

ANDREWS (J. A.)

The electric light
as a illuminator

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THE ELECTRIC LIGHT AS AN ILLUMINATOR.

THE EFFECT OF STRONG LIGHT ON THE EYE.¹

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THAT the exposure of the eye to an excess of light may be attended with harmful effect is a fact attested by the cases recorded in ophthalmic literature; and this subject has assumed a fresh practical importance since the application of electricity to lighting purposes.

Mackenzie, Jäger, Arlt, Dufour, Haab, Emmert, Sulzer, Simeon Snell, and others have recorded cases in which either retinitis or scotoma, or other visual disturbances, have resulted from exposure of the eyes to bright light.

Among 12 cases reported by Jäger as having resulted from looking at an eclipse, 8 cases were without material change; in 4 cases there was choroiditis.

Arlt describes one case of chronic choroiditis produced by looking at the eclipse of July 28, 1851.²

Schirmer gives one case of positive central scotoma after blinding of retina by lamplight, the same having occurred before when the patient looked at the sun or

¹ Read at the Twenty-second Annual Meeting of the American Ophthalmological Society, held at New London, Conn., July 22, 1886.

² Krankheiten des Auges, Bd. iii., p. 127. Prag, 1856.



glaring light. Ophthalmoscopic examination showed an "especially dark macula lutea;" otherwise the fundus was normal.¹

Dufour² gives one case, evidently carefully observed. The whole macula lutea was taken up with a dark-brown pigmented spot, the centre of which formed a sharply defined yellowish-white patch. Vision was reduced to $\frac{1}{20}$ during twenty-two days; the macula region was wholly normal. Vision was improved to $\frac{1}{2}$.

Haab³ relates one case of central scotoma produced by observing the eclipse of the sun.

Emmert⁴ gives one case. Vision reduced to $\frac{2}{10}$; fundus normal.

Simeon Snell (*Ophthalmic Review*, May, 1883, p. 141) records one case of retinitis, caused in a girl, aged twenty, by a "single flash from a sun reflector," in the hands of a boy. The eye was affected immediately; on the next day vision was = Jäger 20. In the neighborhood of the macula and optic disc there was cloudiness of retina. Perfect recovery.

D. Sulzer (*Klin. Monatsbl. f. Augenheilk.*, April, 1883, p. 129) relates four cases of retinal affection from direct observation of the eclipse of the sun of May 16, 1882. The symptoms were central scotoma, slight hyperæmia of the optic disc, exudative condition of the yellow spot, which, in one case, led to pigment degeneration in the region of the yellow spot.

H. R. Swanzy (*Ophthalmic Review*, May, 1883, p. 142) gives two cases of central amblyopia from exposure of the eye to the direct rays of the sun. There was in each case positive central scotoma, and metamorphosia, and a positive flickering after-image, which latter symptom continued four months after the exposure. There was no

¹ *Klin. Monatsbl. f. Augenheilk.*, 1861, p. 251.

² *Bulletin de la Société Médicale de la Suisse romande*, 1879, p. 267. See, also, by the same author, other cases of trouble to the eyes resulting from observing the eclipse of May 16 and 17, 1882.

³ *Correspondenzblatt für Schweizer Aertze*, 1882, p. 383.

⁴ *Revue Médicale de la Suisse romande*, 1882, p. 395.

visible change in fundus. Vision (previously normal) was $\frac{6}{18}$ in right eye. Read with slightly excentric fixation with right eye, owing to central scotoma, although examination in the usual way for central scotoma, either with blackboard or perimeter, gave a negative result, the conclusion being that the defect was extremely small. But the patient declared that he saw Snellen's smallest type with difficulty, owing to the black spot which came just over the word he wished to look at. These cases are also interesting as having occurred in two individuals—a coachman and his employer—from the same cause at the same time.

