1}{8}$ sec.	0	10	0	10	0	2	$\frac{1}{6}$ sec.	0	1	0	4
No. 2, or $\frac{f}{5.657}$	$\frac{1}{80}$ sec.	$\frac{1}{25}$ sec.	$\frac{1}{4}$ sec.	0	20	0	20	0	4	$\frac{1}{3}$ sec.	0	2	0	8
No. 4, or $\frac{f}{8}$	$\frac{1}{40}$ sec.	$\frac{1}{12}$ sec.	$\frac{1}{2}$ sec.	0	40	0	40	0	8	$\frac{2}{3}$ sec.	0	4	0	16
No. 8, or $\frac{f}{11.314}$	$\frac{1}{20}$ sec.	$\frac{1}{6}$ sec.	1 sec.	1	20	1	20	0	16	$1\frac{1}{3}$ sec.	0	8	0	32
No. 16, or $\frac{f}{16}$	$\frac{1}{10}$ sec.	$\frac{1}{3}$ sec.	2 secs.	2	40	2	40	0	32	$2\frac{2}{3}$ secs.	0	16	1	4
No. 32, or $\frac{f}{22.627}$	$\frac{1}{5}$ sec.	$\frac{2}{3}$ sec.	4 secs.	5	20	5	20	1	4	$5\frac{1}{3}$ secs.	0	32	2	8
No. 64, or $\frac{f}{32}$	$\frac{2}{5}$ sec.	$1\frac{1}{3}$ sec.	8 secs.	10	40	10	40	2	8	$10\frac{2}{3}$ secs.	1	4	4	16
No. 128, or $\frac{f}{45.255}$	$\frac{4}{5}$ sec.	$2\frac{2}{3}$ secs.	16 secs.	21	20	21	20	4	16	21 secs.	2	8	8	32
No. 256, or $\frac{f}{64}$	$1\frac{3}{5}$ sec.	$5\frac{1}{3}$ secs.	32 secs.	42	40	42	40	8	32	42 secs.	4	16	17	4

DIAGRAM OF COMPARATIVE EXPOSURES.

Computed for the latitude of Washington, D. C. (38 deg., 54 min., N.)
By Lieut. Commander S. W. Very, U. S. N.



The straight lines in this diagram represent divisions of time; the vertical ones showing the month and day, and the horizontal ones the time of day as shown by a sun-dial.

The curved lines are curves of equal altitudes of the sun, computed for the latitude of Washington, for the year 1889.

The combination of the two systems of lines is designed to enable the Photographer, whether amateur or professional, who has at some time determined the length of exposure required under certain circumstances of subject, clouds, lens, diaphragm, plate or film, etc., to decide what exposure to give *under the same circumstances*, at any time between sunrise and sunset, on any day of the year.

The diagram is based upon one constructed for the latitude of London, published in the *Photographic News*, in 1887, and reprinted in the ANNUAL of 1888, and the same standard of comparison is used in this adaptation—that is, such circumstances of subject, clouds, lens, diaphragm, plate or film, etc., as will require an exposure of one second, at noon of any day between the 4th of April and the 7th of September, or at any time between a quarter to ten in the forenoon and a quarter past two in the afternoon of the 21st of June.

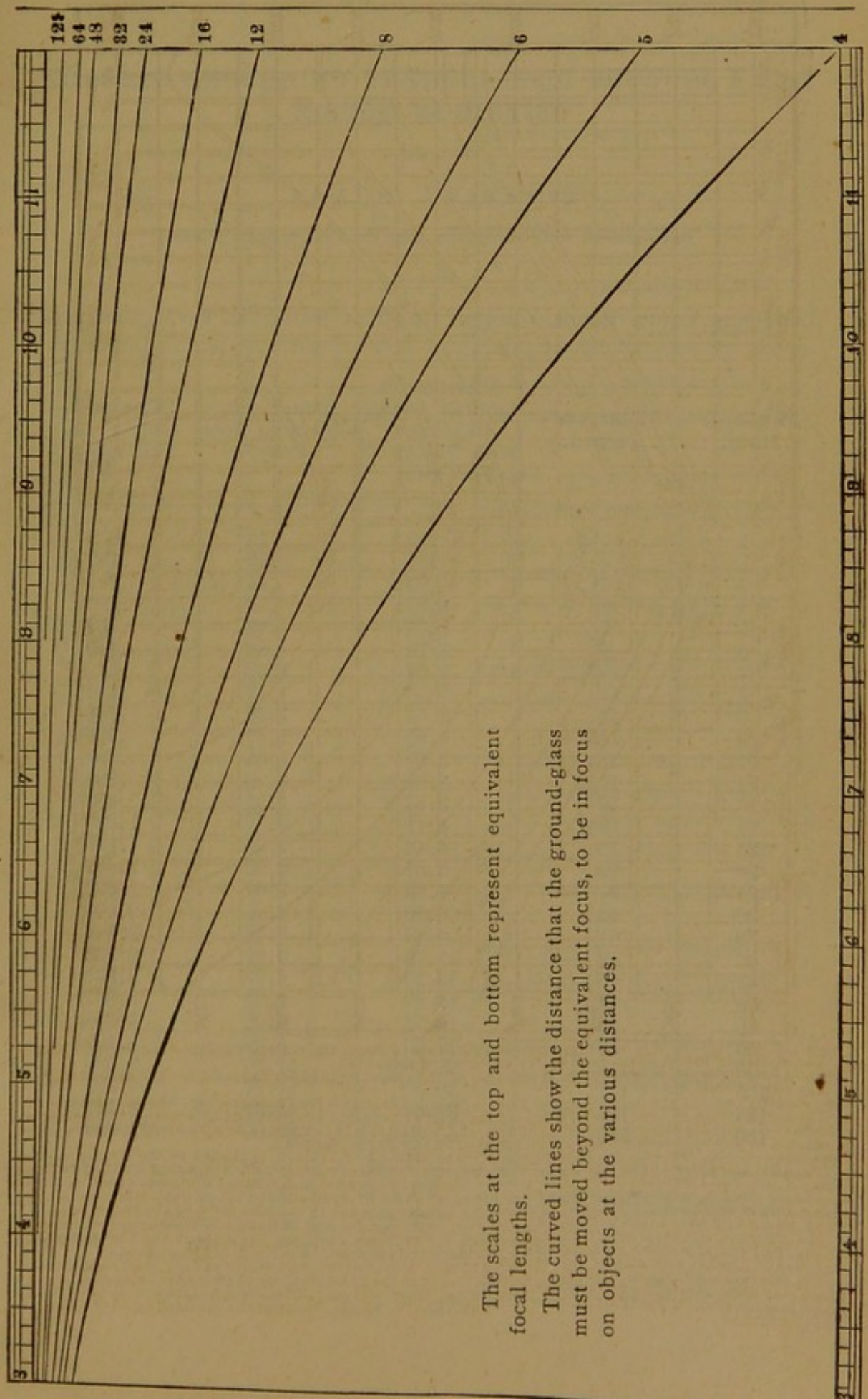
The diagram, although constructed for the year 1889, and for the latitude of Washington, will serve equally well for any other year, and well enough for ordinary purposes, throughout the United States, (exclusive of Alaska), although in the extreme Northern and Southern belts it will not be accurate.

The diagram is strictly accurate for "apparent time," only, but it is sufficiently so for "local mean time," (which may differ 16 minutes from "apparent time"), and in the great majority of places for "standard time," (which in some places differs half an hour from "mean time," and may differ three-quarters of an hour from "apparent time").

SAMUEL W. VERY, *Lieutenant Commander, U. S. Navy.*

FOCUSING SCALES FOR ANY LENS OF FROM 3 TO 12 INCHES EQUIVALENT FOCUS.

Drawn by W. T. WINTRINGHAM.



The scales at the top and bottom represent equivalent focal lengths.

The curved lines show the distance that the ground-glass must be moved beyond the equivalent focus, to be in focus on objects at the various distances.

TABLE SHOWING DISPLACEMENT ON GROUND GLASS OF OBJECTS IN MOTION.

By HENRY L. TOLMAN.

[Republished, with corrections, from the *Photographic Times*.]

Lens 6 in Equiv. Focus, Ground Glass at Principal Focus of Lens.

Miles per Hour.	Feet per Second.	Distance on Ground Glass, in inches, with Object 30 Feet away.	Same with Object 60 Feet away.	Same with Object 120 Feet away.
1	1½	.29	.15	.073
2	3	.59	.29	.147
3	4½	.88	.44	.220
4	6	1.17	.59	.293
5	7½	1.47	.73	.367
6	9	1.76	.88	.440
7	10½	2.05	1·03	.513
8	12	2 35	1.17	.587
9	13	2.64	1.32	.660
10	14½	2.93	1.47	.733
11	16	3.23	1.61	.807
12	17½	3.52	1.76	.880
13	19	3.81	1.91	.953
14	20½	4.11	2.05	1.027
15	22	4.40	2.20	1.100
20	29	5.87	2.93	1.467
25	37	7.33	3.67	1.833
30	44	8.80	4.40	2.200
35	51	10.27	5.13	2.567
40	59	11.73	5.97	2·933
45	66	13.20	6.60	3.300
50	73	14.67	7.33	3.667
55	80	16.13	8.06	4.033
60	88	17.60	8.80	4.400
75	110	22.00	11.00	5.500
100	147	29.33	14.67	7.333
125	183	36.67	18.33	9.167
150	220	44.00	22.00	11.000

LANTERNISTS' READY RFFERENCE TABLE.

(From Optical Magic Lantern Journal.)

If A=focal length of objective, B=diameter of slide, C=diameter of disc on screen, D=distance between objective and screen, then $D=\frac{C \times A}{B}$ $A=\frac{D \times B}{C}$ $C=\frac{D \times B}{A}$

The following table has been computed by these rules and will show by a glance the relations between the size of disc and distance from screen for object glasses of all foci from 4 inches to 15 inches. The diameter of slide is taken as 3 inches, that being the usual opening of the mat.

Distance between Lantern and Screen.	FOCUS OF LENS.											
	4in.	5in.	6in.	7in.	8in.	9in.	10in.	11in.	12in.	13in.	14in.	15in.
	DIAMETER OF DISC.											
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
10 feet.	7 6	6 0	5 0	4 3	3 9	3 4	3 0	2 9	2 6	2 4	2 2	2 0
11 "	8 3	6 7	5 6	4 9	4 2	3 8	3 4	3 0	2 9	2 6	2 4	2 2
12 "	9 0	7 2	6 0	5 2	4 6	4 0	3 7	3 3	3 0	2 9	2 7	2 5
13 "	9 9	7 10	6 6	5 7	4 11	4 4	3 11	3 7	3 3	3 0	2 9	2 7
14 "	10 6	8 5	7 0	6 0	5 3	4 8	4 2	3 10	3 7	3 3	3 0	2 9
15 "	11 3	9 0	7 6	6 5	5 8	5 0	4 6	4 1	3 9	3 6	3 3	3 0
20 "	15 0	12 0	10 0	8 7	7 6	6 8	6 0	5 6	5 0	4 7	4 3	4 0
25 "	18 9	15 0	12 6	10 9	9 4	8 4	7 6	6 10	6 3	5 0	5 4	5 0
30 "	22 6	18 0	15 0	12 10	11 3	10 0	9 0	8 2	7 6	6 11	6 5	6 0
35 "	26 3	21 0	17 6	15 0	13 1	11 8	10 6	9 6	8 9	8 1	7 6	7 0
40 "	30 0	24 0	20 0	17 2	15 0	13 4	12 0	10 10	10 0	9 2	8 6	8 0
45 "	33 9	27 0	22 6	19 3	16 10	15 0	13 6	12 3	11 3	10 4	9 8	9 0
50 "	37 6	30 0	25 0	21 5	18 9	16 8	15 0	13 8	12 .6	11 6	10 9	10 0

EXAMPLES,—An 8in. focus lens at a distance of 35ft. will give a disc of 13ft. 1in. To produce a disc of 12ft. with a lens of 10in. focus, the lantern and screen must be separated by 40ft. To produce a disc of 15ft. at a distance of 45ft. will require a lens of 9in. focus.

