COLOUR-PRINTING.

WYMAN'S TECHNICAL SERIES

3/9
Pub. at 5/-

J. G. M'Intosh

1/6

COLOUR
AND
COLOUR PRINTING

As applied to Lithography,

CONTAINING

AN INTRODUCTION TO THE STUDY OF COLOUR,

AN ACCOUNT OF THE GENERAL AND SPECIAL QUALITIES OF PIGMENTS EMPLOYED,

THEIR MANUFACTURE INTO PRINTING INKS,

AND THE

PRINCIPLES INVOLVED IN THEIR APPLICATION.

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LONDON:
WYMAN & SONS, 74-6, GREAT QUEEN ST.
LINCOLN'S-INN FIELDS.

PREFACE.

WE must ask the readers of this Treatise on Colour Printing as applied to Lithography, to extend to the writer their indulgence for any shortcomings which the better-informed of them may detect in the present endeavour to elucidate what must be acknowledged to be an intricate and a difficult subject. No royal road to a mastery of the details has been traced out, simply because such a method cannot apply to an art the conditions of which are constantly varying. It may be confidently asserted that every new job presents, to a very considerable extent, a fresh problem to be solved, it being exceedingly rare that any work to be carried out has been preceded in the same office by a precisely similar job. When, therefore, what is to be newly taken in hand is found to require several workings, a difficulty at once arises, due to the fact that no one person is likely to be found competent to produce the whole, because the artist and the printer have to co-operate in totally different ways, though both are engaged in producing only one result. It is, however, very desirable that some one person should possess sufficient knowledge of the capabilities of each process, so as to be able to harmonise the labour, if we may use that term, and where necessary to control what are sometimes conflicting interests. For frequently an antagonism exists between the artist and the printer which would not obtain if each one knew a little more of the other's methods and difficulties.

The tendency with the artist is, to expect the printer to reproduce his work on paper just as he has put it upon the stone, whereas it is equally to be expected from the draughtsman, that he should acquire the knowledge of how his work is likely to appear after etching and rolling-up. Further than this, he must learn to know what change his drawing is likely to undergo when it is transformed from the black in which it is drawn, to the colour in which it is to be printed. He should further learn to put less fine work into light colours than into dark ones. It may be laid down as a general rule, that the artist has more to learn from the printer than the latter from the former, and it is therefore to his interest to cultivate a friendly feeling with the person who is to transform his separate drawings into one harmonious, coloured print. His object should not be simply to learn what may be supposed to be printer's secrets, but he should listen attentively to any strictures the printer may pass upon the manner in which the drawing is made, and he should make an effort to elicit them if the printer should be too modest or too uncommunicative to make any comments.

Sometimes, however, it is the printer that is too exacting. Looking upon his own part as the one that is all-important, he thinks the draughtsman's chief endeavour should be to make easy printing. The printer often expects the artist to put twice as much work and colour into his crayon drawings as is necessary, so that he may give it a "good nip" with the acid; he wants him to omit all fine work when there is a little difficulty in keeping it open, not taking into account the probable importance of some particular part being kept soft and delicate. Perhaps the worst fault to be found among printers is, that they rarely look upon the work from an Art stand-point, and, not knowing what the artist is likely to desire, they often go wrong, and more proving is necessary than would be the case if the artist were standing by to say when a proof is satisfactory, or to point out its deficiencies. In our own practice we have found that a personal supervision not only saves the time of the printer, but also that of the draughtsman.

In these days of machine-printing it is further necessary that both artist and proofer should take into consideration the worker who is to come after them,—that is, the machine-printer,—and should further consider the probable effect to be brought about by the, not unlikely, process of transferring for machine-printing. It is after the last process has been gone through that the work will be judged by the public, and it would be as well if due allowance for this were made from the commencement ; since it is hardly fair to resort to the means at the disposal of the hand-printer for producing desirable effects, if the conditions of machine-work will not permit of the same.

A consideration of what has been here stated will convince the reader how much more advantageous it will be to rely upon the statement of general principles, than to attempt to make things easy by giving precise formulæ, which would most likely fail where they were most depended upon. The former is the course we have adopted in the following chapters, and we feel fully convinced that it is the only one which will conduce to the real progress of the student. No amount of mere reading and study of books will make a colour-printer. There must be practice to gain experience, and it is in practice that the most effective and satisfactory study can be accomplished. It would be of little use to point out that so many pounds or ounces of given colours produce certain results ; the colour-printer himself can accumulate a vast storehouse of such notes that will be more useful to him than to other people, because he will be able to appreciate all the circumstances that went towards his deciding upon particular compounds. He should not, however, rely too much on such memoranda, because, as before stated, each particular job demands new study, and principles form a better foundation in most cases than notes made in reference to something else, although the latter will still have their value where the judgment is strengthened by theory as well as by experience.

It may be as well to state that this treatise on Colour Printing as applied to Lithography, is not a complete work in itself, it having been written as a companion volume to the "Grammar of Lithography," of which handbook it must be considered to form a supplementary volume.

In conclusion, the author has much pleasure in acknowledging the assistance so cordially rendered by those friends, including some printing-ink manufacturers of the highest eminence, who have read the proof-sheets before they were submitted to the general reader. Such co-operation cannot but help to increase the value of the work and make it more acceptable to the student.

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COLOUR AND COLOUR PRINTING

AS APPLIED TO LITHOGRAPHY.

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Connexion of Light and Colour—Reflection—Absorption, Darkness, Black—Selective Absorption—Colour-Blindness—Primary and Secondary Colours—Tertiary Colours—Grey, Brown, Broken Hues—Complementary Colours.

CONNEXION OF LIGHT AND COLOUR.—The subject of Colour is so essentially connected with that of Light that the two cannot be dissociated when dealt with as a branch of natural science. It is the object of the present treatise, however, to regard it solely from a practical point of view. There are in the study of colour many seeming contradictions between practice and scientific theory, which would take up much of our space to little purpose if we were to attempt to reconcile them, and as it has been already done in other works before the public, we leave the curious to investigate the scientific basis of the laws of colour in treatises by eminent physicists who have devoted much time and patience to its elucidation.

2. COLOUR IS LIGHT,—coloured light, and it will be well for the student to hasten to distinguish between pigments or colouring-substances and colour, *per se.* It is to be understood that light is not only necessary to enable us to distin-

guish one colour from another, but that colour is neither more nor less than light in a certain condition. There are two distinct theories to account for the existence of coloured light, but both agree that the white light of the sun's rays may be analysed into the colours that are seen in the rainbow. This was originally investigated by Sir Isaac Newton, who by means of a prism of glass separated a ray of white light into red, orange, yellow, green, blue, and violet. He could not, however, resolve the green into its elements of blue and yellow, but as the green lies between these two colours, and the one glides into the other by imperceptible gradations, and as green can be produced by an admixture of blue and yellow pigments, it is not an unfair supposition that blue and yellow are the elements of green. There are scientific reasons for doubting this conclusion,* but as the mixture of pigments is in direct contradiction to some of the results produced by the union of coloured light we shall prefer to adopt a theory, not new, that is in direct consonance with the practice of the painter and colour-printer.

3. Reflection.—In connexion with colour a proper conception of the idea of light is of first importance. There are few but have witnessed the reflection of the light of the sun by a mirror, or from the windows of a house. Before the dawn of science it was thought that some power went from the eye to the object seen, and thus produced the sensation of vision. But the phenomena of reflection is a fair proof that an object is seen, because the light from it enters the eye and produces sensations which we call sight. If a mirror be held on one side of the street so as to intercept some of the sun's rays, those rays may be turned back and directed to the opposite side of the street, so as to illumine the interior of any room to which it may be directed. In this experiment we see a positive proof that light passes from one object to another, and it is only a small effort of imagination to suppose that the light may in like manner

* The author, however, must avow that the ordinary scientific evidence which makes green a primary colour is not to his mind conclusive, his own experiments with the spectrum leading him to the conclusion that the older notion of blue, red, and yellow being the primary colours is really more in accordance with scientific fact than the modern one which makes them to be red, green, and violet.

enter our eyes and produce the sensation of vision. Though we have taken an extreme case in selecting the sun's rays and a polished mirror for illustration, it can easily be conceived that less polished surfaces have the same power in a less degree of reflecting the light that falls upon them. If we stand inside a room at a window, with a sheet of white paper, we can by a little management direct a portion of the light that falls upon it to the darkest part of the room, which will be found under the window. If we take a light *coloured* paper the reflection will be found to be correspondingly coloured. It may be thus proved that all substances give off a portion of the light that falls upon them, and if the surface is not polished it will be given off in all directions, and therefore to the eyes of all beholders. Thus, then, *we see everything in proportion to the amount and quality of the light it gives off.*

4. ABSORPTION : DARKNESS AND BLACK.—In opposition to light there is the quality which we call darkness. Light is represented in the arts by *white*, and darkness by *black.* Darkness must not however be regarded as a positive quality, but as a negative one. It is the absence of light which is darkness. This, however, is not so clear as regards what we call black. A black substance may be placed in the rays of the sun and yet be seen to be black, though it be equally illuminated with its surroundings. How then comes it to be black? It is because most of the coloured elements of the light are *equally absorbed*, instead of being reflected. No merely black pigment will have the quality of totally absorbing all the light that falls upon it. It will reflect some light. If the small quantity of light reflected be bluish or brownish, it will be called a blue or brown black. A comparison of surfaces will illustrate this question of absorption. If black satin, for instance, be compared with black velvet, there will be a marked difference between their degree of darkness. The satin will reflect in some positions a considerable amount of light, which in the case of velvet becomes lost in the depths of its pile. The velvet affords a good instance of the power of absorption.

5. SELECTIVE ABSORPTION OF LIGHT.—The colour of bodies may therefore be said to be due to their power of *selective* absorption. We have seen that white light may be

analysed and split up into six distinct colours, and that these again may by analogy be reduced to three. It is only necessary to suppose that a coloured object possesses the power of absorbing one or more of these colours while it permits the others to go free, or, as it is said, to reflect them, to have a proper understanding of the reason why it appears coloured. Taking it for granted that white light is composed of the three elementary colours, *blue*, *red*, and *yellow*, a red object will be supposed to have absorbed, and imprisoned as it were, the blue and yellow rays, and allowed the red to go free to produce the sensation of redness. In like manner if the red rays have been absorbed, a green effect will be produced upon the eye. Carrying the idea further, it will be conceived that when the whole of one pair of rays is absorbed, and also a portion of the third, the result will be that the object will appear of a darker shade. Thus a dark blue object will have absorbed the whole of the red and yellow rays and a portion of the blue, while, on the other hand, a light blue surface has absorbed a considerable portion of the red and yellow, but not all,—the remainder forming, with a portion of the blue, white light, which dilutes the colour falling into the eye. In like manner all colours may be easily accounted for; the more light there is absorbed, the darker will be the appearance of the colour. The particular hue also depends upon the proportion ot colour-rays absorbed. Thus if we compare a pure blue and a greenish blue, we are led to the conclusion that in the latter the yellow rays have not been so completely absorbed as in the former; a portion of them escaping adds a greenish tinge to what would otherwise have been a pure colour.

6. A Portion of White Light always Reflected.—There are probably few, if any, substances in Nature which absorb or reflect totally, either the whole, or any, of the coloured rays. It may therefore be fairly assumed that all objects give off a portion of white light. No object can be painted so black, but that a hole in its surface will show darker, and it is equally likely that no colour element is completely absorbed. If not absorbed, then what is reflected must mix with the other to form white light. We may therefore lay it down as an axiom that *every surface gives off a portion of white light along with its own particular colour.*

7. HIGH LIGHT AND LOCAL COLOUR.—In the case of curved surfaces the greatest amount will appear to be given off at a point that forms equal angles between its surface and the source of light and the eye of the spectator respectively. This will be what is called the high light, and may easily be seen in any polished object. At a point between this and the part in shade will be found the local colour of the object, unless its surface be so polished that its apparent colour will depend as much upon its surroundings as upon its own inherent hue.

8. PHENOMENA OF COLOUR-BLINDNESS.—The average human eye is so constituted as to distinguish the chief differences of colour, but the anomaly met with in colour-blindness indicates that many persons must constitutionally differ in their power of estimating the varying hues of Nature. The human eye may be conceived as being provided with three sets of nerves, each set taking cognisance of the particular colour designed by Nature for it. If now in any person the power of these three be not properly balanced, there will be a difference in that person's estimate of the colours placed before him if compared with an average observer. We may further conceive of one set being absent or so injured as to be inactive, and in such case to have found an easy explanation of colour-blindness.

9. CONFUSION OF RED AND GREEN.—We will try to point out how it is that persons afflicted with this, perhaps the most common form of colour-blindness, confuse two such essentially different colours as red and green. We have had opportunities of testing more than one person so afflicted, and find that the only distinction they can make is, that the one colour is darker than the other, and that the darker one is red. They seem to have a proper appreciation of both blue and yellow, and of their compound green. Upon the assumption that these people are blind to the red rays, and this taken in conjunction with the fact that most substances yield a considerable amount of white light (par. 6), as well as their own special hue, we think we can explain the reason of a colour-blind person confounding red and green. It is simply that the white light proceeding from a red object has its own red filtered out of it, as it were, by the eye being unable to see red,

and such light must therefore appear green of a darkish shade.

It will be conceded that it is of the utmost importance that those engaged in any profession or trade where colours are employed should possess an average eye for colour, or great errors may be the consequence. We once knew a person who was partially colour-blind, who was obliged to give up his employment in taking orders for colour-printing in consequence of the frequency of his mistakes. When, therefore, a youth is presented for any employment involving the estimation of colours, he should be submitted to an examination to determine whether he may not be physically unsuited for it, the safe course being to assume that he is not suitable until he proves himself to be so. Colour-blind persons are much more numerous than is usually supposed, and it is no unnecessary caution that we give.

10. PRIMARY AND SECONDARY COLOURS.—Between the extremes of light and dark, of white and black, come the intermediate varieties of light, which cannot be relegated either to white on the one hand nor to black on the other.

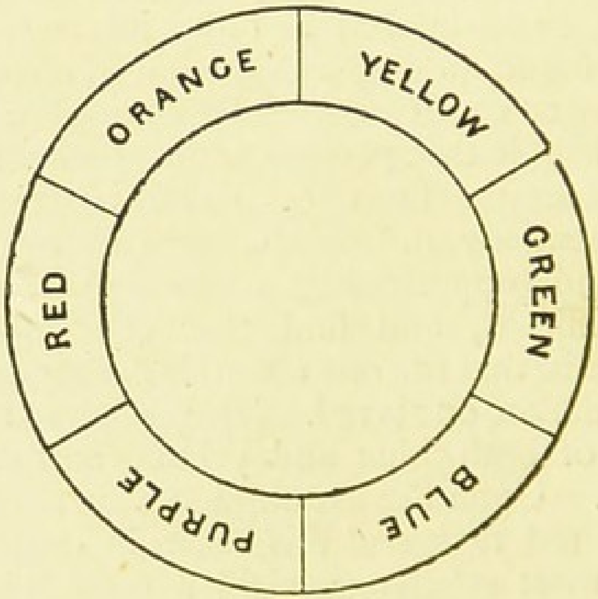

Fig. 1.

These are the colours properly so called, consisting of the primaries, blue, red, and yellow, and the secondaries, purple, orange, and green. If the primaries are represented by appropriate pigments, separated from each other by intervals equal to themselves, they may be united by the secondaries to form a scale of colour similar to what is seen in the rainbow. If the colours be arranged in a circle the scale will be complete, as shown in the diagram (Fig. 1). The idea of colour mixtures may be further developed by conceiving discs of blue, red, and yellow overlapping each other, as shown in diagram (Fig. 2). Here where yellow overlaps blue the result will be green. Yellow over red will produce orange. Red over blue, purple. These effects may be

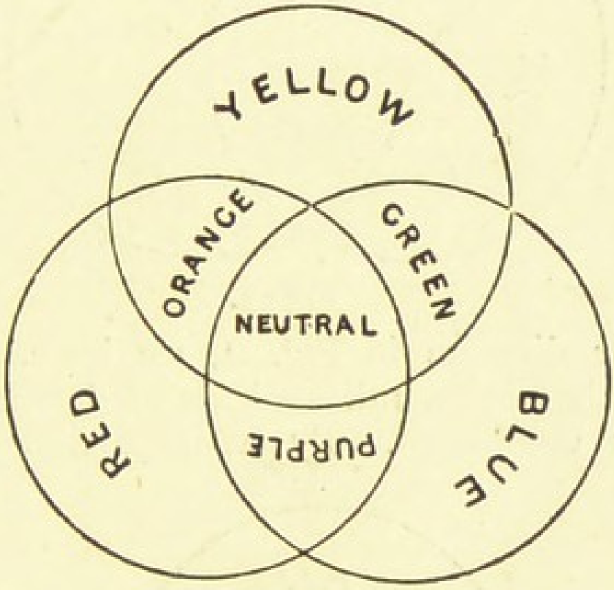

Fig. 2.

approximately attained by means of colour-printing; only imperfectly, however, because the upper colour will always assert itself most strongly; and not quite truly, because the pigments at command are not quite pure, as we shall have further occasion to point out.

11. Tertiary Colours.—In like manner as the secondary colours may be formed from the primaries, the tertiary colours may be made by the union of the secondaries. This may be illustrated in the same way by discs of the secondary colours, as in diagram (Fig. 3). Citrine may be compounded of green and orange. Here the yellow predominates, because it is contained in both the green and the orange. But as we have seen, green contains blue and orange contains red. We have also shown that blue and red unite to form purple. It therefore

follows that the mixture of green and orange is just the same as mixing purple with yellow, if the latter is kept properly predominant. It will be seen that in the modifi-

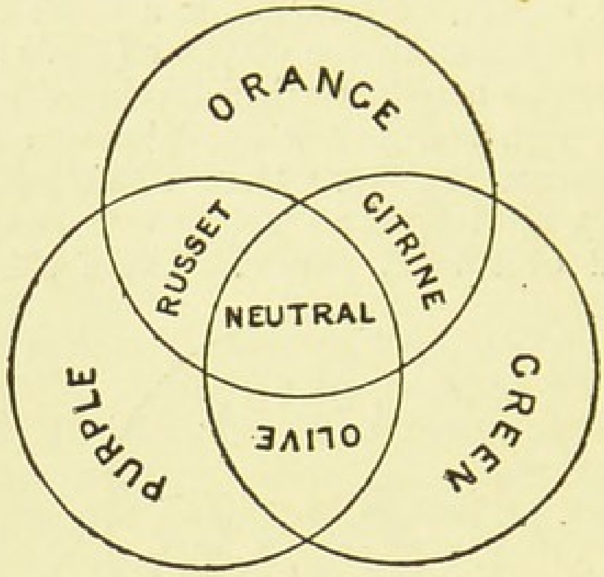

Fig. 3.

cation of our diagram in Fig. 4, we have, at the outer crossings of the circles, indicated the predominant colour in each tertiary compound. By an inspection of the figure

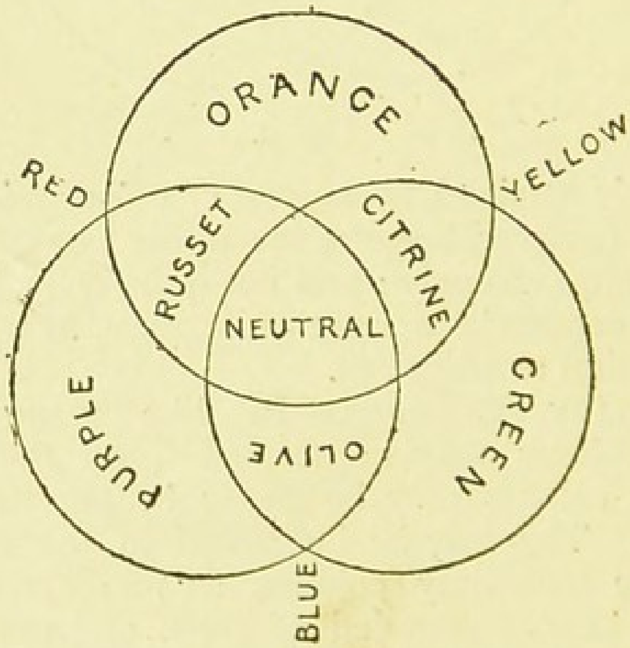

Fig. 4.

and the application of the reasoning applied to orange and green in connexion with citrine to the other compounds, it may be shown that olive can be evolved from blue and orange, and russet from green and red.

12. Grey and Normal Grey.—It will be noticed that in diagrams 2, 3, and 4, the central portion where the primary or secondary colours are all united has been marked *neutral*. If the three primary colours are equally balanced the result will be what is called a neutral or normal grey. If in experimentally determining the mixtures pigments be employed that are both powerful and transparent, the resulting neutral will form a very good imitation of black. A *normal grey* may be formed by mixing white chalk and powdered charcoal, the result being light or dark according as the proportions vary. If now to this truly neutral tone any minute quantity of colour be added so that the neutral grey shall be greatly in excess, the resulting colour will still be called grey, and may be expressed by speaking of it as blue or green grey, &c. &c. Cold and warm greys are frequently spoken of, but greys may be of any hue, and in painting and printing are a very important class of colour tones.

13. Browns.—Another class of tones is formed by breaking down orange with its complementary colour blue. If this be not carried to the extent of neutrality, the result will be a true brown. Browns are by common consent allowed considerable latitude, so as to include citrine and russet; the first being considered a yellow-brown, and the second a red-brown.

14. Broken Hues.—Another way of regarding the tertiary colours is to contemplate them as broken hues. That is, colours degraded by the addition of their complementaries. Looked at thus, olive is a broken blue; citrine a broken yellow; and russet a broken red. In a similar manner broken purples and greens are their respective greys; and a broken orange is a brown.

These results of the union in various proportions of the primary colours may be tabulated as follows, B standing for blue, R for red, and Y for yellow :—

Purple	R	+	B		
Green........................			B	+	Y
Orange	R			+	Y
Grey	R	+	B	+	Y

Olive	R + BB + Y	Broken blue.
Citrine (yellow brown) ...	R + B + YY	,, yellow.
Russet (red brown)	RR + B + Y	,, red.
Purple grey	RR + BB + Y	,, purple.
Green grey..................	R + BB + YY	,, green.
Brown	RR + B + YY	,, orange.

By inspection of the diagrams 2 and 3, it may be seen that in the mixtures of the secondary, to form the tertiary colours, one of the primaries will be repeated. Thus taking the mixture of purple and green as an example, there is blue in the purple and in the green. This is represented in the above table by BB, and so similarly are the other colours.

15. COMPLEMENTARY COLOURS.—We may speak of complementary colours as those which complete the trio of primary hues. It will however be as well to more fully explain, that as white light contains the elementary blue, red, and yellow, so a complementary colour is that which, added to another colour, will complete the white light. This may be considered as true in relation to *light*. But as applied to pigments, we must define a complementary colour as that which, added to another, will make up a neutral grey or black. We may here point out the difference between reflection and absorption in this connexion. When light has been separated by a prism into the rays seen in the spectrum, these rays can be collected and reformed into white light. The separation has been performed by a transparent medium, and the light is allowed to pass on to a screen, from which it is reflected to the eye. The surface sends back nearly all that it has received, and does not modify the light to form another hue, as do material coloured bodies, such as leaves and flowers.

Now when pigments receive white light upon their surface, they absorb a part and reflect the rest, which then reaches the eye as coloured light. If it be carefully thought over, it will be comprehended that for each primary colour we see there are two elements quenched; so that when the three pigments, blue, red, and yellow, are mixed together, there are two elements absorbed in each pigment. Roughly representing then each colour by the number 3, there will be in any equal mixture of the three primary colours six elements quenched out of nine, the remaining three uniting to form a faint white light, which is in effect only grey. Theory is borne out in practice, for when the elementary coloured pigments are dark, the mixture will be a dark grey approaching black.

CHAPTER II.—MUTUAL INFLUENCE OF COLOURS.

Contrast of Light and Dark—White, a Relative Term—Contrast of Colour—Simultaneous Contrast—Brightness—Experiments—Successive Contrast.

CONTRAST OF LIGHT AND DARK.—An important relation of colours to each other is that of *contrast.* The contrast of light and shade may be represented by white and black. By these we mean the extreme ends of the scale of light and dark, and therefore speak more in a theoretical than a practical sense. It is quite possible that in practice a pale yellow or blue may be lighter than something which we call white. Our theoretically pure white is the light of the sun at noonday when illuminating a substance, such as newly-fallen snow. An absolute black may be conceived as that of a hole in a dark box where all reflection is lost. An extreme case of contrast of white and black will therefore be afforded by a white covered box lined with black velvet, or painted black inside, a hole being cut in the white cover, and the box placed in the sun's rays. The white cover being strongly illuminated will appear of extreme whiteness and the cavity profoundly dark or black. Suppose now we stick a pin in the white surface, so that it may cast a shadow. This narrow shadow on the white ground will appear as dark as a black line drawn alongside it. If however we use a larger object, such as the hand, to cause the shadow, it will be found that the shadow does not look black. But yet the light is kept away from the surface as effectually as by the pin. The pin's shadow is very narrow, and shows black only by contrast with the intensity of the white surface, the breadth of which aids in increasing the contrast. We can carry the experiment further by cutting a narrow opening in a piece of opaque cardboard and interposing it between the sun's rays and the white surface. The streak of light falling upon the white surface will appear more intense than the broad illuminated surface in the former experiment, but the part where the light is intercepted will still be recognised as white, though, as compared with the illuminated streak, it is really only grey. The shadow of the pin then could only have been grey, yet it looked black. This is due to what is denominated *simultaneous contrast*, an effect in this case caused by the eye being flooded by so much brilliant light that its power of discriminating a weak light is for the time impaired.

17. WHITE AND BLACK ONLY RELATIVE TERMS.—White is a term therefore which can only be regarded relatively to colour. The same surface may be white or grey, according to the amount of illumination which it receives, and a white pigment may be conceived as the neutral representative of light by contrast with which colours in painting or printing are judged. Whiteness may be stated to be that condition of light which is neither inclined towards black, blue, yellow, red, nor any of their secondary or tertiary compounds.

18.—We have seen that white may be relatively grey, and a further experiment will show that black also may be grey. If we mix lamp-black with a very little gum, starch, or glue, we shall find that it will have a greater intensity while wet than when dry. When dry it will appear what is called dead, but will still be regarded as black. If a strip of paper be painted with this and placed over the hole in the box placed in the sun, as used in the former experiment, in such a manner as only to partially conceal it, it (the black paper) will be seen to be of a dark grey. If now the screen with the slit in it be interposed in such a manner that the light streak falls upon the black paper, the white surface being wholly in shadow the black paper will appear many degrees removed from absolute blackness as compared with the hole in the box. Black therefore is a relative term in the same manner as is white, and may be defined in a similar, though converse, manner, as a condition of darkness which is neither inclined towards white, blue, yellow, red, nor any of their compounds except grey.

19.—Referring to the experiment with the shadow of the pin on the white ground and the deduction therefrom of the principle of *simultaneous contrast*, we are led to a law that may be expressed as follows: *When any two tints or shades of colour are placed in contact, side by side, the lighter one will appear lighter and the darker one darker, than they really are.*

20. CONTRAST OF COLOUR.—From the contrast of light and dark we proceed to the study of the contrast of colour.

It will not be difficult to conceive that the colour which is most effectively the contrast of another, is its complementary. Red is the greatest contrast to green because it contains no element which enters into green. A reference to our diagrams and the study of complementary colours will show at a glance what colours are most effective as contrasts. It will be seen by looking at diagram 2 that the primaries may be contrasted by the secondaries, and the secondaries by the primaries. An inspection of diagram 3 will show that the secondaries may also be contrasted by the tertiaries. Thus choice may be made whether the contrast shall be strong or subdued. We may contrast orange either by the pure primary blue or the broken blue —olive.

The contrasting colours will therefore be as follow:

Blue	and	Orange.
Yellow	,,	Purple.
Red	,,	Green.
Orange	,,	Olive.
Purple	,,	Citrine.
Green	,,	Russet.

21. SIMULTANEOUS CONTRAST OF COLOUR.—We have described the effect of black in making white look more white, and *vice versâ*. In a similar manner a colour is intensified by contrast with its opposite. If the two colours are exposed to the eye together, the contrast is said to be simultaneous; if one after the other, the contrast is said to be successive. Thus red will look reddest in presence of green or in immediate succession to it, and so on with the colours tabulated in the last paragraph.

The effect may be heightened by adding the contrast of light and dark to the contrast of colour. Purple is naturally a dark colour and yellow a light one, so when these are contrasted, the effect is vivid. If it be wished to produce a similar effect with other colours, it can be done by deepening or lightening the one of the pairs forming a complement.

22. Brightness.—The mere effect of contrast will not necessarily produce brilliancy, the idea of which is involved in that of light. So when brilliancy or brightness is required, it must be sought either in lightening the colour itself, or in darkening its complementary. The latter will be the most effective, because it will bring out the *intensity* of the colour at the same time. For instance, if we wish to bring out a red spot with both intensity and brightness, it must be surrounded with a dark full green.

23. Explanatory Experiments. — There are experiments which curiously illustrate the phenomena of simultaneous contrasts. Some of these we will mention.

Let black and white pigments be ground in any kind of size and then mixed together to form about half a dozen gradations. Paint a strip of paper uniformly with each tint or shade. When dry cut off the edges of each so as to form bands of half an inch wide (more or less will do). Lay these together in the order of their depth, neatly edge to edge. If they are carefully stuck to a piece of very thick cardboard they will remain quite flat, but they will not appear so to the eye. The edges will seem to rise, and the whole will have an appearance similar to a fluted column, yet from the very means taken to produce the result, it is known beyond a doubt that each strip is of uniform strength. An easy way of producing the same effect is to take a very dark wash of Indian ink and reduce it to a somewhat pale one by the addition of water. Wash with this a space, say three inches by one and a half. Add a little more dark tint and cover a space three inches by one and a quarter. Proceed in like manner until six bands are produced each a quarter-inch wide. The tints must not be too sloppy, or a hard edge will be made to each wash. When the whole is complete a similar effect will be produced to that before described. Instead of the flat washes, which they really are, each band will seem to be gradated from light to dark, We have attempted in Fig. 5 to represent this by engraving. employing a machine by which each band is cut with absolute uniformity. Other similar experiments may be made to illustrate the law laid down in the close of par. 18. The two edges of each band are modified in effect by—1st, the lighter band making the edge next to it look darker, and 2nd, the darker band causing the edge lying against it to appear lighter.

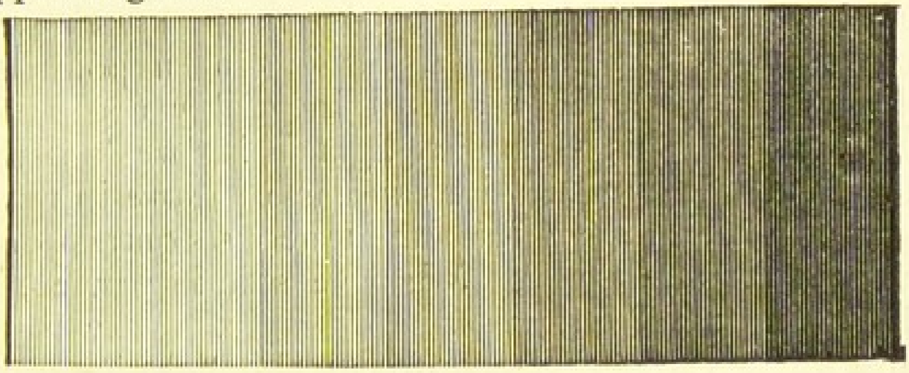

Fig. 5.

We have spoken of the simultaneous contrast of light and dark as applied to shades and tints of black and white, but the same effect will be observed if coloured pigments be employed in a similar manner. When, however, we employ two different colours in juxtaposition, it is not mere light and shade that is affected, but the colours themselves as *colour*.

It has been mentioned in paragraph 15 that a dark, neutral grey is made by combining pigments containing the three primary colours, and that a portion of white light was liberated. Now, it is obvious that if we can weaken the effect on the eye of any element of this reduced light the grey will appear to be tinged with the opposite colour. This may be proved experimentally, as follows:—Grind up charcoal and white chalk with size until it seems midway between black and white when dry. With this evenly paint some pieces of paper. Taken alone it will be impossible to determine the slightest inclination to any colour in the spectrum in this grey surface, but the influence of contrast will render it a very chameleon. Place the grey surface in a good light and lay a piece of bright red paper upon it. After regarding it for a few seconds the grey will seem to be greenish, because the eye having become accustomed to the strong red fails to take ready cognisance of the weaker red, which is an element of the grey in conjunction with the blue and yellow, and therefore it easily sees the latter two, and the grey seems decidedly tinged with green.

Giving the eye a rest and then placing a bright green on the grey, the latter will seem to become russet. In like manner will it appear to change with any other bright colour applied to it in contrast.

The simultaneous contrast of complementary colours has already been mentioned, but the same modifying causes act on colours not complementary. It has been pointed out in par. 6, that white light almost invariably accompanies coloured light. This secondary light being weak is therefore subject to the modifications spoken of above in relation to the grey. The reason for simultaneous contrast of two colours can thus be found. We have said in par. 20, that red looks most red in presence of green. Why is this? Because the green of the secondary white light is rendered inappreciable to the eye in the presence of the actual and decided green. The red is therefore heightened in effect, and for a similar reason the green is also exalted, because of the faint red of its secondary white being extinguished by the strong red.

Let us see what happens when the colours are not complementary to each other, as in the case of red and blue. What effect has the red upon the blue? Why the weak red of the faint white accompanying the blue being inoperative in the presence of the strong red, the remaining green unites with the blue to give it a greenish tinge. In like manner the red is influenced in the direction of orange.

24. THE LAW EXPRESSED.—From what has been shown the following general law is deduced:—*That when two colours are placed in juxtaposition, one will seem to partake of the complementary of the other.* This accords with the fact that when the contiguous colours are themselves complementary the effect is heightened, and when they are not complementary their purity is degraded.

