(15)

THE ACTION AND USES OF PRISMATIC COMBINATIONS. *

By Archibald Percival, M.A., M.B., B.S. Camb.

There are two physical conditions which are essential for the binocular (single) vision of a point :—

(1) The retinal images must be definite.

(2) These images must be formed on corresponding areas of the retinæ ; in other words, each eye must be directed towards the same point.

If the first condition fail, owing to some refractive error greater than that which the muscle of accommodation can correct, dimness of sight is usually the only complaint. When, however, the disproportion between the accommodative power and the refractive error is slight, symptoms of headache and accommodative asthenopia arise from the fatigue induced by the strenuous efforts made by the ciliary muscle to compensate for the defect.

Similarly, in anomalies of the directing muscles of the eye, when the defect is great, no effort is made to correct it ; there is no headache, and patients only complain of strabismus and diplopia. Indeed, if the strabismus is well marked, the diplopia is not a troublesome symptom, as the false image falls on a peripheral and relatively insensitive part of the retina. Hence the patient soon learns to neglect or suppress this dim

---

* Read at the Annual Meeting of the British Medical Association, held at Bournemouth, July, 1891.

image, and his chief trouble is his difficulty in recognising the position of objects, and even this is generally but a temporary one. But if his defect is slight, a diplopia may arise of the most annoying description, for two objects appear to exist, which are both clear and well defined, and which yet seem to overlap each other, owing to the fact that their images are formed near the maculæ, in those parts of the retinæ in fact where vision is most distinct. There is, therefore, a very strong desire for fusion of these retinal images, and binocular vision is sometimes maintained by an excessive innervation of the affected muscles, which produces in its turn symptoms of giddiness and headache, and these are generally associated with certain others of the neurasthenic type. If the muscular tension is relaxed even for a moment, double vision occurs, entailing a psychical perplexity which is no less distressing to the unfortunate sufferer.

The symptoms, then, of muscular asthenopia are most accentuated when the want of balance in the ocular muscles is slight, and prisms or prismatic combinations would at first sight appear obviously the rational means of correcting all these muscular defects. Such indiscriminate treatment has, however, proved far from successful, and many ophthalmic surgeons, disappointed with their results, have abandoned the use of prisms, and thrown discredit upon them. It is not unusual, indeed, now to hear operative measures advocated in the strongest terms for all cases.

In the present paper I wish to point out some of the causes of failure, and to indicate those conditions in which we may reasonably hope for a successful issue by ordering prisms or prismatic combinations. The disrepute into which they have fallen is due, I believe, very largely to an imperfect recognition (1) of their precise action; (2) of the special conditions for which they may be appropriately prescribed. There are, however, still deeper causes at work also. The fundamental principles of treatment are still undetermined; there is no uniformity of opinion as to the ideal condition at the production of which we are aiming in our correction of muscular anomalies. Add to this the inexactitude of diagnosis consequent on subjective tests, and our

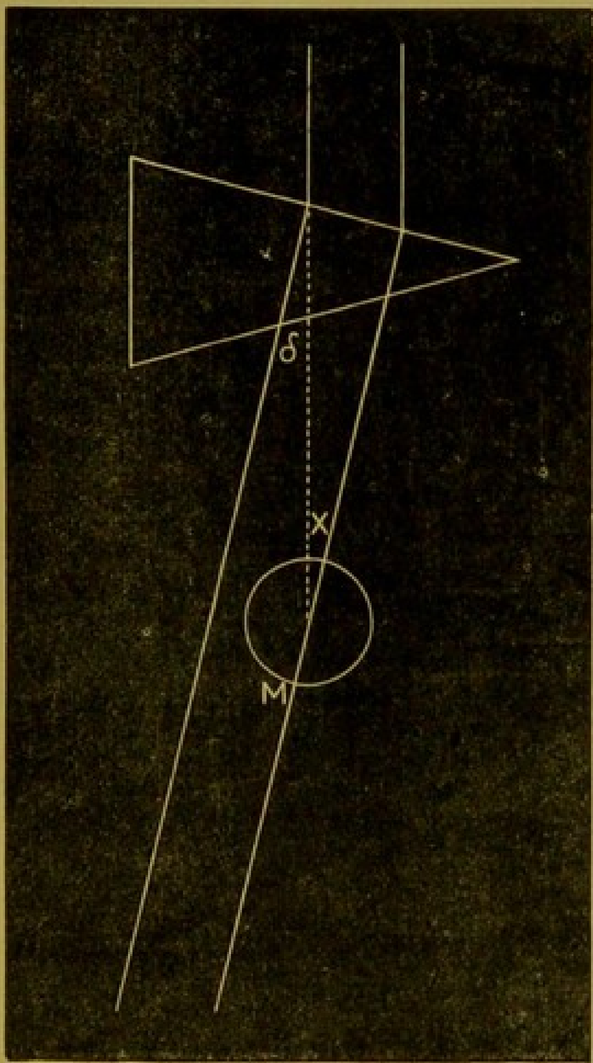

FIG. I.—Parallel rays, after traversing the prism, undergo a deviation δ. The eye has consequently to turn through an angle **X** in order to receive one of these rays on its macula. The angle **X** is equal to the angle δ.

successes will seem to demand more explanation than our failures.

