deferens into the globus major of an epididymis having an obstructed globus minor. The result of this operation was the appearance of spermatozoa in the expressed secretion of the seminal vesicles, from which they had previously been absent. *Edward L. Keyes, Jr.*

SHADOW TEST.*—"Keratoscopy," "Retinoscopy," "Retinoskiascopy," "Korescopy," and other names. An objective method of determining the refraction of the eye.

When, from a certain distance, an observer throws light into an eye by means of a perforated mirror, on looking through the hole in the mirror he sees the entire pupil illuminated with a reddish light. If, now, the mirror is slightly rotated, a dark segment ("shadow") comes into view and, increasing as the mirror is rotated, presently extends over and darkens the entire pupil. The direction in which the "shadow" grows—*i.e.*, the direction in which the border of the shadow moves, whether in the same or in the opposite direction to that in which the mirror is rotated—depends, with certain limitations, on the refraction (hypermetropia, emmetropia, or myopia) of the observed eye, and affords a means, when the necessary conditions are fulfilled, of measuring its refraction.

The perforated mirror used in the shadow test may be either plane or concave.

1. We will assume that a plane mirror is used, and that the observer's eye, which is immediately behind the perforation, is stationed at a distance of one metre from the observed eye. The mirror is now adjusted to reflect light, preferably from an Argand burner, directly upon the observed eye, whose pupil is seen filled with a uniform red light. On rotating the mirror to the right (*i.e.*, turning the left side of the mirror forward) a dark "shadow" appears at the left side (*i.e.*, to the observer's left) of the pupil and passes over it, increasing from left to right, until the entire pupil is darkened. Similarly, on rotating the mirror to the left, the shadow appears at the right side of the pupil and passes over it from right to left.

This movement of the border of the shadow in the direction of the rotation of the mirror occurs whenever the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls elsewhere than between the observer's and the observed eye. When, as we have assumed, the observer's eye is stationed at a distance of one metre, the observed eye may be either hypermetropic, emmetropic, or myopic in any degree less than 1 D.

2. On rotating the (plane) mirror to the right the "shadow" appears at the right side of the pupil and passes over it from right to left; or, on rotating the mirror to the left, the shadow appears at the left side of the pupil and passes over it from left to right.

This movement of the border of the shadow in a direction opposite to that of the rotation of the mirror occurs when the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls within the distance at which the observer's eye is stationed. In our assumed case this distance is taken equal to one metre; the observed eye is therefore myopic in some degree greater than 1 D.

3. On rotating the (plane) mirror in any direction, no "shadow" is seen, but the illumination of the pupil fades gradually into darkness. This fading out of the illumination of the pupil in its totality, without any appearance of a moving shadow, occurs only in the case in which the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls at the exact distance at which the observer's eye is stationed, which in our assumed case has been taken equal to one metre; the observed eye is therefore myopic, and its myopia is equal to 1 D.

4. If a concave mirror of short focus is substituted for the plane mirror, in which case a real image of the flame is formed between the observer's and the observed eye, the "shadow" is seen to move in a direction opposite to that in which it moves when the plane mirror is used.

These facts have been utilized for the practical determination of the refraction in several different ways, two of which have been especially cultivated.

I. The observer, stationed at a distance of one metre, and using a concave mirror preferably of about 20 cm. focus, throws light from an Argand burner placed beside or above the patient's head, into the eye whose refraction is to be investigated. If on rotating the (concave) mirror in any direction, he sees the "shadow" moving in the opposite direction, he concludes that the eye is either hypermetropic, emmetropic, or myopic in some degree less than 1 D. Convex glasses, of progressively increasing strength, are then placed, one after another, in a trial frame before the observed eye, until a glass is found through which no shadow movement is discernible in the transition from the illuminated to the darkened state of the pupil. The combination of the observed eye and this convex glass represents myopia of 1 D., and the subtraction of 1 D. from the value of the glass gives the refraction of the eye. For example, if the convex glass measures 3.5 D., the refraction is H = 2.5 D.; if the convex glass measures just 1 D., the eye is emmetropic; if without a glass no moving shadow is seen, the refraction is M = 1 D.

If, on rotating the (concave) mirror, the shadow is seen moving in the same direction, the presence of myopia of a higher grade than 1 D. is established; concave glasses, of progressively increasing strength, are then placed, one after another, in front of the observed eye, until a glass is found through which no shadow movement is seen. The combination of the observed eye and this concave glass represents myopia of 1 D., and the addition of 1 D. to the value of the glass gives the actual myopia.

This is the method advocated by Cuignet, Parent, and others.

II. The observer uses a plain mirror, and does not keep at a fixed distance from the observed eye. We will suppose that he first stations himself at a distance of one-half metre, and sees the "shadow" moving in the same direction as that in which the mirror is rotated, thus establishing the fact that the eye is either hypermetropic, emmetropic, or myopic in some degree less than 2 D. A convex glass of sufficient strength to render the observed eye myopic in excess of 2 D. is then placed before it in a trial frame, thus causing an image of its fundus to be formed in front of the eye of the observer. The observer next approaches the observed eye until he reaches a point at which no moving shadow is discernible—*point of reversal*. The observer's eye is now at the far-point of the observed eye as modified by the convex glass, and the distance from eye to eye is measured by means of a rule or a tape measure. The reciprocal of the fractional part of a metre thus measured represents, in dioptries, the refraction of the observed eye plus the convex glass, and the subtraction of the value of this glass gives the refraction of the eye.

