the disease was slight but painful, and where the patient refused to allow the removal of the disease, I should advise the excision of half an inch or so of the nerve.

ART. IX.—*Ophthalmoscopic Notes.*—*On the Theory and Principles of the Ophthalmoscope.* By HENRY WILSON, F.R.C.S.I.; L.K. and Q.C.P.I.; Assistant Surgeon to St. Mark's Ophthalmic Hospital; Member of the Royal Irish Academy, &c.

IN proportion as our knowledge of the laws of nature increases and as science advances, do the art and means of discovering the seat and nature of disease become more and more developed. The application of the exact sciences in the domain of medicine has resulted in the discovery, or the utilization, of chemical tests and mechanical contrivances whereby the practitioner is enabled to pronounce definitely on disordered conditions, the existence or nature of which he could only have guessed at, without the employment of those means. Morbid changes in the tissues and fluids, such as amyloid degeneration (which has been elucidated by Dr. Robert M'Donnell's able researches), *leucæmia*, &c., with which we were previously unacquainted, have been revealed by the microscope, by chemistry, &c.; diseased conditions of the vocal and respiratory apparatus hitherto unknown, except, perhaps, as *post mortem* appearances, have been not only recognized during life by means of the laryngoscope, but also successfully treated; quite recently the endoscope has been so perfected by my friend Dr. Cruise, as to bring into view the interior of the urethra, bladder, &c.; and the ophthalmoscope has opened quite a new field of investigation. Immediate exploration by instrumental aid, wherever practicable, is gradually superseding, in a great measure, all other methods of investigation, and the practitioner is becoming less and less dependent upon the statements of patients or their friends, which, owing to various causes, are in many instances so very unreliable; thus the art of diagnosis is becoming facilitated and perfected, and in direct ratio to the accuracy of diagnosis will the practice of medicine be less and less empirical.

Since Lænnec's great discovery of auscultation and the stethoscope, no instrument has rendered such vast services as the ophthalmoscope, not merely in the interpretation of purely ocular affections, but also

in the elucidation of disease in other organs. It renders visible in the living eye the various phenomena of healthy and diseased circulation, and many disordered conditions which illustrate and explain physiological and pathological processes elsewhere; by means of it morbid actions and structural changes may be watched from day to day, or hour to hour, and its employment not unfrequently leads to the detection of disease in other organs, such as the brain, kidneys, circulating apparatus, &c.

With the discovery of the ophthalmoscope a new era dawned in ophthalmic literature—discoveries followed each other in rapid succession—optical defects, the nature of which had been hitherto unknown, or misunderstood, have been explained and remedied, and the laws and mechanism of refraction and of accommodation have been but lately satisfactorily explained. In no branch of the profession, indeed, has there been such great progress of late years, as in ophthalmology, and, thanks to the indefatigable and zealous labours of earnest and scientific men, ophthalmic medicine is becoming more closely allied to the exact sciences; it is worthy of note, indeed, that some of the most distinguished oculists of the present day are eminent also as mathematicians.

The importance of the ophthalmoscope as a means of diagnosis can scarcely be overrated. I need only adduce in proof thereof the former definition of *amaurosis*, “that condition in which the patient sees nothing, and the physician likewise nothing;” this definition is now quite untenable, for the instrument renders either positive evidence, and the physician is able to see the cause of the blindness (which is the case in the large majority of amaurotic persons), or else it affords negative evidence, that is of the eye itself being healthy, and the physician is in a position to pronounce the cause of blindness (*amaurosis*) extra-ocular, and he may thereby be led to ascertain the nature and seat of the lesion or disturbance (generally intra-cranial) which has given origin to the blindness.

The term *amaurosis* is becoming less and less frequent, and will, I hope, eventually come to be used only in its true significance, and simply denote a symptom, and not as is but too generally the case at present, a disease.

