result. A brother, eight years older, who works as an anchor smith, is unaffected, also two children, aged 14 and 16, are unaffected.

H—, a man, aged 58, has worked at chainmaking for fifty years, he commenced at the age of 7 by working the bellows. The right eye is healthy and vision normal. He has noticed that the left eye has been failing for the past three years.

On dilating the pupil one sees a well-defined circular opacity about 3 mm. in diameter centrally situated in the posterior cortex. The opacity is not uniformly dense for there is a denser centre suggesting in appearance a cell with its nucleus. Away in the periphery of the lens are a number of dot-like opacities which are arranged in a circle concentric with the edge of the lens.

T. B—, aged 52, has worked at chainmaking all his life. Vision has been failing for the past three or four years.

On dilating the pupils one sees in the right eye a well-defined posterior polar and cortical opacity. The opacity is slightly oval in shape and has a denser "herring bone" centre.

There is also a small but well-defined anterior polar and cortical opacity.

In the left eye the posterior cortical opacity is about the same size as the right (about 2 mm. in diameter) but is more circular. It also is denser in the centre than the periphery. There is a very small anterior polar and cortical opacity.

S. H—, aged 42, has worked at chainmaking all his life. Right vision 6/18 partly. There is a small posterior cortical opacity, but otherwise the lens is clear. Left vision 6/60. The opacity is similar in appearance, but has a slightly larger diameter. No other opacities.

J. P—, aged 43, has worked at chainmaking since he commenced work. Has noticed his vision failing for the past two years. Right vision 6/12. Left vision also 6/12.

A small sharply-defined posterior cortical opacity in each lens; otherwise the lenses are quite transparent.

In all the cases in which the fundi could be seen there was nothing abnormal found.

CONTACT-ILLUMINATION IN THE EXAMINATION OF THE CORNEA AND ANTERIOR PART OF THE EYE

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ILLUMINATION, for purposes of examination of the cornea and anterior portion of the interior of the eye, by the ordinary method of oblique focal concentration of distant light has the unavoidable

objection that the partial interruption of light which takes place on the exterior surface of the cornea materially diminishes the visibility of parts on a deeper plane. First, a vivid image of the source of light is formed by part of the corneal surface, and must needs be circumvented by the observer who is endeavouring to look deep to this surface; secondly, a general indefinite diffusion of light takes place over the whole surface of the cornea—without which the surface would not be visible—and this cannot be circumvented by the observer; both these factors combine to detract from the total volume of light which penetrates to illuminate the deeper structures beyond. Yet another factor to be taken into consideration under these conditions is the influence of contrast; a redundant surface-luminosity of the cornea and surrounding structures must adversely influence an observer's appreciation of fine contrasts among structures on a deeper plane.

The visibility of the interior of a room illuminated only by daylight passing in through a glass window to an observer stationed outside and looking through that window, is exceedingly poor; and these conditions are not favourable for the appreciation of fine defects in the transparency of the glass. Conditions analogous to these obtain in the ordinary method of examination by focal illumination of the cornea, anterior chamber, iris, and lens.

If a room be illuminated from an interior source, the visibility through the window of its interior becomes greater to the observer outside in proportion as the internal illumination of the room exceeds any external illumination of the glass and objects surrounding it. Again, under these conditions, the ready appreciation of the presence of fine defects in the transparency of the glass window is enhanced in so far as these defects interrupt rays of light emerging from the illuminated interior; the defects are appreciated in a negative sense as dark areas contrasting with the lighted background.

I would emphasize that I speak merely of the ready detection of the *presence*, as distinct from the more complex recognition of the *nature*, of any condition causing loss of transparency in the the glass. There is a very practical significance in this distinction. The two mental processes may not coexist; but the second can never originate save as a sequel to the stimulus of the simpler yet primary factor of detection. For a given method of examination of the cornea to be serviceable it should enable an observer to assert positively, in a short time and with the minimum of mental effort, that the cornea is normal in respect of its transparency; that if there is a single minute opacity he can, consistently with rapid examination, be confident of its attracting his attention. In routine examination by oblique illumination the amount of mental energy expended, in assuring oneself that the corneal transparency is normal, may be ordinarily very great; and quite irrespective of the investigation of

the nature of a corneal opacity, any simple device which ensures merely the ready detection of the presence of that opacity—with the minimum of macular fixation on the part of the observer—must be of practical value.

