I am not in sympathy with the views of Colonel Banister and Major Shaw in that it is not necessary to have a clear vision of the target. I have talked with many expert shots of the service, and they are all of the opinion that one must have a clear view of the target.

The experiments conducted by these officers were with men who were good shots and, almost by intuition, due to their experience, they made nearly as good scores when their vision was reduced. It is doubtful if a man with defective vision can ever become an expert marksman. Focusing on the target is essential. This is illustrated in trap shooting—the man does not see his sights, but he does have a clear view of his target.

DR. ARTHUR G. BENNETT, Buffalo, N. Y.: I have had experience in fitting distinguishing marksmen, because near Buffalo there is a rifle range where the experts go for their competition. My experience with them has been that their shooting falls down about the age of presbyopia. I had a shooting contest with a friend, who was myopic; his best vision was 20/100. He shot without glasses, but he had a good view of the rear sight, which I did not have. His myopia was of the simple form that gave a blurred image of the target, but it was increased in size, and he could estimate it closer than I. With that theory in view, I fitted a number of marksmen at Niagara with a focus a few inches beyond the rear sight, and their testimony is that their shooting has come up to the standard that it was before they obtained the glasses. They are satisfied and have referred patients to me from different parts of the United States, and with them I have followed out the same plan with a good deal of success. The focus is about 3 inches in front of the rear sight. It does not give them the sharpest view of the rear sight or quite such a blurred view of the foresight. The target itself is a blur, but is increased in size, and their shooting average has certainly pleased them.

DR. W. C. POSEY, Philadelphia: My own views are in accord with those expressed by Dr. Donovan and Major Halloran, as I believe it should be the aim of the ophthalmologist to correct the eyes of the marksmen with the best degree of acuity possible for the target. In actual warfare, I think it would be ludicrous to send out sharpshooters to pick off the enemy with their vision focused by glasses to 3 inches beyond the rear sight. As a member of a commission appointed from the Medical Reserve Corps by the Surgeon-General of the Army some years ago to prepare a new standard of visual acuity, I was impressed with the little vision required by ordinary troops, nearly all of the firing being done in volleys at the command of the officers, without any attempt at sighting at the enemy. A vision of 20/40 in the best eye seemed to be perfectly adequate for all purposes. I found that many marksmen of note had relinquished an amber tint in their glasses, because they found it did away with the "mirage," the term they employ to designate the atmospheric effect by which they judge of the direction and velocity of the wind, etc. The euphos tint had been given up for the same reason. Dr. Donovan's suggestion that the glasses should be set at some distance from the eyes, in order to avoid the moistening of the lenses by perspiration in field practice, where the men perspire freely and must throw themselves quickly into a prone position, is a good one. The removal of the lower half of the lenses possesses certain technical advantages.

DR. ALEXANDER DUANE, New York: I am inclined to agree with those who express the opinion that sharp vision is necessary for long-range shooting. We do not need to see the object aimed at distinctly. My own personal experience is that with uncorrected vision of 20/40 in the sighting eye, such as I have, I could see well enough at 200 or 300 yards, but when I attempted to qualify at 500 yards as a sharpshooter I could not see the bull's eye well enough to get my eye on it, and I made no success at all as a marksman. I am inclined to agree with the view of Dr. O'Connor, who studied the subject carefully and gathered the opinions of experts in the Army. Like him, I believe that we really do need sharp sight in the Army, such as is required in the Navy. In the Navy they require for ordinary seamen 20/20 and for gun-pointers 20/15, uncorrected vision.

DR. S. D. RISLEY, Philadelphia: So far as my personal experience goes, both in target practice and in shooting at

birds, sharp sight for the object aimed at is essential. I am sure I always regard first the target or bird, and simply gazing through the sight, uncovered the object, getting a clear view of it. Among my friends who are fond of marksmanship, two are very highly myopic and always used their glasses. As marksmen they stand within the first five in the 100 for marksmanship. One said: "My glasses minify the object and when I see it I have it down fine." So that these two men certainly depended on sharp sight for the object itself and not for the rear sight. I am sure that this agrees with my own personal experience.

DR. JOHN A. DONOVAN, Butte, Mont.: We cannot draw very definite conclusions from one individual with myopia. A myope becomes accustomed to a blurred object which to him appears normal. A good shot, in practice, will make much better scores on a blurred target than others can under more favorable conditions. Most Americans are hyperopic and I am inclined to believe our first correction of presbyopia is really correcting the latent hyperopia, which accounts for the better scores obtained with these glasses.