And if by its means we are enabled to make a correct diagnosis, the ophthalmoscope must, of necessity, be useful also in the treatment of disease; while in one instance we are able to pronounce our patient incurable, and spare him the sufferings, mental as well as physical, of futile treatment—in another we are able to declare him

curable, and subject him to appropriate treatment. No doubt long experience and accurate observation, will, in a great number of cases, enable the practitioner to arrive, empirically, at the same conclusions, without the aid of the instrument, but how much more satisfactory to ourselves, and beneficial to the public, when even the youngest practitioner can at once give a prognosis as reliable, if not more so, than that which it has taken a lifetime, perhaps, to be enabled to pronounce.

The ophthalmoscope is especially important and useful in cases of suspected deception in the selection of recruits, for the various public services, or in the examination of those already in such services. Thus, defects can be detected in the eyes of recruits which would unfit them for various duties, and soldiers and others who are really labouring under disease of the internal structures of the globe, the eye presenting, externally, no sign whatever of disease, are now free from the odium which may have formerly attached to them as schemers, while real malingerers are liable to detection and punishment. The Army Medical Department has taken up the subject of the ophthalmoscope very warmly, and there is a special course of study thereon, at Netley, under the able guidance of its distinguished Professor of Military Surgery, Deputy Inspector-General Longmore. This increased attention to the vision of recruits, soldiers, &c., must result in a considerable pecuniary saving to the country at large. The following extract from Dr. Longmore's *Ophthalmic Manual*, published for the guidance of army surgeons, is, I think, equally applicable to civil as to military practice:—

“A soldier who is really the subject of serious disease may, by chance, be regarded as a malingerer, because all the superficial ocular apparatus are free from disease, and all that can be seen by ordinary observation of the deeper structures of the eye are observed to act precisely as they do in eyes that are known to be healthy. We have, unfortunately, conclusive proofs that such errors as these formerly occurred very frequently; and that they led to soldiers being sent on foreign service, often to tropical climates, where their diseases became rapidly aggravated, so that they had shortly to be invalided home again, as well as to the retention for considerable periods at home stations of others who were useless, and who had at last to be discharged from the service, after much expense being incurred by their prolonged maintenance. If a defect of vision really exists the medical officer should be able to report to his professional superiors, the exact cause of the disability, for on this

also may hinge many points of importance to the public service, to the soldier, and to the State. If the defective vision be the result of some natural abnormality of the refractive media, or special form of the globe, the service has suffered from the admission into its ranks of an ineligible recruit. If the defect be the result of disease, such as too often follows service under the glare of a tropical sun, then the soldier has suffered from his employment by the State, and is entitled to compensation according to the degree of his disability. There is only one way in which a diagnosis, in these cases, can be truly arrived at, and that is by means of the ophthalmoscope." ^a These, and other considerations, point to the very great practical utility of the instrument, the cost of which is trifling, and the manipulation not difficult; I would, therefore, claim for it a larger share of the attention of the Irish profession than has been, I think, hitherto accorded to it. ^b

Before, however, entering upon the subject of the ophthalmoscope, I would direct attention to other methods of illumining and examining the eye. In the ophthalmoscopic examination we illumine the bottom of the eye, as shall be presently explained, by light *transmitted* through the transparent media; hence, any opacities in the latter will intercept some of the light, and appear simply opaque, as happens also in microscopic examinations; to determine the colour and character of these opacities, therefore, *incident* light must be employed, and this is effected by means of *focal* or *oblique illumination*. Focal or lateral illumination consists in concentrating, on any given spot of the eye, by means of a convex lens, the light from a lamp placed at the patient's side. I am in the habit of using for this purpose a two-inch convex lens. The apartment should be darkened, and a lamp placed about one foot and a half from the patient's side and towards the front, so that the flame and eye shall be nearly on a level, and the globe to be examined illumined, while the opposite eye remains in darkness; the convex lens is then held

^a One of the most able and exhaustive reports on ophthalmic surgery which has appeared of late years is that contained in the Army Medical Reports for 1860, written by Assistant-surgeon Dr. Frank, the merits of whose writings and teachings are universally acknowledged. Dr. Frank has withdrawn from the army, and it is much to be regretted that the State has thereby lost the services of so accomplished and efficient a medical officer. The greater part of his report is devoted to the examination of the deep-seated diseases of the eye, which can be recognized and studied only by means of the ophthalmoscope.

