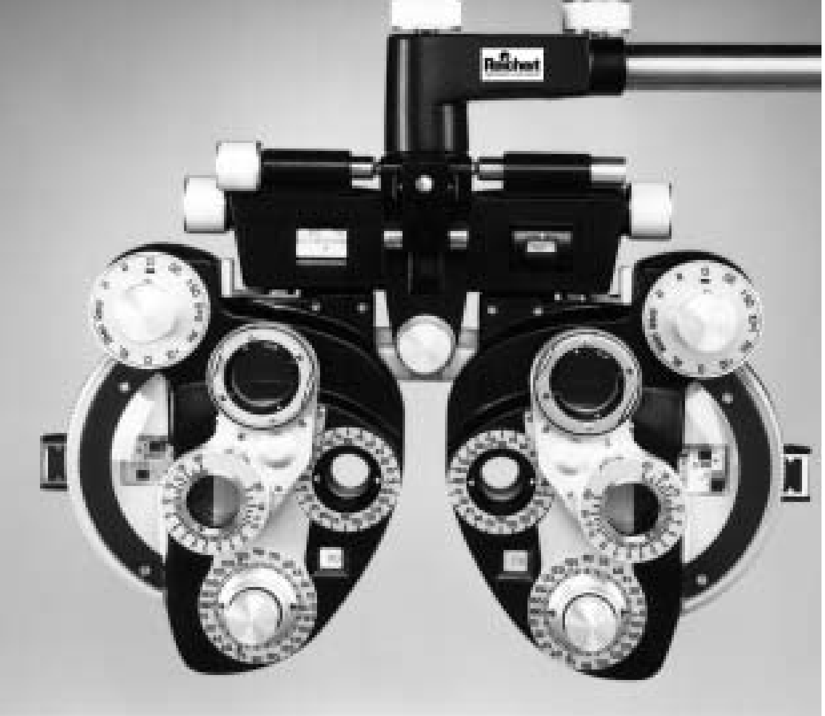

Reichert Phoroptor® Refracting Instrument

Clinical Manual on Refraction

Reichert
Ophthalmic Instruments

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Contents

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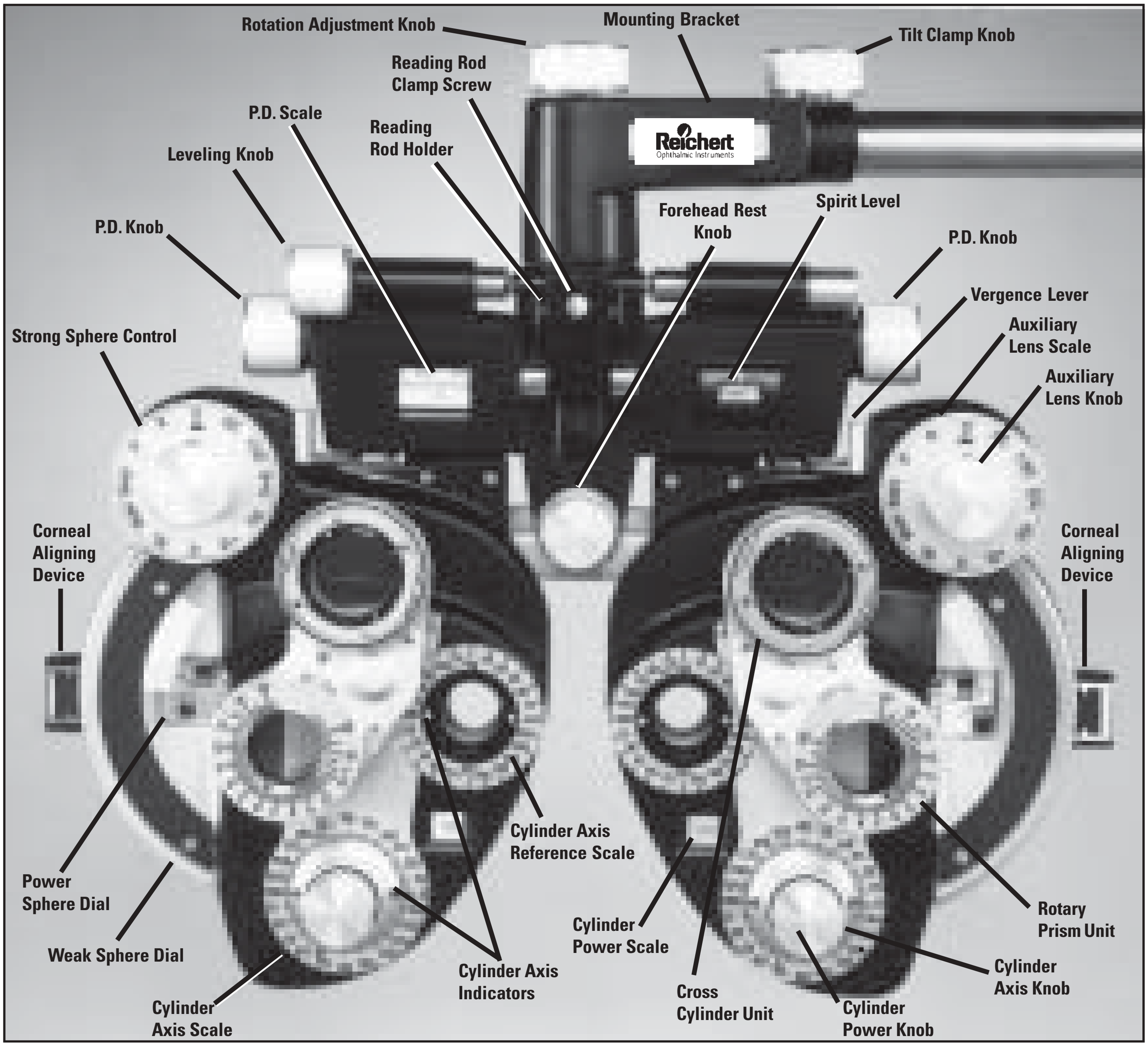


Reichert PHOROPTOR® Refracting Instrument

Preface

The "Clinical Manual on Refraction with the Reichert PHOROPTOR® Refracting Instrument" was written by Robert E. Bannon, D.O.S.

This manual is dedicated to Dr. Bannon, former Assistant Professor of Physiologic Optics, Dartmouth Eye Institute, Hanover, N.H.; Assistant Professor of Optometry, Columbia University, N.Y., N.Y.; Associate Research Professor (Ophthalmology), State University of New York at Buffalo; Instructor, Lancaster Ophthalmology Courses, Colby College, Waterville, Maine.

This manual is intended for those who wish to begin to use the PHOROPTOR Refracting Instrument. It is quite basic, with very little about the optical principles which are involved in determining the refractive error.

Since this manual is not intended to take the place of current texts on Optics and Refraction, a list of texts is appended for those who wish to understand the optical principles in refraction.

Most of the material in this manual is based upon Dr. Bannon's experience as a refractionist, papers written and lectures given over a period of fifty years.

I. Symptomology & Preliminary Observations

Many things may be observed about patients as they come into the examination room, as they relate symptoms and history. The patient may be large and robust, small and delicate, anxious or nervous, wiry, overweight, or underweight. These observations, in conjunction with the person's occupation and symptoms, may mean a great deal.

A robust or a wiry person often accepts a full refractive correction. Delicate or nervous patients may be bothered by big changes in their prescription but may be helped by relatively small changes which would be unnoticed by rugged individuals.