25.—*Successive contrast* depends upon exactly the same general principle. When a colour is presented to the eye for several seconds, it fails to appreciate the same colour in the accompanying white light of the next presented colour. Thus if a bright orange wafer or other similarly coloured substance be placed upon a piece of white paper in a strong light, and be steadfastly regarded for a few seconds, a faint blue spot of the same shape will be seen if the wafer be suddenly moved away. A bright green wafer similarly employed will be followed by a reddish spot; and so on. In a similar manner the grey paper before mentioned may be used as a ground with like results.

In performing these experiments it will be found that the effect of successive contrast is more striking than that of simultaneous contrast, because what may be denominated the phantom colour is superposed upon a ground which makes it more clear. We have explained that red against grey makes the latter look greenish, but the effect is made much more visible by successive contrast. If a bright red wafer is laid upon the grey ground, and suddenly removed after a few seconds of intent observation, its place on the retina will be occupied by a spot of greenish hue, which, differing distinctly from the ground, is a striking proof of the previous influence of the red upon the eye. This red colour may be supposed to have tired that part of the retinal nerves, and so rendered it, for a time, incapable of being affected by a weak light of the same hue. When therefore the weak white light accompanying the grey ground falls upon this spot in the eye, the red portion of such light does not influence it, while the green has full play and is distinctly seen.

We have in this chapter tried to give an intelligible reason for the phenomena of simultaneous and successive contrast. It appears to us that some writers have misunderstood the subject, for in their explanations they seem to teach that the eye itself supplies the contrasting colour as a means of relief to the over-excited nerves. We believe that this view is held by many who have simply received their information from popular expositions. That the explanation is as we have stated it will be clear to those who study the subject sufficiently and without bias. In saying this we make no claim to any discovery, because some of the more modern treatises on light and colour agree with the views herein expressed.

We have now made the student acquainted with the main facts ot the theory of Light and Colour, as far as their relation to painting and printing is concerned. Upon these facts have been built certain theories of harmony of colouring, which may well find a place ıarther on in this treatise.

CHAPTER III.—General Properties of Pigments as applied to Printing.

Light Represented by White—Tints, Shades, Hues, Purity of Colour—Opacity, Transparency—Body, Power—Permanency—Mutual Influence—Drying.

IN painting, printing, and other arts, various material substances called pigments are employed to represent the colours of Nature, which they do with variable degrees of success, their principal defect being their want of power to convey proper ideas of lightness and darkness. No painting can properly express the glory of a sunset sky, the brilliancy of noonday, or the obscurity of a cavern; the best that can be done only faintly approaches the reality.

27. Light represented by White Pigments.—In the practice of colouring, white plays an important part, either as a surface, such as paper, over which are spread pigments more or less transparent; or as a body colour, such as chalk, white-lead, or zinc-white, which is mixed with the pigments themselves to give them a power of hiding the ground over which they may be placed, as well as to impart to them the particular strength of tint intended by the artist. In water-colour painting, as generally practised, and in colour-printing in oil-colours, the white ground is an important factor, the colour in each case being spread over it in a thin film. In oil and distemper painting white pigment is added to the colours, and the work is much the same in effect whether laid on thickly or thinly. White thus comes to represent light, while a black or other dark pigment may be used to degrade colour to represent shade.

28. Tints, Shades, and Hues.—Now, when a pigment is lightened, either by the white ground showing through it, or by the addition of white body-colour to it, it is said to be a *tint* of that colour. A *shade* of a colour, on the contrary, is such a degradation of it as may be formed by the addition

of black or other dark pigment. The addition of white to black forms a neutral grey.

Another attribute of colour is denominated *hue*. This word is employed to indicate the mutual relation of colour as distinct from light or dark. Thus a green may be of yellow or blue hue, blue may be of a green or purple hue, and red of a purple or orange hue. The word *hue* therefore indicates a quality which may be distinguished, whether the colour be light or dark.

29. PURITY AND IMPURITY OF COLOUR.—A very important matter for the student is to be able to distinguish colours as to their purity. It may be roughly stated that there are no pigments to be obtained that will represent colours absolutely. Yellows will be found to have a tendency to either green or orange; red will lean on one side to purple or on the other to orange; while blue will either favour purple or green.

These tendencies may be taken advantage of in compounding colours. If we desire to compound a bright green we may take a blue and yellow, which already incline to that colour. In a similar manner we may select colours for compounding purple and orange. In mixing for tertiaries this care need not be exercised, because, as their names import, each one contains the three primary colours. Thus, russet may be regarded as red broken down by additions of blue and yellow (or green). By inspection of diagrams 3 and 4 green will be found opposite russet. In the same manner citrine is yellow broken with purple, and olive is blue broken with orange.

By thus training the mind to detect in any colour a tendency in hue towards another one, a power is gained over it in subjecting it to any particular use; and in the actual mixing of colours time will be saved, when making compounds for matching other hues, in consequence of the knowledge previously gained of the pigments individually.

It is probable that, if pigments existed of absolute purity representing blue, red, and yellow, no others would be required for compounding mixtures to imitate any hues; but, as these cannot be had, pigments in relation to mere colour may advantageously be selected in pairs. Thus, for red we may choose vermilion and crimson lake, or vermilion and carmine. For yellow, lemon chrome and a deeper, more golden tint, called chrome No. 2. For blue, Chinese or Prussian blue and oriental blue, cobalt, or ultramarine. The student should purchase these in the convenient form of water-colour cakes, and will then be in a position to make many instructive experimental mixtures.

30. Opacity and Transparency.—Pigments differ also in their qualities of opacity and transparency; that is to say, in their power of either covering up another colour when laid over it, or of allowing it to show through. As an opaque body vermilion may be instanced, and crimson lake as a transparent one.

31. Body and Power.—The word *body* is applied as a quality of pigments, but its meaning varies as applied to an opaque or transparent pigment. It is most often applied to opaque pigments, which are spoken of generally as "body colours"; and thus, any transparent colour, when mixed with opaque white, becomes a "body colour." Opaque pigments having the power of completely hiding other colours beneath them, are said to have a good *body;* but the term, as applied to transparent colours, means that they have a great power in imparting their own hue to a white pigment; or, in other words, it indicates that the pigment possesses great colouring power in proportion to its bulk. As the word *body* has been used in this double sense, it is well to have another word for denoting what is meant by it in connexion with transparent pigments. That word is *power.* When a pigment possesses the quality of largely influencing a mixture, or of colouring a great quantity of oil or water in proportion to its bulk, it is said to possess great *power.*

We have, then, three good words for distinguishing three important qualities of material colours,—*transparency*, *body*, and *power.*

Practically, it is of much importance to know these qualities in pigments, both in painting and printing. In the production of any imitations of material objects, either natural or artificial, the qualities of body or opacity and transparency must be thoroughly understood and well borne in mind. It would be quite improper, for instance, to commence a picture with transparent colours and to finish with opaque ones. To proceed thus would be to destroy aërial effect and transparency of shadow. The reverse order must be taken or the result will be poor and heavy. Lights in the foreground, and the whole of the distances in a landscape, can well be produced with body colours; but in the shades and shadows the best effects will be got by the use of pigments having transparency, the most transparent being employed as a glaze to represent the deepest parts. In our lists of colours we shall point out the comparative transparency of each pigment, leaving it to be inferred that those which are most deficient in transparency have the greatest opacity or body.

32. PERMANENCY.—Another important consideration is the permanency of colours. Pigments are differently affected by different causes. Light, heat, darkness, impure air variously affect various pigments and dyes. Thus, impure air containing the vapour of sulphurous compounds acts strongly upon white colours having lead for their basis, while the same pigments stand any amount of strong light. Crimson and rose colours prepared from any source except the madder-root or alizarine will not bear the continued influence of strong light, but are fairly permanent under the influence of darkness or impure air. Heat strongly influences some colours, as is seen more particularly in those instances when it is employed to vary the hues of certain earthy matters. Yellow ochre by burning becomes changed to light red, and analogous changes occur in Sienna earth and many other substances. Other colours, on the contrary, are comparatively unaffected by high temperatures,—such as zinc-white, cobalt and smalt blues, &c.

33. INFLUENCE OF PIGMENTS UPON EACH OTHER.—Besides the changes wrought by extraneous influences, others are brought about by the injudicious mixture of one pigment with another which acts chemically upon it. Thus many pigments should not be mixed with colours containing lead, which, generally speaking, have the tendency to change such pigments towards blackness. Others, again, should not be incorporated with those that contain iron. When we come to speak of individual colours we shall note these peculiarities.

34. DRYING.—Pigments also vary in another important particular, that is, their power of drying in oil and oil

varnishes. Oils dry by the absorption of oxygen from some source; it may be from the atmosphere, or from the pigments with which they are ground. Some of the colours, such as the oxides of the metals, are rich in oxygen and are good dryers, while others, being deficient, may even retard desiccation. It will sometimes happen that pigments which are bad dryers require the addition of some substance which will facilitate their hardening. Such helps are employed both by the painter and printer, and we shall have occasion to point them out in another place.

35. How Oils Dry.—The correct idea of the way in which oils dry should be mastered by the student. It is no uncommon thing to imagine that the putting of printed work into a drying-room facilitates the drying of printing-ink in the same manner as the water is dried out of paper, viz., by evaporation. This is a mistake, for the ink really dries by taking to itself a new something, and not by parting with anything. It therefore really becomes heavier. By special arrangements oil may be made to absorb so much oxygen-gas as to become something like india-rubber in its qualities. This is frequently seen when improper oil is used in lubricating machinery, it becomes "gummy" by absorbing oxygen from the atmosphere. Vegetable oils are, as a rule, more liable to this defect than animal oils; hence the latter are most in favour as lubricants. Oil, when applied to machinery, shows this tendency to oxidise in a very marked manner, because the continual change of place of its particles exposes it more thoroughly to the action of the air, and therefore to oxygen, than would be the case if it remained in a state of rest. Oil varnishes, such as are employed in printing-ink, are affected in like manner; but the varnishes in which the essential oils, such as spirits of turpentine, are used, and the spirit varnishes in which benzole or alcohol is employed, act principally by the evaporation of the solvents. Sometimes two kinds of varnish, as oil and turpentine varnishes, are combined in one, in which case the drying consists in the evaporation of the turpentine as well as the absorption of oxygen by the oil. Though warm air facilitates the drying of oils, it is not by causing evaporation of its particles, as in the drying of water out of paper,

but by facilitating the absorption of oxygen from the air, which consists of two gases, oxygen and nitrogen.

The following short description of experiments made on this subject by Chevreul will help the student to appreciate and remember the fact that oils and oil varnishes dry by the absorption of oxygen.

Four pieces of wood were painted on one side with white-lead ground in pure linseed oil, and on the other side with zinc-white ground in the same medium.

No. 1 was exposed in the open air. In 24 hours the white-lead was almost dry. The zinc-white was set but not dry. In 72 hours both were perfectly dry.

No. 2 was exposed in a half-gallon glass jar and carefully closed. In 24 hours the white-lead was not quite dry, and the zinc-white was only set. In 72 hours both were perfectly dry.

No. 3 was exposed in a similar jar, in which the air had been replaced by dry oxygen gas. In 24 hours both white-lead and zinc-white were quite dry.

Piece No. 4 was exposed in a similar jar, filled with carbonic acid gas instead of air. After 72 hours the white-lead was almost set but did not adhere to the wood, coming off entirely when rubbed with the finger. At the same time the zinc-white was absolutely wet.

The effect of temperature on the drying of inks is considerable, so that, if the drying-room is not artificially heated, it may take five or six times as much dryers in winter as in summer to make out for extremes in temperature.

In experiment No. 4 it will be seen that carbonic acid gas did not permit of the paint drying, yet it is a gas rich in oxygen. The latter is, however, so bound up with carbon that it will not readily leave it, whereas the oxygen in the air is not a chemical compound but only mixed with its accompanying nitrogen, and is perfectly free to unite with any substance for which it has an affinity. If these facts be kept in mind, much misapprehension will be saved on the subject of drying of inks.

36. We have in this and the previous chapters laid down certain general principles, and explained what is to be understood by words and phrases connected with the subject of colours and pigments. These must be thoroughly

mastered so as to be brought to the mind whenever required, as they will frequently be used in the following pages. What we have said might have been made to fill a volume of itself if it had been treated as fully as its importance demands. As, however, we desire to condense this treatise into convenient limits we have been as concise as consistent with our desire to make ourselves understood. If we have not made our meaning as clear as desirable through being too concise, we ask the reader to make up for the deficiency by increased attention and determination to master what is meant.

CHAPTER IV.—Yellow Pigments.

OF Yellow.—This colour is that which nearest approaches light, and yellow pigments are most nearly allied to white ones. In pictorial compositions yellow requires careful management to make it agreeable to cultivated taste. It is, speaking generally, least agreeable when it is tinged with green, and most agreeable when there is a perceptible leaning towards orange. In decorative work it may be called an aggressive colour on account of its tendency to claim a front place; it is therefore called an *advancing* colour. In most artificial lights, yellow and its compounds suffer deterioration in consequence of such lights being themselves yellow; exception must, however, be made as regards the electric light, which is now coming into extended use. Great caution must, therefore, be exercised when employing yellow ink on foggy days and by gaslight; also towards evening on bright days. At these times one is very apt to be deceived and to be led to employ a yellow too deep in tone, or to use a green or orange containing too large a proportion of yellow. As a means by which to guard against such errors, we recommend the printer to provide himself with a small quantity of magnesium ribbon or wire to be employed in emergencies. This metal, which resembles silver, may be obtained of most dealers in philosophical instruments, and is usually retailed at about sixpence per yard. It possesses the property of burning easily and very rapidly with an intensity and brilliancy fairly rivalling the electric light, and by its aid colours are readily seen in their proper hues. A convenient way to employ it is to cut with scissors a piece about two inches in length, obliquely, so as to have it pointed. The object of doing this is to render it more easy to ignite. It may conveniently be held in a match or other small piece of wood having a slit made in it with a knife. So short a piece as two inches will only last a few seconds, but sufficiently long to estimate the effect which is being produced by the yellow ink.

Yellow is employed in compounding *green* with blues and *orange* with reds. It may be taken that there is no purely yellow pigment that the printer can employ, and in making compounds it becomes necessary to have regard to the hue sought. If a pure green be required, a yellow must be taken that is either pure or already inclined to green, and, as the pure colour cannot be obtained, such a colour as lemon chrome or yellow lake must be employed in conjunction with such blue as Prussian, Antwerp, or Chinese blues: the chrome if an opaque colour be required; the lake if a transparent one be demanded.

A little consideration will show that a yellow of the opposite kind must be chosen in mixing an orange ink.

38. CHROME YELLOW, though not an unobjectionable pigment, is one of very great importance to the colour-printer. It is easily ground in varnish and works readily on the roller. It covers well, being one of our most opaque colours. Chemically it is a chromate of lead, and is obtainable in a variety of hues, varying from a pale lemon to an orange approaching red. It should be soft to the touch, easily broken between the fingers and thumb with a crackling noise, and yet not gritty. Its variety of hue and its general, good-working qualities make it a favourite with the printer. In some situations, such as bright light and pure air, it appears to be a fairly permanent colour; but under the opposite influences chrome yellows are not to be relied upon, as they frequently turn black. They form good tints with white, and brilliant greens with Prussian and Antwerp blues, though as an element of green with these iron blues they are not reliable. Good low tones

of green may be compounded of the various hues of chrome by an addition of black ink. These are, no doubt, as permanent as the chrome itself, because the carbon forming the black ink is chemically inert.

There are varieties of these pigments known by other names, such as *Cologne yellow* or *jaune de Cologne*, from its being imported from that town. It differs from the true chromate of lead in containing the sulphates of lead and lime in addition. It is also known as *jaune mineral*, though there is a chloride of lead also known by the same name (42). In chromo works imitative of high art, where the principal considerations are permanency and intrinsic excellence, chrome yellows should be avoided as far as possible, and for brilliant effects cadmium yellow is to be preferred.

In addition to the chromates of lead, there are other chrome yellows which, though not suitable in printing, are useful in paper-staining. The principal of these are—*chromate of lime*, a fine straw-coloured pigment; *chromate of baryta*, a similar colour; and *chromate of zinc*, a pale yellow which has been called *buttercup yellow*.

39. CADMIUM YELLOW was for years confined to the palette of the artist; but its general good character has, notwithstanding its high price, won for it a place in the workshop of the printer. It is a sulphide of cadmium, is found in nature as the mineral *greenockite*, and may be prepared from solutions of salts of cadmium by the addition thereto of sulphuretted hydrogen or sulphide of ammonia. It closely resembles yellow orpiment,—arsenious sulphide—but may be distinguished from it by not being volatile and being insoluble in liquid ammonia. It is a warm, bright yellow pigment, permanent with flake-white as a tint, and an excellent colour for use in evening skies. It is a valuable addition to the palette and has been long enough in use to establish its claims to favour. Cadmium yellow with blue pigments produces rich and durable greens, which should not be mixed with lead colours to form tints.

40. YELLOW LAKE, a yellow of a lemon colour, is occasionally useful as a finishing or glazing ink where transparency is essential. It will not stand under the influence of strong light, and is therefore not fit for show-

cards or chromos for framing, though it may be relied upon for book-illustrations, which are rarely exposed to bright light. Impure air does not injure it. It is met with in commerce in the form of tears or drops, and is thence also called *drop yellow*. It is a vegetable extract in conjunction with alumina, thus resembling other lakes in constitution. When ground in varnish it has very little resemblance to the fine colour it prints, for in the mass it is more like a brown. It possesses this peculiarity in common with most transparent pigments, and when any ink looks very much darker on the slab than it does upon paper it may be taken as a general indication of transparency. This pigment is a compound which varies in hue and other qualities with each different manufacture; therefore one make, when good, should be adhered to. The best class of yellow lakes is difficult to discover, as the sources from which they may be made are so various. The berries of the dyers' buckthorn — *rhamnus infectorius*, variously known as *French*, *Avignon*, *Persian*, and *Turkey* berries—seem to be the principal source. Inferior qualities for paper-staining are prepared from *weld*, *quercitron*, *yellow-wood*, &c. In all cases, the dyestuff is boiled with alum and the colouring-matter precipitated by carbonate of soda or potash. It is not a safe colour with which to compound tints, and is especially unsuitable with lead and other metallic pigments. It may be said generally that it should not be used in mixtures, since more permanent tints may be compounded from or found in other pigments.

41. NAPLES YELLOW was, as its name indicates, originally prepared at Naples, probably from some mineral of volcanic origin. It is compounded artificially from the oxides of lead and antimony, and may be obtained of various depths of colour. It is not so intense as either of the colours previously mentioned, and may be described as a light, warm yellow of pleasing tone. It is not an eligible pigment for the colour-printer, and is only to be employed under circumstances of an imperative nature. It covers other colours, and may be used alone for this purpose. It is very unsuitable for forming mixtures with any colours containing iron, and must therefore be kept from the ochres, Prussian and Antwerp blues, and other similar

pigments. For like reason neither a steel palette-knife nor an iron slab must be employed with it. A bone or ivory spatula is needed. In presence of light it is a very permanent colour, though liable to turn black under the influence of damp and impure air. It dries well.

42. PATENT YELLOW, TURNER'S YELLOW, or MONTPELLIER YELLOW, is a fused sub-chloride of lead of bright yellow colour, having a striking resemblance to chrome. It is hard, heavy, and crystalline, works well, but is easily injured both by light and by impure air. Other names for this pigment are—*Kasler*, *Cassel*, *mineral*, and *Verona* yellows. A variety of this yellow discovered by Mérimée is rich in tone and said to be durable. Its trade names are *antimony yellow* and *superfine mineral yellow*.

43. MASSICOT, or MASTICOT, is an oxide of lead of variable colour. Though it is prepared from white-lead by partial calcination, it cannot be used with it for pale tints, because, under such conditions, massicot soon returns to the white colour of its prototype. However, if used by itself, its permanency is about the same as that of white-lead, to which in general qualities it is intimately related.

44. YELLOW OCHRES.—There are various earthy colours, all of a similar nature, known as the ochres, the principal ones of a yellow colour being known as yellow ochre or mineral yellow, Oxford ochre, stone ochre, Roman ochre, brown ochre, York brown, &c. They rank among the most durable of colours, and though not brilliant may be most usefully employed whenever their low tone will permit. They are very useful as tints when employed with a considerable amount of varnish, though it is difficult to print them up to their full strength of colour. This arises from the fact that in the mass their colour is not deep, and varnish will not carry a heavy amount of such pigment and still retain its essential character of antipathy to water to insure clean printing. With Prussian blue they form a series of low-toned greens which may be employed with advantage if their hue be suitable to the work in hand. All the ochres and the next-mentioned pigment are reddened by the action of fire. They are all of a similar chemical character, being clays more or less coloured with peroxide of iron (ferric oxide).

45. Terra di Sienna, or Raw Sienna, in common with the ochres, seems to depend upon iron for its colouring matter. Though still impure, it is a brighter yellow, and has more power and transparency, than the ochres, being a valuable pigment of undoubted general permanency. It is a very hard pigment, and should be bought finely ground instead of in its natural state, to save time in grinding. It is a kind of natural yellow lake, and mixes well with that pigment when it is required to be brightened and to preserve its natural transparency. This pigment is named after the town of Sienna in Italy.

46. Mineral Yellows:—Yellow Orpiment, Orpin, Yellow Realgar, Royal Yellow, is a yellow arsenious sulphide, either natural or artificial, beautifully bright and pure in colour, but unfortunately its other qualities are not by any means as good. It does not agree in mixtures with most other metallic colours, and when used with the lead whites its tints are soon destroyed. It must not be employed with the chromes, Naples yellow, masticot, nor red-lead, but with the sulphides, such as vermilion, or alone it may fairly be depended upon. It is very poisonous. *King's yellow* and *Chinese yellow* are almost identical substances. Arsenite of lead is sometimes substituted for orpiment. The colour is equally fine and said to be more durable. It is called *arsenic yellow* and *mineral yellow*. Turbith or Turpeth Mineral, a sub-sulphate of mercury of a bright yellow colour, highly poisonous, forms a magnificent green with Prussian blue, which is said to have no tendency to become black. Mineral Straw Yellow is a basic sulphate of lead of little value. Iodide of Lead is a bright yellow of unstable character.

47. Gamboge, a natural gum-resin, Gallstone, a substance formed in the gall-bladder of oxen and similar animals, and Indian Yellow, Purree, Jaune Indienne, are neither of them suitable as printing-inks, though their beauty of colour is very attractive. The latter pigment contains magnesia and alumina, combined with organic colouring matter said to be obtained from the urine of camels which are fed upon the rind of the mangosteen.

48. Aureolin is a pigment somewhat more recently introduced than those previously noted and still too high

in price to make it a likely addition to the workshop of the colour-printer. It is a preparation of cobalt produced from the nitrate, of a golden yellow, and is considered permanent. It is chiefly used by artists.

49. MARS YELLOW, JAUNE DE FER, JAUNE DE MARS, IRON YELLOW, is a bright iron ochre of the nature of sienna, similar in its general behaviour to the ochres, but somewhat more transparent. It is much esteemed among artists. On account of the abundant supply of the natural ochres it is at present relatively too high in price to take the place among printers' pigments that its value warrants. It is prepared from green copperas, alum, and carbonate of potash.

50. ANILINE YELLOWS.—The introduction of the derivatives of coal-tar has almost revolutionised the art of dyeing, and it is not unfair to suppose that the manufacture of pigments will be influenced to a somewhat similar degree, if not to so great an extent. The coal-tar colours are remarkable for their great variety of hues and for their great tinctorial power. The latter quality is shown by the fact that one grain of pure mauve crystal (mauve was the first coal-tar colour made) will strongly colour half a million grains of water. As there is much popular misunderstanding in regard to the coal-tar colours, many people thinking these dyes are extracted direct from the tar, we go a little out of our way to show our readers the steps by which the colours are reached. These operations are altogether so unlike the manufacture of ordinary pigments, that we feel we shall be excused for drawing attention to them on account of the interest that naturally attaches to them.

Among the numerous products (over fifty) of the distillation of coal-tar, *crude naphtha* is one of the easiest to obtain. By further distillation and treatment with steam and sulphuric acid in order to precipitate the tarry matters, *benzol* is separated in conjunction with other less volatile matters, which remain behind during still further distillations. This fairly pure commercial benzol is, in turn, treated with fuming nitric acid, which results in *nitro-benzol*, a dense yellow fluid heavier than water. Nitro-benzol is then, by suitable chemical means, made to take up a definite proportion of hydrogen, and it then changes its character and becomes *aniline*. Now, aniline in its pure state is a colourless liquid, and, of itself, gives no evidence of the wonderful colours which can be produced from it by further chemical combinations. Some idea of the trouble involved in these processes may be formed from the fact that 100lb. of coal producing $10\frac{3}{4}$lb. of coal-tar yields only $2\frac{1}{4}$ ounces of aniline. This base, when acted upon by various salts and acids, forms a great variety of colours. Other products of coal-tar, such as phenol (carbolic acid), naphthalin, and paranaphthalin (or anthracene), form the starting-points for other colours, so that from a few comparatively colourless materials nearly every variety of hue may be obtained. Among this wealth of tinctorial substances there are but few that have found their way into favour with the chromo-printer, and of them little can be said in favour of their permanency, the best being but fugitive in comparison with such pigments as vermilion.

Among the least successful adaptations to requirements of the litho-printer are the yellows. There are several splendid yellow dyes among the coal-tar colours, but the endeavours made to produce yellow lakes from them have not met with much success so far as we can learn, though we believe they will ultimately be obtained. This is the more to be desired, because the yellows promise to be among the most permanent of the coal-tar series.

CHAPTER V.—Red Pigments.

OF Red.—Red is a simple primary colour intermediate between yellow and blue both in colour and in point of light and shade. Yellow being an advancing and blue a retiring colour, red comes between them in this respect and holds a middle place. Red is warm, powerful, beautiful, and cheerful in its effect on most observers, and communicates something of this influence in converting yellow into orange and blue into purple. Nature seems to reserve it for its most gorgeous and lovely effects, the mind being similarly affected by its developments among the floral creation and the carnations of the human face. Red may usually be divided into the two classes of Crimson and Scarlet. It is hardly possible to find a truly neutral red combined with any great degree of brilliancy. Crimson is a red having an infusion of blue in it, while scarlet is a red that is inclined to yellow. The artist uses red in its purity but sparingly, unless in connexion with draperies or other masses where it is demanded, and even there he usually keeps it for the higher lights. In a landscape it is often useful, properly placed, to contrast pleasantly with the more pervading hues of green, and often takes the form of a woman in a red cloak. As a decorative element it may be more freely used, more especially when broken down with white, black, or gray. Among printers it is of immense service in attracting the eye to anything important, and is largely used in almost all chromatic methods of arresting the attention by advertisement. A printer who can print a brilliant, clean, and solid red generally prides himself thereon, and deservedly so, for it indicates care in having everything clean and in having the amount and quality of varnish properly proportioned to the pigment used.

52. VERMILION.—Chemically this pigment is a *mercuric sulphide*, and is generally called in the old works on chemistry *bi-sulphuret of mercury* and in more recent ones *proto-sulphide of mercury*. The same compound of 200 parts by weight of quicksilver to 32 parts of sulphur is understood in each name. It is found naturally in a crystalline state, and is then called *cinnabar*. It is largely produced artificially, both in this country and on the Continent. Much vermilion is imported from China, where a native cinnabar is found so pure as only to require grinding to make it fit for use. Chinese vermilion is of a less scarlet hue than other kinds, and is much esteemed among artists in consequence, though there is no demand for it with the ink-maker. Both the natural and artificial kinds possess similar properties and may be used with perfect safety as long as they are not adulterated. Vermilion is necessarily an expensive colour and varies in cost with the alternations of the price of the metal from which it is manufactured. It is useless, therefore, to expect

to purchase this colour at extra-low quotations, for in practice it is found that about 90 per cent. of mercury is required to manufacture any given weight of vermilion. Its price is also practically enhanced by its extreme density, for so heavy a colour obviously cannot go so far as a lighter one; it is, therefore, in fact, really more costly than some lighter colours that fetch far more per pound. From these considerations it is easily understood how great is the temptation to adulterate this pigment, and consequently it has obtained among some persons an undeservedly bad character for permanency, both in strong light and impure air. Some samples of so-called vermilions are found to fade in strong light. These will be generally found to have been strengthened in colour by the addition of some of the more brilliant and fugitive scarlet lakes, which, fading out, leave only the vermilion (or perhaps red-lead) behind. The colour is not merely paled but degraded also, for the lakes in fading leave behind a dirty residuum. On the other hand, the sample may be discovered to have become dirty and dark when exposed to impure air, indicating its contamination with some foreign substance.

The lithographic printer has always the means at hand for testing the quality of his vermilion, for the application of nitric or muriatic acid will not change its colour, while some of the imitations will be changed to a bright yellow by nitric acid. If placed upon a strip of iron in a bright coal fire, a small quantity of vermilion is quickly and entirely dissipated, both of its elements being volatilised by heat. The acid test is the most easy to apply when it has been ground into ink, and by rubbing it on paper with the finger impure vermilion rubs out yellow. Vermilion makes a valuable printing-ink, but is apt to deceive the inexperienced printer, especially at machine. It is common for the workman to estimate the strength of his ink by the manner in which it drops off the knife, and carrying out the same practice in regard to vermilion he is surprised that he cannot work with facility in consequence of his ink sticking to his slab and refusing to distribute and to yield presentable impressions. A moment's consideration will show, however, that so heavy a pigment will fall easily from the knife even when considerably in excess of the proper amount of varnish. The addition of varnish will soon prove that what seemed to be a very thin ink had really been overcharged with colour, and that further thinning it had brought it into a condition which not only improved it, so far as to keep its proper place upon the slab and roller, but also permitted of impressions being taken carrying a larger amount of colour. This defect is, however, sometimes due to the adulteration with red-lead, which, being a very powerful dryer, soon brings the varnish into a pasty state, quite inconsistent with comfortable working.

53. GERANIUM RED, PURE SCARLET, IODINE SCARLET. —This fascinating colour, which exceeds vermilion in purity and brilliancy, is a mercuric iodide, or iodide of mercury. It is similar to vermilion in its body and opacity as well as in colour, but there the comparison ends, for it has scarcely any other good quality. Strong light somewhat deadens its brilliancy, but impure air destroys its colour, and frequently reduces it to a metallic state that resembles black-lead. It cannot be trusted in contact with an ordinary palette knife nor in mixture; should occasion, therefore, make its employment imperative, it must be used by itself and with great care.

For GERANIUM LAKE see par. 65.

54. INDIAN RED and TURKEY RED* are ores of iron called red hematite. Chemically it is a peroxide of iron or ferric oxide. It is also known by other names, such as *sesquioxide of iron*, *colcothar*, *crocus*, *carbonate of iron*, *rouge*, *trip*, *brown red*, *English red*. It may be prepared artificially by causing iron to rust in the air, or by the calcination of ferrous sulphate,—common green copperas. The natural product is hard and gritty and requires well grinding, washing, and drying to make it fit for ink-making. It is of a dark red colour, somewhat purplish in hue, and by many would be considered a brown. It is scarcely fit for printing very fine work, though for solid back-grounds and similar jobs it is very useful, as it possesses considerable opacity, being in this respect something like vermilion. It is a very permanent colour, and is much esteemed by the artist in

* This pigment has also been called *Persian Red*, though the name is generally now restricted to a red-coloured chromate of lead. (See par. 70.)

making certain flesh-tints with white-lead which are as permanent as a lead tint can be. Both Indian red and vermilion in conjunction with blues of the cobalt class make tints with flake-white which would pass among many for lake-produced tints. It should be kept in a very dry place, as it is apt to absorb moisture. Should it be damp, it may be baked previous to making it into ink.

55. LIGHT RED is a red ochre, produced by burning the yellow and brown ochres, the brightest being obtained by calcining the purest yellow. It is an admirable colour for flesh-tints with flake-white for lighter complexions than those formed with Indian red. The colour is permanent.

56. VENETIAN RED, or SCARLET OCHRE, is a very similar pigment to the two foregoing, but holds a middle place between light red, than which it is deeper and purer, and Indian red, which is darker and more purple. The true Venetian red was, doubtless, a native ochre, but it is now prepared from ferrous sulphate (sulphate of iron, green vitriol, or green copperas, all meaning the same thing).

Prussian red and *rouge de Mars* are names of similar pigments, while *Spanish red* is the name of an ochre which differs but little from it.

57. LAKE PIGMENTS.—The term lake when used alone usually signifies certain beautiful pigments of a red hue. As there are, however, blue, yellow, orange, green, purple, and brown lakes, it will be as well to point out the more exact signification of the word. In dyeing, certain colours are soluble in some mentrua, and are frequently fixed upon the goods, silk, cotton, or wool, by means of certain salts called mordants. In this lies the principle of making lake pigments, but instead of the colouring matter being precipitated into the fabric, it is removed from the fluid dye by filtration or decantation. The principal precipitants are alum and the fixed carbonated alkalies. Sometimes both carbonate of potash or soda and alum are used. The colouring matter may be more soluble in presence of the alkali and may afterwards be precipitated with alum; or it may be boiled with alum and precipitated with a carbonate. Sometimes the colour is further modified by the addition of a third salt. Lakes may therefore be regarded as soluble colours precipitated

upon earthy bases, the colouring matter itself being usually of vegetable or animal origin. To a certain extent the ochres may be regarded as natural lakes, the colouring matter being mineral. The mineral colours which are neither lakes nor ochres are chemical compounds of more simple and definite composition, which cannot be upset without entirely changing the nature of them. Thus vermilion is a definite compound of mercury and sulphur, the proportion of which cannot be altered without leaving a residue totally different to itself. On account of the highly complex nature of the animal and vegetable substances whence the lakes are obtained, they have not usually much stability, and should, therefore, not be used when more permanent pigments will answer the same purpose. The number of possible lakes amounts to thousands, but the most of them are worthless. The chief ones of value are mentioned in their proper place.

