ON THE INFLUENCE OF ARTIFICIAL LIGHT

IN CAUSING

IMPAIRED VISION,

AND ON

SOME METHODS OF PREVENTING, OR LESSENING, ITS INJURIOUS ACTION ON THE EYE.

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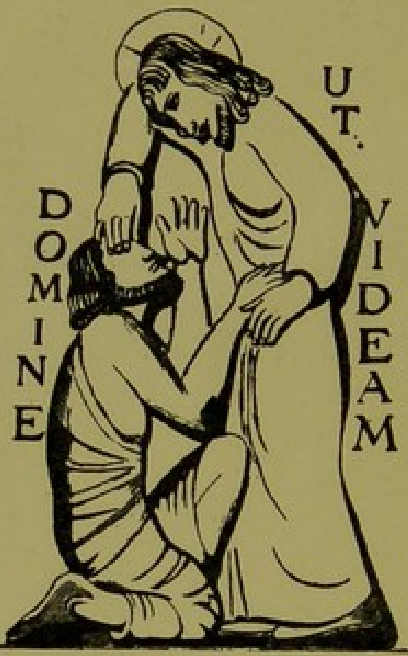
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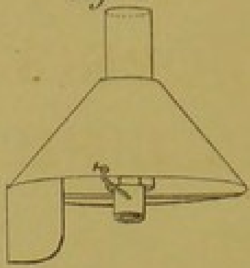

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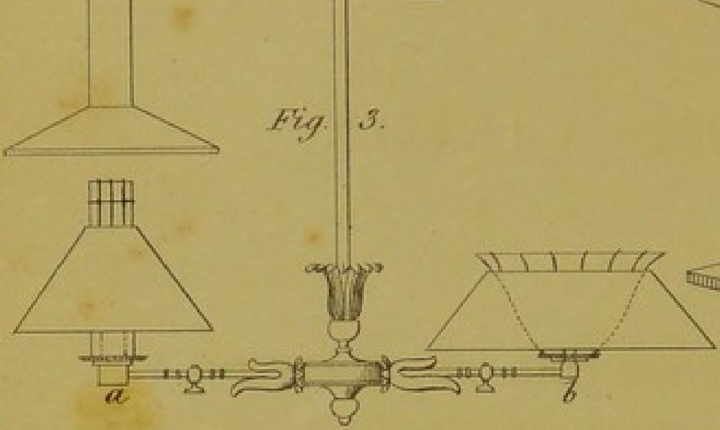

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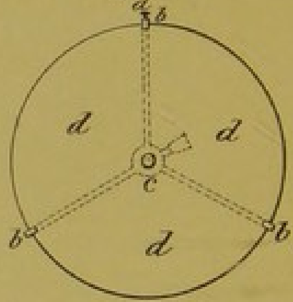

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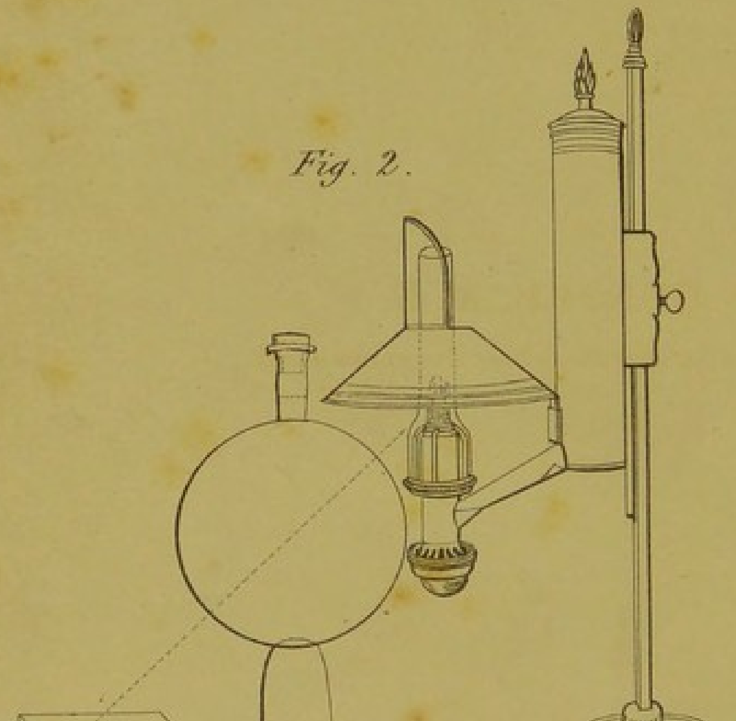

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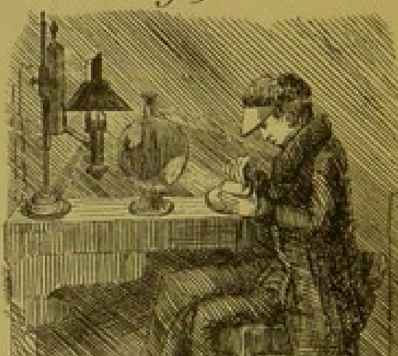

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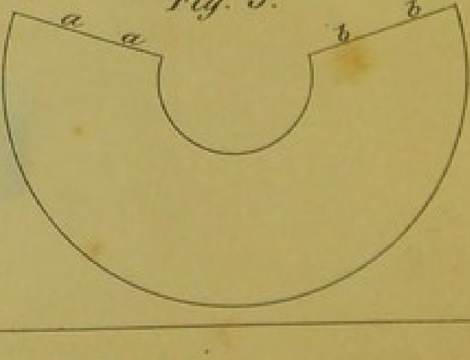

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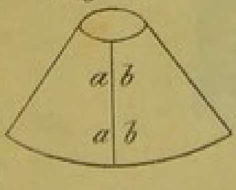

ON THE INFLUENCE OF ARTIFICIAL LIGHT

IN CAUSING

IMPAIRED VISION,

AND ON

SOME METHODS OF PREVENTING, OR LESSENING, ITS INJURIOUS ACTION ON THE EYE.

BY

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PREFACE.

The frequency of Impaired Vision from the injudicious employment of Artificial Light, and the very general misconceptions regarding it, have repeatedly suggested to me the propriety of calling public attention to the subject. As, however, the injurious action of Artificial Light on the Eye had not been specially treated of by any former author, so far as I am aware, it was necessary to engage in a variety of experimental investigations connected with the subject, which occupied a considerable time, and have been only lately completed. The theoretical and practical results of these investigations are embodied in the following pages; in which I have endeavoured to explain, in a familiar manner, and by a reference to well-known optical principles, the nature and causes of the injurious action of Artificial Light on the Eye, and to point out in what way the knowledge of these principles may be practically applied for the diminution of the evil.

9 Brunswick Street,
Hillside Crescent, 1840.

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INTRODUCTION.

Sources of Natural and Artificial Light—Effect of Intense Light on the Eye—General causes of the more injurious Action of Artificial Light—Experiment illustrating the production of Partial Insensibility of the Retina, by the unequal Action of the Constituent Rays in Artificial Light.

LIGHT derived from the sun and heavenly bodies is called *natural*, or *celestial*; that procured from other sources is said to be *artificial*, or *terrestrial.*

Artificial light may be produced in various ways; as by combustion, chemical action, electricity, galvanism, and phosphorescence: but combustion is always the source of that used for ordinary domestic purposes. In the following pages whenever the term *artificial light* is employed, it is always to be understood, unless otherwise expressed, as applying only to that particular kind obtained by the combustion of hydro-carburetted inflammable matter; such as oil, wax, and tallow, coal or oil-gas, naphtha, resin, and other substances.

The continued employment of the eyes on minute and strongly illuminated objects, is apt to be followed by a state of insensibility of the retinæ and optic nerves, the organs which convey to the mind, through the medium of the brain, the knowledge of the impressions produced by the rays of light, when refracted to a focus in the bottom of the eye, by the action of its humours. The degree of this insensibility to light, varies according to circumstances. If the exciting cause has not continued to act for a long time, or with much intensity, it may be so very slight as not to be observed, excepting under particular conditions; but in other cases it takes place to a much greater extent, and coming on slowly and insidiously, it materially interferes with the distinctness of vision, and ultimately causes total blindness. In this state, though the forms of external objects are distinctly depicted on the bottom of the eyes, by their refracting humours, or *image-forming* organs, they are no longer perceived by their retinæ and optic nerves, or *image-feeling* organs. This species of impaired vision is called Amaurosis, or Nervous Blindness, and is quite different from that caused by cataract, or by opacity of the cornea, which are diseases of the *image-forming* organs.

Impaired sensibility of the nervous structures of the eye, may be brought on by the improper use either of natural or of artificial light; but the latter is comparatively much more injurious than the former. The principal causes of this difference are,

1. The bad colour and defective chromatic constitution of the rays of artificial light.

2. Their great heating power in proportion to their illuminating effect.

3. The formation and disengagement of carbonic acid gas during combustion.

4. The unsteadiness, and the generally disadvantageous position and direction of the light.

The full explanation of the mode of action of these causes is reserved for a subsequent chapter; at present it is sufficient merely to enumerate them.

The following very simple experiment may be made by any one inclined to doubt that artificial light is more hurtful to the eye than common daylight. Tie up the left eye, and with the other look steadily and closely, for about a minute, at some very small object placed on a sheet of white paper, and strongly illuminated with ordinary day-light, but not exposed to the direct rays of the sun: then uncover the left eye, and look at some distant white surface, such as the ceiling of the room, first with the left eye and then with the right one. It will be found that there is not much difference in its appearance as seen by the one eye or by the other, though, in general, it will be a very little brighter to the left eye. After this darken the room, by closing the shutters, tie up the left eye again, and then with the right one look at the same object, placed on a sheet of white paper as formerly, but illuminated by a large tallow candle or oil-lamp, so that it shall be seen as distinctly as it was in day-light. Keep the right eye fixed on this object for about a minute, so as to examine it closely and narrowly: then extinguish the candle or lamp, open the shutters, and uncover the left eye. When both eyes are now turned to the ceiling, it will appear somewhat dim and indistinct; and on looking at it first with the one eye, and then with the other, the difference will be very remarkable. To the left eye, which had not been exposed to the action of the artificial light, it will appear unchanged;* but to the right eye it will be very dim, and of a dark blue or purple colour. This shows that, by exposure to candle light, the retina of the right eye has been rendered partially insensible to the action of day-light; for in candle-light the red and yellow rays are in excess, and excite the retina unequally, so that when it is exposed to day-light, in which these rays are less abundant, it is not uniformly acted on, and it sees the blue rays which are *complementary* to the orange light of the flame. But

* Sometimes it is of a pale reddish or yellowish-white colour, when seen by the left eye.

besides this, the general sensibility of the retina to all the three rays composing white light is much diminished; because, from the bad colour of the artificial light, its defining power is small as compared with its quantity, and in order to see an object as distinctly as in day-light, a much greater amount of luminous matter is required.*

The effect produced on the right eye in this experiment soon goes off, and though it always takes place, to a certain extent, when artificial light is used, it is not much observed; because, as both eyes are equally affected, the contrast is not very striking. But if any one will read or write by candle-light for some hours, with one eye closed, he will be rendered fully sensible of its very injurious action, when he afterwards compares the state of one eye with that of the other. By rest the eyes are restored to their healthy condition; but if they have been very long exposed, not merely to the action of the bad colour of the light, but also to its heating effects, whilst at the same time the brain

* If the flame of the candle be of a very red tinge, the complementary colour will be green, and if it be pure yellow, the complementary colour will be purple, or very deep violet. The colour seen by the eye in daylight, after exposure to artificial light, is always the one that was wanting to make the artificial light pure white; and for this reason it is said to be *complementary*.

has suffered from the narcotic action of the carbonic acid gas disengaged during combustion, the diminished sensibility of the retina to light becomes a permanent affection, and at length terminates in total blindness, too often of a perfectly incurable nature.

In the following pages it is my intention, 1. To describe the symptoms and progress of the disease of the eyes caused by the injudicious use of artificial light. 2. To explain on scientific principles how it happens that artificial light proves so injurious. 3. To give some practical information as to the means of preserving the sight, the choice and employment of different kinds of artificial light, and a description of some new methods of using it with safety and convenience.

CHAPTER I.

EFFECTS OF ARTIFICIAL LIGHT ON THE EYE.

Premonitory Affection of Lining Membrane of Eyelids—First Symptoms of Disease of Retina—Appearance of Dark Films or Muscæ Volitantes—Progress of Amaurotic Cases—Dilatation, Immobility or Irregularity of the Pupil—Distinction between Cataractous and Nervous Blindness—Bad effects of Magnifying Glasses in the Incipient Stage of Nervous Blindness—Spectacles useful only in Disease of the Image-forming Organs—Comparative frequency of Nervous Blindness in different Classes of Society.