When the observed eye is myopic in excess of 2 D., so that its far-point lies within the distance of one-half metre at which the eye of the observer is stationed, the movement of the shadow is in the direction opposite to that in which the mirror is rotated, and the distance of the point of reversal from the observed eye gives the measure of the myopia.

When the myopia of the observed eye is in excess of 4 D. or 5 D., the point of reversal falls too near the eye for an entirely trustworthy measurement of its distance. In such a case a concave glass, of sufficient strength to carry the far-point back to a distance of from one-quarter metre to one-half metre, is placed before the observed eye, and the value of this (concave) glass must be added to that obtained by measuring the distance of the point of reversal.

This is the method advocated by Chibret, Schweigger, and others.

* The writer desires again to acknowledge his indebtedness to Dr. John Green, of St. Louis, for assistance most kindly rendered in revising the present article for the press.

In emmetropia, and in simple ametropia (hypermetropia and myopia), the movement of the mirrored image of the flame, whether virtual or real, and that of the "shadow" are always in one and the same plane passing through the observer's and the observed eye. The same is true also in astigmatism whenever the plane in which the image moves, as determined by the direction in which the mirror is rotated, passes through either of the two principal meridians of the observed eye. The shadow test is, therefore, perfectly adapted to the measurement of the refraction of an astigmatic eye in each of its two principal meridians. If, however, the shadow is seen to move in a plane other than that determined by the direction of the rotation of the mirror (see Fig. 4266), it is certain both that the observed eye is astigmatic, and that the plane in which the mirrored image moves does not pass through either of its principal meridians. To find a principal meridian, whether of greatest or least refraction, it is then only necessary to vary the direction in which the mirror is rotated, until the shadow is seen to move in the same or in the opposite direction. The statement made by different writers, that the direction of the obliquely moving shadow corresponds to that of one or the other of the two principal meridians, is erroneous.

The idea of utilizing the direction of the movement of the "shadow" in the pupil for the practical determination of the refraction originated with Cuignet (1873), but he gave a wrong explanation of the phenomenon and so was led to give to the procedure the very unsuitable name "keratoscopy." Landolt (1878) was the first to propose a nearly correct theory, and his and Parent's descriptions have contributed largely to the popularization of the method. Credit must also be given to Chibret (1882) for the important modification of the procedure in which the plane mirror is used at a varying distance. Leroy and Monoyer have further developed the theory, which, strange to say, had been erroneously, or at best inadequately, stated during a number of years.

The theory of the shadow test will be best understood if we consider a few special cases:

I. We will assume that the observed eye is emmetropic, and that the test is made with a plane mirror at a distance of one-half metre. An image of the source of light (Argand burner) is formed at the fundus of the observed eye, which, within the limits of this image, is strongly illuminated so that every point gives out rays of light as if it were self-luminous. The details of this illuminated area at the fundus are, however, indistinguishable, or at best imperfectly distinguishable, inasmuch as, by the conditions of the test, the observer's eye is accommodated, not for the fundus, but for the pupil of the observed eye. The illuminated area is seen, therefore, in circles of confusion, consequently as a more or less diffuse red light shining through the pupil.

How much of the illuminated area is, in any case, visible to the observer, is determined in part by the diameter of the pupil of the observed eye, and in part also by the size of the hole in the mirror, or, if this is rather large, by the diameter of the pupil of the observer's eye. Let $a\,a'$ (Fig. 4267, *I*) represent a portion of the illuminated area (image of the flame) at the fundus of the observed eye, which we assume to be directed upon the hole in the mirror, consequently upon the pupil of the eye of the observer. Let $a\,P\,p\,\pi$ represent a limiting ray passing out of the pupil of the observed eye to enter the pupil of the observer's eye; similarly, let a' represent the origin of another limiting ray, as determined by the points P' and p', meeting the retina of the observer's eye at π'. Now $P\,P'$ and $p'\,p$ represent, respectively, the diameters of the two (circular) pupils, consequently $a\,a'$ and $\pi\,\pi'$ must also represent diameters of circles. We will call the circular area $a\,a'$ the *visible circle*. Inasmuch as the illuminated area (image of an Argand burner when the distance of the mirror is taken anywhere between the limits of one metre and one-quarter metre) is considerably larger than that of the visible circle, the entire pupil $P\,P'$ will be lighted up, and the visible circle $a\,a'$ will coincide throughout with the two pupils, $P\,P'$ and pp', and with the circle $\pi\,\pi'$ at the fundus of the eye of the observer. But we have already seen that the visible circle $a\,a'$ is pictured at $\pi\,\pi'$ in circles of confusion; hence the impression made on the observer is rather that of the illuminated pupil $P\,P'$ than of the circle $a\,a'$.