^b The various forms of ophthalmoscopes, as well as lenses and other optical appliances, can be had at Mr. Yeates', 2, Grafton street.

between the thumb and index finger, two inches from the eye, as indicated in the woodcut, in such a manner that the rays from the

Fig. 1.

flame shall pass through it and be brought to a focus on the cornea. If it be desired to examine the iris, capsule, or lens, the convex lens must be held nearer to the eye so as to focus the rays on these parts. This mode of examination can also be practised by intercepting and concentrating on the eye, by the same lens, direct beams of sunlight; but the eye is, as a rule, not very tolerant of such illumination, and sunbeams are not always at command; ordinary diffused daylight does not suffice for the purpose. Another method of effecting *oblique illumination* consists in reflecting on or into the eye, by means of a mirror, the rays from a lamp, while the observer places his eye nearly in the line of these rays. This is best accomplished by holding a small circular plane mirror, or, better still, the ordinary ophthalmoscope mirror itself, just over or in front of the eyebrow, so that the rays from a lamp, placed at the side or above and behind the head of the patient shall be reflected into the observed eye. The distance between observer and patient is then diminished or increased, and slight rotatory movements of the mirror on its own axis executed until a satisfactory illumination is obtained of the part to be examined. Although it is only of recent years that these methods have received that attention which they undoubtedly deserve, similar modes of examination have long been known, and occasionally employed. Mackenzie mentions, at p. 508 of his *Practical Treatise on the Diseases of the Eye*, published in 1840, the circumstance of his having seen what he considered the effects of hyaloiditis, "in directing the light of a gas jet through the pupil with a lens;" and at p. 639 he speaks of concentrating the light on a cataractous opacity by means of a double convex lens. Himly in his *Krankheiten und Missbildungen des menschlichen Auges*, 1843, likewise recommends the ordinary daylight to be concentrated on the eye by means of a convex lens; he also advises illumination by means of reflected light from a mirror, but says it should be used only with completely blind eyes. He noticed a greyish or greenish appearance of the pupil when the interior of the eye was illumined,

and states that the blackness of the interior always ceases when strong illumination is used. It is worthy of note how very near to the discovery of the ophthalmoscope this author had arrived. By focal or oblique illumination each portion of the *cornea* may be brought successively into view. Opacities and irregularities in or on that membrane are exhibited with surprising distinctness; the effusions in *iritis*, covered with red vessels; the sequences of inflammation, such as adhesions, patches of pigment on the capsule of the lens, &c., are brought very clearly into view; their colour, extent, and consistency, are incomparably better ascertained by focal than by any other mode of illumination, and we are thus enabled to estimate the length of time which may have elapsed since the occurrence of the active inflammation. Partial or total loss of vision may occasionally form the subject of a medico-legal inquiry, and any iritic complication which might exist would afford valuable information. But it is principally in examinations of the *crystalline lens* and its capsule that I would advocate these methods; for the determination of the condition of these parts I rely altogether on focal illumination. The anterior capsule affords, as a rule, in health, a very faint reflection, but in young persons there should be no reflection from the interior of the lens, which should hence be invisible. The lens itself is composed of such various elements—tubes, fibres, &c., &c.—and is of such complicated arrangement, that it can be perfectly transparent only when all its component parts exhibit exactly the same refractive index. About the middle period of life (thirty), the individual parts begin to undergo an alteration in their refractive condition, and reflect a certain portion of the incident light, and consequently become visible. This fact should be always remembered, lest the natural reflection peculiar to advanced age be mistaken for cataract. If, when this reflection is strongly marked, the lens is examined by transmitted light, by means of the ophthalmoscope mirror, it will often be found perfectly transparent.

