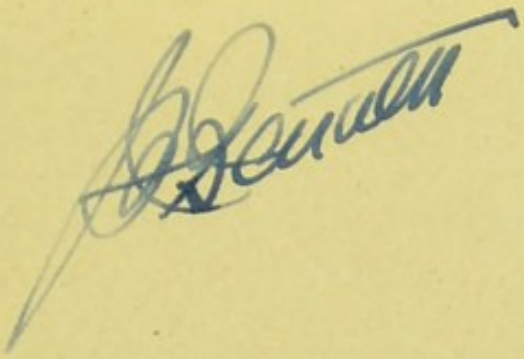
Stereoscopic treatment of heterophobia and heterotropia : designed to accompany the phoro-optometer stereoscope and the Wells selection of stereoscopic charts / by David W. Wells.

Stereoscopic Treatment of Heterophoria and Heterotropia

David W. Wells, M.D.



STEREOSCOPIC TREATMENT OF HETEROPHORIA AND HETEROTROPIA

Designed to Accompany the Phoro-optometer Stereoscope and the Wells Selection of Stereoscopic Charts

By

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PREFACE.

Concerning the clinical importance of heterophoria ophthalmologists are not agreed. As a protest against the extravagant claims made by some enthusiasts, there has arisen a class of eminent practitioners whose members absolutely ignore the subject and omit all tests for imbalance, unless there exists actual heterotropia. The author believes he occupies a middle ground, and that the opinions herein expressed are conservative.

The orthoptic treatment of heterotropia is not always successful, but there is a growing conviction that the surgeon who rests content with securing a cosmetic cure has not discharged his whole duty to his patient.

It is unfortunately still true that the majority of heterotropic cases are not seen by the ophthalmologist until the condition is quite firmly established. No opportunity should be lost to warn the family physician that the time to begin treatment is the minute the deviation is noticed.

Believing that the cases of heterophoria requiring relief are much more numerous than those of actual heterotropia, the greater part of this essay will be devoted to the former condition.

For the benefit of the beginner in ophthalmology a brief summary is given of the important points of binocular vision, the factors upon which depends orthophoria, the causes of heterophoria, and a discussion of the different methods of testing. While the treatment here presented is principally stereoscopic fusion training, other adjuvants are advised. The stereoscopic method is outlined with considerable detail, and is the result of several years' experience. It is earnestly hoped that many others may find in the phoro-optometer stereoscope and the charts here described that same degree of satisfaction which they afford to the author.

If the instructions seem more didactic than is consistent with good taste, he can only plead that he is attempting to lay before the reader his own method, and would gladly welcome any suggestions for improving it.

Believing that the limitations of the orthoptic treatment of heterotropia should be thoroughly understood, the indications for operative interference have been briefly stated.

D. W. W.

Hotel Westminster, Copley Square, Boston, Jan., 1912.

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CHAPTER I.

BINOCULAR VISION.—LAW OF CORRESPONDING POINTS.—SEMI-DECUSSATION.—FUSION FACULTY.

BINOCULAR single vision is a rather intricate psychic faculty dependent on certain exact physical conditions. With each eye we see a separate object and, according to the law of corresponding points, it is necessary that the images of the object fall upon corresponding points of the two retinæ in order that single binocular vision may be realized. For central vision these points are the two maculæ, and for peripheral vision these points must be equally to the right, to the left, above or below the two maculæ.

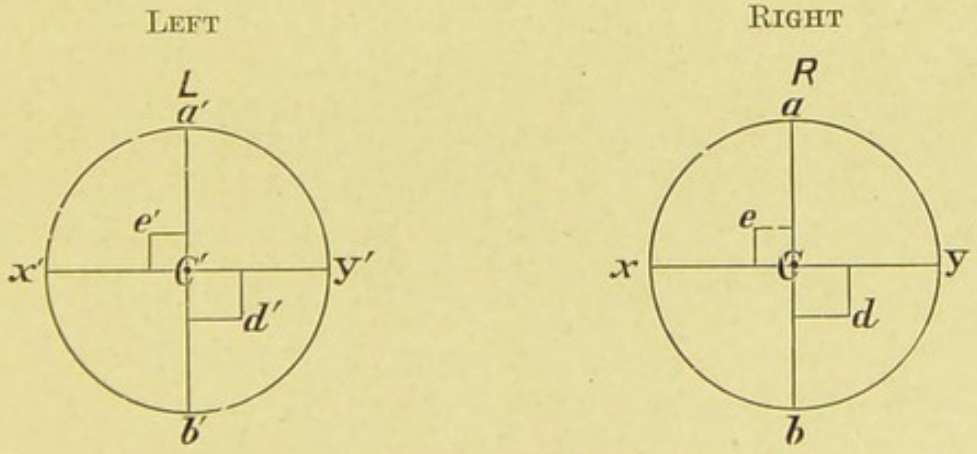

FIG. 1.—CORRESPONDING RETINAL POINTS. (LE CONTE.)

The field of binocular single vision is that portion of the two fields which can be seen by both eyes simultaneously, the projection of a single impression depending upon the semi-decussation of the fibers of the optic nerve, which occurs only in man and the higher apes. Semi-decussation is, therefore, the first physical essential.

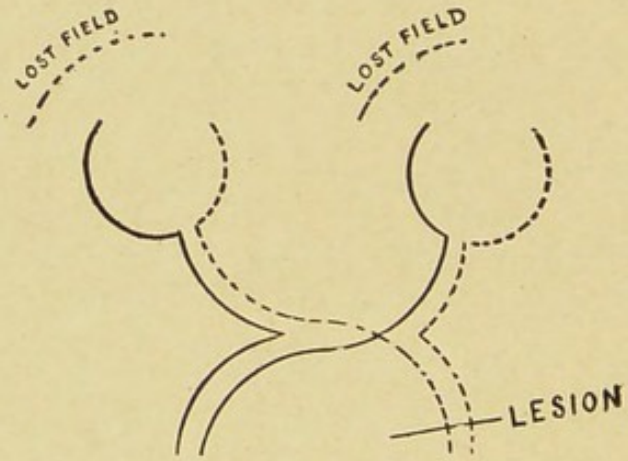

FIG. 2.—SEMI-DECUSSATION OF OPTIC NERVE.

To explain this, and the clinical facts of hemianopsia, it is assumed that at the chiasm each neuron divides into two, one of which crosses to the nasal side of the opposite eye, while the other goes to the temporal side of the eye on the same side, the end organs occupying corresponding points in the two retinæ.

A second physical requisite is the perfect coordination of the twelve extrinsic muscles,

that the eyes may be so directed to any point in the binocular field, that the images shall fall on corresponding points.

When it is realized that a deviation of less than a millimeter* in the position of corresponding points means diplopia for small objects, it is almost inconceivable that any mechanics alone could secure the desired result.†

THE FUSION FACULTY.

According to Worth, sight in the newborn is limited to fixation of a light so that all the finer qualities are the result of personal experience. The involuntary movements of the eyes of infants would show that there is no conception of binocular vision. The full development of the fusion faculty is not attained till the fifth or sixth year with the normal child.

Physiological diplopia means that objects nearer or farther than the point fixed are

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*According to Suter: "Refraction and Motility of the Eye," page 142. "The fovea centralis, upon which falls the image of every object attracting mental attention, does not exceed 0.4 mm. in diameter." Taking the distance of the nodal point in front of the retina to be 15 mm. Dennett, of New York, has shown by theorem of similar triangles, that, at a distance of one-half meter, an object to be discerned with normal acuity cannot exceed 13.5+ mm. in diameter.

†Sanford: "Experimental Psychology," page 106.

always seen double, but the adult has so far succeeded in ignoring this, that it is sometimes difficult to make him realize the doubling.

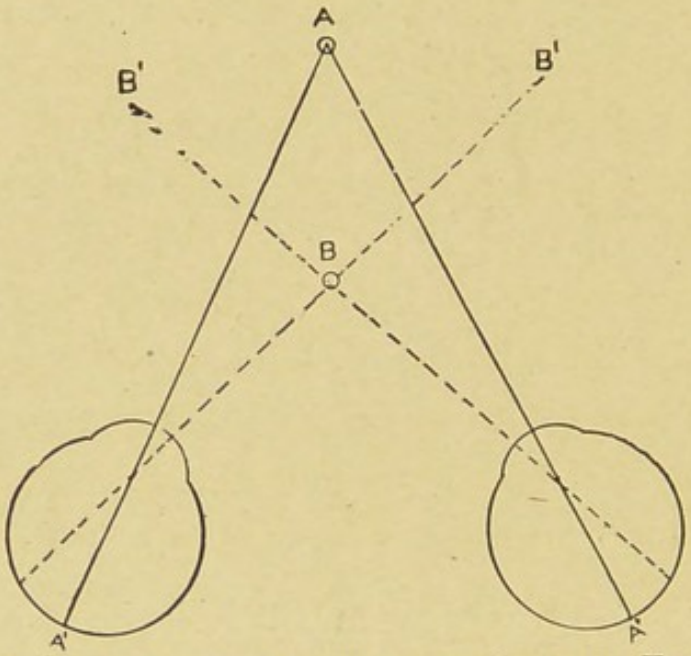

FIG. 3.—PHYSIOLOGICAL DIPLOPIA OF OBJECTS FARTHER OR NEARER THAN THE POINT FIXED.

THERE can be little doubt that this fact plays a very important role in the child's experience, the fusing at different distances developing the idea of perspective. Omitting the few cases of congenital defect, strabismus, better called heterotropia, if we adopt the more recent nomenclature, begins between the ages of one and four, a time during which the fusion faculty should be developing. The significance of this fact in the treatment of this condition has been

so ably presented by Worth that the reader is referred to his classic treatise on Squint.

The argument is here introduced to emphasize the fact that the third essential to binocular single vision is the psychic one of the fusion faculty. Without such an overruling guidance the necessarily exact coordination is inconceivable.

A discussion of the academic question of the existence of a fusion *center* is not essential to our purpose, and those interested are referred to Savage, "Ophthalmic Myology," and "Ophthalmo-neuro-myology"; Duane, "The Extra Ocular Muscles," in Posey & Spiller's "Eye and Nervous System."

The frequent clinical experience, that loss of sight of one eye is frequently followed by divergence, is an unanswerable argument for the importance of the fusion faculty in keeping eyes straight and it is the purpose of this writing to show that it plays quite as important a part in the production and the cure of those *tendencies* to turn, grouped under the name heterophoria. Even Stevens, who did such pioneer work in calling attention to heterophoria as a cause of asthenopia and reflex nervous disturbances, has devoted himself entirely to the physical side of the subject.

CHAPTER II.

ORTHOPHORIA.—HETEROPHORIA.—STEVENS' PHOROMETER.—SAVAGE'S MONOCULAR PHOROMETER.—WELLS' HANDY PHOROMETER.—PRENTICE-WILLIAMS' PRISOMETER.—SCREEN TEST.—DUCTION.—CAUSES OF HETEROPHORIA.—SYMPTOMS OF HETEROPHORIA.

ORTHOPHORIA—right tending—is the condition where both eyes *tend* to look at the same point at all distances. Those who believe in the disturbing influence of kataphoria and anaphoria would dissent from calling this a condition of perfect muscle balance. While orthophoria necessitates normal orbits, proper strength, insertion and nerve supply of muscles, it is also influenced by other factors. Sight requires accommodation for all distances from ten inches to infinity, and fixation of the two eyes upon this spot. This is a most beautiful example of coordination, but is easily disturbed by an abnormality of accommodation, which may be in the ciliary muscle itself, or in a refractive error which necessitates abnormal accommodation for its correction.

It therefore follows that muscle tests should be made with the patient wearing his correcting

glasses, and also without, so that the *influence of the refractive error* may be determined. As absolute perfection is not to be expected, it would be advisable to adopt a minimum error which might still allow the classification orthophoria.

HETEROPHORIA—cross or wrong tending—is the condition of most of the human family if sufficiently careful tests are made. It would, therefore, be desirable to adopt some standard which recognizes a minimum of error to warrant the term heterophoria.

Only the principal forms, esophoria, tendency in; exophoria, tendency out, and hyperphoria, tendency of one above the other, will be here considered. Cyclophoria, a twisting tendency; anaphoria, a tendency of both eyes above the normal level; kataphoria, a tendency of both eyes below the normal level, are conditions which the writer does not feel qualified to discuss, much less to treat stereoscopically.

METHODS OF TESTING.

Stevens' phorometer is probably most universally used. Savage objects to this method because both images are artificially displaced.

The Savage monocular phorometer consists of a rotary prism and a displacing prism *before*

the same eye. This, he says, prevents the eye which is in the primary position from participating.

The same result is obtained with the Wells' handy phorometer, which consists of a single ten-diopter prism and a weighted disc.