The action of plane prisms is too well known to call for more than passing notice. It is very simple when they are designated by their refractive power.* Their

* This suggestion was originally made by Dr. Jackson, and it is now ably supported by Dr. Landolt and many other leading ophthalmologists.

effect on the eye is, of course, identical with that on luminous rays (Fig. 1). "A strabismus of 15° requires a prism of 15°*d* to correct it; when a diplopia is corrected by a prism of 10°*d* it corresponds to a strabismus of 10°, and so on."*

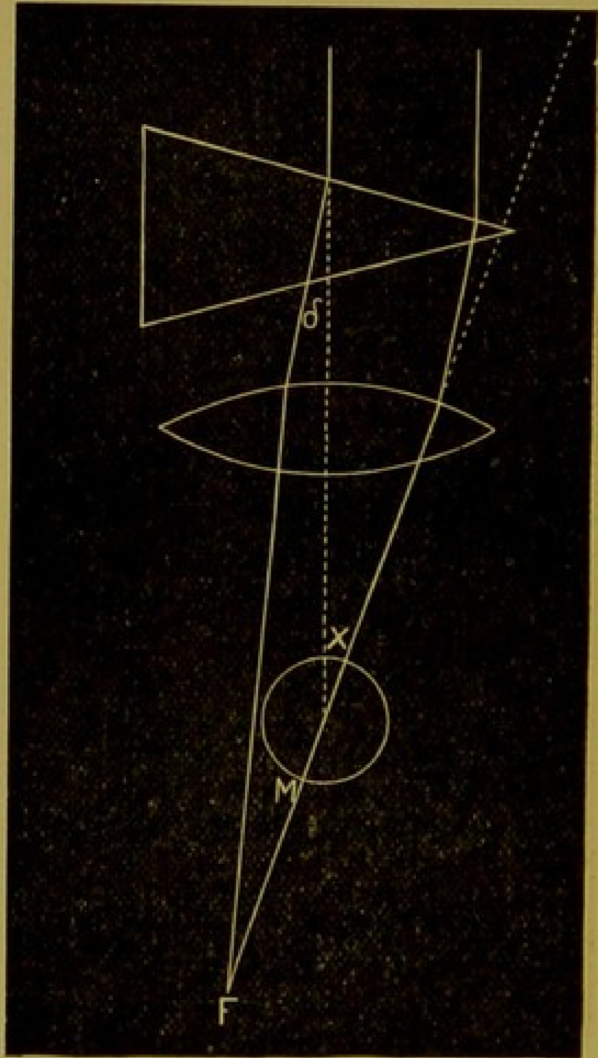

FIG. 2.—Parallel rays of light on traversing the prism as before undergo a deviation δ. On reacting the lens, since the pencil of rays is oblique, they will converge to the (secondary) focus F, which is not on the principal axis. The visual line must consequently undergo a deviation **X**. The ray of light which it receives on its macula passes through an eccentric portion of the lens, which therefore acts as an additional prism. Accordingly in this case **X** is greater than δ.

When, however, a spherical lens is used in conjunction with the prism, this simple relation no longer

---

* *Vide* paper by Dr. Landolt, "On the Numbering of Prismatic Glasses," *Knapp's Archives of Ophthalmology*, vol. xix., No. 4, p. 498.

obtains, for we have now to remember that the visual line traverses an eccentric portion of the lens, so that the deviating effect of this potential decentration must also be taken into account (*vide* Fig. 2). This complication necessarily also arises when the two glasses are