58. MADDER LAKE, ROSE MADDER, ROSE RUBIATE, PINK MADDER, and FIELD'S LAKE, are originally preparations from the root of the plant *rubia tinctoria*, and were until lately the only reliably permanent pigments of a rose colour. Their chief defect is a deficiency of power, as no amount of coaxing will make them yield an ink having the colouring qualities of other but less permanent lakes. They are not liable to change, either by light or impure air or by mixture with flake-white and other colours. They are very valuable for delicate carnations in flesh and in pink draperies, where the importance of the work warrants the expense and trouble attending their use. We have had in our possession for the last five and twenty years a chromo of our own production in which a pink dress is as bright and delicate as when first printed. Madder lake is not a good dryer in printers' varnish, a defect for which gold-size or sugar of lead may be employed as a remedy. Madder may be distinguished from other rose lakes and carmine by remaining uninjured when tested either by ammonia or dilute muriatic acid.

ALIZARINE, one of the most important colouring principles contained in madder, has of late years been found to be obtainable from paranaphthaline or anthracene—one of the products of coal-tar. The manufacture of this artificial alizarine has lately become so important as seriously to affect the madder-growing industry. It is not merely a substitute for that prepared from madder, but seems to be identical both in chemical composition and behaviour. Many of the coal-tar colours are undoubtedly fugitive, but that this is not the case with all of them is clearly shown by the identity of the two alizarines.

59. Cochineal Lakes.—These may be either *crimson* or *scarlet*. *Florentine*, *Chinese*, *Hamburg*, *Roman*, and *Venetian* lakes are all varieties of this pigment, which is prepared from infusions of the cochineal insects from which the colouring matter is precipitated by alum, &c. They are colours of great beauty and much utility, but they will not bear any considerable quantity of light, though they stand pretty well when preserved from it. They do not make good tints with white-lead. When employed in lithographic printing they do not behave as pleasantly as many inks, and are always liable to stain the stone and damping-cloth. They are bad dryers and go " livery " by keeping, for which reason they should not be mixed in quantities with the idea of keeping them for any lengthened period. When they become thus set, these inks do not distribute nor ink properly, and must be re-ground with new varnish to make them serviceable, and even then they are very inferior in working qualities to newly-ground ink. In selecting these colours one must not be deceived by the apparent brilliancy of the colour in bulk, for it may be taken for granted that when they have such an appearance something has been added to bring it out, for their natural aspect is a dark colour. It should be borne in mind that cochineal has a variable market-value, and that the price of a genuine sample of either of these lakes must depend upon the cost of the materials from which it is made. As a general rule, it will be found that the cheaper these pigments are offered the lighter in colour they will be. We are not now alluding to the madder lakes, as they are naturally very much lighter in appearance, but to those made from cochineal and similar sources. If pure, they will be quite dark in colour, and when wetted will exhibit a deep hue approaching marroon. If this does not happen, one may be sure they have been adulterated.

Other lakes called CARMINATED LAKE, PARIS LAKE,* VIENNA LAKE, are prepared from the residual liquor of the carmine manufacture precipitated by freshly-prepared alumina. They are of little account, and cannot be recommended even on the score of economy.

60. LAC LAKE is prepared from the Indian *lac*, and is sometimes called Indian lake. In colour it is less brilliant than the cochineal lakes, but is considered by many to be more permanent. This pigment was probably used by the Venetians in their paintings, and it certainly seems to have stood the test of time better than most other transparent red pigments. It must be remembered, however, that the painter can lay on pigment to any thickness he may require, but the colour-printer is restricted to the quantity that can be yielded by the roller and yet stand the impression employed in printing without squeezing out of place. Lac lakes are similar to cochineal pigments in the qualities connected with drying and tinting. Lac in its natural state is called stick-lac, and consists of small insects cemented into a mass by means of a resinous matter which exudes from the twigs of the trees which they infest.

61. BRAZIL WOOD LAKE.—Under this name we may include other lakes made from any of the various dye-woods. They are greatly inferior to the lakes previously mentioned, and their only recommendation is their cheapness, though even in this latter quality they are superseded by magenta lake which is in every way superior.

62. ROSE PINK is a very inferior pigment, much used among paper-stainers and in common distemper painting. It is produced by dyeing chalk, &c., with a decoction of Brazil-wood or other similar dye-stuff. It is one of the most fugitive of pigments, and should not be employed by the colour-printer under any circumstances.

63. CARMINE.—This fine red pigment is prepared in a similar manner and from similar materials as the cochineal lakes. It seems to vary from them in the fact, that in the

* The word *Paris* is not to be understood as applying to all French lakes. It is a name that has been given to a colour of but little value. The name has been so often applied to pigments, that it must not be hastily assumed that because a lake is offered under that name it is necessarily of poor quality.

manufacture of carmine a smaller quantity of precipitating salts are employed, and these bring down only the finest particles of colour. In actual practice it takes about 1 lb. weight of cochineal to produce 1½ oz. of carmine, consequently it is very high in price. When pure, it is wholly soluble in liquor ammonia, which may be therefore used to detect any adulteration to which it is very liable, starch being among its most common additions. The most brilliant pigments, as seen in the mass, are often the most ineligible for painting or printing; for when the pure pigment is naturally dark in colour it is an easy matter to give it a brilliancy by the addition of something white, which brings out its beauty. When, however, it comes to be ground in oil or varnish, this extraneous matter takes up so much vehicle that it becomes difficult to bring out the full strength of the colour, more especially in printing.

Carmine, in common with the other cochineal and similar lake pigments, is wanting in permanency when exposed to light, nor does it make durable tints with flake-white. Therefore in tints, either with simple varnish or white, it should not be used in any work that is likely to be exposed in shop-windows, &c. In book-illustrations it may be trusted.

Carmine is much esteemed by the letterpress printer; but the lithographer has very little to say in its favour, as it is so difficult to work. Different samples vary much, and probably the mode of manufacture has something to do with it. As a precipitated pigment it ought, theoretically, to behave with the litho-printer as well as the crimson and scarlet lakes made from the same source, but it is not so. We believe most manufacturers employ gelatine, albumen, or similar matter to assist in the separation, and this probably helps to make it less suitable for lithography, these substances being influenced by water.

64. Madder Carmine.—What has been said of madder lakes applies equally to this pigment, as it bears the same relation to them as the carmine of cochineal bears to cochineal lakes. This colour is probably now prepared from alizarine (58).

65. Geranium Lake.—A modern colour of the coal-tar series, prepared for the use of the printer as an intensely

brilliant red of rosy hue. Unfortunately its permanency is in an inverse ratio to its beauty.

For GERANIUM RED see par. 53.

66. COBALT PINK is an expensive colour but little known said to be very durable. In its preparation, nitrate of cobalt is made into a paste with carbonate of magnesia and dried. It is then calcined and carefully ground.

CHAPTER VI.—OF BLUE AND BLUE PIGMENTS.

BLUE is the third primary colour that demands our notice. It is the nearest of its class to Shade, as yellow is to Light. It is a retiring colour, in the sense that it is the pervading hue of distances in landscape and of the cloudless midday sky. In other situations it has a similar character when placed among other colours, unless it happens to be pure while its accompaniments are low in tone. It induces also a feeling of coolness, in contradistinction to orange and red, which are warm colours. Blue is to most people an agreeable colour, for it is the predominant primary in nature, whether regarded in the blue sky or sea, or as the principal element of the green landscape, or the grey of the clouds and distances. There are no really pure blue pigments, for there is not one that is equally suited to compound both greens and purples. The best at command have a tendency to one or other of these secondaries, and in compounding them care must be taken to employ the pigment best suited to the purpose, when purity of tone in the secondary is required. It is thought by many that the azure of the sky is produced by a combination of light with darkness, and there is some degree of probability in the idea, though it does not follow that blue is a compound colour. It is not unlikely that the aqueous particles illuminated by the light of the sun and seen against the background of the darkness of space produce the azure, and that when there is least moisture the blue is deepest. When, however, the watery matter increases, as it does practically nearer the horizon by reason of there being more of it to look through, the colour changes to green, yellow, and orange. A familiar instance of this may be seen when milk is spilt upon a black or even brown tea-tray, or when white pigment is thinly scumbled over any dark surface; the otherwise white matter then seems decidedly blue. The same effect is also observable in some of the opalescent fluids and glasses which look somewhat blue by reflected, and decidedly orange by transmitted, light.

Blue is seen to least advantage in connexion with green and purple, but is more agreeable in the company of orange, yellow, or red. In relation to artificial light, blue is apt to look either purple or green; and we refer our readers to what we have said in par. 37 in regard to estimating yellow as being similarly applicable to blue. It will be well for the lithographic printer to sometimes inquire by what light his work is to be seen before he determines what pigment to use. What looks well by daylight may be unsuitable at the dinner-party or in the ball-room.

68. PRUSSIAN BLUE is produced when prussiate of potash is added to a persalt of iron. Its composition is somewhat complicated, and it is known under a variety of chemical names, the more recent of which differ from previous ones, according to the theory of chemistry in vogue at the period when the name was given. It is a most useful colour to the litho-printer, containing, as it does, ten times more colouring matter than ultramarine, and can be printed from shades approaching black to the palest azure. When employed very deep in colour, it has a violet, metallic lustre, and is then called *bronze-blue.* To get this peculiarity in perfection the varnish used must be of the thinnest that can be worked with, and it is better if the paper have a dead enamel surface. It forms fairly permanent tints with the lead whites, and, though somewhat inclined to be greenish, these tints are very agreeable and show their colour pretty well under artificial illumination. It forms a brilliant green with lemon chrome, though it is hardly to be relied upon, having a tendency to turn dark in impure air. With yellow lakes it forms transparent greens, which are often called green lakes. With crimson lake deep transparent purples are produced; while, with vermilion, greys of great utility may be compounded. Prussian blue

is sometimes a valuable addition to black ink, to which it imparts great richness and depth, and causes it to dry more rapidly. Were it not for an injurious, hardening effect upon the leather rollers, it would be more commonly used with black ink than it now is. A soft, velvety face to a roller is so important to the printer, that he is shy of introducing drying additions to ink where not imperatively necessary. On account of this powerful drying quality it is not advisable to order large quantities of Prussian blue ink, and when in the tins it is well to not only keep the lids on, but to cover it with water or oil, to more effectually protect it from the air. Considering what we have said (par. 35) about varnishes and oils drying by the absorption of oxygen, it may be thought that water, which contains eight-ninths of oxygen, would be a more powerful oxydiser than air. The fact, however, is the other way, for in water the oxygen is so united by chemical affinity to the hydrogen that it takes a very powerful force to separate them ; whereas the air parts with its oxygen easily, because it is merely mixed or diluted with nitrogen and still retains its gaseous form. Prussian blue is known from indigo by its bronzy fracture. It is very hard and requires much grinding. An insufficiently-ground Prussian blue soon makes itself known to the printer by staining the stone, damping-cloth, and hands, the work becoming messy and easily dragged with the cloth. This pigment is adulterated only to make it look prettier in the mass, though it may sometimes contain alumina, as in Antwerp blue, as part of the process of manufacture and not necessarily as an adulteration. If it contains chalk it will effervesce with acids, and if contaminated with starch it will become pasty by boiling with water. When dissolved in dilute hydrochloric acid and boiled, the addition of ammonia causes no precipitate from the filtered liquid. When adulterated with sulphate of lead or sulphate of baryta acids give no effervescence, but these substances are left behind when the blue is dissolved by an acid. Alkalies destroy its colour. This pigment is also known by the names, *Berlin blue*, *Parisian blue*, *prussiate of iron*, *ferro-prussiate of iron*, *cyanide of iron*, *ferro-cyanide of iron*, *ferro-sesqui-cyanide of iron*, *per-cyanide of iron.* In some chemical books the term "cyanuret" is used instead of "cyanide"; while in the most recent works it is called simply *ferric ferro-cyanide.*

Pigments of great tinctorial power, like Prussian blue, are apt to work too greasily, because no very great quantity is required to give considerable depth of colour. The varnish is then practically in excess, and requires an addition to the ink to work pleasantly. Strong varnish corrects this tendency to fatten, but it retards too much the free working of the ink. Common whiting will have a similar effect without the drawbacks attending strong varnish. Ground with the ink, it but little affects its transparency while it improves its working. The addition of the whiting also destroys any acid the colour may be contaminated with.

69. VARIETIES OF PRUSSIAN BLUE are somewhat numerous, as by suitable additions this colour can be made to appear of various hues in the dry state. Amongst those most frequently met with by printers is ANTWERP BLUE, *Haarlem blue*, or *mineral blue*, which is something of a blue lake, though not called such. It sometimes has a base of alumina, at other times magnesia and oxide of zinc are made to do similar duty. CHINESE and *Saxon* blues are of similar character. In the manufacture of *Paris blue*, *Turnbull's blue*, or *Chinese blue*, a nitrate of iron is used instead of the sulphate ordinarily employed, and the colour is more violet. Monthier's blue is a Prussian blue having ammonia used in its manufacture. The term Paris blue is not at all a reliable one, for the same name has been given to blues of totally different character. From what has been said, it is clear that a printer who is in possession of a good sample of Prussian blue has all he requires of this class of colour, because he can modify it to his requirements. Old, damp walls destroy the colour of Prussian blue in pictures hung against them.

70. ULTRAMARINE BLUE was originally prepared from a precious stone named *lapis lazuli* found in Persia and Siberia. It was reduced to small fragments, the colourless parts being rejected, then heated to redness, quenched in water, and finally ground to the necessary degree of fineness. It is the highest in price and the most esteemed of all modern pigments, being of the most beautiful colour,—neither inclined to purple nor green,—unchangeable under

nearly all circumstances, and altogether a desirable addition to the artist's palette. Its costliness places it altogether outside the work of the printer, who must be thankful that art has placed within his reach a substitute which not only fairly approaches it in colour, but is actually similar in chemical composition.

71. FACTITIOUS ULTRAMARINE, OR GUIMET'S BLUE.—The manufacture of this pigment seems to have been arrived at by following up the lesson derived from an analysis of the genuine colour. There are several ways of manufacturing this pigment, but the essential composition seems to be sulphide of sodium in conjunction with alumina. The ingredients, which vary with different manufacturers, are combined under the influence of a red heat during a period of many hours, then cooled, pulverised, and washed. It is at first green, but by adding sulphur and re-calcining it becomes blue. This pigment possesses in a fair degree most of the good qualities of its prototype, but for many years it withstood the efforts of the ink-maker to bring it into proper condition for the uses of the litho-printer. Its employment was for a long time restricted to dusting it upon a light blue printed in strong varnish; and many times has the atmosphere of the printing-room been rendered unbearable by the sulphuretted hydrogen formed during the preparation of the colour to prevent it soiling the paper. The genuine ultramarine is not affected by nitric acid, but the artificial product strongly effervesces when brought into contact with it. When thus treated it was found to become moist, its particles more adherent, and to less soil the paper when applied to it. Sometimes it was moistened with sugar and water for the same object. Means have, however, been found of late years to make an ultramarine that can easily be worked as a lithographic ink, and it has been found of immense service in chromo-printing. It is usually sold under the designation of

72. ORIENTAL BLUE.—This is a soft pigment that does not require any great amount of grinding, and is of a fairly-pure azure blue, more inclining to purple than to green. It is not only very agreeable in hue when used pure, but in mixtures holds a high place in compounding greys more especially of a purple cast. It may be taken as a general rule,

that more agreeable and more aërial greys can be made from this pigment than from Prussian blue. Oriental or cobalt blue with vermilion make a somewhat purple grey of so pure and delicate a tone that most printers would pronounce it to be made of crimson or scarlet lake and blue. A mixture of this kind possesses the great advantage of permanence in a very much higher degree than when made from cochineal or similar lakes. Indeed, these latter should never be used in printing if other more permanent colours can be made to serve the purpose. Both elements of this mixture of vermilion and oriental blue are colours that will stand most crucial tests, and as they both contain the same element—sulphur—as an essential ingredient, there is every probability of the mixture being as permanent as its elements. With Indian and Venetian reds similar tints may be made in conjunction with white-lead, which, indeed, may be at any time used with the ultramarine blues when it is required to have a body-colour of light hue as in backgrounds and pale tints. When, however, a decided purple is wanted, it will be necessary to use a lake of crimson hue, which will preferably be one of the madders. The ultramarines resist fire and alkalies, but are discoloured by hydrochloric acid, which does not injure cobalt. When mixed with gum, if a dirty red or brown colour be found upon its surface it indicates an excess of sulphide of sodium which tends to change the colour of the pigment.

73. Cobalt, or Thénard's Blue.—This blue, which is very pure in water-colour, has a little tendency to green when employed in oil and varnish. It is, however, but very slight in degree, and the peculiarity is perhaps less due to the pigment itself than to the varnish with which it is worked. Though it is not injured by the action of acids and alkalies nor by the long-continued action of light, its lustre is thought to be impaired by time and impure air. It is a transparent colour of great use in skies and aërial distances, for which it may sometimes be improved by the addition of other blues to alter its tone, though care should be taken that the cobalt should form the chief part of the compound. In spite of what we have said about its deterioration under some circumstances, it is quite an eligible pigment, because the alteration it undergoes is

never great, and it is pretty sure to be on an equality of permanence with some other colours that most likely cannot be done without.

Cobalt is prepared by adding arseniate or phosphate of cobalt to freshly-prepared alumina, drying and heating to a red heat. Other names of this pigment are:—*Saxon blue*, *Vienna blue*, *Paris blue*, *Dutch ultramarine*, *Dumont's blue*, *&c.* When cobalt is contaminated with Prussian blue, it may be detected by immersing it in lime-water, which in an hour becomes yellow and forms an ochreous precipitate.

74. CÆRULEUM is another preparation of cobalt of comparatively recent introduction, somewhat greenish in hue, but not inclined to violet when seen by artificial light. It is well suited as a transparent sky blue of light tint, and is in much repute among artists. It is an oxide of cobalt upon a base of silica, oxide of tin, and sulphate of lead. A mixture of ultramarine, Naples yellow, and white-lead is sometimes substituted for it. For the printer's use it is somewhat deficient in power.

75. SMALT and ROYAL BLUES are silicious preparations of cobalt, which are variously coarse and gritty or fairly fine in texture, according to the care with which they have been prepared. In common with some other vitreous colours, they are liable to change, and they further present few qualities to recommend them to the colour-printer. *Dumont's blue* properly belongs to this class.

76. INDIGO, *Indian blue*, is manufactured in the Indies from the indigo plant, or *anil*, from which comes the word aniline (par. 50), which was first discovered by Unverdorben in indigo, and afterwards by Runge among the coal-tar products. Indigo is prepared from several plants bearing the general name of *indigofera* (indigo-bearing), and is of great use in dyeing, in which it produces very fast colours. It is, doubtless, from this fact that indigo derives its general reputation for durability in water and oil, in both which vehicles it is, however, less reliable than Prussian blue. Its colour is deeper and lower than that of the latter. Its tints with flake-white are far from permanent, not even preserving their hue within the pages of a book. From what has been said, it will be correctly inferred that this pigment possesses no qualities which the printer cannot better obtain from

other sources. Some printers recommend it for tints with varnish; but, as a matter of fact, it can be banished from the workshop without regret, as Prussian blue, broken down with black and a little vermilion or other red added to remove the greenness, will answer for imitating its colour, while the permanence of the compound will be greater than the simple colour. This forms an exception to the generally correct rule, that simple colours are more durable than compound ones.

77. INDIGO CARMINE.—This improperly-named colour, which is also known as *intense blue*, is precipitated from a solution of indigo in fuming sulphuric acid by carbonate of potash. In colour it is equal and similar to Antwerp blue. This form of indigo is much the more durable, but its high price is a bar to its use in the printer's workshop.

78. COBALT ULTRAMARINE, or GAHN'S ULTRAMARINE, is an oxide of cobalt in conjunction with alumina. It is deeper in colour than ordinary cobalt, but in common with it possesses the defect of becoming violet by artificial light.

79. We have now disposed of the chief mineral blue colours, and among them are included nearly all that interest the chromo-printer. There remain other colours which the intelligent workman should not be ignorant of, though some of them which have been celebrated in their time are scarcely now obtainable. There are also others of new invention which, though not very desirable, are to be found in the market, and are sometimes by interested parties forced upon the attention of the printer. Among the more ancient pigments, blues which owed their colouring matter to copper held a high place, and it is of some of these we shall next speak.

80. COPPER BLUES.—*Mountain blue*, *azurite*, *Armenian stone*, is a basic carbonate of copper found in quartz rocks; *blue verditer*, *Bremen blue*, *Péligot blue*, a hydrated oxide of copper; *blue ash*, *cendres blue*, *Schweinfurt blue*, are arseniates of copper in conjunction with lime. All these colours, which are sky blue in hue, stand better in water-colour and crayon-painting than in oil, in which they have a tendency to turn green, and therefore they are unsuited to the printer employing an oil varnish. They stand the action of light, but impure air and time turn them green

and ultimately blacken them. This is, perhaps, accounted for by the fact that pigments of almost identical chemical composition are found among the greens.

81. BLUE LAKES may be manufactured in such a variety of ways that no reliance whatever is to be placed on the name. They may be of the most fugitive character, or may be fairly permanent. *Iris blue*, *litmus blue*, are vegetable extracts allied with earthy matter, and are the most fugitive of the class. Others, compounded of Prussian blue and alumina or similar base, are fairly reliable. Others, sometimes called *mineral blues*, are compounded of white earths, such as kaolin and indigo.

The blue dyes formed from the coal-tar product *aniline* have been used in forming blue lakes with much success, and under many names are to be found among printers' pigments. The aniline blues—*regina blue*, *bleu de Lyons*, &c.—have the reputation of being among the fastest of the coal-tar dyes; but it does not follow, as we have seen in the case of indigo, that they form permanent pigments. They can be formed of different hues, and can be made either pure in colour or bordering upon violet or green. Lithographers who find any advantage in using these colours should ascertain from the vendors what they are, and also note what influence time, light, &c., have upon them.

CHAPTER VII.—ORANGE PIGMENTS.

OF ORANGE.—This secondary colour, which is intermediate between yellow and red, may be compounded of any red and yellow pigments, but the purest orange will result from those colours which already are somewhat inclined to it in hue. When orange inclines much towards red it is called *scarlet*, and when it borders upon yellow it will most likely be called a golden yellow, it being difficult to draw the line where the particular hue begins or where it ends. Even among various samples of the fruit from which this colour takes its names there is a similar variety of hue, for while some are nearly red others approach the colour of the lemon. The natural idea attaching to orange is that of warmth, derived, no doubt, from the ordinary colour of fire, but also as being the complementary contrasting colour of blue with which we associate the idea of coolness. In painting it is advancing, thus again being the opposite of blue, though in this respect not so much so as yellow, because the latter is more allied to the brilliancy of white. With green, orange forms the tertiary *citrine*, and with purple, another tertiary colour, *russet*, while with a little black it forms *browns*. Orange may be formed in printing either direct from an orange pigment; from the mixture of red and yellow used on the roller; or from their mixture upon the paper. If a red, such as vermilion, be first printed and then yellow printed over it, the result will be orange: more orange, indeed, than when the yellow is covered by the vermilion. In the latter case, the vermilion is so opaque that the underlying yellow has but little influence. When the printings are few and the yellow, as is mostly the case, is printed first, a rose lake may be printed over it to obtain orange. Lighter tints may be obtained by printing lines, chalking, or stippling, in red on the solid yellow. Of course, the orange colour in this case will be more inclined to yellow than when the red is printed of full strength. If it be required to have a similar hue to that obtained by printing the colours solidly over each other but at the same time lighter, the yellow also must be treated in line, chalk, or stipple, so as to preserve a proper proportion. It will generally be found, however, that the yellow-stone, as seen rolled up in block, will print much lighter than an inexperienced person would expect, and allowance must therefore be made for an amount of paleness that would not be so apparent in any primary other than yellow.

It is difficult, as previously noted, to determine whether a colour is orange or red, or to distinguish between orange and yellow when it borders on those colours. So much is this the case, that some writers do not seem to recognise the distinctive character of orange, but class the pigments of this hue as either yellow, red, or brown. The appearance of the colour in the mass or in its fullest strength in painting seems sometimes to determine the question as to its hue. We do not think this a fair way to treat the subject, for, if it were so, Prussian blue could hardly be classed among the blues, or crimson lake among the reds. The best opinion is probably formed of the colour of a pigment by adding it to a white, such as chalk or white-lead, or thinning it down and spreading it on paper, or mixing it with oil or water on a white porcelain slab; the distinguishing character then given to the white pigment, to the paper, or other white surface, will show what the colour is. Viewed in this manner, burnt sienna ceases to be a brown and shows its orange hue quite distinctly.

83. Red-lead, Minium, Saturn Red, Sinoper or Synoper are names of lead oxides that are more scarlet in hue than vermilion, but less brilliant than the iodide of mercury. The name *minium* was formerly applied to artificially-prepared vermilion, and by many ancient writers the oxide of lead has been mistaken for cinnabar* (52). In consequence of its being a rapid dryer it may be used in that capacity in low-toned browns which require such an addition. Its chief value is as a flesh-tint in conjunction with varnish alone, as it cannot be used in combination with flake-white, with which or other lead colours its tints are very fugitive. The drying qualities of this pigment may also be employed in preparing glazed rollers. Too much pigment should not be used, as the object should be to make the leather inpervious without overloading. When this colour is required, as an ink, to be printed of considerable strength it will be found to be totally unworkable in ordinary varnish, the oxidising effect upon which is so strong that it sets upon the slab instead of distributing upon the roller. The only remedy for this is to employ an animal fat, such as lard, instead of varnish. If wanted of full strength, grind the pigment in the animal fat and use it without varnish. If a more "tinty" colour is required, a little varnish may be added to it.

Another variety of this pigment is known by the name of

* *Sinoper* or *synoper* is probably a corruption of the word cinnabar (see Par. 52). Sinoper is also the name of a *red* ferruginous quartz. It is possible that by ill-informed people both substances may have been confounded with cinnabar, the German name of which, zinnober, comes somewhat nearer to sinoper than does cinnabar.

orange-lead and *mineral orange.* It is more in request among lithographers than red-lead, but its character in no way differs from it beyond its being more orange in hue.

84. ORANGE CHROME.—This beautiful pigment seems to be a variety of the yellow chromate of lead or plumbic chromate, in the manufacture of which a quantity of di-plumbic chromate is thrown down during precipitation and gives the otherwise bright yellow an orange hue. It is therefore a mixture of the yellow and red chromates of lead, and in general qualities what has been said of chrome yellows (38) applies equally to this and the next colour.

85. CHROME RED, PERSIAN RED, should, perhaps, have taken a proper place among red pigments, but in chemical constitution it is so like the orange chrome that it has been thought best to treat it in more immediate connexion with that pigment. When the yellow neutral chromate of lead or plumbic chromate is boiled with a suitable alkali it parts with some of its chromic acid and becomes of a red hue. When well prepared, chrome red is even more brilliant than vermilion, but less durable, though in this respect it is superior to the chrome yellows and orange-lead. It is sometimes called di-chromate of lead, though improperly so, for it is more correctly a sub-chromate of that metal. Di-plumbic chromate is its most recent name and more correctly indicates its chemical composition.

This pigment is occasionally but incorrectly called *Mars scarlet*, a name which properly signifies an *iron* red, Mars having been the name given to iron by the old alchymists. It is also called by the French *laque mineral*, a name also given to an orange oxide of iron, and to

86. CHROMATE OF MERCURY.—This is often called a red, though it is more properly an orange. It is an ochreous red when in powder, but when ground in oil it is a bright orange, which forms fine tints with white. It is, however, a colour of no importance to the printer, for besides its being changeable in light and in impure air, it cannot be a cheap colour, being derived from an expensive metal,—mercury.

87. ORANGE ORPIMENT or REALGAR is a bright orange bi-sulphide of arsenic not durable in colour, and cannot be

employed with other colours having lead or mercury for their bases. Two varieties of this pigment are known, one of which is a natural product, the other an artificial one. The natural realgar is the more red, and was called by the ancients sandarac. As a pigment it is like in character to yellow orpiment, which the older painters burned to give it the orange hue.

88. MARS ORANGE is an oxide of iron, artificially prepared, of the nature of the ochres, but more transparent. Even greater care must be taken with it than with the true ochres in compounding tints with colours affected by iron, because it is purer and more chemically active.

89. ORANGE OCHRE is a very bright yellow ochre which has been submitted to calcination, and which in its general character and properties resembles the light and Venetian reds. What is said of them applies equally to this. *Spanish ochre* is another name for it.

90. BURNT SIENNA is a yellow sienna made orange by burning. It is not a pure colour, but borders on russet. The action of fire makes it more transparent and better drying. It is a very durable and useful colour to the printer, though if used too freely as an element in chromos it is apt to look "foxy."

91. VERMILION OF ANTIMONY, ANTIMONY ORANGE.—This substitute for cinnabar is a fair approach to it in colour and other qualities, when ground in oil or varnish. As a water-colour it does not maintain its lustre. It is said by some authorities to be unalterable by light, and makes good tints with flake-white. It is oxidised by nitric acid, the powerful caustic alkalies of soda and potash destroy it, while their carbonates and ammonia affect it but little. It is a bad dryer and injurious to many colours. Chemically, it is a sulphide of antimony.

92. CHINESE ORANGE.—This is comparatively a new colour prepared from an organic substance on a zinc base. Purpurate of ammonia or murexide is a crystalline dye-stuff of a golden-green colour by reflected light, though red by transmitted light. It is prepared from the uric acid found in the excrements of serpents, from which it can be obtained in great purity. Peruvian guano, however, is a source from which it can be got in greater abundance

and is therefore more in use. With acetate of zinc it gives an orange yellow, which, we believe, is the colour called *Chinese orange*.

CHAPTER VIII.—PURPLE PIGMENTS.

PURPLE is another of the secondary colours, which comes between *red* and *blue*, and may be composed of them. The only reds which make good purples are those which already incline somewhat to it, such as carmine and the madder and other rose lakes. Reds of a scarlet hue do not assist in forming good purples. Blues of a green hue should not be used in compounding purple, though, with a suitable red, Chinese blue or Prussian blue may be used with good effect, especially if a very transparent colour be required. Oriental blue may also be used. No compound, however, can be formed which can replace a pigment like the aniline colour, *mauve*. Purple is more allied to darkness than are the other two secondary colours, orange and green. It is warm or cool according as it approaches red or blue, and constitutes the natural contrast of the primary yellow and the tertiary citrine. It is not a great element in landscape, except occasionally in the distances and sometimes in the clouds of evening skies, to which it imparts a most gorgeous effect. Among the ancients it was highly thought of and associated with the supreme ruling power, whether of emperor or king. The celebrated Tyrian purple was, perhaps, as highly esteemed on account of its extreme costliness as for its inherent beauty, for in the time of Augustus a pound of wool dyed with this colour was valued at thirty pounds sterling. This Tyrian dye forms a good example of how the material world, organic or inorganic,—animal, vegetable, and mineral,—has been ransacked in search of beautiful colours. According to Pliny, it was found in a small sac in the throats of two molluscs, named *buccinum* and *purpura*. Each animal yielded only a single drop, though the whole of the buccinum might be employed when an inferior dye only was required. At first, this drop of fluid is colourless, but in about fortyeight hours' exposure to the air it becomes purple, passing through the intermediate stages of yellow, green, blue, and red,—no apparent recommendation to its permanency one would think; yet it was a very fast colour, and it is on record that a piece of cloth dyed with this substance was known to retain its colour for about 200 years—how much longer is not known. The full beauty of purple cannot be seen under the ordinary atmospheric conditions, more especially in a place like London, where the ruling character of the light is generally yellow. It is the same in artificial light (except the electric), whose yellow colour does not afford the necessary conditions for showing it, being in direct opposition to purple. For a similar reason, our varnishes and our fashionable toned papers all help to deteriorate and tone down purple pigments. When purple approaches red in hue it is called *crimson*, on the other side, when it becomes more blue, it is denominated *violet*, *lilac*, &c. The idea of purple, therefore, is not distinctly associated with any particular hue, but includes all variations which can neither be called red nor blue, but yet can be formed with them.

Purples may be produced in printing either by selecting a pigment which is itself purple, or mixing suitable red and blue, or by first printing one colour and then printing the other over it, in a manner similar to that explained for producing orange. (See par. 87.)

94. MAGENTA LAKE.—This is one of the coal-tar series of colours prepared from aniline oil by acting upon it with oxidising agents, the result being the organic base rosaniline. This in conjunction with acetic acid forms an acetate of rosaniline, perhaps the best of the colours denominated magenta. This colour, when prepared for printing, forms a splendid purple red, has considerable power, is in many cases a very useful pigment, but like most colours of its class is deficient in permanency. It is not always alike in hue, as each manufacturer has his own method of working, which not unfrequently leads to a variation of colour. It is for this reason that we have placed magenta among the purples, for, though it sometimes assumes a more rosy hue, it most generally is more allied to purple. This pigment does not dry well alone.

95. MAUVE LAKE, ANILINE PURPLE.—In paragraph 50 we have given some idea of the formation of aniline from which the first coal-tar colour, mauve, was prepared. We proceed a step further. Sulphuric acid and aniline are boiled together with water in the proportions necessary for forming sulphate of aniline. In another vessel bi-chromate of potash is dissolved. The two solutions are added to each other, when, after standing a couple of days, the crude mauve is deposited as a dense, black powder. This requires purification. Like most other coal-tar colours, mauve lake is a most beautiful pigment and is much in demand as a printing-ink. It can be had in various qualities, the best of which is probably that which proves cheapest. Unless freshly ground it is apt to be livery, in which state it does not print well, more especially on the machine, and deteriorates the work upon the stone by destroying the fine lines and otherwise generally giving to the drawing a raw appearance. This may sometimes be remedied by adding a more greasy quality to the ink by grinding with it a small quantity of soap. When, however, this defect occurs it is usually owing to the employment of an ink which will not permit of much lowering with varnish, that already in the ink having been deteriorated by contact with the mauve colour. If an ink of a higher quality—that is, one containing more colouring-matter—be employed instead, the printing will most probably go on pleasantly, because such ink will carry more varnish, and is therefore brought more into the condition of a new ink. Mauve ink is unfortunately as fugitive as it is beautiful, but it is nevertheless a valuable colour to the printer where, as in most instances perhaps, the work is only required to last a short time. Like magenta, mauve is not always to be had of one uniform hue, and the printer will sometimes find it necessary to modify it with blue or red to get the exact colour he requires.

96. VIOLET LAKE is another colour derived from aniline, and in general character bears a close relation to mauve. Hofmann's violet and Britannia violets are names of aniline dyes which doubtless can be utilised in making lakes suitable for the colour-printer.