Deutschmann (*Von Graefé's Archiv*, vol. xxviii., 1883, p. 241) records four cases of damage to the eye, caused by watching the eclipse of the sun on May 17th, 1882. Three of the patients had gazed at the sun with the naked eye; in the fourth case, a dark-blue glass had been used. Every one of the four had noticed, immediately after gazing at the sun, a dark or semi-blind patch in the middle of the field of vision, and in each a small positive scotoma was found on examination; scotoma not absolute in any of the cases. Gradual improvement occurred in all, but absolutely perfect vision was not recovered in any case. The ophthalmoscope showed corresponding changes in all, viz.: in the cases seen early, a small, bright-white spot at the centre of the macula lutea, and around this a blood-red ring shading off into the normal color; in the older case (four months), an appearance less easily distinguishable from that of the normal eye, and similar to that which the other cases presented when recovery was nearly complete.

Under the caption "Neuroses of the Visual Nerve-apparatus, caused by the Continuous Action of Bright Light," Mr. Reich (*Von Graefé's Archiv*, vol. xxvi., 1880, p. 135) described an epidemic of snow-blindness which occurred among a body of laborers engaged in clearing a way through masses of snow which obstructed the road between Passawaur and Mrleti, in the

Caucasus. The rays of the sun, reflected from the vast stretches of snow on every side, produced an intense glare of light, which the unaccustomed eye could not support without the protection of dark glasses. A few of the sturdiest among the laborers were able to work with impunity, but the majority, and especially the weakly and anæmic, suffered severely in their eyes, in spite of various devices to protect them from the light. Among 70 strongly marked cases, 30 were so severe that the men were absolutely unable to continue their work or to find their way home. They were collected in a covered place, where Reich found them, on his arrival, prone on their faces, striving to hide their eyes from the light, and crying out from pain. Photophobia was present in all the cases. Hyperæmia of the conjunctiva, with more or less injection of the ciliary vessels, and even chemosis, was found in all the severe cases; those with chemosis complaining the most of pain. Cornea not affected in any case. The pain, generally of a cutting character, did not cease in darkness. Strong *contraction* of the *pupils* in all cases, except two, in which they were *dilated*, and in these two cases there seemed to be some degree of retinal anæsthesia and contraction of the visual field; the ophthalmoscope showed capillary hyperæmia of the optic discs and some over-fulness of the retinal arteries and veins; ciliary injection and chemosis were present in both cases, and the eyeball tension appeared to be somewhat increased. Recovery was gradual, but complete, in all cases. The author declared that the impairment of vision was not of the nature either of hemeralopia or nyctalopia, meaning by the latter the condition in which vision is persistently defective in ordinary light, but improved in diminished light. The conjunctival hyperæmia, which played a very unimportant part in the affection, is referred by the author to reflex dilatation of vessels through the action of light. W. C. Rockliffe (*Ophthalmic Review*, September, 1882, p. 308) records a case of acute conjunctivitis which

he referred to the action of the *electric light*, the patient having been engaged in adjusting the carbon points of a Siemen's electric lamp of *three-thousand-candle power*, which he did without colored spectacles. The patient had noticed on other occasions that, on descending the ladder, after adjusting the carbon points, and a short expose, in close proximity to this very intense light, that he was unable to perceive the people on the street, but that this effect soon passed off. On a particular occasion, as his power of vision returned (in about fifteen minutes), there followed a rapidly increasing lachrymation, photophobia, pain, and swelling of the lids, the whole of these symptoms having been developed in thirty minutes. Rockliffe describes the lids of both eyes as having been very hot, red, swollen, and brawny, and as being on a level with the superciliary ridge, the swelling extending some distance below the brow. The pain was most acute in and around the eye. The conjunctival vessels were exceedingly large, and the eyelids and the eyeballs were a brilliant scarlet. The corneæ were clear. All of these symptoms yielded to a brisk purge and a lead lotion in forty-eight hours. His fellow-workman was similarly affected, but to a less degree.