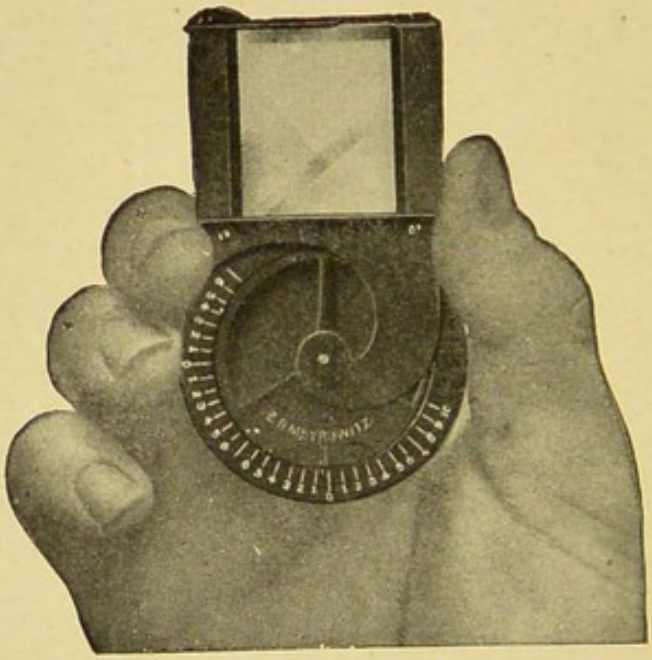

FIG. 4.—WELLS' HANDY PHOROMETER.

When the prism is tilted till the double images are horizontal or vertical the index on the disc indicates the amount and kind of heterophoria. This instrument is not intended to measure fractions of a prism diopter.

The Maddox rod is a very accurate test. A test which diagnoses and measures the error at

the same time is one devised by Charles F. Prentice, of New York, in 1890. It is based on the principle that a prism of 1$^{\Delta}$ causes a deviation of 1 cm. at 1 m., 5 cm. at 5 m., etc. It is, therefore, constructed for any distance, 5 or 6 m.*

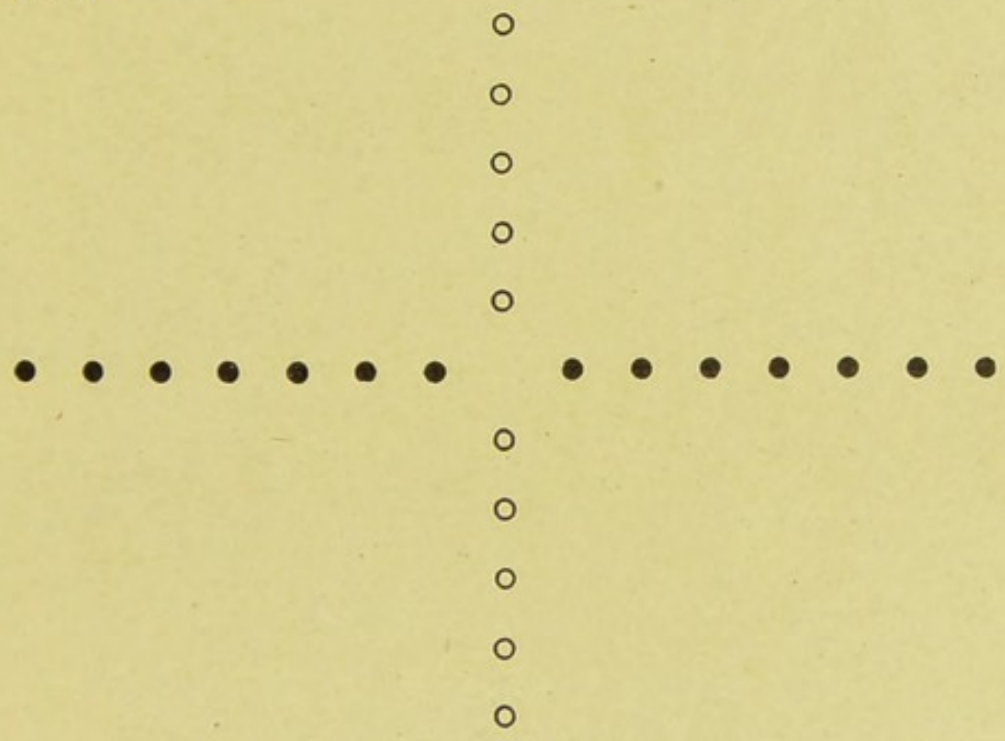

FIG. 5.—PRENTICE PRISMOMETER AND PHOROMETER.

The Wells apparatus, which has been in use since 1891, is copied from Prentice and consists of lights 1 cm. diameter, 5 cm. between centers, on the wall 5 m. from the patient.

*Prentice: "Ophthalmic Lenses"—Shows that for exact tangent measurement of prism diopters, a 6 m. distance is essential.

Vertical lights are green—horizontal lights red. Patient is armed with red glass before one eye of sufficient color to obscure the green, green glass before the other eye of sufficient depth of color to obscure the red. If red glass be before right and green before left, right eye will see horizontal red lights and left eye vertical green lights.

If orthophoria exists a perfect cross will be seen as if both the colors were seen by one eye. If exophoria, green lights will be displaced to the right, *one spot for each prism diopter.* If only two red lights are seen to the right of the green, patient has 5^{Δ} of exophoria. Red line seen on a level with the first green spot below the center indicates 1^{Δ} right hyperphoria. Williams, of Boston, has improved this test by substituting luminous figures for the round spots, the arrangement being such that the tendency to *"horizontalize"* or *"verticalize"* is entirely eliminated. The theoretical superiority of this test is that it obviates the necessity of distorting, blurring or displacing either retinal image.*

By all of these tests quite similar results

*The writer has fallen into the habit of calling this the chromatic test. It might be called the "red and green," or perhaps the Prentice-Williams', unless someone has prior claim.

should be obtained, but in one's record the particular tests employed should be indicated.

The cover or screen test is quite generally employed, and consists in alternately covering each eye with a card, while the patient fixes a distant light. The eye behind the card deviates if orthophoria does not exist, and recovers its fixation when the other eye is covered. Prisms held before one eye until all motion stops, measure the amount of the error. This method the writer learned from Suffa, of Boston, in 1895.

This cover test differs from all of the others in that it is a strictly monocular test, and the influence of the fusion faculty is entirely eliminated. It is argued by the advocates of this method that it most truly reveals the real tendency.

In cases of high degree of heterophoria, or occasional heterotropia, the movement of each eye *behind* the screen should be observed—noting which recovers its fixation the more quickly on removing the screen. Obviously this is the favorite eye, and the one that lags will be the one that is suppressed in the tests of fusion to be given later.

DUCTION.

Whether the case be one of orthophoria or heterophoria it is important to know the strength of the recti muscles, as many orthophoric patients have such weak muscles that they are unable to do continuous work without asthenopia or nervous disturbance.

Normal accommodation means that each eye shall be able to focus an object as near as 8 to 10 cm. If the pupillary distance be 60 mm., convergence to this distance requires 60$^{\Delta}$. If the average reading distance be taken as 30 cm., 20$^{\Delta}$ would be used.

As the comfortable maintenance of accommodation at 30 cm. requires an *ability* to accommodate at 10 cm., so the convergence faculty must be much greater than the amount habitually used.

Cross,* of Worcester, Mass., "believes that if the fusion range is not at least twenty per cent. in excess, there are apt to be more or less asthenopic symptoms."

Landolt† says, "We have tried to determine the quota of convergence, and our experience

*Personal communication.

†"Norris and Oliver System of Eye Diseases," Vol. IV, p. 133.

seems to demonstrate that this *reserve* amount ought to be about twice as great as the convergence required by the work."

Evidently the amount of reserve convergence necessary varies with the hours of application. It is certainly conservative to say that the actual power should be double that ordinarily used.

Duction is measured by the power to overcome prisms and maintain single vision. Loose prisms from the trial case may be used until the limit is reached, but the rotary prism is more convenient.

Howe* has maintained that the accurate measurement of duction requires the use of prisms in reverse direction, beginning with one *beyond* the patient's ability to overcome, and working down to weaker, until the strongest which can be fused is found. This method was adopted by the A. M. A., 1907, as the standard, which, it would be understood, had been employed when cases were reported to the society.

The writer pleads guilty to having continued the old way, but admits that repeated trials often give quite different results, showing increasing power.

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*"The Muscles of the Eye."

Although there is no general agreement among the writers on this subject, it is probably conservative to consider 24$^{\Delta}$ as normal duction for the interni, 8$^{\Delta}$ for the externi.

CAUSES OF HETEROPHORIA.

There are five generally accepted causes of heterophoria:

First. The malformation of cranium and orbits.

Second. Abnormal power, weakness or strength of one or more muscles.

Third. Tendons too long or too short.

Fourth. Insertions of tendons too far farward or back.

Fifth. Errors of refraction.

But it is the author's belief that a sixth cause, very generally overlooked, is an incomplete development of the fusion faculty. This does not mean that the patient possesses *no* fusion sense. Fusion faculty is a question of degree. Many true strabismics have a rudimentary fusion power. The great majority of people can fuse large stereoscopic pictures, but many fail conspicuously when given type of the size ordinarily used. If only a slight suppression of one is detected during the test, we must remember

that the very conditions of the test *force* the patient's *attention* to the separate objects for the two eyes, and that under ordinary conditions suppression is probably much more habitual.

It is also important to discover the amplitude of fusion. Many patients who possess a high degree of fusion faculty with the stereoscope adapted *exactly* to their normal balance, show but little power to overcome the slightest obstacle. Such cases cannot maintain correct fusion under the varying conditions which the ordinary use of the eyes imposes.

SYMPTOMS OF HETEROPHORIA.

Errors of refraction and heterophoria are so often co-existent that it is difficult to assign to each factor its distinctive symptoms.

Not until the refraction has been determined under a cycloplegic can one be *certain* in any given case that symptoms quite characteristic of hetrophoria are not produced by the refractive error. Clinical experience in relieving a certain train of symptoms, which have persisted after correction of refraction, by treating the heterophoria, is the basis for the opinion here expressed.

In the order of importance the author would arrange the symptoms as follows:

Confusion.—No localized head pain, or pain may be referred to the suboccipital region or upper part of back. To the question, "In what part of the head is the disturbance?" the reply, "Oh, I don't know, all over," is so frequent that it is well nigh pathognomonic. Inability to fix one's mind on study or reading is a frequent complaint.

Difficult Fixation.—If esophoria, of a distant object like a public speaker. If exophoria, annoyance in conversation in trying to "look one in the eye."

Vertigo.—Of mild type, probably better expressed by the word confusion.

Drowsiness—after reading but a short time.

General Nervous Disturbance.—This is a very large and somewhat dangerous subject, but it is certainly conservative to say that heterophoria is frequently *a factor* in migraine, "nervous dyspepsia" and epilepsey. How small an error may give rise to symptoms is a matter of idiosyncrasy. The same may be said of refractive errors.

For a further discussion of this subject, the reader is referred to Stevens, "Functional Nervous Diseases" (1884); Howe, "The Muscles of the Eye" (1907).

CHAPTER III.

TREATMENT OF HETEROPHORIA. — PRISMATIC GLASSES. — OPERATIVE. — MUSCLE TRAINING. — FUSION AND MUSCLE TRAINING.—PHORO-OPTOMETER STEREOSCOPE.

TREATMENT OF HETEROPHORIA.

Ordinarily the *time* for treatment is not until after the correction of the refractive error, as this alone may suffice to cure the heterophoria, and, as a general rule, with patients under thirty-five, not until the use of a cycloplegic has excluded latent refractive error. If the refractive error be slight as compared with the heterophoria, one is justified in treating the heterophoria and ignoring the refractive error. If the treatment be by other means than the wearing of prisms, the patient is naturally quite pleased to be relieved without being condemned to wearing glasses.

METHODS OF TREATMENT.

First.—The wearing of prismatic glasses, simple or combined with the refractive correction, the prisms so placed as to correct all or part of the heterophoria. This is often quite

satisfactory in the low degrees and may even reduce the error, but it usually has the opposite effect.

This increase is believed by many to be the simple uncovering of a latent tendency. In esophoria the liability to increase is greater, so that one may regret the procedure.

The use of prisms in the reverse position, to stimulate the defective muscle, has been advocated by some. The author's few attempts to follow this suggestion have not been sufficiently promising to warrant continuance.

Second.—Tenotomies and Advancements.

In the higher degrees (more than 10^{Δ} of exophoria or 5^{Δ} of esophoria) surgical interference is justified. For the indications the reader is referred to the advice of Jackson in "Wood's System of Ophthalmic Operations."