To explain the phenomenon of the moving "shadow" we will suppose that the observer, whose attention is fixed on the illuminating pupil $P\,P'$ of the observed eye, now rotates the mirror a little to the right (see Fig. 4268), thus displacing the mirrored (virtual) image of the flame to the left, consequently displacing the real image of the flame at the fundus of the observed eye to the right. The displaced image of the flame, as it passes over the visible circle, presently leaves a segment of the latter without illumination, consequently a segment of the pupil $P\,P'$ darkened (see Fig. 4269). As already explained, the border of this dark segment is seen somewhat imperfectly defined, thus suggesting a shadow with its penumbra, and accounting, in a way, for the name "shadow test."

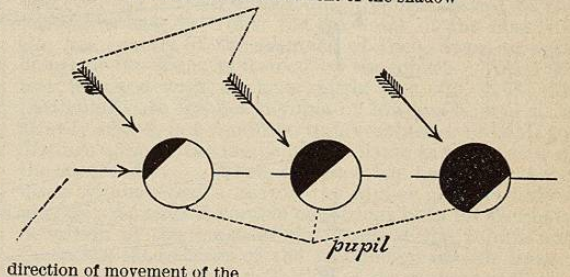

FIG. 4266.

It will be observed that in this case (emmetropia of the observed eye) the growth of the darkened segment of the pupil (movement of the shadow) is in the same direction as that in which the (plane) mirror is rotated, the reversed movement at π, or at π', being perceived as a direct movement at a or at a', consequently at P or at P'.

II. We will now assume that the observed eye is hypermetropic, the other conditions remaining as before (see Fig. 4267, *II*). Comparing *I* and *II*, Fig. 4267, it is evident that nothing essential has been changed, as regards either the formation of the "shadow" or the direction of its movement. The illuminated area (image of the flame) is, however, smaller, and the visible circle larger, than in the case of emmetropia of the observed eye. The dark border of the illuminated area will therefore pass the limit of the visible circle more quickly (the rate of rotation of the mirror being assumed to be unchanged), but more time will be required for its transit. We have seen that the apparent diameter of the visible circle is the same as that of the pupil; the rate of passage of the shadow across the pupil is therefore slower in hypermetropia than in emmetropia.

In hypermetropia of the observed eye the conditions for obtaining a clearer view of the details of the fundus, when the eye of the observer is accommodated for its pupil, are more favorable than in emmetropia, and the higher the grade of the hypermetropia (*i.e.*, the less the distance at which the virtual image, $h\,h'$, of the visible circle lies behind the plane of the pupil) the more clearly will the retinal vessels, etc., be seen. On the other hand, hypermetropia of the observed eye is unfavorable for the accurate focusing of the image of the flame on its retina, and for this reason the outlines of this image are less sharply defined than in emmetropia. The advantage, to the observer, of the clearer view which he obtains of the image of the flame is, however, greater than the disadvantage resulting from its less perfect definition; hence the free border of the shadow, as it traverses the pupil, appears more sharply defined in hypermetropia than in emmetropia, and the higher the grade of the hypermetropia, the more distinct, on the whole, does the shadow appear.

