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NEWER METHODS IN PERIMETRY AND THE CHARACTER OF STUDIES FOR WHICH THEY ARE ESPECIALLY ADAPTED*

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BEFORE taking up the subject offered for discussion, I wish to express to the Master and Council and to the members present my deep appreciation of the honour of the invitation to open the discussion and the privilege of taking part in the scientific programme of this Congress.

It is a very great pleasure indeed to meet personally so many of you whom I have known only by reputation and by your contributions to this great science, and it is equally gratifying to be permitted to discuss with you some of the problems of ophthalmology, which, though old, are young in interest.

The theme selected by the Council opens up many avenues of approach. It would not be doing justice to the subject nor would it be fair to the members of this Congress to attempt to include in a single communication all the interesting paths which we might follow. It was suggested, therefore, that I limit my remarks to "Newer Methods" and the particular types of cases for which they are especially adapted.

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During the course of the discussion it is not unlikely that some of you may feel disinclined to accept without reservation some of the views which may be presented touching upon certain phases of the subject. They are, however, the result of honest convictions arrived at, not hastily, but only after due thought for some years past in private and hospital practice and in the class room. If any opinion expressed seems to be lacking in a truly orthodox ring, may I ask that you withhold final judgment until you have put it to a practical test and have fully satisfied yourselves that it is or is not tenable. The fact that we may not all agree should not deter us from the freest expression of opinion, as only by such frank interchange of thought and experiences can we hope to make progress.

It will be well at the outset to distinguish clearly between what may be called laboratory methods, such, for example, as are practised by physicists in establishing varying degrees of retinal sensitivity to form and colour stimuli, and practical methods such as may be used in routine office practice to determine the presence or absence of a pathological process and the approximate extent of such process. It is the latter group of procedures which we have in mind in this discussion. Were it not for the time element and the technicalities involved in laboratory methods, it would be ideal to apply these accurate tests to our clinical investigations. Our nearest approach to accuracy can only be reached by adopting, so far as possible, laboratory procedures modified so as to bring them within the practice of the average ophthalmologist. For example, by special light control and the use of spectral colours¹, yellow, blue, and red are recognized as far in the periphery as form. It is not possible to obtain such correct scientific standards, however, in the average office, much as it is desirable, and we are therefore obliged to accept as our standards the colour limitations which have long been recognized.

In a communication before the Ophthalmological Society of the United Kingdom in 1905², Mr. Sinclair quoted from Helmholtz the following: "The entire field corresponds to a drawing, in which the important feature is carefully executed in detail, while the other parts are roughly sketched in, and the more roughly the further they lie from the important feature." Along with our increasing knowledge of perimetry has come a realization of the importance of a study of the special feature and this special feature for the most part is found in the central zone. The silhouette of the field, although valuable in so far as it goes, gives little intimation of the individual characteristics or defects which the preserved field may possess. The classical perimeter, in principle scientifically constructed, and practical in delimiting the outlines of a given field, fails utterly in the important work of studying changes peculiar to the central zone. In order to make these studies, one is obliged to

select an instrument more elastic in operation and more delicate and pliable in manipulation than the conventional and clumsy perimeter in its present form.

The von Graefe³ and de Wecker⁴ tangent screen has furnished us with the principle, the adaptation of which has entered into the construction of modern instruments. As the value of the principle of the stereoscope is indicated by the great number of modifications which the original stereoscope has undergone, so the value of the tangent screen is reflected in the great number of modifications of the original tangent plane, which make up our modern equipment. Each modification possesses a peculiar adaptability for the study of a specific type of case, and this specialization, as it were, has also narrowed the scope of work for which it is adapted. This is well illustrated in the stereo-campimetric slate of Lloyd, of which we will have occasion to speak later. The tangent plane is now the instrument of choice in all central field studies.

That an element of error* may creep into the findings between the twenty and forty degree area is admitted if a movable stimulus is employed. This error, however, is so small that it becomes negligible, particularly in the type of plane which now is in more common use.

One of the most marked advancements made in the tangent plane is its use in certain studies at close range. For rapid, practical and routine work this is a decided improvement, and balancing up the advantages gained thereby and the disadvantages, it marks a step in the right direction.