Another preliminary observation is the patient's posture, carriage and height. Especially in prescribing bifocals or near corrections, it helps to keep in mind the height of each patient; the length of their arms, their carriage, whether or not they sit erect or slouch, and whether or not they tilt their head. Faulty posture may cause a compensatory head tilt which may induce an apparent hyperphoria or, vice versa, a hyperphoria may cause a head tilt and faulty posture. Faces that are asymmetric suggest anisometropia. Small eyes may be hyperopic and large eyes myopic. Dark complexion and brown eyes usually require more cycloplegia than fair-complexioned, blue-eyed individuals. The latter are more sensitive to excessive light and also seem to become presbyopic at an older age than darker pigmented persons.

How patients wear their glasses — i.e., whether they appear to be properly adjusted, whether the frame is too small or large, the bifocal segments too high or low — may be a clue to the patient's symptoms. A manifest strabismus, alternating monocular vision, nystagmus, excessive blinking or staring, frowning, squinting, tearing and other objective clues can be readily observed. In fact, it is easier and more significant to observe these clues before, rather than during, the examination. During the examination, patients' eyes and faces are obscured by the PHOROPTOR® and they may correct or compensate for tendencies evident in a relaxed situation.

Measurement of Glasses Worn

It is very helpful to know about the patient's glasses early in the examination. The centering of the lenses should be compared with the patient's interpupillary distance, and it is a good practice to note the curves and thicknesses of the lenses.

During the recording of the symptoms and history, the patient's statements about the effect of his or her glasses will have greater significance if their power and other characteristics are known. Also, comparing the patient's symptoms with the power of the glasses worn will help determine which tests are most necessary.

Chief Complaint

Even though the patient is referred by another practitioner who has described the case, it is a good practice to ask such patients, as well as all other patients, to explain the purpose of their visit.

The patient may have no significant ocular complaint but feels it is time for a "check-up', or the patient may have broken or lost their glasses. In some cases, there is a complicated ocular condition out of proportion with the patient's lack of complaints and, vice-versa, there are often patients with numerous symptoms whose eyes are practically perfect.

Recording the "Chief Complaint" is particularly helpful when, at the completion of the examination, the contemplated treatment is considered in light of whether it is directed toward relieving the Chief Complaint. It has happened that a patient's chief complaint is difficulty in close work, but the findings indicate more minus power improved the distance vision and this is prescribed leaving the patient with the same, if not greater, discomfort for close work.

The onset, frequency, and duration of the Chief Complaint should be elicited as well as the important point of whether or not the Chief Complaint is associated with the use of the eyes. It is frequently found that patients are bothered by some discomfort, such as headaches not associated with the use of the eyes but which the patient "hopes" will be relieved by new glasses. One must be on guard that they do not give unwarranted hope or a false sense of security to patients having a serious vascular or neurological condition which requires medical attention rather than new glasses.

Classification of Patient's Symptoms

1. Visual symptoms include blurring, doubling, shadowing of print or other objects. These may be merely observations that annoy or worry the patient. These phenomena may not be accompanied by any ache, pain or other somatic discomfort, but may be of great concern to the patient. Sometimes, a reasonable explanation may be all that is needed to relieve the patient's apprehension. Most often, the patient's visual symptoms are associated with refractive errors readily relieved with the proper optical correction.

2. Ocular symptoms include those somatic discomforts described as eye-ache, pain, fatigue, pulling sensation, burning, tearing, etc., which are referred to collectively as "eye-strain" or "asthenopia." These symptoms, when directly related to the specific use of the eyes, are most often relieved by the correction of a refractive error or neuro-muscular imbalance. It is important to determine whether the complaints are associated with some specific uses of the eyes for distance or near work or both. The therapy prescribed should be directed toward relieving the complaints without introducing new discomforts.

3. Referred symptoms include headaches of all types, gastro-intestinal disturbances, vertigo, nausea, nervousness, general fatigue, etc., which patients believe, or hope, are due to their eyes. In some cases, it is found that ocular anomalies are contributing factors. The most common referred symptom associated with inadequate refractive or neuro-muscular correction is headaches. It is important to determine the onset, frequency and duration, and the extent to which the complaint is associated with the use of the eyes. This information is valuable in cases of headaches or other referred symptoms.

The location of the headaches is of some importance according to certain authorities. Frontal headaches may be caused by esophoria, hyperopia, anisometropia or hyperphoria; occipital and suboccipital headaches may be due to convergence insufficiency. Some unilateral headaches may be caused by ciliary spasm, spasm of single ocular muscles, localized neuralgia, inflammation of the gasserian ganglion, etc.

On the other hand, headaches may be associated with intracranial pressure, brain tumor, migraine, hypertension, anxiety, nervous tension, etc. Hence, it is important to obtain a case history with respect to incidence, intensity, location, onset, duration, frequency, relation to muscle spasm, photophobia, periodicity, gastrointestinal disturbance, vertigo, mood, sleep, fever, family history, etc.

While ocular anomalies are responsible for a great variety of headaches, other possibilities should not be neglected. Sometimes, treatment is confined to the eyes alone. A careful case history and analysis of previous therapies often reveal an unsuspected clue that will help solve the problem. Obviously, it is necessary to be somewhat of a detective in hunting down the cause of the patient's discomfort.

History

Once the Chief Complaint is determined, appropriate questions should elicit pertinent information relative to the visual, medical, occupational and family history. Some patients will recount, in considerable detail, plenty of history that is not germane to the current complaint. Hence, it is best to first obtain the nature of the Chief Complaint and then direct the patient's recital of past events that have some bearing upon the Chief Complaint.

It is also helpful to determine what treatment the patient has had and to know the results of such treatment. A clue to the severity of the Chief Complaint is provided by the extent to which the patient has sought prior treatment. Sometimes patients describe symptoms which seem to be severe, but inquiry into the history reveals that patients have not paid much attention to their complaints because they have not sought professional advice for several years. When reminded of this point, the patient may remark: "Oh, I really could not be bothered running to doctors all the time." This suggests the patient's numerous symptoms are not much of a handicap, and extensive investigations are not desired by the patient. On the other hand, patients who have sought professional help frequently indicate they do wish to have extensive investigations.

As mentioned, the points in the history that should be elicited will depend greatly upon the nature of the Chief Complaint. In general, the following items of information should be sought: family history with respect to similar symptoms; ocular condition as a child; age and reason for first ocular treatment; and what seemed to precipitate the Chief Complaint, i.e., illness, accident, new work, increased eye use, change of diet or other factors.

Referring Patients

The reputations of successful practitioners are built upon how they have helped patients, both directly through their practice and indirectly through referral to another specialist for diagnosis and treatment. Patients who have had headaches or other symptoms unrelieved by refractive treatment may have some anomaly of graver importance, the early detection and treatment of which may prevent eventual blindness, impairment of health, or even an untimely death.

It is not always adequate to say: "I have provided you with the best glasses possible and if your headaches continue you should have a physical examination." It is helpful, in cases of referred symptoms especially, to consider the initial findings and correction as diagnostic and to insist upon an early recheck. If, at the recheck consultation, the symptoms persist and the refractive findings are substantially the same, some vascular or other anomaly may be suspected. In advising a patient to consult his or her physician, a definite appointment should be made and a summary of the symptoms, history and ocular findings transmitted.

Summary

The importance of a careful history with special attention to its relation to the Chief Complaint, its onset, frequency and duration, and associated phenomena, is of crucial value in the successful handling of patients. No instrumental measures or refractive data can take the place of careful consideration of the patient's complaints and history. One's ability to use special techniques and amass a welter of numerical data is a minor matter compared to the judgment of when to use various techniques and how to evaluate the significance of certain data with respect to the patient's complaint. This judgment is founded upon careful history taking and interpretation of the patient's symptoms. The judgment of practitioners in such matters will be proportionate to their ability to analyze and interpret their patient as a person rather than as a set of findings.