Although the writer has a number of successful tenotomies to his credit. the result in esophoria and exophoria has, on the whole, been unsatisfactory—usually insufficient. For extreme degrees of exophoria 20^{Δ}-25^{Δ}, advancement of the weak muscle gives good results. (The author is strongly in favor of advancement over tenotomy in nearly all cases of heterotropia.) Certain it is that all surgery should be deferred

until fusion and muscle training have been thoroly tried.

Third.—Muscle Training.

This has been used principally for exophoria. Gould arms the patient with a pair of prisms bases out, 10$^{\Delta}$ stronger than he can fuse. Eyes are closed, and on opening he fixes a candle held 10 to 20 inches away. The accommodation assists the convergence and two lights are fused. Candle is carried to opposite side of room while patient holds images fused. This process is repeated with increased strength of prisms till diplopia results.

Payne, of Boston, gives patients o. u. pr. 4$^{\Delta}$ to 8$^{\Delta}$ base out in a spectacle frame for home use. Candle is placed on opposite side of the room. This the patient fuses counting ten slowly, the spectacle is raised and count is continued to twenty, still fixing the light. Prisms are lowered and count continued to thirty, raised and count to forty. This process is continued to one hundred and twenty, which should require about two minutes.

Loose Prisms.—It has been a very common practice to supply the patient with half a dozen loose prisms from 3$^{\Delta}$ to 35$^{\Delta}$, so that by combinations he can use an amount gradually increased

3△. With these held before the eyes he fuses the two images of a candle across the room.

After noticing several patients allow an eye to deviate outward, suppress its image, and then declare they saw one, the writer decided that loose prisms could be used safely only *under the eyes of the oculist.* If there were any practicable way of utilizing binocular conceptions at a distance this objection might be overruled.

FUSION AND MUSCLE TRAINING.

The use of the stereoscope in after treatment of cases operated on for strabismus has been advocated by Smith with his fusion tubes, by Landolt with a modified form of stereoscope, having an arrangement for reducing the illumination of the object seen with the fixing eye, and by the late Richard Derby, who devised a stereoscope with movable object carriers.

Worth devised the amblyoscope, a reflecting stereoscope, with which fusion is possible, notwithstanding a high degree of esotropia, as a means of curing this condition in the young.

In 1896 Javal brought out his great work "Manuel du Strabisme." He seems to have been the first to adapt the principle of the stereoscope to "latent strabismus," or heterophoria,

and to him the writer feels most indebted. It was his stereoscope with five adjustments that suggested the utilizing of the phoro-optometer for the same purpose. It seems incredible that a work of such great merit should not have appeared in English.

His charts, graded from easy to difficult, opened up an entirely new and practical field in fusion training. In 1904 some of these were reproduced in English in the "Wells Selection of Stereoscopic Charts." Most of the other charts, like Kroll's, Dahlfeld's and Hale's, were adapted to secure only the rudiments of binocular vision.

Much good work can doubtless be done with an ordinary stereoscope, but in order to carry out the author's methods one must have a phoro-optometer, with two rotary prisms and the stereoscopic attachment. The phoro-optometer had been in constant use several years before its adaptability as a training stereoscope was discovered.

The first apparatus was made with an adjustable focus so that spheres from +5.00 to +10.00 could be used. This was later discarded and a permanent distance of 10 cm. used. With this +10. spheres are always in focus.

Following the model of the late Dr. Richard Derby, adjustable object carriers were provided, with somewhat elaborate mechanism for vertical adjustment and an endless screw for approximating and separating them. This was essential to secure a gradual and smooth movement, otherwise the eyes ceased to follow and fuse the two objects.

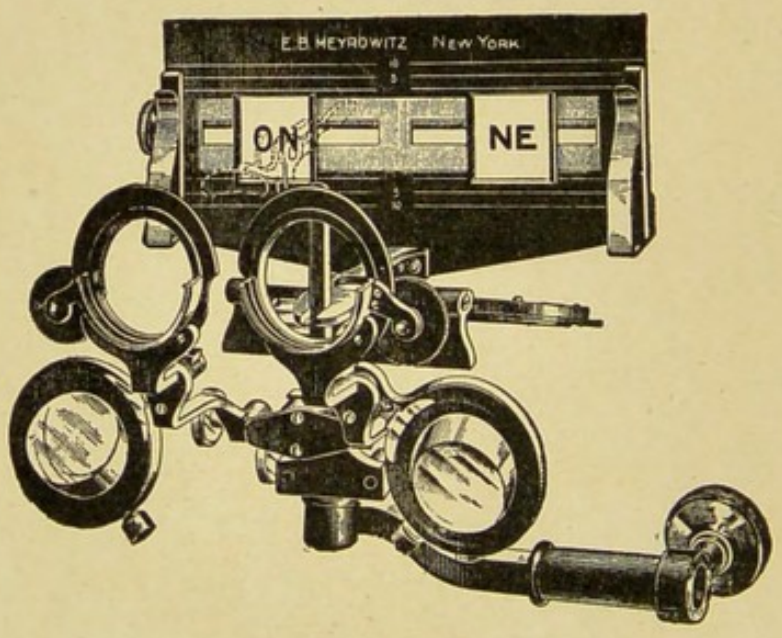

FIG. 6.—PHORO-OPTOMETER STEREOSCOPE.

After using this arrangement some time, it was discovered that patients who found great difficulty in keeping the objects fused as the carriers were approximated, were much less disturbed if the spheres were separated by turning the screw for pupillary adjustment, and that

a much greater degree of prism could in this way be fused.

The Wells stereoscopic attachment to the phoro-optometer illustrated in "Meyrowitz Bulletin," 1903, shows the movable object carriers, but in the author's instrument they soon became fixed at 6 cm. apart.

It was later discovered that if one were a little

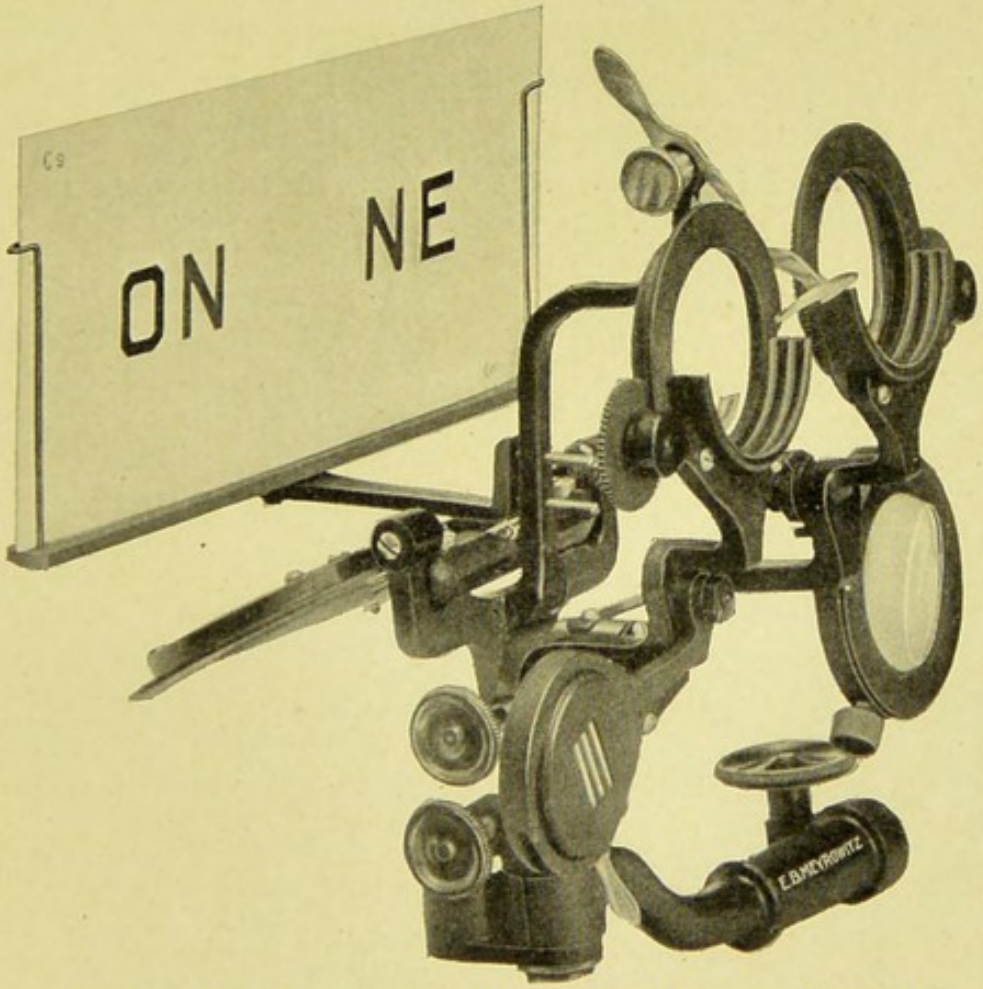

FIG. 7.—NEW PHORO-OPTOMETER STEREOSCOPE SHOWING SIMPLE CLIP TO HOLD CARDS.

careless in fixing the objects in the carriers, a slight tilting or vertical error interfered with fusing, so the object carriers fell into disuse and stereoscopic cards were used instead. The improved form is, therefore, simply the addition to the phoro-optometer of a clip to hold the cards.

In 1904 the Wells selection of stereoscopic cards was published. This was a selection of the most useful from those previously brought out by Kroll, Dahlfeld, Hale and Javal. Only a few new cards were added by the writer.

A second edition has now become necessary. The new edition includes some very ingenious tests in fusing complementary colors by Dr. George A. Shepard, of New York, and a new set for amplitude training by the author. The lettering and grading have been somewhat changed.

To guard against any misunderstanding the *reader should bear in mind* that in the instructions which follow, the letters and figures refer to the second edition, which is being published at the same time with this book.

DECENTERING SPHERES TO SECURE PRISM.

The application of the principle of decentering of the spheres for the purpose of introduc-

ing extra prismatic effect, as applied to fusion training, is believed to be original with Javal,* but it has been greatly extended by the author, and its superiority over any other method known to him justifies a somewhat detailed description.

With o. u. +10., cards at 10 cm. are in focus. If the separation corresponds to that of the pupillary distance of the patient's eyes, no prismatic element is exhibited. If decentered 1 mm., 1$^{\Delta}$ approximately is produced. Thus +10. spheres make the calculation of the prism extremely simple. If the spheres are decentered out 5 mm., we have put before the patient 5$^{\Delta}$ of prism base out, just as truly as tho a 5$^{\Delta}$ prism were inserted in the clip. If the spheres are decentered *in* 5 mm., 5$^{\Delta}$ base in is obtained. As the pupillary adjustment may be varied from 50 to 75 mm., it follows that 10$^{\Delta}$ or more may be utilized by this simple principle of decentration.

*"Manuel du Strabisme," p. 115.

CHAPTER IV.

STEREOSCOPIC TREATMENT OF EXOPHORIA.—AUTHOR'S CARD FOR MEASUREMENT OF STEREOSCOPIC HETEROPHORIA.—AMPLITUDE OF FUSION.—RECOVERY EXERCISES.—HOME EXERCISES.—THE SUPPRESSED EYE.—CONTROLLED READING.—AUTHOR'S DEVICE.—NUMBER OF CASES TREATED AND RESULTS.

STEREOSCOPIC TREATMENT OF EXOPHORIA.