One of the first effects of the improper use of artificial light is a degree of subacute, or chronic inflammation of the lining membrane of the eyelids. This mucous membrane, which in health is of a white or very pale rosy tint, when inflamed becomes injected with blood, and of a deep red colour, as may be seen by drawing down, and gently everting the lower lid, so as to expose its inner surface. When this disease exists in a slight form, it gives but little uneasiness during the day-time; but at night, when the eyes are employed on objects illuminated by a candle or other artificial light, they become hot, watery, and irritable; the lids feel dry and stiff, as if from a want of their proper lubricating secretion, and they are extremely painful and itchy, obliging the patient to be continually rubbing them. Sometimes the pain is described as acute and burning, but more frequently it is merely of a dry and itchy character. In many cases there is a peculiar and most disagreeable twitching or quivering of the eyelids, causing involuntary nictitation, which comes on in fits at short intervals, and though not actually painful, is nevertheless very annoying.

The natural secretions of the lids usually are diminished at the commencement of inflammation of the lining membrane of the eyelids, but after the disease has continued for some time, they often are greatly increased in quantity. The tears suffuse the eyes, flow over the cheeks, and produce troublesome excoriations. At other times, the secretions, without being much increased in quantity, are greatly altered in quality, and in place of being thin and watery, they become of a thick, gummy, or muco-purulent consistency. When this takes place, the distinctness of vision often is very much impaired, and bright objects, such as the flame of a candle, appear to be surrounded with a luminous halo of variously coloured rings. But this kind of defective vision is very different from that arising from diminished sensibility of the retina; it is merely a consequence of the collected secretions forming a mechanical obstruction to the passage of the rays of light through the cornea, and after wiping or bathing the eyes, the patient finds that, for a time, he can see as well as ever. All these symptoms are much aggravated by exposure to sudden variations of temperature, or to cold air, particularly in the evening, after the eyes have been much exerted in reading or writing.

Chronic inflammation of the lining membrane of the eyelids seldom causes much annoyance during the day-time; whereas the symptoms of insensibility of the retina are often much more observed during the day than at night, at least at their commencement, though after they have continued for some time, and the disease has gained ground, they are perceived at night as well as during the day. The severity of the symptoms just described varies in different cases. Sometimes the dryness and itchiness of the eyelids are quite intolerable; but in other instances, the increased flow of tears, the suffusion of the eyes, and the altered state of the secretions, are most complained of; and sometimes there is little or no uneasiness whatever. In many cases the patient, on awaking in the morning, finds the upper and lower lids firmly adhering by their edges, in consequence of the drying-up of the thick yellow secretion, poured out by the Meibomian glands during sleep, and which, collecting at the roots of the eyelashes, acts as a cement, and often becomes so hard, that it requires long continued bathing with warm water before the eyelids can be opened.

The above symptoms of chronic inflammation of the eyelids are to be regarded as merely premonitory of those more serious ones occasioned by disease of the nervous organs of the eye. In some cases they are altogether wanting, and the gradually increasing insensibility of the retina to light is the first thing that alarms the patient, and makes him seek for medical assistance. But in other cases, inflammation of the lining membrane of the eyelids continues for a long time, unaccompanied by any affection of the retina. When this happens, it often causes the total destruction of the eyelashes, and a thickened callous state of the lids, particularly of the lower ones, which, in consequence of the excoriation from the constant trickling of the tears over the cheeks, become permanently everted, and give rise to much deformity. Such cases, however, are exceptions; and in general, long before this, symptoms of disease of the retina begin to shew themselves, if the eyes are still much exposed to the injurious action of artificial light. When once inflammation of the lining membrane of the eyelids becomes a chronic affection, it greatly assists the action of the artificial light in causing insensibility of the nerves of vision; for as the accumulated mucous secretions present a mechanical obstacle to the passage of the rays of light, and render the formation of the images of objects on the retina less distinct, the patient is obliged to use a stronger light than would otherwise be necessary: whilst at the same time, in consequence of the loss and destruction of the eyelashes occasioned by the disease, a great number of extraneous rays are allowed to enter the eye, and interfere with the distinctness of vision.

FIRST SYMPTOMS OF DISEASE OF THE RETINA AND OPTIC NERVE.

An unusual degree of irritability to light is very generally observed for a short time before the sensibility of the retina becomes impaired; it is probably caused by a state of subacute inflammation of the organ. Light of ordinary intensity produces an unpleasant sensation; and the patient remarks, after looking steadily for a few minutes at some object moderately illuminated, such as the page of a printed book, and then shutting his eyes or extinguishing the light, that he still sees before him a tolerably distinct, and slightly diminished representation of the object. This image, or spectrum as it is called, may continue visible for two or three minutes, when it gradually vanishes away. Very often the representation of the object, though on a small scale, is remarkably distinct and well defined. It usually is of a white or yellow colour, sometimes it appears red or violet, and frequently it passes through a succession of chromatic changes before it finally disappears. This spectral image seems to be suspended in the air at a distance of from ten to fifteen inches from the spectator; the motions of it are in an opposite direction to those of his eye, for it passes upwards when he looks downwards, and sinks downwards when he rolls his eyeball upwards. It is caused by the morbidly increased sensibility of the retina, which retains the impressions of light for a greater length of time than when it is in a healthy condition.*

* In ordinary circumstances, the impressions of light are perceived by the eye for a short time after their cause has ceased to act; as is proved by the well known experiment of whirling in the hand a burning stick, the point of which describes a circle of light. "M. D'Arcy found that the light of a live coal, moving rapidly through the air at the distance of 165 feet, continued its impressions on the eye during the *seventh part of a second.*" This property of the retina to retain the impressions of light is one of the many examples of beautiful contrivance and of infinite wisdom in the mechanism of the organ of vision; for as it was necessary that the eyelids should occasionally pass over the surface of the clear cornea, for the purpose of wiping away any particles of dust, and keeping the parts properly lubricated, some provision had to be made to prevent objects being blotted out

During this state of morbidly increased sensibility to light, there is very often during the day time, a dull heavy feeling in the forehead, hardly amounting to pain, but causing the patient frequently to pass his hand across his brow; and in reading or writing at night there is an unpleasant sensation of distention in the orbits, along with increased lachrymation, and frequent twittering or quivering of the eyelids. Another very constant symptom, at this period of the disease, is the appearance of brilliant flashes of fire when the eyes are touched or rubbed, however gently, in the dark. In many cases these flashes are seen even without the eyes being touched; and they are very common on first lying down in bed, particularly after reading, writing, or sewing, for some hours previously by candle, or other artificial light. When these symptoms have continued for a time varying from a few weeks to as many months, and sometimes not till after a year or more, they are followed by others, of a totally different, and much more alarming nature, indicative of diminished sensibility of the nerves of vision. Of these symptoms, the first noticed is the appearance of

and rendered invisible during that time. This has been accomplished by making the eyelids move with great rapidity, and by giving to the retina a power of retaining the impressions of light during the interval.

DARK FILMS OR MUSCÆ VOLITANTES.

Some day, when the light is moderately strong, and diffused by a cloudy sky, or misty state of the atmosphere, the patient, when looking at some object, such as a sheet of paper, a white wall or ceiling, or a light fleecy cloud, suddenly observes a small dark coloured and indistinct spot, or film, floating in the air between him and the object: if he attempt to inspect it more minutely, it instantly disappears, and he tries in vain to get another sight of it. But in a short while after, when he has ceased to think of it, the film again appears for an instant, and then vanishes away. The usual colour of this film, when seen upon a white surface, is nearly black, but when seen in contrast with an orange or yellow coloured surface, it appears of a dingy blue or violet tint. From the gradual shading and thinning of the edges, its form is not very well defined, but it almost always is of an irregular shape, and has very much the appearance of a small bit of fine cobweb or a particle of soot; and many patients compare it to a small bundle of black fur-down floating through the air before them. Whoever has remarked the form, size, and general appearance of the fine particles of carbonaceous matter that are disseminated in the air of a room after lighting candles, the wicks of which had been wetted with oil of turpentine to make them take fire readily, will have a perfect idea of those dark films, or *muscæ volitantes*, as they are called, to which they bear a very striking resemblance. At the commencement of the disease, the films, though of a very dark colour, are not perfectly opaque, and when they come between the eye and an object, the latter can still be seen through them, though of course it appears very dim. In most cases only one film or *musca* is seen before each eye in the first instance, but afterwards their number is much increased, and they appear more frequently; at the same time they are observed to be larger and more opaque, and they remain much longer visible than they did at first. It frequently happens that these films appear before one eye only, and I have remarked, in a great many cases where this happened, that the eye affected was the right one much oftener than the left one, probably in consequence of its being more excited when the sight is employed on near objects, as in reading or writing.

When one of these films is first observed, it is often very difficult for the patient to be convinced that it is not merely some light substance floating in the air, and he generally makes an attempt to drive it away with his hand; in doing so he rolls the eyeball, and as the film immediately disappears, he is confirmed in his belief that what he saw was nothing more than perhaps a bit of cobweb or a particle of soot. After some time he begins to doubt the correctness of this supposition, by the frequent recurrence of the symptom, and by finding that the cobweb is seen by no one but himself. At last he is quite convinced that the film is really caused by some defect in the eye itself, by observing its motions; for so long as the eye is kept stationary, the film remains stationary also, but the moment the eye is moved it flies off in an opposite direction. When the eyeball is slowly rolled upwards to the light, the film gradually sinks downwards, and if, just as it appears to be going out of sight, the eye be suddenly directed downwards, that instant the film flies away upwards, and is seen no more at that time. This very remarkable phenomenon is caused by a small portion of the retina having become insensible to the action of the rays of light; so that though a luminous image be formed on it, by the refracting humours of the eye it is not perceived; and the same effect is produced as if that part of the retina had been kept quite dark. But as the retina forms a part of the eyeball, and participates in all its motions, the consequence is, that if that portion of it which has become insensible to light be not situated in the centre, the spectral film can never be seen in the axis of vision ; and whenever an attempt is made to bring it into that position the eyeball must be moved, and at the same time the film will move also, but in an opposite direction, in consequence of the eye being a sphere, the motions of which are round its centre, and not in a progressive direction.

At first these *muscæ volitantes* are perceived only at intervals, often of some days, and generally are most common the day after the eyes have more than usually been excited in working by artificial light. Their duration is very transitory, and they seldom continue visible for more than a few seconds at a time. They are not often seen when looking at a coloured object, particularly if its colour be of a red or orange hue; but they are much more frequently observed when the eyes are turned to a white surface, such as a sheet of paper, the ceiling of a room, or a light cloud in the sky ; and a misty day in summer, when the sun's light is strong, and much diffused by the atmospheric vapours, is by far the most favourable time for their appearance. In the first stages of the disease the dark films are not often seen by artificial light, at least in cases where the insensibility of the retina is either entirely or chiefly occasioned by its injurious action ; the cause of which apparent anomaly will be explained afterwards. But when the eye looks at the flame of a candle or lamp, either with or without the intervention of a shade of obscured glass, there very frequently is a curious appearance, as if a number of very minute and transparent globules, resembling drops of oil on the surface of water, and connected with each other like the links of a chain, were floating slowly through the air, in the same way as the dark films observed in day-light.

After a while all these symptoms are aggravated, the dark spectra appear much more frequently and in greater numbers, their size is increased, and very often they coalesce and form one large film, which constantly remains before the eyes. At the same time their density and opacity become much greater, so that in passing over an object they completely obscure it, and, when reading or writing, the patient often finds the half or the whole of a word, and sometimes an entire line completely blotted out, the paper at that place appearing of a dark purple or bluish tinge. Certain changes may now be observed in the eye itself, which before this presented no external symptom of disease; the pupil is no longer of a perfectly round shape, but assumes a square or triangular or irregular form; and for the most part it is considerably dilated. The mobility of the pupil generally is much impaired, and it no longer expands when the eye is shaded, or contracts when exposed to a strong light; or if these motions are not altogether lost, they are performed in a very partial, sluggish, and imperfect manner. Still there is no visible *opacity*, the pupil retaining its black colour; but an experienced person can easily detect a want of that peculiar jet black lustre so characteristic of the eye in a state of health; and in the final stages of nervous blindness, when the pupil is very much dilated, and the sight quite gone, this lustreless dead-like appearance of the eye is sufficiently striking to be remarked by any one.*

When once the pupil becomes irregular or immoveable, the sight is very much impaired; and all objects, whether seen by day or by night, appear clouded in a thick mist. Sometimes there is a remarkable sparkling appearance in the air, which seems filled with innumerable and very minute crystalline particles, highly illuminated, and often presenting various prismatic colours. At the same time, there is a constant dull pain in the forehead, which sometimes is very severe, particularly

* In other kinds of blindness, such as that from cataract and other diseases of the *image-forming* apparatus, the pupil or clear cornea is always occupied by a white, greyish, or yellow-coloured opacity, whilst the retina continues quite sensible; the blindness being entirely caused by the impediment to the passage of the rays of light into the bottom of the eye; whereas, in nervous blindness, the light is readily admitted, and the images are distinctly formed; but, from the diseased state of the retinal expansion of the optic nerve, their presence is not perceived.

in the morning after first getting up; and when the patient tries to look closely at any near object, there often is an intolerable feeling of distention and uneasiness in the orbit. As the disease advances, all pain ceases; the light, in place of being too strong and disagreeable, as at first, when the retina was in an excited and morbidly irritable condition, can hardly be procured of sufficient intensity, and the patient may now be said to have a thirst for light in place of a horror of it, as was formerly the case.*

* This desire for a strong light, so characteristic of the advanced stage of nervous blindness, is precisely the reverse of what takes place in cataractous blindness, when the patient sees best in a dull light, because, as the cataract hinders the free passage of the rays of light into the eye, whatever dilates the pupil will improve the vision; and as the pupil dilates when the eye is shaded, such patients, when they wish to see well, take care to shade their eyes with their hand, or by turning their back to the light; and for the same reason they see much better towards sunset than at noon: but in confirmed amaurosis or nervous blindness, the patient sees best in the fore-noon, and with his face to the light. When two blind persons, one affected with cataract, and the other with amaurosis, enter a room, it always is easy to distinguish the one from the other, merely by attending to their gait; the one with cataract holds his head down, or turned away from the light, and shades his eyes with his hands; the other looks straight before him, inclining his head upwards to the window, so that his retina may be acted on by the greatest quantity of light.