The purple colours just treated of have almost universally replaced the older pigments, but, as it is intended to make this treatise a fairly comprehensive one, the latter must not be omitted.

97. PURPLE LAKE OF COCHINEAL is a rich, deep colour inclined to crimson. It is similar in working qualities and want of permanency to other cochineal lakes. *Purple lac lake* resembles it in colour, though it is less brilliant. It is more durable.

98. CARMINE VIOLET, BURNT CARMINE, is, as its name indicates, prepared from cochineal carmine by partially charring it. It is an expensive colour of little brilliancy, but of great richness and depth. It is not likely, therefore, to be employed by the lithographer. A similar colour of greater permanency may be obtained from *madder carmine* by heating it over a spirit-lamp and stirring it until the required hue is arrived at.

99. PURPLE MADDER OR PURPURINE is a very rich, deep, transparent carmine prepared from madder (or perhaps, at the present day, from alizarine). It is not brilliant, but possesses permanency, and may, therefore, be safely used for delicate tints in works of value.

100. PURPLE OCHRE OR MINERAL PURPLE is an ochre found in the Forest of Dean. It is of the nature of Indian red, having a similar body and opacity, but cooler in colour, forming permanent tints with white. *Violet de Mars* is a similar colour artificially prepared from iron.

101. PURPLE OF CASSIUS OR GOLD PURPLE is prepared by precipitation from mixed solutions of chloride of tin and chloride of gold. It is of deep, rich colour, not bright, and forms the purple used in enamel and porcelain painting. Unless in this latter connexion, it is not likely to be employed by the printer.

102. The first two pigments on this list are the only ones that recommend themselves to the chromatic printer, and they simply because they cannot be imitated by mixture. In pictorial work, the purples are usually compounded from reds and blues on the paper. In this manner greater brilliancy is attained than by mixing them to form an ink, and the expense of a separate purple-printing is saved. By artfully employing sometimes blue and sometimes red for high lights, much variety, richness, and brilliancy are

arrived at, and more satisfactory effects are obtained than would result from employing a more brilliant ink as a separate printing.

CHAPTER IX.—GREEN PIGMENTS.

OF GREEN.—This secondary colour is intermediate between *blue* and *yellow*, and may be formed of them by mixture, as already shown when treating of these colours separately. Considering its relative brightness, green can perhaps be better borne by the eye in large masses than other colours, as may be seen in the trees and green fields of the landscape, though even there it is only at certain times and seasons that the colour attains any marked degree of brilliancy. Generally speaking, the trees are much darker in hue than the grass, while their height shuts the fields out from view in the distant prospect. The intervening atmosphere also helps to tone the green into grey and purple, and so renders it more harmonious with the blue sky. *Green* forms with *orange* the tertiary colour *citrine*, and with *purple* the tertiary *olive*.

It is most effectively contrasted by *red*. In printing green regard should be had to the light by which it is to be seen. If it is to be seen by the ordinary artificial lights, it will bear more of the yellow element than would be proper for daylight or the electric light. For a similar reason due care must be taken when it is being mixed or printed by gaslight for daylight use, in which case the magnesium light may be employed, as stated in our previous remarks on yellow pigments. In pictorial work green, as a separate printing, is often omitted, and frequently with advantage to the effect, its place being supplied by different proportions of the blues and yellows that cannot be done without. Unless very carefully used and duly modified by the yellows, blues, and greys, a green printing in landscape is apt to seem too pervading, whereas the green effects produced by combinations, in differing strengths, of blue, yellow, and grey, and these modified by judicious touches of red, possess greater variety and harmony. The chief greens in use are prepared from salts of copper, and of those we shall first treat.

104. Emerald Green.—This most brilliant colour, which cannot be successfully imitated by any mixture or replaced by any substitute, is a compound of copper and arsenic.

Unfortunately, it is a bad working colour in any medium, and cannot be employed by the printer in an ink. Resort is therefore had to printing in a strong varnish, and applying the pigment as a dry powder so as to adhere to the already-printed varnish, just in the same manner as bronze is used. It is so deadly a poison, however, that it is almost cruelty to employ any one on this kind of work, and printers now steadily refuse to take orders if this colour be insisted upon. Some twenty and more years ago it was no uncommon thing to employ it on show-cards and labels, in conjunction with ultramarine applied in a similar manner, a light blue ink made from Chinese blue being used to hold both the colours on the same sheet. Now that bronzing-machines are employed for putting on bronze-powders without poisoning the atmosphere of the workshop, it is not unlikely that a revival of the use of this colour may take place, as it is reasonable to suppose that a similar apparatus would answer the purpose for putting on this poisonous green.

105. Scheele's Green.—*Schweinfurt*, *Vienna*, *Mitis*, *Kirchberger*, *Paul Veronese*, *Neuwied*, and *Paris Greens* are other combinations of copper and arsenic. They are generally opaque and permanent pigments, which may be used without change in combination with flake-white. These colours are less affected by damp and impure air than most other copper greens.

106. Stannate of Copper is said to form a fine green, not inferior in colour to the arsenical green. Theoretically, this should form the same green as is found on old bronze castings, the stannate of copper being simply a combination of copper, tin, and oxygen, while bronze (not to be confounded with the printers' bronze-powders) is an alloy of copper and tin.

107. Brunswick Greens are prepared in different ways by different manufacturers, sometimes from poor copper ores treated with hydrochloric acid and then exposed to the

air. In another way it is produced by acting on waste copper filings and clippings with sal-ammoniac. Yet another way of proceeding is to add solution carbonate of ammonia to a mixed solution of alum and blue vitriol (sulphate of copper). The Brunswick greens most frequently met with are mixtures of Chinese or Prussian blue and chromate of lead or zinc, with a basis of barytas or carbonate of lime. The various lighter shades of colour are produced by additions of alum or sulphate of baryta. From the various modes in which these copper greens may be fabricated, it is clear that they may be sold under many names which afford no clue whatever to their true character, and different modes of manufacture may result in the same chemical compound. They are all fairly permanent, so far as the action of light is concerned, but they have a tendency to become darkened by the action of moisture and impure air. They have good body and dry well.

108. MALACHITE, MOUNTAIN, and HUNGARY GREENS are native hydrated carbonates of copper found in various parts of the world. They are similar in character to other copper greens.

109. GREEN VERDITER, BREMEN GREEN, is the same chemically as blue verditer, which latter is changed to green by boiling. It is a hydrated oxide of copper.

110. GREEN LAKES have been made from yellow lakes (vegetable) and Prussian blue, and from indigo with mineral yellows. MINERAL GREEN LAKES, however, are the most durable of copper greens, and are made from oxides of copper and zinc precipitated from solutions of those metals by carbonate of potash. These greens may be had of various shades, from light and warm to dark and cool, under the name of *drop greens*.

111. VERDIGRIS is an acetate of copper which stands the action of light when ground in varnish, but is deteriorated by the opposite influences of damp and foul air. It is not at all a safe pigment, but being a powerful dryer it might be useful in that character when mixed with other greens. BRIGHTON GREEN is verdigris in conjunction with sulphate of lime and whiting.

We pass from the copper greens and their compounds to

112. CHROME GREEN, GREEN OXIDE OF CHROMIUM,

and NATIVE GREEN.—These are names of chromic oxide or sesquioxide of chromium. It is the most durable of green pigments, neither affecting, nor affected by, other colours, and insoluble in acids. The emerald owes its colour to this substance, which also forms a valuable pigment in enamel painting.

113. TERRE VERTE, VERONA GREEN, VERONA EARTH, names of clays coloured with oxide of iron, are dull greens much used by landscape-painters. They are very permanent, mix with other colours without injury, have not much power, and dry well. The green earths which are coloured by copper are brighter but not true terre vertes. They are found in Somersetshire, Cyprus, France, and at Verona, in Italy. It has also been called *green bice*, *verdetto*, and *holy green*.

114. GREEN ULTRAMARINE.—In the manufacture of ultramarine blue there is a stage at which it is green, and in this state it may be employed as a pigment, but it has little to recommend it. It is easily decomposed by very weak acids.

115. COBALT GREEN is often formed of cobalt blue and chrome yellow, and partakes of the qualities of those pigments. It can be made by mixture as required. There is also a more durable cobalt green, called *Rinmann's green* and *zinc green*, which is prepared directly from cobalt and oxide of zinc. It is pure in colour, but not powerful. It dries well. Another cobalt green, sometimes called *Prussian green*, is prepared by pouring a solution of ferro-cyanide of potassium into a solution of a salt of cobalt. It is very rich in colour, but easily turned to a purple grey.

116. CHROME YELLOW GREENS. — Greens containing chrome yellow are known under a variety of names. We have shown (par. 97) that there is an oxide of chromium which properly bears the name of *chrome green*, but the same name is also given to compounds of chrome yellow and Prussian. These colours can be formed in very great variety, are very good working pigments, and would be nearly all the printer could need if their permanency were equal to their other merits. For ordinary work where great durability is not essential they answer well. These mixtures are sometimes called *green lakes*, but they are probably inferior to the genuine green lakes made from copper. In conjunction with alumina they have been called

green cinnabar, *milory green*, *leaf green*, *silk green*, &c., but they have the reputation of instability.

We have mentioned these greens, as we have treated of other pigments, not to indicate their importance, but to show that such mixtures are commonly on sale in the shops, and to point out their character. The intelligent printer will see at once that he has no need whatever to purchase them, because he must have Prussian blue and the chrome yellows among his ordinary stock of pigments, and can, therefore, manufacture them as necessity arises. The same remarks will apply to many other similar compounds.

117. PRUSSIAN GREEN.—Besides the cobalt greens of this name mentioned in par. 115, there are others so called into which Prussian blue enters as a constituent. It is evident that their number may be great. *Barth's green*, which is Prussian blue and the tincture of French berries, is so called, as is also the water-colour pigment composed of Prussian blue and gamboge. Here, again, it is only necessary to take the Prussian blue and yellow lake to form it at once when a transparent colour of this kind is required. GREEN OCHRE, which is prepared from yellow ochre, prussiate of potash, and persulphate of iron, may be similarly prepared from Prussian blue and yellow ochre when required. This latter is not a bright green, but can be recommended on the score of durability when its colour is suitable to the subject to be printed.

118. SAP GREEN, IRIS GREEN, BLADDER GREEN, VENETIAN GREEN, are names of pigments prepared from vegetable juices. They are indifferent colours and suited to water-colour painting only.

119. MANGANESE GREEN, a pigment prepared from nitate of baryta and oxide of manganese, is only fit for the paper-stainer.

120. The most permanent greens may be compounded of the more durable yellows in conjunction with cobalt and ultramarine. They are not very brilliant, and do not form agreeable hues when seen by gas and candlelight, but they have a wide field of usefulness, and for pervading hues in landscape will be found to answer well. Nothing looks so inartistic as a general tone of bright green for trees, &c., while a dull green is in every way more agreeable and true

to nature, and will keep the various parts of the subject well together. Bits of brighter colour may be added by a judicious use of the combinations formed by the blues and yellows which are necessary for other parts of the picture.

CHAPTER X.—Brown Pigments.

We have pointed out in paragraph 13 that brown is most properly a broken orange hue; but, popularly, the term includes all the low tones of russet and citrine. Browns thus incline to yellow on the one hand and to red on the other, but never to blue. In common parlance, both citrine and russet are denominated brown; though it is not a very precise expression when so used. When it is necessary to be more explicit some other word is employed to qualify the term, and hence we speak of *red*-brown, *yellow*-brown, *purple*-brown, &c.

As an element of shade, brown harmonises with most other colours; but it does not go well with blue, as a rule, since it produces too great a tendency to blackness and heaviness. When black is added to yellow, to orange, or to citrine, it is usual and fairly proper to denominate the resulting compound a brown. It is common also, but hardly proper, to call the addition of black to red a brown. It is pardonable, however, to so term it when the red element is itself strongly orange in tendency.

Marone is often called a brown, though it is more properly a deep red which is more inclined to crimson than orange; addition of red (crimson) to brown will therefore produce this colour. Reference to our table of broken colours in paragraph 14 exhibits brown as being built up of RR+YY+B. The addition of red, therefore, to this formula to produce marone exhibits the combination RRR+YY+B, which is just equivalent to breaking down the purity of red by the introduction of a yellow-green.

From the formula RR+YY+B, it follows that the contrasting colour for brown is blue, but it must not therefore be assumed that brown and blue will form a good combination of colour. Much will depend upon the comparative strengths of the colours used, and due care must be taken in determining whether the brown inclines more to red or to yellow.

Hues of brown are very commonly met with in nature, more especially in the autumnal landscape. Its mental effect varies with its different hues; there is a sedateness and gravity about it that recommends it to persons of sober taste. In decoration, its effect is best seen, perhaps, in the lower parts of the composition, where it conveys ideas of substantiality and solidity. It may be relieved with lighter bands of its own colour and also of red, orange, or yellow. It occasionally looks well in conjunction with blue grey or with green when inclined to red.

Brown pigments are numerous, and an endless variety may be produced by mixture, and they are of great utility. The following are the principal:—

122. MADDER BROWN or FIELD'S RUSSET is a colour intermediate, as all russets are, between orange and purple. As its name shows, it is made from madder root, and is the finest and most reliable pigment of its hue that can be found. It has all the good qualities that distinguish the colours of madder, and forms fine transparent greys with ultramarine and cobalt suitable in flesh, clouds, &c. It is not often that it is necessary to use this pigment alone in printing, because economy in the number of workings compels a reliance on the overprinting of the primaries to produce colours similar to, if not like, it. In good work, however, greys are essential, and here madder brown may be used when transparency in them is a necessity. It will be found far preferable than employing brilliant lakes of more than doubtful permanence and then making them dirty to destroy the too purple effect they naturally produce with blue. There are three qualities of this pigment made, though they do not differ much from each other. The darkest, called *intense madder brown*, is the best dryer of the three. This colour may be used as a flesh-tint where mere prettiness is not wanted.

123. PRUSSIATE OF COPPER is another russet colour, but is not likely to be met with as an article of sale. It is made in a similar manner to Prussian blue, a salt of copper

being substituted for one of iron. It is transparent and deep in colour, but otherwise of little value, being liable to change both by light and mixture with other pigments.

124. OLIVE colours can be formed by the mixture of green and purple, or by the mixture of blue and orange, letting the former predominate. Olive may be made by adding a small quantity of yellow or brown ochre to black. *Olive green* may be made by adding black to yellows brighter than ochre. Many of the copper greens may be changed into olive greens by burning them, by which they are rendered more durable and made to dry better than the pigments from which they are made. Fire in this way seems to act upon them in a similar manner to the long-continued action of the atmosphere.

125. RAW UMBER is a pigment which belongs to the class of *citrine*, the tertiary colour produced when orange and green are mixed. It is a natural ochre containing oxide of manganese, which gives it a somewhat powerful drying quality. This may be taken advantage of when a dryer is required for any pigment such as may not be injured by it in colour. Several other pigments of citrine hue are commonly called browns.

126. BROWN PINK is a citrine of variable hue, sometimes approaching green and sometimes orange. It is a pigment of considerable beauty, depth, and transparency; but, besides its being a bad dryer, it is very fugitive, and on the whole is very little required, and can always be done without.

127. BURNT UMBER is, as its name imports, raw umber subjected to the action of fire, by which it is deepened and made more warm in colour, just as yellow ochre is converted into red by the same means. Where its hue serves the purpose required, it forms one of the most eligible pigments of the class denominated browns. It is perfectly durable, and may be used with any other colour. When its own hue is not that which is required, this pigment may still usefully form a foundation upon which other shades of brown may be built. By vermilion it may be reddened and made more opaque; by lakes it may be made richer, deeper, and more transparent; by yellow and burnt sienna it may be made more citrine; and by purple and blue more

olive. It is a powerful dryer, and makes a very useful ink for bronze and metal work, its colour harmonising so well with that of the bronzes that their imperfect application is less apparent than when colours such as chrome yellow are used.

128. VANDYKE BROWN is a fine brown, more transparent and richer than umber, being somewhat bituminous. It is not near so good a dryer as umber, though it is variable in this respect. The best samples are finely ground and washed to free them from their natural impurities. The durability of Vandyke brown is unimpeachable.

Campania brown was celebrated among the old Italian painters, and much resembled the above.

129. CASSEL EARTH, or TERRE DE CASSELL, is a native ochre resembling burnt umber, but more inclined to russet in colour.

Cologne, or as it is sometimes spelt, *Cullen Earth*, is darker than Cassel earth, and much resembles Vandyke brown both in colour and working qualities.

Rubens brown is another similar earth of ochrous texture, and more light in colour than the preceding. It dries well.

130. MANGANESE BROWN is a sesquioxide of manganese, a deep, semi-opaque colour of good body, which dries well and is quite durable.

Cappagh brown is a native manganese bog-earth found at Cappagh, near Cork. It varies in depth, and has a tendency to run during drying. It has been variously named *Euchrome*, *Mineral brown*, *Caledonian* and *Hibernian brown.*

131. ASPHALTUM is used among painters as a pigment, but, in common with some of the last-named colours, will not be found to recommend itself to printers. Among lithographers, asphaltum is sometimes used as an addition to ink when it is required to resist acids. It is also employed as a powder for dusting on the work upon stone when it is intended to be bitten up, just as the powdered rosin may be used. The best asphaltum is called *Bitumen of Judea*, *Jews' Pitch*, *Mineral Pitch*, &c., and is imported from various places abroad. There are also large quantities of it, of an inferior quality, produced in the distillation of tar, for procuring the many substances now made

from that once waste product of gas-making. As an oil-colour used in painting it has little to recommend it beyond its rich transparency, for it is certain to crack, in consequence of the contraction caused by the action of light and time.

Mummy and *Antwerp brown* have asphaltum for their foundation, and are similar in qualities to it.

132. BISTRE is a pigment prepared from the soot proceeding from burning wood. It is of colour approaching citrine, and chiefly used in water-colour painting. It is also produced in the soot from burning peat. Bistre is very attractive of moisture.

133. SEPIA, or SEPPIA, is another water-colour pigment of great power, and in high repute for its good qualities when used in that vehicle. It is not suited for an oil-colour, and therefore not fit for printing-ink.

134. PRUSSIAN BROWN is produced when Prussian blue has been exposed to the action of fire or strong alkali. It is an orange brown, similar to Sienna, and dries well.

CHAPTER XI.—BLACK PIGMENTS.

WHEN blue, red, and yellow are mixed together in neutralising proportions, that is to say, when compounded in such a manner that neither colour can be seen to predominate, the resulting mixture is a grey very nearly allied to black. The compound will most assimilate to black when the primary colours are pigments of great transparency. In this manner, indeed, a pigment of such intensity can be produced that it may be used to shade lampblack itself. Some blacks are impure enough, through imperfect distillation and other causes, to have a decided brown hue, as is seen in China ink. The natural character of black, however, is to be more allied to blue than brown, and this is so recognised by ink-makers that an intense blue, such as Prussian blue, is an almost necessary addition to all black inks.

Independently of this addition, however, the best blacks are so much more akin to blue than to brown that they will communicate a *blue* tint to white, a *green* to yellow, and a *purple* to red. This property may often be utilised in the mixing of low-toned compounds, and printers should keep this carefully in mind, because not only will such mixtures possess permanency, but the powerful influence of black makes it the cheapest addition that can be employed for the purpose of lowering the tone of any colour or compound for which it may be otherwise suitable. We address now the printer who may be supposed to be matching a colour,—not the artist.

The latter will, on the contrary, be careful not to employ too much black, on account of the tendency its greater power gives of lowering the pigments to a point that is disagreeable. The printer, however, is only called upon to make a match of colour for the due representation of the tone in a picture, and is not therefore compelled to employ the same pigments as the artist, who, most probably, has not troubled himself to produce the simplest compound. He has, very likely, taken his colour from those parts of his palette that were most convenient, without troubling which were the most suitable pigments for printing.

In a like manner to the use of the three primary colours, the three secondary, or the three tertiary colours may be employed to produce a black. In this manner they may be utilised in superposition, and by employing the most transparent pigment as the last printing, greater depth and intensity can be produced in chromo-lithography than would result from the employment of black ink. This principle is usually taken advantage of in this connexion with the best results, for it is not often that there is a separate black printing employed in artistic chromo work.

Blacks take the foremost place among our pigments for permanency, because they are for the most part carbons. Now, carbon is an elementary substance the least easily affected by acids and alkalies of all the chemical elements and compounds. Most varieties of carbon are easily changed by burning, but some of them are so incombustible as to require the employment of a powerful electric current, such as is seen employed in the electric light.

All vegetable and animal substances have a basis of carbon, which is the one solid element of which they are mainly composed, the rest being the gases—oxygen, hydrogen, and nitrogen. When any animal or vegetable substance is submitted to the action of great heat in partially-closed vessels, such as the retorts used in gas-making, the gaseous matters are volatilised and carbon remains. Were the air freely admitted during this operation, its oxygen would be taken up by the carbon, and the gaseous substance, called by chemists carbon di-oxide, or carbonic acid gas, would be produced, and nothing would be left but the ashes formed by the earthy matters which co-exist with the inflammable ones. When oily substances are set fire to and burnt without a full supply of air, or when the substance is so inflammable as to volatilise its gases before the air has had time to act upon all the constituents, a substance is formed which is recognised as carbon. It is by the employment of one or other of these processes that the various black pigments of commerce mostly in use are manufactured, such as ivory black, bone black, lampblack, &c. There are also blacks of mineral origin. The number of vegetable and animal substances that could be employed to produce black pigments is very great, but the attention of the printer must be directed to very few. Were it not that it has been thought advisable to mention most of the pigments in the market, whether useful to the printer or not, black might almost be passed over, so thoroughly is it now the practice to leave the manufacture of black inks to the professional ink-maker. The principal ones must, however, be mentioned, and can conveniently be divided into three divisions :—1st, those made as soot; 2nd, those produced by charring; and 3rd, those mineral matters which are naturally black.

136. LAMPBLACK, ESSENCE BLACK, SPIRIT BLACK, &c.—These are names, in common with others, of the blacks formed by the imperfect combustion of animal and vegetable substances, such as fats, oils, hydro-carbons (such as turpentine, benzole, &c.), resinous substances, coal-tar, &c. In all cases the substance is set on fire and the soot is collected by suitable means, which vary according to the mode of manufacture adopted, the principle of which may

be illustrated by holding a plate of metal over any burning oil-lamp or candle having an unprotected flame, when a deposit of soot will be formed.

In the early days of lithography, when ink-making had to be carried on by the printer himself, a favourite way of producing a fine black was by the combustion of turpentine in a common lamp covered by a large cylinder of paper upon which the soot was deposited. This was called *essence black*, and was found to produce a fine quality of black ink when properly ground with linseed oil varnish, and was highly recommended by Racourt, and also by Hullmandel.

In consequence of the numerous possible sources from which lampblack may be manufactured, it is no wonder that under various names there are so many blacks in the market. Most of these blacks are of a greasy nature, on account of the partial condensation of some portion of volatilised and unburnt oily matter. To remove this, the black is put into closed vessels and then heated until this oily matter is burnt away. The black is then called *calcined* or *burnt* lampblack, and is found to be suitable for mixing with water and gums, as well as oils, to form pigments. They are soft and comparatively easily ground, but are harder to grind when calcined.

Gas black is formed in a similar manner and is free from greasy matter.

137. RUSSIAN LAMPBLACK is prepared by burning chips, &c., of resinous woods, and collecting the smoke. It is very apt to take fire spontaneously when mixed with oil and allowed to lie. Poster-bills lying in a heap when newly printed have been known to take fire. Care should therefore be taken over waste sheets, which resemble posters in containing much black ink.

One of the chief merits of black formed as soot is the minute state of subdivision in which it exists, and which much facilitates its incorporation with varnish to form ink, though it requires much grinding to bring it into intimate contact with the varnish.

138. IVORY BLACK, BONE BLACK, HARTSHORN BLACK are the charred animal substances which their names indicate. There is not much to choose among these blacks, as their

quality depends greatly upon the care taken in their preparation. They are prepared by subjecting them to a red heat in closed vessels, care being taken that they are not really burnt. When the vessel is opened, there are usually found parts that are less burnt than others. If too little burnt, the colour is brown, greasy, and a bad drier; if burnt too much, it is cindery, and too grey and opaque. The finest qualities have a high reputation, and are sometimes sold as calcined lampblack.

139. PARIS BLACK, according to some authority, is a fine quality of bone black, formed from bone-dust and burnt with great care. That obtained from most English houses is, however, not obtained from this source.

140. ANIMAL BLACK is formed in a similar manner from almost any kind of refuse animal matters. It is usually in a more finely-divided state than bone or ivory blacks.

141. FRANKFORT BLACK was originally manufactured from the refuse matter of the vineyard, consisting, for the most part, of dried vine twigs and branches and wine lees. These were charred or carbonised in a similar manner as the ivory and other animal blacks. When made on a large scale, other matters, as peach-stones and animal refuse, bone, ivory, and horn-shavings, are also employed. The varying proportions of vegetable and animal matter influence the colour. The more animal matter there is used the greater will be the tendency to brown, the colour produced by vegetable materials inclining more to blue.

142. BLUE BLACK is well-burnt charcoal, often made from beech-wood, and is sometimes known as *beech black* and *vegetable black*.

143. SPANISH BLACK, CORK BLACK, is prepared by charring cork refuse. It is a soft black, and has much of the character of Frankfort black.

144. BLACK-LEAD, PLUMBAGO, or GRAPHITE, is no preparation of lead, but in reality a variety of carbon, and, therefore, allied to the substances before treated of. It is not likely to be employed as a black pigment, except in water-colour painting, but it may be used in the formation of greys with white, and in that capacity possesses the advantage of keeping its place better than other blacks, which have the

fault of rising to the surface in mixtures. While this defect is most likely true as applied to painting, it can hardly happen in printing, on account of the film of colour employed being so thin.

There is a black whose base is lead, and which can be employed as a pigment, namely, an ore of lead called galena, glance, sulphide of lead, sulphuret of lead, or, according to modern chemists, plumbic sulphide.

145. MINERAL BLACK is a variety of carbon found in Devonshire and Wales. It is deeper in colour than graphite, and free from its metallic lustre. BLACK OCHRE and BLACK CHALK are similar substances.

146. MANGANESE BLACK is a peroxide of the metal manganese, and is found as a natural product in the West of England and other places. It possesses many of the characteristics of a good pigment, and stands distinct from most blacks in being a good drier, and, as such, might be found useful.

147. COMPOSITION BLACK.—Prussiate of potash is produced when animal matter is properly heated in conjunction with potash carbonate in iron pots, and a carbonaceous matter remains as a residuum. From this the black is prepared. As prussiate of potash is first formed in the manufacture of Prussian blue, the black formed from this residuum is sometimes called PRUSSIAN BLACK ; but this term is more properly applied to the pigment formed by roasting Prussian blue in a closed crucible until it becomes black.

148. COLOGNE and CASSEL BLACKS are simply varieties of ivory black.

149. BRUNSWICK BLACK and JAPAN BLACK are preparations principally consisting of asphaltum dissolved in oil and turpentine. In colour they are more properly brown, though when thickly applied they appear black. Though not often employed by the printer, they are sometimes used by the lithographic artist as a stopping-out varnish in making up tint stones.

CHAPTER XII.—White Pigments.

WHITE pigments do not play the important part in printing that they do in painting. In the practice of oil and distemper painting, both for pictorial and decorative purposes, white is mixed with all the lighter tones of colour, and upon it depends the representation of light. In water-colour painting, however, light is chiefly and generally got from the white paper, which shows through nearly all portions of the work and performs the same duty as the addition of white to the pigments in the more solid methods of employing them. Many water-colour artists make very free use of white pigment in finishing their pictures, and in this they have an advantage which the colour-printer does not command. There is a great similarity between what is called the old method of water-colour painting and colour-printing, the effect being attained in both by the laying on of thin films of colour, through which the white paper shows. The colour-printer is debarred by the nature of his materials from putting in finishing touches of body-colour, as can be done by the water-colour artist, because the conditions under which it may be applied preclude the possibility of laying it on sufficiently thick to cover effectually any darker shade that may underly it. This is one of the chief defects of colour-printing. All touches of light, grass, stems, &c., in landscapes, the white specks of the eyes in figure subjects, and many similar instances of light upon dark, must be left clean and sharp in many of the printings. This involves not only much exercise of the memory and skill on the part of the copying artist in keeping these matters in good register, but demands corresponding skill on the part of the printer in preserving them; with the practical result, that the parts so treated are never so clear and crisp as in the original painting, in which an opaque pigment has been employed to cover a darker ground beneath. This defect in printing arises from the deficiencies of the pigment in covering power demanding that it shall be laid on thicker than the roller can apply it; or, if it could be so applied, the pressure employed necessarily flattens it out into a film so thin as to let the underlying printings show through it sufficiently to totally destroy the effect intended.

Our best covering pigment is very weak when employed in this manner, as may be seen in attempts to properly back with white the decalcomanie or transfer pictures. These pictures are produced by lithography, and are largely employed for various decorative purposes, being often required for application to black grounds. When they are transferred, of course the colour first printed will be uppermost, and that last printed must be opaque enough to shut out the black ground or the effect will not be what is required. Recourse being had to a printing of flake-white for this purpose, it will be found that but little has been done to conceal the picture; and, if the picture is not concealed, the flake-white will not shut out the background to which it has to be transferred. While the ink is wet, dry flake-white may be rubbed into it, and when as much of this has been applied as the printing will take, the backing is still found to be insufficiently opaque. Even a repetition of the printing and dusting-on of white will scarcely give sufficient body, and recourse is sometimes had to a final backing of metallic substances, such as Dutch metal, bronze powder, or white metal. These various processes are, however, costly, and it is often found more effective and cheaper to employ girls to paint the backs by hand, so that a good body of colour can be applied with the brush at one operation.

A reference to this application of lithography shows very clearly how weak white pigments are in hiding any underlying colours; but it must not be assumed, therefore, that they are of no value in printing. Though they are comparatively useless in shutting out previous printings, they are of much utility in modifying them and of improving the working quality of the tints in which they are employed; and in this latter direction lies their chief importance in chromo-printing. It is mainly as an ingredient in the composition of tint-inks that white pigments are found to be of advantage. Without them tints must necessarily consist almost entirely of varnish, and in consequence their working will be more difficult, for the double reason that the ink will be too greasy in working and will be seen with difficulty on the stone. These two defects are common to all kinds of tint-printing. When a full and dark colour is employed, it is easy to see when the stone is properly inked; but with a thin washy colour this becomes difficult. The addition of white to a tint improves it, inasmuch as it then works more like a full-bodied ink. This use of white also enables one more readily to see whether the stone is properly charged, and helps to conceal little variations in the quantity of ink employed. On the other hand, it is only in the earlier printings of a subject that it is admissible; for, though its covering, or hiding, power, is not great, it has that tendency, and it must therefore be kept out of the finishing colours, because they require to be kept very transparent, so as to permit of previous printings showing through them, and thus being enriched by their varnishing effect.

From what has been previously said, it will have been gathered that there is no white pigment which at all approaches the power of black. What the printer requires is a white that is as powerful in shutting out black as black is in concealing white. This cannot be obtained, nor does chemical science at present hold out any hope of enriching the palette with such a desirable addition. The most generally useful white pigments at present at command are prepared from lead.

151. WHITE-LEAD.—This name may appropriately be applied to either the carbonate or sulphate of lead, as both may be used as pigments. It is to the former, however, that it is chiefly applied, and to the commoner qualities. The better sorts have special designations.

As a general rule, the whiter and heavier the sample the better it is. These whites, however, are not without their faults. They are very subject to change when the air is contaminated with sulphuretted hydrogen gas, more especially when they are used as water-colour. Oil and varnish, however, have a greatly protective influence upon them, though too much of either tends to make them yellow. In the remarks upon other colours it has been shown how many of them there are to which lead whites are injurious. These comprise many colours which are themselves prepared from lead, as well as yellow lakes, and cochineal and vegetal lakes, both crimson and scarlet, &c. The madder lakes, earthy colours, chrome yellow, vermilion, &c., are not so affected.

152. WHITES OF LEAD are known by various appellations, as, for instance, *London* and *Nottingham whites*, *Krems* and *Kremnitz whites*, from the names of the places where they are manufactured. *Flake-white* is of English make, and so called from the form it takes in the manufacture. *Blanc d'argent*, or *silver white*, is also a lead white, but is not prepared from silver, as its name might appear to indicate. Another variety is called *Roman white*, though it is not generally on sale. The whites of lead just enumerated are all mixtures of carbonate and hydrate of lead, the best proportions of which seem to be three of the former to one of the latter; and it is thought by some high authorities that this compound is essential to a good working colour, because neither pure carbonate nor the hydrate, when employed alone, produces a pigment of equal covering power to the mixture.

153. SULPHATE OF LEAD is formed when a soluble lead salt is precipitated by sulphuric acid or a suitable sulphate. It is a very white substance, which may be employed as a pigment, but it is scarcely equal to the carbonate in body and durability.

ZINC WHITE, CHINESE WHITE, an oxide of the metal, at one time was thought likely to prove a formidable rival to white-lead, on account of its greater permanency. It has, however, an inferior body to white-lead, which therefore holds its place in the market as formerly. Zinc oxide is a valuable water-colour pigment, resisting the effects of mixtures and impure air, and is in aquarelle a much superior material to white-lead. Zinc white is also valuable in oil painting and printing under such conditions as preclude the use of flake-white. It requires more grinding than the lead white, and forms an ink that does not distribute so evenly upon the roller and slab as is desirable in a good working colour.

154. SPANISH WHITE, PARIS WHITE, WHITING, TROY WHITE, CHINA WHITE, &c., are various designations of carbonate of lime, and are simply white chalk freed from grit and discoloration. It is employed in distemper painting, paper-staining, the manufacture of glazier's putty, &c., and

may be used by the printer to give some degree of body to his inks without greatly altering their transparency. Much cannot be used, or the ink will too nearly approach the character of putty, and become too pasty for use. This substance, in fact, has little further use than that of modifying the too greasy character of some inks.

155. The foregoing are the whites of chief interest to the chromo-lithographic printer. There are numerous other white pigments, as *tin white*, *pearl white*, *baryta* or *constant white*, &c., but these are of no value in inks, though some of them are important in the preparation of surfaced papers.