To return to the analogy of the glass window through which the outside observer is looking into the room; if the source of light be an exterior one, say in the observer's hand, fine opacities in the glass will be illuminated as bright objects by that light. The chief factor upon which the attraction of the observer's attention to the opacities will depend is the degree of comparative illumination of the background, and this in turn will vary with the quality and distance of that background. If the background be distant and one that does not lend itself to illumination, we have the condition of a dark background against which the illuminated opacities will possess a high visibility in so far as this is not obscured by the formation of an image of the source of light and by surface-scattering. But with the eye, the condition of the corneal surface readily favours image-formation and scattering; and the background (iris) is so close to the cornea that its bright illumination is inevitable.

It has already been pointed out that if the source of light be situated in the interior of the room, opacities in the glass window are revealed as dark areas; but even under favourable conditions the appreciation of fine dark areas against a light background is more dependent upon macular fixation than is, conversely, that of brightly illuminated objects against a dark background.

There is a more striking way in which the visibility of opacities in the glass can be augmented, viz.: by any means which—both exterior and interior being kept relatively dark—illuminates these opacities by circumfused light directed laterally on to them through the substance of the glass from a source situated peripherally in the plane of the glass.

With a view to securing, in accordance with some of the above considerations, the more favourable illumination of the cornea, the surface of the iris and the anterior part of the lens (anterior capsule and subcapsular cortex), I experimented with a source of light placed in immediate apposition to the external surface of the cornea, precaution being taken against escape of light on the exterior surface of the eye. It theoretically was fairly clear before even trying this that the abolition of external surface-scattering, and the diminution to a minimum of the distance separating the source of light from the objects whose illumination will vary inversely with the square of that distance, must give highly favourable conditions for their observation. This in practice proved to be the case almost without exception; I quote below particular cases in which this method appears to be of great value for the examination of the anterior part of the interior of the eye.

The principles involved, however, in the examination of the cornea itself by contact-illumination are not so simple. I had anticipated that any fine alterations in (*e.g.*, nebula), or surface additions to (*e.g.*, keratitis punctata) the substance of the cornea, sufficient to cause loss of transparency, would be rendered evident as dark areas by interruption of rays of light coming towards the observer by reflection from the illuminated interior. In practice this did not prove to be the case, but it was found that the very finest opacities in the corneal substance revealed themselves vividly if the contact-illuminator, instead of being placed wholly on the cornea—as in Fig. 1 (a), where the small circle represents the area covered

FIG. 1 (a).

by the nose of the illuminator—be placed well to the periphery (Fig. 1 [b]), so that almost the whole of its surface overlies not cornea, but sclerotic. Under these circumstances there is only a minimal illumination of the iris and lens, and minute opacities in the cornea, illuminated by circumfused light escaping laterally into the substance of the cornea, stand out in lucid contrast against the background of the dimly illuminated interior. This was not the result I had anticipated in regard to the cornea, and for the above explanation of what is found to occur in practice, I am indebted to Mr. Herbert Parsons.

FIG. 1 (b).