A. Emrys-Jones (*Ophthalmic Review*, April, 1883, p. 106) records the case of a person engaged in experimental work with the arc electric light, which necessitated his gazing intently with the naked eye at the LIGHT, from a distance of a *few inches*. As there was no inconvenience at the time, and that the longer he looked the more accustomed his eye became to the light, he continued his observations for *twenty minutes*. The next morning he awoke with intense pain in the eyes, and profuse lachrymation and photophobia; also slight redness of the conjunctiva, but no swelling of the eyelids. A drop of atropine instilled into the eyes gave instant relief, and as soon as the physiological effects of the atropine had passed off the patient was able to resume his work. Jones also adds a description, written by the pa-

tient himself, who had a great deal to do with electric lighting, in which he speaks of the effect of the light on the eyes of persons engaged in working in close proximity to the light (*arc light*). In the worst cases, which generally arise from adjusting the lamp (*two-thousand-candle power*) while burning, without goggles or smoked glass, the distance of the eyes would average eighteen to twenty-four inches, and with weak eyes *one minute* will produce certain inflammation (?). He thinks that much depends on the nature of the light, as he found that either an excess of current, which produces a violet light, or a defect of current, which gives an orange light, is less injurious than the normal (white, tinged with a sky-blue) light. David Little (*Ophthalmic Review*, July, 1883, p. 197) speaks of a case of retinitis occurring in a gentleman, engaged in scientific experiments with the electric light, who had neglected, on one occasion, to put on his dark spectacles while thus operating; the box containing the electric light was suddenly opened, and the light fell upon his *right* eye. It was a great shock to him, and he was blinded for several minutes; his eyes were very intolerant of light for several days afterward, and he suffered a great deal from headache. Two months after the accident he consulted Dr. Little on account of a mist and dark specks before his *right* eye, which had existed since the accident. Vision of right eye = $\frac{2}{10}$; the vision of left eye was good, and the fundus was normal. There was haziness over the right optic disk and the retina immediately around it.

Eye-affections caused by lightning have been classed in the same category with those ocular disturbances caused by exposure of the eye to strong light, partly, perhaps, because in the older text-books the intense light of lightning was assumed to be the chief agent; but the intensity and duration of lightning are not sufficient, and the lesion so produced does not at all correspond with that produced by lightning, since the scotoma produced by exposure to bright light, as recorded in literature, has

been of limited extent, instead of affecting the entire field as in the case of lightning. Moreover, it is impossible to ascribe to the action of light the associated nerve-lesions, or the structural changes in the choroid and lens, which obviously are caused by lightning. That light, under certain conditions, is capable of producing opacification of the crystalline lens—one of the prominent ocular lesions caused by lightning—has been demonstrated by Czerny, who showed that the direct rays of the sun, condensed by a lens, will produce in the eye of the rabbit an opacity of the crystalline lens in about a quarter of a minute, by coagulation of albumen; but this can hardly afford an adequate explanation of the production of cataract by lightning, for, apart from the less intense brilliancy of a lightning-flash as compared with concentrated sunlight, the duration of the former is much less than a quarter of a minute. Leber (*Von Graefe's Archiv*, vol. xxviii., p. 255), who has given a comprehensive analysis of all that is at present known of ocular injuries caused by lightning, rejects the idea of any mechanical production of the opacification of the lens, and attributes it to a "direct *physico-chemical action* of the electricity on the lens substance by which its albumen is coagulated;" but Leber does not refer this coagulation to heat alone, for it can readily be shown that a higher and more enduring degree of heat would be required than can reach the lens during the lightning-flash, nor was there any external sign of scorching of the eyes in those cases in which cataract was produced by lightning; hence Leber regards the coagulation of albumen to be a kind of catalytic action, as compared with the curdling of milk which occurs during a thunder-storm. Leber further suggests that this catalytic action is not confined to the lens, but would probably be discoverable as an opacity in many other structures, were they transparent. The opacity of the lens in these cases is said to be permanent, and the non-vascu-

larity of the lens may furnish an adequate explanation of the permanence of the lesion in this body. This is certainly a reasonable hypothesis, but it does not necessarily exclude the probability of a mechanical injury to the lens, simply because the capsule of this body remains undisturbed, any more than the rupture of the choroid, and hemorrhage from the choroid and retina, and partial detachment of the retina, which are also known to occur from the shock without the patient being struck by the lightning, and without rupture of the external tissues. Thus we see intense light is not the chief agent in an electrical explosion in producing the eye-affliction.