Let us suppose a case of exophoria of 10^{Δ} distance, adduction subnormal, greater convergence faculty needed. With o. u. +10. in the clips, centered to correspond to patient's pupillary distance, card marked B_1 is put in clip, and

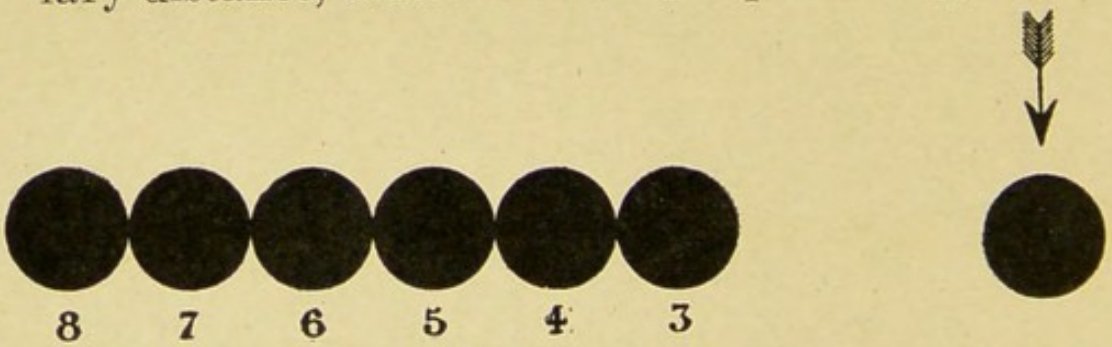

FIG. 8.—B1.

the patient is asked over which dot he sees the arrow. He will probably answer "five" or "between five and six." If five, this means that he has selected the number five spot with which

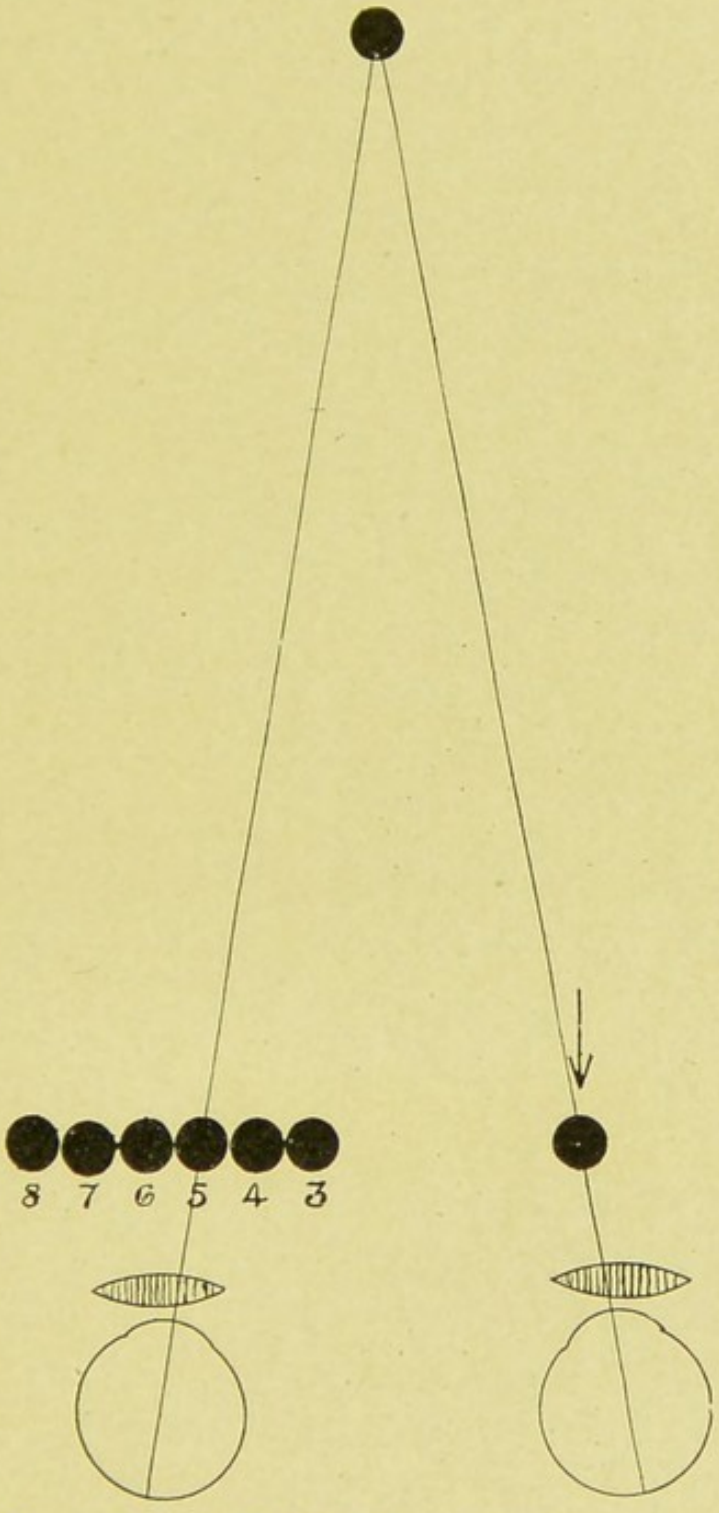

FIG. 9.—SHOWING THE LINES OF SIGHT WHEN THE PATIENT SEES THE ARROW OVER 5.

to fuse the arrow spot, therefore 5 cm. is the patient's easiest fusion distance with o. u. +10. Glasses correcting the refractive error should, of course, be worn and if there is much presbyopia, the o. u. + 10. should be made enough stronger to correct it. This will slightly increase the prismatic effect of the decentering.

Eyes are closed and the two rotary prisms swung into position to give o. u. 5^{Δ} base out. Patient opens his eyes and again states position of arrow. If over six the amount of prism which makes six centimeters the easiest fusion distance has been found. If not correct one or two trials will secure it. Should arrow be seen between six and seven, less than o. u. 5^{Δ} is required; should it be seen between five and six, more than o. u. 5^{Δ} is needed.

As all the cards, except series H. B and I, are 6 cm. between centers, the stereoscope is now approximately suited to this particular patient, and we, therefore, proceed to test his fusion faculty. Unless the case be one of anisometropia or amblyopia, it is well to begin with series F.

Patient should see the vertical line passing through the dot. If the line, which is seen by the left eye, is too far to the right; that is,

heteronomous diplopia, the prism base out should be reduced till the direct alignment is secured. If the line be to the left of the dot, it is evident that the reverse is indicated.

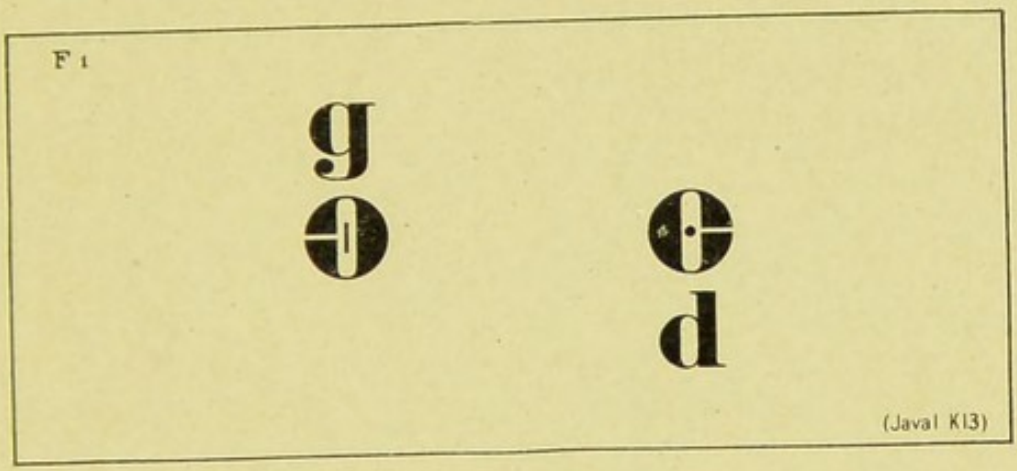

FIG. 10.—F1.

By means of the card B_3 the exact prism needed may be determined. Obviously it is the amount with which the patient sees the lines intersect at six, but the cruder method with B_1 is preferable in the beginning.

B_3 is designed especially for the accurate measurement of *stereoscopic hyperphoria,* which is often quite different from that shown by other tests. The divisions of the red vertical line are 5 mm. apart. If the black horizontal line is seen to cross the red vertical line at H, 5^{Δ} right hyperphoria is exhibited. Hyper-

phoria may interfere with fusion. It is then necessary to correct all or part of it with a vertical prism in the clip.

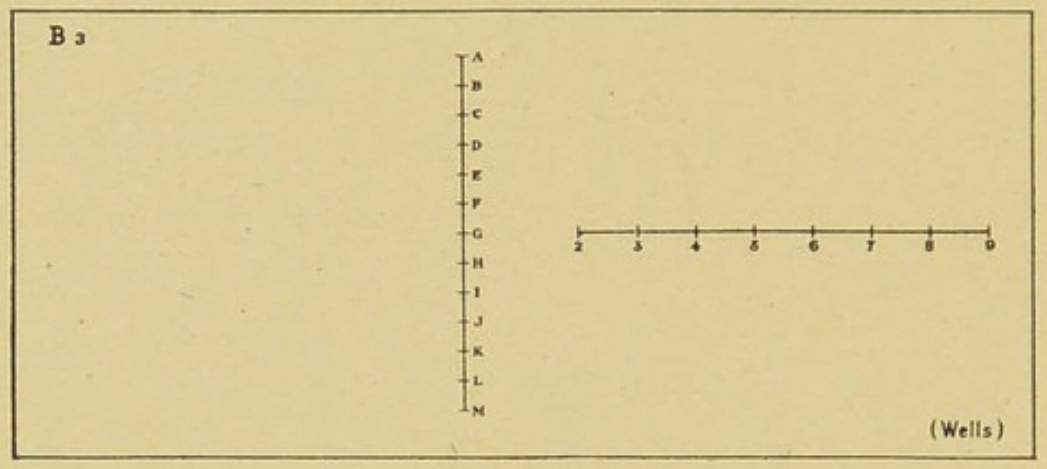

Fig. 11.

Patient's eyes are closed (unless otherwise stated, it is to be assumed that patient's eyes are always closed before each change) and succeeding numbers of F used in numerical order. It should be noted if either eye fails to see its respective lines and dots, and if suppression occur, whether it be always of the same eye or of alternate, right and left. Let us suppose that, beginning with F_4, the left eye fails to see the line or dots belonging to the left picture, altho the letters are correctly read.

The case should be recorded:

"Stereoscope + 10. = 5 cm., ⊂ Pr. o. u. 5$^{\Delta}$ B out = 6 cm. Suppresses Left $F_{4, 5, 6, 7, 8}$."

This test might have been made with C_9 or series G, but it has been found that series F furnishes quicker and more reliable information.

Series E is devoted to perspective.

If with E_1, the antero-posterior relation of the dots is correctly stated, the subsequent numbers are tried in order. If E_5 is not correctly seen, to the record is added "E, o. k. to 4" or "Fails E_5."

AMPLITUDE OF FUSION.

C_7 is now put in place, and as the N's are just six centimeters between centers, the two N's are perfectly fused and the patient reads " O N E."

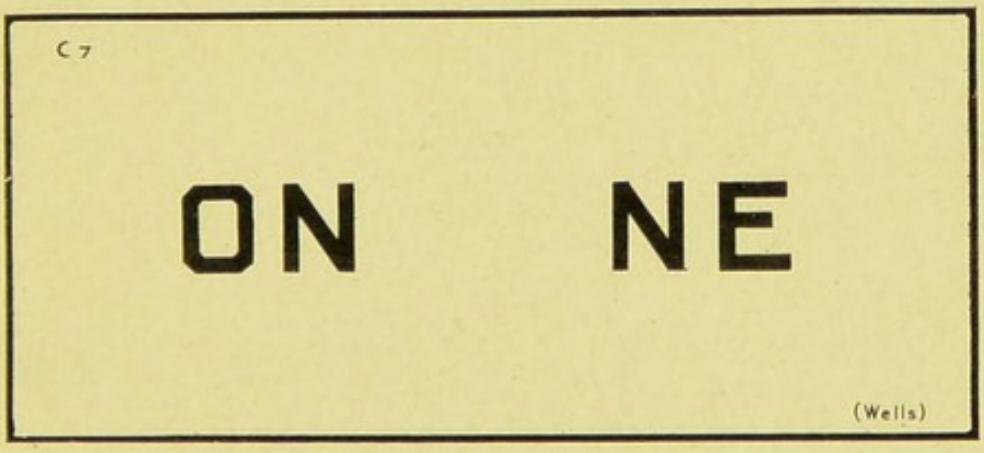

FIG. 12.—C7.

Now while the patient watches the fused image, the P. D. of the spheres is increased by gradually turning the screw to the limit (75 mm.

P. D.). Eyes are then closed and P. D. of spheres is reduced to minimum (55 mm.). 5^{Δ} more, making 20^{Δ} in all, is now turned up in each prism. Patient will fuse this easily—but let us note just what has been accomplished.

Assume P. D. = 60 mm., then he has fused 20^{Δ} less $5^{\Delta} = 15^{\Delta}$. As 10^{Δ} was required to bring the arrow over six on the B_1 card, 15^{Δ} less $10^{\Delta} = 5^{\Delta}$ = effort put forth. This process is repeated, adding from 5^{Δ} to 10^{Δ} each time till the "ONE" breaks apart before the spheres are fully separated. If this occur, using o. u. Pr. 25^{Δ}, when spheres show 65^{Δ} P. D., record should read, "amplitude 'ONE' or C_7 55^{Δ}."

Much can be learned by watching the patient's eyes over the top of the phoro-optometer. Usually they both converge equally, but occasionally one eye will participate but little, and this will be the eye which is suppressed in the finer tests of fusion faculty. The treatment of this condition will be taken up later, but it is here noted to emphasize the importance of observing all the conditions.