II. Retinoscopy

The optical principle of retinoscopy is to observe the reflected light from the patient's eye and to bring, by the use of lenses, that point which is conjugate to the patient's retina (patient's Far Point) to the plane of the entrance pupil of your own eye.

The reflected light from the patient's eye is referred to as the "fundus reflex," although it appears to be in the plane of the patient's pupil.

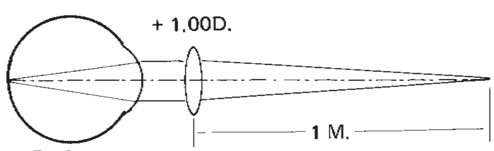
If it were possible to observe this fundus reflex at a distance of 20 feet. (optical infinity), the lens power producing conjugacy at that distance would represent the static correction of the ametropia.

However, there is not sufficient light reflected from the patient's eye to be seen at 20 feet. It is necessary to be within 40 inches (1 meter) to see the fundus reflex clearly.

Working Distance

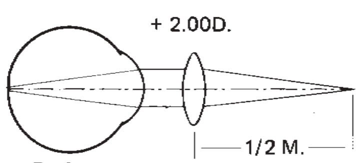
The distance at which the examiner observes the fundus reflex is referred to as the "working distance," and the lens power necessary to compensate for this distance is termed the "working lens" or the "Retinoscopy Lens."

Light rays from an emmetropic patient's eye leave the eye in parallel lines (zero vergence).



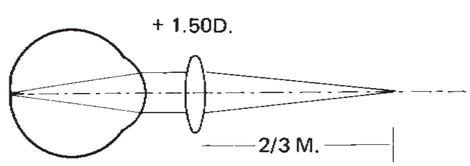
Patient

If the working distance is 1 meter, a + 1 .OOD sphere (Retinoscopy Lens) is necessary to bring the parallel rays to a focus at 1 meter, making the patient's eye conjugate with the examiner's eye.



Patient

If the working distance is 1/2 meter, a +2.00D sphere (Retinoscopy Lens) is required.



Patient

If the working distance is 2/3 meter, a + 1 .5D sphere (Retinoscopy Lens) is required.

To avoid making a calculation for every case — i.e., subtracting the power of the Retinoscopy Lens from the total lens power necessary to obtain neutralization — most examiners place in the trial frame the lens power required to compensate for the working distance. A Retinoscopy Lens (marked "R") is provided in the auxiliary dial of the PHOROPTOR.

Choice of Working Distance

A table (or a graph) can be made to show the range (or sensitivity) for various working distances allowing a practical degree of accuracy, for example ±0.25D.

A long working distance of 1 meter has considerable range (53 cm or 21 in.) in which the reflex would appear neutral within ±0.25D. Also, less light from the retinoscope at 1 meter reaches the patient's eye and less light returns compared to a closer working distance. In addition, the distance of 1 meter is beyond arm's length, and reaching for trial case lenses or the PHOROPTOR dials requires the examiner to bend forward for each lens change.

Working Distance	Linear Equivalent of ±0.25D Range
50 cm (20 in.)	44.4 – 57.1 cm (17.5 – 22.5 in.)
66.6 cm (26 in.)	57.1 – 80 cm (22.5 – 31.5 in.)
100 cm (40 in.)	80 – 133.3 cm (31.5 – 52.5 in.)

A working distance of 1/2 meter provides much more light to the patient's eye and returning from the patient's eye. However, reaching for the trial lenses or the PHOROPTOR dials from 1/2 meter is awkward, except for short-armed examiners. Most important, at 1/2 meter the range of neutralization within ± 0.25D is very small — 13 cm or 5 in. — and the examiner must be very careful not to exceed this small range.

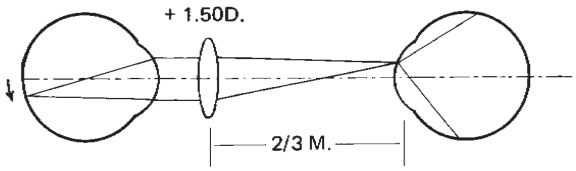
A working distance of 2/3 meter is most commonly used. The amount of light from 2/3 meter and that returning from the patient's eye is adequate for most of the moderate degrees of ametropia. (For high ametropia, it is helpful to start the retinoscopy test at the shorter distance of 1/2 meter or even closer.) Reaching for trial lenses or PHOROPTOR dials from 2/3 meter is quite convenient for most examiners. Also, the linear range of neutrality within ±0.25D is reasonably, but not unwieldy, large (23 cm or 9 in.).

Fundus Reflex Movements

The optics of the movements of the fundus reflex seen in Retinoscopy can best be understood by considering the patient's retina as the light source.

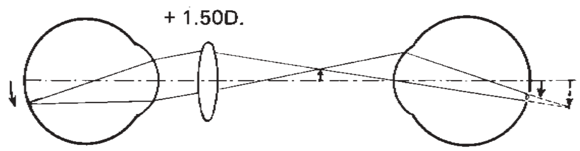
Without the Retinoscopy Lens in place before the patient's eye, the vergence of the rays from the patient's retina will be parallel in emmetropia, convergent in myopia, and divergent in hyperopia.

In an emmetropic eye (or when the ametropia has been corrected by lenses), with the Retinoscopy Lens in place, the examiner sees no motion (or a very fast motion), since the image of the patient's retina coincides with the examiner's eye.



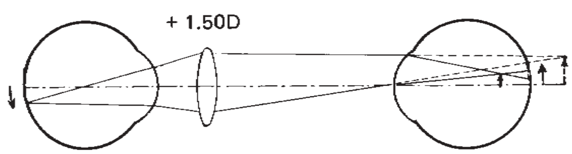
Patient **Examiner**

In a myopic eye, with the Retinoscopy Lens in place, the examiner sees an "against movement" because the image of the patient's retina is between the patient and the examiner. This forms a blurred disc on the examiner's retina, which moves in the same direction as the light cast on the patient's retina, but is interpreted by the examiner to move in the opposite direction.



Patient **Examiner**

In a hyperopic eye, with the Retinoscopy Lens in place, the examiner sees a "with motion" because the image of the patient's retina is behind the examiner's eye. This forms a blurred disc on the examiner's retina, which moves in the opposite direction as the light cast on the patient's retina, but is interpreted by the examiner to move in the same direction.



Patient **Examiner**

The characteristic appearance of the fundus reflex associated with high and low degrees of ametropia is summarized below*.

What has been noted applies to the use of a plane mirror in retinoscopy. When a concave mirror is used, as in some methods of Streak Retinoscopy, the fundus reflex motions are opposite to that when a plane mirror is used.

Streak Retinoscopy

The lamp used in Streak Retinoscopes has a line filament which provides a bandlike (or streak) image, instead of the round or circular image provided by the Spot-type Retinoscopes.

In addition, the Streak Retinoscopes provide a means of focusing the line filament by varying the distance of the condensing lens from the lamp, or vice versa, and thus achieving either the plane mirror or the concave mirror effect.

When the instrument is adjusted for the plane mirror effect – i.e. the streak is broad or wide on the patient's eye – the fundus reflex movements are the same as in Spot Retinoscopy.

When the instrument is adjusted for the concave mirror effect – i.e. the streak is thin or narrow on the patient's eye – the fundus reflex movements are the opposite.

Streak Retinoscopy enables one to determine the axis of the cylindrical correction more exactly by aligning the fine streak seen in the patient's pupil with that outside of the pupil (on the iris and sclera). Also, Streak Retinoscopy is helpful in high ametropia since the concave mirror effect enables the examiner to see the fundus reflex much better.

The objective determination of the refractive error by retinoscopy is essential in certain patients — i.e. very young children, illiterates, deaf mutes, those who understand and speak only a language unfamiliar to the examiner, in short, all those for whom the subjective tests are impossible or unreliable.