I am not sure that we can entirely ignore the claims of those who feel that perimetry requires too much time. Having in mind this objection, by shortening the working distance of the campimeter, I have been enabled to evolve a practical working hand campimeter,⁸ which admits of speedy and accurate operation not only in studies of the central zone but also of a large part of the peripheral field. In addition to shortening the working distance, the average normal blind spot of Mariotte has been definitely placed and outlined on the screen, so that the blind spot may be studied with ease. In fact, it is my custom to begin the study of the field by outlining the normal blind spot. There is a double advantage in this procedure. First, one makes a routine habit of measuring the blind spot, and thereby develops very helpful information in unsuspected cases of its enlargement. A second advantage lies in the training which the patient receives in

* The defects of the campimeter are well known. For a more detailed study of the comparative value of the perimeter and campimeter the reader is referred to the author's text-book, "The Principles and Practice of Perimetry"⁵, to "Campimeter versus Arc Perimeter"⁶, and to "The Value and Limitations of Perimetric Methods of Study"⁷.

concentration. In my experience, holding the patient's attention is one of the difficulties in perimetry; at the same time it is the *sine qua non* of field taking. I am partial to this hand campimeter for a major portion of routine field studies, not because it is an instrument of my own designing *per se*, but because it is the product of a long series of studies leading to the construction of a campimeter with the widest range of applicability consistent with accurate results, ease of operation and with the fewest disadvantages—in other words, a practical routine instrument. That it has accomplished its mission far beyond expectations is evinced by the large number now in use in the United States. In the hands of those who have given it a fair test and have acquired its technique, it has practically displaced the perimeter, the latter instrument being reserved for the few cases in which nearly normal fields must be taken. It is hardly within the scope of this paper to dilate on its merits further than to point out its especial adaptability to certain phases of study. In fact, it needs no defence in its radical shifting of the distance at which studies are made as the practical results yielded furnish the most convincing of arguments.

A type of plane similar to the hand campimeter, but operated at a distance of sixty centimetres, has been constructed by Gradle, of Chicago.⁹ There is much to commend in Gradle's instrument. A second point of fixation is interposed midway between the patient's eye and fixation point on the board. This holds the patient's attention and insures more uniform alignment. As on the hand campimeter, the average normal blind spot is marked out so that enlargements are easily recognized. The principal point of excellence lies in the method of presenting the stimulus to the patient's eye. The test objects consist of metal balls of definite sizes, which are moved on the tangent surface by a magnet from behind the screen and only the small ball is visible to the patient. This, however, is purely a laboratory instrument, as the author himself states, "the instrument is too technical for general adoption in routine office practice."

The Bjerrum method of study at long range, two metres from the board, with minute test object, has not grown into favour, at least in the United States, except for special studies. These larger types are especially adapted to the study of the tubular field, to the outlining of small scotomata which elude accurate study at close range, to an analytic study of the blind spot of Mariotte in accessory sinus disease, in glaucoma, etc., *at a one metre radius* and to the plotting of the light field in mature cataract.

Possibly the greatest progress in our modern methods within a limited range of applicability is the evolution of the original stereoscopic method of study by means of Haitz's charts, to the

large angled stereoscopic slate of Lloyd, of Brooklyn.¹⁰ The wide angled stereoscope has made it possible to include for study an area extending about twelve degrees to the nasal side, twenty-five degrees down, twenty-five degrees above the fixation point, and thirty degrees to the temporal side. Within these limits, and with central vision preserved in one eye to insure perfect fixation, no instrument at our command offers so much in accuracy of study and ease of operation. Even though the radius is but 205 millimetres, the outlining of a scotoma and of the blind spot of Mariotte is accomplished accurately and more expeditiously than with any of the larger types of tangent screens.

A discussion of newer methods before this Congress would not be complete were we to omit the scotometer which Col. Elliot has devised.¹¹ As this is a frank expression of a personal opinion, Col. Elliot will doubtless pardon any adverse criticism of his instrument if the criticism is given in order to get at the truth.

The screen for the most part is an excellent one, and if great care is exercised in its operation, accurate results can be obtained. For reasons which will appear later in this communication, the test objects might advantageously be enlarged. The objection which I regard as quite important, but which may be removed by very deliberate and careful manipulation of the instrument, is its *inelasticity*. It is the same objection which must necessarily be raised against the perimeter or any automatic scotometer in which the test object is mechanically moved along a fixed line either circumferentially or radially. Any such device, if care is not exercised, may lead to artefacts and findings far from the truth. One of the greatest difficulties which the student encounters is to outline an irregular defect. He persistently develops sharp angles which rarely exist, and misses indentations which may be present. This is largely the result of moving the test object mechanically, as it were, in a groove. Only when the test object is carried over a tangent surface by hand, or by such device as Gradle employs, or by great care with the Elliot scotometer, will a real angular defect be reproduced true to nature.

The essential principle upon which the newer methods of study are based is *flexibility*. In the operation of the perimeter one is constantly conscious of working in a groove, and feels the need of greater freedom of manipulation of the test object. The tangent plane admits of this freedom and, therefore, has been accepted as a distinct improvement over mechanical devices which operate in set grooves and channels. While mechanical scotometers overcome some of the marked defects of the perimeter, they tend to neutralize the chief advantage which the campimeter possesses, namely, *elasticity*. If we divest the campimeter of this attribute, from a clinical standpoint, there is little in it to commend, and the

perimeter may as well be reinstated into popular favour. Were we, however, to choose between a radial or circumferential mechanical movement, we would undoubtedly choose the latter.