Within limits, the more tenuous the opacity, the more peripherally should the source of contact-illumination be situated, provided that just sufficient area of the nose of the illuminator projects over the corneal side of the limbus to ensure a lateral scattering of light through the substance of the cornea. Visibility is the most important factor in the *detection* of the presence of a fine opacity in the cornea; and other things being equal the visibility becomes relatively greater the darker the interior which constitutes the contrasting background. The latter obtains to the maximum degree when, as above stated, the contact-light is situated at the extreme

periphery; but once the opacity* is so detected (*e.g.* the fine punctate haze indicative of former perforation by a needle or by a fragment of steel; or the old track of a single small blood vessel in the substance of an otherwise clear cornea) this peripheral position of the contact-light is not always the most favourable for the elucidation of the actual *structure* of the opacity; much as in the method of the dark ground illumination in microscopy, visibility is increased at the expense of resolution. Having, with the naked eye, detected thus the presence of the opacity, the observer will often appreciate its structure with the loupe more favourably if he bring the edge of the contact-illuminator nearer to the opacity (Fig. 1 [c]) to a degree which—in practice readily ascertained by experience—is dependent on various factors concerned on the one hand with the opacity, and on the other with the condition of the structures forming the visual background. This will be referred to below.

FIG. 1 (c).

The contact-illuminator is illustrated in Fig. 2.

A small †4-volt lamp (L), elongated, but of small diameter is screwed into the end of a tube (R) which transmits the usual conducting wire (not shown in illustration) to the lamp; the diameter of the tube (R) should slightly exceed that of the metal mount of the lamp. Over both the lamp and this inner tube, an outer metal tube (t) slides as an easy fit. Let into the front end of this tube is a small plate of glass, its outer face coming dead flush with the end of the metal tube. The success or failure of the appliance depends upon the workmanship in the fixation of this glass and upon the proper finish of this contact-end generally. The glass is ground to the inside diameter of the outer metal tube: a thin metal collar (C) is fixed tight into the metal tube as a shoulder for the deep face of the glass to abut on. The fixation of the glass is completed with

*The word "opacity" is here used in its widest sense to include any structural alteration in the corneal substance causing a localized impairment of the normal corneal transparency.

† The lamp is of a similar pattern to those used in some electric ophthalmoscopes; it is obtainable in London at a price of about 3/6. They vary a little in the distance which separates the filament from the distal end of the glass bulb; one in which this distance is small should be chosen. When purchasing, it should be specified that the lamp is for use with a 3-cell dry battery or 2-cell accumulator, either of which gives a little over four volts. With this lamp a rheostat in the circuit is unnecessary. I have had one of these lamps in use daily for several months and it is still good.

Canada-balsam. The termination of the metal tube is burnished so that there is no sharpness in its free edge which makes contact with the eye. The distance of the lamp from the contact plate is regulated by sliding the outer tube on the inner one, fixation being controlled by a milled cap (S) having a slightly conical threaded bore which screws on to the taper-threaded, split termination of the outer metal tube; a quarter turn of the cap relaxes or fixes the grip of the outer tube on the inner. The flexible twin wire is not illustrated; but the obvious precaution is necessary that, where it enters the end of the apparatus, it meets with no sharp edge which might fray it; neglect of this simple detail in the making is a frequent cause of unreliability in small electrical apparatus of this type. The flexible

FIG. 2.

wires may, instead of being a fixture to the instrument, more conveniently terminate in a small detachable contact plug (not shown in the illustration) which in turn fits to the tail end of the apparatus. The best connector for this purpose which I know—one both small and efficient—is a pattern having a bayonet action that is fitted to one make of urethroscope much used in London, and I see no reason why it could not be adapted to use in the present instance.

The above design seems, from a practical point of view, the best pattern for general use compatible with simple construction. Certain ophthalmic conditions are revealed rather better by optical modifications of the above design—such for example as the improved illumination referred to below of very minute objects on the anterior lens capsule when they are illuminated by a beam of light which, striking obliquely through the cornea, is composed of rays slightly

convergent; but the slight gain in special circumstances attained by such optical modifications as I have been able to try has not yet suggested a departure from the above simplicity of design. It is not intended that the use of such an apparatus should be limited to certain special conditions.