III. The observed eye is assumed to be myopic in some degree less than 2 D., the observer being stationed, as

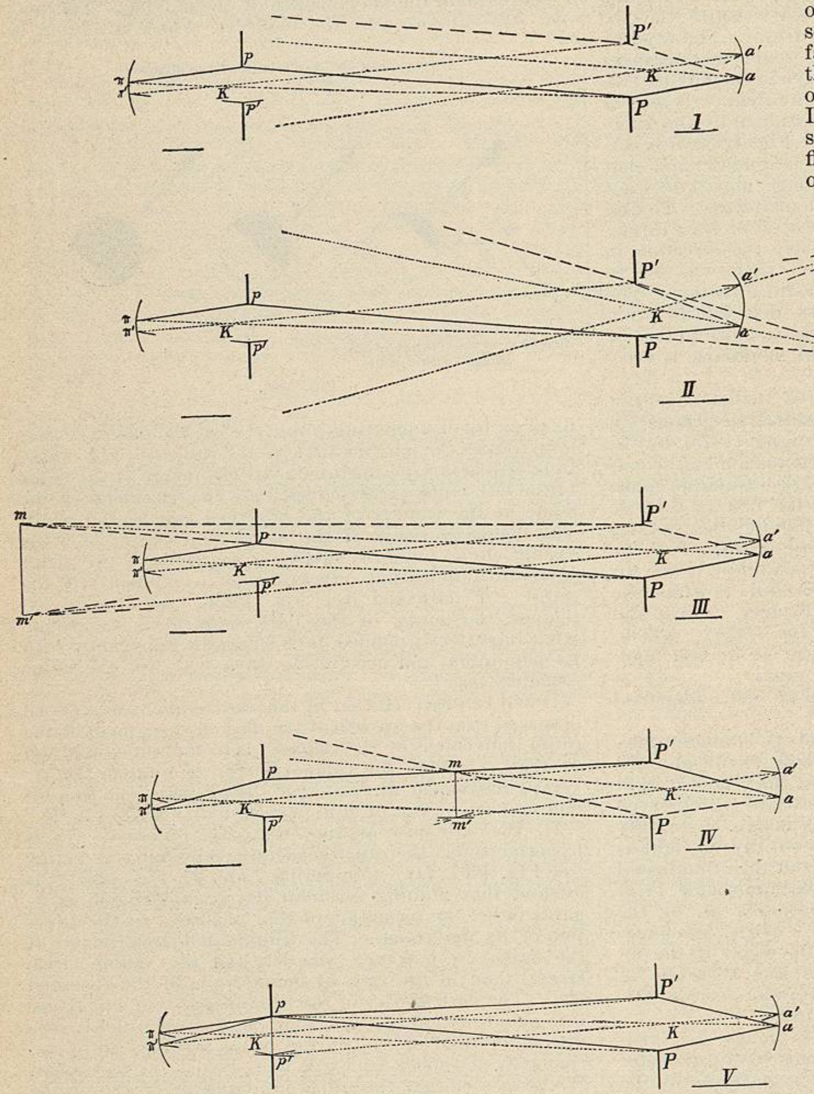

FIG. 4267.

before, at a distance of one-half metre (see Fig. 4267, *III*). Comparing *III* with *I* and *II*, Fig. 4267, we see by inspection that the conditions which determine the forma-

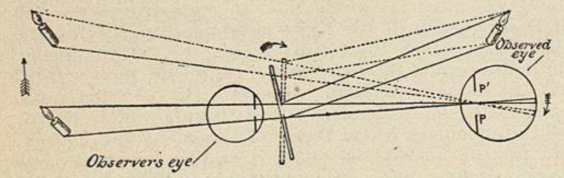

FIG. 4268.

tion and the direction of movement of the "shadow" still remain unchanged. The illuminated area (image of the flame) is, however, somewhat larger, and the visible circle smaller than in emmetropia. The appearance of the shadow will therefore be somewhat retarded, but its transit across the pupil will be accomplished in less time, consequently at a more rapid rate of movement.

In the case under consideration (myopia of less than 2 D.) the conditions are especially favorable for the formation of a sharply defined image of the flame on the retina of the observed eye, but they are even less favorable than in emmetropia for the accurate picturing of this image on the retina of the observer's eye. In fact, the disadvantage to the observer of viewing the image of the flame in larger circles of confusion outweighs any advantage accruing from the more perfect definition of this image, and this preponderance of disadvantage increases, in a progressively augmenting ratio, as the grade of myopia approaches the limit in which the far-point of the observed eye lies exactly at the distance of the pupil of the observer's eye (*i.e.*, 2 D., when, as we have assumed, the observer is stationed at a distance of one-half metre). In this limiting position of the far-point of the observed eye (point of reversal) no shadow outline, consequently no shadow movement, is discernible.

IV. The far-point of the observed eye is assumed to lie in front of the eye of the observer (myopia of the observed eye in excess of 2 D., when the observer is stationed at the assumed distance of one-half metre—see Fig. 4267, *IV*). A new condition now comes into play. A real image, $m'\ m$, of the visible circle $a\ a'$ is formed at the far-point of the observed eye. Of this image a second image $\pi\ \pi'$ (which is a twice inverted, therefore an erect image of $a\ a'$) is pictured on the retina of the eye of the observer, who sees the image of the flame at $a\ a'$ inverted, and the direction of its motion, consequently the direction of the shadow movement, reversed. The higher the grade of the myopia, the larger is the illuminated area (image of the flame), and the larger also is the visible circle, the latter increasing, however, at a greater rate than the former. Conversely, the lower the grade of the myopia within the assumed limit of 2 D. (*i.e.*, the nearer to the plane $p'\ p$ of the pupil of the observer's eye the real image $m'\ m$ falls), the smaller is the portion

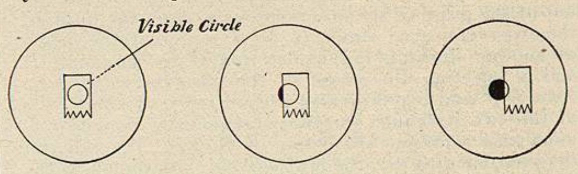

FIG. 4269.

of the fundus at $a\ a'$—*i.e.*, the visible circle—from which rays of light can enter the eye of the observer. Again, the higher the grade of the myopia (*i.e.*, the nearer to the plane $P\ P'$ of the pupil of the observed eye the real

image $m'\ m$ falls), the sharper will be the definition of the shadow outline. Conversely, the lower the grade of the myopia (*i.e.*, the nearer to $p'\ p$ the real image $m'\ m$ falls), the less advantageous will be the conditions for seeing it distinctly; consequently the more imperfect will be the definition of the shadow outline, until, in the assumed limit of 2 D., no shadow outline, consequently no shadow movement, will be seen.