It is not possible in so brief a paper, nor is it germane to the subject, to refer to all the perimeters and tangent planes which have been contributed on this and the other side of the Atlantic. It is necessary to confine our discussion to principles and to newer methods and instruments which offer some modification of established principles and customs. In passing, however, it is interesting to note that in the *Transactions of the Ophthalmological Society of the United Kingdom* for 1918 no fewer than eight varieties of perimeters and campimeters were reported among the Museum specimens.

Before taking up the special adaptability of these newer methods to specific types of field studies, two particular phases of the subject need further elaboration, namely, the distance of the eye from the tangent plane and certain phases of the test object. Between the Bjerrum method of study with minute objects at long range, and the author's hand campimeter or Schweigger's hand perimeter at close range, there is considerable difference on first thought. To reconcile the two methods it will be necessary to weigh the evidence for and against in each instance.

To the examination at close range the following objections are raised: First, the test object, even though small, stimulates a larger number of perceptive end organs and, therefore, is not so analytic as when the same test object is used at a greater distance. Second, in presbyopes and hypermetropes vision is not accurate at close range. Third, an error at this distance is proportionately greater than when studies are made at a longer distance.

The first objection is hardly valid since in any central study one chooses the smallest object that can be clearly seen. At one metre distance a test object one millimetre in diameter is an unsatisfactory stimulus for anything but white at twelve centimetres beyond the fixation mark. If there is doubt in the mind of anyone as to the correctness of this statement, he can easily verify it by attempting to make reproducible colour or even form studies under these conditions. Furthermore, if the assumption is correct that one of the chief functions of the peripheral retina is the recognition of moving objects as well as objects at rest, it is not essential that a test object should be so small as to stimulate only one rod or cone. As a matter of fact, it is hardly possible in the peri-macular region to use a test object so small as to stimulate but one end organ. As the peripheral zone is poorly supplied with rods and cones, and the stimulus becomes less well-defined in the extreme periphery, a moving stimulus is logically the proper test object to employ in order to determine peripheral sensitivity. To overcome this

falling off in peripheral sensitivity, the intensity of the stimulus should be increased or the size of the test object should be enlarged. In lieu of these measures a slight movement imparted to the test object tends in a measure to better peripheral stimulation. There is nothing gained, therefore, by a minute test object unless one is making careful laboratory quantitative studies of the peripheral retina. (Since writing this paper I noted in re-reading the chapter on Perimetry by H. Wilbrand¹², in Norris and Oliver, that Wilbrand calls attention to the value of this method and quotes Aubert to the same effect.)

The second objection is equally without foundation since suitable glasses can and should be worn for central studies if vision is defective. A presbyopic correction may be worn with advantage. The same objection may be raised in testing a myopic patient on a screen or perimeter of long radius. One cannot hope to work at all times under ideal conditions when the subject cannot be selected as in physiological studies, but a pathological clientèle with normal and abnormal refractive conditions are presented for investigation. It is essential that we meet conditions as we find them in practice and that ametropia shall receive due consideration before field studies are attempted. If it is not possible or feasible to correct such errors, the tangent plane with a radius suitable for the patient should be selected.

The third objection has an element of truth in it. An error is proportionately greater as the radius of examination is shortened. Care, however, can overcome this.

The great advantage at close range is the sharp definition which the patient is able to make. Variations in the colour tones are definitely and promptly recognized as full saturation of colour is approached. Purity of colour depends directly upon the intensity of the illumination. As it is also influenced by the distance of the eye from the illuminated surface, it is absolutely essential that the angle of the colour stimulus be sufficiently large to excite colour vision, and this is brought about either by increasing the size of the stimulus or by shortening the radius of the arc. In laboratory studies it is accomplished by increasing the intensity of the illumination.

A second great advantage at close range is the ease with which concentration on the point of fixation can be maintained by the patient. To appreciate fully the second fact, one must have practised and be familiar with both methods.

It is well to bear in mind that binocular fixation should be employed at all times when feasible as it insures better and more comfortable fixation. This applies especially to blind spot studies, and can easily be executed on any tangent plane by holding a piece of cardboard in place between the eyes.