I may here give the measurements of my own present illuminator. The overall length of the small lamp (L) is about 2 centimetres; the diameter of its glass part is 4.6 millimetres, and of its metal mount 5.7 millimetres. The diameter of the inner tube (R) is 6.2 millimetres; the outer tube (t) is 6.5 millimetres inside, and 7.9 millimetres outside; its length is 11 centimetres, so that the overall length of the appliance, allowing for a slight projection of the inner tube is about 12 centimetres. Tubing of standard measurement has been employed in the making.

Mr. Herbert Parsons suggested that, with a view to producing the maximum of lateral scattering of light in the substance of the cornea, frosting of the outer surface of the contact-glass would be helpful in that optically the frosted surface acts virtually as the illuminating source. I am not quite sure how far conditions are improved by this. It must be borne in mind that examination of the cornea by peripheral contact-illumination is not the only use to which it is proposed the apparatus should be put, and that frosting of the glass to a high degree will impair the amount of light available for the other purpose of examination of the interior of the eye. I think that dense frosting of the surface of the glass may tend to create an undue glare from the sclerotic immediately surrounding the illuminator. In my present illuminator the surface is but very faintly frosted, only just sufficiently to mask a sharp view of the luminous filament.

Before leaving the subject of design of the illuminator, I must admit that a glass contact piece having a diameter of 6.0 to 6.5 millimetres whilst excellent for contact illumination of the interior (Fig. 1 [a]) is not without its disadvantage for peripheral contact-illumination of the cornea (Fig. 1 [b]), because part of the glass must be so far back on the sclerotic that, in some eyes, the illumination overlaps the limited area deep to which the ciliary body prevents transillumination; with the consequence that a red glow in the pupil may in part replace the desired dark background. This is overcome by having a small cap of thin metal which slips over the end of the illuminator, having a central terminal aperture 4 millimetres in diameter. The cap is slipped on for peripheral illumination and the limitation of the beam ensures that light does not impinge on that area of the sclerotic which is posterior to the ciliary body. A very fair result is thereby attained, which in effect almost comes up to, though it does not quite reach the standard of true contact-illumination by an appliance constructed with a smaller contact-

glass. It is to be admitted that this cap adds a slight difficulty to sterilization. I think that for anyone who proposes to use the appliance extensively it is worth having two illuminators with a small and large contact-piece respectively. This may be provided either by two separate outer tubes to slip over a common core and lamp; the interchanging, however, would be slow, and it would be

FIG. 3.

much better to have two separate illuminators, each of which fits a common bayonet connection as referred to above. The constructional details of the second illuminator are as follows: the same lamp and tubing of the same diameter are used, but the glass is not sprung into the end of the tube itself; a small cap (A. 9 mm.

FIG. 4.

diameter) is soldered to the end of the tube, having an approximately 4 mm. central aperture into which is fixed the glass contact piece 4 mm. diameter. The 9 mm. diameter of the metal mount provides a rim around the glass of $2\frac{1}{2}$ mm. In peripheral

illumination this rim is an advantage, as it lessens the glare from the sclerotic immediately around the illuminator. As no glare takes place in the corneal substance, this cap may be mounted excentrically, so as to bring the glass nearer one part of the circumference of the tube, and an arc may be filed out of the cap at this part. In applying the illuminator, this arc will be turned towards the cornea as in Fig. 5.

It remains to mention the source of electric current. No apparatus of this sort is of practical utility for constant use unless the current is reliable, and the only really reliable portable source is a small (say 30 amp. hour) two-cell accumulator in a wooden box, to which a simple switch is fixed. The size of the lamp filament is such that the intervention of a rheostat is unnecessary. I have now used such an outfit daily for some nine months; the accumulator—a spare one being kept—is sent to be charged once a month (cost 1s. 6d.) before it shows signs of exhaustion. I have at no time been inconvenienced by failure of

FIG. 5.