TABLE FOR ENLARGEMENT AND REDUCTION

COMPUTED FOR CENTIMETERS OR INCHES.

Equivalent Focus of the Lens.	DISTANCES OF THE OBJECT AND THE GROUND GLASS SCREEN FROM THE CENTER OF THE OBJECTIVE.																							
	1 *t.*	2 *t.*	3 *t.*	4 *t.*	5 *t.*	6 *t.*	7 *t.*	8 *t.*	9 *t.*	10 *t.*	11 *t.*	12 *t.*	13 *t.*	14 *t.*	15 *t.*	16 *t.*	17 *t.*	18 *t.*	19 *t.*	20 *t.*	21 *t.*	22 *t.*	23 *t.*	24 *t.*	25 *t.*
5..	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
	10	7.5	6.7	6.2	6	5.8	5.7	5.6	5.6	5.5	5.4	5.4	5.4	5.4	5.3	5.3	5.3	5.3	5.3	5.3	5.2	5.2	5.2	5.2	5.2
6..	12	18	24	30	36	42	48	54	60	66	72	78	84	90	92	102	108	114	120	126	132	138	144	150	156
	12	9	8	7.5	7.2	7	6.9	6.8	6.7	6.6	6.5	6.5	6.4	6.4	6.4	6.4	6.4	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.2
7..	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147	154	161	168	175	182
	14	10.5	9.3	8.8	8.4	8.2	8	7.9	7.8	7.7	7.6	7.6	7.5	7.5	7.5	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3
8..	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160	168	176	184	192	200	208
	16	12	10.7	10	9.6	9.3	9.1	9	8.8	8.8	8.7	8.7	8.6	8.6	8.5	8.5	8.5	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.3
9..	18	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153	162	171	180	189	198	207	216	225	234
	18	13.5	12	11.3	10.8	10.5	10.3	10.1	9.9	9.9	9.8	9.8	9.7	9.6	9.6	9.6	9 5	9.5	9.5	9.5	9.4	9.4	9.4	9.4	9.4
10..	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260
	20	15	13.3	12.5	12	11.7	11.4	11.3	11.1	11	10.9	10.8	10.8	10.7	10.7	10.6	10.6	10.6	10.5	10.5	10.5	10.5	10.4	10.4	10.4
11..	22	33	44	55	66	77	88	99	110	121	132	143	154	165	176	187	198	209	220	231	242	253	264	275	286
	22	16.5	14.7	13.8	13.2	12.8	12.6	12.4	12.2	12.1	12	11.9	11.8	11.8	11.7	11.7	11.6	11.6	11.6	11.6	11.5	11.5	11.5	11.5	11.4
12..	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312
	24	18	16	15	14.4	14	13.7	13.5	13.3	13.2	13.1	13	12.9	12.9	12.8	12.7	12.7	12.7	12.6	12.6	12.6	12.5	12.5	12.5	12.5
13..	26	39	52	65	78	91	104	117	130	143	156	169	182	195	208	221	234	247	260	273	286	299	312	325	338
	26	19.5	17.3	16.3	15.6	15.1	14.9	14.6	14·4	14.3	14.2	14.1	14	13.9	13.9	13.8	13.8	13.7	13.7	13.7	13.6	13.6	13.6	13.5	13.5
14..	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280	294	308	322	336	350	364
	28	21	18.7	17.5	16.8	16.3	16	15.8	15.6	15.4	15.3	15.2	15.1	15	14.9	14.9	14.8	14.8	14.7	14.7	14.7	14.6	14.6	14.6	14.6
15..	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	315	330	345	360	375	390
	30	22.5	20	18.8	18	17.5	17.1	16.9	16.7	16.5	16.4	16.3	16.2	16.1	16	15.9	15.9	15.8	15.8	15.8	15.7	15.7	15.7	15.6	15.6

16..	32	48	64	80	96	112	128	144	160	176	192	208	224	240	256	272	288	304	320	336	352	368	384	400	416
	32	24	21.3	20	19.2	18.7	18.3	18	17.8	17.6	17.5	17.3	17.2	17.1	17.1	16.9	16.9	16.9	16.8	16.8	16.8	16.7	16.7	16.7	16.6
17..	34	51	68	85	102	119	136	153	170	187	204	221	238	255	272	289	306	323	340	357	374	391	408	425	442
	34	25.5	22.7	21.3	20.4	19.8	19.4	19.1	18.9	18.7	18.5	18.4	18.3	18.2	18.1	18.1	18	17.9	17.9	17.9	17.8	17.8	17.7	17.7	17.7
18..	36	54	72	90	108	126	144	162	180	198	216	234	252	270	288	306	324	342	360	378	396	414	432	450	468
	36	27	24	22.5	21.6	21	20.6	20.3	20	19.8	19.6	19.5	19.4	19.3	19.2	19.1	19.1	19	18.9	18.9	18.8	18.8	18.8	18.8	18.7
19..	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342	361	380	399	418	437	456	475	494
	38	28.5	25.3	23.8	22.8	22.2	21.7	21.4	21.1	20.9	20.7	20.6	20.5	20.4	20.3	20.2	20.1	20.1	20	20	19.9	19.8	19.8	19.8	19.8
20..	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520
	40	30	26.6	25	24	23.3	22.9	22.5	22.2	22	21.8	21.7	21.5	21.4	21.3	21.3	21.2	21.2	21.1	21	21	20.9	20.9	20.8	20.8
21..	42	63	84	105	126	147	168	189	210	231	252	273	294	315	336	357	378	399	420	441	462	483	504	525	546
	42	31.5	28	26.3	25.2	24.5	24	23.7	23.3	23.1	22.9	22.8	22.6	22.5	22.4	22.3	22.2	22.2	22.1	22.1	22	21.9	21.9	21.9	21.8
22..	44	66	88	110	132	154	176	198	220	242	264	286	308	330	352	374	396	418	440	462	484	506	528	550	572
	44	33	29.3	27.5	26.4	25.7	25.1	24.8	24.4	24.2	24	23.8	23.7	23.6	23.5	23.4	23.2	23.2	23.2	23.1	23	23	23	22.9	22.1
23..	46	69	92	115	138	161	184	207	230	253	276	299	322	345	368	391	414	437	460	483	506	529	552	575	598
	46	34.5	30.7	28.8	27.6	26.7	26.3	25.9	25.6	25.3	25.1	24.9	24.8	24.6	24.5	24.4	24 3	24.3	24.2	24.2	24.1	24	24	24	23 9
24..	48	72	96	120	144	168	192	216	240	264	288	312	336	360	384	408	432	456	480	504	528	552	576	600	624
	48	36	32	30	28.8	28	27.4	27	26.7	26.4	26.2	26	25.8	25.7	25.6	25.5	25.4	25.3	25.3	25.2	25.1	25.1	25	25	25
25..	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650
	50	37.5	33.3	31.3	30	29.2	28.6	28.1	27.8	27.5	27.3	27.1	26.9	26.8	26.7	26.6	26.5	26.4	26.3	26.3	26.2	26.1	26.1	26	26

The use of the above table will best be explained by illustrations :

To enlarge six times with a lens of 15 centimeters (or inches) focal length. We find in the table under 6 *t.* and opposite the figures $\frac{105}{17.5}$, hence the object must be 17.5, and the screen 105 centimeters (or inches) from the centre of the lens.

To reduce eight times with a lens of 19 centimeters (or inches) focus, the object must be 171 and the screen 21.4 centimeters (or inches) from centre of lens.

The table can be formulated thus : Where p = focal length of lens, a = distance from ground-glass to centre of lens and b = distance from object to centre of lens, then $\frac{1}{a} + \frac{1}{b} = \frac{1}{p}$

TABLE OF THE SYMBOLS, ATOMICITY, ATOMIC AND EQUIVALENT WEIGHTS OF THE ELEMENTS.

	Symbol and Atomic Value.	Atomic Weight.	Equivalent Weight.
Aluminium (Al_2^{vi})	Al^{iv}	27·5	9·13
Antimony ($Sb^{''}$)	Sb^{v}	122	40·66
Arsenicum ($As^{'''}$)	$As^{'}$	75	25·0
Barium	$Ba^{''}$	137	68·5
Beryllium, or Glucinum	$Be^{''}$	9·5	4·7
Bismuth ($Bi^{'''}$)	Bi^{v}	208	69·33
Boron	$B^{'''}$	11	3·66
Bromine	$Br^{'}$	80	80·0
Cadmium	$Cd^{''}$	112	56·0
Cæsium	$Cs^{'}$	133	135·0
Calcium	$Ca^{''}$	40	20·0
Carbon ($C^{''}$)	C^{iv}	12	3·0
Cerium ($Ce^{''}$)	Ce^{vi}	92	46·0
Chlorine	$Cl^{'}$	35·5	35 5
Chromium Cr_2^{vi})	Cr^{vi}	52·5	26·1
Cobalt ($Co^{''}$)	Co^{vi}	58·8	29·4
Copper	$Cu^{''}$	63·5	63·4 / 31·7
Davyum	—	—	—
Decipium	—	—	—
Didymium	$D^{''}$	96	47·5
Erbium (?)	$Eb^{''}$	112·6	56·3
Fluorine	$F^{'}$	19	19·0
Gallium	—	—	—
Gold	$Au^{'''}$	196·7	65·33
Hydrogen	$H^{'}$	1	1·
Indium	In^{vi}	75·6	37·8
Iodine	$I^{'}$	127	127·0
Iridium	Ir^{iv}	107	49·5
Iron ($Fe^{''}$ & Fe_2^{vi})	Fe^{vi}	56	28·0 / 18·66
Lanthanium	$La^{'}$	92	46·4
Lavœsium	—	—	—
Lead ($Pb^{''}$)	Pb^{iv}	207	103·5
Lithium	$L^{'}$	7	7·0
Magnesium	$Mg^{''}$	24	12·0
Manganese ($Mn^{''}$ & Mn^{iv})	Mn^{vi}	55	27·5
Mercury	$Hg^{''}$	200	200·0 / 100·0
Molybdenum	Mo^{vi}	96	45·4
Mosandeum	—	—	—
Nephmium	—	—	—
Nickel ($Ni^{''}$)	Ni^{vi}	58·8	29·4
Niobium	Nb^{v}	97·6	18·8
Nitrogen ($N^{'}$ & $N^{'''}$)	N^{v}	14	4·66
Norwegium	—	—	—
Osmium	Os^{iv}	199	49·75

TABLE OF SYMBOLS, ETC.—(*Continued.*)

	Symbol and Atomic Value.	Atomic Weight.	Equivalent Weights.
Oxygen	O''	16	8·0
Palladium	Pd^{iv}	106·5	53·25
Phillipium	—	—	—
Phosphorus (P''')	P^{v}	31	10·33
Platinum	Pt^{iv}	198	98·7 49·35
Potassium (Kalium)	K'	39	39·1
Rhodium	Rh^{iv}	104·3	52·2
Rubidium	Rb'	85·3	85·4
Ruthenium	Ru^{iv}	104·2	26·0
Scandium	—	—	—
Selenium	Se^{vi}	79·5	39·7
Silicon (Silicium)	Si^{iv}	28	7·0
Silver	Ag'	108	108·0
Sodium (Natrium)	Na'	23	23·0
Strontium	Sr''	87·5	43·75
Sulphur S'' & S^{iv})	S^{vi}	32	16·
Tantalum	Ta^{v}	182	36·4
Tellurium	Te^{vi}	129	64·0
Terbium (?)	—	—	—
Thallium	Tl''	204	204·0
Thorinum (Thorium)	Th''	232	57·87
Tin (Sn'')	Sn^{iv}	118	59·0 29·5
Titanium	Ti^{iv}	50	12·5
Tungsten	W^{vi}	184	46·0
Uralium	—	—	—
Uranium	U^{vi}	120	60·
Vanadium	V^{v}	51·3	17·1
Yttirbium	—	—	—
Yttrium	Y''	61·7	30·85
Zinc	Zn''	65	32·6
Zirconium	Zr^{iv}	89·5	22·4

TABLE OF SYMBOLS, MOLECULAR WEIGHT AND SOLUBILITIES OF THE PRINCIPAL CHEMICALS USED IN PHOTOGRAPHY.