V. The far-point of the observed eye is assumed to lie at the exact distance of the pupil of the observer's eye (myopia of 2 D., when the observer is stationed at the assumed distance of one-half metre—see Fig. 4267, *V*). In this case the real image of the visible circle (*cf.* *V.*, with *III* and *IV*, Fig. 4267) is formed at and fills the pupil, $p\ p'$, of the eye of the observer, the point p corresponding to a, and p' to a'. Now the outermost rays, $a\ P\ p$ and $a\ P'\ p$, of the limiting pencil originating at a to pass out of the pupil of the observed eye and enter the pupil of the observer's eye, are refracted to π and π', respectively, at the retina of the observer; and, in like manner, all intermediate rays belonging to the same pencil are refracted each to its own point intermediate between π and π'; hence every point in the circle $\pi\ \pi'$ is faintly illuminated by rays emanating from a. Similarly, the limiting pencil originating at a', likewise all pencils originating at points lying between a and a', contribute each its own share to the general illumination of the circle $\pi\ \pi'$, consequently to the illumination of $P\ P'$, the pupil of the observed eye, in its totality. The effect of the rotation of the mirror is manifested, therefore, by a gradual fading out of the light in the pupil, and not, as in Cases I. to IV, by the appearance of a moving "shadow." It will be further observed (*cf.* *I*, *II*, *III*, *IV*, and *V*, Fig. 4267) that in this case the diameter of the visible circle (*i.e.*, of the area at the fundus of the observed eye from which rays of light can pass out through its pupil to enter the pupil of the observer's eye) is as its minimum.

Comparing these several cases, we draw the following deductions:

(*a*) Appearance and direction of movement of the shadow. Whenever a "shadow," appearing at the side of the pupil of the observed eye, is seen to move in the same direction as that in which the (plane) mirror is rotated, the eye is either hypermetropic, emmetropic, or myopic in such (lower) degree that its far-point lies behind the eye of the observer—Cases I. to III.

When the "shadow" is seen to move in the direction opposite to that in which the (plane) mirror is rotated, the eye is myopic in such (higher) degree that its far-point lies in front of the eye of the observer—Case IV.

When no shadow outline is discernible, the illumination of the entire pupil fading gradually into darkness whatever may be the direction in which the mirror is rotated, the eye is myopic in such degree that its far-point lies at the distance of the eye of the observer—Case V.

(*b*) Distinctness of the shadow outline. The definition of the shadow outline is always less perfect than that of the image of the flame at the fundus of the observed eye, for the reason that the (virtual or real) image of this image, which we may regard as the object actually viewed by the observer, is formed either at an infinite distance from the pupil of the observed eye (in emmetropia), at a finite and always considerable distance behind the pupil (in hypermetropia), or at a finite and always considerable distance in front of the pupil (in myopia). In no case, therefore, can this image be perfectly focused by the eye of the observer, when, in accordance with the requirements of the test, the latter is accommodated for the pupil of the observed eye. Nevertheless, in high grades both of hypermetropia and of myopia, the difference in the distance (from the observer) of the pupil and the image is not so great as to prevent a fairly distinct view of both at the same time. In hypermetropia (Case II.) of decreasing grade, passing through emmetropia (Case I.) and myopia of relatively low grade (Case III.), to the limiting grade of myopia (Case V.), in which the image of the visible circle at the fundus of the observed eye lies at and fills the pupil of the eye of the observer; likewise in myopia of relatively high grade (Case IV.), decreasing to approach the same limit (Case V.), the distinctness of the shadow outline diminishes at a rapidly increasing rate, until, in the limiting case (Case V.), the shadow outline and the shadow movement vanish together.

Again, the image of the flame at the fundus of the observed eye is itself imperfectly defined, except in the particular case in which the far-point of the observed eye lies exactly at the distance of the (virtual or real) image of the flame as formed by the mirror. When the test is made with a plane mirror (see Fig. 4268) this particular case implies myopia of low grade, which, as already stated, is a condition unfavorable for obtaining a distinct view of the image of the flame at the fundus of the observed eye. When, on the other hand, the test is made with a concave mirror, the higher grades of myopia offer the most favorable conditions both for the sharp definition of the image of the flame at the fundus and for seeing the outlines of the real image of this image, consequently for good definition of the shadow outline.

Narrowness of the pupil, whether of the observed eye or of the eye of the observer, is favorable to the definition both of the image of the flame, at the fundus of the former, and of the image of this image, as pictured on the retina of the latter. But narrowness of either pupil, and still more of both pupils, involves a notable limitation of the area of the visible circle (see Fig. 4267) and narrowness of the pupil of the observed eye involves also a diminution (in the ratio of the square of its diameter) of the brightness of the image of the flame at its fundus. Furthermore, a narrow pupil is unfavorable for observing the passage of the shadow. For these reasons, it will readily be comprehended that the preponderance of advantage may be greatly on the side of a large and well-lighted pupil, and this is in practice found to be the case. To this end the diameter of the hole in the mirror should be somewhat greater than that of the pupil of the observer's eye, and the pupil of the observed eye, unless naturally rather wide, should be dilated by instilling a solution of one of the weaker-acting mydriatics.