The difficulties encountered in testing out a patient by small objects at long range are, first, the inability to secure constant and *reproducible* results. If the patient is fairly intelligent, approximately uniform answers may be obtained, providing a white test object is used, and this sufficiently large. The element of fatigue necessarily contributes to this uncertainty when the test object employed subtends too small an angle, such, for example, as is recommended by the Bjerrum method of a two-metre radius. In the second place, as the threshold for colours is a variable quantity depending upon individual sensibility and variability in the illumination, etc., when the third factor is added, namely, *pathology*, the uncertainty of the point where a colour is distinctly recognized, is increased. This uncertainty is augmented by moving the patient farther from the board, and diminished either by bringing the eye closer to the tangent surface or by increasing the diameter of the test object. In my experience, bringing the eye closer to the screen offers the best results in the greatest number of cases, because it increases the intensity of the stimulus, and enlarges the angle which the stimulus subtends. In this connection it is interesting to note that Ferree and Rand, in their important studies of retinal sensitivity, in the Physiologic Laboratories at Bryn Mawr College, used a tangent plane which they designated as a rotary campimeter, and that most of these studies were made at a radius of twenty-five centimetres^{13,14}. The advantage of working at a metre distance is that a careful analysis can be made of a defect which has been uncovered by routine methods. It admits of more minute study of a small or large scotoma, provided the test object used subtends the same angle as that which is employed on a plane of a shorter radius. This advantage, however, is only obtained when the radius is not over one metre, and the size of the test object is uniformly maintained.

Briefly, therefore, the short plane is best adapted for routine studies because it accomplishes its purpose expeditiously and with fair accuracy. The plane of a one metre radius admits of more careful analysis of the "important feature" referred to by Helmholtz.

The test object.—Newer ideas in reference to the stimulus can best be studied under the following headings:

- a. Nomenclature.
- b. The size of the stimulus.
- c. Method of exposing the test object to the eye especially in the peripheral field.
- d. Direction in which the test object should be moved.
- e. Fixed stimulus.
- a. The manner of designating the size of the stimulus needs special consideration. The size of the test object used in the past was

designated as a rule in millimetres.¹⁵ In view of the great number of perimeters and campimeters with varying radii now in use, linear measure is inappropriate because we are dealing with angles, and unsatisfactory because the angles which the same test object will subtend must vary with the length of the radius. For example, to say that a five millimetre test object was used in developing a certain field means really nothing definite unless the radius of the instrument is given; and if one is accustomed to operate on a perimeter or campimeter of a longer or shorter radius, the designating of the test object in millimetres is confusing. To speak of the size of the stimulus in degrees or minutes, therefore, is in the interests of uniformity and has done much to simplify what has been rather vague and indefinite in the past. Changes of this kind require time to inaugurate thoroughly, but it is one of the newer methods which undoubtedly will and should replace the old.*

b. The size of the test object.—Little has appeared in literature¹⁶ of a definite character as to the exact size of the test object. It has generally been understood that an object five millimetres in diameter was considered as a standard for measurements on a perimeter of 330 millimetre radius. On the Bjerrum screen a test object as small as one and two millimetres was recommended. Reference has already been made to the objections to so small an object for satisfactory work. In certain individual cases the size of the object will be determined by the state of vision. When visual acuity is much reduced, the test object to be used should subtend the smallest angle compatible with clear vision. For general use we can be more specific. Within the twenty degree circle, a one-half degree or thirty minute test object is the smallest stimulus which will yield uniform, and, therefore, satisfactory results. At one metre this test object will measure 8.75 mm. in diameter. On the author's hand campimeter it will measure 1.5 mm. and on the average perimeter of a thirty-three centimetre radius, approximately 3 mm. For colour studies even this is too small and a one degree object is more satisfactory. For peripheral retinal studies a two degree test object should be our standard. It is well known, of course, that an increase in the size of the test object tends to a larger field, or to put it in a way which is nearer to the truth, diminishing the size of the stimulus tends to contract the field. This is especially true if the test object is smaller than one degree. For routine studies, therefore, it is important to have a fair and reasonable standard and for peripheral retinal sensitivity, it is my belief that two degrees is a safe limit as this will apply to colours as well as to form. It is not fair to apply

* The size of the test object has been expressed in degrees in a number of instances recorded in literature, but no one, so far as I have been able to discover, has ever insisted that it should be uniformly so expressed.

central visual acuity tests to peripheral vision. According to Dor,¹⁷ a point five degrees excentric to the fovea has but one-fourth the visual acuity of the fovea; at twenty degrees it is but a fortieth, and at forty degrees the acuity is one one-hundred-and-twentieth of that of the fovea. If fifty to seventy seconds is the angle usually required for definite special perception, a stimulus considerably larger should be employed for peripheral stimulation. Studies by Ferree and Rand¹ led these investigators to the conclusion that chromatic sensitivity of the retina fell off moderately up to a given point and then very abruptly, so that a great increase in the intensity was necessary to register any perception of colour. It is essential, therefore, that the stimulus employed be of sufficient size to make the testing of the peripheral field of some value. Although it will be impossible, perhaps, to obtain laboratory accuracy, an average field for each colour can be established by means of the attempts at the standardization proposed. The use of a uniform size in the stimulus for peripheral studies will furnish one step in the direction of standardization. A stimulus of two degrees should be the minimum angle subtended.