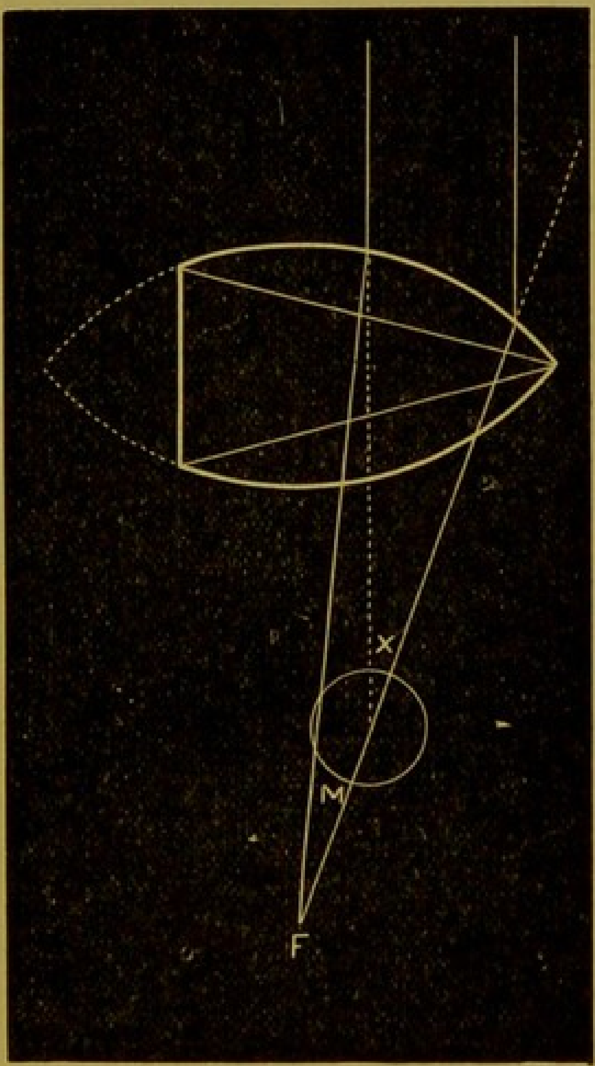

FIG. 3.—The position of the prism does not affect the result, even if it is put inside the lens, as in a primosphere the deviating effect is the same. The angle **X** has the same magnitude as in Fig. 2.

fused into one prismosphere or decentred lens (*vide* Fig. 3). Dr. Ernest Maddox, two years ago, alluded to this peculiarity of prismatic combinations. He pointed out that when concave prismospheres were used, the effect on the direction of the ocular fixation lines was always less than that of the prism; but that when convex combinations were used, their action was greater or less than that of plane prisms, according as the distance of the object was greater or less than the focal length of the lens. Unfortunately he went no farther, and he did not determine the extent of this difference of action. It is obvious that prismatic combinations cannot be prescribed with any attempt at scientific precision until this point is determined: I will not now weary you with the mathematical solution of the problem, which I have published elsewhere (*Knapp's Archives of Ophthalmology*, vol. xx., No. 2). The result may be expressed in the following form: If the prismosphere be regarded as a lens of focal length, f, which is decentred to the extent of d millimetres, where X represents its deviating action :—

$$\tan X = \frac{dp - fm}{fp - k(p - f)}$$

k is the distance of the glasses from the ocular centres; m represents half the distance between the ocular centres corresponding in adults usually to a distance of 32 millimetres; p denotes the distance of the object from the glass.

When the lens is concave a negative value must of course be given to f, so that the formula becomes

$$\tan X = -\frac{dp + fm}{fp + k(p + f)}$$

I have drawn up a series of tables for reference by assigning their respective values to the variables in these formulæ. They were published in the original communication, but I venture to insert them also in this paper. These tables enable one to determine the extent to which a lens should be decentred, or, in other words, the prism with which it should be combined, in order to produce a given deviation, and, *vice versâ*, the exact action of a prism when used in conjunction with a lens. It will be found, for instance, that a prism of $5°30'd$, when combined with a convex lens of + 9 D, has the same deviating effect as a plane prism of $7°17'd$. To induce, however, this deviation in a myopic eye of -9 D, a prism of $9°4'\ d$ would be required, if used in association with a concave lens of -9 D.

When investigating the condition of the ocular muscles, we are frequently obliged to use a combination of lenses and prisms.* A considerable error of diagnosis may be introduced by neglecting the deviating effect of the lens in the combination. It is hoped, therefore, that these tables will aid in securing greater accuracy in diagnosis.

What, now, are the special conditions for which they may be appropriately prescribed?

The general proviso may be made that the muscular defect must in all cases be limited in extent: as is well known, prisms of more than $2°d$ cannot be worn with comfort, owing to their weight and the chromatic aberration which is necessarily entailed. Slight errors, however, frequently induce a train of most distressing symptoms, especially, perhaps, in cases of hyperphoria.

It will be advisable, however, to consider the deviations in the vertical and horizontal planes separately.

The term Hyperphoria has been introduced by Dr. George Stevens to express that condition in which there is a want of balance between the muscles which elevate and depress the globe—where, in fact, there is a tendency of one visual line above the other. Dr. Stevens has done much to elucidate these faulty tendencies of the ocular muscles,† but he advocates operative

---

* Thus in determining the absolute minimum of convergence, the patient should be provided with glasses which enable him to define some distant object without exerting his accommodation. The strongest abducting prism compatible with single vision when held before these glasses enables one to find the minimum of convergence, with the help of the tables which are appended.

† "The Anomalies of the Ocular Muscles," by Dr. George T. Stevens, *Knapp's Archives of Ophthalmology*, vols. xvi., xvii., xviii.

procedures somewhat too unreservedly in my opinion.*

I believe that prisms, which correct the defect completely, will be almost always successful in these cases, as the error in each eye rarely exceeds 2°,† and is generally much less; and the order can of course be given with less compunction if the patient is already condemned to wear glasses to correct his refractive errors. In such cases, of course, attention must be paid to the complication introduced by the lenses, and the prescription must be made out in accordance with the formulæ given above, or the result will not improbably be disappointing.