THE FINDINGS OF THE TROPOMETER IN 100 NORMAL EYES AND ITS VALUE IN THE STUDY OF STRABISMUS

WENDELL REBER, M.D.
PHILADELPHIA

Despite the fact that it is twenty-two years since Stevens introduced his tropometer to the profession (1890), it must be admitted that the instrument has not come into what might be called popular use. It is true that Nicati eighteen years earlier adapted the ordinary perimeter to the rough estimation of the rotational power of the eyes; but to Stevens must belong the credit of devising a thoroughly practical instrument of sufficient mechanical convenience and scientific accuracy to justify its every-day use in ophthalmic practice. To maintain that it is without its limitations would be absurd; and to claim that it is without practical advantages is equally at variance with the facts. The truth, as is usual, is likely to be found midway between these two extremes.

There are many ways of estimating the rotational powers of the eyes; all of more or less use. Casey Wood's method of using words of two letters to be carried as far out on the inside of the arc of the perimeter as they can be read is well known and among the most practical and useful of all the perimeter methods. It is a subjective method and, in patients of average or more than average intelligence, a valuable test. Dr. Wood has modified this method somewhat as is shown in the following letter:

My dear Dr. Reber:—Many years ago, I made some observations on the field of monocular fixation in its relation to heterophoria and muscular asthenopia.

While I regard this method as roughly useful and in most instances a practical one, yet I have never regarded perimetric measurements as efficient as the tropometer of Stevens, if for no other reason than that the ocular movements inwards can be better measured with the latter instrument. Whatever method be chosen, however, standards normal to each instrument should be established for purposes of comparison. The normal extent of each excursion is likely to vary in different forms of the tropometer, just as it varies from time to time in the same individual and in different individuals.

With this proviso let me say, that I propose what I regard as an improvement on the original lettered strips that present a mixture of letters and figures. Following a suggestion of my assistant, Dr. A. S. Rochester, a certain area on the strips is concealed by the object carrier of the perimeter so that the

patient may read continuously as fast as the carrier is removed from this fixation point. I hope to publish a description of this little device so that judgment may be passed on it.

Let me add that whenever the field of monocular fixation is measured, the recording chart should have a normal field traced on it for purposes of comparison as in the ordinary charts of the field of vision.

Cordially yours,

CASEY WOOD.

An objective perimeter method to which I myself resorted for some years with much satisfaction is to have the patient hold in his hand Schweigger's hand perimeter. A small electric light is then carried along the arc of the perimeter and the patient instructed to follow it with the eye under examination. The surgeon meanwhile determines the movement of the eye by watching closely the movement of the corneal image made by the electric light. The moment the tiny image begins to waver, the eye is reaching its limit of rotation in that particular meridian.

This method is fairly accurate, requires no special apparatus and is quickly applied. The chief objection is that it is only an approximate measurement. Howe sought to obviate the objections to this method by mounting on the arc of the perimeter a small telescope whose axis is at all times perpendicular to the arc and exactly in the direction of a radius of the perimeter. Naturally this lends the needed element of exactitude to the estimation of the ocular rotations—but the tropometer is much easier to use, in less time, and with quite as much exactness. Indeed it is so easy of application that it may well be asked why it has not come into more general use.

To appreciate properly the usefulness of the instrument, it is essential that one should be familiar with the behavior of normal eyes under its observation.

The limits of the normal field of fixation,¹ as found by early observers are shown in Table 1.

TABLE 1.—LIMITS OF THE NORMAL FIELD OF FIXATION

	Scherman	Volkman	Hering	Kuster	Schneller	Landolt	Duane
Up	34	35	20	33		44	43
Down	57	50	62	44		50	63
Temporalward	42	38	43	43	40-54	46	53
Nasalward	45	42	44	45	52-56	44	51

The wide variation in the excursions above cited cannot fail to excite interest. For instance, the difference in Hering's and Landolt's observations of 24 degrees in the upward rotation and 12 degrees in the downward rotation demands some manner of explanation. I think it may be found in the fact that these early observers resorted entirely to perimeter methods in their observations which, as I have already stated, are but approximate at best. Moreover, tests made with the perimeter are much more open to differences in interpretation than are tropometer tests—hence the equation of error will be much larger, as above graphically shown.

Duane (quoted by Howe) alludes to the difficulties of ascertaining the exact limits of the field of fixation; he gives the results of several measurements made on the same individual and states his belief that it seldom happens that any two tests agree exactly in all their details. That such tests do not agree *exactly* cannot be

gainsaid. But that they do correspond fairly well can be claimed, I believe. Two individuals were selected for the purpose, one (A) a woman in secretarial work; the other (B) a youth of 16. Estimates were made on three different days without any knowledge of the results secured at the previous examination. The records are given in Table 2.