c. While discussing the test object, it is opportune to speak of the *technique of exposing the stimulus to the eye*, a point which is rarely dwelt upon. A special function of the peripheral retina is the detection of moving objects as well as response to stationary stimuli. It is my custom, therefore, to approach from beyond the field of vision to the most peripheral visual point in a deliberate manner, imparting a slight vibratory movement to the stimulus. This furnishes the sort of stimulus from which the peripheral retina is physiologically best adapted to receive impressions.¹² It is, however, impracticable on any mechanically operating perimeter or campimeter and can only be practised when the test object is in the dexterous hand of the operator. The detection of a moving object is not the only function of the peripheral retina. It is, however, a most important one, and, according to Spiller¹⁸ and Riddoch¹⁹, probably one of its primitive functions. According to the same authorities, it is the last function to disappear and the first to reappear in atrophic or nutritional disturbances. At all events, it is a most important function, and it undoubtedly marks the extreme boundary of vision. When the question of minute peripheral loss is under consideration, routine studies can be supplemented by quantitative tests in which the periphery is studied by test objects varied in size or more correctly by the physiological method of varying the intensity of the stimulus. The vibration of the test object is of exceptional value in obtaining satisfactory results in illiterate patients, in much contracted fields and, in general, helps to reduce the time of "field taking." Movement of the test object is not necessary nor advisable in a great number

of cases, but those of you who have practised "field taking" routinely will appreciate the advantage of this method in a certain number of difficult cases.

d. What perhaps is not new, but about which our newer ideas are very definite and possibly dogmatic, is the manner of approach to the visual line, whether to pass the object from visible to invisible or the reverse. In my own studies and in my class room, the test object is always passed from a blind area to a functioning part of the retina. This is observed not only in the periphery but in the blind spot of Mariotte and in other scotomata. If I may be permitted again to refer to Col. Elliot's scotometer, and the very remarkable irregularities which the instrument develops, it has occurred to me that the irregularities may in a measure be due to the fact that certain parts of the outline are developed by passing the object from functioning to blind retina and other points from blind to functioning retina. The desire of the average patient to help and please and make a good showing is encouraged by passing from a visible to an invisible point in the field. It rarely is dependable. Fixation is less apt to wander when the image is passed from invisible to visible. It is my belief that a blind spot should be developed from within the blind area outward and the peripheral field from without towards the centre of fixation. It is hardly necessary to say that in outlining the blind spot of Mariotte, or any central scotoma, the object should be passed back and forth in both directions until the boundary is definitely fixed. This is particularly necessary in outlining that part of the scotoma which is most remote from the point of fixation.

e. A fixed stimulus.—A method which has been followed with excellent results in physiological studies of peripheral retinal sensitivity is that of fixing the test object and having the patient rotate the eye—a movable fixing point. This method is employed in order to use spectral colours and standard illumination. In the Bryn Mawr College Physiologic Laboratories, Drs. Ferree and Rand have done most excellent work in physiological investigation by means of this method.²⁰ Doubtless other physicists follow the same routine. It requires a rather difficult *technique* for adoption in routine office practice, much as it would be desirable to practise perimetry with spectral colours and uniform illumination. For pre-exposure and surrounding field, which Drs. Ferree and Rand insist are important factors in peripheral retinal studies, it is well adapted. It is, however, too distinctly a laboratory procedure to be adopted in routine office practice.

What can be said in favour of the most recent types of automatic perimeters, equipped with test objects of coloured glass through which light is transmitted? Like most of the so-called improvements of the perimeter, which really possess no merit other than

as time saving devices, this form of illumination has added nothing of value. It opens up an avenue of discussion which would lead us too far from our theme. It is sufficient to say that this form of illumination adds but another serious defect and complicates rather than simplifies our efforts at standardization. If the perimeter is to be used at all, best and most accurate results will be obtained by using it in its simplest form, namely, the original Förster model without the sliding carriage but with hand manipulated test objects adapted to its radial length. These objects should be similar in form to those used on the Lloyd slate, or the test objects as suggested by Ferree in his new model exhibited before the American Ophthalmological Society, June 15-16, 1920.²¹

In view of the excellent work done by physicists and especially by Drs. Ferree and Rand in physiological studies of the blind spot, of relative retinal sensitivity and light standardization, a few moments should be spent in summing up what seems to be suitable for our adoption in the methods which they employ.