When the causes of the disease here described continue to act, total blindness results : the patient is quite unable to guide himself, or even to tell light from darkness, and in some cases he can turn his eyes to the meridian sun, without perceiving the slightest indication of light. But, in general, the blindness caused by the injurious action of artificial light stops short of this, and though the patient may be quite unable to read even the largest type, he can see to guide himself, and to distinguish large objects. In confirmed nervous blindness no relief is obtained by the employment of any kind of spectacles ; though in the slighter forms of the disease, and particularly in its incipient stage, some little assistance is obtained by using condensing lenses, which throw a greater quantity of light upon the palsied nerve of vision. For this purpose many use convex magnifying spectacles of 7 or 8, and sometimes even of only 4 or 5 inches focus, but they act merely as palliatives, and in the end they render the sight much feebler than it was before employing them. Before beginning to use spectacles, a person ought to ask himself, or should get some competent judge to inform him, whether the impaired state of his vision proceeds from a defective state of the *image-forming* or of the *image-feeling* organs of the eye. The former of these conditions is the only one in which optical instruments can be of any service; for in the latter state, they will do much harm, even although they appear to be useful in the first instance, Such mistakes are of everyday occurrence, and the above remarks are equally applicable to many of those cases where persons who have for some time used spectacles of one focus, purpose to change them for others of greater power; for though such changes are occasionally required, they are not by any means so necessary as many suppose them to be; and, before laying aside one pair of spectacles for another pair of greater power, they should first of all be certain that the inefficacy of the old ones depends on some change in the refractive humours of the eye, and not on impaired sensibility of its nerve.

The time that may elapse, from the first appearance of the disease just described to its full development, varies from a few months to several years, according to circumstances. As a general rule it may be asserted that the symptoms of palsy of the retina progress in an accelerated ratio; and when the dark spectra are seen by artificial light, as well as during the day, continuing visible for some minutes at a time, and assuming a very dark and opaque appearance, the future progress of the disease will be rapid, and an incurable blindness will result, unless prompt measures are had recourse to for the purpose of checking its advances.

Some individuals are much more liable than others to suffer from the injurious action of artificial light, particularly those of a fair complexion and with grey or light blue eyes.

Amaurosis or nervous blindness may arise from other causes, than the improper use of artificial light. Of these the most common are diseased states of the brain, heart, stomach, and uterus ; improper diet and regimen, and the habitual and excessive use of spirituous liquors, or of tobacco and other narcotics, all of which causes may act either singly or combined. It therefore happens that if, in any case where a tendency to this affection of the sight is first of all induced, by the constant and improper exposure of the eyes to artificial light, any one of the above pathological causes is at the same time in operation, it will greatly accelerate the progress of the disease. Such combinations of *exciting* and *predisposing* causes, are very frequently met with in practice ; particularly in certain classes of workmen, such for instance, as tailors, in whom the constant and severe exertion of the eyes, on minute objects, by artificial light, acts as the exciting cause, and the sedentary nature of their employment acts as the pedisposing cause.

Nearly two-thirds of all the cases of amaurosis or nervous blindness, that are met with in practice, occur in those who use their eyes very much by artificial light, particularly persons belonging to the following classes of society.

I. Literary men, students, clerks, transcribers, compositors, and others much engaged in reading or writing at night.

II. Tailors, sempstresses, and shoemakers. These persons generally work late at night, and often are obliged to use artificial light, even in the day time, in consequence of the frequently obscure, and almost under-ground situation of their places of business, which often are very ill ventilated, and oppressively warm.

III. Engineers, stokers, enamellers, glassblowers, and other persons much exposed to the combined action of intense light and heat.

Amaurosis is not common in labourers and country people, who do not use their eyes much by artificial light, and in them, it for the most part is the consequence either of intemperance, or of disease of the brain or stomach, or of some previous injury or disease of the other parts of the eye.

CHAPTER II.

CAUSES OF THE INJURIOUS ACTION OF ARTIFICIAL LIGHT.

Proximate causes of Amaurosis or Nervous Blindness—Rationale of the production of Light by Combustion—Sir Isaac Newton's discovery of the Compound Nature of Sun Light—Difference in the Composition of Natural and Artificial Light—Comparative purity of Light obtained by the combustion of different substances—Causes of the different appearance of Colours as seen by Natural or by Artificial Light—Effects of the peculiar Colour of Artificial Light on the Eyes—Table of the force of the different coloured Rays—Heating power of Artificial Light—Effects of the Carbonic Acid Gas generated during Combustion—Injurious effects of an unsteady or improperly placed Light.

IMPAIRED vision from disease of the nervous organs of the eye, may arise from several distinct morbid conditions, either of the organ itself, or of those other organs which are connected with it by continuity or contiguity of structure, or by some peculiar sympathy. These states are termed the *proximate*, or *pathological causes ;* in contradistinction to the external or visible agencies, which, in medical phraseology, are called the *remote* causes.

The principal pathological, or proximate causes of amaurosis are, 1*st*, Disease of the retina; which is the delicate cup-shaped expansion of the extremity of the optic nerve that lines the bottom of the eye, and on which the images of external objects are depicted, in the same way as they are on the concave white table of a camera obscura.

2*d*, Disease of the optic nerves, which pass backwards from the retina to the brain: or disease of the brain itself.

3*d*, Diseased and peculiar conditions, of the general system, acting sympathetically on the retina and optic nerves. In particular, disorders of the digestive, or of the uterine system, mental affections, injuries of certain nerves of the face, and general debility.

4*th*, Previous or concomitant diseases of the other parts of the eye. These may act directly, by extending to and implicating the retina; or indirectly, by rendering the formation of images imperfect, and necessitating the employment of a very intense light.

In the following pages it will be shewn, that the improper use of artificial light comprises the first, second, and fourth, of these *proximate* or *abstract* causes of impaired vision. To understand this, it is necessary to explain the difference in the general nature and properties of light, as obtained from natural or from artificial sources.

NATURE AND GENERAL PROPERTIES OF LIGHT.

Philosophers have no certain knowledge of the immediate cause of the sun's light. Some suppose it proceeds from an electrical or phosphorescent state of his atmosphere; and others believe it to be produced by the combustion of his solid body. The light obtained from candles, oil, coal-gas, and other ordinary sources, is caused by the intense ignition of numerous particles of carbon or charcoal, deposited in the flame in a state of very fine division. When any ordinary inflammable substance, such as wood, paper, oil, or tallow, is set on fire, it is decomposed, and its elements are resolved into a gas or vapour called carbureted hydrogen. This gas is compounded of a certain proportion of carbon dissolved in hydrogen, or simple inflammable air. When, therefore, a common inflammable substance, such as oil or tallow, is said to be burned, the expression is not chemically correct; for it is not the substance that is burned, but rather the gas that is formed by its decomposition, in consequence of the application of heat.* The carbureted hydrogen

* This is easily illustrated by blowing out a fully lighted wax-taper, and immediately afterwards presenting it to a flame. It will be seen that it is the smoke or gas issuing from it that catches fire, the heat of which continues to decompose the wax

gas when heated takes fire, and it in its turn suffers decomposition. The hydrogen of it combines with a portion of the atmospheric air, and forms steam; and, at the same instant, the carbon is precipitated into the flame, and, uniting with another portion of the air, is converted into carbonic acid gas. The particles of precipitated carbon in their passage through the flame becoming intensely heated, are thrown into a state of vibration, and give out light. The same phenomena take place when coal or oil gases, which are compounds of carbon and hydrogen, are burned, so as to supply light; the only difference being, that the heat employed to extract the light giving gas from the inflammable substance, is applied at a distant manufactory.

Thus it appears, that all ordinary artificial light, produced by the combustion either of solid or gaseous substances, depends on the same abstract causes, viz. the burning of carbureted hydrogen gas, and the precipitation and ignition of the carbon it contains. But the light so procured materially differs

of the taper, and so supplies more gas till all the wax is expended. In a candle or lamp, the use of the wick is to draw up the oil or melted grease, which is to be resolved into gas by coming in contact with the flame: it is by no means essential that the wick itself should burn; and in some descriptions of lamps, it is formed of incombustible asbestos, or of very fine silver wire.

in many respects from that of the sun, and especially in the proportion of its constituent rays.

Sir Isaac Newton was the first to discover that solar light was not of a simple nature, but compounded of several different coloured rays, which appeared white when united in certain proportions. By means of a triangular prism of glass, he separated a beam of white light into seven different coloured rays, commonly called the seven prismatic colours, viz. red, orange, yellow, green, blue, indigo, violet. Sir Isaac, by another experiment, shewed that these coloured rays, when reunited after their first separation, formed white light; and thus his great discovery of the compound nature of light was demonstrated in a twofold way.

More recent experiments have shewn that, in reality, there are only three primitive colours, viz. red, yellow, and blue; the orange being a mixture of yellow and red, the green formed by yellow and blue, and indigo and violet by different proportions of blue and red.* When blue, red, and yellow powders are mixed together, or when the rim of a wheel is painted of these three olours in proper

* Dr Milner, quoted by Clark in his work on Landscape Painting, 1816.—D. R. Hay of Edinburgh, "Laws of Harmonious Colouring. 1828,"—Brewster in Edin. Phil. Transactions, 1831.

proportions, and then made to revolve rapidly, white, or a colour very closely resembling it, is produced, and the only cause of its not being perfectly white is the impossibility of obtaining material colours equal in purity to "the sunbeam's dyes."

A beam of common day-light is composed of red, yellow, and blue rays. The experiments of Field prove that these colours are in the following proportions, red 5, yellow 3, blue 8.* If the above relative proportions of these rays be altered, as is the case in ordinary artificial light, the compound will not be pure white, but will partake more or less of the colour of the rays that are in excess. When the charcoal that is deposited in ordinary flame is not raised to a very high temperature, it gives out red light, at a higher temperature the light is orange, or yellow coloured, if the heat be still more increased, the blue rays are formed in greater abundance, and the light becomes much whiter. In a common smoky flame many of the particles of carbon are at a red heat, but by employing a chimney the temperature of the flame is raised, the smoke is consumed, and the light becomes much purer, and if oxygen gas be admitted to the flame, as in the Bude light to be afterwards de-

* "Chromatography" by George Field, London, 1835.

scribed, the temperature of the particles of carbon is much augmented, a greater quantity of blue rays is formed, and the light becomes of a beautiful and almost perfectly pure white colour. To develope the blue rays, which are so necessary to neutralize the red and yellow ones, the particles of charcoal in the flame must be very intensely heated, because the vibrations of blue light are much more rapid than those of red or yellow light. The light and heat, however, do not always increase in a co-equal proportion, for, by a proper arrangement, the former may be produced in a far higher ratio than the latter, so that though one flame may be twice as hot as another one, it may be giving out four times more light.

In common artificial light there always is an excess of the yellow and of the red rays, which give it more or less of an orange or yellow colour, according to the way in which the light is arranged, and according to the substances from which it is procured. The purest ordinary artificial light is obtained from different materials in nearly the following order. Oil-gas — Naphtha — Sperm-oil— Coal-gas from the best parrot-coal—Wax, Spermaceti, and Stearine Candles—Vegetable Oils— Moulded Tallow Candles—Coal-gas from inferior coal, such as is used in London—Coarse Oils and Dipped Tallow Candles.