TABLE 2.—LIMITS OF FIELD OF FIXATION IN TWO PERSONS ON THREE DAYS

A: WOMAN IN SECRETARIAL WORK				
	Up	Down	Nasal	Temporal
R. E.	32	50	50	37
	36	55	45	45
	32	52	50	40
	32	48	42	42
L. E.	35	50	45	45
	37	45	45	45
B: YOUTH, AGED 16				
	Up	Down	Nasal	Temporal
R. E.	40	50	48	48
	40	50	50	50
	42	55	55	55
	42	55	55	50
L. E.	45	52	60	48
	40	55	48	48

The figures show a slight variation of from 3 to 5 degrees in the patients from day to day and in the upward rotation in one, a variant of 7 degrees as also in the temporal rotation in the other case. Naturally, if two or more observations are taken in any one case (and this is most excellent practice) they can justly be averaged and good working conclusions deduced therefrom. Indeed, repeated observations are of the same value in this line of our work as in refraction work and ought never to be omitted if the opportunity offers.

After consideration of the variations in normal rotations noted by the early observers, I was led into investigations bearing on this subject for my own satisfaction. Within the last two years I have selected fifty individuals (100 eyes) with normal muscle balance for infinity as the subjects of this inquiry. All of these individuals presented (with two exceptions) low grade hypermetropia or its allied states (1.00 diopter total or less). The two myopes showed a total of 2 diopters of error in one case and 5.50 diopters in the other.²

The rotations in these one hundred normal eyes were tabulated and averaged, affording the following tabulation, which I now use for my guidance:

Upward	30 degrees	Nasalward	50 degrees
Downward	52 degrees	Temporalward ...	48 degrees

Naturally in a series of such cases there were considerable variations from the averages just noted. For instance, in one case the upward rotation was but 25 degrees in the right eye (equals 11 degrees less than the average); however, it was but 28 degrees in the other eye, showing plainly a deficiency of upward rotation in both eyes. In this case the downward rotation equaled 54 and 52 degrees, respectively, conforming to the normal averages. This patient presented perfect muscle balance for both infinity and 13 inches (33 cm.) the occupation distance. Another case showed upward rotation in the right eye of 25 degrees and in the left eye of 29 degrees, but the downward rotations were 54 and 50 degrees, again pointing to the elevators as insufficient in their work.

On the other hand, excessive upward rotation was found in some cases, conspicuously in Case 29 of the

2. I am much indebted to Dr. Joseph L. McCool, my former office associate, now located in Portland, Ore., for the major portion of this work on normal individuals.

1. Howe: The Muscles of the Eye, 1.

series in which upward rotation equaled 45 degrees in the right eye and 47 degrees in the left eye. But the downward rotations were 50 degrees in both eyes (equals normal) so that the case takes on the features of excess upward rotation pure and simple, as the lateral rotations were normal. This case presented esophoria of 1 degree for infinity, but as we generally find in cases of excessive upward rotation, there was exophoria of 7 degrees at the reading distance (13 inches). This patient (a young man of superb physical build) presented an obstinate habit blepharospasm, only partially relieved by accurate refraction and convergence training.

After repeated observations Dr. McCool and myself are both of the opinion that the factor of error in taking observations is about 5 degrees.

The variations in our own series are as follows:^a

	Up	Down	Nasal	Temporal
Highest	48	65	60	60
Lowest	25	35	38	40

One other fact is of interest. If the averages established by the early observers already quoted in the table (Schuerman, Volkman, Hering, Kuster, Schneller, Landolt and Duane) are themselves averaged they approach very closely to those established in my own series, to-wit:

	Up	Down	Nasal	Temporal
Averages of early ob- servers	34	54	47.4	45.7
Reber	36	52	50	48

I am therefore inclined to believe that the averages established for my own satisfaction will be likely to be pretty closely approximated by those that may be arrived at by most other present-day investigators whether in our own country or abroad.

It might be of interest also to note that I have had the eye-piece containing the tangent scale so modified that the scale can be rotated through 135 degrees of the circle instead of 90 degrees. This can be very easily done by any mechanical optician and enables the ophthalmologist to estimate the two main oblique rotations as well as the vertical and lateral ones.

While, as I have said, the tropometer is easy of application, it is not so easy to form correct judgments as to the significance of the rotations when their limits have been learned. Lucien Howe has very well said:

It is important to remember that the limits of the fields of fixation are not to be judged *entirely by the number of degrees* which an eye can turn in any given direction. Much also depends on the *manner* in which the motion is made. In some individuals, when the group of muscles under examination is strong, the eye will turn without hesitation to a certain point . . . which is the limit of motion in that direction, and the globe can be held in that position steadily and without effort for several seconds. On the other hand, when this group of muscles is weak and the eye approaches the limit of fixation, it does so in a halting fashion.