CHAPTER XIII.—Selected Pigments.

AFTER the foregoing details relating to the various pigments to be found in the colour-shops, it will be expected that a selected list of those most useful should be presented to the reader.

156. Yellows.—*Cadmium yellow* is most to be recommended for works of sufficient importance to warrant the employment of a costly pigment. In the ordinary run of work *chrome yellow*, in its various hues, will be found all-sufficient. The *lemon chrome* cannot be imitated, and is most useful in compounding bright greens. It is not often required to be used alone, as the next in depth is more generally agreeable. *Deep chrome* and *orange chrome* can be imitated by the addition of vermilion to the medium shade. It is better, however, to use the pure chrome if otherwise convenient.

Yellow lake should be chosen when it is necessary to employ a transparent pigment.

157. Reds.—A cheap red ink, of good colour and working qualities, may be obtained of the ink-maker. It may

be had as an imitation vermilion, than which it is somewhat richer, or as a red more approaching crimson than orange. It is not permanent. A similar ink may be made from the best *red-lead*, modified by *geranium lake*, though we cannot recommend the printer to prepare such an ink for himself.

Vermilion can be recommended for permanency and good working qualities. It may be had pale and deep. When necessary, a little brilliant lake may be added to it to increase its richness; but it must be remembered that in course of time the lake will fade away and leave the vermilion more dirty-looking than it would have been without it.

For delicate shades of pink, it must be remembered that *madder* is the only source of a permanent ink; but, unfortunately, its power is weak. The somewhat dull *lac* and *cochineal lakes* stand next in order of permanence, but at the present day they give place in most kinds of work to the more brilliant, but fugitive, *geranium lake*. This pigment soon fades under the influence of strong light, but for book-illustrations and album use it stands well enough. No printer should employ it for show-card and similar work without distinctly cautioning his customer as to its character, as it is likely to bring him a bad reputation. It is scarcely good policy to have one's imprint to a piece of faded lithography.

158. BLUES.—*Blues* of an ultramarine character, such as *Oriental blue*, are, in a general way, the most agreeable to the eye, and are now to be had of good working quality and stable character. *Prussian blue* is also of much importance to the printer, as it can be employed of an intensity almost black or of the palest tint. It may be modified with the other blue to suit particular requirements. *Cobalt blue* is not much in request, but it can scarcely be successfully imitated, and therefore is occasionally employed in work of a particular nature. When a blue of the hue of indigo is required, it may be obtained by the addition of black to a mixture of *Oriental* and *Prussian blues*.

159. ORANGE.—*Orange vermilion* may be employed, but it frequently happens that *orange-lead* is so called. This latter is often used as a delicate flesh-tint, but an addition of a fatty matter, such as lard, is necessary to prevent its

drying upon the ink-table so rapidly as to destroy its printing quality. *Orange chrome* has the usual good qualities of the chrome yellows. *Burnt sienna* is a less brilliant orange than the preceding, but possesses qualities that make it a highly-valuable pigment, more especially in mixtures. Any of the yellows and reds may be employed in the preparation of orange, due regard being had to the peculiarities of the elements.

160. PURPLE.—The preparation sold as *mauve ink* is the most generally useful purple, though unfortunately it is far from being permanent. Indeed, there is no pigment in use, except madder (and that is not brilliant), of a violet or purple hue that can be relied upon for stability. Mauve varies much in price and quality. The best will generally be found to be the cheapest, as it not only contains more colouring matter, but is less likely to act injuriously upon the stone than the lower quality. Purples may be compounded from blues and lake reds, and will vary in character in the same degree as the pigments from which they are made. None of them can be made so rich and brilliant as is the aniline *mauve*. This colour varies, and may be had either with a blue or red hue.

161. GREEN.—*Green lake* may be kept of three shades, the middle one being the most distinctly green. For special uses, the blues and yellows form the elements of a great variety of tones. The most vivid is made of *lemon chrome* and *Prussian blue*. For low tones use *Oriental blue* with *cadmium yellow*, varied by another colour when necessary. *Yellow lake* and *Prussian blue* make a transparent green. When brilliancy and richness are sought, use the full-toned yellows with Prussian blue.

162. BROWN.—As a basis or used alone, *burnt umber* is exceedingly useful. It is somewhat transparent, but it may be made more warm and opaque by the addition of *vermilion;* more citrine and opaque by admixture with the *chrome yellows;* and more cool by the addition of *black*. Its transparency may be preserved and its colour enriched by *crimson lake*, or lightened and warmed by *burnt sienna*. It may be converted into a very low-toned green by *Prussian blue*. *Vermilion* and *black* may be the foundation of a series of opaque browns, which can be modified by

other pigments to particular hues. In this manner good imitations of *light* and *Indian reds* may be effected, which will print better than the purer pigments. For imitating Indian red, use *vermilion* with a little *black* and *Oriental blue.* In using black in a mixture, proceed *very* cautiously, as it is powerful, and but little is needed unless the tone is required to be very dark indeed. The best way of proceeding is to add the black to a portion of the colour instead of to the whole. Most likely it will be found that too much has been used, so that a portion of this mixture can be added to another part of the colour to be modified. In this manner any mistake that may be made can be easily rectified. It is very vexatious to find that perhaps the whole of the ink just at the moment at hand has been spoiled through the want of a little caution.

163. With the pigments enumerated in this chapter nearly every kind of colour, tint, and shade in a painting or a piece of decoration can be successfully imitated. It is, however, a convenience to have some of the more broken colours at command, and that chiefly for the facility they afford of producing simple tints without waste of time in matching, when it is known that one pigment will produce what is required. Thus, *orange red*, *Venetian red*, and *Indian red* make flesh-tints—fair, medium, and dark. In like manner, nearly all the pigments in use among oil-painters may be utilised in lithography. The tube colours employed by artists in oil are indeed very convenient for making small quantities of tint-inks when added to middle varnish, with or without an admixture of white, and are often used when taking proofs. They are, however, not suitable for ink with any pretensions to fulness of colour, and they are too expensive when a considerable quantity is required.

CHAPTER XIV.—Preparation of Printing-ink.

IT will be unnecessary to treat of the preparation of lithographic varnish in this work, because it has already been described by us in the "Grammar of Lithography"; but concerning the methods of grinding colours and preparation of the corresponding inks something more is required than can be found in that work.

In the last chapter the tube colours in use by artists have been mentioned as material easily converted into tint-inks on a small scale, and of that method nothing more need be said. When a large quantity of tint-ink is required, or when ink of greater depth than tube colours will yield is to be employed, then resort must be had to the direct union of the pigment with the printing varnish. There are two ways of performing this—one is by hand and the other by machine labour. The former is suited for small quantities of coloured ink, and the latter for larger ones.

In making small quantities of ink, the pigment should be bought of fine quality and already reduced by machinery to an impalpable powder. Pigments may be bought more cheaply in the crude state, but it is only the softest and most easily ground that should be so purchased, for it is false economy to spend hand-labour in what can be done so much better and at less cost by proper mechanical appliances. It must be borne in mind that small quantities of ink are not to be ground by hand for the sake of economy, when it is convenient to send to the ink-manufacturer, because he is always willing to supply as small quantities of ink as the printer requires, knowing, as he does, that inks do not keep indefinitely. There are, however, times when and places where inks cannot be had just when wanted, so that it becomes imperative for the printer to be able to prepare his own.

165. Pigments are, as a rule, ground in thin varnish, and as stiffly as it is possible to work them. The object being, as before stated, to make up a small quantity of ink,

the ordinary stone upon which the printer distributes the ink upon his roller is utilised as a slab for the grinding, and as this is not of large dimensions much cannot be operated on at a time. Proceed, therefore, to put not more than a dessert-spoonful of varnish upon the slab, and then put as much colour to it as can be worked into it with the palette-knife. It must now be ground with the muller. This should have by preference a square section, measuring about three inches by two. Its face should not be flat, but round in one direction, thus ⌣ . If flat, the two longer edges of its face should be rounded off, so that they may be brought into use when required. Gripping the muller firmly with two hands, it is to be rubbed backward and forward, from and to the operator, and over as much of the slab as is convenient. In a little while it will be found that the ink becomes thinner and will carry more pigment. Sprinkle a little more over it and again use the muller. Proceed in this manner until as much pigment is incorporated with the varnish as is consistent with the use of the muller, which at this stage will be found to pass over the ink with difficulty, but yet without much tendency to displace it. The ink should now be scraped into the middle of the slab by means of a stiff palette-knife having a square end, and ground again. The operation must be repeated until the ink appears to work quite smoothly, and shows a surface free from any appearance of grittiness when the palette-knife is drawn across with a sideway motion. A person unused to this operation will find it a very tiresome proceeding, but the practical printer sets about it in a business-like manner and soon accomplishes it.

166. The ink in the condition just indicated is too stiff for use, and if an attempt were made to distribute it upon the roller it would be found to lie about it in patches. To bring it into a state suitable for printing, it requires the addition of more varnish. It cannot be too much impressed upon the mind of the lithographic printer that the essential matter of his ink is varnish, and under all circumstances the "varnishy" nature of his ink must be preserved. The more pigment the varnish will carry without destroying its printing properties, the better working the ink will be. The nature of the varnish to be added will depend upon the

kind of printing to be performed and the quality of paper upon which it is to be done. One great point to be aimed at is, that the ink shall be free working, and that indicates thin varnish. But thin varnish has a tendency to clog the work and print too heavy. This is corrected by the cautious addition of a stronger varnish. If too much be added, the ink will be difficult to work, and will tear soft papers when they are being lifted from the stone. Plate paper and half-sized paper will bear more thin varnish than will hard-sized paper, yet the latter kind of paper demands an ink to be made with thin varnish if depth of colour be a requisite of the ink. It is obvious that a hard-sized writing-paper will not absorb ink in the process of printing like a soft paper does, and, as it carries it on its surface, only a small quantity can be applied without smashing. The ink must, therefore, be reduced with just as much (and no more) thin varnish as will make it work freely, trusting to the thickening quality of the pigment to prevent the ink spreading. Suppose, however, on the other hand, that the ink is required to print a middle shade of its colour upon the same kind of hard paper. Obviously, the most simple way of effecting this is to reduce the quantity of the ink upon the roller; but the result is not quite satisfactory, because the printing presents the appearance of having been intended to be darker. There is a difficulty, also, in keeping anything like equality among the impressions, because the addition of fresh ink upon the roller at once restores the darkness of the colour. Resort must, therefore, be had to some method whereby the work can be kept more regular in colour. This may be accomplished by the addition of sufficient white ink to produce the required strength of colour. A distinct advantage in an ink so made is, that in course of working it is easier to keep up equality of tone than when no white ink is employed. But it may be that the addition of white will quite spoil the ink for the purpose intended, as, for instance, when it forms part of one of a series of colours in a chromo, and it is required to be transparent. Under these circumstances, resort must be had to varnish alone as an addition; and as the necessary quantity of thin varnish would most probably make the ink too soft and cause it to fill-in the fine work, a small quantity of strong varnish must be employed in place of some of the thin varnish.

167. It follows, from what has been just stated, that the lighter the colour to be printed the stronger or medium varnish must be used to keep the work clean and open if the ink is to be free from white.

168. On the other hand, equal care must be taken not to put too much thin or thick varnish into ink, because under such circumstances the ink must be laid on thickly to get up the necessary strength of colour, and then the pressure squeezes it out beyond its proper place, and a sloppy effect is produced, which is not only disagreeable in itself, but is calculated to injure the work on the stone by making contiguous lines or dottings run together.

169. An ink containing too much varnish for hard-sized papers may work very well on printing or plate paper, providing its pores are not already filled up by a previous printing, which would indeed bring it, practically, into the condition of having been sized.

Similar effects may be observed in printing the different classes of writing-papers. An ink may be producing very good work upon a common quality of writing-paper, but when applied to a paper like Joynson's extra super, it will give no sharpness of impression combined with depth of colour, because, lying on the surface, it gets smashed in the process of taking the impression. The ink for this and similar makes of paper should have as little varnish as is consistent with free working, and that of the thinnest.

170. Now let it be supposed that an ink has been prepared with too much varnish. If with too much *thin* varnish, then nothing can be done with it except to add more pigment. It may, however, happen that too much medium or strong varnish has been made use of, and that in consequence the ink does not easily take to the work on the stone,—that is, it does not work freely. The addition of thin varnish would probably be too slow a cure, because, by the time enough was added to bring the ink to a working consistency, the proportion of pigment would be so reduced that the colour would be too weak. Resort must, therefore, be had to something of an oily nature

that is less tenacious than thin varnish to correct this. Now, the varnish being made by burning linseed-oil, and the strongest varnish being most burnt, it follows that if raw oil be added it will more quickly reduce the ink than the addition of thin varnish, and that a proper quantity will fairly bring it to a condition such as would have resulted from the use of thin varnish alone in the first place. Such a quantity may yet be too much, and by similar reasoning we are led to conclude that thinner oils will act still more quickly, and in olive-oil we find a very useful material for the purpose. Some printers, however, feel the need of going even further than this, and use a still more limpid oil, viz., oil of turpentine. This, however, is objectionable on account of its volatility, and ink doctored with it must be constantly changing in consequence. As we have pointed out in the "Grammar of Lithography," paraffin-oil is much better, because it does not evaporate freely at ordinary temperatures, and is fairly as limpid as turpentine. It only takes little to break down the tenacity of any ink, and is found to be very useful in machine-printing, more especially when working on papers of weak fibre.

171. There is yet another mode of breaking down the tenacity of printing-ink, by the addition of substances of the nature of tallow. Most printers have noticed that their re-transfer ink is not *stringy* when tempering it for transfer pulling. This arises from the nature of its composition, and similar results are obtained by the addition of solid paraffin and other mineral fatty substances to their ink. These substances can be obtained almost anywhere formed into candles. We believe the most convenient way of employing it is to dissolve it in turpentine or paraffin-oil, and form it into a paste, just in the manner that a mixture of beeswax and turpentine is prepared for domestic use. In this manner it should be easy to add it to the ink.

172. We have been treating on the methods of reducing the too adhesive quality of inks. but there are occasions when this very quality requires to be strengthened, as in inks for holding bronze-powders and dusted colours. For these purposes the ink is employed with the major part of middle varnish or the addition of a considerable portion of

strong varnish. It is sometimes further strengthened by the addition of japanner's gold size, copal varnish, Canada balsam, rosin, Venice turpentine, &c. Some printers follow another course and add strong flour-paste and glue to their ink. The best pigment for a bronze ink for general use is burnt umber, as it harmonises well with the bronze, and does not show so much as most other colours do if the bronze becomes accidentally rubbed off. Other colours may be made use of with bronzes of different and special hues. Indeed, the colour of a bronze may be modified by that of the ink underlying it; for it is certain that a bronze dusted on a vermilion ink will look more red than one applied to an umber basis.

173. When the ink is to be used to hold a dusted pigment, it must partake of its colour or that of its elements. Thus a green or a blue may be used as an ink for dusted green. If green ink be used the effect will be enhanced beyond that produced by a blue ink; but the latter has its advantages, because it can be used as a base for either a blue or green dusted colour.

174. When bronzes are used on enamel paper, care must be taken to examine its nature. With some papers the enamel surface will peel off the paper and adhere to the stone by reason of the ink being too strong; but if an attempt be made to reduce the ink to suit the paper, the bronze will probably rub off when the ink is dry. Under these circumstances the ink must be kept as stiff as possible by means of a strong varnish while the pigment is reduced in quantity. An ordinary vermilion ink may be used to hold bronze on an ivory card, because it is made of writing-paper which is strongly sized, and consequently the ink lies on the surface and holds the bronze. Use such an ink with an ordinary enamel card and the bronze will most probably wipe off the next morning, because the varnish has penetrated the enamel and left the pigment on the surface in a state that possesses no hold for the bronze-powder. By keeping the ink as tenacious as will permit of the enamel being lifted from the stone, reducing the pigment to the utmost, *and by means of lightened pressure using as much ink as is workable*, success may be attained in printing on such paper.

175. Those who use large quantities of ink, and whose business is carried on somewhat remote from practical manufactories, not unfrequently make it themselves, for which they employ suitable machinery, consisting usually of two machines,—one for grinding the raw material into a suitable powder, and the other for grinding the powder with varnish into ink. It is evident that, as all colours may be bought ready ground, the first machine may be done without even by the large consumer.

176. There are various machines sold for grinding inks, and we cannot do better than refer our readers to the various manufacturers, who will be pleased to show them and describe their various merits, and will not be slow to point out the defects of other systems. An idea may be attained of what will be likely to suit any one particular use by taking note, not only of what the maker says in favour of his own production, but also of what he indicates as being weak points in others. Unless, however, the inquirer well knows what he wants, he should make a point of seeing the decried machine, when its maker, by answering some well-chosen questions, will show up the defects of the other make. By thus inquiring of different producers, the printer is soon coached up in the principal points a good ink-grinding machine should possess.

177. The grinding-machine that seems most in favour consists of three perfectly true rollers set horizontally in a frame, with arrangements for keeping them in contact. These rollers in the best machines are made of granite or some similar substance, the chief requirement being that they shall be very hard, so as to effectually grind the pigment and be unaffected by any of the colours used. The colour, being roughly mixed with the varnish, is ground by being squeezed between the rollers, and as it is brought forward from the back it is scraped off by a self-acting knife and forced down a spout. It is then put back, and the operation repeated as often as necessary, the attendant being able to form a fair judgment by passing the palette knife edgewise across the ground ink, which will appear the more smooth the more it is ground.

178. Another machine is constructed on the principle of the mortar-mill. An upright revolving shaft carries a

horizontal arm, at the end of which is a heavy granite stone shaped like an ordinary grindstone. This stone travels in a circular path, revolving as it goes, and carries with it a scraper, which brings under its track again the ink that has been squeezed out. When the ink is sufficiently ground, the attendant removes it from the circular tract and from the wheel.

179. A third class of machine is constructed on the principle of grinding with a muller. A circular table is made to revolve in a horizontal position, while a muller (or mullers) above is made to travel over it while itself revolving at the same time. The ink being kept from working off the edge of the table is sent back to the middle, and is then re-ground again and again until the operation is completed.

180. We offer no opinion as to the comparative merits of these machines, and we doubt whether they pay their cost, unless the consumption of ink is very large. There is, however, another side to the question when the printer is carrying on his business in such remote places as the colonies.

The printer in an ordinary position may purchase his inks ready ground, but he must be careful not to overstock himself, as inks do not improve by keeping, though we once heard a traveller, desirous of booking a large order, assert that they did.

181. A useful stock of dry colours, which can be had of the ink-manufacturer, should always be at the command of the country printer, who is thus prepared for emergencies.

182. We recommend generally that a printer should purchase ready-ground inks, and that they should be those which are ground stiffly and of good quality. There is scarcely any economy in purchasing the lower-priced inks in any one class, since if they are genuine the lower-priced ones are simply made thinner by the addition of varnish, which the printer can do for himself, and sometimes with advantage. We have said that inks do not improve by keeping, and we have also shown that some deteriorate by the action of the pigment, or the dryers, upon the varnish. Now, supposing a stiff ink is bought and suffers a little

deterioration, this will be favourably modified by the addition of the varnish; whereas, if it had been bought thin enough for use, it would probably have been spoiled. Another reason for buying a stiffer ink than is required for use is, that the ink is under the control of the printer, who can easily adapt it to the temperature of the day or night, the latter in most workshops being the warmer on account of the heat derived from the gas.

183. The changes due to temperature need some consideration from the printer, for it is not invariable even during the night and working by gaslight. It will further depend upon his position in the house where he is working. He may occupy a middle floor, where he may get much heat from the shop below him. Suppose, then, he has to light up at four o'clock and continue until twelve, while the shop below is closed at seven. After that hour his place will become cooler, and his ink will work more stiffly than during the warmer period. Suppose, further, that he is the only one left in the shop, it is not unlikely that the temperature will fall to a point even lower than in the daytime, the small amount of gas he himself is using not being sufficient to keep up the heat.

Under these various circumstances, the ink will act differently, and produce a corresponding effect on the work, unless the printer resort to a rate of rolling, or variation in damping, or both, calculated to counteract the influence of change of temperature.

184. Though we have recommended the printer to purchase ready-made inks, it must not be understood to apply in all cases. He should, for instance, either mix up his own compounds, or tell his ink-maker from what to make them. He should not have to rely upon his ink-maker on account of his own ignorance of such important matters. The practical colour-printer ought to have an intimate knowledge of his pigments and inks, even though he may find it expedient to employ another to produce them for him. If he has the knowledge to make them for himself, he will not expect impossible things from the manufacturer. The latter, as long as he is paid a fair price for his goods, is usually quite willing to work to any formula that is given him. The printer who has not this knowledge should

acquire it. It has been shown him what pigments are best worthy his attention, and most of them may be had ready ground into ink; thus far his path is made smooth.

185. There is scarcely a tint or shade that cannot be produced from some three appropriate inks (black and white excepted). Suppose it is required to match a green of some peculiar hue. First, consider whether it is most blue or most yellow; whether it is bright or mellow; and whether it inclines to grey. After this examination, it should be easy to decide upon the proper blue and yellow to employ. It may now be further modified by addition of red, crimson, orange, or brown, and still further by black or white, or both. The colour of the ink, as seen upon the slab in the mass, must not be depended upon as an indication of the colour it will be when printed. Ink in thick layers shows a hue, as a rule, derived from its more opaque element, whereas, when printed, it may look more like its more transparent one. A most notable instance of this occurs when vermilion is mixed with Prussian blue to form a grey. Upon the slab the ink may have a strong red tinge, while it will appear to be much more blue than red when printed. It therefore behoves the printer to always proceed cautiously until he gains experience, and to this end he must try his colour as he mixes it. With this in view, he may take a little on the tip of his finger and dab it upon a piece of white paper; but here again he is likely to go wrong, through applying more ink to the paper than will be applied to it in printing.

186. It may be taken as a good general rule that the colour of the paper, or of the previously printed ink, will show through any printing. If, therefore, in his trials the printer applies enough ink to the paper to obscure it altogether, he will most likely err as to its hue as well as regarding its strength, for if it be a match to what is required when in that condition, it will probably be far from it when thinned down with varnish and printed of its proper consistency. To guard against this, the colours must be dabbed off the finger (which must be clean) until reduced to printing strength, and this is often most easily done by first thinning the ink with a little turps.

187. Reverting to paragraph 185, it may be stated that

the principle laid down for matching green may be pursued with other mixtures. The point is to get an *insight* into the colours, and, as it were, to mentally analyse them into their chromatic constituents. A box of water-colours containing the pigments most in use by the printer will be found very handy for this purpose, and will conduce to economy in both time and material.

To avoid being led into error by the water-colours drying dead and into the paper, sufficient gum mucilage may be added at the close of the mixture to make it approach more nearly the nature of pigments ground in varnish. It is well to prevent the gum sticking to the colours themselves by adding it to the mixed colour when it is brought pretty near to the tone required.

188. Beginners are very frequently wrong in mixing inks for the machine by starting with too much of some powerful ingredient, which involves the use of a large quantity of some other colour to counteract it, that more is mixed than necessary. The method we recommend to prevent this is as follows:—Procure a small set of scales and weights, such as photographers use, and which may be purchased at from two shillings and sixpence upwards. We will now suppose that it is the practice of the establishment to make its own ink. Having determined, by the assistance of the colour-box, what the mixture is to consist of, proceed to weigh out, say, two drams of each *dry pigment*, and put them on pieces of paper conveniently placed. We will suppose that these colours are finely powdered, and that in the majority of instances they can be mixed with sufficient accuracy by means of the palette-knife. If this cannot be done, recourse must certainly be had to grinding, which will make no difference to the work, beyond lengthening the operation. Take a little at a time from the several portions that are to be mixed, and see that there is no colour left about knife, slab, or muller, to upset the calculations. When the correct mixture is arrived at, it will be easy to find out how much of each element has been used by weighing what is left of it. If it has been estimated that the job will take ten pounds of stiff ink, it will be an easy calculation to find out how much of each must be used to form it. Supposing this to have been satisfactorily

performed and worked out in practice, an impression in that mixture of colours may be taken, put into a book, and the component parts and weights of the mixture entered against it for future reference. But suppose it is the practice of the house to purchase ready-made coloured inks, how are we to proceed then? The colour-box having been resorted to, as before, to determine what the colours are to be, the ink-maker must be applied to for samples of stiff ink at certain prices. From these, equal weights (or they may, if more convenient, be unequal, the point being to record the weights first taken) are put upon pieces of paper as before, and the mixture is made in a similar manner. The residues are weighed, and a calculation made as to what is required. The ink-maker is now requested to compound the mixture in certain proportions from the stock from which samples were taken. If the bulk of ink supplied is not then like the experimental mixture, the manufacturer may be interviewed to know the reason why; for there must be something wrong, either in the mixture, or in the samples not being representative ones. If the quantity be large, the maker may be glad to know the proportions of the dry colours, so that he may make a special grinding for the job, and in that case the first-described method may be practised.

While on this subject, we may say that it is well to be on good terms with the ink-maker, and to keep to one if satisfied with his general dealing. He will then do much for you that he would not do if he found it was your habit to be constantly running after others in order to secure some doubtful advantage.

CHAPTER XV.—OF THE CONSIDERATIONS WHICH DETERMINE THE NUMBER AND ORDER OF THE PRINTINGS.

WHEN a coloured drawing or painting is taken in hand, it is necessary to decide, at least approximately, the number of printings in which it is to be executed, and this must be done beforehand, even when it is determined that nothing shall be stinted which is calculated to perfect the result. The reason of this is, that, unless the draughtsman knows how many colours he is permitted to employ, he will not be able to estimate the amount of drawing to be put into each one. He should not start by attempting to use the least possible number, and then have to resort to supplementary ones when the deficiencies of the small number are found out. The reason of this will be seen by a study of a supposititious example.

190. It may be taken that the minimum number of colours that can be employed to produce anything like a complete chromatic scale is three: namely, red, yellow, and blue (from which can be produced secondary and tertiary colours), and that these must be associated with a fourth printing to give to them modelling and depth of shade. Now, supposing that it is required, with these four printings at command, to produce a landscape with children —the latter being introduced for the opportunity they afford of making the most of the colours. In a subject such as this, it is most likely that a black or dark brown printing will be employed for outlining, shading, and keeping the subject well together to produce unity and breadth of effect. Under these somewhat restricted conditions, it is not likely that a separate key-stone would be brought into use, and the only permissible course would be, to first produce a fairly well-finished subject, to be printed in brown, black, or dark purple-grey.

In making this first drawing, every outline of the subject must be put in, and nearly all the modelling. We say that *nearly* all must be put in, because something may be left to the effects that can be obtained by one colour underlying another. The sets-off having been laid down (*vide* "Grammar of Lithography"), the yellow stone is the best one to make up and print first, so let the drawing be examined to see where it is to be applied. We find that one of the children is to have a yellow skirt with red spots. Upon examination, the middle tone of it is seen to be a full yellow of warm hue, and that upon the most illuminated side the colour is paler, while upon the shaded side it becomes orange with a tint of brown. Now, the part which is brownish, that which is orange, and that which is of a full yellow, must all be painted in with lithographic ink, while that which is more pale must be drawn (in crayon, if on a grained stone, and with ink, in lines or dots, if on a polished stone) of a little lighter colour. The yellow itself, even when full, is but pale, as compared with the other printings; therefore care must be taken to draw it darker upon the stone than appears necessary when working in black, as it becomes so much paler in proportion when printed. Keeping still to the figures, the arms and faces must have a tint of yellow put upon them, because some kind of flesh-tint has, in this instance, to be produced by combination with the red, whereas in a more finished print there would be a separate flesh-tint used. If any figure have golden hair, a ground-work of yellow must be laid for that; also any scarlet tone of red and orange, and all shades of brown, must be underlaid with the yellow. Leaving the figures, now look to buildings and suchlike, and then pass to the grass and trees. Both these will probably need the full strength of yellow to form the green with the blue. Observe, however, that as the distance is approached the green is more blue, and that in the extreme distance there is no green. If there be any sunset effect, some yellow will be required in the sky; but it will need thoughtful treatment, and will want to be modified by the subsequent red printing to prevent a tendency to green which the yellow will impart to the after-printed blue.

191. Supposing, now, the yellow stone to be finished, it is passed to the printer, who rolls it up in black ink and makes it ready for printing. Having prepared an ink of golden

yellow, say No. 2 chrome, he proves it by printing an impression upon the set-off prints to test the register, and then pulls other impressions upon clean paper.

The draughtsman should now take the blue stone in hand, and seeking out all blue, green, purple, and grey in the picture, should draw the blue in proper proportion, according to the best of his judgment. He will want to ascertain the key-note for his colour, and that may probably be found in some part of the children's dress, as in a scarf, sash, hat, &c. As he has only one blue at his command, it is obvious that the strongest and most important bit of blue must determine its full strength, and that all lighter gradations must be produced by modifications of his drawing, and thus his sky, and a good deal of the green in the landscape, may, and probably will, require working up something short of solid colour. Advantage may be taken of this to introduce some degree of variety into the green by not working the blue over it of uniform strength. The light side of trees may have less blue than the dark sides, and light places in the grass, and more especially in the foreground, may have the blue worked much lighter than the general tone. This will prevent flatness and uniformity of effect. In the dress of the children anything approaching purple and grey, as well as blue, must have its proper share of blue colour, and it may also be used in the shades of brown, &c., to assist in preventing too great a monotony of tone, which is likely to result from the too-pervading effect of the dark printing by which the picture is to be finished.

192. The stone, having been sent to the printer, is in due course used for printing upon the previously-produced yellow, and then the student can form some idea as to whether he has been working in the right direction, and whether any modification is likely to be required.

In a similar manner to the others, the red stone is taken in hand, and to make the most of this red it has, in all probability, previously been determined that it shall be a deep rose-coloured lake, because some approach to vermilion hues can be obtained by using such a red in conjunction with yellow, whereas rosy tones cannot be obtained with vermilion.

Looking, then, first to the children's dresses, the key-strength is determined, and then all shades of pink, scarlet (having an underlay of yellow), and purple are worked out. There will be the spots on the yellow frock, the purple jacket, the pink hat, the grey stockings, the maroon petticoat, the shades in the blue draperies, which all require working up in this colour, each one according to the strength demanded. This colour, being the last used of the three, will have most prominence, and will be of itself deeper than the other two; and, therefore, it must be worked up in fine lines or dots very differently to what was necessary for the yellow. It must be applied on the flesh of the figures with especial care, or a much too ruddy effect will be the result. Any red that may be necessary in the sky will have to be worked in with great delicacy.

193. This colour having been completed and put into the hands of the printer, it is applied to the two previously printed. The impression can now be examined, and the effects obtained noted, more especially in conjunction with what has been printed on the set-off prints. The black or brown outline and general shading colour may now be found to contain more work than is necessary to aid the effects already produced by the three colours—yellow, blue, and red. It may be that the outlines of the distant hills and trees may be no longer necessary, and that some other matters look better without the addition of black or brown; these may, therefore, be removed by scraping, &c., from the original stone before it is added as the final and fourth printing. A critical examination is now required, and it will be well for the student to avoid being too easily pleased with his picture. Viewed with a determination to find some defect, it must be perfect, indeed, if some cannot be discovered. True. But the point to be considered is whether they are such as may be remedied by the means at command. Let us inspect. Well, it seems that the yellow is carried too far and too strongly into the distance, and that the green is too pervading. Then some of the yellow can be taken away by scraping. What other defect do we see? Why, the red seems nearly all in one place; and it would undoubtedly be better if it were less concentrated on the figures in the centre, and if the green were not so uniformly of one colour.

194. Let us proceed to the cure of these two defects. The red stone must be rolled up in black, and prepared to receive new work. A new set-off is put down upon it, and the draughtsman proceeds to distribute, by delicate lining, stippling, or chalking, the red colour more generally over the stone. By judiciously operating on the distance, on the trees, and on the foreground, he corrects the various defects just noticed, and produces a better balance of colour, so that when it is proved again there is more harmony in the picture, and the result is altogether more agreeable. The distance, by the removal of some of the yellow and the addition of a little red, has become more purple and more natural; the trees and grass are less uniformly green; and the foreground has been improved by being made more interesting.

195. The lesson to be gathered from this is, that each colour requires to be distributed as far over the picture as its nature will permit; and it will be found a good general rule in chromo-lithography, to put all the early colours on every part that will bear them, so as to avoid patchiness, trusting to the subsequent printings to bring up the particular hue required.

196. Having completed the printing of our example, let us look it over, with a view to the discovery of its defects as a piece of colouring. The first thing that may be noticed is, that the impressions vary somewhat, and that this variation is very noticeable in the attempt which has been made to form a representation of flesh out of the red and yellow. In one impression the red is too pronounced, while in another the yellow is too full, and in a third there is too much of both, with the result that a sunburnt effect is produced where it was not intended. Where the yellow is too strong, the skin looks too tawny, while at the same time in the landscape portion it is about the proper strength.

Now, where there is a necessity to keep to some particular compound colour, there is obviously more difficulty in attaining it when produced by two printings than there would be if it were made a separate working, because in the latter case there is only the one difficulty of keeping *one* colour to its proper strength. When, however, the colour has to be applied at two different times, there are more chances of variation, because each element may vary and produce its own deviation. To apply this to the case of producing a flesh-colour by red and yellow: let it be supposed that a medium strength of both produces the proper result, it will be obviously wrong to print either colour too light or too dark; but this is just what may happen with such colours. Now, letting R stand for "red," Y for "yellow," D for "dark" and L for "light," we have the following four possible wrong combinations, DR and DY, LR and LY, LR and DY, DR and LY; while, if a separate flesh-colour had been employed, it could only have been wrong in one of two ways, viz., either too light or too dark.

Besides the defect due to combination, there is another, that a strong red and yellow will not produce what is required in point of hue, this defect being more pronounced from the necessity of producing lightness in the red by working it up in lines or dots, which never properly imitates the colour obtained by thinning down with water or varnish; added to all this there is a feeling that what has been done is only a makeshift.