Abbreviations.—s., soluble; v. s., very soluble; sp. s., sparingly soluble; n.s., not soluble; dec., decomposed; del., deliquescent.

Name.	Symbol.	Mol. Weight.	One Part is Soluble in Cold Water	One Part is Soluble in Hot Water.	Alcohol.
Acid, Acetic, Glacial	$HC_2H_3O_2$	60	s.	s.	s.
" Boracic or Boric	H_3BO_3	62	30	3	1 in 30
" Carbolic (see Phenol)	HC_6H_6O	94	16·6	s.	s.
" Chlorhydric (see Hydrochloric)					
" Citric	$H_3C_6H_5O_7,H_2O$	210	·75	·5	10 in 15
" Digallic (see Tannic Acid)					
" Formic	H,CHO_2	46			
" Gallic	$HC_7H_5O_5$	170	100	3	1 in 8
" Hydrobromic	HBr	81			
" Hydriodic	HI	128			
" Hydrochloric	HCl	36·5			
" Hydrocyanic	HCy	27			
" Hydrosulphuric	H_2S	34			
" Muriatic (see Hydrochloric)					
" Nitric	HNO_3	63			
" Nitrous	HNO_2	47			
" Oxalic	$H_2C_2O_4,2H_2O$	126	8	1	n. s.
" Pyrogallic (see Pyrogallol)	$H_3C_6H_3O_3$	126	3·5	1	v.s.& ether
" Salicylic	$HC_7H_5O_3$	138	760	9	v.s.& ether
" Sulphuric	H_2SO_4	98			
" Sulphurous	H_2SO_3	82		al	so in ether
" Tannic (see Digallic Acid)	$H_4C_{27}H_{18}O_{17}$	618	·8	·5	10 in 8
" Tartaric	$H_4C_4H_2O_6$	150	·8	·5	1 in 5
Alcohol, Ethyl	C_2H_5OH	46			
" Methyl (see Wood Alcohol)	CH_3HO	32			
Alum (see Potassium Aluminium Sulphate)					

Alum Chrome (see Potassium Chromic Sulph.)	.....	.....	.....	.....	.....
Ammonia, Gaseous	H_3N	17	v. s.	.....	.....
Ammonium, Bichromate	$(NH_4)_2Cr_2O_7$	253	v. s.	v. s.	.....
" Bromide	NH_4Br	98	1·5	1	1 in 13
" Carbonate (see Sal volatile)	$NH_4HCO_3 + NH_4CO_2NH_2$	175	[illegible]	dec.	sp. s.
" Chloride (see Sal ammoniac)	NH_4Cl	53·5	3	1	sp. s.
Ammonium Fluoride	NH_4F	37	v. s.	v. s.	sp. s.
" Iodide	NH_4I	145	1	·5	s.
" Nitrate	NH_4NO_3	80	2	1	s.
" Oxalate	$(NH_4)_2C_2O_4$	124	v. s.	v. s.	1:2
" Sulphide	NH_4HS	51	v. s.	v. s.	1:2
" Sulpho-cyanide	NH_4CNS	76	1	·5	s.
Barium, Bromide	$BaBr_2$	297	·90	·75	s.
" Chloride	$BaCl_2, 2H_2O$	244	2·18	1·5	sp. s.
" Iodide	BaI_2	391	·48	·35	v. s.
" Per-oxide	BaO_2	169	n. s.	n. s.	in hdchl. acid
Bicarbonate of Potassa (see Potassium Bicarb).	.....	.....	.....	.....	.....
Bicarbonate of Soda (see Sodium Bicarbonate)	.....	.....	.....	.....	.....
Bichloride of Mercury (see Mercuric Chloride)	.....	.....	.....	.....	.....
Bromine	Br	79·8	s.	s.	s.
Borax (see Sodium Biborate)	.....	.....	.....	.....	.....
Cadmium, Bromide	$CdBr_2, 4H_2O$	344	1·5	1	sp. s.
" Chloride	$CdCl_2$	183	·71	·67	sp. s.
" Iodide	CdI_2	366	1·5	1	1 in 2
Calcium, Bromide	$CaBr_2, 4H_2O$	272	1	·75	s.
" Carbonate (see Chalk)	$CaCO_3$	100	n. s.	n. s.	n. s.
" Chloride	$CaCl_2$	111	·75	·5	1 in 10
" Hypochlorite (see Chloride of Lime)	$CaCl_2O_2CaCl_2$	254	sp. s.	sp.	dec.
" Iodide	CaI_2	294	·75	·5	1 in 10
Calomel (see Mercurous Chloride)	.....	.....	.....	.....	.....
Carbonate of Ammonia (see Ammonium Carb)	.....	.....	.....	.....	.....
Carbonate of Potash (see Potassium Carbonate)	.....	.....	.....	.....	.....
" of Soda (see Sodium Carbonate)	.....	.....	.....	.....	.....
Caustic Potash (see Potassium Hydrate)	.....	.....	.....	.....	.....
" Soda (see Sodium Hydrate)	.....	.....	.....	.....	.....

TABLE OF SYMBOLS, MOLECULAR WEIGHT AND SOLUBILITIES OF THE PRINCIPAL CHEMICALS USED IN PHOTOGRAPHY.

Abbreviations.—s., soluble; v. s., very soluble; sp. s., sparingly soluble; n. s., not soluble; dec., decomposed; del., deliquescent.

Name.	Symbol.	Mol. Weight.	One Part is Soluble in Cold Water	One Part is Soluble in Hot Water.	Alcohol.
Chalk (see Calcium Carbonate)					
Chloride of Lime (see Calcium Hypochlorite)					
Chlorine	Cl	35·4	1:2·5	Volumes.	
Chrome, Alum (see Potassium Chromic Sulph.)					
Copper Acetate (see Verdigris)	$Cu(C_2H_3O_2)_2,H_2O$	200	14	5	1 in 14
" Bromide	$CuBr_2$	223·4	1	·75	s.
" Chloride	$CuCl_2,H_2O$	170·5	1	·75	v. s.
" Sulphate (see Blue Vitriol),	$CuSO_4.5H_2O$	249·2	3	1	n. s.
" " and Ammonia	$CuSO_4,4NH_3$	245·5	s.	v. s.	n. s.
Corrosive Sublimate (see Mercuric Chloride)					
Epsom Salts (see Magnesium Sulphate)					
Glaubers Salt (see Sodium Sulphate)					
Glycerine	$C_3H_5(HO)_3$	92	s.	s.	s.
Gold, Perchloride	$AuCl_3$	302·5	1	·75	also in ether
Green Vitriol (See Iron Sulphate)					
Hydrokinone	$C_6H_4 2HO$	110	3	s.	also in ether
Hydroxylamine Chloride	NH_3OHCl		v. s.	v. s.	n. s.
Iodine	I	126.6	sp. s.	sp. s.	v. s.
Iron, Ammonium Sulphate	$FeSO_4(NH_4)_2SO_4+6H_2O$	392	v. s.	dec.	n. s.
" Chloride (Ferric)	Fe_2Cl_6	325	·75	·5	1 in 1
" " (Ferrous)	$FeCl_2$	127	2	1	1 in 1
" Citrate	$Fe_2(C_6H_5O_7)_2$	598	s.	s.	n. s.
" Iodide	FeI_2	310	v. s.	v. s.	v. s.
" Nitrate	$Fe(NO_3)_2,6H_2O$	288	v. s.	dec.	dec.
" Oxalate (Ferric)	$Fe_2(C_2O_4)_3$	376	s.	s.	n. s.
" Oxalate (Ferrous)	FeC_2O_4	144	in potass-	ium oxal.	n. s.

Iron, Sulphate (Ferric)	$Fe_2(SO_4)_3$	400	s.	dec.	s.
" Sulphate (Ferrous)	$FeSO_4,7H_2O$	278	1·5	1	n. s.
Lead, Acetate (see Sugar of Lead)	$Pb.(C_2H_3O_2)_2.3H_2O$	379	2·5	2	1 in 12·5
" Carbonate	$(PbCO_3)Pb(HO)_2$	774	n. s.	sp. s.	n. s.
" Iodide	PbI_2	460	s.	s.	n. s.
" Nitrate	$Pb(NO_3)_2$	331	7·7	7	s.
" Oxide	PbO	223	n. s.	n. s.	Alkalis.
Lithium, Bromide	$LiBr$	87	·66	·5	v. s.
" Chloride	$LiCl$	42·5	1·3	1	s.
" Iodide	LiI	134	·61	·5	s.
Magnesium, Bromide	$MgBr_2$	184	1	·75	s.
" Chloride	$MgCl_2$	95	2	1·5	s.
" Iodide	MgI_2	278	1	·75	v. s.
" Sulphate (see Epsom Salt)	$MgSO_4,7H_2O$	246	1·3	1	sp. s.
Mercury, Chloride (Mercuric) (see Corros. Subl)	$HgCl_2$	271	19	3	5
" " (Mercurous) (see Calomel)	Hg_2Cl	235·5	n. s.	n. s.	n. s.
" Cyanide	$HgCy_2$	252	8	2	1 in 20
" Iodide (Mercuric)	HgI_2	454	sp. s.	sp. s.	sp. s.
" " (Mercurous)	Hg_2I	327	n. s.	n. s.	n. s.
Phenol (see Carbolic Acid)					
Platinum Chloride	$PtCl_4$	339	1	·5	s.
Potassa (see Potassium Hydrate)					
Potassium, Aluminium Sulphate (see Alum)	$Al_2(SO_4)_3, K_2SO_4, 24H_2O$	948	10	8	n. s.
" Bicarbonate	$KHCO_3$	100	3	2	n. s.
" Bichromate	$K_2Cr_2O_7$	294·6	10	7	n. s.
" Bromide	KBr	119·1	2	1	1 in 90
" Carbonate	KO_2C_3	138·2	·75	·5	n. s.
" Chlorate	$KClO_3$	122·4	16	2	n. s.
" Chloride	KCl	74·5	3	2	sp. s.
" Chromic Sulph. (see Chrome Alum)	$Cr_2(SO_4)_3, K_2SO_4, 24H_2O$	999	10	dec.	n. s.
" Citrate	$K_3C_6H_5O_7H_2O$	324·3	·6	·3	n. s.
" Cyanide	KCy	65	1	·5	sp. s.
" Ferric Sulphate	$K_2SO_4.Fe_2(SO_4)_3, 24H_2O$	100·6	s.	s.	n. s.
" Ferri-cyanide (see Red Prussiate)	$K_6Fe_2C_{12}N_{12}$	658	2·5	1·2	n. s.
" Ferro-cyanide (see Yel. Pruss.)	$K_4FeC_6 3H_2O$	422	3	1	n. s.