First, *Illumination*.—The contributions of Ferree and Rand to illumination in perimetry,^{21 22} are noteworthy. To the perimeter a "daylite" lamp unit has been added which distributes a band of uniform light in one meridian and as this lamp moves with the arm of the perimeter, the examination is conducted at all times under fairly uniform conditions. They have, therefore, reduced to a practicality a method of illuminating the perimeter which can be practised wherever electricity can be obtained. This contribution to the perimeter has enhanced its value in peripheral studies. This same "daylite" unit has been used in the author's office for illuminating the campimeter for several years past. While the illumination of the flat surface is perhaps not so uniform as the Ferree-Rand method on the perimeter, it is sufficiently accurate for all practical purposes.²³

Second, *Spectral colours*.—It is not possible to use spectral colours excepting in well equipped laboratories. The adoption of mixed pigments expressed as nearly as possible in definite wave lengths, is the nearest approach to spectral colour test objects suitable for our work.*

Third, *Fixed stimulus*.—A fixed stimulus is peculiar in that it reverses the order of investigation to which we are accustomed. For the outlining of the entire peripheral field it is not practical, neither can it be readily applied for the studying of a scotoma in the central field. Because of the limitations in ocular rotations, the head must be moved in order to be able to reach, for example, a 90° point of excentricity. To work in all necessary meridians would be too time consuming and intricate for routine work. In order

* For a more detailed suggestion as to standardization of the colours, the reader is referred to the author's "Uniformity in the Essentials of Perimetry."¹⁵

however, to determine light sense for any given point in the retina by accurate photometric measurements, it may have a field of usefulness in well equipped offices.

Fourth, *Pre-exposure and surrounding field*. More stress is laid by Ferree and Rand on pre-exposure than on surrounding field. They are the first²¹ so far as I know,* to endeavour to bring these most essential principles within the practice of busy ophthalmologists. In the suggestions offered by them to improve the value of the perimeter or to reduce its peripheral field work to greater accuracy, they have suggested a plan by which surrounding field is controlled and the retina involved in study may be properly pre-exposed. For a detailed description of this perimeter the reader is referred to the *Transactions of the American Ophthalmological Society*, 1920. To one who approaches the subject from a clinical standpoint with a full knowledge of our peculiar needs and difficulties, the principle involved strongly appeals, but the special method of applying it to the perimeter does not appeal. It possibly may be the best solution of a difficult problem, but from a practical standpoint it seems to burden the perimeter unnecessarily rather than simplify it.†

However, if the claims of these investigators²² are correct that an error in the peripheral field of as much as twenty degrees can be eliminated by proper pre-exposure, it should appeal to us as worthy of incorporation, if possible, in our methods of study, even at the expense of time. It is more than likely that a little further study along this line may evolve a more readily applied technique.

Experiments.—The effects of pre-exposure on the results is due to the after image. A dark pre-exposure produces a light after image, while a light pre-exposure causes a dark after image. If the retina, therefore, is pre-exposed to a gray of the brightness of the

* They were the first also^{20, 22} to demonstrate clearly the effect on the normal field in physiological studies, when proper pre-exposures are made and the surrounding field is of the brightness of the test object.

† The author has called attention in detail in several papers^{6, 7} to defects in the perimeter. In addition to poor illumination, the test object is decidedly objectionable because it is usually counter sunk in a carrier of considerable size whose movements back and forth attract the patient's attention and prevent proper concentration on the test object. This is a real disadvantage when testing the average patient. The object carrier suggested by Ferree is very much larger and will be even more disturbing than that found on the ordinary perimeter.

As the proposed perimeter will necessarily become a commercial product it is exceedingly doubtful whether the proper standards as outlined by Ferree and Rand will even be approximately maintained. Zentmayer in his report before the American Ophthalmological Society, 1919,²⁴ on standardization of the colours used in perimetry, found that there was no uniformity in the pigment papers employed. If it is difficult to obtain uniformity in a matter so small as this, how much less likely will it be to obtain even an approximate uniformity in the proper selection of the grays required for each test object used. It would seem, therefore, that although pre-exposure and surrounding field are of sufficient importance to command our careful consideration, their practical application to every day perimetry is far from being an accomplished fact.

colour stimulus used, the results obtained must necessarily be more accurate than by our present system. The surrounding field should likewise be of the brightness of the stimulus to prevent contrast or mixing of colour.

There are many details to be worked out before laboratory methods can be so modified as to suit our purposes. One need not assume the rôle of a prophet, however, to forecast the important changes which may be incorporated in future methods of clinical study. They are:—(1) Perimetry will be largely practised on a tangent plane. (2) Light standardization will be a *sine qua non*. (3) The peripheral and the central field will be studied by a movable stimulus. (4) The stimulus will be moved by hand and not by an automatic device. (5) Pre-exposure and surrounding field will be equal to the brightness of the stimulus employed. (6) Light standardization, with photometric measurements made possible, will enable us to determine threshold values in disease, for any particular point in the field, and particularly in the central zone, which will help us to detect disease with greater accuracy in its incipency, and at a time when therapeutic measures may be of real value.

While these changes will necessarily increase the amount of time required to study our cases, the advantage of being able to determine definitely the earliest evidence of disease, which our present methods frequently fail to uncover, will justify the time spent, and will relegate our so-called routine methods into the keeping of those who find perimetry requires too much time to practise.

Blind spot studies.—The methods employed in the study of Mariotte's blind spot are practically those which have been in use for some years past. In the matter of record, and for the purpose of reproducing and thereby verifying abnormal shapes and sizes of normal and abnormal blind spots, the following plan will lead to a better correlation of the changes which may be found.