The tendencies to deviation in the horizontal plane—viz., esophoria and exophoria—require somewhat closer study. There are two classes of cases of this nature, which must be carefully distinguished, for their successful treatment depends on this discrimination :—

(1) Those characterised by feebleness of one or more of the muscles with which is associated an impairment of movement.

(2) Those in which the range, though not contracted in extent, is in an unavailable situation ; in such cases, indeed, the amplitude of the movement is often greater than normal, yet symptoms arise owing to the fact that the position of minimum tension—the zero point, if one may so describe it—is not that consistent with parallelism of the visual axes.

Mannhardt, indeed, in opposition to the prevalent opinion of his time, assumed that all defects were of this nature ; he stated that the range of convergence was practically constant, and was represented by an angle of 24°. Dr. Landolt, to whom we are chiefly indebted

---

* *Cf.* also Dr. White's reference to this subject, in his address on "The Supposed Curative Effect of Operation *per se*," *Brit. Med. Journ.*, July 18th, 1891.

† If there be hyperphoria to the extent of 4°, it may be regarded as a deviation of 2° upwards in one eye, and 2° downwards in the other.

for our knowledge of this subject, gives from 18°30′ to 24° as the normal amplitude of convergence. We may take, then, 18° as the physiological limit, below which the range of convergence cannot fall without indicating feebleness of the directing muscles of the eye.

In the first class of cases, *i.e.*, those due to muscular weakness, prisms to *relieve* the defect should never be given if cure of the affection is the object in view. Progressive deterioration of the condition, necessitating repeated alterations in the glasses, is almost invariable if this line of treatment is pursued. It is, indeed, wholly wrong in principle: exercise, not rest, should be enjoined for all weak muscles. The successful treatment of flat foot and of lateral curvature consists in a systematic exercise of the feeble muscles. Similarly we should endeavour to strengthen the feeble ocular muscles by gymnastic exercise with prisms, which excite them to contract, as suggested by Dr. Dyer. It is true relapses are liable to occur if these exercises are given up too soon, but I believe that, with perseverance, ultimate success is almost certain.

It is not unusual to prescribe prisms which correct part (one-half) of the defect, and to order them to be worn constantly, so that a feeble stimulus may be continuously supplied to incite the sluggish muscles to contract more energetically. Surely our experience in other regions of the body teaches us the lesson that the alternation of rest and activity short of exhaustion is more favourable to nutrition and growth than continuous exertion. This method would seem, therefore, far inferior to that of Dr. Dyer.

It sometimes happens that our object is not to cure the affection; I refer to certain paralytic cases which we accept as incurable. In such, if the error be not too great, prisms may be ordered to correct the diplopia, and the patient may be permitted to wear them constantly. Not cure of the disease, but relief of the symptom is here our object; and even this can only be obtained over a relatively small area of the whole fixation field, "for the relations of the double images become entirely different in its different parts; and it is impracticable to adapt the prisms to these changes," as has been pointed out by Dr. Noyes.

It is then chiefly, in the second class of cases, in those in which the range of movement is represented by an angle of 18° or more that prismatic combinations may be ordered to be constantly worn, and here they are only applicable when the error is not greater than 2° in each eye. If, for instance, the maximum divergence be 4°, instead of the normal 2°, and the maximum convergence be 15°, abducting prisms of 2° *d* may be prescribed, which will have the effect of placing the range in a more available situation; in fact, its limits will now be − 2° and + 17°. Should the patient be a hypermetrope of + 5 D, prismatic combinations of + 5 D convex with 1° 44′ *d* will be sufficient, as the deviating action of this combination is the same as that of a plane prism (*vide* Table I.) of 2° *d*.

If the defect exceed the stated limit of 2°, tenotomy of the preponderating muscles is indicated.*

I have here assumed that muscular errors, due to displacement of the range, should be corrected by altering its position to such an extent that the far point of convergence may occupy its normal site. It remains to be seen whether this assumption is justifiable. The question now opened up is a difficult one, and demands detailed investigation.

Even after the most careful examination of the condition of the ocular muscles, comprising the measurement of the relative range, both when the accommodation is relaxed and when it is exerted for the working distance,

---

* Tenotomy has the disadvantage of diminishing the amplitude of movement, so that unless the range is of the normal extent, advancement of the feeble muscles would be preferable, as by that means the range is increased in amplitude, while it is also rendered more available by the alteration of its position.

as well as the localisation of the (absolute) far and near points of convergence, we still have to determine what condition we wish to induce before ordering prismatic combinations for that purpose.

Is the ideal condition at which we should aim that of rest, or merely that in which fatigue is avoided? The functions of accommodation and convergence are so associated in their action that if the former is called into play, no effort is required in maintaining the latter. Indeed, the dissociation of their action occasions considerable strain and fatigue. The condition of rest does not, therefore, imply inactivity. In the normal state when the eyes are accommodating for a point at a distance of $\frac{1}{3}$ metre, they tend also to converge to the same point. This is indicated by the maintenance of that degree of convergence, even when binocular vision is rendered impossible.