TABLE OF SYMBOLS, MOLECULAR WEIGHT AND SOLUBILITIES OF THE PRINCIPAL CHEMICALS USED IN PHOTOGRAPHY.

Abbreviations.—s., soluble; v.s., very soluble; sp. s., sparingly soluble; n.s., not soluble; dec., decomposed; del., deliquescent.

Name.	Symbol.	Mol. Weight.	One Part is Soluble in Cold Water	One Part is Soluble in Hot Water.	Alcohol.
Potassium, Fluoride	KFl	94	v. s.	v. s.	v. s.
" Hydrate	KOH	56·1	·5	·25	sp. s.
" Iodide	KI	166·1	·75	·5	1 in 16
" Nitrate (see Saltpetre)	KNO_3	101·1	4	1	n. s.
" Oxalate	$KC_2O_4H_2O$	235	3	2	sp. s.
" Permanganate	$K_2Mn_2O_8$	314	16	10	n. s.
" Platino-chloride	K_2PtCl_6	488·4	10	1	s.
" Sulpho-cyanide	$KCyS$	97	2	1	sp. s.
Prussiate of Potash, red (see Potassium Ferri-cyanide)					
Prussiate of Potash, yellow (see Potassium Ferro-cyanide)					
Pyrogallol (see Pyrogallic Acid)					
Sal ammoniac (see Ammonium Chloride)					
Sal soda (see Sodium Carbonate)					
Sal tartar (see Potassium Carbonate)					
Saleratus (see Potassium Bicarbonate)					
Sal volatile (see Ammonium Carbonate)					
Salt, common (see Sodium Chloride)					
Saltpetre (see Potassium Nitrate)					
Saltpetre of Chili (see Sodium Nitrate)					
Sesqui-Carbonate of Soda (see Sodium Carb)					
Silver, Acetate	$AgC_2H_3O_2$	167	sp.s.	sp. s.	n. s.
" Bromide	$AgBr$	188	n. s.	n. s.	in HCl and HBr.

Silver, Carbonate	Ag_2CO_3	276	n. s.	n. s.	n. s.
" Chloride	AgCl	143·5	n. s.	n. s.	Ammonia, cyan. pot-ass. hypo sulphite of soda.
" Citrate	$Ag_3C_6H_5O_7$	513	sp. s.	sp. s.	.....
" Fluoride	AgFl	127	v. s.	v. s.	v. s.
" Iodide	AgI	235	n. s.	n. s.	same as Chloride.
" Nitrate	$AgNO_3$	170	1	·5	sp. s.
" Nitrite	$AgNO_2$	154	300	dec.	n. s.
" Oxalate	$Ag_2C_2O_4$	304	sp. s.	s.	n. s.
" Oxide	Ag_2O	232	n. s.	n. s.	n. s.
" Sulphide	Ag_2S	248	n. s.	n. s.	n. s.
Soda, Caustic (see Sodium Hydrate)	.....	.....	.....	.....	.....
Sodium Acetate	$NaC_2H_3O_2, 6H_2O$	190	3	·66	n. s.
" Biborate (Borax)	$Na_2B_4O_7, 10H_2O$	382	12·5	2	n. s.
" Bromide	NaBr	103	1·25	1	1:16
" Bicarbonate	$NaHCO_3$	84	12	dec.	n. s.
" Carbonate	$Na_2CO_3, 10H_2O$	286	2	1	n. s.
" Chloride	NaCl	58·5	2·75	2·75	n. s.
" Citrate	$Na_3C_6H_5O_7$	258	1	·5	sp. s.
" Hydrate	NaHO	40	1·5	·5	sp. s.
" Hypo-sulphite	$Na_2S_2O_35H_2O$	248	1·5	1	sp. s.
" Iodide	NaI	150	·5	·3	sp. s.
" Nitrate (see Chili Saltpetre)	$NaNO_3$	85	1·36	1	1 in 37
" Sulph-antimonite	$NaSbS_3$	241	s.	s.	n. s.
" Sulphate	$Na_2SO_4, 10H_2O$	322	2	4	s.
" Sulphide	$Na_2S.9H_2O$	240	s.	s.	sp. s.
" Sulphite	$Na_2SO_3, 7H_2O$	252	4	2	sp. s.
" Thio-sulphate (see Hypo-sulphite)	.....	.....	.....	.....	.....
Strontium, Bromide	$SrBr_2, 6H_2O$	355·5	1	·75	sp. s.
" Chloride	$SrCl_2, 6H_2O$	266·5	1·8	1	sp. s.
" Nitrate	$Sr(NO_3)_2$	211·5	5	2	sp. s.

TABLE OF SYMBOLS, MOLECULAR WEIGHT AND SOLUBILITIES OF THE PRINCIPAL CHEMICALS USED IN PHOTOGRAPHY.

Abbreviations.—s., soluble; v.s., very soluble; sp.s., sparingly soluble; n.s., not soluble; dec., decomposed; del., delinquescent.

Name.	Symbol.	Mol. Weight.	One Part is Soluble in Cold Water	One Part is Soluble in Hot Water.	Alcohol.
Sugar of Lead (see Lead Acetate)					
Sulphate Soda (see Sodium Sulphate)					
Tannin (see Digallic Acid)					
Thymol	$C_6H_3(CH_3(C_3H_7)COO$	177	sp.		& in ether
Tin, Chloride (Stannic)	$SnCl_4$	260	dec.	in much	water.
" Chloride (Stannous)	$SnCl_2.2H_2O$	225	v. s.	v. s.	v. s.
Urānium, Bromide	$UBr_2.4H_2O$	352	1	·5	sp. s.
" Nitrate	$UO_2(NO_3)_2, 6H_2O$	384	·5	·25	v. s.
" Sulphate	$UO_2(SO_4),3H_2O$	302	·5	·25	v. s.
Verdigris (see Copper Acetate)					
Vitriol, Blue (see Copper Sulphate)					
" Green (see Iron Sulphate)					
" White (see Zinc Sulphate)					
Washing Soda (see Sodium Carbonate)					
Wood Alcohol (see Alcohol Methyl)					
Zinc, Bromide	$ZnBr_2$	225·2	1	·5	s.
" Chloride	$ZnCl_2$	136·2	·33		s.
" Iodide	ZnI_2	319·2	·33	dec.	v. s.
" Nitrate	$Zn(NO_3)_2,6H_2O$	189	del.	del.	del.
" Sulphate (see White Vitriol)	$ZnSo_4,7H_2O$	287	·7	·5	n. s.

IMPURITIES IN PHOTOGRAPHIC CHEMICALS AND TESTS FOR THEM.

Substance.	Impurities Possibly Present.	Tests.
Ammonia	Carbonic Acid.	Renders lime-water milky.
	Dissolved solid matter	Residue left on evaporation.
	Chlorides.	After acidulating with nitric acid, it gives a precipitate with silver nitrate, which, after washing, is readily soluble in ammonia, and re-precipitated by nitric acid.
	Sulphates.	After acidulating with nitric acid, it gives a precipitate with barium nitrate.
	Lime.	A white precipitate with oxalate of ammonium.
	Lead is often present, derived from the action upon flint glass bottles.	Black precipitate with sulphuretted hydrogen.
Nitric Acid	Traces of sulphuric acid.	After dilution it gives a precipitate with barium nitrate.
	Chlorides.	After dilution it gives a precipitate with silver nitrate.
	Peroxide of nitrogen.	The acid is yellow.
	Iodine may be present if the acid be prepared from sodium nitrate.	After dilution and cooling it gives a blue color with starch paste or mucilage.
Hydrochloric Acid	Free chlorine.	Liberates iodine from solution of potassium iodide. See also chlorides, nitric acid.
	Sulphuric acid.	As above for nitric acid.
	Perchloride of iron.	Yellow color. Brown precipitate with ammonia added till it smells slightly.
Hydrochloric Acid	Arsenic.	Marsh's test.
	Some yellow samples contain no iron, but an organic salt, and give an alkaline ash on ignition of the residue after evaporation.	Reinsh's test; a small piece of copper foil becomes coated on boiling in dilute acid.
Sulphuric Acid	Bisulphate of potassium.	Residue on evaporation.
	Sulphate of lead.	Milkiness on dilution. May be completely freed from lead by diluting with three or four times as much water, and allowing to settle.
	When sold as pure, it invariably contains a trace of iron. Common acid is also liable to contain arsenic, selenium, thallium, and many other substances.	No easy test can be given, as the substances are so numerous; some of them volatile, and most require separation from the acid before detection.
	Organic matter, as a piece of straw in a carboy of acid.	Gives a brown color to the acid.
Acetic Acid	Water.	Does not solidify when cooled to 17° C, (53° F.)
	Sulphurous and hydrochloric acids.	White precipitate with silver nitrate.
	Aldehyde, or volatile tarry matter.	Blackens in the light after adding silver nitrate.
	Organic sulphuric acid.	Smell of garlic.
Citric Acid	Tartaric acid.	Strong solution of potassium acetate added to a strong solution of the acid will deposit white crystalline bitartrate.
Pyrogallic Acid	Metagallic acid.	Black residue insoluble in water.
Silver Nitrate	Free nitric acid.	Reddens litmus paper (neutral silver nitrate does not affect litmus).
Potassium Carbonate	Chlorides and sulphates.	Same as for ammonia.
Potassium Iodide	Potassium carbonate.	A strong solution is alkaline to test paper.
	Sulphates and chlorides.	Same as for ammonia.
	Potassium iodate.	A pretty strong solution becomes yellow from liberation of iodine on addition of dilute sulphuric acid, or better, a strong solution of citric acid.