It is from the excess of red and yellow rays in artificial light, that colours when seen by it, appear so different from what they do in day-light, which contains a larger proportion of blue rays. In artificial light, green has a yellow hue, and blue turns green from the excess of yellow rays; dark blue becomes purple and nearly black; orange, by reflecting its own constituent rays, appears very bright; yellow appears white from there being no really white light to contrast it with, and red has a tawny colour from the excess of yellow; at the same time all the colours except the orange are much impaired in brilliancy, and many of the deeper shades become quite black and sombre, from there not being any pure white light reflected from their surface as in day-light, when even the gravest colours have a remarkable degree of clearness and purity.

In order to see the true colour of artificial light, it should be contrasted with day-light, otherwise it will appear to be much whiter than it really is. In making the experiment, care should be taken that the rays of the two lights shall not interfere with and neutralize each other. This may be done by placing a lighted candle in a box with a round hole cut in its side, so that the emergent rays may form a luminous circle on a sheet of white paper, and then a second luminous circle should be formed on another part of the paper by a beam of day-light admitted through a hole in the closed window shutter, if the two lights be now compared together, the difference in their colour will be rendered very evident.

How is it that the excess of red and yellow rays contained in artificial light, causes it to act so injuriously on the nerves of vision? When the retina of the eye is exposed to light not of a pure white colour, but containing an excess of red and yellow rays, it is unequally excited, and becomes less sensible to those rays that are in excess, so that afterwards, when it views a white object by daylight, the blue rays contained in the white light reflected from the surface of it make a greater impression than the red and the yellow rays, and the object appears more or less of a dingy blue or purple colour, as illustrated by the experiment described in the introductory part of this treatise. This dark blue or purple tinge is *complementary* to the orange or yellow colour of the artificial light.

One colour is said to be *complementary* to another, when the addition of it to the latter completes the chromatic triad necessary to form white light. Thus, green is complementary to red, because green is composed of yellow and blue, which united to red make white light; so blue is complementary to orange, which is composed of red and yellow; and purple, which is formed by a mixture of red and blue, is complementary to yellow. Whenever the eye is long exposed to light of one colour, it becomes partially insensible to it, and sees the opposite or complementary colour. Thus, if a person look at the sun through a dark blue glass, and then regard a white surface, it will appear orange; had the glass been red, the surface would have appeared green, or green if the glass had been red, and so on.* Now, the nerves of the eyes of those persons who work much by artificial light are over-stimulated by the excess of red and yellow rays it contains; and, at certain points of their retinæ, there is an almost total insensibility to these rays. The consequence of this is, that in daylight dark films of a blue or purple colour, which are complementary to the orange or yellow colour of the artificial light, appear before their eyes. The

* At the time of the solar eclipse in 1836, I met with several who asserted that the sun's light was orange, and it was difficult to convince them of the reverse, till they closed the eye with which they had looked at the sun through a *blue* glass. Others, who had used smoked glasses which gave the sun an orange colour, saw everything of a blue colour. For some weeks after the eclipse, I was consulted by several patients, whose eyes had suffered from an incautious exposure to the sun's light. In several of these cases, there were permanent coloured spectra before the eye, occasioned by the use of coloured glasses of too light a tinge. In all these cases, the colours of the spectra were *complementary* to the colours of the glasses through which the sun had been viewed.

peculiar colour of these films is not very obvious, unless they are seen in contrast with a yellow or orange surface, and even then they appear very sombre and almost black, because, in the peculiar state of the eye that gives rise to their appearance, there always coexists a certain degree of diminished sensibility to all the rays composing white light.

At the commencement of amaurotic blindness, these films are not much observed by artificial light, because then the retina is stimulated by the red and yellow rays it contains in excess; but in diffused day-light these rays are not in excess, and the impaired sensibility of the retina shews itself at once.

Although all kinds of coloured light may prove injurious to the eye by stimulating it unequally, some are much more hurtful than others. An excess of blue light is least injurious; then bluish-green, green, yellowish-green, yellow, orange, and red, in the order here given. In good artificial light, the yellow rays are in much greater excess than the red ones; but, on the other hand, the red rays are comparatively more hurtful, in consequence of their greater force and heating power.

The sensation of light is produced by the waves or undulations of a thin ethereal fluid, which pervades all space, and is thrown into a state of vibration by luminous bodies. The size and force of the waves of the different coloured rays composing white light vary considerably, as does also the rapidity of their vibrations: the more rapidly the ray vibrates, and the smaller the size of these vibrations, the less is its force; just as in the ocean, where the ripple waves, though moving with great velocity, have little force, whereas the long but slow heavings of a swell are almost irresistible; or as is the case with sound, to which light bears many analogies, where the higher notes are known to be produced by a greater number of vibrations in a second than the lower notes, the power of which is so much greater. The following Table, by Sir John Herschel, will give an idea of the relative force of the different rays, which is *directly* as the values of the figures in the first column, and *inversely* to those in the second and third columns.

Colour of Rays.	Length of Undulations in Decimal parts of an Inch.	Number of Undulations in an Inch.	Number of Undulations in a Second of Time.
Extreme Red,	0.0000266	37640	458000000000000
Red, ...	0.0000256	39180	477000000000000
Orange, . . .	0.0000240	41610	506000000000000
Yellow, . . .	0.0000227	44000	535000000000000
Green, . . .	0.0000211	47460	577000000000000
Blue, . . .	0.0000196	51110	622000000000000
Indigo, . . .	0.0000185	54070	658000000000000
Violet, . . .	0.0000174	57490	699000000000000
Extreme Violet,	0.0000167	59750	727000000000000

A wave of red light is 266 millionth parts, or 1-thirty-seven-thousandth parts of an inch in length, and its action endures for the $\frac{1}{458}$th millionth of millionth part of a second. A wave of blue light is only 167-millionth parts, or 1-fifty-nine-thousandth parts of an inch in length, and the duration of its action is only the $\frac{1}{727}$th millionth-millionth part of a second of time. These minute spaces and periods are hardly conceivable by the mind; they are deduced from the observation of certain very remarkable and intricate optical phenomena, which are as satisfactory, and in some respects even more so, than observations in any other department of science, and every day some fresh proof is discovered bearing irrefragable evidence of their accuracy. Thus it appears that the relative forces of the red, yellow, and blue rays are nearly in the following ratio.

Red, . . .	266
Yellow, . . .	227
Blue, . . .	167

It will now be evident, that when light contains an excess of red and yellow rays, it must be highly injurious to the eye from the greater force of these rays, and it will now be seen that the terms *soft* as applied to *blue* light, and *harsh* as applied to *red* light, are expressions which, though dictated merely by the imagination, are strictly correct, and perfectly accord with the observations of philosophy.

The heating power of light varies with the colour of it, as is shewn in the following table by Sir Henry Englefield, which exhibits the heights of thermometers placed in the different primary rays composing a beam of white light.

	Rays.		Degrees.	
	Blue,		56	
In the	Yellow,	the thermometer stood at	62	Fahr.*
	Red,		72	

Therefore artificial light, by containing an excess of red and yellow rays, will have a greater primary heating effect in proportion to the illuminating power of it than common day-light.

The above table, like the former one, furnishes an instance of common expressions being in strict conformity with scientific observations; for, in popular phrase, blue is said to be a very cool colour; green is cool, though not so much so as blue, especially if of a yellow tint; yellow is said to be warm, orange still warmer, and red the warmest of all colours; but purple or very deep crimson, which is a mixture of blue and red, is considered as neither warm nor cold.

* The temperature of the green rays, formed by the combination of blue and yellow, was found to be 58°.

There is still another way in which the peculiar colour of artificial light proves injurious to the eyes. It is known that the "*Defining Power*" of pure white light, produced by the combination of its three constituent colours in fit proportions, is greater than the sum of the defining powers of these constituent rays taken separately; but if, in artificial light, one or more of its constituents be in excess, there will not be a corresponding increase in the defining power; and, therefore, in order to see an object by artificial light as distinctly as in day-light, a greater quantity of *light-giving vibrations* are required. In reading or writing by day-light the black ink is strongly contrasted by the pure white paper; but by artificial light, as the paper has an orange or yellow hue, the contrast is not so marked, and for distinct vision it becomes necessary to increase the quantity of the light. In sewing blue coloured fabrics by artificial light, the eyes must be very much exerted, because, in consequence of the fewness of blue rays, which are the only ones reflected from blue surfaces, the cloth appears almost black, excepting in a very intense light. In sewing green coloured fabrics, a similar effect takes place, though to a less extent, in consequence of their reflecting the yellow rays which enter into the composition of green light.

It is a most beautiful provision, that the union of red, yellow, and blue rays in certain proportions, should form pure white light, of a greater defining power than the aggregate of the defining powers of these three rays taken separately; as, in this way, the greatest illuminating effect can be obtained from the smallest expenditure of the light-giving principle, and with the least possible violence to the delicate nerves of vision.

I have thus endeavoured to explain the causes of the injurious action of artificial light, so far as they depend on its defective chromatic constitution, which, though rather an intricate subject, is, nevertheless, one of great interest and importance. The next of these causes is,

THE INDIRECT HEATING POWER OF ARTIFICIAL LIGHT.

It has been shown that the red and yellow rays, which predominate in artificial light, have a considerable heating power; but in addition to the heat that is *contained in* the rays of all kinds of light, whether celestial or terrestrial, a very considerable quantity *accompanies* them, and may be separated from them. The sun's rays are seldom, if ever, allowed to fall directly on a near object, on which the eyes are to be employed for any length of time, without having previously undergone repeated reflections from the atmosphere and clouds, or from the surface of the ground, and the walls and furniture of the apartment, which absorb a great portion of their accompanying heat. But, owing to the non-diffused and concentrated character of artificial light, the rays must be generally allowed to fall directly on the object looked at, from which they are reflected to the eye, along with nearly the whole of their accompanying heat. The heat acts injuriously, not so much on the retina as on the external coats of the eye, and particularly on the lining membrane of the eyelids; and by causing chronic inflammation and a diseased state of the secretions, renders indistinct the images formed on the retina, and necessitates the employment of a greater quantity of light than would otherwise be required. The dry and parched state of the air of a room where many lights are used, is very hurtful, and gives rise to the intolerable itchiness and stiffness of the eyelids so generally complained of. The next circumstance that calls for notice is the

EFFECT OF THE CARBONIC ACID GAS.

That is always formed during the combustion of the substances from which light is procured. This gas is quite invisible. The *smoke* of an ill regulated flame is not carbonic acid gas, but merely particles of unconsumed charcoal, and is comparatively harmless; whereas carbonic acid gas has a most baneful influence on the human body. The colour and smell of smoke soon give notice of its presence in the air of a room; but carbonic acid gas has neither colour nor smell, and it may accumulate to a great extent without being perceived, till after it has acted for some time on the system. It is the absorption of this gas by the lungs and skin, that causes the headach so common after sitting in a crowded room, even in day-light, when this gas is formed solely by the process of respiration, but which is so very generally felt, in a more severe form, after being for some time in crowded and brilliantly lighted assemblies at night, as in churches, ball-rooms, and theatres. A large quantity of carbonic acid gas is very destructive of life. Some gases kill an animal immersed in them, merely by depriving it of pure air, in the same way that water acts in drowning; but carbonic acid gas acts as a most deadly narcotic poison, paralyzing the nervous system, and completely destroying the sensibility of the brain. Like opium and many other narcotics, carbonic acid gas taken in small quantity, as when it has been absorbed by the stomach from effervescing liquors, acts as a temporary stimulant; but in a larger dose, or in small doses continued for a long time, it produces permanently injurious effects on the whole nervous system. It does not act directly on the eye itself, but on the brain, and, in particular, on that part of it with which the optic nerves are connected, the sensibility of which it weakens and ultimately destroys; and then, though the images of external objects be formed on the retina, and though the vibrations they excite be transmitted along the optic nerve, they produce no effect on the brain, and so are never communicated to the mind. The morbific agency of carbonic acid gas is very insidious, and the effect of it very intractable; when conjoined with the other causes already mentioned, it plays an important part in the production of impaired vision from disease of the nervous structures of the eye; and there is no doubt that it often is a predisposing cause of various other serious diseases of the nervous system, especially palsy and apoplexy.

No carbonic acid is disengaged from sun-light; and, although it must always be formed during combustion, yet, by proper precautions, to be afterwards described, the evils arising from the accumulation of it to an injurious extent, in apartments where artificial light is used, may be completely prevented.

THE UNSTEADINESS, AND THE GENERALLY IMPROPER POSITION, OF ARTIFICIAL LIGHT, are the next and the last of the causes of its injurious action on the eyes; and though, for all practical purposes, they may be easily and completely obviated, they are in very general operation. Sun-light is remarkable for the equability with which it flows; and, in looking closely at an object illuminated by it, not the slightest wavering or flickering can be perceived. But all artificial light is more or less unsteady, from the impossibility of perfectly regulating the supply of air and of inflammable material. There is least unsteadiness when, by the use of a glass-chimney, there is a constant and equable current of air on each side of the flame, and when the combustible matter flows in a perfectly uniform stream, as in a gas argand-burner. There is more unsteadiness when the flame is merely enclosed in a wide glass-shade, without a draught-regulating chimney, as in a flat or "fish-tail" gas-burner; and the unsteadiness is greatest when neither chimney nor shade is used, and when the supply of fuel is constantly varying in quantity, as in common candles and the ruder forms of oil-lamps.