In this particular, this form of stereoscope overcomes a serious objection to the amblyoscope, because with the latter, the eyes cannot be watched, and we must depend on the patient's

statements, which are naturally very unreliable, especially when treating children.

But to return to our case:

The limit of fusion would be perhaps 40$^{\Delta}$-50$^{\Delta}$ on this first trial. Phoro-optometer is then removed and loose prisms held before the eyes base out, and strength increased until the limit for fusing a distant light is reached.

Pneumo massage or fine Faradic electricity is given. The pneumo massage is more agreeable to the patient. It may be that this has no further importance than the soothing and suggestive effect.

This whole treatment requires 15 to 25 minutes, and is given three times a week for three weeks, or until sufficient power has been attained. After the 60$^{\Delta}$ of the two rotary prisms has been fused, round prisms from trial case are inserted in the clips. It is practicable to use as high as 10$^{\Delta}$ before the right eye and 20$^{\Delta}$ before the left. This furnishes 90$^{\Delta}$ in all without any decentering. Just what constitutes sufficient power is not a fixed amount for all cases. Successful ones average 80$^{\Delta}$ to 90$^{\Delta}$ with the phoro-optometer stereoscope, and 50$^{\Delta}$-60$^{\Delta}$ loose prisms. Many, especially the younger, will develop an amplitude of over 100$^{\Delta}$, both with

stereoscope and loose prisms. When sufficient power has been gained, time between treatments is gradually lengthened to two a week, one a week, one in two weeks, etc., provided the maximum reached at previous visit is still attainable.

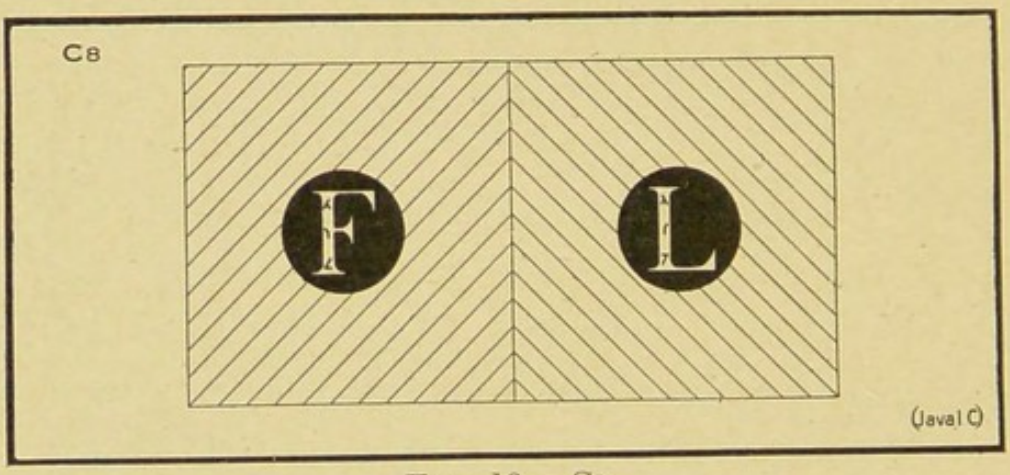

FIG. 13.—C8.

It may be well to try the holding power of other cards, especially the L, F, the fusion of which makes E, but it is believed that the ONE gives the greatest mental stimulus, as one's sense of proportion is disturbed at seeing the letters break apart.

RECOVERY EXERCISES.

The treatment is sometimes varied by what the writer calls the recovery exercise. With C_7 a few trials at decentering are made, the eyes allowed to close when the fusion limit is reached,

and then the patient is told that this time his eyes are to remain open, that he must speak the instant he feels that he is about to lose his fused image, and that the prisms will be turned to help him get it clear again. It requires several trials before he can overcome the tendency to close the eyes, and then the prisms will need to be reduced very much before he will say "all right, I have it now."

After six or eight trials the recovery will be very much quicker and will require only a slight reduction of prism. It is believed that this exercise has considerable practical value in teaching the patient to overcome the slight turning tendencies, which may annoy him in reading.

HOME EXERCISES.

The patient is required to buy a Holmes' stereoscope with clips for inserting extra prisms, and a set of the Wells' stereoscopic charts. It is important that the patient own these, as he is expected to use them occasionally for some months, to insure his retaining his newly acquired faculty. These charts are not to be used indiscriminately, but in accordance with very exact instructions.

If at first examination the case showed a fair

degree of fusion faculty, seeing half the cards in series F, G and E, he is given F and G to use in numerical order, stopping when a few seconds fail to secure perfect fusion of the letters. This exercise requires ten to fifteen minutes and should be done three times a day.

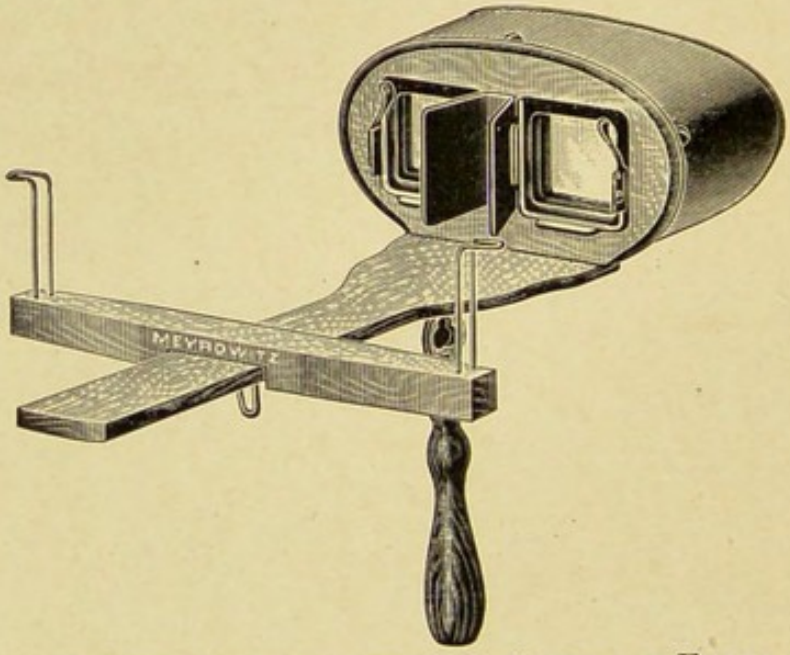

FIG. 14.—HOLMES' STEREOSCOPE WITH CLIPS FOR EXTRA PRISMS.

After second visit, series E may be added to homework with instructions to run rapidly through F and G. When these cards, which are 6 cm. between centers, are mastered fairly (not necessarily perfectly), series H and I are to be used in the following manner: Patient inserts B_1, notes position of arrow and selects the same

number of series H or I to begin with. For example, if with B_1 arrow is seen over six, H_6 is the first to be used. This will be fused with ease, as it is the distance between centers to which patient and stereoscope are adjusted. The order is now toward the smaller number, $5\frac{1}{2}$, 5, $4\frac{1}{2}$, etc., as it is convergence amplitude which is needed. When the narrowest of these cards can be easily fused, a pair of 5^{Δ} prisms is inserted in the clips, bases out, and the same exercise repeated. In exceptional cases a pair of 10^{Δ} prisms is used.

In the average case ten to twelve treatments suffice to put the patient on an independent basis; that is, he has learned the knack, appreciates the relief of perfect fusion, and knows how to send the required neuricity to the internal recti.

For further refinement of fusion, Dr. George A. Shepard, of New York, has devised some very ingenious exercises in fusing colors. His instructions are as follows:

"Series D is designed to be used in those cases in which the muscular power is good, but the patient's ability to blend the images of the two eyes into a satisfactory binocular impression is deficient.

"As the fusion function consists of a subconscious control of the visual lines, it is essential that the activity of the psychic center be strongly stimulated. In order to do this, cases must be individualized and such cards be presented as will best catch the attention and tickle the imagination. While it is still a moot point as to whether the perception of color is to be placed in the sphere of physiology or psychology, there can be no question that the blending of two monocular complementary colors into a neutral tint must be purely psychic. Where objects of the same form are to be fused, or where the separate images are incomplete, a desire for symmetry in the one and a striving to satisfy a memory picture in the other serve as strong incentives to fusion. Hence, it is necessary, in a certain proportion of cases, to eliminate these factors if perfect self-reliance is to be established.

"The D series has retained the same form and size of figure for the two eyes to aid the patient in properly adjusting the visual lines so the colored rectangles shall fall upon the corresponding retinal areas, but the neutralization of the colors demands that proper values be given to each impression. This series cannot be used

to advantage if the patient has congenitally defective color sense or is suffering from nonconcentric contraction of the color field, such as often occurs in neurasthenia.

"The exercise can be made still more exacting by having the form of the colors dissimilar and eliminating the control gray tint, but this would require the constant personal attention of the

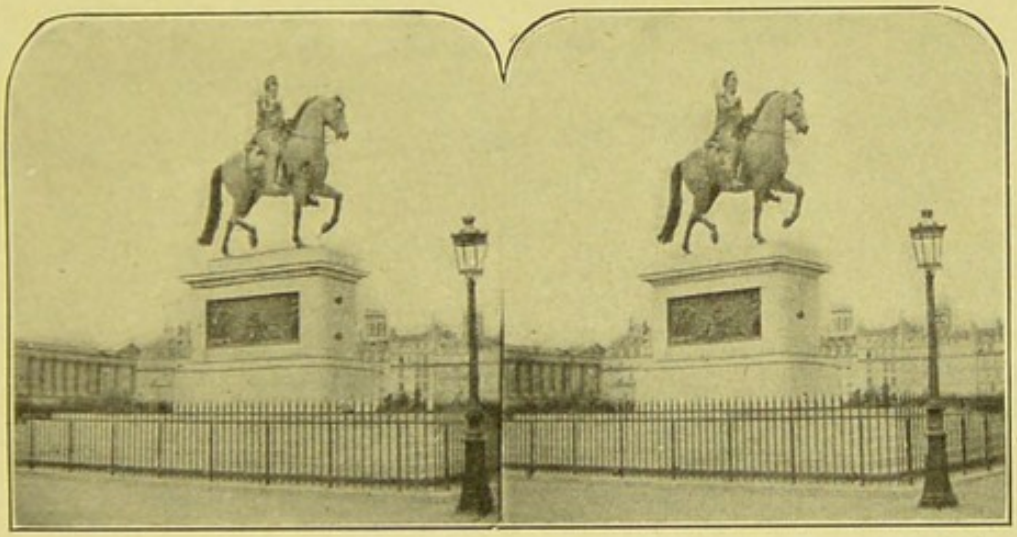

FIG. 15.—SHOWING DOTS MARKED ON STEREOGRAPH.

observer and make the charts less useful for homework."

Many years ago Landolt suggested the use of the ordinary stereoscopic pictures, putting two dots on one picture and a third dot on the other, so that the three will appear in a vertical line in the fused image.

For homework after the patient has ceased his regular visits, two or three dozen of such photos, selected by him, are marked in this way, the dots being made as small as possible. He is thus taught to appreciate the absolute reproduc-

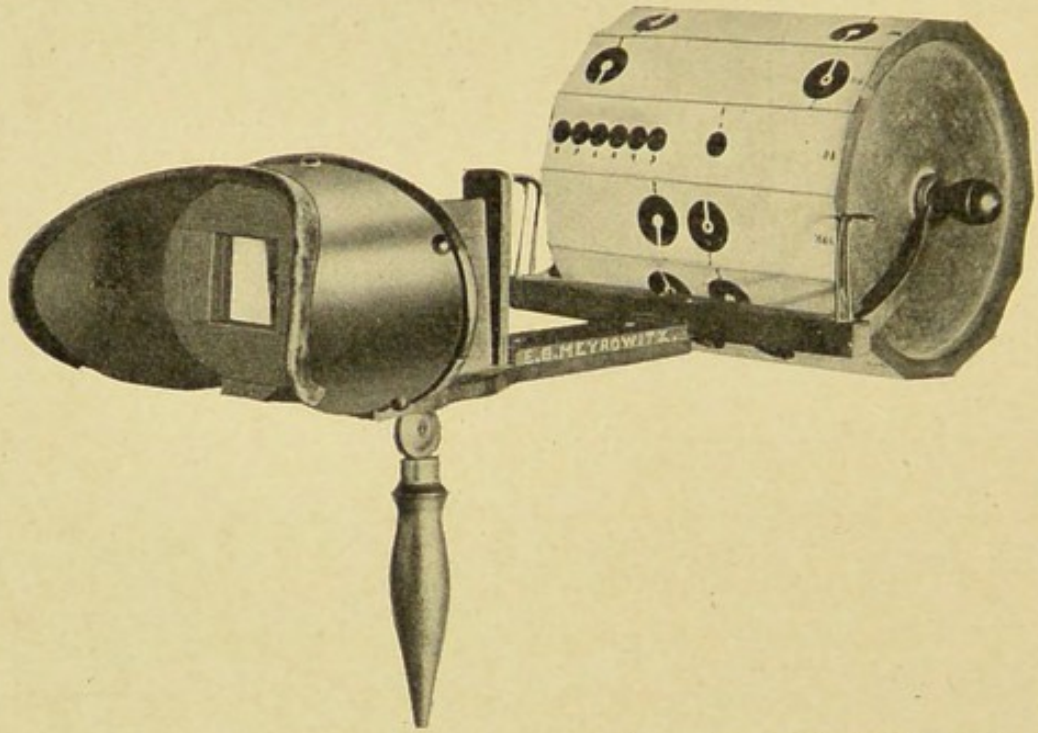

FIG. 16.—DR. CROSS' STEREOSCOPIC ATTACHMENT FOR HOME EXERCISING.

tion of natural scenery, and is constantly able to verify his binocular perception by a glance at the dots.