IMPURITIES IN PHOTOGRAPHIC CHEMICALS AND TESTS FOR THEM.—*Continued.*

Substance.	Impurities Possibly Present.	Test.
Potassium Bromide	Similar to potassium iodide.	See potassium iodide.
Sodium Carbonate	Chlorides and sulphates.	Same as for ammonia.
Sodium Chloride	Chloride of calcium.	Oxalate of ammonium (after addition of a little acetic acid) gives a milkiness or precipitate, indicating calcium; filter this out, and add ammonia, chloride of ammonium, and phosphate of sodium (clear solutions). A precipitate indicates magnesium. Both the above cause dampness in wet weather.
	Chloride of magnesium.	
	Sodium sulphate.	As for sulphates in ammonia.
Potassium Cyanide	Potassium carbonate nearly always present.	Effervescence with dilute acids, giving off a gas carbonic anhydride, which renders lime water turbid.
Potassium Hydrate		
Kaolin	Chalk.	Effervescence with dilute acids.
Water	Sulphates and chlorides.	Same as for ammonia.
	Calcium carbonate, temporary hardness.	Deposited by boiling.
	Ammonia, almost always present in distilled and rain water.	Test as for calcium chloride, see sodium chloride.
		Brown coloration, or precipitate with Nessler's re-agent.
Gelatine	Alum.	Ash, sometimes as much as 10 per cent.
	Fatty matter.	Separated by precipitation with alcohol. Dissolved out by ether or benzine, and left as a residue on evaporation of the solvent.
Ammonium Bromide	Potassium bromide, or other non-volatile bodies.	Leaves a residue when heated.
	Ammonium chloride.	Same as for chlorides in ammonia.
Pyrogallic Acid	Powdered glass.	Left behind on solution.
Potassium Iodide	Potassium bromide.	The crystals of bromide are usually more transparent than those of iodide, but no reliance can be placed on this.
Silver Nitrate	Potassium nitrate, sometimes present in the fused sticks, not in the crystals.	Will not yield the full quantity of chloride on precipitation with HCl. Gives a purple color to flame.
Calcium Chloride	Calcium hydrate.	The clear filtered solution made with distilled water is alkaline to test paper, and gives a precipitate on breathing into it through a tube.
Pure (?) Chemicals generally.	Broken glass, bits of straw, wood, paper, &c.	These impurities either float or sink on the solution, and may easily be seen.

G. M. Jones.

ELSDEN'S TABLE OF POISONS AND ANTIDOTES.

	Poisons.	Remarks.	Characteristic Symptoms.	Antidote.
Caustic Vegetable Acids.	Oxalic Acid. including Potassium Oxalate.	1 dram is the smallest fatal dose known.	Hot, burning sensation in throat and stomach; vomiting, cramps, and numbness.	Chalk, whiting or magnesia, suspended in water. Plaster or mortar can be used in emergency.
Caustic Alkalies.	Ammonia. Potash. Soda.	Vapor of ammonia may cause inflammation of the lungs.	Swelling of tongue, mouth, and fauces; often followed by stricture of the œsophagus.	Vinegar and water.
Metallic Salts.	Mercuric Chloride.	3 grains the smallest known fatal dose.	Acrid, metallic taste, constriction and burning in throat and stomach, followed by nausea and vomiting.	White and yolk of raw eggs with milk. In emergency, flour paste may be used.
	Acetate of Lead.	The sub-acetate is still more poisonous.	Constriction in the throat and at pit of stomach; crampy pains and stiffness of abdomen; blue line round the gums.	Sulphates of soda or magnesia. Emetic of sulphate of zinc.
	Cyanide of Potassium.	*a*. Taken internally, 3 grs. fatal.	Insensibility, slow, gasping respiration, dilated pupils, and spasmodic closure of the jaws.	No certain remedy; cold affusion over the head and neck most efficacious.
		b. Applied to wounds and abrasures of the skin.	Smarting sensation.	Sulphate of iron should be applied immediately.
	Bichromate of Potassium	*a*. Taken internally. *b*. Applied to slight abrasions of the skin.	Irritant pain in stomach, and vomiting. Produces troublesome sores and ulcers.	Emetics and magnesia, or chalk.
	Nitrate of Silver.		Powerful irritant.	Common salt to be given immediately, followed by emetics.
Concentrated Mineral Acids.	Nitric Acid.	2 drams have been fatal. Inhalation of the fumes has also been fatal.	Corrosion of windpipe and violent inflammation.	Bicarbonate of soda, or carbonate of magnesia or chalk, plaster of the apartment beaten up in water.
	Hydrochloric Acid.	½ ounce has caused death.		
	Sulphuric Acid.	1 dram has been fatal.		
	Acetic Acid, concentrated, has as powerful an effect as the mineral acids.			
	Iodine.	Variable in its action; 3 grains have been fatal.	Acrid taste, tightness about the throat, vomiting.	Vomiting should be encouraged, and gruel, arrowroot and starch given freely.
	Ether.	When inhaled.	Effects similar to chloroform.	Cold affusion and artificial respiration.
	Pyrogallol.	2 grains sufficient to kill a dog.	Resemble phosphorus poisoning.	No certain remedy. Speedy emetic desirable.

ACKLAND'S TABLES FOR THE SIMPLIFICATION OF EMULSION CALCULATIONS.

No. 1.

	Equivalent weights.	Weight of $AgNO_3$ required to convert one grain of soluble haloid.	Weight of soluble haloid required to convert one grain $AgNO_3$	Weight of silver haloid produced by one grain of soluble haloid.	Weight of soluble haloid required to produce one grain of silver haloid.	Weight of silver haloid produced from one grain $AgNO_3$.
Ammonium bromide.....	98	1.734	.576	1.918	.521	
Potassium "	119.1	1.427	.700	1.578	.633	
Sodium "	103	1.650	.606	1.825	.548	1.106
Cadmium " com...	172	.988	1.012	1.093	.915	
" " anh....	136	1.25	.800	1.382	.723	
Zinc "	112.1	1.509	.663	1.670	.600	
Ammonium chloride.....	53.5	3.177	.315	2.682	.373	.844
Sodium "	58.5	2.906	.344	2.453	.408	
Ammonium iodide.....	145	1.172	.853	1.620	.617	
Potassium "	166.1	1.023	.977	1.415	.707	1.382
Sodium "	150	1.133	.882	1.566	.638	
Cadmium "	183	.929	1.076	1.284	.778	

Table No. 1 presents the actual weights of haloid or silver, as the case may be, required to convert or combine with one grain of another.

In order to make (say) ten ounces of emulsion by a new formula, which, for the sake of showing the working of the table, we will write down as follows :

Bromide of potassium..... ....".....150 grains.
Iodide of potassium..... 10 "
Chloride of ammonium..... 10 "
Gelatine.....200 "

we want to know how much silver nitrate should be employed in sensitizing this mixture. For this purpose we use the first column, in which we find against each haloid the exact quantity of silver nitrate required to fully decompose one grain. Taking, then, the figures we find in column No. 1 against the three salts in the above formula, and multiplying them by the number of grains of each used, we have the following sum :

Potassium bromide.....150 × 1.427 = 214 } Weight
" iodide..... ..... 10 × 1.023 = 10.23 } silver nitrate
Chloride of ammonium..... ..... 10 × 3.177 = 31.77 } required.

or the total quantity of silver nitrate required for full conversion, 256.00 grains.

TABLE SHOWING COMPARATIVE VALUE OF ALKALINE CARBONATES IN DEVELOPERS.

O. G. MASON.

Commercial Name.	Chemical Symbol.	Molecular Weight.	The Commercial Salt contains of the pure Salt about	100 parts of 36 per cent Acetic Acid Require for Saturation.	Solubility in Water (approximate).
Soda, Caustic	NaHO	40	80 to 92%	26.66 p'rts of 90% Soda	1 part in 2
Sodium Carbonate, Carbonate of Soda, Sal Soda, Crystals,	$Na_2CO_3.10H_2O$	286	96 to 98%	89.38 " 96% "	1 " 2
The same, anhydrous or in dry powder	Na_2CO_3	106	About 98 to 99%	89.38 of 98 to 99% dry Sal Soda.	1 " 6
Sodium Bicarbonate, Bicarbonate of Soda, "Sesqui-carbonate of Soda."	$NaHCO_3$	84	98 to 100%	53.91 of 99% Bicarb. Soda.	1 " 12

Equal work is done by 80 parts of Caustic Soda, 286 parts of Sal Soda (crystals), 106 parts of Sal Soda (dry), 168 parts of Bicarbonate of Soda. These quantities must be increased to make up for any impurity contained in the sample being used; for this purpose the usual percentage of impurity given in the above table may be assumed for all ordinary photographical uses.

Potassa (Caustic Potash)	KHO	56	80 to 95%	37.33 parts of 90% Potassa.	1 part in 1
Potassium Carbonate, Carbonate of Potassa, Sal Tartar, Saleratus,	$K_2CO_3.1\frac{1}{2}H_2O$	165	76 to 96% Usually about 81%	51.11 parts of 81% Carb. Potassa.	1 " 1
Potassium, Carbonate, dry	K_2CO_3	140	About 95%	122.74 parts of 95% Carb. Potassa.	1 " 1
Potassium Bicarbonate, Bicarbonate of Potassa,	$KHCO_3$	100	100%	60 parts of 100% Bicarb. Potassa.	1 " 4

Equal work is done by 112 parts Caustic Potassa, 165 parts (about) ordinary Carbonate Potassa, 200 parts of Bicarbonate Potassa. These quantities must be increased in proportion to impurities, as noted in case of Soda These two alkalies are interchangeable for doing the same amount of work when *pure*, and when the one named in a given formula can not be obtained the table may assist in choosing a substitute of proper strength and solubility.

Dry or anhydrous Carbonate of Potassium is not usually found in the market.

COMPARISON OF EIKONOGEN DEVELOPERS FOR RAPID EXPOSURES.

REDUCED TO ONE OUNCE OF PREPARED DEVELOPER.

By C. W. GRANT.

No.	Water.	Eiko.	Sulph. Sodium.	Carb. Pot.	Remarks.
	1 oz.	Grs.	Grs.	Grs.	
1	480 m.	7.3	43.7	10.9	*American Amateur Photographer*, Aug. 1890, p. 303.
2	"	8.3	22	11	By Seed Dry Plate Co. *
3	"	5.5	11	11	" Cramer Dry Plate Co. *
4	"	16	64	16	" Harvard " " *
5	"	16	32	16	" Gottheil. AM. ANN., 1890, p. 269.‡‡
6	"	6	30	12A	" W. H. Rau.† AM. ANN., 1890, p. 225.
7	"	12	32	12	" Allen & Rowell.††
8	"	6	24	16	" Eagle D. P. Works.
9	"	6	12	9B	" U. S. Supply Co.
10	"	12	24	8	" John Nicol.** AM. ANN., 1890, p. 41.
11	"	6	28	9C	" F. C. Beach.‡
12	"	5	30	5	" *Photo. Times.****
					" Chautauqua School.
Totals.	5760	106.1	352.7	135.9	Divide by 12—Equals Average.
No. 1	480 m.	8.8	29.4	11.3	Average.
No. 2	480 m.	9.5	29.4	12.2	Average, Nos. 1 to 10 inclusive.
.....	480 m.	12	32	12	Recommended.

Allen & Rowell furnished the following formula for use with their slide plates, and can attest its efficiency, and I use it exclusively for slides and bromide prints, but substitute carb. pot. for c. soda.

Water to make	1 ounce
Sulph. Soda (cryst.)	18 grains
Eiko	3 grains
Quinol	3 grains
Carb. Soda	18 grains
Carb. Lithium	3 grains

* These were taken from an article by Mr. F. C. Beach.

‡‡ Herr Gottheil gives Carb. Pot. (as above) for rapid exposures.

† Mr. Rau considers Eiko. with Carb. *Soda*, inferior to Pyro.

‡ Mr. Beach considers Carb. Pot. more powerful than Carb. Soda, and less liable to cause stains. Confirmed by Gottheil, Rau, Nos. 1, 2, 3, 4, 5, 7, 8, 10, 12, and by compiler.

††—A. Given as 24 grs. Carb Soda.

***—C. Given as 17 grs. Carb. Soda. Not stated if for rapid exposures.

**—B. Given as 9 grs. Carb. Soda.

AMERICAN, FRENCH, ENGLISH AND GERMAN MONEY.