There is another class of cases which may be considered in connection with this subject, viz., the opacity of the lens occurring among glass-blowers, in whom the intense radiant heat to which their faces are exposed (148° Fahrenheit) seems to be the chief agent in producing this condition; but I have not found cataract so common among the glass-blowers whom I have examined—284 in all—4.5 per cent. showing lenticular opacities among 65 men under thirty-eight years of age, and twenty per cent. among those men who were over forty years of age. Meyhoffer (*Klin. Monatsblätter f. Augenheilk.*, February, 1886, p. 49) found among 506 glass-blowers just the double of my percentage among those men under forty years of age. I did not find any lesion of the fundus of the eye which could be referred to the occupation as a cause.

In the first class of cases of eye trouble alluded to above, as resulting from exposure of the eyes to direct sunlight, it appears that lesions are produced which are identical to those found by Deutschmann in the retina of rabbits when the direct rays of the sun, condensed by a concave mirror, and then rendered parallel by a convex lens, are caused to enter the dilated pupil. After exposure for only a few seconds the ophthalmoscope revealed a silvery-white patch surrounded by a dark-brown ring in the retina. The microscope showed that the ma-

terial changes consisted in an actual disorganization of a limited area of the retina by coagulation of the albumen in its tissue, and beneath and around this a vascular reaction in the choroid, leading to hyperæmia, exudation, diapedesis of blood-corpuscles, and pigment disturbance. It will be observed by referring to the cases recorded by Arlt, Schirmer, Dufour, Haab, Emmert, and others, of visual disturbance caused by exposure of the eye to direct sunlight, that in the majority of instances there was no demonstrable lesion in the fundus oculi; nor is the evidence as to the causation quite satisfactory when such lesions have been found, the pre-existence of the lesion in the fundus not having been disproved; and yet the similarity between the effects obtained by Deutschmann in his experiments (cited above) on rabbits and those observed in the human eye is presumptive evidence that the actual lesion in the latter case is also a destructive coagulation of albumen in a minute area of the fovea centralis, together with congestive or inflammatory changes beneath and around this spot, although the condensation of the light in the case of Deutschmann's rabbits and the dilatation of their pupils constitute an important difference in the conditions.

In order to ascertain whether the invisible heat-rays were concerned in producing the changes in the fundus found in the rabbit under exposure to direct sunlight, Deutschmann caused the pencil of light to pass through a stratum of water two decimeters thick before reaching the eye. The same effect as before was obtained, but required rather longer for their production; but, of course, the mere exclusion of the obscure heat-rays does not exclude *heat* as the essential cause of the mischief, for it can readily be shown that in the mixed radiation from a luminous object the light is capable of being converted into heat; therefore, that the light-rays also raise the temperature. The use of dark glass in Deutschmann's cases did not suffice to prevent the damage to the retina.

The spectroscope declares that the solar, gas-flame, and electric-light spectra have for their base a continuous strip or band of light—in the case of the gas-flame (the bright part) crossed by the sodium lines only; in that of the sun, by Fraunhofer dark lines; and of the electric (arc) light, by the bright line of carbon. The illuminating power of each of these sources of light is thus shown to be due to the incandescence of their several solid and gaseous constituents.

It is of practical importance to learn something about the relative effect of the different forms of artificial light on the human retina. All forms of artificial light contain, as compared with daylight, an excess of waves of long wave-length, *i.e.*, they are of a *yellowish* hue. In the electric light the short-wave rays predominate, *i.e.*, the violet rays. The ultra-violet region in the light of the electric arc is from six to eight times as long as the whole of the visible part of the spectrum.