The seat, extent, and consistence of lenticular opacities may be accurately determined; and this is, in practice, an object of the greatest moment, for a knowledge of these circumstances will, as a rule, enable us to decide whether the opacity is a stationary or progressive one, or what length of time may elapse before the lens becomes completely opaque, and will also guide us in the selection of an operation. Opaque capsules, exudation membranes, &c., resulting from cataract operations, are best seen by focal illumination; I have been thus enabled, in some instances, to observe accurately

false membranes which I was not able to perceive otherwise, although I possess very acute vision. These cobweb-like glistening membranes are of a greyish colour, with whitish bands or specks scattered through them, or they appear as a cellular network of fine tendinous bands in one or two layers, stretching across the pupillary area, about midway, sometimes between the iris and vitreous, or simply in the pupillary opening of the iris. The impairment of vision caused by these membranes is often very great, and the improvement resulting from their removal is truly astonishing. Partially or completely luxated transparent lenses are also easily recognized by this illumination; the periphery or equator appears, as also in daylight illumination, as a brilliant amber or golden-coloured semicircle, varying in its position as the eye or light vary in their relative positions. This appearance is said to have been observed in the normally placed lens, in albinos, through the iris, which is scarcely at all pigmented; the periphery of the lens can be seen also where the iris is partially or wholly absent. Focal illumination allows us even to examine the anterior part of the *vitreous humour*, and affords the best means of seeing tumours protruding into the chamber of vitreous humour.

The luminous appearance presented by the eyes of certain animals, such as the dog, cat, &c., occupied the attention of philosophers from a very early period. At the commencement of the last century Méry made some investigations on the subject, and while examining a living cat's eye, under water, saw the retinal vessels. This was subsequently confirmed by Lattère, who accounted for it by supposing that the eye under water adapted itself to the new medium, and that the rays, leaving the eye, were divergent, and therefore brought to a focus on the observer's retina, a theory we now know to be fallacious. Based, however, on the fact of the interior of the eye being visible under water, is Czermak's *orthoscope*, which is a box-like apparatus with glass sides, open at one side so as to fit over the eye, and at the top for the reception of water; when fitted on to the integuments, over the orbital margin, it forms a water-tight chamber, projecting into which is the eyeball. The water in front of the cornea acts as a lens, and the natural focus of the eye is displaced forwards, and hence the retinal vessels become visible.

At the beginning of this century Prévost established the fact that the luminosity of animals eyes was not perceptible in a *perfectly* dark apartment, but that some light must be present; he concluded, therefore, that the luminosity was attributable to a *reflection* from

the bottom of the eye, of light which had penetrated from without. He also found that this luminosity could be seen only in certain positions, and not in others. In the dog and cat, and indeed in the majority of the carnivora, in the ruminantia, in the horse, in the cetacea, and in the cartilaginous fish, there exists at the outside of the optic nerve entrance a patch of peculiarly constituted choroid, which is devoid of pigment, and of a beautiful metallic lustre. This is the *tapetum lucidum*; it varies in colour—blue and green being the predominant ones—and has a smooth polished surface, which acts as a concave mirror. The luminosity in these animals is attributable then, not as was anciently supposed, to spontaneous generation of light, &c., but to a reflection of light incident on this tapetum.