1. Studies should be made on a tangent plane of a one metre radius.
2. The test object should subtend an angle of thirty minutes if central vision is approximately normal, about 6/6.
3. The illumination should be standard artificial daylight.
4. Care should be observed that the test object is moved back and forth from invisible to visible and *vice versa* until the boundary is definitely fixed. The points of examination should be close enough to eliminate any artefacts in the shape of sharp angles if they do not exist.
5. Findings should be verified and reproduced by the same or several investigators to be perfectly sure that the findings are correct.
6. When verified as correct they should be preserved in their original size and shapes by cutting out of paper, the same to be filed with the records of the case.

There has been so much diversity in the reports of the shapes of so-called normal blind spots that a plan, such as the one proposed and which the author has put into practice, will give us more accurate information than we have at present. It would be very interesting indeed to gather a collection of normal blind spots studied as outlined above by many investigators. In such a study reproduction is the essential element, and only those which can be verified several times should be regarded as suitable to be reported.

In the second part of our discussion, as we are dealing with principles and not with specific or individual cases, we can speak only in a general way of the types of study for which each method referred to has a special adaptability, and yields most accurate results, with consideration at the same time of the facility with which the examination can be made.

It is probably safe to say that the arc perimeter is best adapted to the outlining of normal or nearly normal form and colour fields. In my experience it has no other function in perimetry for which it is adapted. It is also my belief that a large part of this work can with equal facility be accomplished on some form of tangent screen. With this opinion many may have occasion to disagree. It is not gracious to disturb long accepted and prevalent beliefs, but, in the interests of progress, it is sometimes demanded. The above conclusion is the result of an honest conviction that the perimeter has been made to serve a purpose for which it is mechanically unsuited and that its misuse has brought to the front and developed the possibilities of the tangent screen which demands our careful consideration. We are prone to follow established lines of cleavage even though they may lead us to a fault, and it requires courage to approach by a more direct route. As the diamond drill now opens the treasures of the earth by a bold but direct path and has rendered older and slower methods of approach almost obsolete, so we, as physicians, should be ready to repudiate—if necessary—time-worn methods and traditions when they are shown to be fallacious, even though they served well their purpose in the past. The perimeter has a field in routine office studies, but in its present form a very limited one.

Routine studies of Mariotte's blind spot are most advantageously made on the hand campimeter at close range or on the stereo-campimeter, in either instance by means of binocular fixation when possible. The latter instrument is ideally adapted for this study as it is most accurate and fixation is easily obtained. In the absence of a stereo-campimeter, the hand campimeter is a very good substitute. The large tangent plane of a one metre radius may be employed in very slight enlargements, as the blind area is relatively increased thereby and may admit of easier study, and it should be employed in any analytic study of the blind spot. Some, indeed,

may prefer to use the large tangent screen at all times. It does the work well at a one metre radius within thirty degrees of the fixation point, but consumes more time than the smaller types. At a distance greater than one metre it is unsatisfactory. This is particularly true of colours and is due to the fact, as already pointed out, that the test object is too small at so great a distance to obtain full saturation of colours. The element of fatigue also enters as a factor.

Central field study, included within the forty degree circle, is the special function of one of the various types of the tangent screen. In this investigation the greatest freedom of approaching the defect is demanded. Which type of tangent plane to select is not wholly one of individual preference, although that is a determining factor. The extent of the scotoma, the inclusion or exclusion of the macular area in the defect, and the unilateral or bilateral involvement of the macula are phases which definitely decide the choice of the plane. Any or all of these changes can readily be made on the hand campimeter or on a plane with a radial distance from the eye of not more than thirty-three centimetres. The reasons for this limitation in distance will become apparent later.

To group them, however, to the best advantage for study the following is the classification which has given the author the most satisfactory results.

1. Any defect of the central field when the macula is intact and fixation is possible should be studied on some form of tangent plane. The character of the plane may be determined in part by the individual preference of the operator.

2. Paracentral defects which do not exceed in extent the range of the stereo-campimetric slate of Lloyd are best studied on this plane.

3. All unilateral defects within these same limits, if the fellow eye is normal, or at least able to fix, and the muscle balance is approximately normal, should also be studied on the stereo-campimeter.

4. Central and paracentral studies which require a larger field than that offered by Lloyd's stereo-campimetric slate should be made on the hand campimeter, or a tangent screen of not more than thirty-three centimetre radius. This rule should be followed regardless of the size of the scotomata, if both maculae are included in the scotomatous areas, if the muscle balance is bad, or if fixation in the opposite eye is not possible because of visual disturbance.

5. For a careful analysis of the "important feature" so aptly referred to by Helmholtz, the Bjerrum screen at a one metre radius and with test objects, which subtend an angle of from thirty minutes to two degrees, is the instrument of choice.