American.	French.	English.	German.	American.	French.	English.	German.
dols. c.	*fr. c.*	*s. d.*	*m. pf.*	*dols. c.*	*fr. c.*	*s. d.*	*m. pf.*
0 01	0 05	0 0½	0 04		2 87.5		2 30
0 02	0 10	0 1	0 08	0 56	2 92	2 4	
	0 12.5		0 10		**3 00**		**2 40**
0 03	0 15	0 1½	0 12	0 58	3 02	2 5	
	0 20		0 16	**0 60**	**3 12.5**	**2 6**	**2 50**
0 04	0 21	0 2		0 62	3 23	2 7	
	0 25		0 20		3 25		2 60
0 05	**0 26**	**0 2½**		0 64	3 33	2 8	
0 06	0 31	0 3	0 25		3 37.5		2 70
	0 37.5		0 30	0 66	3 44	2 9	
0 08	0 42	0 4			3 50		2 80
	0 50		0 40	0 68	3 54	2 10	
0 10	0 52	0 5			3 62.5		2 90
0 12	**0 62.5**	0 6	**0 50**	0 70	3 65	2 11	**2 92**
0 14	0 73	0 7		**0 72**	**3 75**	**3 0**	**3 00**
	0 75		0 60	0 74	3 85	3 1	3 08
0 16	0 83	0 8			3 87.5		3 10
	0 87.5		0 70	0 76	3 96	3 2	
0 18	0 94	0 9			**4 00**		**3 20**
	1 00		**0 80**	0 78	4 06	3 3	
0 20	1 04	0 10			4 12.5		3 30
	1 12.5		0 90	**0 80**	4 17	3 4	
0 22	1 15	0 11			4 25		3 40
0 24	**1 25**	**1 0**	**1 00**	0 82	4 27	3 5	
0 25	1 30	1 0½	1 04	**0 84**	**4 37.5**	**3 6**	**3 50**
0 26	1 35	1 1	1 08	0 86	4 48	3 7	
	1 37.5		1 10		4 50		3 60
0 28	1 46	1 2		0 88	4 58	3 8	
	1 50		1 20		4 62.5		3 70
0 30	1 56	1 3		0 90	4 69	3 9	
	1 62.5		1 30		4 75		3 80
0 32	1 67	1 4		0 92	4 79	3 10	
	1 75		1 40		4 87.5		3 90
0 34	1 77	1 5		0 94	4 90	3 11	
0 36	**1 87.5**	**1 6**	**1 50**	**0 96**	**5 00**	**4 0**	**4 00**
0 38	1 98	1 7		1 00	5 21	4 2	4 16
	2 00		1 60	1 20	6 25	5 0	5 00
0 40	2 08	1 8		1 44	7 50	6 0	6 00
	2 12.5		1 70	1 68	8 75	7 0	7 00
0 42	2 19	1 9		1 92	10 00	8 0	8 00
	2 25		1 80	2 16	11 25	9 0	9 00
0 44	2 29	1 10		2 40	12 50	10 0	10 00
	2 37.5		1 90	2 64	13 75	11 0	11 00
0 46	2 40	1 11	1 92	2 88	15 00	12 0	12 00
0 48	**2 50**	**2 0**	**2 00**	3 84	20 00	16 0	16 00
0 50	2 60	2 1	2 08	4 80	25 00	20=£1	20 00
	2 62.5		2 10	9 60	50 00	£2	40 00
0 52	2 71	2 2		14 40	75 00	£3	60 00
	2 5		2 20	19 20	100 00	£4	80 00
0 54	2 81	2 3		24 00	125 00	£5	100 00

STANDARD OF FOREIGN COINS FOR CUSTOMS PURPOSES

As Proclaimed by the Director of the United States Mint, January 1, 1890, and Corrected to Date.

The Value of Imports for the Assessment of Duties is ascertained by converting Currency of Invoice into Money of the United States, as per following Table:

Country.	Unit of Currency.	Sign.	Value in U. S. Cur.
Argentine Republic	Peso = 100 Centavos	$	.96.5
Austria-Hungary	Florin = 100 Kreutzer	Fl.	.34.5
Azores	Milreis = 100 Reis	Rs. $	.83.5
Belgium	Franc = 100 Centimes	Frs.	.19.3
Bolivia	Boliviano = 10 Reales	$	.69.8
Brazil	Milreis = 1000 Reis	Rs. $	.54.6
British North America, *Ex. Newfoundland*	Dollars = 100 Cents	$	1.00
Chili	Peso = 100 Centavos	$	.91.2
China (*Haikwan*)	Tael = 10 Mace	Tael.	1.14.8
Columbia, U. S. of	Peso = 100 Centavos	$	.69 8
Costa Rica	Peso = 100 Centavos	$	.69.8
Cuba	Peso = 100 Centavos	$	.92.6
Denmark	Krone = 100 Ore	Kr.	.26.8
Ecuador	Sucre = 100 Centavos	$	.69.8
Egypt	Pound = 100 Piastres	£	4.94.3
France	Franc = 100 Centimes	Frs.	.19.3
Germany	Mark = 10 Pfennige	Mks.	.23.8
Great Britain	Pound Sterling = 20 Shillings	£	4.86.65
Greece	Drachma = 100 Lepta	Dr.	.19.3
Guatemala	Peso = 100 Centavos	$	.69.8
Hayti	Gourde = 100 Cents	$	.69.5
Honduras	Peso = 100 Centavos	$	.69.8
India	Rupee = 16 Annas	Rs.	.33.2
Italy	Lira = 100 Centesimi	L.	.19.3
Japan	Yen = 100 Sen Gold	Yen.	.99.7
do	do. = do. Silver	Yen.	.75.2
Liberia	Dollar = 100 Cents	$	1.00
Mexico	Peso = 100 Centavos	$	.75.8
Netherlands	Florin = 100 Cents	$	.40.2
Newfoundland	Dollar = 100 Cents	$	1.01.4
Nicaragua	Peso = 100 Centavos	$	.69.8
Norway	Krone = 100 Ore	Kr.	.26.8
Paraguay	Peso = 100 Centavos	$	1.00
Peru	Sol = 100 Centavos	$	.69.8
Porto Rico	Peso = 100 Centavos	$	.92.5
Portugal	Milreis = 1000 Reis	Rs. $	1.08
Russia	Rouble = 100 Copecks	S. Ro.	.55.8
Salvador	Peso = 100 Centavos	$	.69.8
Sandwich Islands	Dollar = 100 Cents	$	1.00
Spain	Peseta = 100 Centimos	Ptas.	.19.3
Sweden	Krone = 100 Ore	Kr.	.26.8
Switzerland	Franc = 100 Centimes	Frs.	.19.3
Tripoli	Mahbub = 20 Piastres	$	.62.9
Tunis	Piastre = 16 Caroubs	Ptrs.	.11.8
Turkey	Piastre = 30 Paras	Ptrs.	.04.4
Uruguay	Patacon = 100 Centavos	$	.94.9
Venezuela	Bolivar = 100 Centimos	Brs.	.14

USUAL SIZES OF FRENCH AND ITALIAN DRY PLATES.

French.		*Inches.*	Italian.		*Inches.*
6½x 9	Centimetres.....	2.5x 3.6	9x12	Centimetres.....	3.6x 4.7
9 x12	"	3.6x 4.7	12x16	"	4.7x 6.3
12 x15	"	4.7x 5.9	12x18	"	4.7x 7.2
13 x18	"	5.1x 7.0	13x18	"	5.1x 7.0
12 x20	"	4.7x 7.8	12x20	"	4.7x 7.8
15 x21	"	5.9x 8.2	18x24	"	7.0x 9.4
15 x22	"	5.9x 8.6	21x27	"	8.2x10.6
18 x24	"	7.2x 9.4	24x30	"	9.4x11.8
21 x27	"	8.2x10.6	27x33	"	10.6x12.9
24 x30	"	9.4x11.8	30x36	"	11.8x14.1
27 x33	"	10.6x12.9	40x50	"	15.7x19.6
27 x35	"	10.6x13.7	50x60	"	19.6x23.6
30 x40	"	11.8x15.7			
40 x50	"	15.7x19.6			
50 x60	"	19.6x23.6			

SIZES OF GLASS, MOUNTS, PAPER, ETC.

Petite cards	1⅝x3⅛
One-ninth plate	2 x2½
One-sixth plate	2¾x3¼
One-fourth plate	3¼x4¼
Half plate	4½x6½ and 4¼x6½
Half plate (English)	4¾x6½
Whole plate (4–4)	6½x8½
Extra 4–4	8 x10

Other sizes are expressed by inches.

Sizes of Mounts.

Stereoscopic	3½x7, 4x7, 4¼x7, 4½x7, 5x8		
Victoria	3¼x5	Minette	1½x2⅜
Imperial	7⅞x9⅞	Card	2½x4⅛
Boudoir	5¼x8½	Cabinet	4¼x6½
Panel	4 x8¼	Promenade	4⅛x7⅞

Sizes of Albumen Paper.

18x22¾, 20½x24½, 22x36, 26x40, 27x42.

Size of blotting paper 19x24

FREEZING MIXTURES.

Parts.	Reducing the Temperature	From Degrees of the Celsius	To Thermometer.
3	Nitrate of sodium + 4 Water	+13.2 deg.	— 5.3 deg.
9	Phosphate of sodium + 4 dilute Nitric acid	+10 "	— 9 "
3	Sulphate of sodium + 2 dilute Nitric acid	+10 "	—10 "
1	Nitrate of sodium + 4 Water		—10.6 "
1	Chloride of potassium + 4 Water		—11.8 "
5	Sal ammoniac + 5 Saltpetre + 16 Water	+10 deg.	—12 "
1	Nitrate of ammonia + 1 Water	+10 "	—15.5 "
8	Sulphate of sodium + 5 conc. Sulphuric acid	+10 "	—17 "
1	Sulphocyanate of Potass. + 1 Water	+18 "	—21 "
1	Chloride of sodium + 3 Snow		—21 "
1	Sal ammoniac + 1 Saltpetre + 1 Water	+ 8 deg.	—24 "
3	Crystal. chloride of calcium + 1 Snow		—36 "
1	Snow + 1 dilute Sulphuric acid	— 5 deg.	—41

U. S. PATENT OFFICE PROCEDURE.

PATENTS are issued in the name of the United States, and under the seal of the Patent Office to any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvement thereof, not known or used by others in this country, and not patented or described in any printed publication in this or any foreign country, before his invention or discovery thereof, and not in public use or on sale for more than two years prior to his application, unless the same is proved to have been abandoned; and by any person who, by his own industry, genius, efforts, and expense, has invented and produced any new and original design for a manufacture, bust, statué, alto-relievo, or bas-relief; any new and original design for the printing of woolen, silk, cotton, or other fabrics, any new and original impression, ornament, pattern, print, or picture to be printed, painted, cast, or otherwise placed on or worked into any article of manufacture; or any new, useful, and original shape or configuration of any article of manufacture, the same not having been known nor used by others before his invention or production thereof, nor patented nor described in any printed publication, upon payment of the fees required by law and other due proceedings had.

Joint inventors are entitled to a joint patent; neither can claim one separately. Independent inventors of distinct and independent improvements in the same machine can not obtain a joint patent for their separate inventions; nor does the fact that one furnishes the capital and another makes the invention entitle them to make application as joint inventors; but in such case they may become joint patentees.

Every patent contains a grant to the patentee, his heirs or assigns, for the term of seventeen years, of the exclusive right to make, use, and vend the invention or discovery throughout the United States and the Territories, referring to the specification for the particulars thereof.