(*c*) Brightness of the pupil. We have given the name "visible circle" to the circular area, at the fundus, from which alone any ray of light can both pass out of the observed eye and enter the eye of the observer. Under the conditions of the shadow test the visible circle is simply that portion of a larger illuminated area (image of the flame) which, seen always in circles of confusion, is visible through the pupil of the observed eye. The image formed on the retina of the observer's eye is, therefore, an indistinct image of the visible circle, but by reason of its indistinctness, together with the fact that its outline is the same as that of the pupil of the observed eye, the impression made on the observer is rather that of an illuminated pupil than of the portion of the fundus behind it. As the size of the image on the observer's retina is independent of the actual size of the visible circle it follows that the larger the visible circle (its brightness being assumed to be constant), or the brighter the image of the flame (the size of the visible circle being assumed to be constant), the stronger will be the illumination of the pupil.

The area of the visible circle is larger, (α) the wider the pupil of the observed eye, (β) the wider the pupil of the observer's eye, (γ) the greater the myopia of the observed eye in excess of the critical grade (Case V.), in which the far-point of the eye lies at the distance of the pupil of the observer's eye, (δ) the less the refraction of the observed eye measured from the same critical grade of myopia, and (ε) the less the distance of the observer's from the observed eye.

The brightness of the image of the flame at the fundus of the observed eye is greater (α) the wider the pupil of the observed eye; and, when the test is made with the concave mirror, the greater the apparent area of the mirror, that is, (ε) the less the distance of the observer's eye (looking through the hole in the mirror) from the observed eye, or (ζ) the larger the concave mirror.

The conditions favorable to a strong illumination of the pupil of the observed eye are then, (α) wideness of its pupil, (β) a fairly large pupil on the part of the observer, (γ) a high grade of myopia of the observed eye, (δ) a high grade of hypermetropia of the observed eye, (ε) a short-observing distance, and (ζ) the use of a large concave mirror. Of these conditions, the first (α) may be secured when necessary by resorting to artificial mydriasis; the second (β) is best attained by observing with relaxed accommodation, the observer correcting the far-point of his own eye for the distance of the pupil of the observed eye by means of a suitable lens mounted behind the hole in the mirror. A short observing distance (ε) may be tried whenever the condition of the observed eye (*e.g.*, exceptionally dark pigmentation of the fundus, narrowness of the pupil from extensive synechiæ, imperfect transparency of the media, etc.) is unfavorable to good illumination of its pupil. The use of a concave mirror of large diameter (ζ) is also a possible resource in cases of exceptional difficulty.

(*d*) The rapidity of the shadow movement (other things being equal) varies inversely with the diameter of the visible circle, over which the image of the flame passes as the mirror is rotated; the smaller the visible circle, the less will be the time occupied in this passage, consequently the more rapid will be the movement of the shadow across the pupil. The darkening of the pupil occurs most quickly in myopia of the particular grade in which the far-point of the observed eye lies at the distance of the pupil of the observer's eye—Case V.; the passage of the "shadow" is progressively slower in higher grades of myopia, also in lower grades of myopia passing through emmetropia and the lower and medium grades of hypermetropia to hypermetropia of high grade.

(*e*) The form of the "shadow" is determined by the form of the image of the source of light. If this is approximately circular the shadow outline will be correspondingly curvilinear, and the shadow will have the form of a crescent. When an Argand burner is used the shadow outline appears as a somewhat ill-defined straight line (see Fig. 4269.)

When the shadow test is made with the concave mirror, the direction of the shadow movement is in every case the opposite of that observed when the plane mirror is used. But with this exception there is no essential change in the reactions. When the observer is stationed at a fixed distance, of say one metre, the concave mirror has the advantage of affording a stronger illumination; when the test is made at a shorter and varying distance, the plane mirror is to be preferred.

The complete theory of the shadow test as applied to the investigation of astigmatism is too complicated to be adequately presented in an elementary paper.

The shadow test is, on the whole, the most exact method which we possess for the objective determination of the refraction of the eye. As compared with the determination of the refraction with the ophthalmoscope by the direct method, it is both more accurate and easier of execution; and this is especially true in the higher grades of myopia, in which measurements made with the ophthalmoscope are always very unsatisfactory. In the measurement of astigmatism it has an advantage over the ophthalmometer of Javal-Schiötz, in that it reveals the total astigmatism of the eye and not merely the corneal asymmetry. On the other hand, the shadow test affords almost no information regarding the condition of the fundus of the eye under examination, and none as regards its acuteness of vision. The true value of the shadow test is therefore as supplementing, not as superseding, other methods of examination.

The technique of the shadow test is comparatively easy to acquire, and it calls for almost no special apparatus; an ophthalmoscope furnished with a concave and a plane mirror and a Rekoss disc, or a clip for holding a correcting glass, and a short tape measure graduated to fractional parts ($\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc.) of a metre, make up the list of essentials.

Carl Koller.

SHANNONDALE SPRINGS.—Jefferson County, West Virginia.