Hence it follows that once facility has been gained in the use of the instrument, much depends on interpretation, just as in the use of the ophthalmoscope, the ophthalmometer, the perimeter, the tonometer, the microscope or any other instrument of precision in use in our science.

THE TROPOMETER IN THE STUDY OF STRABISMUS

In my hands the tropometer has not been of much service in studying the rotations of the globes in children

3. These figures will be seen to approach very closely to those set down by the inventor of the instrument (Stevens: A Treatise on the Motor Apparatus of the Eyes, F. A. Davis Company, 1906), who gives the following as his idea of normal rotations:

Up	Down	Nasal	Temporal
83-87	45-50	about 50	about 45

under 7 years of age. It will be readily seen, therefore, that its use has been confined to those strabismics who have arrived at or very near the age when the operative phase of this question is uppermost. This seems to be the tropometer's largest field of usefulness. Valk⁴ is devoted to it in such cases, and Edward Lauder,⁵ likewise, feels that it is practically indispensable in forming final judgments as to operation.

In the sixteen case histories about to be cited, six (Group I) represent the type that in spite of the most careful orthoptic treatment, have passed their eighth year with a goodly residual deviation. No patient of this group has submitted to operation.

Six more (Group II) present the same previous history as those in Group I, save that the patients have all come to operation.

Four more (Group III) were all strabismics in their early childhood, but under orthoptic treatment alone have secured parallel axes; their rotations furnish interesting reading.

GROUP I. ESOTROPICS WHO SHOULD BE OPERATED ON

CASE 1.—W. S., 9-year-old boy, first seen when 3 years old, and esotropia equaled 35 degrees. Developed after pertussis. No family history of strabismus. Refraction in 1906 was

R.—.50 sph.—.50 cyl. axis 45 degrees
L.—1.00 sph.—.50 cyl. axis 135 degrees

Present refractive status:

R.—1.25 sph.—.75 cyl. axis 45 degrees
L.—1.50 sph.—.75 cyl. axis 135 degrees

His present deviation is 30 degrees, with vision 5/6 in each eye (pure alternating strabismus).

His tropometric rotations equal:

	Up	Down	Nasal	Temporal
R.....	40	40	60	40
L.....	40	45	60	40

As would be expected in alternating esotropia, both eyes show excessive nasal rotation and defective temporal rotation. The vertical muscles are not above suspicion in this case, as upward rotation is excessive in each eye and downward rotation defective (see average normals). The patient will be operated on within the next month or two by advancement of each external rectus.

CASE 2.—T. G., a 12-year-old boy, first seen at 4 years of age. Esotropia 20 degrees. Strong family history of strabismus. Refraction at that time:

R.+4.00 sph.+1.00 cyl. axis 90 degrees equals 5/7
L.+4.00 sph.+1.25 cyl. axis 90 degrees equals 5/7

Last seen January, 1912. Refraction equaled:

R.+3.50 sph.+0.75 cyl. axis 90 degrees equals 5/6
L.+3.25 sph.+1.00 cyl. axis 90 degrees equals 5/6

Deviation still equals 20 degrees.

Tropometer rotations are as follows:

	Up	Down	Nasal	Temporal
R.....	30	45	60	40
L.....	30	50	65	38

Thus, as in the preceding alternating case, both nasal rotations are excessive and both temporal rotations defective. Operation declined.

CASE 3.—I. S., 8-year-old boy, first seen when 5 years old. A frail puny child with a doubtful history of acute polyencephalitis a year before. Esotropia 45 degrees. Left eye deviating constantly. Refraction equaled:

R.+1.00 sph.+ .50 cyl. axis 75 degrees
L.—1.00 sph.—2.00 cyl. axis 135 degrees

Present refraction:

R.+ .50 sph.+ .50 cyl. axis 75 degrees equals 5/6
L.—1.50 sph.—2.50 cyl. axis 145 degrees equals 5/60.

4. Valk: Strabismus or Squint.

5. Lauder, E.: Tr. Am. Acad. Ophth. and Oto-Laryngol., 1906.

The tropometer showed:

	Up	Down	Nasal	Temporal
R.....	30	45	45	40
L.....	30	53	60	33

In this, the monocular type, the abnormal rotations are confined to the deviating (left) eye, the nasal rotations being excessive and the temporal markedly defective. Operation advised—advancement left externus and tenotomy left externus.