On the other hand, it would appear a legitimate presumption that a certain fraction of the amplitude of convergence may be brought into continuous activity without causing fatigue. Our aim may therefore be to provide that no more than this share shall be exercised by the patient.

The methods which we adopt to determine the degree of error which is to be corrected depend obviously on the condition we wish to induce.

A.—If the object in view be to avoid all effort.

(1) The faulty tendency which manifests itself as a deviation by Graefe's dot and line, or Dr. Maddox's glass rod test, may be measured. The test should be applied with the object of fixation at the working distance ($\frac{1}{3}$ metre), as well as at a distance of 6 metres. Any lenses which the patient may require must be first provided, and then prisms must be found which will correct the deviation. Prismospheres can then be ordered which will have the same effect as this combination.

I find that with many patients it is impossible to determine the extent of the diplopia exactly, as the false image is continually shifting, so that this method does not in all cases give accurate results.

(2) The relative range of convergence may be determined after the correction of refractive errors, both when the accommodation is relaxed and when it is exerted for the working distance. Now it may be presumed that the mid point of the relative range represents that degree of convergence which occasions the least strain with the given amount of accommodation. Donder's diagram (for the emmetrope) affords some support for this presumption. This method is given by Dr. Ernest Maddox; * it is more complicated, but admits of greater exactitude than that previously given.

B.—If, however, exemption from fatigue is to be the aim of treatment, we have to determine what degree of effort can be maintained without fatigue. Now, according to Dr. Landolt, not more than one-third of the total power of convergence can be continuously exercised without inducing symptoms. This at once suggests an easy method of dealing with the subject of muscular asthenopia, if the premises can be accepted. There seem, however, to be two sources of error :—(i.) The ratio borne by that portion of convergence which can be exercised to that which must be kept in abeyance may, and probably does, vary with different degrees of accommodation ; in fact, it is the relative, and not the total, range of convergence which must be taken into consideration. (ii.) Patients are found to present individual differences as to their power of maintaining a continuous effort. This tolerance cannot be expressed as a constant fraction of the total power, the ratio must vary in different individuals.

C.—The other method that may be suggested is to give such prisms as shall make the far point of

---

* "The Clinical Use of Prisms," p. 81, by Dr. Ernest Maddox.

convergence assume its normal position. Dr. Landolt appears to adopt this principle as a guide in determining the extent of his operations on the ocular muscles. Its simplicity is certainly in its favour; it is, indeed, comparable to the method well known in the treatment of refractive errors, which is based on the correction of all the manifest hypermetropia.

In deciding on the merits of these various methods, we must take into consideration a further complication involved by the relation of the functions of accommodation and convergence. We know that hypermetropes who do not squint acquire a facility for accommodating without converging. Myopes, again, acquire an extraordinary power of converging without accommodating. It seems not unreasonable to suppose that a similar disturbance of the relative range of accommodation may obtain with the subjects of muscular anomalies. For instance, a patient whose power of divergence is indicated by $-5°$ (instead of $-2°$) may acquire a special facility in overcoming part of this divergence without accommodating. The question then arises, Does this abnormality of the relative range, once acquired, remain constant; or will it disappear after the correction of those defects which have presumably induced it? If possible, is it desirable to obtain this result? The answer to this question has an important bearing on treatment. If we regard this abnormal relation as one that can and should be cured, we would correct all the refractive and muscular errors, and trust to the relative ranges of accommodation and convergence adjusting themselves to the new conditions. We should, in fact, put r_a and r_c in their normal positions by prismospheres that would correct all the hypermetropia, and that would make the maximum power of divergence be represented by $-2°$ (*Cf.* Method C).

If, however, this abnormal relation be incurable, or if it should be allowed to remain, the errors of refraction or those of convergence must only be partially corrected to avoid symptoms arising from its persistence (*Cf.* methods *A* and *B*). *

The solution of these questions is urgently needed, as the very principles of treatment are involved in them. Indeed, a complete investigation of the strengths of the ocular muscles, and their functional relations to different degress of accommodation, demands such prolonged and repeated examinations that they would be quite impossible to carry out in practice with each patient. It is imperative, therefore, to determine what are the points to which we may confine our attention.

I have dealt with this complicated subject at some length, so that its difficulties may be clearly stated and fairly faced. They can only be solved by data furnished by clinical experience. I have latterly adopted the procedure of correcting all the refractive error, and so much of the convergence defect as will enable the eyes to maintain their necessary direction without calling for special exertion (*A*). I have met with some success by acting on this principle, but my experience is not yet large enough to justify me in giving expression to a dogmatic opinion. It is at such a meeting as the present that there is an opportunity of throwing light on the obscurities of the subject by free discussion, based on clinical observation. It is most desirable that further progress should be made in rendering the methods of dealing with muscular asthenopia more precise and scientific. It is obviously to the absence of such precision and accuracy that the not uncommon failure in treatment is to be traced.