It is advisable to insist upon good photographs properly mounted. The H. C. White Company, of Bennington, Vt., offer a fine selection of views from all parts of the world.

Cross, of Worcester, Mass., has devised a cylinder with 13 facets, on which he has pasted the 13 cards of series H. This is mounted on the Holmes stereoscope, arranged with a ratchet so that the patient can turn up one after the other of the cards, progressing in either direction. If, as some think, it is wiser to have a period of relaxation between the repeated efforts of convergence, Cross suggests that patient's eyes may be closed while the cylinder is being revolved.

CONTROLLED READING.

Javal illustrates the control device of Bull, which is an affair somewhat resembling a stereoscope with an opaque bar midway between the eyes and a card placed in the clips. To overcome the possibility of a patient reading alternately with right and left, Javal constructed his "grill," a little table with five vertical bars. This is placed, standing on four legs, on the page to be read.

After experimenting with various appliances the author devised a control which enables the principle to be applied to all of the patient's reading, writing and sewing. A description and illustration of this was published in Meyrowitz Bulletin, January, 1905.

It consists of an ordinary head band, either leather, silk or the metal spring, but in place of the mirror, an aluminum band is attached by the ball and socket joint. This admits of con-

Fig. 17.—Author's Control Device.

siderable adjustment, which can be supplemented by bending the aluminum. The band is blackened to avoid reflections, and is placed half way between the face and the page. If either eye be suppressed a black band is seen across

the page. This is shown to the patient by alternately covering the eyes. If patient does not occupy a conspicuous place, this control can be

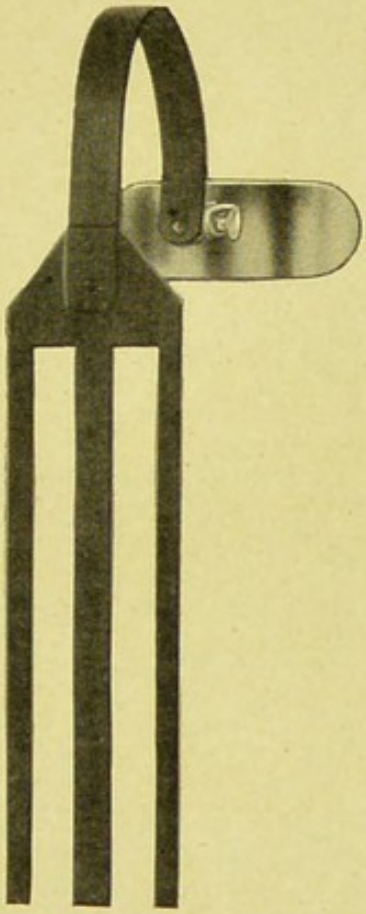

FIG. 18.—TRIPLE CONTROL DEVICE.

used for practically all near work, and this is insisted upon. At first there will be some complaint, but most patients soon come to appreciate

the steadying effect and the ability to read with more comfort.

The latest model, Fig. 18, has three control bands and resembles an inverted trident. The central band is 10 mm. wide, the lateral ones 7, and the spaces 13 mm. If this be held not more than 15 cm. in front of the eyes, the fields overlap sufficiently to allow of comfortable reading, but three times in each line the control principle is brought into play.

With a pupillary distance of 60 mm., the control at 15 cm. and the reading held at 35 cm. (14 inches), the overlapping is about 6 mm. Obviously this increases with the distance.

This triple control necessitates more exact adjustment than the single band, and may not be practicable for *all* near uses, but for quiet reading, it prevents suppression as effectually as Javal's "grill."

The author is familiar with Gould's theory of dextro and sinistro-ocularity,* but feels obliged to differ from the opinion that any marked suppression of either eye is physiological. Undoubtedly many people who habitually suppress

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one eye may not suffer any annoyance from this condition. The same may be said of errors of refraction, but does anyone for that reason consider astigmia physiological? The writer maintains that the habitual use of the two eyes binocularly, with a minimum of suppression of either, is as ideal as is the emmetropic eye to uniocular vision.

Therefore, every known means is utilized to overcome this suppression. If marked, it is admissible to atropinize the favorite eye. One of the less powerful cycloplegics is generally sufficient. A thin film of soap may be smeared on the stereoscopic lens corresponding to the *favorite* eye. The whole object is to force the patient's use of the suppressed eye, by handicapping the favorite one.

NUMBER OF CASES TREATED AND RESULTS.

In advocating a new method of treatment, it is realized that something must be said about results, but it is a somewhat difficult task to report accurately concerning therapeutic accomplishments.

Probably nine-tenths of those treated have

been exophorics, so that of this class there have been a sufficient number to justify one in drawing some conclusions. In the last five years 330 cases of this class have been treated by the methods explained above. Of these about sixty per cent. have gained a good convergence faculty varying from 60$^{\Delta}$ to 90$^{\Delta}$, and the symptoms have been relieved. Some of these have become orthophoric by the various phorometer tests. Others still exhibit some exophoria, but much less than before. These are all classed as "cured." Fifteen per cent. have developed equally good convergence, but symptoms are not relieved. Evidently symptoms were not caused by insufficiency. Fifteen per cent. more have attained to 30$^{\Delta}$ or 40$^{\Delta}$ and secured partial relief.

About ten per cent. must be classed as failures. No improvement in muscle power could be secured. For some reason they did not respond. These last were not given a full course of treatment. If marked improvement is not evident after five or six visits, the treatment is stopped.

Undoubtedly this list includes some cases of nervous instability, which a keener diagnostician would have referred to the neurologist. There have been some relapses, but the great

majority of the "cured" cases have retained sufficient power for all practical purposes. Patients are admonished to test themselves from time to time with the stereoscope and cards, and if they notice any loss of power, to renew the home exercises.

CHAPTER V.

STEREOSCOPIC TREATMENT OF ESOPHORIA.—MAY BE AN EXPRESSION OF CONVERGENCE INSUFFICIENCY.—FUSION TRAINING SAME AS FOR EXOPHORIA.—AMPLITUDE TRAINING THE REVERSE OR MAY BE THE SAME AS FOR EXOPHORIA.

ESOPHORIA.

The proper treatment of esophoria necessitates a proper estimation of all the factors concerned. One is not justified in concluding that the convergence faculty is too strong. Esophoria at distance is often associated with exophoria at near. In these cases duction will be found quite limited.

Paradoxical as it may seem, the writer is convinced that esophoria at a distance is not infrequently an expression of convergence insufficiency. Just how this is brought about he has no very definite opinion, but as the convergence function is the one most directly under the control of the will, it is conceivable that it might be exercised "not wisely, but too well" in a vain effort to overcome some annoying exophoria or hyperphoria.

Esophoria, dependent on latent hyperopia, is quite common, and there is a consensus of opinion as to what this association implies. The constant need of innervation of the ciliary for distance, as well as near, in some way causes an overstimulus of the associated convergence—the coordination is disturbed. The full correction of the whole refractive error under atropine is, therefore, the first requirement and usually gives relief, but many of these cases show no reduction of the esophoria, the symptoms persist and the blurring of distant objects is quite annoying. For these cases and those not hyperopic, what shall be done? The use of prisms base out frequently "begets the calamitous necessity of keeping on." With each increase of prism more esophoria develops, till one may be forced to do a tenotomy or advancement to give his patient relief.

The stereoscopic treatment consists first of a thorough testing of the fusion faculty, and if any defect be found, the use of controlled reading (explained in Chap. IV) and the stereoscopic charts which cultivate a refinement of fusion, like D, E, F, G. To this point the treatment may be identical with that given for exophoria.

In using the phoro-optometer stereoscope, patient should learn to fuse with prism base in, if we are to secure a greater divergence power. The same o. u. +10. are used in the frame, and card B_1 determines the easiest fusion distance by position of arrow. Let us suppose it be seen over three, this means that the two discs 3 cm. apart are the easiest fusion distance.

Rotary prisms 15$^{\Delta}$ each base out ought theoretically to bring the arrow over 6. C_7 ON NE is then introduced and the spheres approximated so as to *reduce* the base out of the rotary prisms. When limit has been reached, patient's eyes are closed and the lenses separated as far as possible, and the base out of the rotaries reduced 5$^{\Delta}$, leaving 10$^{\Delta}$ each.

If the patient's pupillary distance be 60 mm. and the phoro-optometer show 70 mm. P. D., 15$^{\Delta}$ each base out will be exhibited in this wide open position and this will be as easily fused as at first. Now if the spheres be approximated while the patient holds the letters fused, when P. D. 60 has been reached, the prismatic element of the decentering has been eliminated, and the amount as shown by the revolving prisms, 10$^{\Delta}$ each, is the total. If the approximation be continued to 50 P. D., then the 5$^{\Delta}$ each base *in*

produced by the decentering reduces the base *out* of the revolving prisms, and the patient has diverged from his first position and maintained fusion with o. u. 5^{Δ} base out.

Eyes are now closed again and the spheres separated as far as possible. Rotary prisms are now reduced 5^{Δ} each, so that the reading which was before 10^{Δ} is now 5^{Δ}. Patient opens his eyes and if he is able to fuse the ON NE, lenses are approximated as before. This process is repeated with smaller changes in amount of rotary prisms as it becomes evident that patient's limit is becoming reached.

As was said before, the home use of the cards as far as series G is the same with all forms of heterophoria, because with all of these cards the distance between centers is 6 cm., and their use is for the cultivation of a refinement of the fusion faculty. For amplitude training it is evident that the progression in the use of series H and series I must be reverse of that for exophoria; that is, if patient sees the arrow over 4 with B_1 card, he should commence with H_4 or I_4 and work *up* to *higher* numbers, 5, 6, 7, etc. In many cases where there has been present esophoria for distance and exophoria for near the convergence duction has been found so

poorly developed that the writer has treated the case the same as for exophoria, both with the phoro-optometer stereoscope and the home-work for cultivating amplitude.

Increased convergence has relieved the symptoms and *has not increased the esophoria.* In some instances orthophoria has been restored. It is experiences like these which have forced the conclusion that there exists a pseudo-esophoria, which should be interpreted as an insufficiency of convergence and not excess.

CHAPTER VI.

TREATMENT OF HYPERPHORIA.—STEREOSCOPIC TREATMENT NOT PRACTICABLE.—PRISM DUCTION TREATMENT.—AUTHOR'S CARDS FOR RIGHT AND LEFT HYPERPHORIA.

HYPERPHORIA.

In a few cases stereoscopic treatment has been attempted with revolving prisms. The hyperphoria, as indicated by cards B_2 and B_3, is corrected by vertical prism. The ON NE card is introduced, and while the patient holds the image fused the prism correcting hyperphoria is reduced to zero, and as much reverse prism used as the patient will endure without losing the image. This is a kind of stereoscopic duction and can be repeated as many times as thought desirable. The results have not been sufficiently good to warrant its continuance.

In 1908 the writer devised two new series which were published as a supplement to the first edition of stereoscopic charts. These were designed for the treatment of hyperphoria. The characters ON NE were made of block letters 8 mm. square, horizontal separation being

60 mm. in all. Each set consists of five cards. For right hyperphoria the right object NE is lowered 2, 4, 6, 8, 10 mm., corresponding to right hyperphoria of 2^{Δ}, 4^{Δ}, 6^{Δ}, 8^{Δ}, 10^{Δ}, if measured at 10 cm.