The blackness of the human pupil was referred to the complete absorption of light by the choroid membrane which possesses no tapetum. Complete absorption of light is, however, very rare; were the choroid even as dark as charcoal (one of the substances most capable of absorbing light), a portion of the rays would still be reflected, for in their passage from one medium to another rays of light are never so completely and altogether absorbed but that some of them are reflected. Moreover, certain portions of the healthy retina, such as its vessels, as also the intraocular end of the optic nerve, should reflect a large portion of light. The blackness of the pupil cannot, therefore, be owing to absorption of light. Furthermore, we know from practical experience that although the pupil is, under ordinary circumstances, black, yet, it has occasionally been observed to be luminous; thus, I have seen the human eye as brilliant as any animal's eye, on the occasion of a laryngoscopic demonstration, where all the circumstances of Cumming's experiments, to be mentioned presently, were accidentally fulfilled; similar occurrences have been noticed by other observers. The interior of the human eye was long ago noticed to be luminous in albinos, in partial or complete deficiency of the iris, in certain diseased conditions, such as fungus hematodes, various tumours, separation of the retina, &c.; the "cat's-eye amaurosis," first described by Beer, at page 495 of his *Augenkrankheiten*, in which there existed in the bottom of the eye a "concave pale grey or yellowish-white, or reddish opacity," was, I believe, in the majority of instances due to separation of the retina. A consideration of these theories and facts leads to the conclusion that a portion of the light which enters the eye is again reflected from it, but that we are, under ordinary circumstances, unable to perceive it.

One of the first to investigate this subject, and to arrive at some satisfactory conclusions, was Mr. Cumming, formerly house surgeon to the London Hospital; it may be said, indeed, that on his experiments and writings is based the discovery of the ophthalmoscope. In 1846 he published, in the twenty-ninth volume of the *Medico-Chirurgical Transactions*, his essay^a "on a luminous appearance of the human eye," the object of which was "to show that the healthy human eye is equally, or nearly equally, luminous as the eye of the cat, dog, &c., when observed under favourable circumstances; and the application of the abnormal appearance, or want of this luminosity to the detection of changes in the retina and posterior part of the eye." The circumstances necessary for observing this luminosity are, he remarks:—"a. That the eye must be at some distance from the source of light, the distance being greater in proportion to the intensity. b. That the rays of light diffused around the patient (and sometimes around the eye itself), should be excluded. c. That the observer should occupy a position as near as possible to the direct line, between the source of light and the eye examined; hence, it is sometimes necessary for the observer to stand obliquely, that his eye may approach nearer to the direct line." "Let the person under examination sit or stand eight or ten feet from a gas-light, looking a little to the side; standing nearer the gaslight we have only to approach as near as possible to the direct line, between it and the eye to be viewed, at once to see the reflection." It having thus been established that the human eye is, under certain circumstances, equally luminous as that of animals, the enquiry arises what these circumstances are, and how we may at all times, and most effectually for practical purposes, illumine the interior of the eye.

The human eye possesses a dioptric apparatus, and is endowed, in addition to the ordinary refractive powers of its system of lenses, with the vital function of adjustment—altering its focus, and thus accommodating itself for various distances and various sized objects. By means of this *accommodation* we are able to see an object distinctly whether it be one foot or six feet distant. Various have been the explanations of the mechanism whereby this is effected; some imagined it to take place by alteration in the shape of the globe by means of the extrinsic muscles of the eyeball. Kepler, the celebrated mathematician of the 16-17th century, who

^a See Sir Wm. Wilde's notice thereof in the number of this Journal for February, 1847, p. 257.

first described the humours of the eye as refractive media, and the consequent formation of images on the retina, was also the first to ascribe this accommodation to the ciliary ligament, the contraction of which produced, according to him, elongation of the globe, in which movement the retina was carried to a greater distance from the lens when objects were near. Porterfield, a learned physician and mathematician, whose *Treatise on the Eye—the Manner and Phenomena of Vision*, 1759, is still one of the best works we possess, regarded the ciliary ligament as muscular, and attributed to it the function of changing the position of the lens, of increasing or diminishing the distance between it and the retina, according to the different distances of objects to be seen, so that the retina should be “always at a due focal distance behind the crystalline.” According to a still older theory, the ciliary ligament or muscle effected an alteration in the curvature of the lens, and hence in its focus; and this theory has been, in recent times, amply confirmed by the experiments of Helmholtz, Knapp, and others.