(*) In *A* the abnormality of the relation is allowed to persist in its entirety, but in *B* only in part.

EXAMPLES ILLUSTRATING THE USE OF THE TABLES.

TABLE I.—A hypermetrope of + 8 D and esophoria 1 ma at 6 metres will have this convergence defect corrected by decentering the 8 D lens 3·1 — mm. outwards, or, what comes to the same thing, by associating it with a prism of 1° 26′ *d* (not 1° 50′).

TABLE II.—A patient requiring + 12 D glasses for reading, who can only maintain convergence for a distance of ½ metre (2 ma), must have his glasses decentred 4·6 mm. inwards.

TABLE III.—A myope requiring—6 D for reading, who can only maintain 2 ma. of convergence, must have his glasses decentered 4 mm. outwards, or combined with a prism of 1° 24′ *d*, which is practically the same thing. Table II. and Table III. are useful also in estimating the relative range of convergence for reading distance. A myope using — 5 D for reading can obtain binocular vision with a 3° prism held edge inwards before each eye, as well as with a 12° 32′ prism held edge outwards. His relative range is not, however, represented by 15° 32′, but by 12° 46′, or 7 ma.

TABLE I.

				1 D	2 D	3 D	4 D	5 D	6 D	7 D	8 D	9 D	10 D	12 D	14 D	16 D	18 D	20 D
CONVEX.	Divergence decentration inwards. Convergence " outwards.	4 ma.	7°17′	124.5 7°6′	60.5 6°54′	39.1 6°42′	28.5 6°30′	22.1 6°18′	17.8 6°6′	14.7 5°54′	12.5 5°41′	10.7 5°30′	9.3 5°18′	7.1 4°54′	5.6 4°30′	4.5 4°6′	3.6 3°42′	2.9 3°18′
		3 ma.	5°29′	93.3 5°20′	45.3 5°11′	29.3 5°2′	21.3 4°53′	16.5 4°44′	13.3 4°35′	11.1 4°26′	9.3 4°17′	8.0 4°7′	6 9 3°59′	5.3 3°41′	4.2 3°23′	3.3 3°5′	2.7 2°47′	2.1 2°29′
		2 ma.	3°40	62.2 3°33′	30.2 3°28′	19.6 3°21′	14.2 3°16′	11.0 3°9′	8.9 3°4′	7.4 2°57′	6.2 2°52′	5.3 3°45′	4.6 2°40′	3.6 2°27′	2.8 2°15′	2.2 2°3′	1.8 1°51′	1.4 1°39′
		1 ma,	1°50′	31.12 1°47′	15.121 1°44′	9.787 1°41′	7.121 1°38′	5.521 1°35′	4.454 1°32′	3.692 1°29′	3.121 1°26′	2.676 1°23′	2.321 1°20′	1.787 1°14′	1.406 1°8′	1.121 1°2′	.898 55′	.721 50′
			1° o	16.975 58′	8.248 57′	5.339 55′	3.884 53′	3.011 52′	2.429 50′	2.014 48′	1.702 47′	1.460 45′	1.266 43′	.975 40′	.767 37′	.611 33′	.490 30′	.393 27′
CONCAVE.	Convergence decentration inwards. Divergence " outwards		1°	17.935 1°2′	9.207 1°3′	6.298 1°5′	4.843 1°6′	3.970 1°8′	3.389 1°10′	2.973 1°12′	2.661 1°13′	2.419 1°15′	2.225 1°16′	1.934 1°20′	1.726 1°23′	1.570 1°26′	1.449 1°30′	1.352 1°33′
		1 ma.	1°50′	32.879 1°53′	16.879 1°56′	11.546 1°59′	8.879 2°2′	7.279 2°5′	6.212 2°8′	5.450 2°11′	4.879 2°14′	4.435 2°17′	4.079 2°20′	3.546 2°26′	3.165 2°32′	2.879 2°38′	2.657 2°44′	2.479 2°50′
		2 ma.	3°40′	65.75 3°45′	33.7 3°52′	23.1 3°57′	17.7 4°4′	14.5 4°10′	12.4 4°15′	10.9 4°22′	9.7 4°28′	8.8 4°34′	8.1 4°40′	7.1 4°52′	6.3 5°4′	5.7 5°16′	5.3 5°28′	4.9 5°36′
		3 ma.	5°29′	98.6 5°38′	50.6 5°47′	34.6 5°56′	26.6 6°5′	21.8 6°14′	18.6 6°23′	16.3 6°32′	14.6 6°41′	13.3 6°50′	12.2 6°59′	10.6 7°16′	9.5 7°24′	8.6 7°42′	7.9 8°10′	7.4 8°27′
		4 ma.	7°17′	131.5 7°29′	67.5 7°41′	46.2 7°53′	35.5 8°5′	29.1 8°17′	24.8 8°29′	21.8 8°41′	19.5 8°52′	17.7 9°4′	16.3 9°16′	14.2 9°39′	12.6 10°3′	11.5 10°26′	10.6 10°50′	9.9 11°12′

The object of observation is presumed to be at a distance of more than 6 metres from the patient.
The figures in larger type indicate the amount of decentration in millimetres.
The figures in smaller type represent the deviating power of the prisms whose action is equivalent to that of the decentration of the lenses.