This unsteadiness of artificial light is highly irritating to the eyes, particularly if it take place to any extent, as in a gas-burner containing some drops of water; but even in more common cases, a much slighter degree of unsteadiness always proves hurtful, by necessitating the employment of a greater quantity of light than would be required if the flame were always of uniform intensity. To illustrate this, let it be supposed that certain objects, such as the letters on a printed page, can be distinctly seen in light of either eight, nine, or ten degrees of intensity, but that the intermediate degree of nine is preferred: then, if sun-light be used, as it flows in a perfectly uniform manner, and does not suddenly vary in intensity, the eye will be able to read without fatigue for a great length of time, because, from the slowness with which any change in the intensity of the light takes place, the retina and the pupil get time to accommodate themselves to it. If, however, artificial light of the same intensity, viz. nine degrees, be used, and if, at one instant, the intensity be increased to ten degrees, and the next instant reduced to eight degrees, from the flickering of the flame, the retina and pupil of the eye have not time to get accustomed to the change, and a degree of temporary blindness or impaired distinctness results, which is extremely annoying and very fatiguing to the eye. To diminish this disagreeable effect, the reader uses a greater quantity of light; for, by increasing it to an average intensity, say of fourteen degrees, with an extreme variation of one degree each way, as an allowance for the occasional increase or diminution of intensity in consequence of unsteadiness, he obtains a present advantage; because, when the light suddenly changes from an intensity of thirteen degrees to one of fifteen degrees, or the reverse, the sensible difference to the eye is not so great by fifty per cent. as when it varies from eight to ten, or from ten to eight degrees. The relief, however, obtained by this increase of the quantity of light is fraught with ultimate danger; for the retina is too much excited by this increase of one-half in the quantity of light admitted to it, and this state of excitement has already been declared to be the prelude to an opposite state, in which the sensibility to light is greatly diminished.

The generally improper position of the sources of artificial light, allowing a great quantity of extraneous light to pass into the eye, is productive of very bad effects. The eye of man and the higher animals is formed on the same optical principles as a common *camera obscura:* the pupil is the opening for the admission of the light; the humours act as the glasses; and the retina is the table on which the images of external objects are formed. For the perfect action of such an instrument, it is necessary that no light shall be admitted to the table, excepting that which is reflected from the objects to be represented on it. So is it with the eye; for, to obtain the most perfect vision, the pictures of objects painted on its retina must not be rendered indistinct by the simultaneous admission of extraneous rays, such as those proceeding directly from a lamp, and not reflected from the objects. For very perfect vision, even the rays reflected from surrounding objects should be cut off, and, accordingly, in examining an extremely minute point, a considerable increase of distinctness is obtained by looking through a narrow tube.

By means of a working model of the eye, which I constructed, for the purpose of explaining some of the phenomena of vision, in my lectures to the students at the Eye Dispensary, I have repeatedly illustrated, in a practical way, the injurious effects of the admission of extraneous rays into the eye, when it is employed on near objects. In this model the external portion of the eye is represented by a hollow wooden globe, optical glasses are substituted for the clear cornea and the humours, and the retina is made of a bit of tracing paper, with an arrangement behind for exhibiting the images and pictures that are formed on it. When the model is placed, like the eye of a reader, before a printed page, a distinct and legible (though inverted) picture of it is formed on the substitute for the retina; if now a candle be brought into such a position, that a number of its rays pass directly into the model, or if, in other words, the artificial eye see the candle, at the same moment with the type, that instant the image of it becomes indistinct and more or less illegible, and to restore its

CHAPTER III.

PROGNOSIS, AND GENERAL PRINCIPLES OF TREATMENT.

The Prognosis, in Impaired Vision from the improper Use of Artificial Light, depends on its Degree, Duration, and Complications—Confirmed Cases are very difficult to cure—Causes of this Intractibility—General Principles of Treatment of Amaurotic Blindness—Cautions to be observed—Treatment of Inflammation of the Lining Membrane of the Eyelids, or "Blear Eyes."

THE Prognosis, or the opinion to be formed as to the future prospects of cases of impaired vision from disease of the nerves of sight, is a subject that I do not purpose to enter into at any great length, as it is one more adapted for a purely medical treatise than for a popular essay; and to treat of it in all its bearings would involve the discussion of matters quite unintelligible to the general reader. It may be enough to remark, that the Prognosis, in any given case, will chiefly depend on—

I. The degree and duration of the disease.

II. Its complication with other affections, co-operating with the injurious action of artificial light.

1. When the disease is of recent origin, and solely or chiefly caused by the improper use of artificial light; when the sight is not very much impaired; when the dark filmy motes are of small size, not very numerous nor perfectly opaque, and when the patient is in good health otherwise, and of sober and regular habits, the prospect of curing it, or at least of arresting its further progress, is considerable, provided its cause be removed, and suitable treatment adopted. The slower the invasion of the blindness, the more tedious will be the cure. When it has been coming on gradually for many years, and when the sight is almost totally gone, the prognosis must always be unfavourable.

The state of the pupil, in cases of nervous blindness, is generally a good index of their curability. There is hope when the pupil is perfectly round, of its usual size and proper lustre, and when it contracts and dilates in different degrees of light. When the pupil is of irregular shape, but when its motions are tolerably perfect, the case, though less favourable, still is not desperate. When the pupil is irregular in shape, greatly dilated, or contracted to an extremely small size, quite immoveable and lustreless, the case is to be considered as nearly hopeless. But no decided opinion can be formed till after an examination has been made by a competent professional adviser, who will try the effect of condensed light, and also of the extracts of Belladonna or Datura; and if the pupil shew no signs of liveliness under the influence of these agents, all hope may be abandoned.

2. In all cases where the blindness is caused partly by the improper exposure of the eyes to artificial light, and partly by a diseased state of other organs, the prognosis is not very favourable, and must, in a great measure, depend on the nature and curability of these other affections. If the concomitant and co-operating disease be a bad state of the digestive functions, the chance of a cure is greater than if it be some organic affection of the heart, or still more of the brain; and, if it appear that the action of the artificial light has been assisted by the indulgence in some bad habit which may be given up, such as the excessive use of intoxicating liquors, or of tobacco in any form, there will be more hope than if the complication arose from some cause that could not be removed.

The above are the principal circumstances to be considered in forming a general opinion as to the curability and prospects of cases of amaurotic blindness. The only certain information, however, is to be obtained from a regularly educated surgeon, who, after making a deliberate and careful examination of all the other principal organs of the body, as well as of the eye itself, and after duly considering all the circumstances of the case, shall be able to give an opinion that may be relied on; and no one can be a competent oculist, however great his mere manual dexterity, unless he has fairly studied the science of medicine in all its branches, previously to confining his attention to diseases of the eye.

When a person who employs his eyes much on fine work, by artificial light, finds his sight beginning to grow feeble, and experiences any of the symptoms described in the first chapter of this treatise as indicating incipient disease of the retina, such as frequent flashes of light before his eyes when in a dark room, or the appearance of dark films and spectral motes when looking at a white surface or at the sky, it may always be predicted that the case will go on from bad to worse, unless the exciting cause, viz. the excessive or improper exertion of the eyes by artificial light, be removed, or modified by some of the methods presently to be described, and a proper course of treatment adopted. Before leaving this subject, however, I should not omit to mention the unwelcome truth, that, of all the diseases of the eye, numerous though they are, only a few of the rarer and malignant ones are so distressing to the patient, and vexatious to the medical attendant, as impaired sensibility of the retina. Even in the most favourable cases, the cure is tedious, and frequently both surgeon and patient have reason to be glad if the symptoms can be arrested, though they cannot be altogether removed; whilst in bad and confirmed cases, where total blindness exists, almost no treatment whatever proves of any avail. The intractability of this disease depends chiefly on the following causes—

1. Its frequent complication with other affections of an obscure or incurable nature.

2. Its slow and insidious progress before it attracts serious attention.

3. The difficulty of getting patients strictly to conform to, and rigorously to follow out, for a long time, the treatment and regimen prescribed.

4. The deep situation of the retina, in the bottom of the eye, rendering it invisible, and beyond the reach of local applications.

5. The peculiarity of the functions of the retina, and the exquisite delicacy of its organization.

GENERAL PRINCIPLES OF TREATMENT OF AMAUROTIC BLINDNESS.

The first step is to ascertain how far the disease is complicated with, or aggravated by, other affections; especially those of the cerebral, the digestive, and the uterine systems ; and, if possible, to remove or relieve them. Attention should next be directed to the eye itself. In the acute stage, when there is excitement and increased irritability of the retina, the treatment must be the very opposite of that employed in the chronic stage of the disease, where the sensibility of the retina is diminished: the discrimination, however, of the exact line of demarcation between these two opposite states is often a matter of considerable difficulty. In the acute stage, stimulants, either local or general, are quite inadmissible, and depletion and other antiphlogistic remedies are required. If the case be quite a recent one, and not of great severity, these means, along with perfect repose of the organ, may be sufficient, and, at all events, they must be employed till the disease has assumed a chronic form. When this happens, stimulants, such as ammoniacal and ethereal vapours and eye-waters, along with strychnia, and galvanism, or electricity, judiciously and cautiously employed, are the local means most likely to be useful. These remedies should not be used without the superintendence of a professional adviser ; for some of them, such as strychnia, used incautiously, may cause instantaneous death ; and too strong a shock, from a very powerful electric or galvanic battery, transmitted through the head, may render the patient insensible for a time, or it may altogether destroy what sight he had.

Along with the proper and regulated use of these means, a succession of blisters to the nape of the neck, behind the ears, or on the temples, should be tried. Their position is not entirely a matter of indifference; the proper rule to follow, is to place them nearest the seat of the disease in the most chronic cases, and at a greater distance from it in those that are less so. Local bleeding is not required in very chronic cases; but in the subacute forms, where there is a tendency of blood to the head, repeated cupping on the temples is often of very great service. Above all, abstinence from every cause of cerebral excitement, especially the use of spirituous liquors, or of tobacco, in any form, must be strictly enforced in the great majority of cases; although, now and then, in certain instances, there may be circumstances to render advisable the cautious use of diffusable stimulants and a rather generous diet.

The eyes should be rested as much as possible, and when artificial light is used, it should be modified and rendered less irritating by one or other of the methods presently to be described.

Blue spectacles and wire gauze preserves often afford considerable relief in slight cases, but when once the sight has become very much impaired, they are of no use whatever.

TREATMENT OF INFLAMMATION OF THE LINING MEMBRANE OF THE EYELIDS.

If the disease be acute, and the eyelids painful to the touch, great relief is obtained by applying two or three leeches to their *outside* skin, a little way from their edges, or blood may be taken from the lining membrane itself by scarifications; but on no account should leeches be applied to the inside of the lids, as some recommend, for the swelling caused by their bites is very irritating to the eye-ball. After the local bleeding, blisters should be placed behind the ears, and the parts dressed with savine ointment for a few days, to promote a discharge. Along with these local measures a rather spare diet, abstinence from wine and spirits, or fermented liquors, active exercise, and one or two doses of some mild saline aperient, will either complete the cure, or bring the disease to a chronic state. When this happens, or if the complaint has been chronic from the first, local stimulants, in the form of collyria, or of ointments and salves, should be employed. Of the collyria or eye-waters, the most useful is an aqueous solution of sulphate of zinc *(white vitriol)*, of the strength of six grains to four ounces of distilled water, with the addition of quarter of a fluid ounce of compound tincture of lavender, and three drops of *diluted* sulphuric acid. This should be applied three times a-day, by means of an eye-water glass, which is to be filled with the solution, then everted over the open eye, and held there for a few seconds. The collyrium should cause a degree of smarting for a minute or two after its application, but if the pain be severe, or continue for a considerable time after, it should be diluted with a little rose water. A solution of the sulphate of alumina *(rock alum)*, of the strength of twelve grains to four ounces of distilled water, may be substituted for the above ; it is rather less stimulating, and, if thought proper, may be used alternately with the zinc wash. When the *dryness* of the lids is much complained of, an eye-water composed of fifteen grains of subcarbonate of potassa *(salt of tartar)* dissolved in four ounces of water, with the addition of six drops of tincture of capsicum, often affords very great relief ; it should be applied, with an eye-water glass, three or four times a-day.

Bathing the eyes with simple cold water is often of great service, as a preventive of the injurious effects of the heat that accompanies artificial light. The patient should provide a basinful, in which he should occasionally immerse his whole face, taking care to keep his eyes open at the time.