CASE 4.—L. B., a 10-year-old boy, undersized, neurotic, son of a neurasthenic mother. First seen when 8 years old. Deviation 32 degrees, left eye deviating constantly. Present refraction:

R.+0.25 sph.+0.75 cyl. axis 90 degrees equals 5/5
L.+0.25 sph.+0.75 cyl. axis 90 degrees equals 5/15

Has worn glasses for five years. Deviation now 30 degrees. Tropometer equals:

	Up	Down	Nasal	Temporal
R.....	42	45	60	45
L.....	40	58	65	35

This is another typical monocular case, although the vertical muscles are not above suspicion. Operation declined.

CASE 5.—L. G., a 9-year-old boy when first seen; deviation equaled 35 degrees, always the right eye. A paternal uncle had strabismus in childhood. Patient ophthalmoscopically normal in both eyes, but examination revealed a small positive central scotoma in the right (deviating) eye. Present deviation 25 degrees. Present refraction:

R. (retinoscope)+0.75 sph.+0.25 cyl. axis 90 equals 1/60
L.+1.25 sph. equals 5/5

Tropometer shows:

	Up	Down	Nasal	Temporal
R.....	48	50	65	45
L.....	50	45	48	45

Excessive nasal rotation in the deviating eye is here shown, as would be expected. The temporal deviation is normal, however, and the action of the elevators so markedly excessive that were I permitted to operate on this case I should tenotomize both superior recti (moderately) before directing any surgery to the lateral muscles.

CASE 6.—M. B., a 7-year-old girl, developed esotropia in her second year. Right eye deviated always. No family history of strabismus. Deviation 37 degrees, right eye. Eye-grounds normal. Refraction is:

R. (retinoscope)—1.00 cyl. axis 180 degrees equals 2/60.
L.+0.75 cyl. 90 degrees equals 5/7

The rotations are:

	Up	Down	Nasal	Temporal
R.....	34	51	60	35
L.....	40	45	55	40

Advised tenotomy right internus and advancement right externus. Operation declined.

In these six cases, deficient temporal rotation is shown in one or both eyes according as they are monocular or alternating esotropias; or the nasal rotation of the deviating eye or eyes is excessive; or in some cases both conditions obtain.

They may be summarized as follows:

TABLE 3.—DEFICIENT TEMPORAL ROTATION IN SIX CASES
SUITABLE FOR OPERATION

Case	Variety of Esotropia	Up	Down	Nasal	Temporal
1	Alternating.....	R. 40 L. 40	40 45	60 60	40 40
2	Alternating.....	R. 30 L. 30	45 50	60 65	40 38
3	Monocular..... L. E.	R. 30 L. 30	45 53	45 60	40 33
4	Monocular..... L. E.	R. 42 L. 40	45 58	60 65	45 35
5	Monocular..... R. E.	R. 48 L. 50	50 45	65 48	45 45
6	Monocular..... R. E.	R. 34 L. 40	61 45	60 55	35 40

GROUP II. ESOTROPICS AND HYPERTROPICS WHO HAVE BEEN OPERATED ON AFTER TROPOMETRIC STUDY

CASE 7.—R. B., boy 9 years old when first seen, June 2, 1908. Monocular esotropia of 40 degrees, left eye deviating. Wearing:

R.—0.75 cyl. axis 180 degrees equals 5/15
L.—0.50 sph.—1.00 cyl. axis 85 degrees equals 5/30

Under thorough cycloplegia there was found:

R.—0.50 sph.+2.00 cyl. axis 45 degrees equals 5/0
L.—2.00 sph.—4.00 cyl. axis 170 degrees equals 5/12

Eye-grounds were normal. Stereoscopic exercises were ordered and faithfully followed out. Two years later the deviation equaled 30 degrees and refraction was:

R.—2.00 cyl. axis 180 degrees equals 5/7
L.—2.00 sph.—4.00 cyl. axis 180 degrees equals 5/15

The tropometer at this date showed:

	Up	Down	Nasal	Temporal
R.....	45	45	60	45
L.....	45	50	70	40

Dec. 27, 1912, under local anesthesia, modified tenotomy of both superior recti and internal recti; this because of the preponderance of upward rotation as shown by the tropometer. March 2, 1911, about 5 degrees of residual convergent deviation. Rotations at this date:

	Up	Down	Nasal	Temporal
R.....	30	50	50	48
L.....	30	52	52	45

CASE 8.—J. S., a boy aged 16, first seen July 16, 1910, with left hyperesotropia, the upward deviation being 10 degrees, the inward 50 degrees. The eye-grounds were normal. He was wearing:

R.+4.00 sph.+1.00 cyl. axis 90 degrees
L.+4.00 sph.