*Summary of Characteristic Fundus Reflexes

	In Low Ametropia	In High Ametropia	In Neutrality
BRIGHTNESS (brillance)	Bright	Dull	Very Bright
SPEED	Fast	Slow Sluggish	Very Fast or No Motion
SIZE	Large	Small	Very Large
SHAPE	Round in Spherical Errors Oval in Astigmatic Errors		

One cannot learn to do retinoscopy well merely by reading about the optical principles and following directions. One must practice, practice and practice the technique in order to recognize and interpret the characteristics of the various reflex motions, such as speed or slowness, brilliance or dullness, size and shape, etc. A "practice" or schematic eye is very helpful in getting started on learning retinoscopy as these schematic eyes can be adjusted to simulate various degrees of ametropia, and trial case lenses are used to correct the ametropia. Furthermore, the schematic eyes do not accommodate and they maintain fixation much better than human eyes.

Difficult as it may seem at first, retinoscopy, with persistent practice, soon becomes a very rewarding skill. Retinoscopy, requiring only a few minutes for each eye, reveals the major portion of the refractive error and paves the way for the more critical refinements of subjective testing.

If satisfactory retinoscopy cannot be done – due to an irregular or scarred cornea, opacities in the ocular media, pupil size too small, or other reasons – one must rely upon determining the proper spherical power as described under myopia and hyperopia. The minimum minus or maximum plus sphere power which provides good vision must be determined.

As will be described later, the Pinhole Disc provides a valuable clue as to the degree of vision that should be obtained with lenses. If the vision is not improved by the Pinhole Disc, refractive errors are not the primary cause of the poor vision.

III. Spherical Refractive Errors

1. Myopia: The myopic (near-sighted) person sees clearly at some near distance, depending upon the amount of the myopia, while their far distance vision is blurred. For example, a distance visual acuity of 20/200 or less with clear vision for fine print at 20 inches is typical of a 2.00D myope.

When the distance vision is blurred, but the near vision is clear, the most remote near point at which fine print can be read is an approximate indication of the amount of the myopia (assuming no significant astigmatism). For example:

Myopia of	Distance Acuity	Reads Fine Print at:
-1.00D	20/80	40 inches
-2.00D	20/200	20 inches
-3.00D	20/400	13 inches
-4.00D	less than 20/400	10 inches

The degree of myopia is measured with the PHOROPTOR by simply determining the weakest minus sphere power for each eye (monocularly) which provides good (20/20 or 20/15) visual acuity. Refractionists must be careful that they do not stimulate the patient’s accommodation and thus obtain a certain amount of pseudomyopia.

2. Hyperopia: Just the opposite of the myope, the hyperopic (far-sighted) person sees better for far distances than for near distances.

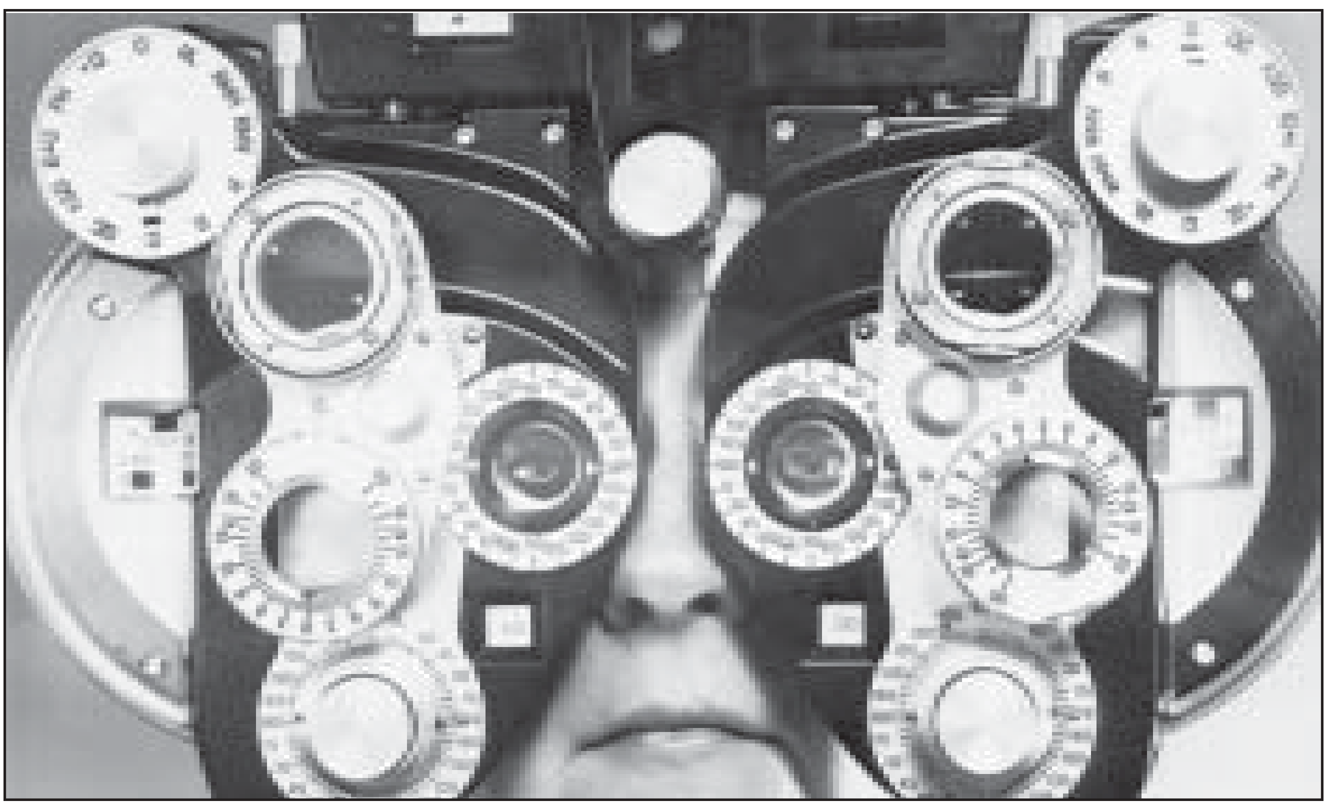


Figure 1 – Front view of PHOROPTOR Refracting Instrument with patient's eytes centered in apertures.

The young hyperopic individual complains more often of discomfort for close work, while the older hyperope complains of blurred near vision.

Unlike myopes who cannot improve their vision by accommodation, hyperopes are able to improve their vision by accommodation, which presents more difficulty in the determination of refractive error.

If a cycloplegia is not used, the measurement of the degree of hyperopia with the PHOROPTOR may not reveal the total amount. However, that portion of the hyperopia which is found without cycloplegia is usually adequate to provide clear comfortable vision.

Briefly stated, the strongest plus sphere which provides clear distance vision (20/20 or 20/15) is a measure of the manifest hyperopia. Depending upon the patient's age and amplitude of accommodation, near point tests (to be discussed later) may uncover a certain degree of latent hyperopia.

IV. Subjective Tests

The objective tests of ophthalmometry* and retinoscopy provide valuable guides to the nature and approximate amount of the refractive error. However, it is the subjective tests which provide the "last word" in determining the patient's prescription. Only patients can judge which portion of the image ray bundle serves gives them the best and most comfortable visual acuity.

Preliminary Procedure

The PHOROPTOR is adjusted to the patient according to the instrument manual instructions. The following points warrant repeating:

1. Patients are instructed to hold their heads in a normal, natural position while viewing a target. A helpful suggestion is to ask patients to hold their heads as though someone was going to take a photograph or paint a picture of them. The chair height should be such that the patient's eyes, in primary direction of gaze, are slightly above the projected target, so he or she is required to look down (5 to 10°) to see the target.