POST-OFFICE.—Charlestown. Hotel.

ACCESS.—Viâ Baltimore and Ohio or Norfolk and Western Railroad to Charlestown, thence five miles by carriage to springs.

This delightful old summer resort is situated in the bend of the Shenandoah River, at the foot of the Blue Ridge Mountains. Shannondale was formerly one of the most noted of the Virginia watering-places. The large hotel was burned during the war, and no other was built for a number of years. The present hotel has accommodations for upward of one hundred guests. It is pleasantly located and overlooks the Shenandoah River, where excellent boating and fishing may be had. The place is much frequented during the summer by visitors from Washington, Baltimore, Philadelphia, and other localities. It is highly esteemed for its fine scenery and for the beneficial character of the mineral waters. The springs are three in number. An analysis by Dr. Stewart showed the presence of two hundred and forty grains of solid ingredients to the United States gallon. They consisted chiefly of the sulphate and carbonate of calcium and the sulphate of magnesium. There is also a small proportion of the sulphate and the carbonate of iron, and an undetermined quantity of carbonic acid and sulphureted hydrogen gas. The water has laxative, diuretic, and tonic effects. It may be classed as a saline-calcic-chalybeate. There are several bath-houses at the resort.

James K. Crook.

SHARON SPRINGS.—Schoharie County, New York.

POST-OFFICE.—Sharon Springs. Hotels, boarding-houses, and cottages.

ACCESS.—Viâ Albany and Susquehanna Railroad direct to the springs; also viâ New York Central Railroad to Palatine Bridge, and thence by stage nine miles to springs.

The village of Sharon Springs is situated in a valley about eleven hundred feet above the sea-level; the streets are provided with good sidewalks, and are well shaded with maple-trees. The air is pure and bracing and free from malarial influences. Even in the warmest of summer weather the nights are cool and pleasant for sleeping. The springs are easy of access within the village limits on the edge of a natural forest abounding in pleasant walks. The surrounding country is hilly and affords interesting drives and pleasant scenery. Excellent accommodations, conformable to any taste or grade of expenditure, may be obtained in the village. Sharon is one of the well-established old resorts of New York State, its waters having been used for medicinal purposes since early in the last century. The old bathing buildings were destroyed by fire a few years ago and have been replaced by the present spacious establishment, believed to be unexcelled for its purposes anywhere in the country. There are several valuable springs at Sharon, the most important being the White Sulphur, the Magnesia, and the so-called Eye-water Spring. The waters of the White Sulphur Spring are used both internally and for bathing purposes. The water is clear and bright as it issues from the spring, of an agreeable temperature for drinking (48° F.), and free of the roughness and acerbity which so often characterize sulphur waters. It is conducted to the bath-house and heated to any desired temperature for bathing. This spring yields fourteen hundred or fifteen hundred gallons of water per hour, so that the supply is always fresh and abundant. The Magnesia Spring is also valuable for drinking purposes. The third spring is used extensively as a lotion for inflammatory conditions of the eye, which fact has led to the designation of the Eye-water Spring. A chalybeate spring is also found within the village limits. The following analyses of three of the springs were made a number of years ago:

ONE UNITED STATES GALLON CONTAINS:

Solids.	White Sulphur Spring. (Lawrence Reid.) Grains.	Gardner Magnesia Spring. (J. G. Pohll.) Grains.	Eye-water Spring. (Lawrence Reid.) Grains.
Sodium bicarbonate	......	0.54	......
Calcium bicarbonate	......	9.70	......
Magnesium bicarbonate	24.00	1.36	32.00
Calcium sulphate	85.40	93.50	77.50
Magnesium sulphate	34.00	19.68	7.50
Sodium chloride } Magnesium chloride }	2.70	{ 1.23 } { .44 }	2.50
Calcium chloride	......	.16	......
Calcium sulphide } Magnesium sulphide }	3.00	.63	......
Silica	......	.40	......
Total	149.10	127.64	119.50
Gases.	Cu. in.	Cu. in.	Cu. in.
Sulphureted hydrogen	20.50	6.00	......
Carbonic acid	......	2.22	......
Atmospheric air	......	3.00	......

The sulphur baths here have a wide reputation in the treatment of gout, rheumatism, and certain forms of paralysis. They are also serviceable in cases in which exudations are to be absorbed, *e.g.*, in old gunshot wounds, stiff joints, glandular enlargements, etc. It is said that many of the consequences of high living, such as congestion of the liver, abdominal plethora, and hemorrhoids, are quite certain to be benefited by a course of the Sharon waters. They are useful also in metallic poisoning and in ridding the system of chronic syphilitic infection, etc. The methods of employing sulphur waters at the well-known French spas, Aix-les-Bains, Challes, and Allevard, were adopted at Sharon Springs in 1884, and have been in successful operation since that time. The sulphur water of Sharon is also used commercially.

James K. Crook.

SHEBOYGAN MINERAL WELL.—Sheboygan County, Wisconsin.

POST-OFFICE.—Sheboygan. Hotels.