Under thorough cycloplegia we found:

R.+4.00 sph.+1.50 cyl. axis 90 degrees equals 5/4
L.+4.00 sph.+1.50 cyl. axis 135 degrees equals 5/7

The rotations follow:

	Up	Down	Nasal	Temporal
R.....	45	42	60	45
L.....	50	35	65	30

Sept. 1, 1910, under local anesthesia the left superior rectus was tenotomized, by which the left eye was brought down almost on a level with the right eye and the lateral deviation reduced 10 degrees, leaving a residual convergence of the left eye of 40 degrees. A month later operation was performed consisting of wide resection and advancement of the left externus and moderate tenotomy of the internus. Result was 10 degrees of residual convergence under cover for infinity.

CASE 9.—L. Z., a boy aged 11, first seen Nov. 13, 1911. Pure alternating esotropia of 50 degrees. Wearing:

R.—19.00 sph. equals 5/30
L.—18.00 sph.—1.00 cyl. axis 165 degrees equals 5/30

Eye-grounds characteristic of high myopia, but no staphyloma posterior, and retina and chorioid in unusually good condition. Tropometer showed:

	Up	Down	Nasal	Temporal
R.....	25	40	70	30
L.....	30	45	60	30

One week later, under local anesthesia, moderate tenotomy of both interni and advancement of both externi. March 1, 1911, result, residual convergence for infinity of scant 10 degrees under cover.

Refraction to-day:

R.—20.00 sph.—1.00 cyl. axis 75 degrees equals 5/15
L.—16.00 sph.—1.00 cyl. axis 135 degrees equals 5/15

These were ordered for constant wear.

CASE 10.—May 11, 1908, H. C., a woman aged 25. Esotropia since infancy. Left eye always deviating. Vision equals right,

5/7; left, 5/12. Esotropia equals 20 degrees. Eye-grounds normal. Refraction showed:

R.+0.50 sph. 25 cyl. axis 100 degrees equals 5/5
L.+0.75 cyl. axis 90 degrees equals 5/7

Rotations with tropometer:

	Up	Down	Nasal	Temporal
R.....	35	50	53	40
L.....	30	50	55	15

The left eye stopped promptly when the 15-degree mark was reached. Under local anesthesia, advancement left externus.

Result, residual convergence for infinity of 5 degrees. It is not unlikely that in this case there was congenital paresis of the left external rectus.

CASE 11.—Mrs. A. C., aged 30. Strabismus since childhood, always left eye. Vision, R, 5/9; L, 5/60. Eye-grounds normal. Tropometer equals:

	Up	Down	Nasal	Temporal
R.....	50	00	45	50
L.....	30	50	35	10

As in the preceding case, the diagnosis here was congenital paresis of the external rectus. (See illustration of motor fields.) Under local anesthesia, advancement of the left external rectus was attempted, but practically no muscle was found save a small thin fibrous tendon. Wide resection of the conjunctiva and capsule was therefore done. Result, poor. Not more than 10 degrees of external rotation gained, although the position of the eye was somewhat improved. This may be attributed to the fact that one of the stitches pulled out. The

Motor fields in Case 11.

final postoperative diagnosis was congenital underdevelopment of the left external rectus muscle.

CASE 12.—Patient.—J. C., a boy aged 16. Left esotropia of 10 degrees and hypotropia of 20 degrees. Wearing a good correction for the past two years (high H + Ah). The esotropia developed soon after diphtheria six years ago. Patient complained of diplopia in the upper field, giving rise to difficulty in reading and writing. Study of the double images showed paresis of the left superior rectus. The tropometer showed the following rotations:

	Up	Down	Nasal	Temporal
R.....	35	50	52	40
L.....	20	60	58	38

The eye-grounds were normal. Corrected vision equaled right, 5/5; left, 5/7. Under local anesthesia, wide resection (about 5 mm.) of the left superior rectus was done along with tenotomy of the inferior rectus in the same eye, and button-holing of the internal rectus. Result one week later. Lateral balance and 2 degrees of residual left hypophoria. No subsequent estimate of the tropometric rotations was made, as the patient went to his home in a distant city one week after operation; but later he reported that he could use his eyes in all near work with perfect comfort.

Remarks.—In each of the cases in this group, the tropometer gave positive and accurate indications as to operation and as to which muscle should be operated on. It is freely admitted that by close inspection of the

behavior of the ocular muscles alone most operators would have arrived at probably the same conclusion as to operation; but they would have been obliged to proceed to operation without precise knowledge as to the rotational powers of the muscles they were about to operate on.

GROUP III. ESOTROPICS THAT ARRIVED AT PARALLELISM OF THE VISUAL AXES ON ORTHOPTIC TREATMENT ALONE.