Ointments and salves should be used only at bed-time. If composed of simple materials, such as lard, or lard and wax, they merely prevent the adhesion of the edges of the lids during sleep ; but when they are made slightly stimulating, they are of great use in removing the chronic inflammation of their lining membrane. Of the ointments none answers so well as the citrine ointment *(Unguentum Nitratis Hydrargyri mite)*. The red precipitate salve *(Unguentum Oxydi Hydrargyri rubri per acid. nitricum)* is often prescribed, but, unless it has been specially prepared for ophthalmic purposes, it is apt to prove highly irritating. A small portion of the citrine ointment, not larger than a split pea, and previously softened at the flame of a candle, should be taken on the point of the little finger, *and the lower lid being drawn a little down, so as to expose its inner surface*, the ointment is to be gently inserted between the eyelids, and about the roots of the eye-lashes. It is a much more elegant process to apply the softened ointment by means of a camel's hair pencil, but there is always a risk of leaving some of the hairs between the lids, which may remain there, and bring on serious inflammation of the eyeball itself. The eyes should be bathed with warm milk and water in the morning, and one or other of the eye-waters just described, should be used during the day-time. By a steady perseverance in these means, avoiding the excessive exertion of the eyes by artificial light, observing good hours, and paying a little attention to diet and exercise, a speedy cure will, in most cases, be obtained. When the affection is a very obstinate one, of long standing, and when the eyelids are thickened and callous, they require to be freely touched with lunar caustic, and to be frequently scarified: but these remedies are very dangerous if misapplied, and should never be used but by a surgeon.

When the eyelashes are completely destroyed, nothing will make them grow again; but if their destruction be partial, it is to be put a stop to by curing the chronic inflammation that gave rise to it, and the remaining eyelashes should have their points cut off, with scissors, once every eight or ten days, to make them grow thick, and so supply the place of those that are lost. The destruction of the eyelashes is a very serious evil; it causes considerable deformity, and, by allowing too much light to enter the eye, greatly assists in the production of impaired sensibility of the nerves of sight.

CHAPTER IV.

ON THE CHOICE OF ARTIFICIAL LIGHT.

Circumstances in which Artificial Light is most injurious to the Eye —Comparative advantages of different kinds of Artificial Light—Olefiant Gas—Naphtha—Oil-Gas—Parrot and Cannel Coal-Gas—Sperm and Fine Oils — Parker's Hot Oil-Lamp — Wax and other Candles—Palmer's Candle-Lamps—Inferior Coal-Gas highly injurious—Great general advantages of good Coal-Gas—How Gas should be used.

It is only when the eyes are exerted on minute objects, that artificial light is so very injurious. In public places the light is not always so strong as to injure the eyes by its direct action, and it proves hurtful chiefly by the quantity of carbonic acid that is produced by the combustion of the light-giving materials; besides, as in such places, the sight is not constantly employed on one object, the bad effects of the peculiar colour of the light are often counteracted by the variety of tints reflected from the walls and furniture. But in reading, writing, sewing, type-setting, and other occupations, requiring the severe, long-continued, and nightly exertion of the eyes, the light requires to be of considerable defining power; and to obtain this, it must be placed very near the eyes, which it injures by its heating effect as well as by its bad colour, as has been fully explained in the preceding pages.

The circumstances to be attended to in considering the comparative advantages of different kinds of artificial light are

1. Purity of colour.
2. Practical convenience.
3. Economy.

The purest light, obtained from the combustion of hydro-carburetted bodies in atmospheric air, is given out by olefiant gas, a compound of hydrogen and carbon, procured by the action of oil of vitriol on spirit of wine; but it is never employed for ordinary purposes, in consequence of its great costliness. Perhaps the next purest light is obtained from naphtha: the nauseous smell, and the difficulty of managing this substance for a long time prevented its coming into general use; but recent improvements have greatly obviated these objections, and, from what I have seen of the performance of the best naphtha lamps now made, I certainly think that the purity of their light is hardly equalled by that of any other lamps in ordinary use.

Oil-gas gives a very fine light, and, at one time, numerous companies were formed for manufacturing it; but the great expense of it proved a barrier to its general introduction. The gas obtained from rosin gives fully as good a light as oil-gas; Professor Daniell took out a patent for it, and a joint-stock company was formed to manufacture it; but, after expending more than L.50,000 on the works, the design was given up, as it was found that, though rosin-gas was of first-rate quality, it was too costly to compete with coal-gas.*

I would place the light of gas made from *parrot* or *cannel* coal as next in purity, and first in convenience and economy. It is now very extensively employed both for outdoor and indoor illumination, and, taken on the whole, is better adapted for general purposes than any other kind of artificial light whatever. The quality of this kind of coal-gas is liable to vary a little, according to the goodness of the coal and the manner of manufacturing it; but that prepared in this city and neighbourhood is of the very best kind, and is quite a different article both in its chemical nature and its effects on the eyes, from the light carburetted hydrogen gas made from *common* coals, such as are used by the London gas companies.

The light procured from the finer sorts of oil, especially refined sperm-oil, is the next in purity, and perhaps, in some instances, even superior, in

* For a description of the ingenious apparatus for making rosin-gas, see Dr Ure's Dictionary of Arts and Manufactures, p. 1076.

this respect, to the light of gas made from parrot or cannel coals; but it is much less convenient and much more costly. In burning oil, for the purposes of illumination, a great deal depends on the construction of the lamp, but the argand arrangement is by far the best, and is almost universally used. There are many minor and ingenious modifications of the argand lamp; the greatest improvement in this respect is in Parker's patent Hot Oil-Lamp, in which the oil is heated before it is supplied to the wick, and in this way is rendered so extremely fluid as to be raised by the capillary attraction of the wick, with the greatest facility, in a perfectly uniform manner, and without any of that tendency to clog, so generally complained of in cold oil-lamps, whilst, at the same time, the brilliancy of the light is greatly increased.*

Next to the finer sorts of oil, the purest light is obtained from wax, spermaceti, stearine, and cocoa-nut candles, but although the quality of their light is good, it wants steadiness, the candles burn down, and all of them are more or less liable to gutter and swill, particularly where there is a varying draught of air. Palmer's Candle-Lamps are so contrived as to combine, in some measure, the cleanliness

* See Dr Ure's evidence before a Committee of the House of Commons, "Report on Lighting the House," No. 501, 1839, pp. 18–38.

and convenience of wax-candles with the steady and uniform light of oil-lamps: in them the flame is kept always at one height, till the whole candle is consumed; no snuffing is required, and they may be fitted with ground glass shades, or opaque reflectors, in the same way as an argand table-lamp. They are certainly a great improvement on common candles, and are admirably adapted for many situations, particularly on shipboard.

The gas distilled from common sea-coal, contains much less carbon, on which it has been shewn that its illuminating power depends,* than gas made from parrot or cannel coal; it burns with a reddish-yellow flame, of great heating power, and very hurtful to the eyes, and is quite unfit for in-door use, excepting in halls, or in public places, where the eyes are not to be much exerted on minute objects. This inferior kind of coal-gas is that generally used in London, and it is a great pity that some of the metropolitan gas companies do not use a better coal, the greater cost of which would be compensated by the gas made from it being much more generally employed in private houses than at present.†

* See Chapter II.

† Report to House of Commons, by Joseph Hedley, Esq. of the Alliance Gas Works, Dublin; also Dr Ure's Dictionary, p. 562.

The light of common coarse oil-lamps and tallow-candles is of very inferior quality. The lamps have the advantage of maintaining the source of the light at one elevation, and the size of the flame does not vary so much as in tallow-candles, particularly the coarser kinds; for in them not only is the colour of their light highly injurious, but from the constant flickering and variation of its intensity according to the state of the wicks, they are quite unfitted for the illumination of minute objects, on which the eyes are to be much employed.

All things considered, I think that the light of gas made from parrot or cannel coal is the best adapted for general purposes: the great recommendations are its purity and equability; its admitting of being so easily placed in any position; the facility of increasing or diminishing its intensity as required; and its cleanliness, safety, and great economy.*

There are three principal ways of burning gas, for the purposes of illumination: 1. The cockspur jet; 2. The flat or "fish-tail" jet; and, 3. The argand. In the cockspur jet, the gas issues from a

* 1164 feet of the best coal-gas, at 10s. per 1000 feet cost 11s. 8d., and gave as much light as 100 lb. of moulded tallow candles (of six to the lb.), which cost L.3 : 2 : 6.—J. Hedley, Report to House of Commons—Dr Ure's Dictionary, p. 563.

small round hole in a steel nozzle, and forms a slender pencil of flame ; this arrangement is hardly ever used now-a-days, as it does not give nearly so much light from the same consumption of gas as the fish-tail and argand burners. In the fish-tail jet, two streams of gas are made to cross each other, just at the point where they pass into the air, and the flame is in the form of a thin triangular sheet, with its apex downwards. This flat burner gives a very fair light ; the chief objection to it is the difficulty of using a chimney to render the flame perfectly steady, and regulate the supply of air. It is a very general opinion that the flat burner is much more economical than the argand; but Dr Ure, Sir J. Robison, and other competent authorities, who have paid much attention to the subject, hold a different opinion. There can be no doubt, however, that in a very great many cases, the flat burner is *indirectly* more economical ; because, from its simplicity, it is not apt to get out of repair, and there are no glass chimneys to break, an accident that is continually happening to argands, used by persons who are ignorant or careless of their proper management ; on this account it is likely to become very generally used. In the argand burner, the gas issues by a great many holes close to each other, and disposed in a circle. When lighted, all these jets unite by their edges, forming a tube of flame, and a chimney being applied, an equable current of air is established on each surface of the flame, which immediately becomes considerably smaller, and of greater brilliancy. Some care is required in the choice of a chimney; if it be too low, the draught is not sufficient, and the flame is not so white as it should be; or if the chimney be too tall, the draught becomes too great, and the gas is consumed very rapidly, giving but little light, and an intense heat. When properly arranged, and carefully attended to, the argand is decidedly the best form of burner; and in no other way can an equally pure and steady flame be procured. It is a common opinion that in an argand, the rays from the inner surface of the hollow cylinder are lost, owing to the apparent opacity of flame; this, however, is a mistake; flame is not opaque, for if a small object be thrust up the centre of the argand flame, it can still be distinctly seen, and, besides, in the best light house lamps now used, one argand is enclosed within another, and often three or four concentric ones are employed, with the best effect, which could not be the case were there any great loss from the apparent opacity of the flame. It is true that objects at a distance are not seen through a sheet of flame; but this arises from the image of the flame formed on the retina being so much brighter than the image of the object, as completely to obscure it; and, for the same reason, in a half darkened room, where a solitary ray of sunshine is admitted, through a hole in the shutter, objects placed on the other side of, but in the same plane with it, are nearly invisible; yet still no one doubts the transparency of sun-light.

In those cases where the sight is much employed on fine work, by gas light, advantage should be taken, during any temporary interruption or interval, of the great facility with which the intensity of the light may be instantly diminished, so as to afford an occasional short period of rest to the eyes, and allow the exhausted retina to recover its tone. The effect of such a temporary repose is often very decided, and a new vigour seems to be imparted to the nerves of sight; especially if, during this short interval, the eyes have been bathed with cold water, recommended in the preceding chapter, as a preventive of the bad effects of the heating power of artificial light.

It is a very common opinion that even the best kind of gas-light is extremely injurious to the sight. Gas-light has certainly done, and is now doing, far more injury to the eyes of thousands than almost any other kind of light; but not from any peculiarity in its optical or chemical nature, as is generally supposed, for it is only the *abuse*, and not the *use*, of gas-light that renders it so extremely hurtful. The actual quantity of light obtained from the dearest kinds of coal-gas, costs fully five times less than the same quantity of light from almost the cheapest of other materials, such as tallow.* Yet, almost all who employ gas, though ready to admit its convenience, are not quite so sure of its economy, simply because its cheapness leads to its abuse, by being burned in enormous quantities, producing a flood of light in the remotest corners of apartments (where the sight is to be exerted on fine work, for hours at a time, and night after night), where there is hardly so much as a single shady spot towards which the exhausted eyes can be turned for relief during any temporary relaxation ; whilst at the same time, it heats the surrounding air to a most injurious degree, and poisons it with carbonic acid. Thus the cheapness of gas-light leads to its abuse; but its other advantages, viz. the facility with which it may be placed in any required position, and increased or diminished in intensity according to the nature of the work, are also too often abused; by having the light placed close to the eyes, without any opaque shade to intercept the extraneous

* See *note*, p. 66.

rays that obscure the distinctness of the picture on the retina; or by employing a stronger and stronger light in proportion as the sensibility of the optic nerves becomes impaired, to obtain a present, though temporary relief, with the certainty of ultimate and permanent injury to the sight.

CHAPTER V.

PREVENTION OF THE INJURIOUS ACTION OF ARTIFICIAL LIGHT.

1. By improving the Colour of Artificial Light; *a* by the addition of the Primary Rays which are deficient; *b* by the absorption of the Primary Rays that are in excess. Practical application of these principles. Fluid condensers. Modification of the Wood-engraver's Lamp.—2. By diminishing the Heating Effect of Artificial Light. Melloni's Experiments.—3. By preventing the accumulation of Carbonic Acid Gas. Ventilation.—4. By the judicious position of the Light, and the proper employment of Shades.