197. One of the most important matters in chromo-work is to shut out the white paper from view as effectually as possible, and this is but indifferently done in the attempt at flesh-imitation we have been considering. In both the red and yellow the white paper, of necessity, shows between the lines or dots forming the tint. It would, therefore, be an obvious gain to substitute a separate flesh printing for the red and yellow combination, and this is almost invariably done even in the cheapest work.

Besides the improvement in the representation of the flesh itself, the separate printing is also a valuable addition to other parts of the picture, and may be used in a variety of places for such a subject as we have been studying. In nearly all cases it may underlie the red and be especially helpful on the lighter side of it. In the foreground, it will materially assist the yellow, and in the distance the blue. It may be used in the sky, and assist to shade both yellow and blue on the dresses, while even the greens will benefit by it in all the parts not strongly illuminated.

198. Having arrived thus far, it becomes clear that our

statement at starting was correct, viz., that it is not practicable to commence work with a minimum number of colours and afterwards to add to them in order to make up defects. Thus we cannot super-add the flesh-tint to the already-printed red and yellow, for we ought to omit both these in the representation of flesh if a separate carnation colour is to be employed.

199. If a picture containing any considerable amount of finish be examined, it will be seen that much of the colouring consists of various strengths of grey; indeed, in the practice of the old water-colour painters, it was usual to first produce the light-and-shade effects with that colour, and then add the primary and secondary pigments over it. So in colour-printing it is found to be of great service in producing a harmonious result to use one or two greys. Not only does the use of grey produce harmony, but it helps materially in attaining what artists call *keeping*. It binds the other colours together by underlying their shaded portions, and produces a unity of effect that would be unattainable by working in the more positive colours alone. In more finished productions than the one we have been previously considering, greys as well as flesh-colour should have a place. They can be used to shade up almost anything, and can be made especially useful in skies and distances, in both of which they are of great service in producing delicacy, softness, and truth. Much of the grey—indeed, the chief part—can be put in without any attempt at gradation, the sky excepted. When two greys are used, the lighter one will almost all be laid in solidly, and will be found of essential service in shutting out the white paper, than which nothing is more conducive to the production of finish. It will be found that a light grey may underlie almost every colour, except where the high lights occur.

200. If the finish is to be preserved throughout the subject, it will be found necessary to resort to a still greater number of printings. Two blues, a light and a dark, will be found in every way advantageous, as, besides their value in draperies, they can both be used in the skies and distances. The darker of the two will probably be of great value as an addition to the greys employed in the middle

distance. The lighter of the two blues may be Prussian blue and white, to which may be added a litttle Oriental blue to correct any tendency to green. The darker one may be Oriental blue alone. This system of using colours in pairs, and working one to vary a little in hue from the other, will increase their power of imitating the variety of nature.

Reds are employed in a similar manner, usually a pink and a deep rose colour. With a good yellow, the deep rose may be made to fairly imitate vermilion; and thus the variety may be increased. In nearly every case, the pink may be printed to underlie the deeper colour, or printed all over it, the latter course being best if softness be desired. If it be used *over* the deeper colour, no admixture of white is permissible, as it must then be toned down with varnish alone to bring it to a proper degree of strength.

The same principle of employing similar printings of the same colour to underlie or print over each other may generally be adopted when they run in twos or threes.

201. Unless the imitation of some particular colour be desired, one yellow is often found sufficient; but in flower and fruit subjects of the more finished kind two will be required, and sometimes three. When three are necessary, it will be best to make one of them a transparent one, to be used towards the last in the succession of workings, as then it can be employed for glazing the yellows and greens. Occasionally, when two only are brought into use, the second may be a transparent one, such as yellow lake. This will give lemon tones, and permit of the first yellow being more golden, such as the second shade of chrome.

202. In a landscape with figures it will be found convenient to have a green; but to avoid vulgarity, care should be taken that it is not of a brilliant hue. It should rather be dull than bright, the necessary modifications being made by a judicious employment of the blue, yellow, and red tones in the other printings employed. The chief reason for using a green printing for foliage, grass, &c., is because one single printing of a secondary colour is more under control than the two forming its elements, just as was explained when treating of the flesh-colour. If, for instance, in working the blue, one impression should be too strong,

and that in working the yellow, that colour, as printed upon that particular blue impression, should be too weak, the effect will differ more from the one intended than it would be if it were produced by a direct printing of the green, because, whether the latter be printed too weak or too strong, the blue and yellow elements of it will maintain the proportion originally given to them, any variation being not of hue but of strength.

203. An arrangement of blue (light and dark), red (pink and deep rose), yellow (lemon and golden), two greys and a dark brown, nine workings in all, will produce a fairly-finished picture of flowers, drapery, &c. If there are figures, a flesh-colour will be required as well, and special printings will be necessary for the production of facsimiles of drawings and paintings. In all such cases as copying artistic work, the lithographer must ascertain from his customer whether the reproduction must be of the nature of a facsimile, or whether only a general resemblance in point of colour is sought. If the imitation is to be tolerably exact, then the leading characteristics of the colours must have first consideration, and as many such must be employed as will give the necessary general similitude, without trusting to the effects of over-printing, which are apt to vary in the different impressions. There are many cases, however, where the artist will not insist upon minute imitation, and the proper course is then to produce the best effects with fewer printings than would be necessary for a facsimile reproduction.

204. For some effects it is necessary to resort to a greater number of workings than we have indicated. Thus, sometimes it may be necessary to employ three or four different printings each of blue, red, yellow, green, and purple; and to this may be added other printings, which only the practised colourist would detect in the proof. People unacquainted with the art may have a general idea that there are blue, red, yellow, green, &c., in a picture, and yet will be greatly surprised when told how many different printings are needed to produce the effect seen in the original.

It often happens that some particular colour will have to be a separate printing, because, though it may be easy enough to produce it by the combination of two, three, or more of the other colours, the necessity of preserving a crispness of contour compels the special employment of a distinct working. We recently counted twenty different workings in some book-illustrations of no greatly pretentious character. It is true that there were not so many in any one illustration; but, as they were printed on one sheet, the whole of the twenty printings had to be used, and no more cost would have been incurred in the press work if each picture had contained the whole of the colours.

When a coloured subject is submitted for an estimate, it would be well to ascertain :—

First.—Who is to judge of and pass the proofs?

Second.—If that person can be consulted and his wishes carried out.

Third.—Whether a facsimile or an ordinary good result is wanted.

Fourth.—Whether the colour must be as permanent as the present state of knowledge permits, or whether ordinary pigments may be used.

The order of succession of the printings will depend upon circumstances. One of the first guiding principles is, that opaque colours must precede transparent ones. Another point is, to get the white paper shut out from view as soon as possible, and this involves the use of the lighter colours first; but, if great softness of gradation be wanted, it will be best in the actual printing to work the light ones thin and transparent over the darker ones. In this manner lake would follow vermilion; Prussian blue would fall over Oriental; yellow lake would cover chrome yellow, and so on. Chrome yellow, being opaque and so much covered by other colours, is usually one of the first to be printed. Some printers commence by printing something all over the paper so as to reduce its tendency to absorb water. In landscapes this may be zinc-white modified by yellow ochre or similar pigment to tone down the whiteness of the paper; where this colour is objectionable, either white alone may be used, or it may be modified as required by attendant circumstances.

CHAPTER XVI.—Driers and Drying.

We have elsewhere shown that oil colours do not dry in a similar manner to water colours, viz., by an evaporation of their fluid portion; but that their desiccation comes about by a process of oxidation of the oil or varnish which carries the pigment. Now, one of the ways of improving the drying quality of oil is by heating it, and thus it becomes clear that lithographic varnish must of itself be a better drier, by reason of the heating it has undergone, than the raw oil from which it is made. The boiled oil of commerce, however, is not merely oil boiled, but in the process of boiling it is made to absorb from two to five per cent. of oxide of lead either as litharge or as red lead. If the mixture be kept well stirred, the litharge will dissolve in the oil; but if it be permitted to settle upon the bottom, it will cause the oil to burn, and the lead may then happen to be reduced to the metallic state, while its oxygen has passed from it into the oil.

206. It may here occur to the reader that lithographic varnish could have a strong drying quality easily added to it during its manufacture. That may be so; but besides the fact that there is a proper temperature for making drying oil which is lower than that for the manufacture of varnish, it must be borne in mind that many of the colours employed in printing act as driers, and that, therefore, it is practically best to have the varnish inert in this respect.

It is, moreover, sometimes essential that no lead should enter into the composition of the ink; and this could hardly be the case if its very ground work, the varnish, contained it in the condition of a drier. On the whole, then, it is much more advantageous to employ the varnish in its simplest state of burnt oil.

207. In our descriptions of the various pigments, the colours that have a tendency to give drying qualities to the varnish have been mentioned, and there will be no need of recapitulating them in this chapter; it will be necessary,

however, to point out those substances which, having no colour of their own, are the more suitable for adding to those pigments which have of themselves no drying influence on the varnish.

208. The oxide of lead (litharge) and the acetate of lead (sugar of lead) have long been favourably known for their drying qualities when added to oil paints. They have hardly any colour of their own, and are therefore fit to be ground with those pigments which do not suffer by contact with lead.

Sulphate of zinc (otherwise known as white vitriol and white copperas) is also a well-known drier for delicate colours, and some persons, who wish to bring the advantages of all into one mixture, have added this to the two previously mentioned. The joint use of acetate of lead and sulphate of zinc is chemically wrong, however, as a mutual decomposition sets in, resulting in substances having new and undesirable properties. If the sugar of lead and sulphate of zinc be dissolved separately in water, they form two colourless fluids, but when mixed they become white and opaque, from the sulphuric acid leaving the zinc to unite with the lead and forming an opaque white substance, while the acetic acid leaves the lead for the zinc to form a salt having no drying quality. Thus, instead of gaining any advantage, the mixture of these two salts of zinc and lead produces substances which are much less active as driers than those from which they are obtained. It is true that the change would not take place so quickly in conjunction with an oily mixture, but the tendency would be the same; and the experiment shows conclusively that such a combination is contrary to scientific principles.

209. Modern science has furnished the printer with a greater variety of driers than was formerly known, and some of them are not only more powerful than those previously mentioned, but are chemically better suited for many colours, and are more easily incorporated with the varnish.

210. The benzoates of cobalt and manganese form very powerful siccatives and may be used with good effect in the proportion of 3 parts to 1,000 of varnish. They may be prepared by adding the carbonate of cobalt or the carbonate

of manganese to a solution of benzoic acid until effervescence ceases. Then, after removing the excess of carbonate by filtration, the liquid portion is evaporated to dryness, powdered, and kept for use. Of these two the manganese benzoate is the more powerful.

211. Borates of the same metals prepared in a similar manner are even more powerful, especially the borate of manganese, of which a much smaller quantity will be required to produce an equal effect.

212. Resinates of cobalt and of manganese form excellent driers, and may be prepared from the alkaline resinates of potash or soda dissolved in hot water and then precipitated by the sulphate or chloride of cobalt or manganese.

213. Perhaps the most powerful drier is the borate of manganese, whose energy is so great that it is usually combined with other substances to render it more convenient for use. Thus a transparent drier, which, like oil colours, is most conveniently kept in collapsible tubes, may be prepared by taking equal parts of carbonate of zinc and linseed oil, and incorporating with them 5 per cent. of manganese borate. A similar opaque and dry drier is made by adding 4 per cent. of the manganese borate to a quantity of zinc white (zinc oxide), and after a thorough mixing to use it in the proportion of 5 per cent. as a drier. In this ratio the borate of manganese, which is the actual drier, is reduced to such a proportion as to be one five-hundredth part of the whole mass.

214. Other salts of manganese, such as the acetate, chloride, and sulphate, are also employed in conjunction with zinc sulphate and oxide to form effective driers. There are also several powders in the market which under the name of "dry driers" may be used by the printer with confidence, and which are probably some combinations of manganese similar to those just described.

215. The black oxide of manganese may be employed to make a drying oil of similar qualities to that produced by the use of litharge, but which, of course, contains no lead. Five per cent. of the peroxide of manganese is added to a quantity of oil, which is then boiled and stirred for twelve or more hours. It is used as a 5 or 10 per cent.

addition to paint, and might perhaps find a use in thinning down printing inks for the machine.

216. The liquid drier *terebine* may also be used when the ink will bear thinning. It does not of itself add to the viscidity of the ink, and this would be found of advantage in printing tender papers, and it is so practically colourless that it will not be found to injure the purity of the most delicate inks. We are doubtful whether this drier is to be depended upon as being free from lead. Oil of turpentine is oxygenated by boiling, and will also take up litharge like boiled oil, and thus become a drier very useful in thinning down paint, for which it is principally used. *Terebinthina* is the medical term for turpentine, and has no doubt given the name to this drier, which is probably not true *terebene*, a distillate from oil of turpentine treated with sulphuric acid.

217. Besides pointing out what driers may be employed in lithographic printing, something must also be said about the drying of the work. One of the most essential conditions to quick drying is that the air shall have free access to the printed sheets. It is folly to expect them to *dry* if the work is left in a heap. If the paper be absorbent the ink may enter its substance and so not set off, but that is not drying; nor will it be practicable to so leave them when two or more printings are employed. As we have previously said, inks dry by absorbing oxygen, the chief source of which is the air surrounding the sheets and which must, therefore, be permitted to reach them in necessary quantity, and to act during a sufficient length of time to effect desiccation. It must not be supposed that the addition of a large quantity of driers will proportionately reduce the time for drying, because it is often found that too much drier only effects a gelatinisation of the ink instead of a proper hardening throughout; and then the next colour is found not to print properly. It is, moreover, hardly practicable to use a large quantity of any particular siccative, on account of the difficulty there is in printing an ink so overdosed.

For effective drying it is necessary that the sheets be separated, to facilitate the circulation of air among them, and this may be done by one of the following methods.

218. Drying-racks are employed in some works, and are similar in appearance to the ordinary case-racks in use among letter-press printers. They consist of two upright ends joined together by cross pieces at top and bottom to keep the ends in position. The end pieces have strips of wood tacked on at intervals of about an inch. These carry light frames of wood, across which are stretched pieces of twine to support the printed sheets, which may be placed back to back and laid upon the string. The air will then have sufficiently free access to each side, and many hundreds of sheets may be stowed away in a comparatively small space. If it be thought necessary the dust may be conveniently excluded by a muslin blind, which can be attached to the upper part of the frame like an ordinary blind to a window; the object of using muslin instead of a closer material being to permit the circulation of air. As this piece of printing-room furniture necessarily takes some time to make and costs a little money, the following is found a very efficient substitute.

219. Where the printing-room is high enough the work may be hung over lines near the ceiling, but it will be better to fasten some kind of hook to the sheet and hang the hook to the line, as in this way the sheets are kept in better form for the machine than when they are hung bodily over the line. Some of the cheap clips used in shop-window dressing may be utilised for this purpose. If these be not easily procurable, two of the printed sheets may be pinned together with common pins, back to back, and then hung up by means of a piece of wood, having a cross at the top, resembling the letter T. When the sheets are brought down to be printed again, the pins can be readily removed, and the sheets will be none the worse, generally speaking, because there is usually some margin to be cut off. The room should be lofty where this method is used; else there will be a risk of setting the sheets on fire if they are not properly removed from the vicinity of the gas-lights. Another drawback to the method is found in the unequal temperature to which the sheets are exposed, as the heated air from the gas-lights in winter is sure to reach them. It is difficult to foretell the exact effect upon the printed paper, for the heat from the gas is always accompanied

by an amount of moisture which is proportionate to the gas consumed. If the ventilation be good the sheets may become more dry, but if it be ineffective the moisture will be absorbed by the paper, in consequence of the cooling down which takes place during the night after the gas is put out.

220. When cardboards are being printed they may be stacked face downwards, if narrow strips of waste-boards be placed between them at the ends. If the cards are stiff enough space may be economised by keeping them back to back, and using the strips to separate the printed side only. When the quantity is small, set-off may be prevented, and drying facilitated, by letting them stand on their edges after putting something to support the first one.

221. The drying may sometimes be conveniently done in a separate room, but in winter care must be taken that its temperature does not fall below freezing, otherwise the work will not dry at all. Care should also be taken, if possible, to keep up the same state of moisture in the air of this room as obtains in the workshop. If it be either dryer or damper the sheets will suffer in register.

It is known that the employment of water in the process of lithography increases the moisture of the atmosphere of the room in which the printing is going on. It can also be shown that the more moisture a sheet of paper takes up the larger it becomes, and it is easy to see how this is likely to affect the register in colour printing. It is clear then that the hygrometric condition of the printing and drying rooms should be made to assimilate. If it be too dry, the floor may be sprinkled with water; and if too damp, ventilation must be resorted to.

222. But how is the state of each room to be determined? Most practically, we think, by the use of a pair of wet and dry bulb thermometers in each room. Evaporation of most fluids produces a lower temperature. If, therefore, the bulb of a thermometer be covered with a wet rag, the evaporation of the water will cool down such bulb to a lower point than that shown by one having a dry bulb in a similar position. Again, the dryer the room the greater the evaporation; the more rapid the evaporation the lower the temperature. So the difference in the readings of two

similar thermometers, the one having a moistened bulb and the other a dry one, shows with great exactness the hygrometric condition of the atmosphere. If, however, the air of a room were saturated with moisture, no evaporation would occur at the wet bulb thermometer, which would therefore show no fall of temperature as compared with the dry bulb. It follows from this explanation that when the room is dryest there exists the greatest difference between the readings of the two contiguous thermometers, the wet bulb and dry bulb; and when it is most moist there is the least difference in the readings. By the help of two pairs of instruments it should be possible to fairly keep the air of the two rooms in a similar state of moisture or dryness, and we are quite convinced that the purchase of such instruments,—they may be obtained at all vendors of scientific apparatus,—would prove a profitable investment to any one engaged in colour printing. Not only would the instruments be useful as a help in keeping two rooms in a similar condition, but they would prove equally valuable as a guide in maintaining any one room in a proper hygrometric state from day to day. The water used by the printer is fairly unvarying in quantity, but atmospheric influences vary greatly. In practice it would be found that much might be done by the use of extra water in dry weather, and by ventilation in damp weather, to equalise the moisture of the shop, and thereby to improve the register of the work which is frequently so much affected by the variations alluded to.

223. It is not often possible for the printer to know in what condition the paper is delivered to him, whether drier or damper than the atmosphere of the printing-room, and yet this is a point of great importance to him. It is obvious that if it be over-dry, and the printing be commenced at once, an expansion will subsequently take place that will most assuredly throw the first printing out of register. If it be practicable, the sheets should be exposed for a day or two in the printing-room, in the same manner as they will be when placed to dry, so as to be subject to the same atmospheric conditions. If the printing-room cannot be employed they may be exposed in a separate room upon the principles indicated in the last paragraph. Keeping

the sheets together in a mass will be of no service, for it will only make them liable to expand or contract on the edges, which will probably result in their creasing when passing through the machine.

CHAPTER XVII.—TINTS.

THE best mixtures for tints form an important study for the printer, as each subject ordinarily requires special consideration. For this reason some general rules will be of more value than an arbitrary set of combinations of pigments. It should not be lost sight of, that as tints from their very nature contain but a small proportion of colouring matter, the materials to be employed should be of the most permanent kind. In determining what to use it is better to sacrifice a little of some desirable hue and secure a stable tint, than to get exactly the colour wanted by employing pigments of known unreliable character.

The average printer does not seem to realise that in most instances it is desirable that a tint should not only be pale, but broken in colour. He has a predilection for pretty tones, and will use the brightest colours at his command, even though he may have to break them down with some colour that distinctly detracts from their purity, and demonstrates that a colour lower in tone might have been employed in the first instance.

Tints may be either *transparent* or *opaque*, the latter being generally employed. The printer usually finds that it is more easy to print an opaque tint than a transparent one, because he can keep a greater body of ink going for producing uniformity of effect than is the case in printing with a transparent ink.

225. For the production of an opaque tint it is usual to employ a foundation of flake white ink, which may either

be obtained ready-made from the ink manufacturer, or may be ground when mixing the colour. Flake white is not an unexceptionable pigment, because when mixed with some others it is liable to chemical change, and will blacken in the presence of sulphuretted hydrogen gas,—a not unusual constituent of foul and damp air. Lithographic colour-printing, however, is not so liable to suffer from the latter cause as it is from the fading influence of strong light, and, in regard to solar influences, flake white may be described as unexceptionable. If, therefore, care be taken not to employ it along with pigments chemically inimical to it, nor with those easily injured by strong light, flake white will be found a useful basis for tint inks.

Zinc white has a much less objectionable chemical character than flake white, but it is so much inferior in its physical aspects of grittiness, pastiness, and want of opacity, that it obtains but little favour among printers.

226. Transparent tints are formed from the more transparent pigments, and are ground in varnish only. As before stated, they are more difficult to employ than opaque tints, but it is nevertheless very desirable that the printer should obtain a mastery over them, since cases occur in which their use is imperative,—as, for instance, in the finishing colours of most subjects containing many printings.

227. The particular kind of varnish to be used opens up a question of much importance, and we have previously pointed out the principles that govern its employment. We may state here, however, that if the stone has no fine drawing on it to be kept open, the ink may be thin and sloppy; while, on the contrary, it must be stiffened with strong varnish when employed on fine line work, chalk, and etched tints. For the further keeping open of this latter kind of work the ink must be darker in colour than in the former case, so that the effect may be obtained with less ink. On the other hand, care must be taken not to work it so bare as to not fill the grain of the paper.

Opaque Tints.

228. Yellow Tints may be either simply considered as light yellows or as broken ones.

Cadmium yellow works well with flake white, and will be found more permanent than chrome yellows under like conditions.

The *Chrome yellows* are superior in body to flake white, and therefore do not require any of the latter to be mixed with them, and as they vary from lemon to deep orange a great variety of tints may be obtained from them, because one may be modified by another without introducing undesirable chemical mixtures.

Raw sienna and flake white will produce a less pure tint, but one that may be thoroughly recommended for permanency.

Yellow ochre will produce a paler and more sober tint, and may be employed without flake white. The deeper ochres may also be employed with advantage where their hues are suitable.

Naples yellow may be used in some instances. It should not be mixed with any other colour, nor should an iron slab or steel knife be employed.

229. Red Tints of permanent colour may be made of *vermilion* and flake white, adding a touch of crimson or scarlet lake where it is necessary to modify them in that direction. For opaque tints avoid the use of lakes as much as possible. The addition of white to red tends to make it more pinky in hue, and advantage may be taken of this to the partial exclusion of lake from work liable to exposure to light. A tint of vermilion will look more bright after a little exposure than one of scarlet lake and white.

Indian red with white, though not pure in tone, makes a very permanent lakey tint.

Light and Venetian reds with white form a flesh colour of much utility. They may be made more fair by the addition of vermilion, and darker by the addition of Indian red.

Orange red is much used as a flesh tint, but it should be employed without any addition of white. See par. 83.

230. BLUE TINTS.—*Cobalt blue* is well suited for employment in light tints, because it being somewhat weak in colour, more of the pigment is used in conjunction with flake white than would be the case with a more powerful blue, and permanency would thus be favoured.

Prussian blue and white form a similar colour, though somewhat more green, which may be corrected by adding Oriental blue.

Oriental blue and white yield a colourless green and cold than the Prussian blue mixture, but very agreeable in tone. A combination of these two comes perhaps nearer to a pure blue than either of them alone.

Indigo and white is a mixture that should not be resorted to for pale blue. See par. 76.

231. ORANGE TINTS.—These have been partly alluded to under YELLOW and RED.

Burnt sienna and white make a useful mixture, while purer tints may be made from *vermilion* and *cadmium yellow*; or *vermilion* and *raw sienna* in conjunction with white.

Mars orange and *orange ochre* are colours that may also be safely used with flake white for tints.

232. PURPLE TINTS.—Unfortunately, all the brilliant pigments of a purple or violet colour are very fugitive. When brightness is a *sine quâ non* in a tint, the *magenta*, *mauve*, *purple*, and *violet* lakes must be used, but these are all very evanescent, and should therefore be avoided if possible.

Vermilion and *Oriental blue* form a mixture, either alone or in conjunction with white, that can be highly recommended for its great general utility and permanency. Not many persons seem to be acquainted with it, the lakes having so commonly been resorted to that the value of this compound has been generally overlooked. If shown to most printers, impressions in this colour would be pronounced to contain a lake pigment, so near does it come to such connexion.

Purple ochre or *mineral purple* forms permanent tints with white, as also does *Violet de Mars*.

233. GREEN TINTS.—Among greens there is a great choice for the production of tints; but the selection should be carefully made.

Where great brightness is needed, a mixture of *lemon chrome* and *Prussian blue* may be employed in conjunction with white, but white in conjunction with the different hues of the green lakes is, perhaps, more to be relied upon for standing the tests of time and impure air.

Where more sober tones will answer the purpose, they may be obtained from such mixtures as *yellow ochre* or *raw sienna* with *Prussian blue* and white. *Burnt sienna* and the same blue form a yet duller green.

More permanent green tints are afforded by the *green oxide* of *chromium*, and *Rinmann's* or *cobalt green*, which safely mix with white. The green ochre called *terra verte* is a bluish though not bright colour that forms reliable tints in conjunction with white.

In the mixed greens less brilliancy and greater permanency may be secured by employing *Oriental blue* in place of Prussian blue, and still duller tones may be obtained by the addition of a small quantity of black to any of them. A little black ink added to the lighter chromes produces greens of very low tone.

234. BROWN TINTS.—The number of possible combinations of white with other pigments to form brown tints is practically endless. *Burnt umber* forms, with flake white, what is commonly known as stone colour, which designation means, however, nothing very definite, seeing that stones themselves vary very widely in colour. We have said (in par. 127), that any colour may be mixed with umber, but as in nearly all opaque tints the chief component is flake white, it is obvious that it is that pigment, and not the umber, which determines what other colour may be used with it to modify the tint to the hue desired. With this limitation, these two pigments may be made the basis of a most useful series of browns, which can be rendered more yellow, orange, red, or green, by proper additions of colours unaffected by white lead.

Purplish brown tint, however, should not be made from burnt umber basis, because it would need so much additional pigment that it would be best to adopt another colour to begin with. In such a case it would therefore be advisable to add *Indian red* to the white for a foundation.

Raw umber with white forms a tint with a tendency to yellow.

Vandyke brown and white form a tint of warmer hue than *burnt umber*, and, where found suitable as a mixture requiring no modification, it may be used preferably to a more complicated combination.

Where the printer's stock consists principally of the brighter colours, it may sometimes be necessary as a saving of time to employ them in compounding a brown. *Vermilion* and *black*,—the same modified with a little *chrome*, a little *green*, or a portion of *blue*,—may all be employed, as may also those that are mentioned under the head of Red tints.

235. Grey Tints may be formed by a great number of different combinations of pigments, but in practice it is as well to select good foundation compounds and to modify them as required. *Black ink* and flake white yield a normal grey, which may be modified in any direction. Add *Prussian blue* and it becomes inclined to green, if the black ink contained no blue. *Oriental blue* added will give a purer tint, and in this manner any colour may be used to modify the normal tint.

Vermilion and *Prussian blue* make a good grey with white when combined in proper proportions. The more purple mixture of *vermilion* and *Oriental blue* may be considered a good ground for pearly greys.

The foregoing combinations for tints might be increased to almost any extent, but only the most useful have been indicated.

236. To avoid waste of material, first set out upon the slab nearly as much white ink as will print the job in hand. Take a small portion of this upon the palette knife, add a little of the dark coloured ink to it, and mix. It will most probably prove too deep in colour. If so, and the whole mass had been so treated and brought to the same dark tint, a waste would have resulted. If it look but a little darker, the whole may be added to a larger quantity, but it must be remembered that the ink will most likely print much darker than it looks upon the slab. A trial impression having been taken, an idea will be obtained as to whether it will answer the purpose. If too dark, it may

either be lightened by adding more white, or by using less upon the roller; this being determined by the quality of the impression. If the ink be too light, of course it must be darkened by the addition of more dark ink, adding it to a portion only of that upon the slab.

It must be understood that we are not advising experienced colour-printers,—they will know what to do, and long experience makes them too cautious to fall into the error of adding more colour at a time than necessary; but we say to the inexperienced, always modify only a portion of the colour at a time until you arrive at the tint required. Having made a portion of the ink to the proper hue and strength, set a little of that aside upon the slab while the rest is mixed, which done, add the portion set aside to the whole quantity.

Transparent Tints.

237. Having at some length described the making of *opaque* tints, it will be easy to point out the pigments most suitable for *transparent* tints. As a general rule the latter require to be worked with stronger varnish than the former, so as to keep the work open.

238. Yellow.—*Yellow lake* is the most transparent yellow, and next to that *raw sienna.* Where the latter will answer the purpose it is to be preferred because it is permanent. It is more warm in colour than yellow lake, which is of a lemon tone. Sometimes the two may be combined with advantage. *Aureolin* may be used where its price does not prohibit its employment.

239. Red.—The *madder lakes* should be employed for light tints, but they are not sufficiently strong for the darker effects, which may be obtained from *crimson* and *scarlet cochineal lakes.* When less purity of tone is desirable *lac lake* may be resorted to, but where none of these are brilliant enough, the fugitive but vivid *geranium lake* will produce a splendid colour, but it will not stand many days' exposure to sunlight before it is greatly deteriorated.

240. Blue.—The most transparent is *Prussian blue*, but all the blues in use among colour-printers are more or less fit for finishing or glazing.

241. ORANGE.—*Burnt sienna* and the orange-coloured ochres are more or less transparent when used with varnish alone. The red *lake pigments* with *transparent yellow* make the most transparent tints, but they are not permanent. (*See* under heads of YELLOW and RED.)

242. PURPLE.—*Madder purple* is the most reliable colour, though not brilliant. The *cochineal* and *lac* purples come next in order of durability. The *blues* with the corresponding *red lakes* may also be used, and where brilliant effects are imperative, the aniline colours, *mauve* and *magenta* or *geranium lake* with Oriental blue may be brought into use, though we would only use them when compelled, and never for high-class work of permanent value.

243. GREEN.—There are no bright and transparent greens of any reliability, and fortunately they are not likely to be required by the colour-printer, because, when he does use green, it is not in the later printings and usually it requires to be glazed over in the shades with colours of a warm hue. Should, however, a transparent green be a necessity, it is perhaps best formed from *Prussian blue* and *yellow lake* or *raw sienna.* For lower tones of green *Oriental blue* may be substituted. The *green oxide* of *chromium* and *terra verte* may be made use of where their somewhat sober hues are suitable to their employment.

244. BROWN.—Nearly all the brown pigments we have enumerated in Chapter X. are transparent colours, but probably the most generally useful for the colour-printer are *madder brown* and *burnt umber*, either of which may be used by itself, or the two may be combined. For commoner purposes *crimson* and *lac lakes* may be employed with burnt umber where great richness is desirable.

245. GREY.—The better sorts of purple tints before mentioned may be modified by the addition of suitable browns to make good grey tints, which, however, are not often required as transparent printings. It is generally better to employ them as opaque printings in an earlier stage of the work, and then pigments of undoubted permanency are available for their production.

246. The advantages of transparent colours in works of much finish are said by Field to be "to unite and give tone and atmosphere generally, with beauty and life, to solid or

opaque colours of their own hues; to convert primary into secondary, and secondary into tertiary colours with brilliancy; to deepen and enrich dark colours and shadows, and to give force and tone to black itself."

CHAPTER XVIII.—Theories of Colour.

CONSIDERING how frequently the colour-printer is called upon to co-operate with artists and cultivators of science, it comes fairly within the province of this treatise to shortly point out the different theories that have been propounded to account for colour phenomena; the object being to enable the printer to appreciate some matters which his purely practical experience might teach him to regard as contrary to common sense. If he feels interested, it may lead him to study the subject further, and if he is not so disposed it will at least show him that there are other points of view which should be treated with respect and consideration, and that his daily practice affords only one phase of observation in connexion with the subject of colour.

248. A necessary step towards a fuller appreciation of the subject is, to be able to conceive of colour existing not only apart from pigments, but as formed in the brain only. To make this more clear, something must be understood of the mode of propagation of light itself, about which there are two theories. The older is called the "Corpuscular" theory, which conceives that there is an emanation of luminous *particles* from the light-giving object, which produce the sensations of light and colour when received by the eye. There are so many phenomena which are either unexplained by this theory, or are at variance with it, that it is not held by the scientists of the present day, who almost universally admit the "Undulatory" theory as being the true one. This supposes that throughout space there is an elastic ether to which a luminous body com-

municates undulations of transcendent velocity which constitute light ; and that under ordinary conditions these undulations, called waves, proceed in all directions from the luminous body in a manner similar to those produced on the surface of a smooth pond of water by throwing into it a stone. Light travels at a rate approaching 200,000 miles in a second. It is estimated that there are about 50,000 waves of ordinary light in the length of an inch, that they vary from 30,000 to 60,000, and that it is these variations that produce the phenomena of colour, each colour requiring invariably the same number of vibrations of the ether in a given space or time.

249. We may represent a succession of waves by , in which the distance between the tips of two next-lying waves is called the wave-length. These lengths vary for each colour, that for red being the longest, and that for violet the shortest. In recent works of science it is usual to express measurements and weights by the French metric system, and in relation to these wave-lengths to suppose a millimetre, which is very nearly one-twenty-fifth part of an English inch, to be divided into ten million parts, and to express the wave-lengths for each colour in a number of these parts. Thus it has been estimated by Professor Rood* that to the following pigments, which approach somewhat the colours of the spectrum, belong the wave-lengths set opposite to them

Name of colour.	Wave-length in $\frac{1}{10000000}$ mm.
Vermilion	6,290
Red lead	6,061
Pale chrome yellow	5,820
Emerald green	5,234
Prussian blue	4,899
Cobalt blue	4,790
Ultramarine, artificial	4,472
Same washed with Hoffmann's violet BB	4,257

* See "Modern Chromatics," by Ogden N. Rood, in the International Series published by Messrs. Kegan Paul & Co. A work which lucidly states the present scientific knowledge on the subject of colour.

250. When a ray of light from the sun is made to traverse a piece of glass of triangular section, after having come through a hole in the shutter of a darkened room, it does not go straight through it, but is bent out of its course, and if a piece of paper be held to receive the light it will be seen to be no longer what is called white light, but it has spread into larger dimensions and become of the colours of the rainbow. Those who are of an experimental turn may study the same phenomena by placing a narrow strip of white paper upon a piece of black velvet, and by then looking at it through a prism in ordinary daylight.