2. The height and inter-pupillary distance of the PHOROPTOR are adjusted so the patient's eyes are in the center of the apertures (see Figure 1, p. 5).

It is better that the patient lean into the PHOROPTOR rather than lean back against the back headrest.

3. The refractionist should check the vertex distance of the patient's cornea with respect to the rear of the PHOROPTOR to insure that the patient's eyes are not too close to the rear surface. Being too close to the rear surface results in the eye lashes touching the lenses. Being too far away from the rear surface requires, when the correction is above 4.00D, a compensatory adjustment to the lens powers determined —(see PHOROPTOR manual).

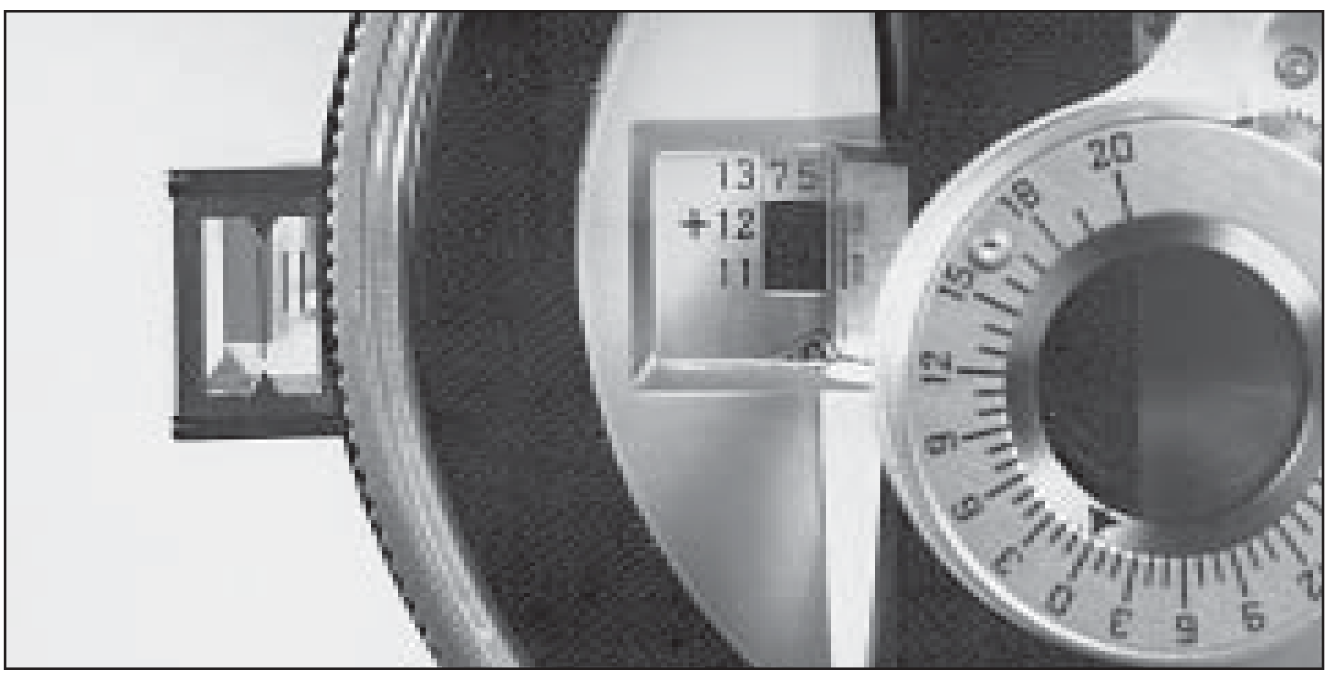


Figure 2 – Front view showing vertex distance scale.

* Technique of measuring the radii of the cornea is described in the manual of instructions accompanying the Ophthalmometer.

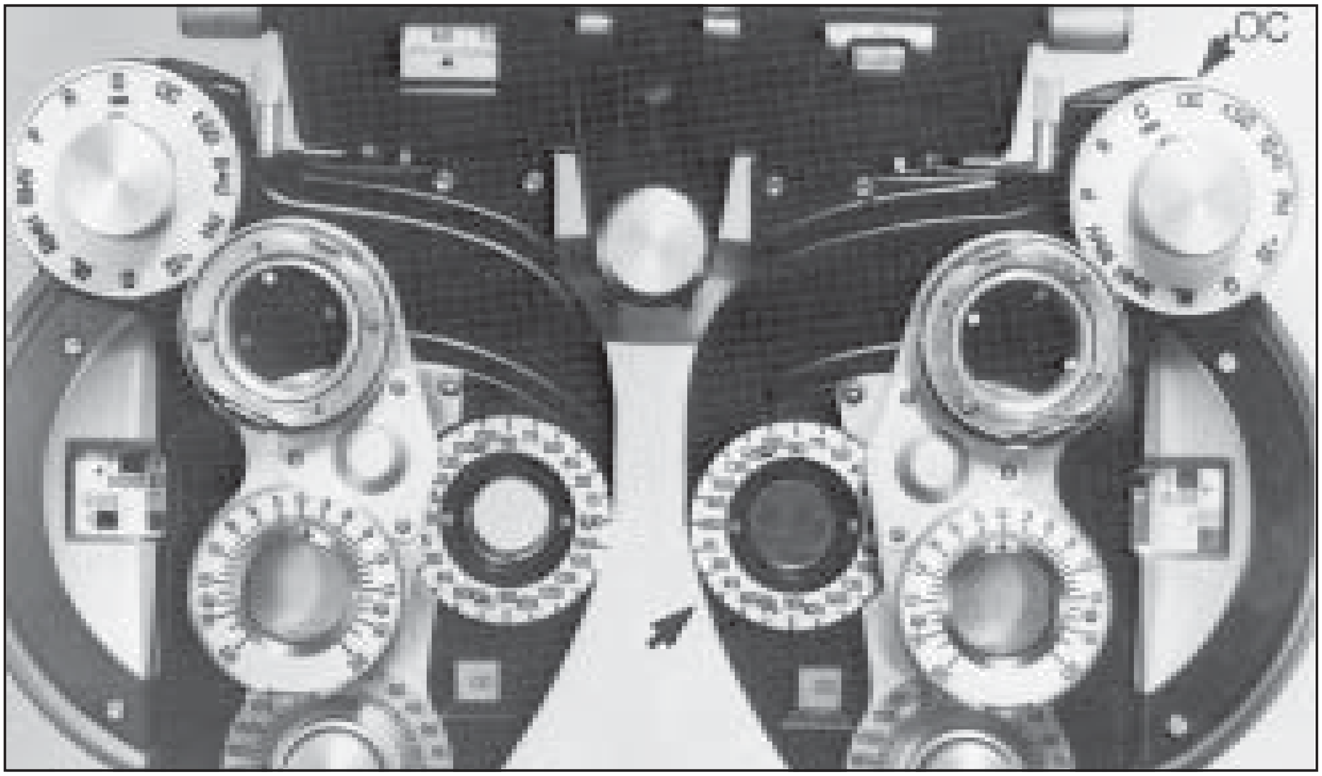


Figure 3 – Front view with left eye occluded by "OC" disc.