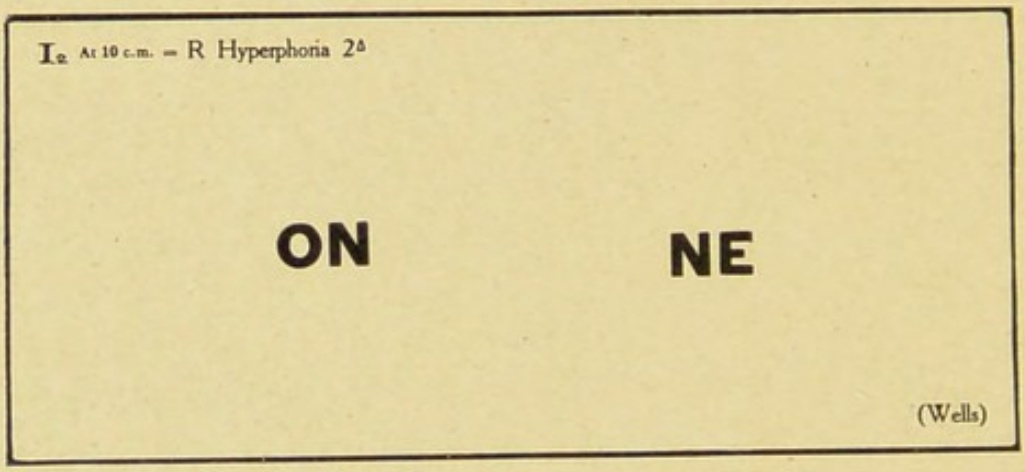

FIG. 19.—DISCONTINUED SERIES.

For left hyperphoria the left object ON is lowered 2, 4, 6, 8, 10 mm., corresponding to left

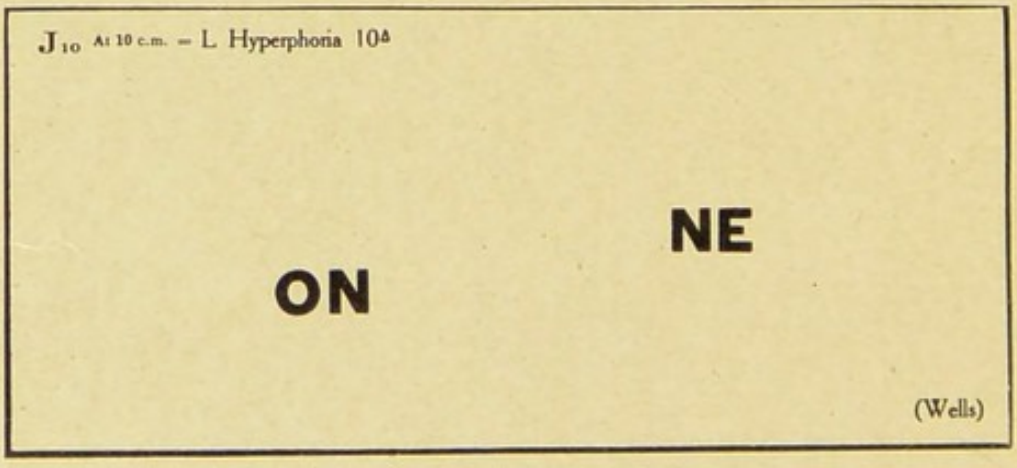

FIG. 20.—DISCONTINUED SERIES.

hyperphoria of 2^{Δ}, 4^{Δ}, 6^{Δ}, 8^{Δ}, 10^{Δ}, if measured at 10 cm.

The writer's idea was that if a patient with right hyperphoria of 8^{Δ} could fuse I_8 most easily, he should be able to progress to I_6, I_4, I_2, and thence to the ordinary cards with both sides horizontal. The results, however, were not satisfactory even when hyperphoria measured with B_4 in stereoscope at 10 cm. corresponded to hyperphoria measured at 5 M. Since no one with whom the writer has communicated has had better results with series I and J, they have been omitted from the present edition.

A stereoscope might be constructed in which the spheres could be decentered vertically and the same principle applied as for training convergence and divergence, but of the result the writer is not particularly sanguine.

Hyperphoria frequently disappears as the convergence power increases, and if it remains in sufficient amount to give rise to symptoms, it is the author's practice to correct it with a prism, or if of high degree by tenotomy or advancement.

CHAPTER VII.

STEREOSCOPIC TREATMENT OF HETEROTROPIA.—OF CONCOMITANT ESOTROPIA.—THE AMBLYOSCOPE.—AUTHOR'S DEVIOMETER.—THE PERCENTAGE OF CURES.—THE TIME FOR OPERATION.—TREATMENT OF ALTERNATING ESOTROPIA.—TREATMENT OF EXOTROPIA.

ESOTROPIA.

Ever since Worth's first publication in the *Lancet,* May 11, 1901, the writer has been a conscientious follower of his methods. His suggestion of atropinizing or bandaging the fixing eye for months is certainly of great value, and although it had been previously practiced by Landolt and Javal, Worth did well in emphasizing it so forcibly.

A certain number of cases of concomitant esotropia can be cured by this method and the use of the amblyoscope, but this latter instrument has been rather disappointing. There are definite drawbacks to its practicability. In the first place, one cannot see the child's eyes and is, therefore, forced to depend on his statement as to what he sees. The imagination of the child

is very vivid and no one who has tried to carry out this treatment can have failed to be at his "wit's end" many times to know just what was taking place. Then it is absolutely essential that

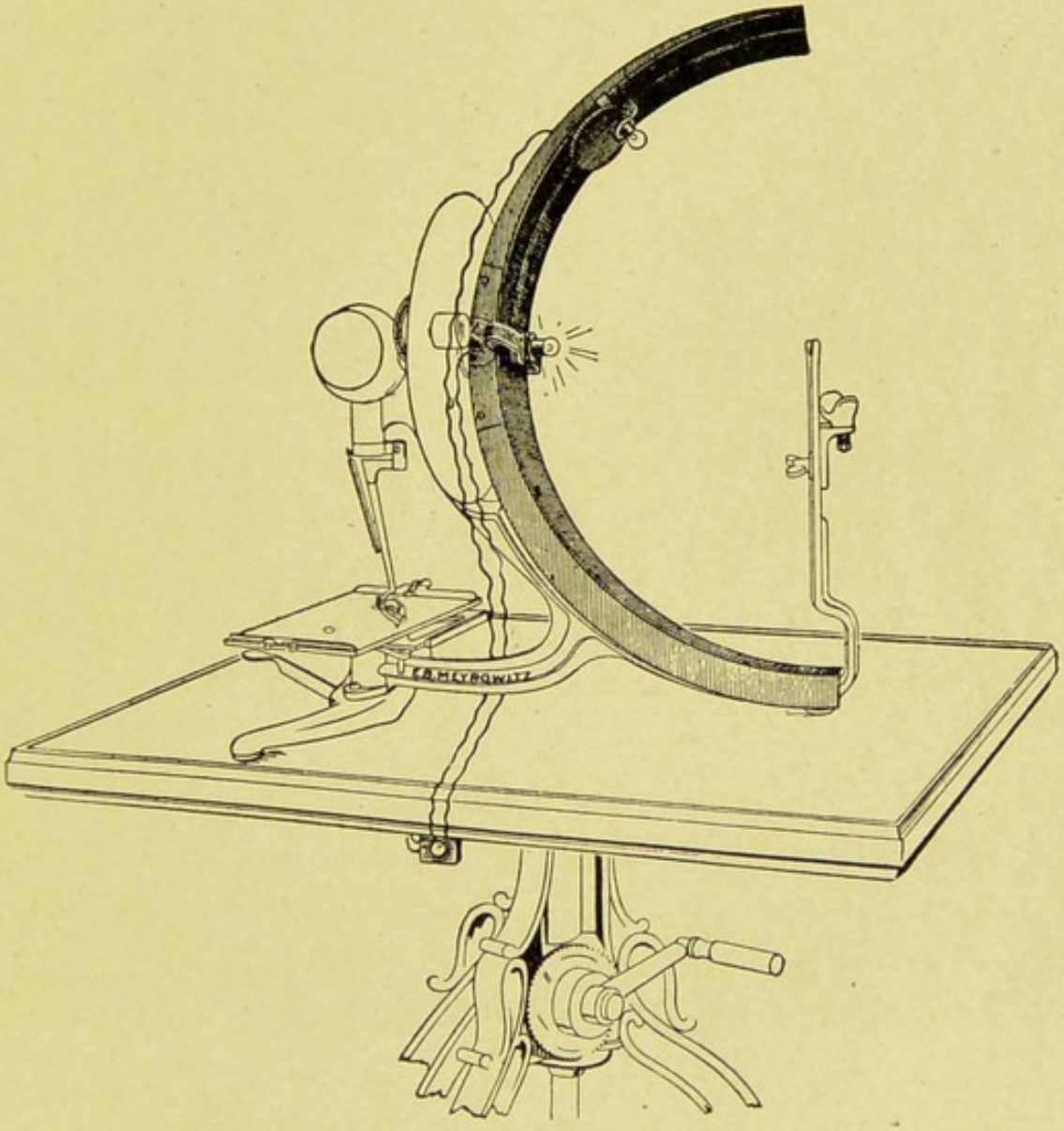

FIG. 21.—THE AUTHOR'S DEVIOMETER ATTACHMENT TO THE PERIMETER.

the case be seen early and that the parent's intelligent cooperation be secured.

Following Worth's suggestion the writer devised a deviometer attachment to the perimeter, with which it is possible to measure the angle of the deviation in quite young children.

A concealed switch is so arranged that the central light, which the child naturally fixes, is put out at the same instant the movable one is lighted. Thus, before he has time to change his fixation, the reflection of the movable one is noted on the cornea. A few trials suffice to make it central, and the degree of heterotropia is read off on the arc.

This ability to make comparative measurements is an essential part of the treatment, in order to know if the error is getting less. The wearing of full correcting glass in the fixing eye and occasional atropine in the same, with some less than full correction of refraction for suppressed eye, will usually reduce the error one-half. Little more than this can be done with a very young child. As soon as possible Worth's marble test should be used to get a crude idea of visual acuity.

When the child is able to comprehend the amblyoscope, it is given with the simplest pic-

tures for home use, and the phoro-optometer stereoscope used at the office. Fusion can often be secured with the latter in a case needing o. u. prism 30$^{\Delta}$ base out. Here we make use of A_1 for left esotropia, A_2 for right esotropia.

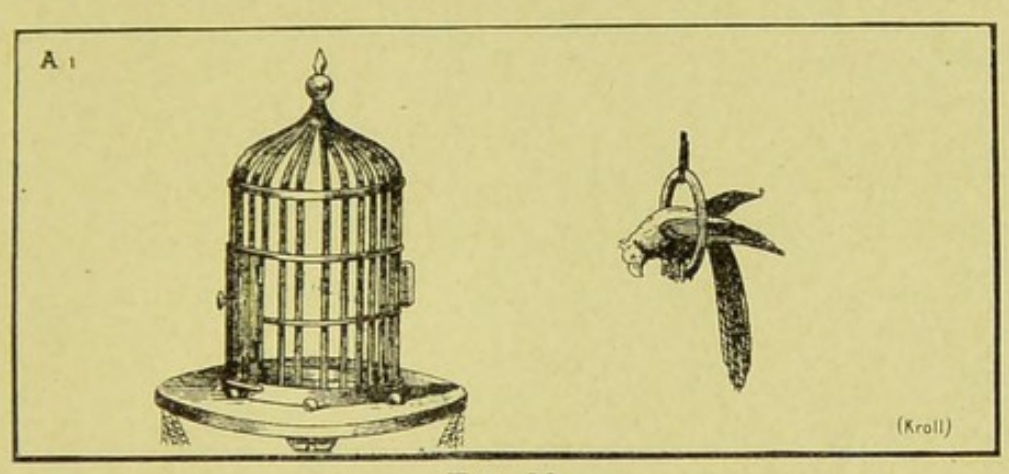

FIG. 22.

Not until concrete pictures like C_1, C_2, C_3 can be fused need one expect much from stereoscopic exercises.

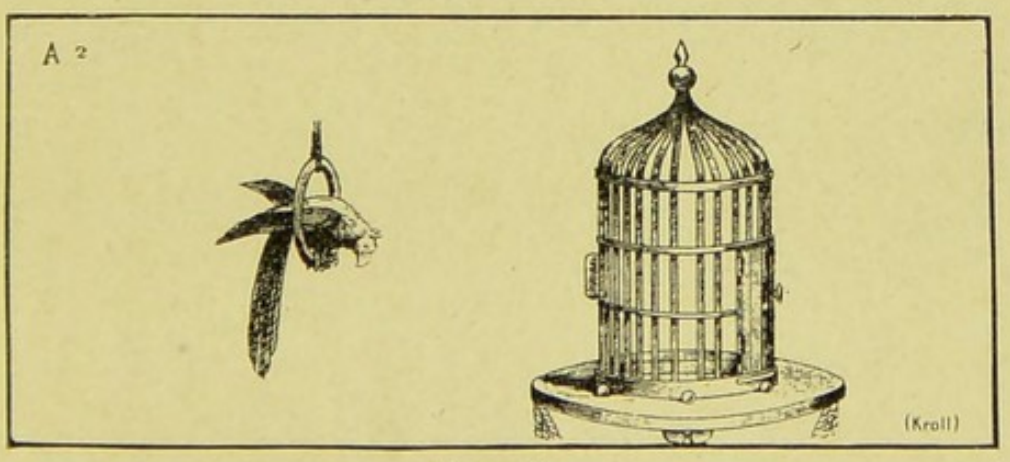

FIG. 23.