After the separation of the colours by the prism, if they are collected by a lens and brought to a focus, the light again becomes of its original white colour. From this it is deduced that white light is composed of red, orange, yellow, green, blue, and purple, and although the prismatic spectrum forms a band of colours in which red is at one end, and purple, or rather violet, at the other, yet it may be conceived as forming a circle, as previously shown in par. 10. If we place three spots of colour in the positions of blue, red, and yellow, in that diagram, and then blend them into each other, we produce the intermediate colours of purple, orange, and green, which so-called secondary colours occupy a similar medial position in the spectrum. Having regard to these analogies, a theory was formed that there are in nature only three simple and primary colours, blue, red, and yellow, and that all other colour is derived from them; material substances absorbing and reflecting the elemental colours in various ratios according to their nature. Now, this theory is quite consistent with the practice of the painter and colour-printer, and a system of decorative colouring has been founded upon it that has met with very general approval and about which we shall have something more to say further on.

251. While blue and yellow pigments make green, the green of the spectrum cannot be resolved into blue and yellow, nor can its blue and yellow be made to produce green when both are refracted to one spot at the same time. On the contrary, they are found to make white light.

252. Various kinds of apparatus have been devised for

the purpose of showing the results of mixing coloured lights as distinguished from mixing coloured substances, and it is not unfairly held by scientific men that a true theory of colour should more agree with the results of employing the former than the latter.

Some of the more remarkable facts that do not agree with similar mixtures of pigments are as follows:—

Green and red light produce	......	Orange
Yellow and blue ,, ,,	......	White
Yellow and dark purple ,,	......	Yellow
Purple and green ,,	......	White
Yellow and blue green ,,	......	Yellowish white.

In experiments with coloured lights, then, blue, red, and yellow fail in making the same intermediate colours as are obtained from corresponding pigments, and it is argued, therefore, that they are not, as regards light, primary colours. Dr. Young found that he could produce a much more complete series of colours by variously proportioning red, green, and violet, while Professor Clerk Maxwell chooses scarlet, green, and blue for the same purpose.* Helmholtz considers that red, green, and violet, are nearer the truth than scarlet, green, and blue, but he himself selects five, viz.:—red, yellow, green, blue, and violet as producing primary colour sensations.

It will be observed that, though these three authorities differ, yet there is a consensus of opinion among them that green is a primary and not a compound colour, as would be taught us by the mixing of pigments, and, though a knowledge of these theories may be of very little or no service to the printer in mixing his inks, yet they have a bearing upon the artistic application of them, as systems of harmony and contrast have been proposed which differ according as the older or newer theory is set up as the foundation. A consideration of this matter in the next chapter will reintroduce the student to practical subjects, while the matter in this chapter must be taken as the merest glimpse into a subject about which many volumes have been written.

* The colours chosen by Maxwell are fairly represented by the pigments Vermilion, Emerald green, and Ultramarine.

CHAPTER XIX.

Harmonious Employment of Colours.

AN agreeable selection and arrangement of colours in printing, as in every other branch of decorative art, is a matter of the greatest importance, and one which deserves much study and every consideration. It must be admitted, however, that the printer is often called upon to produce effects more startling than chaste, and more certain to catch the eye of the million than of the refined few, because it is probably the former to whom an appeal is made to become the purchasers of the commodities so glaringly advertised. Novelty is therefore frequently a greater consideration than artistic excellence, just as the vagaries of fashion in dress are in greater favour than sensibly-designed and healthy garments. Even the requirements of showy announcements may, however, have infused into them something of art, if customers will only give the experience of the printer a fair consideration when he submits his point of view for their approval.

When, as is sometimes the case, the choice of colour for the first proofs of a job is left to the printer, he should endeavour to consider the character of his customer. If he knows nothing of him, his connexions, or his surroundings, he might, when taking the order, make some simple suggestion or observation which would tend to draw the customer out and afford a clue as to what he would like. It may be that the printer has very decided notions about matters of colour, which have secured him a reputation that has so favourably impressed the client that he confidently leaves the matter in his hands; but it is not for such prominent printers that these pages are primarily intended. It is possible that what is contained in this treatise may assist in forming and maintaining strong opinions on the subject, among some readers, but we warn them against insisting too strongly on individual predilections, and advise them to submit their opinions with due modesty and discrimination. It must often be the case that the customer's taste differs from that of the printer. Nor is this to be wondered at when it is considered that the *clientèle* to be appealed to is many-sided, while the printer only represents one man's opinion.

254. Before proceeding to point out any systematic principles as a basis for colouring, we will indicate what seems to have been the practice of the old illuminators and herald painters. It is probable that these never had any formulated principles of colour to guide them, and that they simply wrought according to their individual taste, controlled though, it may have been, by a certain consensus of opinion among them as to what did or did not look well.

In heraldic painting it is a rule—and no doubt a good one—*not to employ colour upon colour, nor metal upon metal.* It would thus, for instance, not be proper to paint a red cross upon a blue ground, nor to place a silver one upon a field of gold. The following may be taken as good general rules of practice, and, as they are easily remembered, they will form a good starting-point for the student in the employment of colour :—

A. *Upon any ground of colour use only white, black, and yellow, or gold, in the ornamentations.*

Almost every reader will be able to call to mind instances where good results have followed the application of this rule.

B. *Upon a ground of white, black, yellow, or gold, any colour may be employed.*

C. *Where colours other than white, black, yellow, or gold lie side by side, they should be separated by a band of white, black, yellow, or gold.*

This rule is intended to apply only to ornamental work, and not to natural representations.

D. *In shading ornamental work, the cleanest and brightest effect is gained by employing a darker shade of the same or of a closely similar colour.*

E. *In heightening, or lightening, the illuminated side of any ornament, similar colours of a lighter tint should be employed.*

F. *Notwithstanding the two last rules, it is permissible to employ two contrasting colours on the same band, stem, or other ornament, providing they are separated according to rule* C.

G. *In massing colours the brightest and purest should occupy the smallest spaces, and* vice versâ.

H. *In any colour composition, the colour should be heavier and fuller at the bottom than at the top.*

255. A theory of colouring elaborated by Field, and very successfully carried out by many decorative artists, more especially by Owen Jones, is based upon the principle that in any complete scheme of chromatic decoration all the colours necessary to make white light should be employed in such proportion as will secure what has been called a neutralised bloom. These proportions were arrived at from the following considerations :—that white light is decomposed by the use of a prism into six distinct colours, viz., red, orange, yellow, green, blue, and violet. That of these six colours employed as pigments, three, viz., orange, green, and violet, can be compounded by admixture of some two of the other three,—blue, red, and yellow,—while these themselves cannot be produced by any similar process. That red, blue, and yellow, are therefore primary colours, and form theoretically and practically the equivalent of white light.

By a parity of reasoning it follows that any two of these formed into a mixture and used along with the third are sufficient to fulfil the conditions of equivalents to white light, though so few colours may not be as pleasing to the eye as would be a greater variety of hues fulfilling the same conditions.

256. By a study of the spectrum, followed up by actual experiments on pigments, the numerical value of the colours were determined to be proportioned thus :—Red, 5, yellow, 3, and blue, 8. So, in any decoration in which these three colours were employed of equal intensity the space occupied was to be determined according to those numbers, while, if either were lightened, it must be spread over a space increased in proportion to the degree of attenuation.

257. The value of the secondary colours was obtained by adding together the figures belonging to the primaries

from which they are compounded. In this way green becomes estimated as 11, being formed of blue, 8, and yellow, 3; and so on with the others, as shown in the table which follows :—

If Red	= 5,	yellow = 3,	blue = 8,
then Orange	= 8,	= red 5 +	yellow 3.
Green	= 11,	= yellow 3 +	blue 8.
Purple	= 13,	= red 5 +	blue 8.

In like manner :—

Citrine	= 19,	= orange 8 +	green 11.
Olive	= 24,	= green 11 +	purple 13.
Russet	= 21,	= orange 8 +	purple 13.

258. If in any composition it be determined to employ russet as the predominating hue, that, if estimated at 21, will require to be balanced by 11 of green, or by 8 of blue and 3 of yellow, just according whether it be determined to use two or three different colours. Setting these down in a tabular form for the sake of being rendered more plain to the eye, we have :—

19 citrine balanced by	13 purple or by	8 blue and 5 red,
24 olive ,, ,,	8 orange or by	5 red and 3 yellow,
21 russet ,, ,,	11 green or by	8 blue and 3 yellow.

This table exhibits three dual and three triple combinations of colour, but by adopting the secondary colours as starting-points we command three more pairs of colour, viz. :—

13 purple balanced by 3 yellow.
8 orange ,, ,, 8 blue.
11 green ,, ,, 5 red.

A step further back brings us to the starting-point of the triple combination,—

5 red + 3 yellow + 8 blue.

It must not be supposed, however, that the number of possible combinations has been exhausted. Should it be required, for instance, to employ both purple and orange, what colour should be used to balance them? By inspecting the previous table it is seen that 13 purple requires 3 yellow, and that 8 of orange requires 8 of blue. These, however, taken together are four colours, while only three are wanted, but by adding 3 of yellow to 8 of blue we make 11 of green, which being equal to them is also equal to the balancing of both purple and orange, so we have the triad 13 purple, 8 orange, and 11 green. Similarly we may tabulate the following triple and quadruple combinations :—

13 purple 8 orange	balanced by	11 green or	3 yellow 8 blue,
13 purple 11 green	,, ,,	8 orange or	3 yellow 5 red,
8 orange 11 green	,, ,,	13 purple or	8 blue 5 red.

Here the pairs in the first column may be used with the single colour in the second column to form triple combinations, or with the pairs in the third column to make quadruple ones.

259. By a similar arrangement the tertiary colours may be brought into requisition as in the next table :

19 citrine 24 olive	balanced by 21 russet or	8 orange 13 purple or	3 yellow 10 red 8 blue.
19 citrine 21 russet	balanced by 24 olive or	11 green 13 purple or	3 yellow 16 blue 5 red.
24 olive 21 russet	balanced by 19 citrine or	8 orange 11 green or	5 red, 6 yellow 8 blue.

The above shows three, four, or five combinations, just as the colours in the second, third, or fourth column are used in conjunction with the pairs shown in the first.

It will be observed that the middle colour in each set in the last column has a different numerical value set against it to what has been previously given for it. In fact, it is just double. By examination of the first set an explanation of this and the other sets will be arrived at. The 3 yellow, 10 red, and 8 blue, are the equivalents of the 8 orange and 13 purple, into both of which red enters as 5 in each. Another way of looking at the matter is, that as green enters into both the citrine and the olive it requires 5 of red to balance each portion of green—viz., ten.

260. In treating of these combinations it is supposed that the colours employed have been as nearly as possible the typical ones found in the spectrum. There are, however, a great variety of hues used in practice that more or less depart from this ideal, and the last table affords a good field for the study of some variations in strict accordance with the theory.

Taking the citrine, olive, orange, and purple combination, let us see how far the two latter may be modified in point of colour without departing from the proper theoretical balance. By taking the red from the orange, adding it to the purple, the orange is replaced by yellow and the purple by purple-red, and the resulting combination is one of citrine, olive, yellow, and purple-red. On the same principle the red may be taken from the purple, leaving blue, and added to the orange which becomes scarlet, the combination then being citrine, olive, scarlet, and blue.

But the modification may be made to fall short of the entire transposition of the colour by taking only a little from one and adding to the other. Our sample combination may be modified in the tertiary portion, as by taking away some of the green from the citrine and adding it to the olive to make an olive-green. If the contrary be done the olive will be more purple, while the citrine is made to approach apple-green.

261. What has already been set down in the tabular form, and what has been shown as to the variety of modifications colours may be made to undergo, give some idea of the immense number of combinations that are possible. In addition to these, however, there remains to be pointed out the fact that all these arrangements may again be extended by the addition of white or black to the whole or part of the colours, and by addition of white to some and black to others. The effect on the eye may thus be

totally altered without changing the hues of the colour arrangement fixed upon. Let us revert to our former sample. Suppose in one case the citrine and olive to be balanced by bands of bright blue and scarlet, as indicated in one of the modifications, and that in another case the blue and scarlet were attenuated by being mixed with a large proportion of white, so as to be spread over a wider surface, the general effect of the whole would be different in each case, though both would embody the same theoretical scheme of colour, considered as colour only. A still further difference could be made, on the same principle, by reserving part of the bright colour, for employment on small spaces, while the bulk of it was used in combination with white.

Suppose, however, that the addition of white, while enabling the colour to cover the space required without crudity, yet made it too light, then an addition of black to the white to make a grey would so modify the colour as to make it agreeable, and that also in strict accordance with theory.

262. In introducing the pigments under their various denominations of blue, red, and so on, we have made allusion to the mental effects they generally produce in the observer. Now these must often be taken into consideration in the practical application of colour. The principal points to be attended to are, that some are advancing while others are retiring; that some indicate warmth while others seem to be cool; and that bright colours are assertive while broken hues are modest. It is not difficult, therefore, to see that much use can be made of these qualities of colour in their practical application to decorative work.

Yellow has a tendency to come to the front, while blue is content to keep in the background, and red to hold a middle place. Suppose one were making a design for the decoration of a room, it would be folly to paint anything yellow that ought not to be prominent; nor would it be judicious to use blue for the front member of a moulding unless the object were to tone down the effect of a projection already too great. Should it, however, be imperative that such projecting part should be blue, and yet prominent, the colour employed must be brilliant in hue and light in tone, to counteract its naturally receding quality. In a similar manner the peculiarity of red to hold a middle place may be obviated by lightening or darkening it to get the effect desired, but the same cannot so easily be done with yellow if yellowness is to be preserved. It is more easy to conceive of darkness in connexion with blue and red than with yellow, for as soon as that is degraded beyond a deep golden hue, it seems to be no longer a yellow, but to become a brown.

There is, however, a way of making even yellow retire without destroying its natural brilliancy, and that is by placing lines, dottings, or small diapers upon it in brown or purple in such a manner that the spaces between consist of the pure yellow, which is thus kept down in colour without being destroyed, as it would be by mere mixture.

263. It is sometimes desirable to give what is called a dominant tone to a composition. This is, so far, a departure from the idea of "a neutralised bloom," but it is still possible to conduct such a piece of colouring upon the principles of equivalency where variety of colouring is desirable. If great simplicity be sought, it may be most easily attained by restricting the colouring to varying tones in a low key of the one colour, but where richness is sought it will be better to conduct the colouring on the system of numerical values, departing from it only to give an agreeable prominence to some desirable hue.

264. It would perhaps not be easy to select a better case for illustration than the difference that should obtain in the colour decoration of a winter and of a summer residence. Without going into any argument to prove the proposition, it may be assumed that in summer the most agreeable colouring for an apartment would be one that is suggestive of coolness, while in winter the feeling produced should be that of warmth. In the one case a predominance of blue and in the other of red would be desirable. Not that the apartments should suggest either blue or red, but that these colours should be allowed to exceed the quantity numerically set down as five and eight in our previous exposition, so that either warmth or coolness would be the resulting characteristic according to the colour made to predominate.

This will serve as an instance of a principle which may be varied at the will of the colourist; it does not need further illustration at our hands, because if the student has followed our meaning in the preceding pages he will easily grasp the idea we wish to convey. If he cannot fully comprehend it, the best way will be to begin the chapter again and to carefully note each point as it is set down. In a work of this description one cannot adopt the plan pursued in popular expositions, because the subject of this chapter alone would suffice to fill a volume if it were treated at the length which its importance demands.

265. Having shown how large a variety of possible and agreeable combinations of colour may be evolved from the application of the principle of equivalent values, attention must now be directed to the influence of simultaneous contrast. An explanation of the effects due to this influence has been given in Chapter II., and a careful study of the subject is demanded of all engaged in the practical employment of colour. Vivid colours are stimulating and tiring to the eye-nerves, and if such colours be essential in any composition, and intended to produce their full effect, they must be separated by contrasting or neutral hues calculated to give rest to the eye, so that it shall be able to receive the full value of such colour. Let us suppose that the eye, having been regarding a bright blue, is brought to view a pure red, and that it is required that such red shall influence the eye so as to seem to be a pure red. The influence of the blue on the eye is to dispose it to see orange, so that if the red immediately join the blue, it will appear to be of a more orange hue than it is intended. If, however, the eye in its passage from blue to red meets an interval of grey, or a succession of intervals of russet and green, it will be able to see the red in all its purity. If, on the other hand, the nature of the case compels an almost sudden departure from the one to the other and both are to be bright and pure, the best effect will be obtained by giving to the red a tinge of blue, so as to prevent its appearing of too strongly an orange colour.

We may here take an instance familiar to the colour-printer. If a bill be printed in an ultramarine blue and vermilion, the latter colour will look too orange because, though the eye does not supply an actual orange complement to the blue, as some people suppose, yet it is predisposed by the tiring influence of the blue to see orange among the white light which accompanies the colour next in succession. This, as is well known, is corrected by the addition of a lake to the vermilion, which helps to better satisfy the eye. Let attention be now paid to the influence exerted by the red upon the blue. The eye having dwelt upon the red becomes more disposed to see green, but the ultramarine blue, being already somewhat tinged with red (that is, it somewhat approaches violet), does not require any further addition of red to counteract the tendency to green which would otherwise ensue.

Wherever the transition from one colour to another is of the nature neither of a contrast nor of a gradation, each should partake somewhat of the hue of the other, if it be desirable that each shall appear to the eye as pure in colour.

To apply this principle to any other colours is a comparatively easy matter when it is once thoroughly grasped by the practical colourist, and it will therefore be unnecessary to pursue it any further.

266. Having laid before the reader an epitome of the system of harmonious colouring, based upon the theory that the three primary colours are blue, red, and yellow, something may now be said about the practical application of the newer theory. It must be impressed upon the reader that the study of pigments will not help much in this case, and that colour must be treated as colour only. There are several ways of showing that when two coloured lights, such as are seen in the spectrum, are made to fall upon the eye at the same time, the resulting colour sensation is not the same as would be experienced by the mixture of two similarly coloured pigments. These are facts generally acknowledged by the scientific world, and as such we accept them for our purpose.

We have elsewhere (par. 15) alluded to the definition of complementary colours, as those which, when united, produce the sensation of white light. This is the definition commonly received by the votaries of science, and must of course be accepted by the student.

267. Experiments conducted with coloured lights instead of pigments teach that white is produced—

By red and greenish blue,
By orange and blue (Antwerp blue),
By yellow and ultramarine (pure, not French),
By greenish yellow and violet,
By green and purple;

and that, therefore, these are the true complementary colours. An examination shows that they only approximate to those set down in our opening chapters, but it will be seen that these pairs form combinations which are favourites with many persons of acknowledged taste.

A further extension of the principle of contrast of colours, as exhibited by the previous table, is shown as follows:

Spectrum red	is contrasted by	green blue,
Vermilion	,,	less green blue,
Red lead	,,	Prussian blue,
Orange	,,	Antwerp blue,
Orange yellow	,,	pure blue,
Yellow	,,	real ultramarine blue,
Greenish yellow	,,	French ditto,
Yellow green	,,	violet,
Green	,,	purple,
Emerald green	,,	red purple,
Blue green	,,	carmine.

When, therefore, it is desirable in decoration to contrast colours according to this newer, and as at present understood more scientific, theory, the combinations here set down must be employed instead of those that have been treated of before. As a practical system, this latter theory lacks the simplicity and decisiveness of the older one, and is therefore not much employed. Those, however, who prefer, for instance, to contrast purple with green instead of with yellow, can find a reason for it in the newer teaching.

268. Leaving the theories, and relying upon the experience of Chevreul and others, we give the following as having been approved good combinations :—

Pure red and blue.
Vermilion and blue.
Vermilion and Prussian blue.
Red lead and blue.
Red lead and Antwerp blue.
Red lead and yellow green.
Red lead and yellow or orange.

When vermilion or red lead is employed with green the latter should be dark.

Orange with blue or green.
Golden orange and ultramarine.
Golden orange and violet.
Golden orange and purple.
Yellow and violet.
Yellow and purple red.
Dark yellow and green (?)
Greenish yellow and violet.
Golden yellow and purple.
Grass green and violet (best when pale).
Sea green and vermilion.
Sea green and red lead.
Sea green and violet.
Antwerp blue and chrome yellow.
Antwerp blue and Naples yellow.
Antwerp blue and light carmine.
Antwerp blue and ultramarine.

269. The following are considered bad, or at least doubtful combinations:—

Pure red and bright green.
Pure red and yellow.
Pure red and red lead.
Pure red and violet.
Vermilion and bright green.
Vermilion and yellow or violet.
Red lead and blue green.
Orange yellow and purple red.
Orange yellow and pure red.
Orange yellow and sea green.
Yellow and pure red.
Yellow and blue.
Yellow and blue green.
Yellow and green.
Greenish yellow and vermilion, or pure red.
Greenish yellow and orange yellow.
Greenish yellow and Antwerp blue.
Grass green and rose colour.
Grass green and carmine.
Grass green and blue.
Emerald green and violet.
Emerald green and purple.
Emerald green and red.
Emerald green with orange or yellow.
Sea green and purple red.
Sea green and carmine.
Sea green and blue.
Sea green and yellow.
Antwerp blue and violet.
Antwerp blue and purple.
Ultramarine and carmine.
Ultramarine and purple or violet.
Violet and purple.
Violet and carmine.

These combinations set down as of, at least, doubtful desirability, are made less objectionable by lightening or deepening one or both of them, as then they affect the eye in a less decided manner.

270. An inspection of the list of those given as good pairs of colours will reveal the fact that many of them approach closely to the contrasting colours of Field's theory; and it is the opinion of persons who are well acquainted with the science of Chromatics, that as a practical system for the decorator and painter, the older theory is much more readily understood and of far easier application. No set of rules, however complete or scientific, will make a good colourist. Some people have a natural aptitude for the employment of colour which is rapidly developed under favourable circumstances. Such persons have not merely a power to discriminate between the delicate hues presented by nature to the observing eye,—which may, however, be possessed in an equal degree by all persons having healthy and normal visual organs,—but they are able to bring these hues together in agreeable combinations so as to give pleasure to those who have cultivated a taste for chromatic beauty. The rules for the employment of colour are not so much needed for these gifted ones,—though even they cannot but benefit by a knowledge of them,—as they are for those of less favoured capacity; for by the aid of these rules the latter are enabled to produce combinations which, if not of the highest order of merit, can at least be tolerated by the more refined.

The colour-printer, in the course of proofing his work, should be on the look-out for such accidental combinations as frequently occur without being sought for. In trying to arrive at some definite colour by overprinting or mingling of stipple, he sometimes obtains an excellent colour effect which is in itself beautiful, though perhaps not quite what is desirable for the subject under manipulation; if these are taken care of they may often prove useful in suggesting effects which might not be thought of otherwise.

CHAPTER XX

ARRANGEMENTS OF PIGMENTS ACCORDING TO THEIR VARIOUS QUALITIES. HERALDIC COLOURS.

THE following colours being little liable to change under the action of light or impure air should be selected, where otherwise practicable, for posters and show-cards, which, as is well known, are exposed to strong light and other influences detrimental to their preservation. Chromo pictures for framing should also have their inks prepared, as far as possible, from the same pigments.

Yellow.—Raw sienna, cadmium yellow, and the several ochres.

Red.—Vermilion, madder carmine, madder lakes, red ochre, light red, Venetian and Indian reds.

Blue.—Ultramarine, Oriental blue.

Orange.—Orange ochre, Mars orange, burnt sienna, burnt Roman ochre.

Purple.—Madder purple, purple ochre.

Green.—Oxide of chromium, cobalt green, terra verte.

Brown.—Vandyke, bistre, raw and burnt umber, Cassel and Cologne earths, manganese brown, Cappagh brown.

Black.—All the carbon blacks.

White.—Zinc white, constant white, Spanish white.

272. The following pigments, though acted upon by impure air, are but little affected by light, and rank next to those given above as the most eligible for the purposes of the colour-printer, provided they are not used in improper mixtures :—

Yellow.—Chrome, patent yellow, mineral yellow, Massicot, Naples yellow.

Red.—Red lead and chrome red.

Blue.—Cobalt, blue verditer, mountain blue.

Orange.—Orange lead or mineral orange, orange chrome.

Green.—Green verditer, ordinary chrome greens, green lakes, mountain green.

White.—Flake and other lead whites.

273. The following pigments change by light and exposure to pure air, but are not much affected by the opposite influences, and may therefore be used for books and similar work if not otherwise disqualified. Among them will be found some of our most attractive colours :—

Yellow.—Dutch, English, and Italian pinks, yellow lake, orpiment, king's yellow, Indian yellow, gallstone.

Red.—The cochineal lakes, the aniline lakes.

Blue.—Prussian, Antwerp, and indigo blues.

Orange.—Orpiment, sulphide of antimony.

Purple.—Cochineal and lac purples, aniline purples.

Brown.—Brown pink.

274. The pigments which change by admixture of flake white and other lead pigments, and which should not be used with lead driers, are the following :—

Yellow.—Dutch, English, and Italian pinks, Massicot, orpiment, king's yellow, Chinese and Indian yellows, gallstone, yellow lake.

Red.—All the cochineal and lac lakes, carmine, rose pink.

Blue.—Indigo.

Orange.—Sulphide of antimony, orange lead, and orpiment.

Purple.—Burnt carmine, purple lake.

Brown.—Brown pink.

275. The following pigments are the principal ones compounded from lead :—

Yellow.—Naples yellow, patent yellow, Massicot, chrome yellows.

Orange.—Orange lead, orange chromes.

Red.—Red lead, chrome red.

Green.—Any compounded from the above yellows with blue, such as common chrome green.

276. The following pigments should not be used with a steel palette knife, nor on an iron table ; nor should they be mixed with pigments containing iron :—

Yellow.—Naples, Chinese, king's, and patent yellows.

Red.—Carmine, scarlet lake.

Blue.—Blue verditer, mountain, and intense blues.

Orange.—Sulphide of antimony.

Green.—Verdigris, green verditer.

277.—These pigments contain iron, and are therefore not suitable for mixing with the foregoing (par. 276).

Yellow.—The ochres, raw sienna, Mars yellow.

Red.—Indian red, Venetian red, light red, red ochre.

Blue.—Prussian and Antwerp blues, Chinese blue.

Orange.—Mars orange, burnt sienna.

Green.—Prussian green and the common chrome greens containing the above blues.

Brown.—Prussian brown.

278. The following colours are transparent and suitable for finishing, if eligible in other respects :—

Yellow.—Raw sienna, Indian yellow, gallstone, yellow lake, English, Italian, and Dutch pinks.

Red.—Madder lakes, madder carmine, the cochineal, lac, and similar lakes, aniline lakes.

Blue.—Ultramarine and cobalt blues, Prussian, Chinese, and Antwerp blues, indigo, and intense blue.

Orange.—Madder and Mars orange, burnt sienna.

Purple.—Madder purple, burnt carmine, cochineal, lac, and aniline purples.

Green.—Chromium oxide, Prussian green, terra verte, verdigris.

Brown.—Madder brown, burnt umber, Vandyke brown, Cologne earth, bistre, brown pink, Prussian brown, asphaltum.

279. We will close this chapter with a short account of heraldic colours and of the method used by engravers to represent them in black and white.

Argent may be silver, the pearl, or white, and is represented in engraving by leaving the space white. It is symbolised by ☽, the Moon.

Or may be gold, the topaz, or yellow. It is indicated by finely dotting the surface. Symbolised by ☉, the Sun.

Gules is red, vermilion, and represents the ruby. For it the engraver makes vertical lines. Its symbol is ♂, Mars.

Azure is blue, the sapphire, indicated by horizontal lines. Its symbol is ♃, Jupiter.

Vert is green, represented by the emerald, and indicated by lines in the direction of the downstroke of the letter V, thus, \\\. It is symbolised by ♀, Venus.

Purpure is purple; the amethyst represents it. Its lines correspond to the upstroke of the V, ///. Its sign is ☿, Mercury.

Tenne is orange. Among the precious stones the jacynth is appropriated to it. The engraver represents it by the crossing of the lines devoted to *Vert* and *Purpure*. Its sign is ☊, the Dragon's head.

Sanguin is murrey, or dark red, and is represented by the sardonyx stone. In engraving the lines are horizontal, crossed by diagonal ones in the direction used for green. It is symbolised by ☋, the Dragon's tail.

Sable is black, and, strange to say, it is represented by the diamond, and was so generations before it was discovered that this precious mineral is only a crystallised form of carbon. The engraver, to indicate it, crosses the lines vertically and horizontally very closely in copperplate engraving, so closely indeed that it looks nearly black. Its symbol is ♄, or Saturn.

CHAPTER XXI.—Transparency Printing.

THE printing of transparent trade announcements is carried out in but few lithographic establishments. It has been made the subject of a patent, and, though we cannot see how such work can be considered to be an invention, it being more of the nature of a happy thought, yet there is no doubt that the fact of its having been patented has deterred many printers from practising it who would otherwise have entered the field of competition. We propose, therefore, in this chapter, to point out how such work may be accomplished.

281. One of the principal elements of success is the selection of a proper paper. One of the chief distinctions between English and Continental papers lies in the sizing. Our home-made papers are usually, if not invariably, sized with a resin soap in conjunction with gelatine, which produces a more impervious paper than foreign makes, in which starch is the sizing material employed. If a sample each of English and French writing-paper, of similar weight and substance, be taken and sprinkled with a few drops of turps, it will be found that more time will be taken to penetrate the former than the latter. The foreign paper will take it so readily as to become instantly transparent. It follows, therefore, that it is easy to determine what paper is most suited for this kind of work; all one has to do is to put a little turpentine, or oil, upon the face of it, and if it penetrates quickly and without patches it will answer the purpose. A foreign bank post of good substance is a paper that will answer for this kind of printing, so that there need be no difficulty in obtaining what is needed.

282. It may be thought that the ordinary tracing-paper of commerce would furnish all that is necessary as a basis for the colour printing, but a little reflection will show that it does not fulfil some of the essential conditions. Tracing-paper is prepared with a varnish which penetrates its substance and remains there. It is evident, therefore, that any colour printed upon it will be less rich in effect than is the case where the ink can be absorbed by it, and such a transparency would, consequently, prove less striking.

It will not be found necessary to use any large quantity of varnish in the ink, but it must be made with transparent pigments, such as Prussian blue, yellow lake, rose and crimson lakes. As a red, vermilion is not of much service, because it is but slightly translucent, yet for some effects it is useful, and may be employed in shading a more transparent red colour.

To get a rich effect as good a body of ink as can be effectually printed must be employed, because, when viewed as a transparency, the printed portion appears much lighter than it does when seen by a reflected light.

283. Frequently these prints are fastened to shop-

windows, and have to do duty and be fairly effective by daylight as well as at night when a gaslight is behind them. Such prints must be modified to that special purpose in the designing, and in such case bronze may sometimes be used advantageously to be seen as a light colour in front, but as a dark one when illuminated from behind.

In practice these transparencies are printed upon paper as thin as can be successfully manipulated, with transparent colours for the masses, and opaque ones for the shading. Enough dryers must be used to well fix them, and when quite dry the prints are varnished at the back so as to permit light to more readily pass through them.

284. The varnish must be applied from the back, because, if used on the front, it would not only be more liable to disturb the colours, but the latter would help to keep out the varnish from the paper, and at such places the colour would be less translucent. When it is applied at the back, it can penetrate quite to that portion of the ink which has entered the paper.

285. On some of these transparencies there may be seen an effect, as if the varnish had not been applied to some parts, and a less transparent result is attained, such as a diapered ground, or borders to the letters, and suchlike. This may be effected by printing a white at such parts, which will give a certain amount of opacity that is very pleasing, and possesses somewhat the appearance of ground and polished diapered glass.

286. This reference to glass reminds us of another application of lithography to transparencies in which it is the ink only that is transferred to glass.

By referring to the "Grammar of Lithography" the mode of printing for this application will be found described under "Decalcomanie," with this difference that the printings need not be reversed, as there explained, nor must any attempt be made to back up with white. After the printing has been done in transparent inks on the coated paper, it is transferred to the glass, and the gum composition carefully washed off to prevent subsequent cracking.

287. If it be desired to get the same effect on the glass as is obtained by translucent paper, the glass may be ground.

If it be wished to preserve the dead appearance of the ground glass, the varnish cement cannot be employed, because that would too effectually restore transparency to the roughened surface. In this case a new varnished surface must be printed on, or laid on by hand, to the already printed surface, omitting the groundwork. Indeed, the varnish must be only applied to what has been previously printed, unless it be desired to restore transparency to the ground glass for producing diapers and suchlike. The newly-printed varnish having been applied to the glass, it is then put aside to set and harden previously to the print being soaked off in the usual way.

288. Another application of the transfer method, though not as transparencies, comes so naturally into this place that we proceed to mention it.

The imitation of painting on glass is readily accomplished thus:—Transfer a non-reversed decalcomanic print to glass by a liberal use of crystal varnish, being very particular to exclude air-bubbles; let it harden and then remove the print by soaking in water, and wash away the soluble coating of the paper from the back of the glass. The back ol the whole may now be covered with opaque white paint, or it may be painted white at the back of the subject only, and when that is dry the rest of the ground may be gilded or painted of another colour.

If the middle of the letters of a showbill so treated be left uncovered, crumpled metal foils may be placed at the back with excellent effect, but an arrangement must be made in framing that the backing board do not press upon it.

289. Crystal varnish is the best we know of for transparency work, because it is but little liable to change. It may be made by mixing equal parts of spirits of turpentine and Canada balsam by means of heat applied through the medium of a water-bath. Copal and other cheaper varnishes may be used, but they are not so colourless as that made from balsam, and therefore do not answer so well the intended purpose.

CHAPTER XXII.—VARNISHING SHOW-CARDS, ETC.