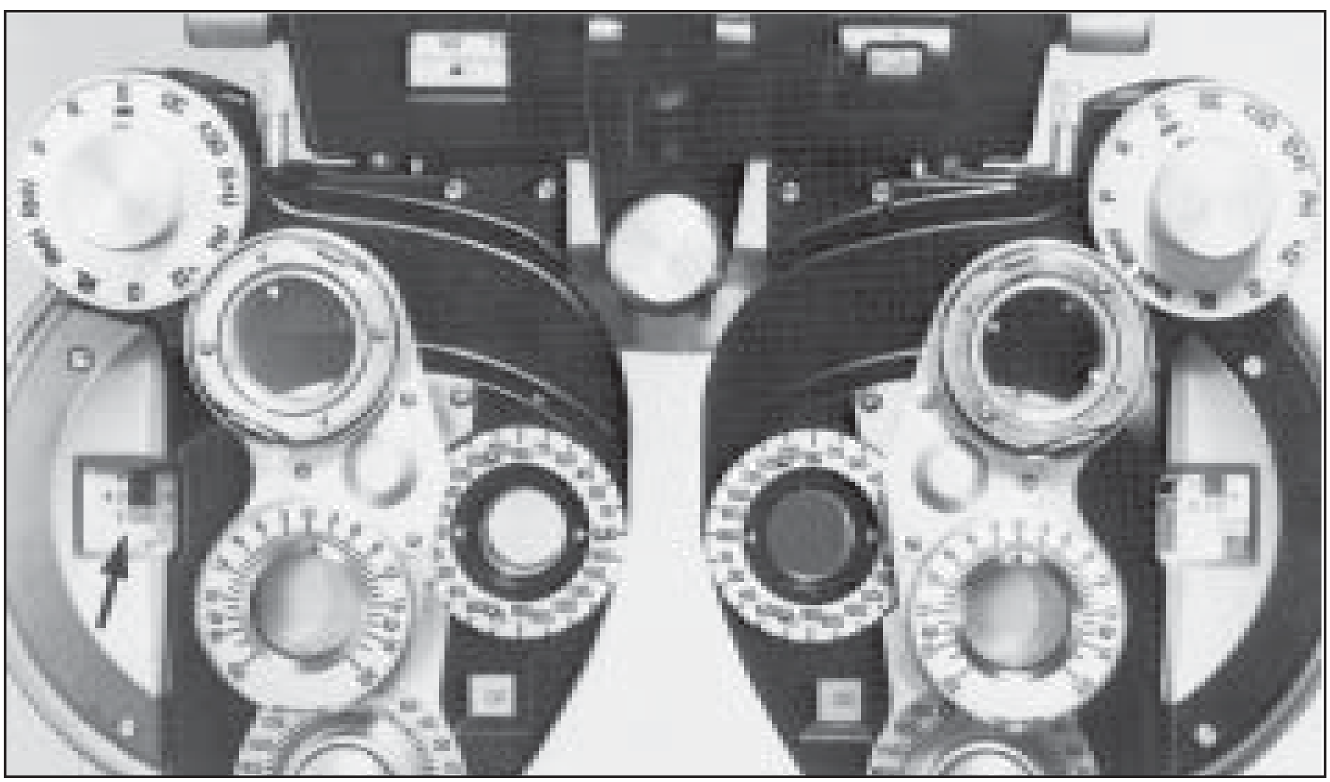


Figure 4 – Front view with +2.00D Sph. before right eye.

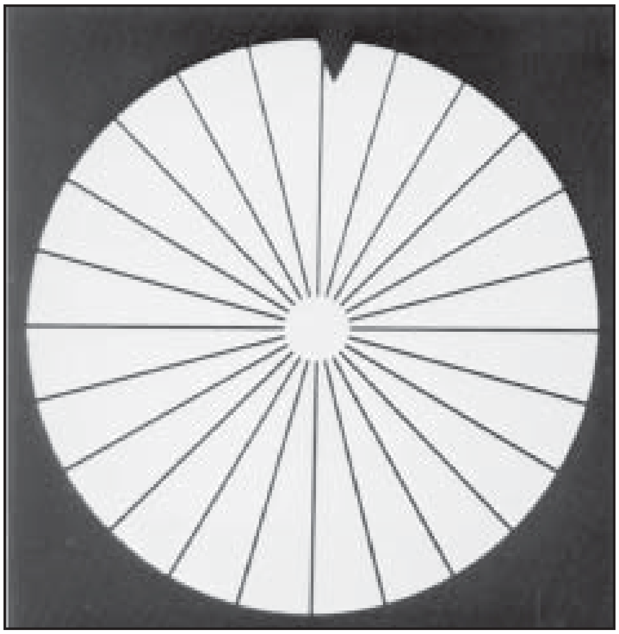


Figure 5 – View of projected astigmatic chart.

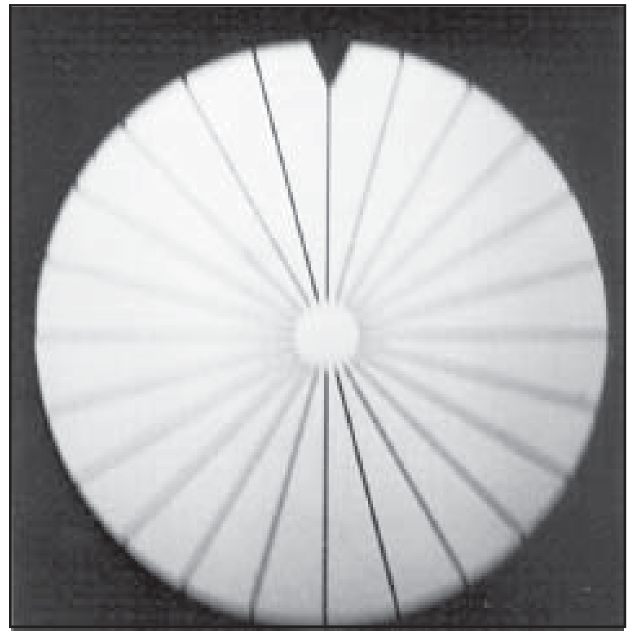


Figure 6 – Astigmatic chart (seen by patient) with two lines clearer.