the apparatus. Dry batteries for anything like frequent use are unsuitable because of their tendency to fall below the potential required to keep the filament fully bright. If a dry battery must be used, on occasions where an accumulator is inconvenient, it should be composed of three cells of not too small a size, these giving an equivalent voltage to that of two accumulator cells. Any attempt at designing a contact-illuminator with a small dry battery in an enlarged handle is unsuitable for various practical reasons, among which are the added clumsiness to an apparatus in the use of which delicacy of application is essential; and the inevitably small size of the dry cells, which makes their rapid exhaustion unavoidable. For practical use, it is essential that the lamp filament should be vividly lit by an unvarying current, which can be relied upon to maintain its strength in spite of long and frequent use. No portable source so fully fills this requirement as an accumulator. I have emphasized these details as to the accessory part of the apparatus at some length, because the unsatisfactory working of unsuitable or unsuitably used electrical apparatus often unjusti-

fiably tends to prejudice the employment, in routine work, of illuminating appliances depending on a portable source of electric current.

As to the method of using the illuminator—the observer may best stand at the right side of the seated patient for the examination of either eye. The lids are held open by the ring finger of each hand, the lower lid by the right and the upper lid by the left finger. The illuminator is held near its contact end by the thumb and first two fingers of the right hand much as one would hold a pencil; and the loupe by the thumb and forefinger of the left hand. The end of the illuminator has been sterilized by wiping with a piece of lint moistened with antiseptic; a drop of 1 or 2 per cent. cocaine has previously been instilled with the usual caution to the patient to shut the eye until exposure is necessary. It is necessary to warn the patient that the light will be put close up to his eye; and in the first application undue hastiness should be avoided. Any patient will involuntarily resent unexpected or brusque application of the illuminator, not because the amount of light

FIG. 6.

reaching the retina is any more than it is in oblique focal illumination, but because the unconscious protective closure of the lids is evoked by nothing so readily as the unlooked for approach of a luminous object close to the eye. When the illuminator is properly handled I have not found patients in any way more resentful of it than they are of focal illumination. It is not good practice to hold the lower lid down with the illuminator instead of doing so with the finger; delicacy of touch cannot be imparted to an appliance subserving two functions. With practice, extreme delicacy of application of the illuminator becomes automatic; but to an observer unaccustomed to its use, it is not difficult for him to lose sight of what is happening to the illuminator whilst his attention is concentrated on the loupe. It is almost unnecessary to add that the illuminator should be lifted when moved from one place to another, and not be scraped over the surface of the epithelium.

With the patient looking horizontally in front, both his eyes being open, the illuminator is first lightly placed on the sclerotic near 4 o'clock of the limbus, and carefully moved towards the cornea until its edge just overlaps the limbus.

A preliminary naked eye survey should always be made before using the loupe. It has already been claimed above that a material advantage of the method is in the ease with which one is enabled, by peripheral application of the illuminator, to assert positively that a given cornea is normal as regards its transparency, so readily does a small nebula illuminated against the dark background declare itself to naked eye observation. Peripheral application should always precede corneal application; the observer should resist the temptation mechanically to place the illuminator straight in the cornea at the outset (as in Fig. 1 [a]), his attention being attracted to something thereby vividly lit up in the anterior chamber, with the result that he may miss detection of some minute abnormality in the cornea. Having detected any fine object in the cornea, the observer may examine it with the loupe by bringing the edge of the illuminator sufficiently close to the object to reveal its nature to the best advantage. It will be found generally that the darker the object in colour the closer, within certain limits, should the illuminator approximate to it when one is examining it in detail with the

FIG. 7.

loupe. I will describe later the appearances presented by various pathological conditions of the cornea.

As regards the loupe, the most convenient magnification for ordinary use is the usual $\times 10$ monocular loupe; the mount should not be large, to give the observer the maximum of available space. For the examination of some very minute changes in an otherwise clear cornea (such as the punctate orange-brown specks referred to below) the lighting by contact-illumination is so favourable that a loupe of higher power may well be employed, *e.g.*, a $\times 16$; but the circumstances in which a loupe of this power is advantageous are limited, and are restricted essentially to changes of fine degree in a limited field.