There is very little holding power in discrete pictures, either with the stereoscope or amblyoscope, the bird *out of* the cage makes just as pleasing a picture as the bird *in* the cage, but when the head of C_2 loses an eye or an ear, one's sense of propriety is offended.

The prismatic element can be reduced by decentering, the same as in treating esophoria, and the eyes may be watched all the time over the top of the instrument to note their movements. In a favorable case the home stereoscope with as high as o. u. 15$^{\Delta}$ base out can be used, the amount being reduced as conditions warrant.

It is somewhat difficult to state exactly the percentage of cures that may be expected by orthoptic treatment alone. It is almost impossible to carry out the full treatment with dispensary patients.

Emerson,* of Orange, N. J., says: "In private practice, patients of good social condition, who carry out the treatment with intelligence and perseverance, practically all get well."

This statement is slightly ambiguous, as it is

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*"Journal of the Medical Society of New Jersey," 1911.

not stated in what proportion the necessary "intelligence and perseverance" are exhibited.

Of all the private cases of esotropia seen by the writer during the last five years only twenty-five per cent. were less than six years old. Some of these moved away and were referred to colleagues in other cities. Others gave up the treatment after a few visits.

Excluding the congenital cases, nine per cent. were given the recognized orthoptic treatment, and of these nearly three-quarters were cured and developed a fair degree of binocular vision. A few cases averaging thirteen years of age responded to glasses and fusion-training methods. Most of the other cases were corrected by advancement or advancement and tenotomy. Post-operative fusion training has been used in all except those lacking all fusion sense.

Since only twenty-five per cent. were less than six years old, it is evident that it is still necessary to emphasize the importance of beginning this treatment early.

The intelligent cooperation of the family physician means that he shall refer every case to his ophthalmic surgeon, whenever there is discovered even an *occasional* squint. It is true that the wearing of glasses under two years is

attended with some difficulty, but many other expedients can be used to force the seeing with the turned eye. These may be atropine in the fixing eye and an occlusion bandage. The object of this very early treatment is to preserve the turned eye from amblyopia exanopsia, and to cultivate the fusion faculty during those years when it is developing in the normal child.

This treatment should be continued as long as the deviometer shows improvement. This may be months or years, but it is certainly a mistake to delay operation too long. A rudiment of fusion can often be trained into a refined faculty if the eyes are put approximately straight by operation.

The writer considers the Worth advancement a very satisfactory method, beginning with the external rectus of the esotropic eye.

The one difficult part is the introduction of the scleral suture. Instead of passing the needle directly toward the pupil, it is passed parallel to circumference of the cornea, beginning each one near the median line. This secures a firm hold without encroaching dangerously near the anterior chamber. This method was in vogue at Fuchs' clinic in 1905. If the convergence is not sufficient to justify tenotomy of the internus,

it is given a thorough stretching (Panas) before the sutures are tied. If the effect be insufficient the externus of the other eye should be advanced in the same manner.

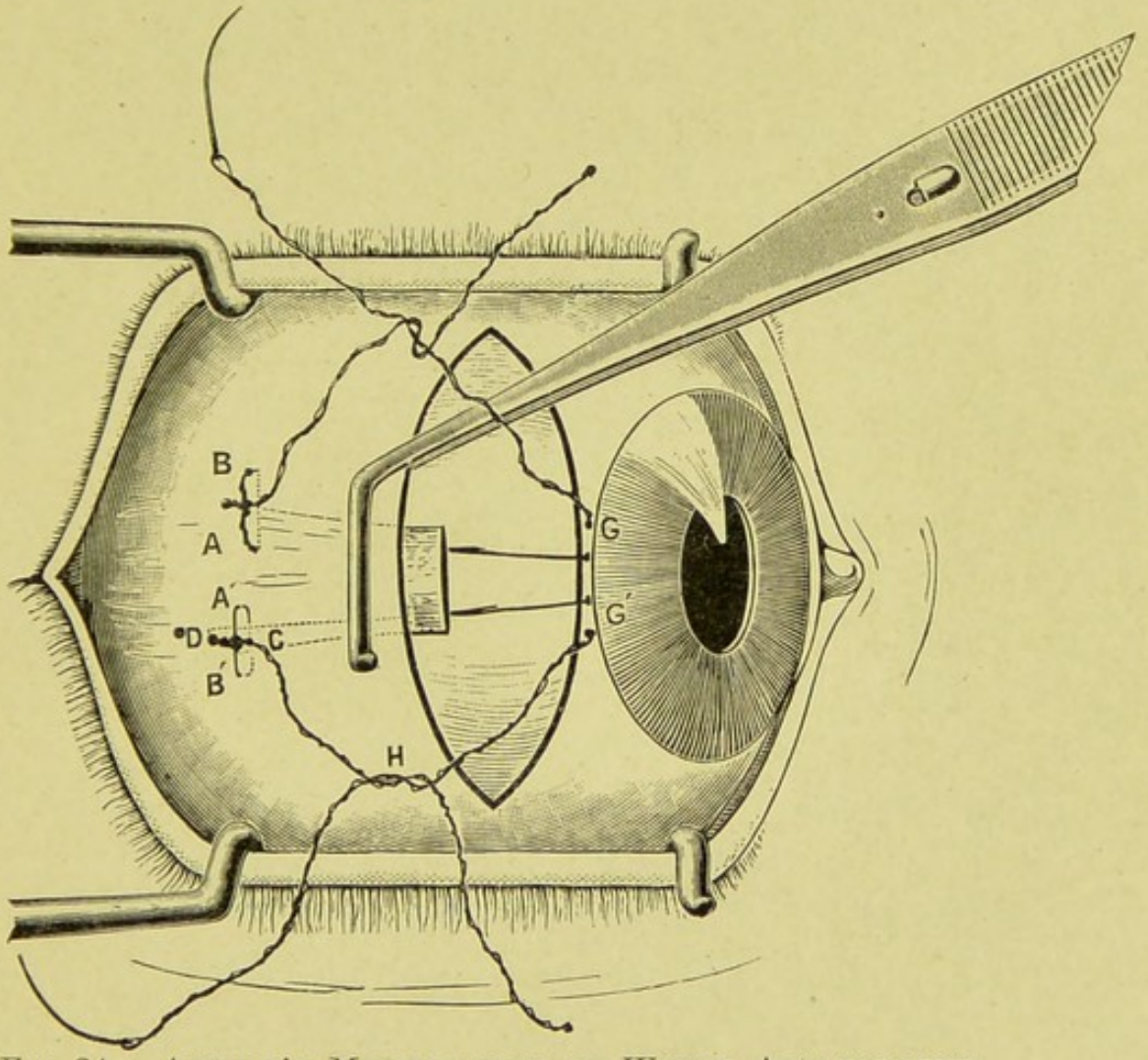

FIG. 24.—AUTHOR'S MODIFICATION OF WORTH ADVANCEMENT.

ALTERNATING ESOTROPIA.

In these cases vision is usually equal in the two eyes, and there is very little refractive error.

A cycloplegic, or even a slight blurring of either eye, causes it to converge and the other eye to fix. Fusion faculty is usually nil, and any sort of orthoptic treatment generally of little use. Advancement of both external recti is usually required.

EXOTROPIA.

If occasional, stereoscopic treatment and fusion training will usually cure the exotropia, the method is the same as for exophoria. The result is often orthophoria by phorometer, Maddox rod or chromatic test, but exophoria may be still shown by the screen test. As the normal condition of the individual is with both eyes participating, it seems appropriate to use a binocular test, especially the chromatic, in which the tendency to horizontalize and verticalize is reduced to a minimum. This also shows the value of the fusion faculty in maintaining orthophoria. If the exotropia exists all the time immediate advancement of the internal rectus, followed by stereoscopic training, is indicated.

CHAPTER VIII.

THEORIES.—PSYCHIC ELEMENT.—THE CHOICE OF CARDS.—SUPERABUNDANCE OF AMPLITUDE A VALUABLE RESERVE.—CONCLUDING REMARKS.

A highly developed fusion faculty, with good amplitude, is essential to the state called muscle balance. In correcting or relieving heterophoria, the first essential is the development of a refined fusion sense, if such does not exist, or in making habitual its employment in the psychic interpretation of two retinal images.

The power of a muscle depends not alone on its own physical properties, such as size, nutrition, place of attachment, etc., but also on the strength of the nervous stimulus which excites its action. In discussing this subject in 1902 the writer made the following statement: "The rapid development of adduction which is so often obtained by this so-called 'gymnastics,' strongly suggests that the gain is not a muscle hypertrophy, but an increase in innervation, either in the responsiveness of the end organ in the muscle, or the convergence center, or both." In the educational treatment of tabes the incoordination is overcome by teaching the patient

to gauge his motor impulses by the eye in lieu of the normal sensory control. Repeated artificial contractions of the internal rectus (the ciliary remaining relaxed) establish a habit of increased action, so that it no longer lags when the impulse to converge and accommodate is felt. The coordinating center may also be taught to better appreciate the advantages of binocular perspective. This is no special pleading, but is analogous to other sensations. The pianist makes his fingers educate his brain that the brain may do better work with the fingers. Tasks consciously performed are in time relegated to subconscious control. If this interpretation of muscle gymnastics be accepted, it is evident that the first indication is to teach the patient the fascination of true binocular fusion. Just as in the ordinary prism exercises, with the eye fixed on a distant point, the aversion to diplopia is an incentive to increased muscle action, so here the fused image becomes an anchor. With the eyes fastened on a fused image, made up of half pictures, one strongly resists an impulse which tends to pull it to pieces. The decentering of plus 10. lenses is a subtle means of insinuating such an influence.

In all exercises of this sort there is a psychic

factor which should be utilized. Whether there is or is not a fusion *center,* there is a fusion faculty which can be cultivated, in proportion to the patient's attention and cooperation.

To do this, while the phoro-optometer stereoscope is being used, the patient should be repeatedly directed to fix his attention on the red N. To help him do this he should be told to analyze the color, to decide just what shade of red it is, or to fix his attention on the oblique line of the N. Other expedients will suggest themselves if the importance of this fixation of attention is appreciated. No distracting sounds should be tolerated; in fact, there should be no third party in the room.

The patient should also be aware that the oculist is thinking only of him, and whenever any gain, however slight, is evident, as one watches the eyes over the stereoscope, some word of commendation should be volunteered. If no such commendation should be justified, he should be encouraged by the suggestion, "Now try a little harder this time."

The difference in the holding power of different cards has been mentioned. Formerly C_8 of Javal was used. This consists of separate letters L and F, the fusion of which gives E.

After considerable experimenting the author devised the ON NE, the two N's printed in red, and believes this possesses the greatest holding power of anything yet produced. In the first place the word spells O N E, and when disjointed the ON NE is meaningless. More letters are superfluous and detract from fixation. That there is a subtle suggestion in this, one can easily verify in the following way: After the card ON NE has been used on several occasions, if the prism is arranged so patient sees arrow over 6 of the card B_1, and if then C_7 is dropped into the clip, the patient will often be confused, but will be immediately relieved if 5^{Δ} or 10^{Δ} more of prism be turned up. This shows that while conditions were exactly right for easy fusion of C_7, the instant that card appeared he immediately remembered what it had previously required and involuntarily converged his eyes more than was necessary.

In convergence insufficiency we are dealing with an incoordination of convergence and accommodation. The nerve impulse sufficient to secure accommodation is insufficient for convergence. To relieve this and to restore coordination, it is necessary to incite, associate and to make habitual a greater degree of convergence

with a given amount of accommodation. For this reason it has always seemed to the writer that exercises which brings into play the accommodation as well as the convergence are illogical; *e. g.*, dot exercises or candle as used by Gould.

With eyes fixed on a distant light, it is assumed the accommodation is zero, but this is difficult to verify. When emmetropic eyes looking through plus 10. lenses see clearly at the focal distance, 10 cm., we have proof that accommodation is relaxed and it is under these conditions that we secure a very abnormal amount of convergence. To a certain extent the same is true of the home use of the stereoscope with additional prisms in the clips.

With perhaps one-half of one's successful cases, orthophoria will be secured, with the other half the heterophoria will be reduced, but the patient will have secured such a superabundance of amplitude that he is able to overcome the wrong tendencies automatically without discomfort.