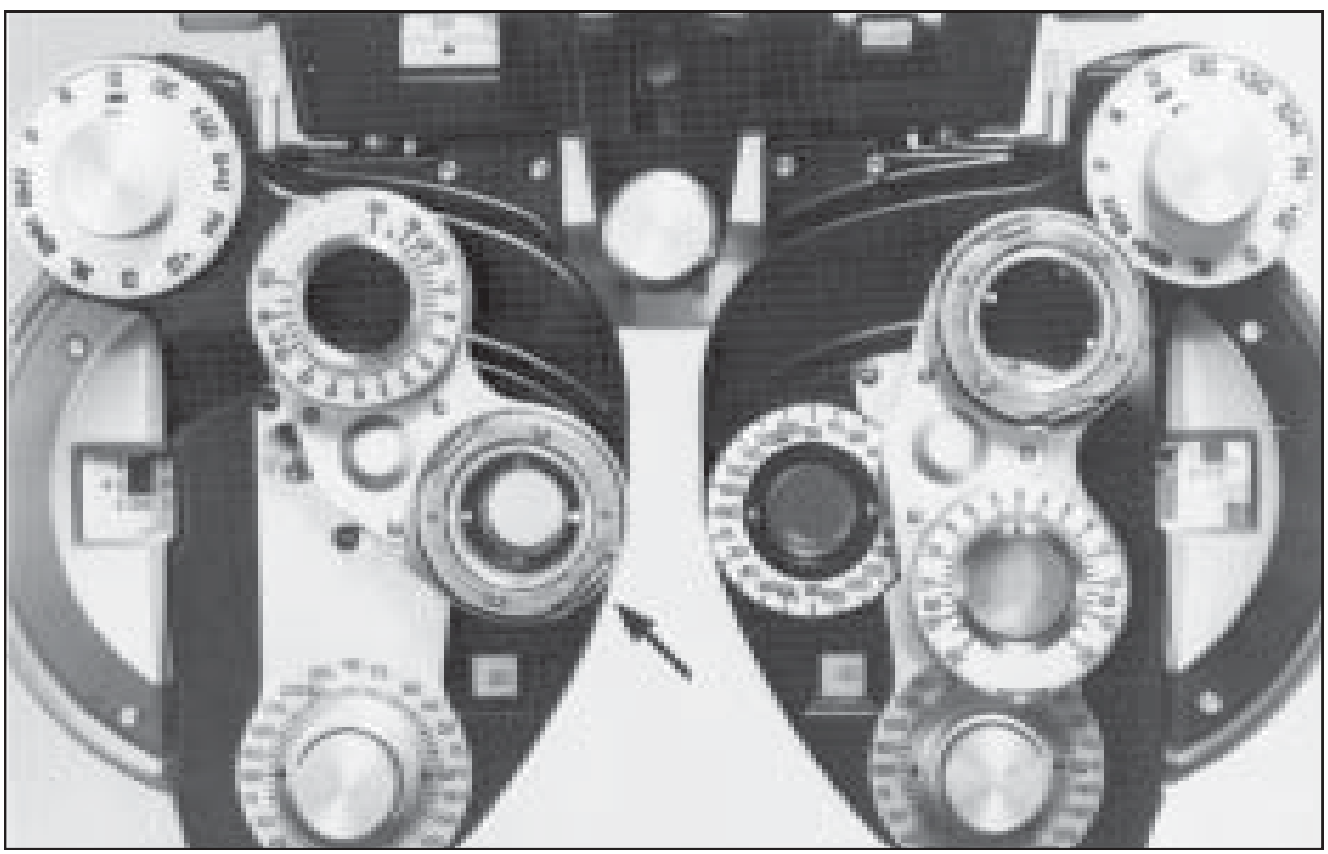


Figure 7 – Flip cross cylinder unit before right eye.

Refraction Procedure – Astigmatic Dial

The eye which has the best vision and the least refractive error is refracted first. This is usually the right eye.

1. The left eye is covered (occluded) with the "OC Disc" (see Figure 3, p.7).

2. The maximum plus (or minimum minus) sphere power,* determined by retinoscopy, should remain before the patient's right eye (see Figure 4, p. 8) while the astigmatic chart is projected (see Figure 5, p. 8).

3. The patient is asked which lines (or spokes of the wheel) appear blackest and clearest (see Figure 6, p. 8).

4. If the suspected amount of the astigmatism is small, or if the patient is hesitant in reporting any lines clearer, it is well to demonstrate to the patient what he or she might be expected to see. This can be done by introducing the Flip Cross Cylinder unit (see Figure 7, p. 8).

5. The Cross Cylinder is flipped – for example, minus cylinder axis 90, 180, 45 and 135. If the patient responds that the vertical, then the horizontal, then the 45th meridian, and then the 135th meridian lines appear clear, the examiner may conclude that any astigmatism present must be 0.25D or less.

6. Obviously, if the patient reports the appropriate lines clearer in only three positions of the Flip Cross Cylinder, but not in one certain position, the clue is that there is a cylinder indicated with minus axis in the position which makes all the lines on the chart more nearly alike.

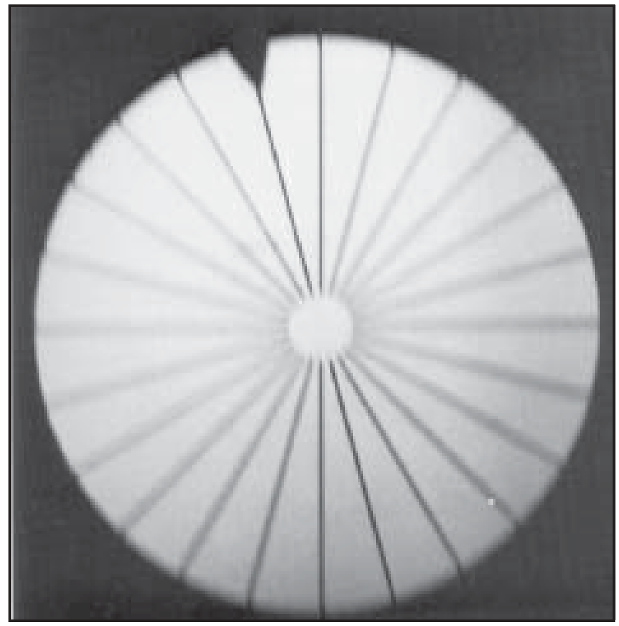


Figure 8 – Rotating arrowhead on astigmatic chart indicates clearest lines.

7. From the lensmeter measurement of the patient's glasses and the visual acuity with them, as well as from the ophthalmometer readings and the retinoscopic findings, refractionists have a pretty good indication of what they expect the patient to see on the astigmatic fan chart. Hence, they may ask whether the line on the astigmatic chart corresponding to the most out of focus meridian appears clearer.

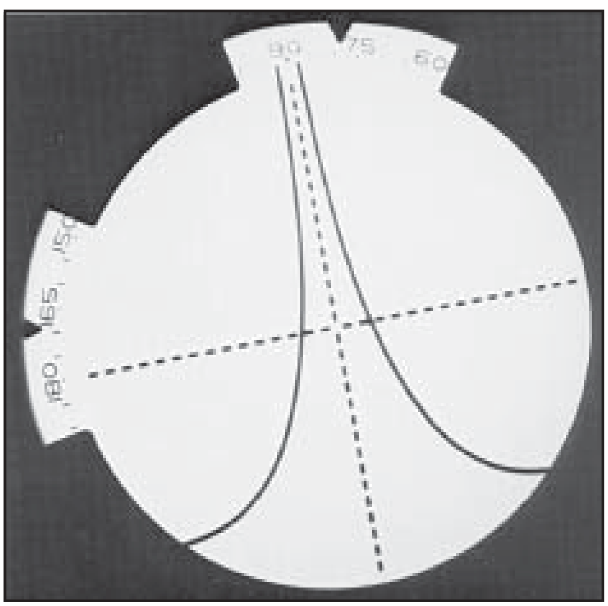


Figure 9 – Paraboline chart with narrow end of curved lines coinciding with meridian indicated by astigmatic chart.

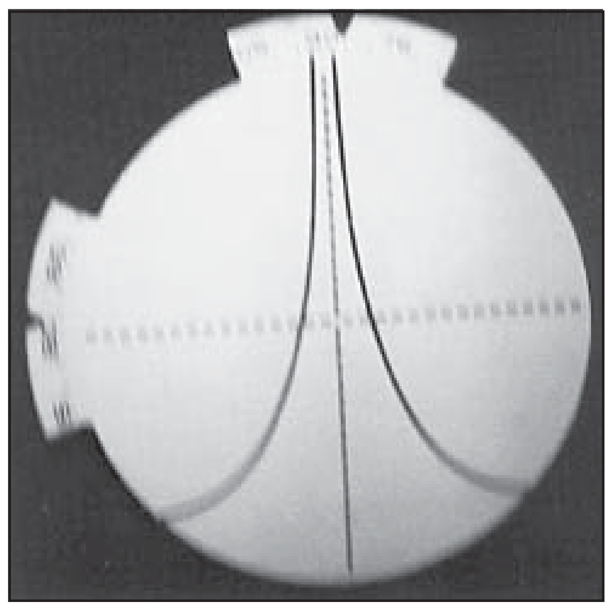


Figure 10 – Right side of narrow end of curved lines appears blacker.

* That is "with" motion in all meridians has been corrected until point of reversal – i.e., "against" motion in all meridians. This should result in a fogging sphere power of 0.25 to 0.50D. If retinoscopy cannot be done, the spherical power providing optimum vision – as outlined in the sections on myopia and hyperopia – may be used as the fogging sphere, provided 0.50D or more plus (or less minus) is added.