If it appear that the inventor, at the time of making his application, believed himself to be the first inventor or discoverer, a patent will not be refused on account of the invention or discovery, or any part thereof, having been known or used in any foreign country before his invention or discovery thereof, if it had not been before patented or described in any printed publication.

Letters Patent granted a foreign government will not while in force prevent the inventor from obtaining a patent in the United States, unless the invention shall have been introduced into public use into the United States more than two years prior to the application. But every patent granted for an invention which is the subject of Letters Patent still in force and previously granted to the same inventor in a foreign country will be so limited as to expire at the same time with such foreign patent, or, if there be more than one, at the same time with the one having the shortest unexpired term, but in no case will it be in force more than seventeen years.

APPLICATIONS.

Application for a patent must be made in writing to the Commissioner of Patents. The applicant must also file in the Patent Office a written description of the same, and of the manner and process of making, constructing, compounding, and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, compound and use the same; and in case of a machine, he must explain the principle thereof, and the best mode in which he has contemplated applying that principle, so as to distinguish it from other inventions, and particularly point out and distinctly claim the part, improvement, or

CONVERSION OF FRENCH BAROMETER MEASUREMENTS INTO ENGLISH.

M. M.	Inches.	M. M.	Inches.	M. M.	Inches.	M. M.	Inches.	M. M.	Inches.	M. M.	Inches.
		640	**25.197**			**700**	**27.560**			**760**	**29.922**
39—	—25.158	41—	—25.237	99—	—27.520	1—	—27.599	59—	—29.882	61—	—29.961
38..	..25.119	42..	..25.276	98..	..27.481	2..	..27.638	58..	..29.843	**762**	**30**
37—	—25.079	43—	—25.315	97—	—27.441	3—	—27.678	57—	—29.804	63—	—30.040
36..	..25.040	44..	..25.355	96..	..27.402	4..	..27.717	56..	..29.764	64..	..30.079
35—	—25.000	45—	—25.394	95—	—27.363	5—	—27.756	55—	—29.725	65—	—30.119
34..	..24.961	46..	..25.433	94..	..27.323	6..	..27.796	54..	..29.686	66..	..30.158
33—	—24.922	47—	—25.473	93—	—27.284	7—	—27.835	53—	—29.646	67—	—30.197
32..	..24.882	48..	..25.512	92..	..27.245	8..	..27.875	52..	..29.607	68..	..30.237
31—	—24.843	49—	—25.552	91—	—27.205	9—	—27.914	51—	—29.567	69—	—30.276
630	**24.804**	**650**	**25.591**	**690**	**27.166**	**710**	**27.953**	**750**	**29.528**	**770**	**30.316**
29—	—24.764	51—	—25.630	89—	—27.126	11—	. 28.993	49—	--29.489	71—	—30.355
28..	..24.725	52..	..25.670	88..	..27.087	12..	—28.032	48..	..29.449	72..	..30.394
27—	..24.685	53—	—25.709	87—	—27.048	13—	..28.071	47—	—29.410	73—	—30.434
26..	—24.646	54..	..25.748	86..	..27.008	14..	—28.111	46..	..29.371	74..	..30.473
25—	..24.607	55—	—25.788	85—	—26.969	15—	..28.150	45—	—29.331	75—	—30.512
24..	—24.567	56..	..25.827	84..	..26.930	16..	—28.189	44..	..29.292	76..	..30.552
23—	..24.528	57—	—25.868	83—	—26.890	17—	. 28.229	43—	—29.252	77—	—30.591
22..	—24.489	58..	..25.906	82..	..26.851	18..	—28.268	42..	..29.213	78..	..30.630
21—	..24.449	59—	—25.945	81—	—26.812	19—	..28.308	41—	—29.174	79—	—30.670
620	**24.410**	**660**	**25.985**	**680**	**26.772**	**720**	**28.347**	**740**	**29.134**	**780**	**30.709**
19..	24.370	61—	—26.024	79—	..26.733	21—	—28.386	39—	--29.095	81—	—30.749
18—	24.331	62..	..26.063	78..	—26.693	22..	..28.426	38..	..29.056	82..	..30.788
17..	24.292	63—	—26.103	77—	..26.654	23—	—28.465	37—	—29.016	83—	—30.827
16—	24.252	64..	..26.142	76..	—26.615	24..	..28.504	36..	..28.977	84..	..30.867
15..	24.213	65—	—26.182	75—	..26.575	25—	—28.544	35—	—28.938	85—	--30.906
14—	24.174	66..	..26.221	74..	—26.536	26..	..28.583	34..	..28.898	86..	..30.945
13..	24.134	67—	—26.260	73—	..26.497	27—	—28.623	33—	—28.859	87—	—30.985
12—	24.095	68..	..26.300	72..	—26.457	28..	..28.662	32..	..28.819	88..	..31.024
11..	24.056	69—	—26.339	71—	..26.418	29—	—28.701	31—	—28.780	89—	—31.063
610	**24.016**			**670**	**26.378**			**730**	**28.741**	**790**	**31.103**
Read up.		Read down.		Read up.		Read down.		Read up.		Read down.	

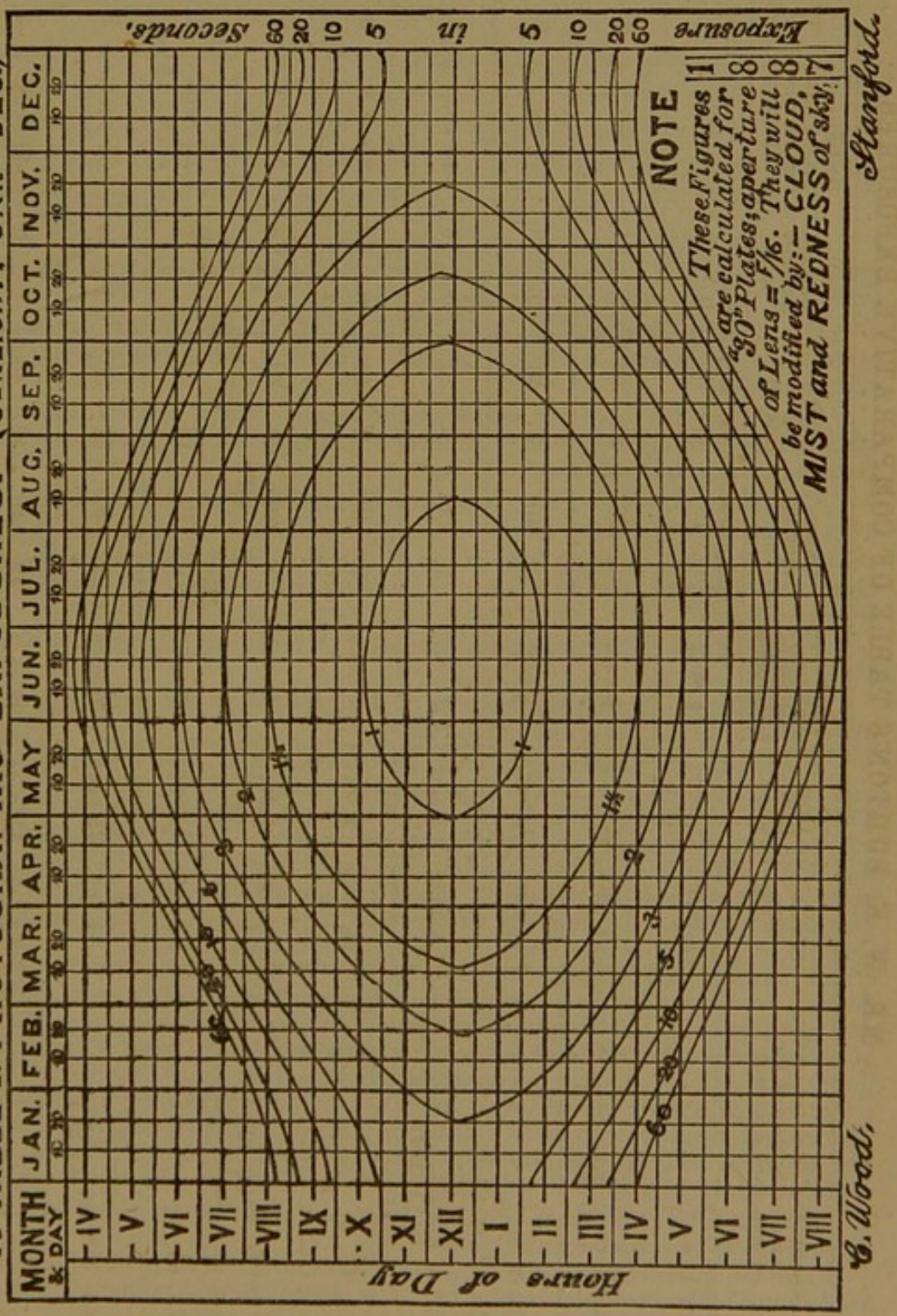
FRENCH, ENGLISH, AMERICAN AND GERMAN MONEY.

French.	English.	American.	German.	French.	English.	American.	German.
fr. c.	*s. d.*	*dols. c.*	*m. pf.*	*fr. c.*	*s. d.*	*dols. c.*	*m. pf.*
0 05	0 0½	0 01	0 04	2 87.5	.....	.....	2 30
0 10	0 1	0 02	0 08	2 92	2 4	0 56	.....
0 12.5	.....	.....	0 10	**3 00**	.....	.....	**2 40**
0 15	0 1½	0 03	0 12	3 02	2 5	0 58	.....
0 20	.....	.....	0 16	**3 12.5**	**2 6**	**0 60**	**2 50**
0 21	0 2	0 04	.....	3 23	2 7	0 62	.....
0 25	.....	.....	0 20	3 25	.....	.....	2 60
0 26	**0 2½**	**0 05**	.....	3 33	2 8	0 64	.....
0 31	0 3	0 06	0 25	3 37.5	.....	.....	2 70
0 37.5	.....	.....	0 30	3 44	2 9	0 66	.....
0 42	0 4	0 08	.....	3 50	.....	.....	2 80
0 50	.....	.....	0 40	3 54	2 10	0 68	.....
0 52	0 5	0 10	.....	3 62.5	.....	.....	2 90
0 62.5	**0 6**	**0 12**	**0 50**	3 65	2 11	0 70	2 92
0 73	0 7	0 14	.....	**3 75**	**3 0**	**0 72**	**3 00**
0 75	.....	.....	0 60	3 85	3 1	0 74	3 08
0 83	0 8	0 16	.....	3 87.5	.....	.....	3 10
0 87.5	.....	.....	0 70	3 96	3 2	0 76	.....
0 94	0 9	0 18	.....	**4 00**	.....	.....	**3 20**
1 00	.....	.....	**0 80**	4 06	3 3	0 78	.....
1 04	0 10	0 20	.....	4 12.5	.....	.....	3 30
1 12.5	.....	.....	0 90	4 17	3 4	0 80	.....
1 15	0 11	0 22	.....	4 25	.....	.....	3 40
1 25	**1 0**	**0 24**	**1 00**	4 27	3 5	0 82	.....
1 30	1 0½	0 25	1 04	**4 37.5**	**3 6**	**0 84**	**3 50**
1 35	1 1	0 26	1 08	4 48	3 7	0 86	.....
1 37.5	.....	.....	1 10	4 50	.....	.....	3 60
1 46	1 2	0 28	.....	4 58	3 8	0 88	.....
1 50	.....	.....	1 20	4 62.5	.....	.....	3 70
1 56	1 3	0 30	.....	4 69	3 9	0 90	.....
1 62.5	.....	.....	1 30	4 75	.....	.....	3 80
1 67	1 4	0 32	.....	4 79	3 10	0 92	.....
1 75	.....	.....	1 40	4 87.5	.....	.....	3 90
1 77	1 5	0 34	.....	4 90	3 11	0 94	.....
1 87.5	**1 6**	**0 36**	**1 50**	**5 00**	**4 0**	**0 96**	**4 00**
1 98	1 7	0 38	.....	5 21	4 2	1 00	4 16
2 00	.....	.....	**1 60**	6 25	5 0	1 20	5 00
2 08	1 8	0 40	.....	7 50	6 0	1 44	6 00
2 12.5	.....	.....	1 70	8 75	7 0	1 68	7 00
2 19	1 9	0 42	.....	10 00	8 0	1 92	8 00
2 25	.....	.....	1 80	11 25	9 0	2 16	9 00
2 29	1 10	0 44	.....	12 50	10 0	2 40	10 00
2 37.5	.....	.....	1 90	13 75	11 0	2 64	11 00
2 40	1 11	0 46	1 92	15 00	12 0	2 88	12 00
2 50	**2 0**	**0 48**	**2 00**	20 00	16 0	3 84	16 00
2 60	2 1	0 50	2 08	25 00	20 = £1	4 80	20 00
2 62.5	.....	.....	2 10	50 00	£2	9 60	40 00
2 71	2 2	0 52	.....	75 00	£3	14 40	60 00
2 75	.....	.....	2 20	100 00	£4	19 20	80 00
2 81	2 3	0 54	.....	125 00	£5	24 00	100 00