A normal eye is so constructed that when at rest parallel rays striking the cornea are brought to a focus on the bacillary layer of the retina (Jacob's membrane). Strictly speaking, there is in nature no such thing as parallel rays, for all rays emanating from a luminous point are divergent and must continue so; the divergence of rays coming from an infinite distance is, however, so very slight, and the surface of our eye, on which they impinge so very small, that practically we may look upon them as parallel. If an eye be accommodated for a luminous object—say a flame—rays from it on entering the eye will undergo a certain definite refraction or change of direction whereby they are brought to a focus on the retina; a portion of these rays will be absorbed by the choroid, while the remainder will be reflected; this reflected portion must, however, return from the bottom of the eye in exactly the same line as it entered; it will therefore again undergo a refraction similar in nature, but opposite in direction, to that it underwent on entering; and emerging from the eye these rays will return to the flame from which they originated, and there form their focus. Let A (Fig. 2) be an eye accommodated for F, a flame; rays from the latter impinge on the cornea slightly divergently, and entering the eye will be rendered convergent by the refractive media and brought to a focus at f , at which place there will therefore be an image of F; from this luminous image rays will be reflected outwards in the same line as they entered; they strike the posterior surface of the crystalline

Fig. 2.

lens divergently, are converged by it, and emerge from the eye convergently, and are united into a focus at F ; hence, F , the luminous object and, f , its retinal image will act reciprocally as *conjugate foci*, each being alternately object or image—whichever be the radiant point the other will be the focal point. In like manner, when we regard another individual's pupil, it will be merely a representation of our own; and as our own pupil appears black, and sends no light into the observed eye, the pupil of the latter will consequently appear black also. The eye of the albinó would appear; at first sight, to offer a contradiction to the above, as the pupil in such cases presents, even in ordinary daylight, a reddish or brilliant appearance, but this luminosity is due to rays entering the eye through the very scantily pigmented iris and choroid, parts which ordinarily possess such an abundant pigmentation as to render them very opaque. This may be proved to be the case by holding a blackened card or screen with a central aperture corresponding to the pupil in such a manner before the eye that all rays except those entering through the pupil shall be excluded; the red reflection will then disappear, and the pupil appear black like that of an ordinarily pigmented eye.

In order then for an observer to perceive the returning rays his eye must be in the line of their emergence, *i.e.*, between F and A , or at F , for at any other place (such as at B) A 's pupil will appear black. If we interpose between F and A the illuminating rays would be necessarily cut off; and it is impracticable to place our eye at F . We may, however, bring our eye very close to F , and by looking through the margin of the flame we approach very nearly to the direct line of the emergent rays, and in this position we obtain a bright reflection from behind A 's pupil, as in Cumming's experiments.

Professor Helmholtz, now of the University of Heidelberg, constructed an apparatus by means of which the observer could readily

place his eye in the direct line of the emergent rays; and in 1851 he published an account thereof. The chief features in this invention are the employment of *reflected* light, and the utilization of the laws of refraction. Let A, in Fig. 3, represent the observed

Fig. 3.

eye, and F a flame on the same level, five inches to the side, and a little towards the front of the patient; M, a piece of well polished plane glass, with parallel surfaces, placed one inch in front of A, at such angle that rays falling on it from F shall be reflected into the eye, as if they came from F', which is a point as far behind M as the flame is in front of it. The observed eye will apparently see the flame at F', for which distance (five inches) he then accommodates. The plate M acts as a speculum, but being transparent some of the rays from F pass through it, and are lost; others, however, are reflected into A, and are brought to a focus on its retina—at a—where there will be consequently an image of F. As already explained rays emerge from this image, some of which are reflected back to F by M, while the remainder traverse M to form their focus at F', the point for which the eye is accommodated, and where there will therefore be an image of a. The observer, therefore, can now, by placing his eye, B, behind M, between it and F', readily intercept these rays, but yet he does not receive on his retina an image of a, but merely perceives a brilliant red reflection from A. The cause of this lies in the fact of the rays a M F' being