ACCESS.—Viâ the Ashland division and also the Fond du Lac division of the Chicago and Northwestern Railroad; also viâ steamers on Lake Michigan. The city of Sheboygan is beautifully located at the entrance of the Sheboygan River into Lake Michigan, at an elevation of about 650 feet above the level of the Atlantic Ocean. The mineral well is located in Fountain Park, and is 1,475 feet in depth. It was bored in 1875, and extends down to the granite bed-rock. Abundant water was discovered, the pressure, as indicated by the gauge, being 52.5 pounds to the square inch, or sufficient to raise a column of water to the height of 115 feet. The well was carefully tubed. The water is pure, bright, and sparkling, and entirely free from all surface contamination. The following analysis was made by Prof. Charles F. Chandler, of New York, in 1876:

One United States gallon contains (solids): Sodium chloride, gr. 306.94; potassium chloride, gr. 14.48; lithium chloride, gr. 0.11; magnesium chloride, gr. 54.91; calcium chloride, gr. 27.82; sodium bromide, gr. 0.19; calcium sulphate, gr. 16.98; calcium bicarbonate, gr. 13.66; iron bicarbonate, gr. 0.59; manganese bicarbonate, gr. 0.17; calcium phosphate, gr. 0.04; alumina, gr. 0.13; silica, gr. 0.47; organic matter, sodium iodide, baryta sulphate, and sodium biborate, traces. Total, 436.49 grains.

This water is seen to be very highly mineralized, and is closely allied to those of Kissingen and Kreutznach, in Germany. It contains, however, in addition to all the mineral constituents of those waters (except the nitrate of soda in Kissingen), traces of sulphate of baryta and biborate of soda, and a small quantity of bicarbonate of manganese. It has practically the same therapeutic properties as those waters, and is applicable to the same conditions. The most pronounced effects are laxative, diuretic, and tonic. It seems to act as a stimulant to the mucous membrane generally, and promotes the secretions. It is highly recommended as a remedy in chronic constipation. It is further applicable to a large class of morbid conditions depending upon a deranged circulation and defective secretion, such as dyspepsia, functional disturbances of the liver, hemorrhoids, anæmia and chlorosis, rheumatism, etc. The water is bottled and sold all over the country.

James K. Crook.

SHELDON SPRINGS.—Franklin County, Vermont.

POST-OFFICE.—Sheldon. Hotels.

ACCESS.—Viâ Vermont Central Railroad to St. Albans; thence viâ Missisquoi Valley Railroad to Sheldon.

Persons going to Sheldon Spring, one of the group, should buy tickets for Congress Hall Station, eight miles east of St. Albans. These springs are charmingly situated along the banks of the Missisquoi River, at an elevation of about two thousand feet above the sea-level. Within sight are Mount Mansfield and others of the Green Mountains. The springs are four in number—the "Central," within the village; the "Vermont," half a mile from the village; the "Missisquoi," one mile and a half northward; and the "Sheldon," two miles from the village. So far as I have been able to ascertain, the "Sheldon" is the only spring of which the water has been analyzed; and this analysis shows it to be very feebly mineralized. Notwithstanding this fact, the "Sheldon" water has been found to possess a very useful action in uric-acid gravel, gout, and catarrhal states of the bladder. The waters of the Missisquoi Spring are found on the market.

James K. Crook.

SHOCK. (SURGICAL.)—Shock may be defined as a condition of general vital depression or a state of general exhaustion of the nervous system coupled with a dilatation of the peripheral arterioles and a loss of the normal blood pressure.

Shock may be the result of an accidental injury, an operation, a profound emotion, or an overpowering fear. It is a condition in which the motor, sensory, and sympathetic nervous systems as well as the cerebral cortex are profoundly affected, and their action, for the time being at least, more or less arrested or destroyed.

Shock the result of an injury, an emotion, or of fear, follows very closely upon the action of its cause. When the result of an operation it may become manifest during any of its stages or only at its close. Shock may make its appearance suddenly, or it may come on gradually and be slowly progressive in character.

SYMPTOMS.—The symptoms of shock will depend upon its severity. There may be as the result of some trivial injury a slight faintness, a pallor of the face, and a feeling of nausea which pass off in a moment, or the traumatism may be so severe and so sudden that the heart's action is arrested and the patient succumbs at once. In a well-developed case of shock the patient's sensibilities are lessened and his mental faculties held more or less in abeyance. The pulse will be quickened, feeble, thready, and perhaps irregular. The respirations are increased in frequency, labored, and often irregular. The face and visible mucous membranes are pale, the eyes sunken and listless. The face, hands, and often the entire body are bedewed with a cold, clammy perspiration. The patient is usually torpid and indifferent to his surroundings, the mental faculties are depressed, and occasionally there is complete unconsciousness. The tone of the muscular system is so lessened that it is capable of only feeble contraction, the patient manifesting little disposition to move hand or foot. The sphincter muscles are at times completely relaxed. The temperature of the body may be reduced one, two, or even three degrees. Nausea and vomiting occur in many cases. In the so-called erethistic form the patients are excitable, restless, often incoherent, and even delirious.