395
H

GRAPHIC TABLE OF RELATIVE EXPOSURES.

FROM "*Photo. News.*"



WEATHER INDICATIONS.

TABLE SHOWING THE NUMBER OF CLOUDY, CLEAR, AND RAINY DAYS IN EACH MONTH.

The table of cloudy, clear, and rainy days shows the average indications for lower New England and New York and its neighborhood.

	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Clear	11.0	9.8	11.0	10.3	9.6	10.0	11.2	10.8	12.7	12.0	10.3	10.0
Cloudy	11.0	9.9	10.8	10.4	11.5	11.0	11.1	10.3	10.4	12.0	11.9	11.7
Rain or Snow	9.2	8.2	9.1	9.2	9.8	8.8	8.4	8.1	6.8	6.8	7.8	0.2

Sunset Colors.—A gray, lowering sunset, or one where the sky is green or yellowish green, indicates rain. A red sunrise, with clouds lowering later in the morning, also indicates rain.

Halo (Sun Dogs).—By halo we mean the large circles, or parts of circles, about the sun or moon. A halo occurring after fine weather indicates a storm.

Corona.—By this term we mean the small colored circles frequently seen around the sun or moon. A corona growing smaller indicates rain; growing larger, fair weather.

Rainbows.—A morning rainbow is regarded as a sign of rain; an evening rainbow, of fair weather.

Sky Color.—A deep blue color of the sky, even when seen through clouds, indicates fair weather; a growing whiteness, an approaching storm.

Fog.—Fogs indicate settled weather. A morning fog usually breaks away before noon.

Visibility.—Unusual clearness of the atmosphere, unusual brightness or twinkling of the stars indicates rain.

Clouds.—In observing clouds, we observe their kinds, motions, and outlines. The clouds frequently called "mare's tails" we term Cirri. They are marked by their light texture, fibrous and sundered as in the "mare's tail," or interlacing, as in the far-spreading white cloud, which produce the halo. Small, regularly formed groups of these clouds are frequently seen in fair and settled weather. The Cirri are also the clouds on the forepart of the storm. In this case they are usually more abundant, their outline is very ragged, and they gradually blend into a white, far-reaching cloud bank. The cloud well known as "cotton bales," or "thunder heads," we term cumulus. When they appear during the heat of the day and pass away in the evening, continued fair weather may be expected. When they increase with rapidity, sink into the lower part of the atmosphere, and remain as the evening approaches, rain is at hand. If loose patches appear thrown out from their surfaces, showers may be expected. The clouds usually seen after nightfall, lying in one horizontal plane, and not of great extent, are attendant on fine weather. Small, black, inky clouds and dark scud indicate rain.

Frost.—The first frost and last frost are usually preceded by a temperature very much above the mean.

The table of cloudy, clear, and rainy days, and the weather indications, are from the meteorological tables in "The Connecticut Almanac," prepared by Prof. A. W. Phillips, of Yale College.

TABLE OF COMPARATIVE LIGHT VALUES.

By Rev. Dwight W. Smith.

While there is a wider range in timing the exposure of a dry plate than is generally supposed, yet it is well known that there is but one correct interval for the best results with a normal developer. To best approximate that interval at all available hours of the day and year requires some attention and experience. There was a time when plates of a given brand and sensitiveness were quite unreliable, but now that they are so uniform, and improving more and more in this direction, tables of light values that were found to be comparatively useless will now be found of increasing value. The subjoined table, based upon the diagram in this book, by Lieutenant S. W. Very, U. S. N., has been computed for the first half of each month, and at a glance one may obtain information that would otherwise require time and trouble, and that even skill and experience does not always provide for, especially during the time indicated in which there is a rapid loss of light. It will be seen that in January, the light value for noon is given as 1.7, while at 4 P.M. the exposure would necessarily be more than five times that duration. For July, the most rapid as well as longest available light of any month, the light at noon is indicated by .2 instead of 1.7, and at 3 P.M. more than twice the time will be required.

The first column indicates the hour of the day; the second column the comparative light values in whole numbers and tenths.

JANUARY.		FEBRUARY.		MARCH.		APRIL.	
8	10	8	6	8	3	8	2
9	4	9	4	9	2	9	1.5
10	2.5	10	2	10	1.5	10	1.7
11	2	11	1.7	11	1.2	11	1
12	1.7	12	1.5	12	1	12	1
1	1.7	1	2	1	1	1	1
2	2.5	2	2.7	2	1.7	2	1.2
3	4.5	3	3.5	3	2	3	1.5
4	9	4	5	4	4	4	2
		5	60	5	20	5	4
						6	20

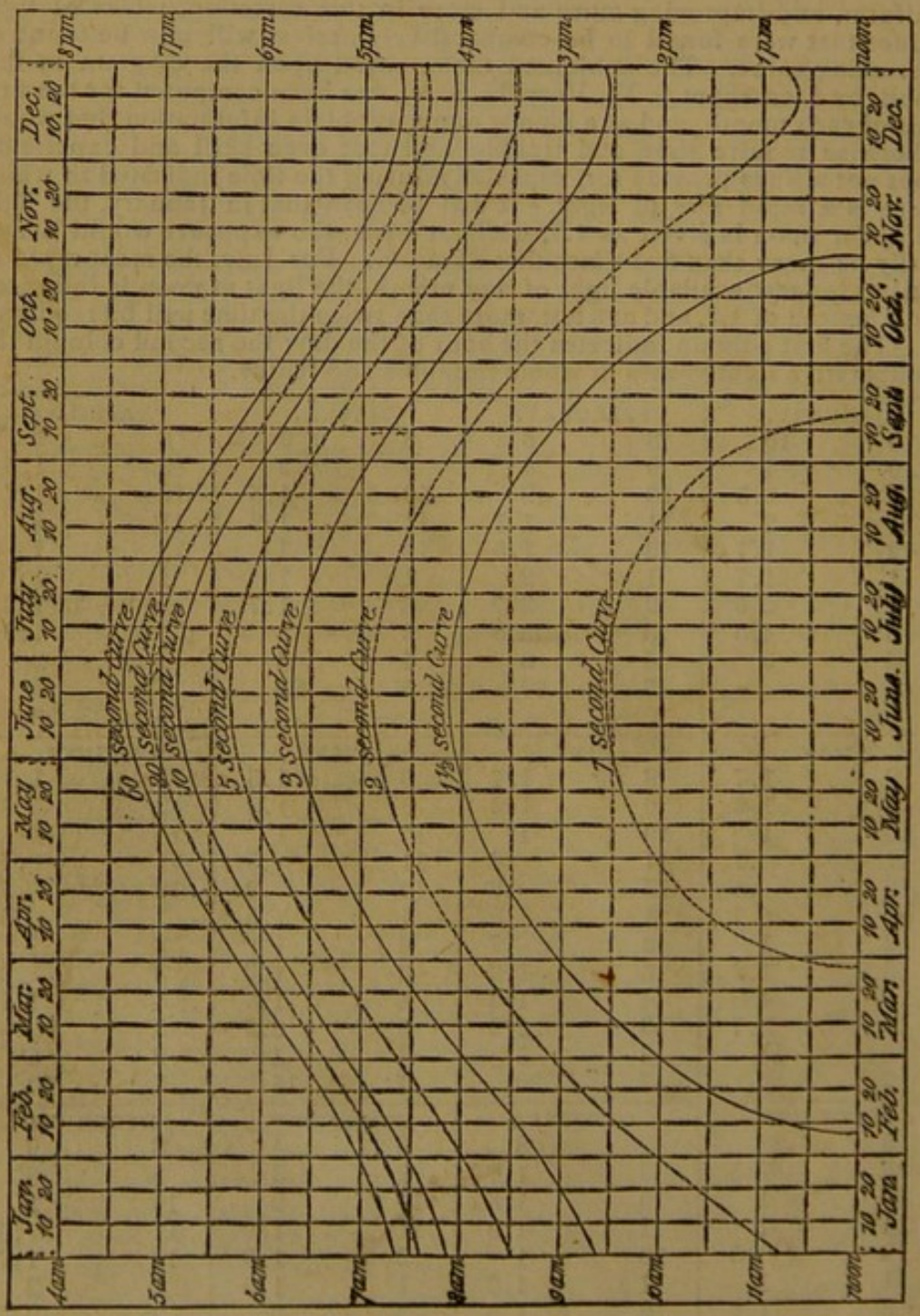
MAY.		JUNE.		JULY.		AUGUST.	
8	1.7	8	1.7	8	1.5	8	1.7
9	1.2	9	1.2	9	1.2	9	1.5
10	1	10	1	10	1	10	1
11	.7	11	.6	11	.5	11	.7
12	.5	12	.3	12	.2	12	.5
1	.7	1	.5	1	.5	1	.5
2	1	2	.7	2	1	2	1
3	1.2	3	1.2	3	1.2	3	1.2
4	1.5	4	1.5	4	1.5	4	1.7
5	2.7	5	2.2	5	2.2	5	2.5
6	15	6	5	6	4	6	5
7	80	7	20	7	15	7	60

SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
8	2	8	3	8	4	8	9
9	1.5	9	1.7	9	3	9	3
10	1	10	1.5	10	2	10	2
11	1	11	1.2	11	1 7	11	1.5
12	.5	12	1	12	1.5	12	1.7
1	1	1	1.2	1	1.5	1	2
2	1.2	2	1.5	2	2	2	2.5
3	1.5	3	2	3	2.5	3	3.5
4	2	4	2.7	4	5	4	8
5	3	5	6	5	20	5	80
6	10	6	40	6	70		

DIAGRAM OF COMPARATIVE EXPOSURES.

Computed for the latitude of Washington, D. C. (38 deg., 54 min., N.)

By Lieut. Commander S. W. Very, U. S. N.



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