This group comprises four cases of esotropia that arrived at parallelism of the visual axes on orthoptic treatment alone. The first two are monocular cases—the last two alternating ones.

CASE 13.—A 14-year-old boy, studied for several years. When first seen he exhibited deviation of the right eye of 28 degrees and vision in that eye of 1/60. To-day his vision in the right eye is 5/30 and his eyes are straight. His refraction is a high H + Ah condition. His rotations are:

	Up	Down	Nasal	Temporal
R.....	35	43	45	45
L.....	35	50	50	42

CASE 14.—A 12-year-old girl, whose case has been studied for seven years. Esotropia (right eye) 32 degrees when first seen and vision in that eye 3/60. After seven years' use of a good correction and stereoscopic treatment, she presents absolutely straight eyes. She is the subject of high myopic astigmatism, her vision being to-day: right, 5/15; left, 5/6 partly. The rotations at present are:

	Up	Down	Nasal	Temporal
R.....	35	46	50	40
L.....	30	45	45	40

CASES 15 and 16.—Brother and sister, both studied for seven years. The boy was 8 and the girl 11 when first seen. Both were treated for high esotropia by a confrère when 3 years of age. High H + Ah conditions were in evidence in both cases, totalling 4 diopters in the boy and 6½ diopters in the girl. In both cases vision is full 5/5 in both eyes, and the muscle balance is normal, with full binocular vision. The boy's rotations are:

	Up	Down	Nasal	Temporal
R.....	40	55	55	45
L.....	41	50	58	47

And the girl's:

	Up	Down	Nasal	Temporal
R.....	32	58	50	40
L.....	31	55	45	41

These cases just cited are splendid illustrations of the results that often attend the earliest careful attention to strabismic children. When the refraction is thoroughly studied and the eyes put under proper working conditions the eyes and their muscles and innervations develop along normal instead of abnormal lines. Once abnormal innervational habits have been formed, abnormal conditions probably develop in the muscles concerned, such as spasm and overdevelopment in the internal recti of esotropics and stretching and underdevelopment of the external recti. Under such conditions it will be difficult to accomplish the same result in the grown child without operation, as has just been shown in the four cases cited.

When operation becomes imperative and has been decided on, the methods in vogue are to have the patient follow the surgeon's finger in the lateral and vertical meridians. This furnishes information as to the behavior of the associated muscles of the eyes as well as giving some idea of the rotational power of each eye. The study of each eye in relation to its fellow ought never to be omitted, for in this way pareses are often detected. But individual study of the rotational power of each eye with

the tropometer is equally, if not more important, and will lend much greater accuracy to all such observations.

The plea is made for the fullest study of each case of esotropia before proceeding to operation; and as an aid to the exactness of details in such study nothing at present exceeds in value the tropometer.

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ABSTRACT OF DISCUSSION

DR. EDWARD LAUDER, Cleveland: The observer should be familiar with the behavior of normal eyes under the tropometer. In orthophoria there are variations from the normal rotations, namely, 33° upward, 50° downward, 55° inward and 50° outward, as given in several text-books. In all orthophoric cases, however, the approximate relative rotations, as given, obtain, so that, having thoroughly learned and appreciated this fact, we more readily learn to interpret our readings in all abnormal cases.

To any one who has used the tropometer the question of the proper adjustment of the head, no doubt, has presented itself. Great care should be used in this, and when making the ocular rotations the patient should grip the piece of wood firmly with his teeth so that he will avoid the incentive to turn his head. Perfect adjustment of the head being difficult, it is well, in investigating any case of ocular rotation, to make several examinations at different times, and in this way either prove the findings or arrive at a satisfactory average.

Considering the value of the tropometer in the study of strabismus, I cannot fully agree with Dr. Reber when he says, "This seems to be the tropometer's largest field of usefulness." What substitute have we in the investigation of numerous cases of latent strabismus or heterophoria? Furthermore, there are those two other types of cases—dextrophoria and levophoria—in the investigation of which we would be entirely at sea did we not have the use of a tropometer.

DR. FRANCIS VALK, New York: I have always held the tropometer to be one of our best instruments. It invariably confirms all the other examinations. Dr. Reber seems much worried because it does not give exact averages. We say that 20/20 is an average for vision, and yet it is not, for many must have noticed vision 20/15 and 20/10 even. If we take Dr. Stevens' records of 33 up and about 55 down and 55 in and 50 out, that is enough. What I look at is simply the relation which these figures bear to each other. What difference does it make if one figure appears to be 49 instead of 50? The point is, where these conditions of heterophoria exist, to find the relation of one to the other; then you know, what the true muscle balance is. If we are specialists we must be able and willing to diagnose every case of abnormal motility. The great advantage of the use of this instrument in your practice when you come to correct the motility and refraction is beyond argument.