When one eye is totally blind, squint or muscle imbalance of a marked degree is present, or when both maculae are involved and stereoscopic vision is not possible, "field taking" requires a special

technique. Under these conditions several methods have been proposed. Two only of these methods have seemed to me to be practical. The first is to make use of the patient's muscle sense in the following manner. The index finger of the patient's right hand is placed on the fixation point and the patient is instructed to look at the end of his finger. This can be done with much accuracy and with little wandering of the eye by the most illiterate patient, providing muscle sense has not been lost. In order to do this comfortably the distance of the campimeter from the eye should not be over thirty-three centimetres—a convenient reach for the average arm. One can proceed in this manner to outline a central scotoma with fair accuracy. The accompanying charts illustrate well the practicality of the method, as that taken on the campimeter by this method compares well with the one studied on the stereoscopic slate. If muscle sense is lost, as it often is in tabes, the method is impracticable and another may be substituted.

This second method is a modification of the one which the late Wendell Reber practised. Reber drew a cross in crayon on the blackboard and connected the ends by a curved line. The patient was instructed to look at the circle, and the central part of the cross was erased until only the peripheral ends were visible. With these four points as a fixation for the eye, the test object was passed back and forth between the points and the blind area was definitely determined. This method, of course, admits of error, as the gaze may be directed too far in any one direction. It, however, offers a fairly satisfactory solution of a difficult proposition.

The following method is suggested in order to reduce the percentage of error to a minimum. The patient is seated at a perimeter, the point of fixation being, of course, invisible. He is now instructed to look along the horizontal plane of the perimeter until the fixation point becomes visible. With the eye in this position the lamp of a luminous ophthalmoscope is now moved along the arm of the perimeter until the corneal reflex of the light rests in the pupillary centre and the degree is noted on the perimeter. (This method is similar to that of measuring the angle of squint on a perimeter.) If the right eye, for example, were moved to the right fifteen degrees, the nasal limit of the scotoma would be fifteen degrees to the nasal side of the fixation point. These measurements are taken in the four cardinal directions of the eye. Four white markers are now placed on the campimeter as determined by the luminous points on the perimeter and the definite outline of the scotoma can be obtained with little chance for error. The four points now used for fixation are accurately located, and the scotoma can be definitely outlined and the peripheral field may be studied as well. This perhaps is painstaking but accurate.

Fixation in bilateral central scotoma, I have no doubt, has caused each one of you much thought and worry, and if anyone has a simpler and less arduous method to propose in these troublesome cases, we will all be indebted to the gentleman who will furnish it. Many suggestions have been made, including those of Hess, Walker, and others, but unfortunately they are not practical for routine office use.

What might have served as an appropriate introduction will apply equally well in closing. The title of the paper in a way is misleading. Modern methods are not new. They are simply an adaptation of old principles to more recent conceptions—a choice in other words of specific instruments for particular tasks. What really is new is a developing consciousness in the profession that perimetry is an essential part of ophthalmology to be employed in the daily routine of office practice, and not simply an interesting bit of investigation to be practised in one's leisure moments.

Like photography, perimetry has passed from the shadow or silhouette phase to one of topography—from a study of outlines and boundaries to feature studies. This has necessitated a change in methods and a higher specialization of instruments. How much we have gained in knowledge of many obscure conditions by methods of careful analysis is well illustrated in glaucoma. Rönne's steps, Bjerrum's sign, and the colour changes beautifully differentiate between the ascending atrophy in glaucoma and the descending type of primary optic atrophy. This is but one of the refinements made possible by modern campimetry.

In short, newer methods in perimetry consist in the choice of the right instrument for a definite task, feature studies of the central zone as well as tracing the boundary, and the use of the tangent plane as the instrument of choice with the perimeter as a necessary adjunct.

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A FEW NOTES REGARDING THE DETERMINATION OF THE LIMITS OF THE VISUAL FIELD*

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THE method indicated by Bjerrum in 1889 of determining the limits of and defects in the visual field is rightly used in cases where the object is to trace the more delicate workings of the retina.

The principles indicated by him have been further worked out by his pupils, particularly by Rönne in Copenhagen, and subjected to wide practical tests. Shortly after the publication, oculists, especially in England, adopted this method, as witness the number of apparatus constructed there for the accurate definition of the visual field and scotomata, and the introduction of a quantitative method of accurately arriving at this definition (Traquair).

(1) The fixation point.

Nowadays, the black curtain and the white and coloured discs of different sizes, belong to the usual outfit of every oculist. Still there are some drawbacks connected with this so widely adopted method, which in the determination of the visual field play a certain rôle. This matter demands a great amount of attention on the part of the examiner as well as that of the patient, and of the latter also a power of endurance demanding much of his often already reduced will power. It is, therefore, necessary to remove as far as possible everything which can divert the patient's attention,

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