TABLE II.—(Convex.)

			1 D	2 D	3 D	4 D	5 D	6 D	7 D	8 D	9 D	10 D	12 D	14 D	16 D	18 D	20 D
Diverging.	4 ma.	7°17′	240.6 13°32′	118.5 13°20′	77.8 13°8′	57.5 12°57′	45.3 12°46′	37.2 12°34′	31.3 12°22′	27.0 12°11′	23.6 11°59′	20.9 11°48′	16.8 11°26′	13.9 11°2′	11.7 10°47′	10.0 10°21′	8.7 9°51
	3 ma.	5°29′	206.6 11°40′	101.9 11°31′	67.1 11°23′	49.7 11°14′	39.2 11°6′	32.2 10°57′	27.2 10°48′	23.5 10°39′	20.6 10°31′	18.3 10°22′	14.8 10°4′	12.3 9°47	10.4 9°29′	9.0 9°11′	7.8 8°54′
	2 ma.	3°40′	172.6 9°47′	85.4 9°42′	56.3 9°36′	41.8 9°30′	33.1 9°24′	27.3 9°18′	23.1 9°12′	20.0 9°7′	17.6 9°1′	15.7 88°55′	12.8 8°43′	10.7 8°31′	9.1 8°17′	7.9 8°7′	6.9 7°56′
	1 ma.	1°50′	138.6 7°53′	68.8 7°50′	45.6 7°48′	34.0 7°45′	27.0 7°42′	22.3 7°39′	19.0 7°36′	16.5 7°33′	14.6 7°30′	13.1 7°27′	10.7 7°21′	9.1 7°15′	7.8 7°9′	6.9 7°3′	6.1 6°57′
		0	104.6236 5°58′	52.3118 5°58′	34.8745 5°58′	26.1559 5°58′	20.9247 5°58′	17.4372 5°58′	14.9462 5°58′	13.0779 5°58′	11.6248 5°58″	10.4623 5°58′	8.7186 5°58′	7.4731 5°58′	6.5389 5°58	5.8124 5°58′	5.2312 5°58′
Converging.	1 ma.	1°50′	70.6 4°2′	35.7 4°5′	24.1 4°8′	18.3 4°11′	14.8 4°14′	12.5 4°18′	10.8 4°21′	9.6 4°23′	8.6 4°26′	7.8 4°29′	6.7 4°36′	5.8 4°41′	5.2 4°47′	4.7 4°53′	4.3 4°59′
	2 ma.	3°40′	36.6 2°6′	19.2 2°12′	13.4 2°18′	10.5 2°24′	8.7 2°30′	7.6 2°36′	6.7 2°42′	6.1 2°48′	5.6 2°54′	5.2 3°	4.6 3°12′	4.2 3°24′	3.9 3°36′	3.7 3°48′	3.5 4°
	3 ma.	5°29′	2.6 9′	2.6 18′	2.6 27′	2.6 36′	2.6 45′	2.6 54′	2.6 1°3′	2.6 1°13′	2.6 1°22′	2.6 1°31′	2.6 1°49′	2.6 2°7′	2.6 2°25′	2.6 2°43′	2.6 3°1′
	4 ma.	7°17′	—31.3 (1°48′)	—13.9 (1°36′)	—8.1 (1°24′)	—5.2 (1°12)	—3.4 (59′)	—2.3 (47′)	—1.4 (35′)	—.84 (23′)	—.36 (11′)	.03 1′	.61 25′	1.02 49′	1.3 1°13′	1.58 1°37′	1.77 2°2′
Difference for 1 ma.			33.995 1°57′	16.558 1°54′	10.743 1°51′	7.839 1°48′	6.0957 1°45′	4.933 1°42′	4.1029 1°39′	3.4801 1°36′	2.9957 1°33′	2.6082 1°30′	2.0270 1°24′	1.6119 1°18′	1.3004 1°12′	1.0582 1°6′	.8645 59′
Difference for 1°			18.54 1°3′	9.032 1°2′	5.861 1°	4.276 59°	3.325 57′	2.691 55′	2.2380 53′	1.8983 52′	1.6341 50′	1.4227 49′	1.1057 46′	.8792 42′	7.093 39′	.5772 36′	.471 32′

The object of observation is presumed to be $\frac{1}{3}$ metre from the centre of rotation of the globe.
The figures in larger type give the amount of decentration in millimetres.
—ve sign indicates decentration outwards ; +ve sign decentration inwards.
The figures in smaller type represent the deviating power of the prisms whose action is equivalent to that of the decentration of the lenses. When enclosed in brackets the prisms are adducting in function, and should be placed edges inwards.

TABLE III.—(Concave.)