DR. A. DUANE, New York: While I agree with Dr. Reber as to the importance of testing the rotation of each eye separately, I cannot agree with him that this measurement is nearly as valuable a means of diagnosis or as valuable an indication for treatment as the measurement of the coordinate movements—convergent, divergent and parallel—of the two eyes acting together. All my observation has led me to believe that ordinary squint is essentially a disturbance of coordination; that it is an affection of convergence or divergence, and does not involve, primarily at least, the inward and outward rotations *per se*. At all events, some cases of squint are alike in rotations and yet are different in nature and require different treatment. Thus a convergent squint in which the convergent element is in excess, as shown by the fact that the deviation is considerably more marked for near than for distance, and that attempts at convergence beget a spasmodic inversion of the eye, is essentially different from a case in which the deviation is at least as great for distance as for near, and the converging power is evidently not excessive. And yet in these two differing cases the monocular rotations may show little or no difference. So also two cases of divergent

squint may be quite alike, so far as the power of monocular rotation is concerned, and yet may differ *in toto* in nature. In one, the deviation for distance is great for distance and less for near, and the power of convergence, absolute or relative, is still good; in the other, the deviation for near is much greater than for distance, and convergence is *nil*. The former will require one method of treatment, the latter another, even though the movements of each eye in the two cases are the same. Even in parietic squint, unless pronounced, I find the measurement of the rotations of each eye taken separately an unsafe guide—far less trustworthy than the measurement of the parallel movements of the two eyes, as determined by the variation of the screen deviation in different directions of the gaze, the lagging of one eye behind the other (on the contrary its spasmodic shooting beyond the other) in one definite portion of the field of fixation, and the measurement of diplopia on the tangent plane.

DR. G. C. SAVAGE, Nashville: Dr. Reber is right in his contention that the inherent strength of a muscle to be operated on should first be known. In heterophoria this can be done in one of three ways; first, by the rotary prism, determining the duction power of the muscles; second, by the perimeter, determining the verting power of the muscles; third, by the tropometer, also showing the verting power. The duction is applicable only to heterophoric conditions, and in my judgment is the test that should be resorted to in these cases. In heterophoria the verting test alone is possible, and this must be accomplished by the use of either the perimeter or the tropometer. With the perimeter adversion is interfered with by the nose, and supervision is interfered with by the brow. With the tropometer there is no interference with the version test in any direction. Of course, both the tropometer and the perimeter could be used in determining the verting power of the muscles in cases of orthophoria, as can also the duction test by means of the rotary prism, but the latter I conceive to be far preferable. The duction test shows whether the orthophoria is sthenic or asthenic; and if the latter, it gives indication as to necessary treatment by means of exercise. In lateral and vertical heterophoria the duction power of one of a pair of opposing muscles should be greater than the duction power of the other member of the pair, and yet the one with greater power may, in itself, not be intrinsically too powerful, and if this be the case, the strong muscle should not be operated on, but the weaker muscle should be given greater strength by being advanced or shortened, the latter being the safer and the surer operation. Even the duction test will show that the stronger muscle is inherently too strong, and yet the excess in strength is not very great, and then the indication would be to do a partial tenotomy of the stronger and a shortening of the weaker muscle. If in a case of esophoria the abduction should be 6 or 8 degrees, then the internus alone should be operated on. In determining the muscle to be operated on and the character of operation to be done, the tropometer or verting test would not fall far behind the phorometer or duction test. Only the verting test is available in cases of heterotropia. If the too strong muscle has excess of verting power, it, of course, should be weakened, and in nearly all cases this will be true; or if its excess of verting power is not great, then the balance must be restored by shortening or advancing its opposing muscle at the time that the tenotomy of the too strong muscle is done. The tropometer will rarely fail to show that the too strong muscle has too much verting power; hence, in nearly all cases of heterotropia such a muscle should be weakened. The cases are rare in which a weak muscle should not be simultaneously shortened or advanced.

DR. WENDELL REBER, Philadelphia: The point as to heterophoria touched on by Dr. Valk is one of the things that led me to take up the tropometer once more. I was careful to say that in high-grade latent deviations the instrument would be advantageous, but in ordinary cases of imbalance I am still skeptical. I agree absolutely with Dr. Duane about the study of coordination or associated movements. I believe that by combining the study of the associated and coordinated movements with a study of the individual muscles, we shall arrive at information about the eyes that we have not heretofore had.