convergent, and being still further converged by the dioptric apparatus of B (a normal eye) they unite into their focus between the lens and retina at o (indicated in Fig. 3 by the interrupted lines), where they become divergent and form a circle of dispersion, $c d$, on B's retina—hence there is no distinct image of a . By interposing a concave lens, L, however, between M and B these convergent rays are rendered divergent (indicated by the dotted lines), and entering B are again converged by the refractive media, so as to be focussed on B's retina at a' . The observer, B, will therefore now obtain a clear and well-defined image of the illumined spot a . No matter where B placed his eye so long as the rays from A were convergent he could only obtain a confused and indistinct image. This simple contrivance was improved by the addition of other plates of glass, which, together with suitable lens, were fitted into an appropriate tubular case, and was styled by its inventor *speculum oculi* or *ophthalmoscope*, and is no doubt the first ophthalmoscope, properly so called, by means of which the retina of the living eye could be seen. The subject was, I believe, first brought before the English profession by Dr. Sanders, in the *Monthly Journal of Medical Science* for July, 1852. Professor Wharton Jones announced in the *British and Foreign Medico-Chirurgical Review* for October, 1854, that Mr. Babbage had, seven years previously, showed him the model of an ophthalmoscope which “consisted of a bit of plain mirror, with the silvering scraped off at two or three small spots in the middle, fixed within a tube at such an angle that the rays of light, falling on it through an opening in the side of the tube, were reflected into the eye to be observed, and to which the one end of the tube was directed. The observer looked through the clear spots of the mirror from the other end.” It is much to be regretted, for the sake of British ophthalmic surgery, that this discovery was not made public, or even utilized by the learned professor of ophthalmic medicine and surgery in University College Hospital, London, at an earlier period.

By means of Helmholtz's ophthalmoscope, just described, the image of the flame could be projected *successively* on different portions of the bottom of the eye, and thus gradually an examination of the whole fundus^a might be obtained. Although the instrument was subsequently much improved by Epkens, by its deviser, and others, it was always difficult to manipulate, and the

^a By the term *fundus* is meant all that part of the eye lying behind the lens and vitreous humour, viz., optic nerve entrance, retina, choroid, sclerotic, and blood-vessels.

field of illumination being so very small, it was of but little practical value.

As I have endeavoured to explain, the illumination consisted in bringing to a focus exactly on the retina the image of a flame. Another method, conceived by Professor Brücke, consists in illuminating the fundus by means of a *circle of dispersed light*. In 1847, Brücke published an account of his experiment, whereby the illumination of the interior of the eye could be easily and satisfactorily demonstrated. This experiment, which is based on a knowledge of the laws of refraction and accommodation, already briefly alluded to, consists in adjusting the vision for a shorter or longer distance than that occupied by a flame placed in front of the eye, so that instead of an image of the flame there shall be merely dispersed light on the fundus. While the observed eye A (Fig. 2) remains adjusted or accommodated for the distance A F, move the flame nearer to the eye—to F'; its image would now fall at f' , but that the retina is interposed; therefore a part of the fundus $a b$ will be illumined by diffused light. From this circle of dispersion $a b$, rays are reflected outwards which must return, and form their focus, not in the flame from which they originated, but at the distance for which the eye is accommodated—F, at which place there will consequently be an image $b' a'$ formed of $a b$. If the observer's eye now occupy a position anywhere between b' and a' (behind and to the side of F), the returning rays are readily perceived, the luminosity of A's pupil becomes very apparent, and even the details of the fundus are occasionally seen. This image $b' a'$ is formed at a considerable distance from the observed eye, is inverted, large, faint, and indistinct, and the details, as a rule, not recognizable; hence, though perfect as a means of rendering the illumination visible, it is, as a means of seeing the individual parts, practically useless.