Even the electric light looks yellow as compared with daylight, which latter, although generally called *white*, has been shown to be decidedly *bluish*; but, as far as mere *color* is concerned, the *electric light* approaches nearer to that of the *sun* than does the gas or lamp flame. But which has the more to do in producing evil effects on the eye after long and continuous work by artificial light—*color* or *heat*? Meyer gives the following proportionate constitution for three kinds of artificial light:

| | Red. | Green. | Blue. | Violet. |
|-----------------|------|--------|-------|---------|
| Electric | 2 | 1 | 0.8 | 1 |
| Petroleum | 3 | 0.6 | 0.2 | 0.1 |
| Gas..... | 4 | 0.4 | 0.2 | 0.1 |

Gas emits the greatest amount of heat; petroleum lies between gas and the electric light, which latter, from the fact that there are no gaseous products to radiate heat without light, taken together with the high temperature of the incandescent carbon, unite to give us the maximum of light with the minimum of heat. Those who

have a great deal to do with the *arc electric light*, which is intensely brilliant, say that the injurious effect on the eye depends a great deal on the nature of the light, *i.e.*, a violet light, produced by an excess of current, or an orange light, given by a defect of current, is less injurious than the normal light—white, tinged with ashy blue—and that a fluctuating light is always more dangerous than a steady one.

Tyndall has shown that the value of the luminous radiation from the flame of oil, gas, and the electric light is as follows :

| | Luminous. | Obscure. |
|---------------------|-----------|----------|
| Oil flame..... | 3 | 97 |
| Gas flame | 4 | 96 |
| Electric light..... | 10 | 90 |

We have, therefore, with the *electric light*, the *maximum of light* with the *minimum of heat*. We have seen that in the electric light the short-wave rays predominate, *i.e.*, the *violet rays*, and that the *ultra-violet* region in the electric arc is from six to eight times as long as the whole of the visible part of the spectrum. We know that chemical action is more energetic in this part of the spectrum than in any other part, and that this action extends beyond the violet to the *ultra-violet rays*, and the properties of this part of the spectrum are very strikingly shown by the pronounced action exerted by the electric light in the growth of plant life.

Chardonnet (Vision des radiations ultra-violettes, Compt. Rend. hebd. des séances de l'Acad., No. 8) has recently made some interesting investigations on the absorption of ultra-violet rays by the media of the eye, particularly by the crystalline lens, this absorption not being done without fatiguing the eye, especially when it concerns the long and brilliant spectrum of the *electric arc*. But he found, on photographing the spectrum of the incandescent electric light, that the spectrum hardly passed beyond the visible spectrum; hence he inferred that this incandescent electric light saved the media be-

fore the retina the labor of absorbing and diffusing the ultra-violet spectra. I do not believe that we should attach much practical importance to this explanation. It is easy to convince one's self that the inconstant and unsteady intense glare of the *arc electric light*, only faintly modified by an *opal* or *ground-glass globe*, is extremely distressing to the eyes.

So far all the cases of injury to the eye from the electric light recorded in medical literature have resulted from exposure of the eye in close proximity to the *arc electric light*, and this has, in every instance, been of a very intense brilliancy, generally that used for street illuminating purposes—two-thousand-candle power—which may be actually fifteen-hundred-candle power. In many of these cases a pre-existent abnormal condition of the eye was not excluded; and if we compare the groups of cases so far recorded, the evidence seems to me to point more directly to a vaso-motor disturbance—*i.e.*, that we can best account for the condition by invocation of the sympathetic nervous system, rather than by assuming an actual mechanical or chemical injury. The severe pain and photophobia complained of would certainly be explained by the excessive stimulation of the whole retina, and, corresponding thereto, a general hyperæmia of the uveal tract; and these causes might naturally augment any pre-existing retinal or choroidal affection. At any rate, with regard to retinal changes it is not by any means established that simple dazzling by bright light can produce a progressive diffuse retinitis, such as has been claimed it has. However, the case of the late Professor of Physics at the University of Ghent, J. Plateau, who, in 1829, while trying to observe the effect of irritation of the retina, gazed steadily at the sun for twenty seconds, chronic irido-choroiditis having resulted (?), followed by total blindness in the course of fourteen years, is on record.