For the improvement, by optical means, of the naturally bad colour of artificial light, on which its injurious action so much depends, two different methods may be employed.

1. The addition, by reflection, of the blue rays that are deficient.

2. The subtraction, by absorption, of the red and yellow rays that are in excess.

In the first of these methods, the light that passes upwards is to be deprived of its red and yellow rays by some *blue* intercepting surface, to reflect downwards the few remaining blue rays, which, mingling with the reddish-yellow coloured light, proceeding directly from the flame, shall form a compound light of a white colour, from the primary rays contained in it being nearly in the same proportions to each other as in day-light.

In the second method, the direct light emanating from the flame is to be passed through some transparent medium of a blue tint, such as stained glass, or a coloured fluid, which shall absorb the excess of red and yellow rays, and transmit white light.

I will begin by describing the first, or the reflective method of improving the colour of artificial light, as being the simplest, and, perhaps, the most generally useful.

All that is requisite is to provide a conical reflector, Fig. 1., the inner surface of which should be stained or painted of a sky-blue or azure colour; this reflector must be placed round the flame in the way that is represented in Figs. 2, 3, 4, and 7. The effect of this arrangement is, that all the light passing upwards is intercepted by the sloping sides of the reflector, its red and yellow rays are absorbed, whilst the blue ones reflected downwards, and made to combine with and improve the bad colour of the light proceeding directly from the flame.

The reflectors may be made of any convenient material such as silk, tinted paper, or painted metal. The silk reflectors are the most elegant, but they are more expensive, and apt to be injured by the heat; those made of stiff paper or bristol board, of the same colour as the bit of blue paper inserted in the plate, are cheap, easily made, and answer very well; but the most durable, and perhaps the best, are made of tin-plate or sheet-brass, bronzed on the outside, and painted of a light sky-blue on the inside.

To form a conical reflector, such as Fig. 1, the paper or other material should be cut into the shape of Fig. 5, and then the edges *aa* and *bb* united to each other. When the reflector is made of paper or silk, it may be supported on a wire frame which is to be hooked on to the top of the glass chimney, or to the shade of the lamp, as at *a* and *b* in Fig. 3. When the reflector is of metal, it may be supported in the same way; though it is better to have a three-branched gallery, screwed to the burner, and on which the edges of the reflector may rest. Candle-lamps, such as Palmer's patent ones, are easily fitted with reflectors; but common candles should be placed on a stand such as Fig. 4; or the candlesticks may have an upright brass rod attached to them, Fig. 7, on which the reflector may be made to slide and be adjusted by means of a thumb screw.

No pigment answers so well for giving the necessary tint to the reflecting surface, as a mixture of ultra-marine, and prussian blue; but cobalt and saunder's blue (cendres bleues?) may be substituted; and, indeed, almost any light blue will be found to answer; prussian blue by itself, turns green by exposure to the heat of the flame, and many of the others lose their proper lustre; none of them being either so pure a colour, or of such an unchangeable nature, as the ultra-marine. The blue surface of the reflector should be smooth, but without any gloss; when painted metal is used, no varnish should be put on, but the paint should appear quite dead, or "flat," as it is technically termed.

When a light blue-coloured reflector is placed over an ordinary flame, the effect is very marked; objects, such as the page of a book, no longer appear of a reddish-yellow colour, but of a much whiter and purer colour; the light becomes delightfully cool and agreeable to the eyes, and, from its whiteness, its defining power is much increased.

When a common white reflector is used, the brilliancy of the light is considerably augmented; but as this is the effect of the reflection of all the rays which enter into its composition, the advantage is not nearly so great as when the increase in defining power is obtained by adding only the blue rays, which are the least injurious to the eye, from their feebler impulse and greater coolness;* while at the same time the retina is stimulated by light, the primary rays of which are more nearly in the same proportion to each other that they are in sun-light.

The colour of artificial light may be improved according to the second method, by transmitting it through a solid or fluid medium of a pale blue colour, to absorb the excess of red and yellow rays. In this method the chief difficulty is to obviate the great loss of light that takes place, and for this purpose it will not do to increase the intensity of the primary light itself, as that would cause a greatly increased consumption of materials, with much heat and carbonic acid gas. The plan to be adopted is to concentrate the transmitted light either by means of bright metal reflectors, or by making the surfaces of the absorbing medium convex, so that it may act as a condensing lens.

Pale blue spectacles have the effect of absorbing the excess of red and yellow rays contained in artificial light; but their use is not advisable; as, from the greater warmth of the absorbed rays, they become hot and uncomfortable; and, from the loss of light they occasion, they require to be removed when the eye is turned for a moment to any other object than that on which the light is concentrated.

When the glass chimney of an argand lamp is

* See Chapter ii. pp. 36–39.

stained of a very pale blue colour, it makes the light of a better colour, but much less intense; if, however, a conical reflector of bright metal, such as block-tin or plated copper be added, then all the rays that pass upwards will be reflected downwards, and the intensity of the light thrown on the object considerably augmented, whilst, at the same time, the proportions of its primary rays will nearly resemble those of pure sun-light. Fig. 6 represents another arrangement for improving the colour of artificial light, and which may be easily adapted to either an argand or a flat burner,—*b b b*, is a three-branched support, made to screw on to the burner *c*, two of the branches have incurved extremities, and the third has a small thumb-screw at *a*; their length is 3½ inches, and they support a circular plate of glass, *d d d* with a hole in the centre, a little larger than is required to admit the burner *c*; this plate of glass is stained blue, of such a depth of tint, that a bit of white paper seen through it, in day-light, appears nearly of the colour of the blue sky; over this glass-plate there is placed a conical tin or silvered copper reflector, secured by the thumb-screw *a*; this reflector is four inches high, and the opening at the upper part is three and a half inches wide.

The best way of imparting the necessary blue tint to the glass chimneys and shades, or to the circular plate of glass in the last arrangement, is to paint them with ultra-marine, worked up with mastic varnish, and applied very evenly. This answers better than the cobalt-blue enamel employed by the glass-stainers, which transmits a considerable quantity of red light: and although not so durable as enamel, yet, with ordinary care, it will last a long time.

Shoemakers and some other artizans in Germany, and wood-engravers in England, frequently employ a very simple method of condensing, and, at the same time, cooling the rays of artificial light, which, with a slight modification, may also serve the purpose of improving its colour, and of rendering it still less heating and injurious to the eyes. It consists in having a large globular bottle, filled with pure water, placed between the object and the light, the rays from which, in their passage through the water, are converged into a dense parallel beam, in consequence of the spherical shape of the bottle; and thus, their illuminating power is much increased, whilst, at the same time, they are deprived of a great portion of their heat. Fig. 2 represents an ordinary wood-engraver's argand lamp, provided with a common white reflector, and placed behind and a little above the globular water-bottle. This figure is taken from Jackson's late work on Wood Engraving, in which he, as a practical man, speaks highly of its advantages.* When the bottle is filled with clear water, the transmitted light suffers no change in colour; but, if a small quantity of the *ammoniuret of copper* be added, so as to tinge it of a pale blue, it will have the effect of greatly improving the colour of the light, by absorbing the red and yellow rays that are in excess. The ammoniuret of copper is easily prepared, by rubbing together in a mortar equal parts of sulphate of copper *(blue vitriol)* and carbonate of ammonia *(hartshorn)*, and then adding about three times the bulk of pure distilled water. This mixture has an intensely deep blue colour; it should be kept in a tightly corked phial, and a few drops of it are quite sufficient to tinge several quarts of water. The quantity of this ammoniuret solution required to be added to the water will vary according to the capacity of the bottle. The best way of judging when enough has been added, is to place a bit of white paper behind the bottle in day-light, and, as soon as its colour, when seen through the fluid, becomes of a fine sky-blue, no more of the ammoniuret should be added; and the blue tint of the water should be hardly visible in artificial light. The ammoniuret of copper may be procured ready made at any che-

* The History and Practice of Wood Engraving. by J. Jackson. London, 1839.

mist's shop. It is such a very cheap substance, that, for a few pence, as much may be had as will colour nearly a hogshead of water.

Of diminishing the Heating Effect of Artificial Light.—Professor Melloni has proved by experiment, that when the rays of artificial light are passed through even a very thin stratum of water, their heating power is diminished by eighty-nine per cent., but without almost any increase in the temperature of the water, in consequence of its greater capacity for caloric.* From this it is obvious, how very beneficial it must be to employ the fluid condensers just described, in all instances where it is necessary to use a very strong light, as in engraving, and similar occupations. In ordinary cases, however, this is hardly required ; as the heat, so much complained of when the eyes are exerted by artificial light, is radiated from the flame in all directions, and, by rendering the air of the apartment dry and parched, increases the evaporation from the surface of the eyes, causing an unpleasant feeling of stiffness and itchiness, and inducing chronic inflammation of the lining membrane of the eyelids. To avoid these effects, the light should be placed in a well ventilated room, and care must be had to obtain the highest illuminating power,

* Annales de Chemie et de Physique, t. liii.

with the lowest consumption of inflammable matter. It must always be kept in mind, that the heat produced during combustion bears no constant ratio to the quantity of light obtained; for if, in burning gas or oil, too great a draught of air be given, there will be a rapid combustion and great heat, with very little light. Much also depends on the quality of the material from which the light is procured; the greater quantity of carbon it contains, the greater is its illuminating power in proportion to its heating effect, and *vice versa* when it contains but little carbon. Gas made from common coal, such as that used in London, contains little carbon and much hydrogen, or simple inflammable air, which, when inflamed, gives very little light and great heat; and this is the cause of the very injurious heating effect of such inferior kinds of gas, when employed for in-door lighting.

The best way of obviating the drying effect of combustion on the air of a room is to provide a proper system of ventilation; but, in rooms warmed by hot air, or where there is a stove in place of an open fire, it will be found very useful to have a flat dish, containing water, set in some convenient situation, the evaporation of which maintains a proper degree of moisture in the air. Those engaged in very fine work, requiring a very strong light, will find it useful to have a large sponge, soaked in water, and laid in an earthenware or wooden bowl, set on the table before them, to render the surrounding air moist and agreeably cool by its evaporation. When the light is nearly on a level with the eye, and shaded with a metallic reflector, the outside of the reflector should be covered with wood or leather, or some other bad conductor of heat.

Of preventing the effects of the Carbonic Acid Gas.—There is no direct way of diminishing the quantity of carbonic acid gas that is formed during the combustion of carburetted inflammable bodies, such as oil, wax, tallow, or gas; as the quantity formed by the combustion of a given weight of these materials is always the same, whether it be carried on slowly or rapidly, with much or with little air. But the carbonic acid gas, generated in an apartment where artificial light is used, may be indirectly diminished by a proper regulation of the combustion, so as to obtain the greatest intensity of light with the smallest consumption of materials. Thus, if each of two lamps be made to give the same intensity of light, and if in one of them there be too great a draught of air, it will consume more oil, and produce much more carbonic acid, than the other in which the supply of air is properly regulated.

Carbonic acid gas is a little more than one-half heavier than common air, but when first formed it is at a very high temperature, and, from its expansion, it is lighter than the surrounding air; it therefore ascends to the roof, and when there is no opening for its escape, it remains there till it cools, and then, by its superior gravity, it descends and mixes with the lower strata of air. When a room is well ventilated, or when there is an open fire-place, the carbonic acid gas is carried off, before it has time to act injuriously on the body. In small, low roofed, or ill ventilated rooms, or where there is no open fire-place or other channel by which the carbonic acid gas may make its escape, it accumulates to a great extent, causing headach, difficult respiration, with other unpleasant symptoms, and, in the course of time, producing most injurious effect on the nervous system; such as giddiness and confusion of ideas; indistinct vision, or sometimes total blindness; and even inducing apoplectic and paralytic attacks, in persons who have been long and constantly exposed to the deleterious action of this subtile agent.

In all cases where a number of individuals are congregated in small and ill ventilated apartments, where artificial light is much employed, as in the workshops of many classes of artisans, some special means of carrying off the carbonic acid gas, and heated air generated by respiration and combustion, should be provided by having ventilators in the roof, communicating directly with the open air, or leading into some chimney, in which there is a constant draught. In such places great advantage is derived from having a metal tube with a funnel-shaped extremity placed over the lights, as represented in fig. 3, and communicating either with the open air, or with a chimney. By such an arrangement the carbonic is removed as soon as it is formed, and the air of the apartment kept cool and comfortable, especially if care be had to enclose the ventilating tube in a case of wood or leather, or some other bad conductor of heat. The good effects of this method of carrying off the carbonic acid generated in low-roofed and confined places are often very striking. In the low-roofed counting-house of a merchant of my acquaintance it was at one time impossible to remain for more than an hour, or an hour and a half of an evening, when the gas was lit, without suffering from an intolerable sense of oppression at the chest, with severe head-ach and dimness of sight, in consequence of there being no proper channel for the escape of the carbonic acid and heated air; but by employing ventilating tubes, with funnel-shaped extremities, placed over the gas-burners, and communicating through an opening in the ceiling with a large empty loft on the next floor, all these bad effects were removed, and the air of the room, even after using artificial light for many hours of an evening, remained perfectly pure, and of an agreeable temperature.