The cornea having been examined, the attention is turned to the interior, for which purpose the illuminator is placed in some such position as that of Fig. 1 (a). Although, as with the cornea, I will defer till later discussing the appearance of various clinical conditions of the interior, one may here say that there are certain fine conditions which, to be revealed at their best, do not require maximum illumination, such for example, as exceedingly fine deposit, especially when it is old and colourless, on an otherwise clear anterior lens

capsule. This would seem to be largely connected with the penetration of light into the substance of the lens which forms the background; it varies with certain factors, among which is the size of the pupil. I will refer to this matter again. I may here say that for some conditions the submaximal illumination of the anterior chamber secured by such a position as that of Fig. 7. yields effects which are better than those attained by the more central position of Fig. 1 (a).

In applying the illuminator to the cornea for examination of the anterior chamber, it is not essential that the whole face of the illuminator should be in apposition to the cornea. It is generally enough if that part of its circumference which is close to or on the sclerotic makes contact, while the remainder of its surface makes only bare contact with the globe (Fig. 8).

In no branch of medicine does the appreciation of colour lend more aid to observation and deduction than it does in ophthalmology,

FIG. 8.

and one great advantage of this method of illumination of the anterior chamber is that objects are always vividly revealed in all their true colour, such for example as pigment, a foreign body, fine vessels on the iris, siderosis, specks of blood pigment deposited in the lens-capsule of an aphakic eye, etc. Another advantage is in the enhanced appreciation of stereoscopic depth. If the observer places his eye as close as possible to the loupe, apparent stereoscopic depth, even though monocular, is very pronounced under the effective illumination of this method; and appreciation of planes is greatly facilitated by the high degree of parallax which is obtainable when, as is the case, comparative planes at considerable depth are rendered visible. It should be emphasized that parallax is not to be obtained by moving the loupe, the effect of which is to give such a magnification of the length of traverse that the observer cannot appreciate alterations in the view point of a picture which is itself

as a whole undergoing oscillatory change of position. The observer should, with the loupe stationary, *oscillate his own head* to obtain parallax, the result of which is to produce successive changes in the composition of a picture whose position as a whole is unchanging.

There are various clinical conditions to the detection and examination of which contact-illumination is particularly suitable, and before enumerating those concerned with the interior of the eye, one may first dispose of those associated with the cornea.

(*To be concluded.*)

ANNOTATIONS

Cataract in Ironworkers

Some years ago the unusually great incidence of cataract in glassworkers attracted considerable attention. It was found that the cataract in its typical form was very characteristic, and the Home Office felt justified in placing it upon the schedule of diseases under the Workmen's Compensation Act. At the suggestion of Sir Clifford Allbutt they also asked the Royal Society to investigate the causation of the cataract. A committee was formed, which made observations upon the radiations to which the eyes of the workmen were exposed in the course of their duties. It was obvious that the heat factor was one which could not be ignored, and the secretary of the committee instituted an enquiry amongst ophthalmologists practising in ironworking centres to find out whether cataract was also unduly prevalent among this class of workmen. The results were entirely negative. In the following years, researches were conducted upon the absorption of various radiations by the media of the eye, among others, ultra-violet and heat radiations. Chiefly owing to the excellent research conducted by Professor A. V. Hill and Dr. H. Hartridge it became evident that the heat factor was probably of prime importance, and it became increasingly difficult to understand why certain classes of ironworkers, exposed to similar conditions so far as heat was concerned, were apparently immune. The missing link was discovered by Mr. Bernard Cridland in 1915, when he showed at the Section of Ophthalmology of the Royal Society of Medicine a case of cataract in a puddler, indistinguishable in appearance from glassworkers' cataract. Since that date Mr. Cridland has continued his investigations and has gathered together other cases in puddlers. More recently, Dr. St. Clair Roberts, of Dudley, has observed many such cases in chainmakers. Simultaneously, Dr. J. J. Healy, of Llanelly, who was already