So far as I have been able to ascertain, no case of ac-

cident to the eye has been reported as having been caused by the *incandescent electric light*. Of the 1,100 persons whom I have examined and observed during the past year who work by day or by night for many hours by the *incandescent electric light* of *Edison's lamp*, there was not a single instance of injury to the eye ; but, on the contrary, I was surprised to find that a considerable number of these persons, with a high degree of myopia and choroidal changes, were absolutely comfortable while working by this light, and they expressed themselves as having experienced a great improvement in the condition in their eyes since they had begun to work by the electric light (Edison lamp of twelve- to sixteen-candle power), always shaded from the eyes, the light being thrown down upon the work from a short elevation. Many persons among typesetters and copyists have told me that formerly, when gas was in use in the establishment in which they worked, they went home from their work with their eyes red, watering, and aching, and this was especially the case among short-sighted persons, but that they could work longer by the Edison light (the arc light distressing them), and without discomfort. Of course, every form of artificial light is more or less dazzling when the source of light casts its image on the retina. We certainly can avoid this dazzling in the gas or petroleum flame by means of an appropriate shade ; but, in order to secure the requisite amount of illumination, we must either approach the light close to the head, and thereby expose the eyes to the undesirable radiant heat, or increase the illumination at a greater distance, and thereby make an increased demand upon the vital parts of the atmospheric air in the room, thus vitiating the latter, which is a very undesirable equivalent. The amount of heat radiated by the electric light is very unimportant ; and when, after sunlight, we add to its unrivalled qualities as an illuminator the steadiness and absence of combustion from the *incandescent lamp of Edison*—there being, therefore, no consumption or vitiation of the at-

mospheric air induced by it—together with the practical clinical fact that it is a greater comfort for even persons with existing eye affections to work by this light than by any other artificial illuminator, we must, from a therapeutic point of view, concede to the incandescent electric light advantages not possessed by any other artificial means of illuminating; and anyone who has given the subject thoughtful consideration will at once see the great blessing which would come from introducing this kind of light into our *night-schools, theatres, public halls,* and those innumerable *counting-rooms* in this great city where large numbers of human beings work by artificial light during the entire day or night, the demand upon the atmospheric air by the individuals alone being, in the absence of adequate means of ventilation, and in the majority of instances very little ventilation at all, in these overcrowded places, terrible enough without the additional mischievous agent in vitiating the atmospheric air present in the many *gas flames*. The advantage of using the incandescent light in our ophthalmoscopic dark-chamber must be evident to every ophthalmic surgeon.

My conclusions are as follows:

The *arc electric light* is not so objectionable on account of its intense brilliancy, which can be modified by means of an opal or ground-glass shade or globe.

The gazing at the *arc lamp* for many seconds is attended with great risk to the eyes. The *arc light*, in its present state, should be positively rejected as unsuitable and actually harmful to the human eye, particularly on account of its unsteadiness.

The *incandescent light of Edison*, because of its steadiness, adequate power and composition, is safe, and occupies at present the first position as a means of artificial illumination. By its use the accommodation of the eye is less taxed than by other illuminators.

The light may advantageously be placed on the table in *front of* the person using it, but it should *never shine*

directly into the eye, but always be *completely hidden* from the eyes by means of an opaque shade made of glass or tin, and the light be thrown down upon the work. For obvious reasons, it is further believed that the incandescent electric light is especially beneficial to hypermetropes and myopes.

40 WEST TWENTY-FOURTH STREET.