			—1 D	—2 D	—3 D	—4 D	—5 D	—6 D	—7 D	—8 D	—9 D	10 D	—12 D	—14 D	—16 D	—18 D	—20 D
Diverging.	4 ma.	7°17′	—247.6 13°55′	—125.6 14°6′	—84.9 14°17′	—64.5 14°28′	—52.3 14°40′	—44.2 14°51′	—38.4 15°2′	—34.0 15°14′	—30.6 15°25′	—27.9 15°36′	—23.8 15°59′	—20.9 16°21′	—18.8 16°43′	—17.1 17°5′	—15.7 17°27′
	3 ma.	5°29′	—211.9 11°58′	—107.2 12°7′	—72.4 12°15′	—54.9 12°24′	—44.5 12°32′	—37.5 12°41′	—32.5 12°49′	—28.8 12°58′	—25.9 13°7′	—23.5 13°16′	—20.1 13°33′	—17.6 13°50′	—15.7 14°7′	—14.3 14°24′	—13.1 14°41′
	2 ma.	3°40′	—176.1 9°59′	—88.9 10°5′	—59.9 10°11′	—45.3 10°17′	—36.6 10°23′	—30.8 10°29′	—26.7 10°35′	—23.5 10°40′	—21.1 10°46′	—19.2 10°52′	—16.3 11°4′	—14.2 11°15′	—12.6 11°27′	—11.4 11°39′	—10.5 11°50′
	1 ma.	1°50′	—140.4 7°59′	—70.6 8°2′	—47.4 8°5′	—35.7 8°8′	—28.8 8°11′	—24.1 8°14′	—20.8 8°17′	—18.3 8°20′	—16.4 8°23′	—14.8 8°26′	—12.5 8°32′	—10.8 8°38′	—9.6 8°44′	—8.6 8°50′	—7.8 8°56′
		0	—104.6236 5°58′	—52.3118 5°58′	—34.8745 5°58′	—26.1559 5°58′	—20.9247 5°58′	—17.4372 5°58′	—14.9462 5°58′	—13.0779 5°58′	—11.6248 5°58′	10.4623 5°58′	—8.7186 5°58′	—7.4731 5°58′	—6.539 5°58′	—5.8124 5°58′	—5.2312 5°58′
Converging.	1 ma.	1°50′	—68.9 3°56′	—34.0 3°53′	—22.4 3°50′	—16.5 3°47′	—13.1 3°44′	—10.7 3°41′	—9.1 3°38′	—7.8 3°35′	—6.9 3°32′	—6.1 3°29′	—4.9 3°23′	—4.1 3°17′	—3.5 3°11′	—3.0 3°5′	—2.6 2°59′
	2 ma.	3°40′	—33.1 1°54′	—15.7 1°48′	—9.8 1°42′	—6.9 1°36′	—5.2 1°30′	—4.0 1°24	—3.2 1°18′	—2.6 1°12′	—2.1 1°5′	—1.7 59′	—1.1 47′	—.73 35′	—.42 23′	—.18 11′	.01 (1′)
	3 ma.	5°29′	2.6 (9′)	2.6 (18′)	2.6 (27′)	+2.6 (36′)	2.6 (45′)	2.6 (54′)	2.6 (1°3′)	2.6 (1°12′)	2.6 (1°21′)	2.6 (1°31′)	2.6 (1°49′)	2.6 (2°7′)	2.6 (2°25′)	2.6 (2°43′)	2.6 (3°1′)
	4 am.	7°17′	38.4 (2°12′)	20.9 (2°24′)	15.1 (2°36′)	12.2 (2°48′)	10.5 (3°)	9.3 (3°12′)	8.5 (3°24′)	7.9 (3°36′)	7.4 (3°48′)	7.0 (4°)	6.4 (4°24′)	6.0 (4°48′)	5.7 (5°12′)	5.4 (5°36′)	5.2 (6°)
Difference for 1 ma.			35.754 2°3′	18.316 2°6′	12.504 2°9′	9.598 2°12′	7.854 2°15′	6.6916 2°18′	5.8613 2°21′	5.2385 2°24′	4.7541 2°27′	4.3667 2°30′	3.7854 2°36′	3.3702 2°42′	3.0588 2°48′	2.8167 2°54′	2.6229 3°
Difference for 1°			19.502 1°7′	10.088 1°9′	6.820 1°10′	5.235 1°12′	4.284 1°14′	3.650 1°15′	3.1971 1°17′	2.8574 1°18′	2.5932 1°20′	2.3819 1°22′	2.0648 1°25′	1.8383 1°28′	1.6685 1°32′	1.5364 1°35′	1.4307 1°38′

The object of observation is presumed to be ⅓ metre from the centre of rotation of the globe.
The figures in larger type give the amount of decentration in millimetres.
—ve sign indicates decentration outwards ; +ve sign decentration inwards.
The figures in smaller type represent the deviating power of the prisms whose action is equivalent to that of the decentration of the lenses. When enclosed in brackets the prisms are abducting in function, and should be placed edges inwards.