This method of ventilating should be employed in all similar close and confined situations; the cost of it is trifling; and by having the funnels made to fit to a short tube in the ceiling, with a common bayonet socket, they could be easily removed during the day-time, if thought necessary, and replaced in an instant when wanted. It is rarely necessary to have any such special means of ventilating the rooms of private houses, where there are open fire-places; but when they are warmed by stoves, or by steam or hot water pipes, there is not a sufficient draught to carry off the carbonic acid, and some special provision ought to be made for their proper ventilation.

Bell-glasses are frequently suspended over the burners of oil or gas lamps; they merely help to keep the ceiling clean, by collecting some of the particles of unconsumed carbon that escape in the form of smoke from an ill-regulated flame, and are of no service whatever in ventilating the apartment, or preventing the accumulation of carbonic acid, which, in ordinary circumstances, is always a gaseous substance. Perhaps if these bell-glasses were to be turned upside down, and partly filled with water, its evaporation might be beneficial by supplying a proper degree of moisture to the parched air; in which case they would be quite as ornamental, and much more useful than they are at present.

Of the employment of Shades.—Shades of different kinds are very generally employed for the purpose of diffusing and softening the light, or of intercepting the extraneous rays that would otherwise pass into the eye, along with those reflected from the object looked at. Those intended for diffusing and softening the light are generally made of ground glass, though sometimes of biscuit porcelain. They diffuse and equalize the light in a large room, by presenting a great number of luminous points, from which the light is radiated in all directions; and they soften the glare, by dividing the brilliancy of the small flame over a considerable extent of surface. Although ground glass shades are almost universally employed, there is a considerable difference of opinion as to their utility. Sir David Brewster, who has paid much attention to this subject, gives it as his decided opinion, that they are extremely hurtful to the eye, from their increasing the number of radiant luminous points, the light from which acts on a more extensive surface of the retina, than if it proceeded from a small naked flame. I cannot quite agree with Sir David that ground glass shades are actually hurtful; for, though the light radiated from them affects a larger surface of the retina than if it came from a small naked flame, the brilliancy of the image on the retina is diminished in exactly the same proportion as its size is increased; but, at the same time, I am clearly of opinion, that their advantages as a protection to the eye are greatly overrated. The principal use of ground glass is to diffuse the light equally, and it ought always to be employed in public places, or in the sitting rooms of private houses. In libraries, or in counting-rooms, workshops, and such places, where the light should be concentrated on the objects on which the eyes are to be specially exerted, whilst the rest of the apartment should be in comparative obscurity (so as to afford an occasional rest to the eye), ground glass shades are unnecessary, as they occasion a considerable loss of light by diffusing it. In such places it is far better to employ opaque shades, made of metal or some other material, as formerly described; which, whilst they protect the eyes from the extraneous rays, may also, if made in the manner directed at the commencement of this chapter, serve to correct the bad colour of the light, by reflecting the blue rays in which it is naturally deficient.

When the light in a room, which is to be used for general purposes, such as a dining room, is suspended from the ceiling, so as to be elevated above the eyes by about forty degrees, no opaque intercepting shade is required. When the light is placed lower down, as when a common table lamp is used, the eyes of those sitting round it should be protected by having a shade of some opaque substance in the form of a circular band, of about four inches in breadth, placed round the circumference of the ground glass moon, as recommended by Dr Arnott ;* and which allows a brilliant light to fall on the table, whilst the rays that pass upwards to the ceiling and upper part of the walls being reflected, diffuse a sufficient and very agreeable light in the rest of the room.

Those who work much by artificial light ought to be very careful to have the source of the light completely screened from their eyes : the best position for it is about three feet above the table ; and the conical reflecting shade should have a tail-piece added to it, as shewn in fig. 8, the more effectually to prevent any of the extraneous rays entering the eye in any position of the head. When it is impossible or not convenient to have the source of the light so much elevated, the reflecting shade should be covered with wood on the outside, or it should be made double, with felt interposed, to diminish the quantity of heat radiated from its surface.

* Report on Lighting the House of Commons.

The common green silk candle-screens are useful in intercepting the extraneous rays; but they do not increase the intensity, or improve the colour, of the light, and it is much better to use the conical blue-coloured reflectors that have been already described.

Many are in the habit of wearing a green shade, as in fig. 9, but it is better to have the intercepting screen attached to the light itself: and, when a water-bottle is used, the upper part of it should have a bit of black paper pasted on it to absorb the horizontal rays. Those who work much over strong fires will find it very useful to wear a shade, such as the one in fig. 9, made of light pasteboard, blackened on the inside, and covered with tinfoil on the outside, so as to reflect the rays of heat that are radiated from the fire.

Such are some of the principal methods of preventing or diminishing the injurious action of artificial light: let no one suppose, however, that, by any such arrangements, even the best kinds of it can be rendered at all equal to day-light, as a safe and proper stimulus to the eye. The only certain way of avoiding the injurious effects of artificial light, described in the preceding pages, is to use it as sparingly as possible. This is a subject that is too little attended to at present; for the very late hours to which shops and other places of business are kept open; the ridiculously late period of the night to which our public amusements are protracted; with the bad example of our legislative assemblies sitting in debate till long after midnight; are customs which, being productive of much evil, should be discouraged as much as possible.

NOTE

ON THE

FINAL CAUSE OF BLUE COLOUR OF THE SKY.

The atmosphere always contains more or less moisture, which may be either dissolved in it, or merely mechanically mixed with it, according to the temperature, the state of the barometer, and other circumstances. So long as the moisture is quite dissolved in the air, and invisible, it has little or no effect on the rays of sun-light. As soon, however, as, from a decrease in temperature or other causes, the moisture is precipitated, or condensed, so as to form visible vapours, it materially obstructs the passage of the light. But all the three primitive rays, composing white light, are not equally obstructed : those which have the least force,* viz. the blue rays, suffer the greatest loss ; the yellow rays suffer less loss, and the forcible

* See Chapter II., pp. 36, 37.

red rays least of all. This is the cause of the red appearance of the sun during a frost, when the air contains so much condensed moisture, that only the red rays can make their way through it. Towards sun-set the condensed vapours first of all obstruct only the blue rays, and allow the yellow and red ones to pass, producing a beautiful golden hue, which gradually approaches to deep orange; till, at last, when the sun is just about to sink below the horizon, the quantity of condensed vapours is so great as to obstruct both the blue and the yellow rays; and then are seen those splendid red tints that render the setting sun such a beautiful object, especially in the tropics, where the quantity of moisture condensed at sunset, is so much greater than in temperate regions. Similar phenomena, though in an inverted order, take place at sun-rise, when the increasing power of the sun dispels the vapours of the morning.

As it is seldom that the air, even in the tropics, contains no watery particles in a state of mere mechanical admixture; and as there always exists a notable quantity of them in the earlier part of the day, before the air has become sufficiently warm to dissolve them; and, in the afternoon, for some hours before sunset, when the temperature begins to decline; some provision had to be made to prevent the day-light having always more or less of an orange hue. This has been done by giving to the sky a beautiful blue colour,* so that the blue light, reflected from that part of it which is opposite the sun, being diffused over the surface of the earth, and combining with the direct light of the sun (which has been deprived of a portion of its blue rays by the impeding effect of the watery particles mixed with the air), restores its whiteness; in the same way as the blue reflecting shades described in the preceding pages, supply the rays that are deficient in the reddish yellow-coloured light of common flame.

On the tops of high mountains, or in the tropics during the heat of the day, where the air is either very dry, or contains the moisture in a state of perfect solution, the sky is intensely blue; because the compensating rays reflected from it are not required, and appear in excess. As soon, however, as the heat begins to decline, the dissolved moisture forms visible vapour, and the blue light, reflected from the sky, becomes necessary to whiten the now slightly orange-coloured light proceeding directly from the sun. When, at last, the sun approaches the horizon, and is about to set; the accumulated vapours present such an obstacle to the feebler blue and yellow rays as to intercept them altogether,

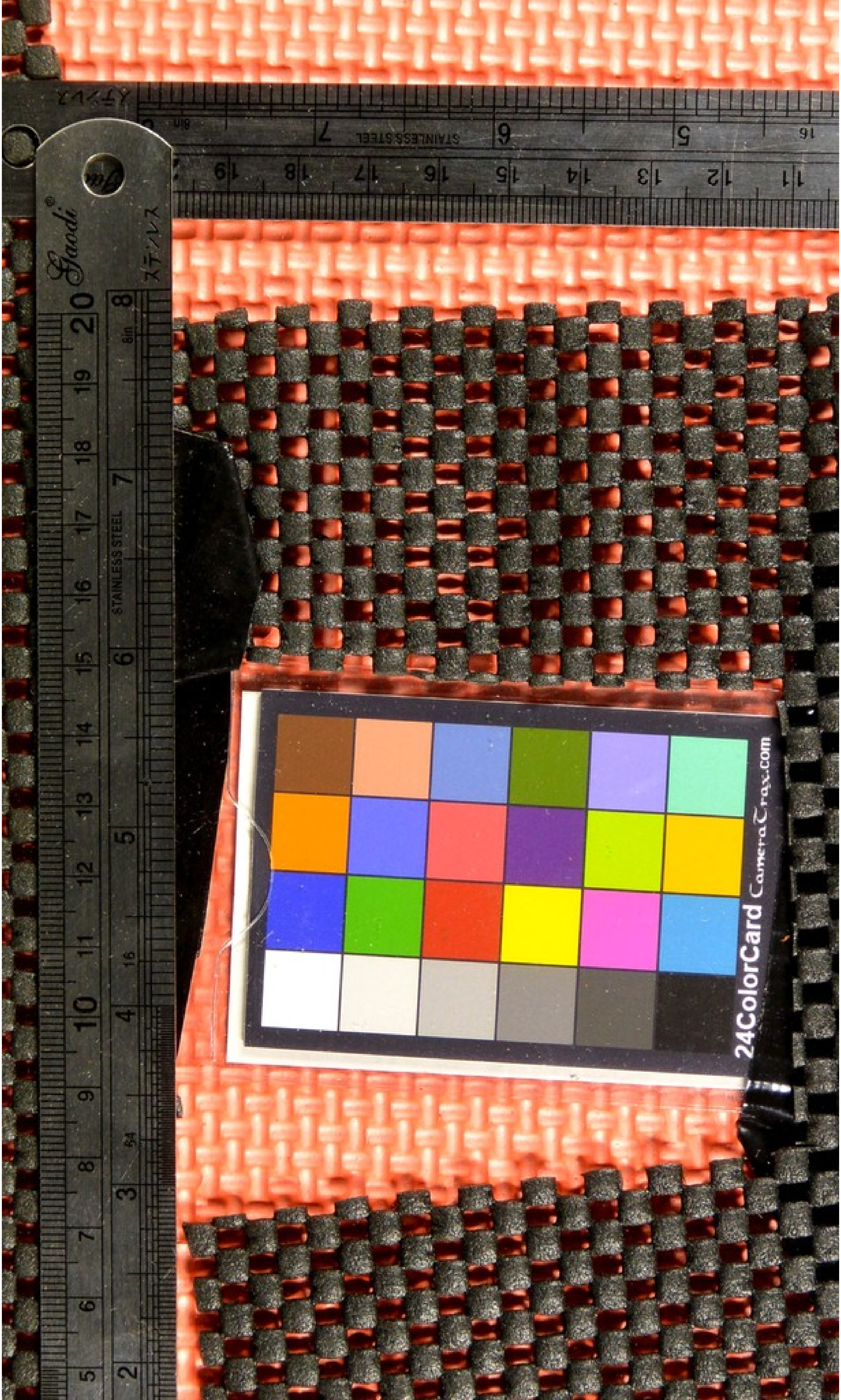
* It is only the air of our globe that is blue: the *actual sky itself*, seen from vast altitudes, is known to be absolutely black.

and the compensating colour of the sky is of no avail; nor is it required, as the light has now become so faint that no harm results from its red colour.

The circumstance of the red rays of light being the warmest as well as the most forcible,* furnishes a beautiful and striking instance of benevolent contrivance for moderating the cold of winter; accelerating the genial increase of temperature at sunrise; and preventing its too sudden decline at sunset: for these warm rays, from their superior force, are those which reach the earth in greatest abundance during frost; whilst they are the first to penetrate the rising mists at the dawn of the morning; and the last to be intercepted by the accumulating vapours at the close of the evening.

* *Vide* ch. ii. page 38.

FINIS.



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