WE have often been asked for information connected with the varnishing of show-cards, labels, &c., and have been requested to supply "the most recent and best methods." We may at once say, that to do this would involve a knowledge of everybody's secrets, to which we have no pretension. It will be readily understood that these requests come from the country and abroad. In London and some other large towns the advantage is possessed of being able to employ persons who make this kind of work a special study and occupation, so that the master-printer does not trouble himself to ascertain what are the exact means employed, for if he did, the probability is that the varnisher would take every care to preserve his secrets, for which not many would blame him. It would, therefore, be presumption on our part to pretend to say that the methods we have to communicate are either the best or the most recent. Circumstances influence the choice of varnishes, which, like most things, vary in quality and in price. There are cases where the commonest varnishes will be found good enough, and others where mere sheen is insufficient. When the main object is to simply heighten the colour and give a gloss, low-priced varnishes, which are easily abraded and scratched, may well answer the purpose, but other circumstances will perhaps demand the combination of both hardness and toughness.

291. To those who are interested in carrying out the process of varnishing on their own premises, we recommend the purchasing of varnish samples from various houses and of different qualities, then fairly try them, and be guided by the result; complete knowledge is thus gained of that which will not answer the desired purpose as well as with

that which will. In carrying out these experiments the varnishes must be classified and notified, so as to ascertain how far the different claims of their manufacturers are substantiated under trial. It must be noted first how they behave under the operation of laying on; how long they take to dry, so that they bear fair handling; how much longer they take to dry before the work will bear packing; for a varnish may be seemingly dry and yet become very sticky when long in contact with another surface. When thoroughly dry and all tackiness is removed examine them as to hardness, toughness, liability to scratch, &c.

292. Varnishes may be divided into:—Aqueous, alcoholic, and turpentine varnishes, according to the nature of the solvent. Aqueous solutions of gums, &c., are generally employed on paper to bear out the varnish proper subsequently applied. Alcoholic or spirit varnishes require to be laid on very quickly, evenly, and surely, so as to avoid going over the same place twice, as they dry very rapidly. They require either the surface they are to be applied to, or the room in which the work is performed, to be kept warm, as at an ordinary temperature they are apt to chill and become dull. It is not merely because the spirit is an alcoholic one that this chilling takes place, but that all commercial spirits of wine contain a considerable proportion of water, and if the temperature be low the spirit evaporates and leaves the water behind, which breaks up the surface and makes it appear dull. When the room or the article is warm enough the evaporation of the alcohol and the water takes place almost at the same time, and consequently a brilliant surface is left. The stronger the spirit employed the less likely the varnish is to become chilled, but the more dexterity is required in laying it on. When turpentine varnishes are employed the difficulty of chilling does not ordinarily happen, because the spirit or oil is not liable to the defect of containing two distinct fluids of different natures, the one being a solvent of resin and the other not, as in the case of spirits of wine. The chief point to consider in manipulating these varnishes is not to make them frothy by too much working of the brush.

293. The proper selection and maintenance of brushes is

of much importance. They should be wide, elastic, and neither too hard nor too soft. The hair should be long, but a new brush will not work so satisfactorily as an old one with about a fifth or a fourth of its length reduced by wear. If it be required to utilise an old oil-brush, it must be thoroughly washed in spirits of turpentine, which must be squeezed out as far as possible and finally dried by rubbing it upon a piece of old linen. The varnish must be well worked into it before using it upon its proper work. Brushes are best kept suspended in their varnish in a narrow can, the hair not touching the bottom or sides. Some persons keep them in turpentine or wash them out, but neither plan is good. If kept in turps and then put into varnish, it will be some time before they will work evenly, as the turps will gradually mix with the varnish and render the work uneven. The system of washing out will necessitate the use of so much turpentine that it will not be found economical. It is, moreover, liable to be ill done, and then the brush is spoilt by reason of some of the resinous matter being left behind.

294. The gum resins suitable for the manufacture of varnishes for white paper are not numerous. Some of them are soluble in spirits of wine and not in turpentine, some in turps and not in spirits, while others are soluble in both. Some are freely soluble, while others require long digestion assisted by heat. Here we may digress to point out that great caution is required when heat is employed, as there is great danger of the vapours catching fire and doing mischief. Possible sources of fires should be guarded against by all printers.

295. Nearly all papers require a preliminary coating of a sizing material to enable them to bear out the varnish, which would otherwise penetrate their substance and make them semi-transparent. When the paper is very soft, such as a plate paper, it should have a first coating of starch paste, which will bear out the gelatine sizing afterwards laid on. It is often best to give two coats of size, but that must depend upon the nature of the paper and the ability of the workman, who can often make one coat quite as effective as two. Before, however, any size is employed, the printing must be thoroughly dry, or the size will not

adhere firmly to it. The size may consist of any kind of good gelatinous matter free from grease. Isinglass, parchment cuttings, transparent gelatine, fine glue, are all suitable. Gelatine itself may be employed as a varnish if a solution of chrome alum be added to it just before using, and it must be kept warm so as to avoid its setting. The chrome alum will prevent its resolubility, so that if the paper so varnished be subsequently wetted, even by hot water, it will only swell up a little, but will not dissolve. Paper may be floated on a dish of such solution instead of employing a brush. In employing parchment cuttings, boil them till they form a stiff jelly on cooling: for isinglass and gelatines about one ounce may be put into a pint of water, allowed to stand all night, and then dissolved by heat. Very fine thin gelatine may be obtained that only requires a very short time for soaking before solution.

296. Mr. H. Mayo, of Birmingham, gives the following instructions for using the spirit varnish supplied by him for show-cards, &c. In the main they correspond with those we have already given, but in a few points where he is more precise we gladly quote him. He says:—"The brush must be a flat camel-hair, about five inches wide, double filled. The pot ought to be of earthenware, not too deep, to hold about a quart, with a cover to fit. Tie a string round its rim, and from it another across the top, for the purpose of drawing the brush over when too full. Always put the brush back into the pot. The varnish may be thinned by the addition of methylated spirit." He adds further, that "the best papers for printing upon, which are intended to be varnished, are enamel and drawing papers, which, if good, do not require sizing." Our readers must not, however, accept this statement without qualification. It is equivalent to stating that papers which are already heavily sized do not require further sizing. It will occur to all litho printers that these papers are not suited for some work. The suitability of the paper for the kind of work in hand is of primary importance, and should be duly considered. In many instances, no doubt, highly-sized papers may be employed, and then no after-sizing will be necessary for quickly drying spirit varnishes, but where beauty of impression is paramount, a soft paper must be

used, and then subsequently sized. In this connexion we may draw the notice of the reader to the advantage of rolling all work previously to varnishing it. The application of the sizing fluid has a strong tendency to make the paper rough, just the same as the wetting of letter paper spoils the gloss obtained by milling. The varnish has not this influence on the paper. It, therefore, follows that it will take less varnish to produce the proper effect on a smooth surface than on a rough one, and we think it will save the cost of the rolling in making the varnish go further, besides the advantage got in the improvement of the work. The application of a watery fluid to paper and card tends also to destroy its flatness. This the rolling will in great measure restore.

297. In our Recipes for Varnishes, we shall select those that have distinct features. It will be obvious to those who look over them that other proportions and selections may be made. We have something, however, to say about the solvents.

The spirits of turpentine should be of the best quality. This and benzole should be free from greasy matter. To test it, apply a little to a piece of fine printing or plate paper, and observe whether on drying it leaves any stain. It should leave none. Or a little may be put upon a piece of clean glass, when it should evaporate without any residue. Alcohol or spirits of wine may be either pure or methylated. The latter is quite as good for the purpose as the former, and about one-fourth its price. Methylated spirit is also of two kinds, one called "finish spirit" contains a little gum lac, which renders it unfit for some purposes. The other contains no addition except the methylic alcohol, which is used to make it too nauseous for a beverage. The addition of methylic spirit, however, in no way retards its usefulness in other respects, and therefore fully answers its purpose of protecting the revenue, while it is a great boon to the manufacturer to be able to employ an efficient spirit without having to pay the heavy duty imposed upon it when intended for the purpose of drinking.

The strength of all alcohol, whether contaminated with methylic spirit or not, is judged of by its comparative freedom from water. What is called "proof-spirit" is that degree of strength which allows the explosion of gunpowder when saturated with it. The following may be employed as a test, a weaker spirit not being fit for varnish. Put a small quantity of gunpowder in a teaspoon and fill it up with the spirit to be tested. Set the spirit on fire, and when it burns down to the gunpowder the latter will also take fire and explode if the spirit be "proof" strength. Spirits are denominated as "over" and "under" proof. The first is written "O.P." and the latter "U.P." Methylated spirit may be had as high as 64 o.p., but we believe it cannot be obtained in the market in any higher degree. Alcohol absolutely free from water would be represented by 100 o.p. A fair approach to this strength can be obtained under the name of *absolute alcohol*, but on account of it being expensive to manufacture, and being an article on which the duty is levied, and for other reasons very dear, it is little in demand.

Another mode of testing spirit is by comparing its weight with that of water, and when great accuracy is required, instruments called hydrometers are employed. The better of two samples can easily be selected by successively filling the same bottle with them and carefully noting the weight of each. Alcohol is lighter than water: therefore that bottleful which weighs the lightest is also strongest. Turpentine and benzole may be tested in a similar manner; for, although they are not mixable with water, they may contain resinous matter which increases their weight; therefore the lighter sample will be a stronger solvent for the gum resins to be added in varnish-making.

Benzole is a comparatively new spirit, and has probably not yet been fully tested as a solvent for resins, &c., suitable for varnishes. With dammar resin it is employed as a varnish by many photographers. It will probably be found to replace turpentine as a solvent in many instances. It is very quick in evaporating, and great care must be taken in its employment on account of the extreme inflammability of its vapour. It is possible also that advantage may be taken of its power of dissolving pure caoutchouc to employ it in that connexion for toughening varnishes otherwise brittle.

In selecting gums and resins, choose the lightest and brightest-looking pieces, because for the purpose intended the varnish must be as free from colour as possible. Any dark or dirty samples would only deteriorate the varnish, and their employment would be false economy.

On account of its quick-drying quality, alcoholic or "spirit" varnish has, of late years, become a great favourite for glazing printed work; but it requires much experience, as we have before said, to lay it on evenly with the brush, and much thought has been bestowed on the problem of applying it by machinery. There are now more than one make of varnishing machine to be had, and the following description will serve to give an idea. The sheets are fed into a gripper in a similar manner to the feeding of sheets into a litho-machine, and are carried round with the cylinder, and brought into contact with an indiarubber roller covered with the varnish, which is supplied to it from a receptacle like an ink-duct on a printing-machine, and which can be regulated in a similar way. A self-acting arrangement keeps the varnish in the duct apparatus always at the same height, and supplied from a reservoir, so that as long as this reservoir contains any varnish the supply will remain good in the duct. The sheets are removed by an attendant, and laid upon a travelling apron, whence they are taken by other attendants and hung upon lines to dry in the usual manner. It is said that on suitable paper the machine will successfully varnish sheets immediately after they are printed, without smearing the ink in the slightest degree, at the rate of 600 or 800 sheets per hour, with an expenditure of one-quarter horse-power for driving it. When the work requires previous sizing, the same machine may be employed for effecting this, as it makes little difference in working it whether it be employed in varnishing, sizing, or gumming. A clean-up is all that is necessary in changing from one kind of work to another.

Recipes for Varnishing.

298. The following recipes have been selected from various sources and to the best of our judgment, but we do not undertake to say that there are no inaccuracies, either of

substance or proportion. We believe our selection is a careful one, as we have rejected those which have appeared to us unsuitable, either from promising to be of bad colour or demanding too difficult manipulation. Many of the ingredients appear in different recipes, in conjunction with others and in different proportion. In making experimental trials, the simplest mixtures should first be selected, and then additions made and their effects noticed. An acquaintance with the values of the component parts will thus be more quickly attained.

Spirit Varnishes.

299. Gum sandarach, 10 oz.; gum mastic, 4 oz.; camphor, ½ oz.; digest with 24 oz. of alcohol 64 o.p.

Gum sandarach, 4 oz.; gum mastic, 8 oz.; copaiba balsam, 4 oz.; white turpentine, 6 oz.; spirits of turpentine, 8 oz.; alcohol, 5 quarts. Digest at a low heat.

Mastic and sandarach each 4 oz.; alcohol, 30 oz. When dissolved add 8 oz. Canada balsam, and dissolve it by help of gentle heat and frequent shaking.

Sandarach, 8 oz.; mastic, 4 oz.; Canada balsam, 4 oz.; alcohol, 2 pints. Make as last.

Sandarach, 5 oz.; mastic, 1 oz.; gum anime, ¼ oz.; alcohol, 1 pint. Dissolve by gentle heat in a clean vessel.

Gum sandarach, 8 oz.; clear turpentine, 3 oz.; alcohol, 1½ pint.

Gum mastic, 4 oz.; gum juniper, 8 oz.; turpentine, 1 oz.; alcohol, 2 quarts.

Sandarach, 6 oz.; elemi, 4 oz.; anime, 1 oz.; camphor, ½ oz.; alcohol, 1 quart.

Dissolve 2 oz. of orange shellac in 16 oz. of rectified spirits of wine. This varnish possesses the characteristic colour of shellac, and consequently is not fit for work containing any purity in the whites or colours. To bleach it add 4 oz. of freshly burnt animal charcoal, and boil it for a few minutes in a water-bath. The charcoal should decolorise it. To know if this has been effectually performed, filter a portion of it through a piece of silk, and again through white blotting-paper. If this portion be colourless the whole may be treated the same way. If not clear enough add more charcoal and repeat the boiling. A similar varnish may be made with bleached shellac, which does not require the employment of charcoal, but it will be found that the bleached shellac is not quite so readily soluble as the natural product.

TURPENTINE VARNISHES.

300. Boil Chio turpentine till brittle, then powder and dissolve in spirits of turpentine.

Canada balsam, 6 oz.; white resin, 6 oz.; spirits of turpentine, 1 quart. Dissolve.

Canada balsam, 2 oz.; spirits of turpentine, 4 oz. Warm and stir until the balsam is dissolved.

Canada balsam and spirits of turpentine of each 1 oz. This is also known as Crystal Varnish.

Best and whitest resin, 8 oz.; spirits of turpentine, 1 pint. Powder the resin, and warm by means of a water-bath until dissolved.

Take of gum mastic of fine quality 8 oz., of spirits of turpentine, 1 pint. Set it in a sand-bath to dissolve.

Dammar gum, 5 oz.; gum mastic, ½ oz.; gum sandarach, 2½ oz.; spirits of turpentine, ½ pint. Digest in a water-bath until dissolved, stirring or shaking it occasionally.

We have purposely omitted from the foregoing recipes all varnishes containing gum copal, on account of the special requirements for fusing, it being quite unlikely to be employed by those who make varnish for their own use. The oil varnishes we have also not given on account of their slow-drying qualities; nevertheless, drying-oil may be an advantageous addition, in small quantities, to any turpentine varnish that proves too brittle.

For printed window transparencies a varnish containing pale drying-oil is of great importance, for being thin and easily bent, they are very liable to be injured if the varnish is not tough. Some of the above varnishes, with the addition indicated, may prove useful; but we recommend in preference the employment of good coach-body varnish, sufficiently diluted with turpentine to enable it to be laid evenly on the thin paper. This varnish consists of copal, drying-oil, and turpentine, commoner qualities having a proportion of gum-anime in their composition.

We cannot close these articles without again cautioning our readers against the risk of fire, &c. We recommend any experiments in heating the solvents to be conducted out-of-doors until their nature is so thoroughly understood that the experience and confidence gained enable the operator to work with them safely in a closed apartment.

CHAPTER XXIII.

Mechanical Aids to Artistic Work.

ARTISTS generally look with disfavour on mechanical means of operating, but when the work to be done is of itself mechanical, whether effected by manual labour or not, then even the most conservative will be found to hail the advent of more rapid methods.

It is not merely stippling, however, that is accomplished by Day's Patent Shading Mediums; but all varieties of line-work, for which the lithographer has been hitherto dependent upon transfers from engraved plates, can quite as easily be effected as, and more expeditiously in many cases than, by the older methods. Not only does this system successfully perform all that can be done by transferring from line and stipple plates, but it goes much beyond, and produces effects that could not be secured by former methods in lithography. This will be understood when we point out that lines and dottings can be accurately thickened where required, and effects obtained exactly similar to what is seen in the skies of good wood-engravings.

The most generally useful adjunct in this connexion is to be found in prepared sheets of gelatine, having lines, dots, &c., *in relief* on one side, while they are smooth upon the other. They are transparent, and similar in substance to the gelatine film familiar to the artist for tracing pictures for key-stones. This transparency is a very valuable feature, because it permits the outlines, &c., of the drawing on stone to be readily seen, and enables the artist to know what he is about. The lines on these films being thus in relief, they can readily be inked up in transfer ink by means of an ordinary letterpress roller, which is a far more simple operation than pulling transfers at a press.

302. Having fixed our reader's attention upon the simplicity of these films, he will probably require to know how they are best used. Here a little necessary complication steps in. It is true, they may be held by one hand while they are burnished on the back by the other, and so transfer the work on them to the stone; but it requires something more to make the best of them. The film is stretched upon a frame having hinges removable and adaptable to any size frame. The hinges are secured to adjustable plates on a bar, so as to enable the operator to place his film just where it is required. One of these plates carries a screw pintle which is adjustable, while the other is provided with a spring, so that the frame can be removed at pleasure and set back again to exactly the same position; thus providing for a re-inking of the film when needed. The pintles, or pivots, are held by nuts; and, by means of the screws, to which are attached little dials and pointers, the frame can be moved to throw the shading lines out of register when it is required to thicken them. The movement of one degree on the dial represents $\frac{1}{500}$ of an inch, while a complete turn indicates $\frac{1}{32}$ of an inch. By means of a resetting of the adjustable pintle, the frame may be moved in the opposite direction. These very ingenious little contrivances are a great power in the hands of the artist. A movement of $\frac{1}{500}$ of an inch enables him to perceptibly thicken a line, while a greater movement permits of lines being made between those previously rubbed down. Thus, if the lines transferred first are supposed to be $\frac{1}{80}$ of an inch apart, a movement of the frame $\frac{1}{160}$ of an inch will just double the number of lines and produce the same effect as lines 160 to the inch. It will easily be understood, however, that this movement may be divided into two or

three operations, with a rubbing down to each, the result being a thickening of the lines to the extent of making them twice as wide. This process may, indeed, be carried so far as to make the lines so thick as almost to touch, and here will be seen the necessity of having the means of detaching the frame, applying fresh ink, and putting it back again in absolutely exact register. Stippling may be thickened in a similar manner, and various patterns of grain can be produced out of one plate.

303. Yet a further power the artist possesses over these films, in the fact that they are, to a considerable extent, elastic; so, by applying greater pressure to the style or burnisher, a stronger effect is produced upon the stone. Then, again, by putting wavy lines over straight ones, light stipple over darker, and stipple over lines, a great variety of texture may be produced. It will thus be seen, from what we have stated, that not only is there a great saving in labour effected by this invention, but the results are such as are unattainable by hand labour.

But to revert again to our description of the apparatus. The bar to which the frame is attached is fastened by clamps to two cross-bars, which are, in turn, borne each by two adjustable posts secured to a board. By these arrangements the apparatus is adaptable to any size and thickness of stone, and completely under the control of the artist.

The invention has been patented, and the claims in the specification are very comprehensive, and cover the "Method of lining, shading, stippling, hatching, graining, printing, or tinting pictures or other objects in one or more colours, which consists in applying pressure to the back of a printing film, having *an inked printing face* in relief"; and "the method of forming light or heavy, straight, swelled, or wavy lines, stipples, or grain and combinations thereof, which consists in applying a variable pressure by the action of a stylus or other instrument to the back of a printing film having elastic or yielding printing faces."

CHAPTER XXIV.

Machines for Enlarging and Reducing.

Fougeadoire's.

MACHINES for Enlarging and Reducing by means of the elastic properties of indiarubber have been in use now for a considerable number of years—long enough, indeed, for the process to be considered old rather than new. The process once proposed, the genius of inventors has devised various practical means of carrying it out; consequently, we hear from time to time of improved contrivances to effect the object. One of the most recent of these is a machine brought out by M. A. Fougeadoire, of Paris.

The mechanism seems to have been brought to the greatest degree of simplicity consistent with efficiency. By merely turning a handle the indiarubber surface expands or contracts equally in all directions; while by disconnecting a wheel the dimensions can be altered in one direction only—that is, either in height or breadth, at discretion; thus a circle may be turned into an oval. The indiarubber is attached by eyelets and hooks to bars on its four sides, the opposite ones being held parallel, and in any position, to form either a square or a parallelogram. By means of cramping-screws which are part of the mechanism, always in proper position, the four bars form a frame which is detachable from the main part of the machine, so as more readily to take an impression or lay it down upon the stone, which latter operation must be performed by one pull only. The *modus operandi* is as follows.

Either an enlargement or a reduction may be required. If the former, the indiarubber is laid upon the machine, and the handle turned sufficiently to stretch it only a little, to make it smooth and taut. The surface is next covered with a patent elastic transfer-composition, supplied by the maker, and which is then dried. The impression is now pulled upon it in re-transfer ink, the frame being removed from the machine in order to admit of this being done. It is afterwards replaced upon the machine, and then, by turning the handle, brought to the desired size, and fixed in position. It is finally taken off the machine, placed upon the stone, and transferred by one pull through.

Supposing a reduction is wanted, the indiarubber is placed upon the machine and slightly stretched as before. Two dots may then be placed upon it to indicate the size to which the subject is to be reduced. The rubber is then stretched until these two dots are separated far enough to represent the corresponding actual dimension of the subject. The frame being taken off the machine, an impression is pulled upon it rather bare of ink, and, being returned to the machine, the indiarubber is slackened until the reduced size is arrived at. It is then fixed in that position, and the frame removed for the re-transfer.

When an alteration in proportion is required, the handle is turned, and the subject equally altered until one dimension is arrived at. The proper wheel is then disconnected, and the alteration made in one direction only.

By an ingenious arrangement of helical springs in connexion with the hooks holding the rubber, their proper sliding upon the bars is accurately insured, thus obviating a serious defect in many previous contrivances.

We may add, that the agency for this country has been placed in the hands of Messrs. Benjamin Winstone & Son, of 100, Shoe-lane, London.

Pieper's Precision-Pantograph.

305. "Carl Pieper's Precision-Pantograph" is based upon the same general principles that underlie the construction of the one just described, but it varies in details, and is supplemented by a special press which, doubtless, adds much to its efficiency, and enables wood-blocks and other type-high surfaces to be readily brought under its action. In connexion with it there are also two wood

supporting-frames, which will not only prove very useful when operating, but will form a stand for the machine. The press used is a platen, and therefore different to anything the lithographer usually employs ; but it will be found in practice that this kind of press is least likely to put the indiarubber out of shape, for from the very nature of that material it is very susceptible to the influence of any improper motion that may be communicated to it. In reducing from one size to another, the indiarubber sheet is first stretched by turning the proper handle, and when sufficiently expanded it is fixed in that position by fastening the nuts (which must have been set loose) at the crossing of the slots in the parallel bars. It must then be taken off the eight pegs by which it was attached to the screw expanding-gear, and placed over the stone, upon corresponding adjustable pegs attached to the table. By turning the discs upon these pegs, the indiarubber is carefully brought to very nearly touch the stone, and is ready to receive the impression. The bridge of the screw-press can, by suitable mechanism, be made to pass from one end of the table to the other, and can consequently be moved out of the way while the indiarubber is placed over the stone, and be put back again to make the impression. It only requires the exercise of a little ingenuity then to take each impression in a series of colour stones absolutely upon the same part of the indiarubber, and thereby to ensure similar expansion or contraction in every one of the series.

The impression having been obtained on the indiarubber, the frame is removed from the stone and placed upon the pegs of the stretching apparatus and slackened back to the required size. Being fastened in the new position, it is placed as before, but this time over a clean stone, to which it is transferred in a similar manner to the taking of the impression just described.

CHAPTER XXV.

Substitutes for Lithographic Stone.

AFTER Senefelder had made Lithography an accomplished fact, and had turned to contemplate the results and shortcomings (they were not many) of his process, he could not help admitting that one of its principal defects was the want of portability in the printing plates when of a large size. It is obvious that a stone weighing several hundred pounds is no easy matter to run in and out of a press by hand, and it is equally clear that, when many stones are required, they occupy much room and demand great strength in the buildings in which they are stored. So much is this the case, that a lithographic printer usually speaks of having so many tons of this material on his premises. Any really good substitute for stone would, therefore, be a boon to the trade generally. With a man of Senefelder's mental activity, prompt action is readily taken to remedy any observed defect, and he soon succeeded in providing a promising substitute. He was, however, probably by reason of the multiplicity of his engagements, never able to satisfy himself in this particular, and a real substitute for the natural product of the Bavarian quarries remained yet to be discovered. Senefelder not only succeeded in fabricating a substance resembling the Solenhofen stone, but experimented with the various metals, and demonstrated that the principles of chemical printing were applicable to other surfaces. The subsequent use of zinc in this connexion was so far successful, that the search for another material more nearly like stone was practically discontinued. It is true that most excellent work has been printed from this metal, but it is universally conceded that printing from it, and more especially the preparation in proofing, is more difficult than similar work from stone. Admitting for a moment, however, that its manipulation is quite as easy as that of stone to the initiated, there still remains the fact that comparatively few lithographic printers have had the opportunity of exercising their skill in this direction. Practically, then, stone keeps the field because printers are trained to a knowledge of its peculiarities. If it were possible, then, to supply the printer with a printing-surface which should behave in all respects like stone as regards transferring, printing, and drawing, there would appear to be every chance for the advantages of a more portable material to be fully recognised.

Möller's Patent claims to fulfil these highly desirable conditions, for it is nothing less than the preparation of a plate of metal with a calcareous film of exactly the same chemical composition as lithographic stone. It has long been known that carbonate of lime is soluble in water when free carbonic acid is present. This is shown in the familiar instance of a deposit of calcic carbonate upon the sides and bottoms of vessels in which water is frequently boiled. The heat drives off the carbonic acid as a gas, and the carbonate becomes deposited. Water containing the lime carbonate is said to be hard, and one of the means employed for softening it consists in adding quicklime, which, uniting with the free carbonic acid, forms carbonate of lime; this is deposited along with the carbonate naturally belonging to it, because there is no longer any free acid to keep it in solution. We believe the inventor uses this solvent power of carbon dioxide (carbonate acid) for coating the plates of metal. The calcic carbonate is insoluble in water, but, as is well known in the manufacture of aërated beverages, water can be very highly impregnated with carbonic acid under great pressure, and in this condition the carbonate of lime can be formed into an aqueous solution. Now, this substance is the chief ingredient of lithographic stone, and exists therein in conjunction with a little silicious and aluminous earth.

However difficult the problem of producing a substitute for litho stone might appear when first approached, it seems to vanish when the key to its solution is made manifest. The patentee, of course, has had many practical difficulties to encounter and overcome, but he seems now to have so far mastered them that we are promised the possibility of being able to keep the stone solution bottled up ready for making a new surface when corrections are necessary.

We need do no more than allude to the many promised advantages of using plates of this kind as compared with litho stones of large dimensions. The surface can be put upon the thinnest zinc or other metal, so that it only requires experience to determine what gauge of metal it is best to employ. If the thin plates such as are employed for tympans should prove of sufficient thickness, then it becomes a question whether it would ever be worth while to send them to be re-faced, even though the statement of the patentee may be quite true, that it is as easy to re-coat one of these plates as it is to grind and polish an ordinary stone.

307. We are creditably informed that one of the largest lithographers in the French capital has, for some years past, so mastered the details of printing from zinc plates, that he now uses them to the entire exclusion of stone, and finds them answer every purpose. The saving in first cost, and in the breaking and storage connected with stones is something very considerable.

For the machine it is required that some special arrangement for holding the plates be resorted to, but as this possesses little practical difficulty to the engineer, it need not stand much in the way of the adoption of zinc. If the plates are thick, the edges may be bevelled and grasped by suitable adjustable clips; while for very thin plates, the edges may be bent over the bevelled edge of a planed iron slab, and held by a suitable gripping apparatus.

The attention of the lithographer having been well aroused in this connexion, we have no doubt that the problem of producing an efficient substitute for the lithographic stone will soon be solved, even if it be not already done.

CHAPTER XXVI.

The Hoeschotype Photo-Chromic Printing Process.

IN the "Grammar of Lithography" we have very briefly drawn attention to the Albertype and Heliotype processes in both of which surfaces of gelatine are employed and printed after the lithographic manner. To a certain extent the gelatine may he said to be a substitute for stone, the printing image being obtained by photography instead of drawing or transferring. A surface of gelatine has also been employed in other ways for printing from, but we wish now to draw attention to an application more nearly allied to our subject of Colour Printing. The printing from photo-impressed gelatine surfaces is now an extensively practised branch of industry and it has been lately applied with great promise of success to the production of colour-prints. Printing by this process gives such a variety of soft gradations, that far more may be got out of one such printing-plate than out of any drawing on stone or engraving. In the film of gelatine which forms the printing surface there is, when acted upon by the joint influence of light and a proper chromic salt, a selective affinity for printing-ink which exists in no other process. A wash-like tint can thus be got which in lithography and engraving would be impossible. Supposing, then, that three suitable colour-plates be prepared by this process, representing respectively blue, red, and yellow. Each of these plates will yield gradations from the lightest to the darkest, and each one will be soft and even in character, like a wash of water-colour. Suppose, now, that in practice each plate is given five gradations of shade, and that we represent them by the numbers 1, 2, 3, 4, and 5, 1 representing the lightest and 5 the darkest tint of colour, and that B, R, Y stand respectively for blue, red, and yellow, the combinations of these may be practically unlimited. If we print 3 B over 4 Y we shall have a green with a tendency to yellow, but fairly pure in character. If over this we print 1 R we warm its tone; if 2 R be printed over it, it will become less green and more autumnal in character. In like manner we may compound colours possessing any desired hue. If in addition to these three colours we employ a grey and a brown to assist in giving form and light and shade to a subject, the power of imitating a copy is so increased that, so far as this means of printing is concerned, little more is required to give a fair *fac-simile* of any water-colour painting.

309. A practical way of carrying out this system of printing, which may conveniently be called Photo-chromography, has been invented by Herr F. G. Hoesch, a photo-lithographer, of Nuremberg. A photographic negative of the picture to be reproduced is made, and from it are printed five proofs in grey colour. An artist who has been used to chromo-lithography is then employed to work up these photo-prints, but instead of working by stippling, hatching, &c., he employs definite tints, composed of white and black, mixed to form five different gradations from white to black. On the one that is to represent the yellow he first paints out in white wherever yellow is not to occur; he paints in black what is to be a full yellow, and the intermediate gradations are laid in with the varying shades of grey. In like manner are painted up the impressions representing the blue, red, grey, and brown printings. From these prints photographic negatives are taken of the size the work is to be. Thick glass plates are then covered with a film of gelatine made sensitive to light by means of a bichromate salt. The negatives having been placed upon these plates, they are exposed to light for a short time, and are then washed to remove the yellow bichromate salt. They can now be printed from after the manner of lithography (the surface being kept damp during the printing), the plate receiving ink just in proportion as the light has acted upon it. By printing in appropriate colours from each plate so as to fall in proper register upon one piece of paper, a highly-finished picture is produced. All the colour in the lights is secured by the three primary

colour printings, red, blue, and yellow, while the toning into half-tints and shades is effected by the grey and brown printings.

310. Such is the general principle of the Hoeschotype, but for facilitating the matching of the colours of the original painting, the inventor has contrived a colour-scale, printed by the process, which gives over 1,000 different gradations of hues, tints, and shades from only five printing-plates. By cutting a square out of a piece of paper and laying the hole so made over any portion of the painting, and then comparing in a similar manner the colour-scale with it, a reference to the margin will give the combination of the tints of colour necessary to form a similar match in printing. The requisite number of photographs are then to be painted with the proper tints in the right places. Every part of the picture is to be thus treated. By adopting this system a person inexperienced in the production of chromo pictures may make a very fair copy, but it follows that an expert chromo-lithographer will possess experience that will much facilitate the expedition of such work. It is of very great importance that no mistake should occur, as it is not easy to improve the plates after they are once made. If an omission or a mistake occur, it may be corrected on the painting from which the negative is taken, and a fresh printing-plate may then be easily produced.

It is claimed that these plates may be printed by steam machinery, similarly to lithographic impressions, but not quite so quickly. One source of weakness in the process is that no colour pigment at present in use is pure in tone. Thus in selecting a blue it cannot do equally well for producing green and purples ; no red will answer equally for both crimsons and scarlets. As chromo-lithography, or any analogous process, demands more printings to get an approach to the softness of effect of the new method, a greater variety of colour may be introduced and superior brilliancy attained, because of two blues, one may tend to purple, while another favours green. In the full tints of the colour, therefore, the chromo-lithograph will have the advantage. Of course the same principle may be adopted in the new process, but if the colours are to be much increased in number, one great advantage will be lost.

It remains to be seen whether the printing can be carried on by steam machinery at a speed high enough for it to successfully compete with other known processes. It is already acknowledged that the plates will not yield anything like the same number of impressions as a stone or block, and though it is very easy to prepare other plates when the negative is once taken, it will of course delay the machine somewhat to replace a worn plate. Another point is that a worn plate does not fail at once, and some of the impressions might appear to be unequal to others, and should it so happen that impressions in one colour from a worn plate fall upon impressions in another colour from a plate yielding full effects, the result would undoubtedly be unsatisfactory. It is true that lithography and other processes are liable to the same failing, but as the stone or block prints longer numbers, it is not like having to renew a plate several times.

We have little fear that the process is going to replace older methods. The collographic mode of printing as applied to one colour has long been in use in this country and on the continent without injuring the prospects of lithography. It has made a branch of business for itself, and doubtless the new development will do the same, and we think there may be a great future awaiting it.

311. A limited liability company was formed in 1882, to work this process, but it ceased to exist early in 1885. We think one of the errors committed was the attempt to work in too few printings. We have, in a previous chapter shown the difficulties met with by the lithographer in keeping up a particular tone of colour when it results from the printing of one over the other. Now, the same thing may happen in printing in this new process, for however delicate and full of gradation each printing may be, it does not lessen the difficulty that comes from trying to get a precise tone of colour by means of the union of two others applied at different times.

We think that in spite of the non-success of the process in this country up to the present time that much will yet be done with it, and that it might well be combined with lithography by using the latter for such colours, &c., as are not eligible in printing from gelatine.

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