To the acute and reasoning mind of Helmholtz, however, this experiment suggested a practical idea, and in his hands assumed a new and great importance, for from it he deduced and perfected a method of obtaining easily a well-defined image of the fundus. This method consisted in projecting on the fundus a large circle of dispersion, and converging the reflected rays to a focus at a short and convenient distance, by means of a double convex lens of short focus held before the eye. Rays of light falling on this convex lens are refracted, and enter the eye convergently; they are still further converged by the crystalline lens of the

eye and brought to a focus somewhere between this and the retina; from this focus they diverge, and fall on the fundus in the shape of dispersed light; from this circle of dispersion rays are reflected from the fundus, and emerge parallel if the eye be accommodated for parallel rays (as a rule, however, they emerge slightly convergently). Meeting the convex lens in front of the eye, they are converged and united within the plane of the principal focus of the lens, at which place an image of the fundus is formed. The flame of a candle or lamp placed before the eye was used for the illumination, and a screen was fixed behind the flame, so that the observer was enabled to bring his eye close to the source of illumination, and thus be as nearly as possible in the direct line of the emergent rays. To obviate the inconveniences and difficulties attendant on this mode of illumination Professor Ruete had recourse to *mirrors*. Concave mirrors possess the property of rendering rays falling on their surface from a certain distance convergent; therefore in them we possess a means of producing a circle of dispersion in the retina. Fig. 4 illustrates the passage of rays to and from the fundus.

Fig. 4.

Let A be the observed eye, accommodated for distance, *i.e.*, for parallel rays, *o* its optical centre, and F the flame placed behind or to the side of A, so that the cornea and pupil may be in darkness. A concave mirror, M, of suitable focus is now held in front of A, so that rays falling on it divergently or parallel from F are reflected into the eye convergently, and illumine the fundus as dispersed light; from this circle of dispersion rays are reflected outwards to form at *f*, *f*, as already mentioned, a large inverted and indistinct image of the fundus; if we now interpose between A and M, at its focal distance from A, a double convex lens L, of short focus—two inches—the rays from M will be rendered more convergent by L, and still further so by the dioptric apparatus of A, so that they will

unite behind the lens of the latter and form on the fundus a circle of dispersion $c d$; from any points of this circle, such as from $a b$, pencils of rays will be reflected and emerge from the eye parallel to the lines (dotted) through the optical centre; they are, however, converged by L , and brought to their foci at $b' a'$, at which place, then, there will be an inverted, magnified, and distinct image of $a b$ (the interrupted lines indicate the course of rays from a , and similar ones may be traced from b). By making an opening in the mirror at E , and placing our eye there, and accommodating our vision for the distance $E b' a'$, we readily become cognizant of the image. As is evident, this is an *aërial image situate between the observer and the convex lens*; it is also actually *inverted* and enlarged. If it be desired to obtain an enlargement of this image, it may be effected by placing behind the mirror another convex lens, but of a longer focal distance than L ; or we may primarily produce a large image of $a b$ by having L of a long focal distance, such as four inches, for such a lens will be of a lower converging capacity than one of two inches; and hence the image will be larger. By the above process we illumine the greater part of the fundus, and by using a convex lens of very short focus we obtain a very large field, *i.e.*, a view of nearly the whole illuminated portion, but the details are very small; by using a lens of longer focus the field of vision is curtailed, but the parts much magnified: thus, for instance, if we employ a lens of two-inch focus we obtain an image of the entire fundus, whereas if we use one of four we merely obtain an image of the optic nerve entrance. This mode of examining has been termed the *indirect*, or the examination of the reversed aërial image, to distinguish it from another, styled the *direct*—in which a *virtual erect* image of the fundus is seen.

ART. X.—*On the Use of Sulphite of Magnesia in the Treatment of Zymotic Diseases.* By H. R. DE RICCI.

IT is now upwards of two years since I last published, in the pages of this Journal, the results of my investigations in the treatment and prophylaxis of zymotic diseases by the administration of the alkaline and earthy sulphites, and especially by the sulphite of magnesia; but, although my pen has so long been silent on this highly interesting and most important branch of therapeutics, it is not because I