8. The line, or lines, indicated by the patient are pointed out by the rotating arrowhead on the astigmatic fan chart (see Figure 8, p. 9). This arrowhead is geared to the Paraboline Chart and when it is presented, the position (meridian) where the two curved lines almost come together will coincide with that of the clearest meridian on the fan chart (see Figure 9, p. 9).

9. To refine the location of the clearest meridian more exactly, the patient is asked whether one side (or limb) of the two curved lines appears blacker at the end where they almost meet.

10. When one side appears blacker (see Figure 10, p. 9), the Paraboline target is rotated — away from the blacker side — until the other side just appears blacker (see Figure 11, below). The optimum position — where both sides appear equally black — is halfway between the positions where one side is just blacker than the other and vice versa (see Figure 12, below).

11. Once the exact astigmatic axis has been determined, as above, the patient's attention is directed to the two straight lines and the patient is asked to note that the line which appears to run together more — i.e. more nearly forms a continuous line — is the one which goes through the narrow end of the two curved lines, while the other straight line (at right angles to the first one) appears to be a more blurred dotted line—i.e. has more gaps in it (see Figure 12, below).

12. Minus cylinder power is added at axis 90° from the straight line appearing more continuous (or at axis coincident with the more blurred dotted line) until both straight lines appear as equally clear dotted lines.

Spherical Balance

Once the astigmatism has been corrected for each eye, as per the refraction procedure, the Snellen letters are presented and the patient is asked to read the smallest line of letters possible — first, with one eye, then the other and binocularly.

Assuming that each eye was slightly fogged as a result of the retinoscopy sphere being the maximum plus, or minimum minus, the patient should be barely able to read the 20/20 line with each eye (provided each eye is capable of good vision)* and binocularly, he may read the 20/20 line fairly well.

To ascertain that each eye was properly fogged— i.e. that the maximum plus or minimum minus sphere was found by retinoscopy, first add +0.25D sphere; then, + 0.50D sphere monocularly. If the added + 0.25D sphere blurs each eye one line of letters (e.g. from 20/20 to 20/25) the conclusion is that retinoscopy did determine the maximum plus or minimum minus sphere. Also, when the vision of each eye blurs the same for the same amount of added plus sphere, the indication is that the proper spherical balance has been determined.

Knowing what should happen, as above, when test conditions and results are ideal, enables one to cope with other situations which may occur. For example:

1. When the monocular vision, following the astigmatic chart test, is a good 20/20 or better the probability is that there was an inadequate fog determined by retinoscopy.

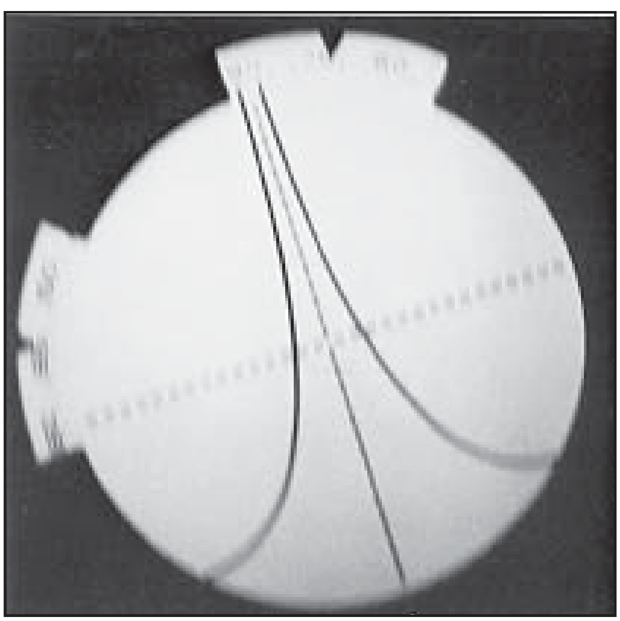


Figure 11 – Left side of narrow end of curved lines appears blacker.

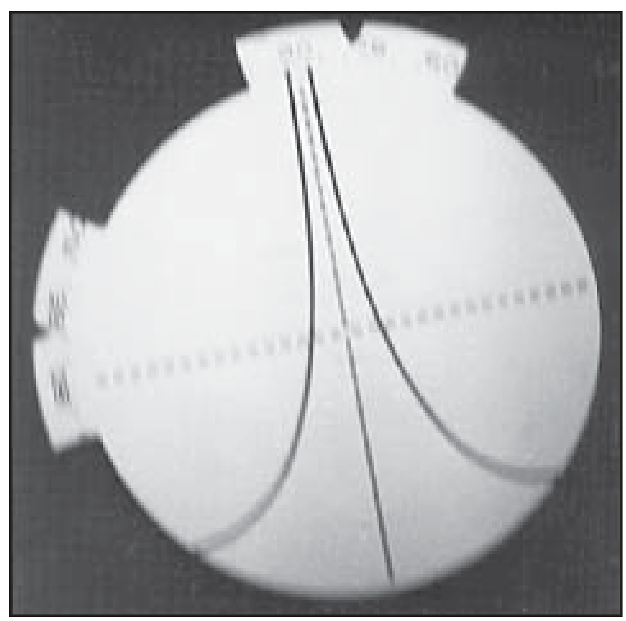


Figure 12 – Both sides of narrow end of curved lines appear equally black.

* The Pinhole Disc test, described later, may be used to determine whether an eye is capable of good vision.

2. This suspicion is further confirmed if, on adding + 0.25D and +0.50D sphere, the acuity improves rather than becomes impaired.

3. When this occurs, the plus sphere power is increased (or the minus sphere power decreased) until an additional +0.25D and a +0.50D sphere does reduce the acuity, first one line and then two lines. The sphere which does provide this situation is the "ideal fogging sphere" and the cylinder correction should be rechecked on the astigmatic charts, as previously described.

NOTE: Even though the above subjective tests apply particularly to the non-cycloplegic technique, they may be used equally well when a cycloplegia is used, since even with a cycloplegia, there is often a significant amount of residual accommodation.

Jackson Cross Cylinder Tests

Some refractionists prefer to use the Cross Cylinder technique, rather than the Astigmatic Charts, relying on their retinoscopy to determine the approximate cylinder power and axis, then refining this correction by the Cross Cylinder test on letters. Others prefer to use Astigmatic Charts exclusively. The majority of patients respond to both tests equally well. The refractionist should be able to perform both tests as there are a few patients who respond better — i.e. are more critical and accurate — on one test than on the other.

Procedure: Checking the Axis

1. Have the sphere and cylinder, determined by retinoscopy and modified by the Astigmatic Chart before the patient's eyes.

2. Test first one eye and then the other with the occluder (OC) before the eye not being tested.

3. The eye should not be fogged — as in the Astigmatic Chart test.

4. Patient fixate two or three letters on the smallest line they can read.

5. Rotate the PHOROPTOR turret unit containing the Cross Cylinder* in front of the main aperture for the eye being tested (see Figure 13, below).

6. Visual indication that the Cross Cylinder unit is in the correct position for Axis Check is that the position of the knurled flip knob correspond to the axis of the correcting cylinder (see Figure 13, below).

NOTE: If the Cross Cylinder is not in the Axis Check position, but in the Power Check position, it should be rotated 45° counterclockwise to a detent.

7. The Cross Cylinder lens is "flipped" from Position 1 to Position 2 by rotating the knurled knob with the thumb (see Figure 14, p. 12).

8. The patient is asked: "Do you see the letters better now in Position 1, or now in Position 2?" Some patients respond better to the opposite question: "Are the letters worse (more blurred) in Position 1 or 2?"

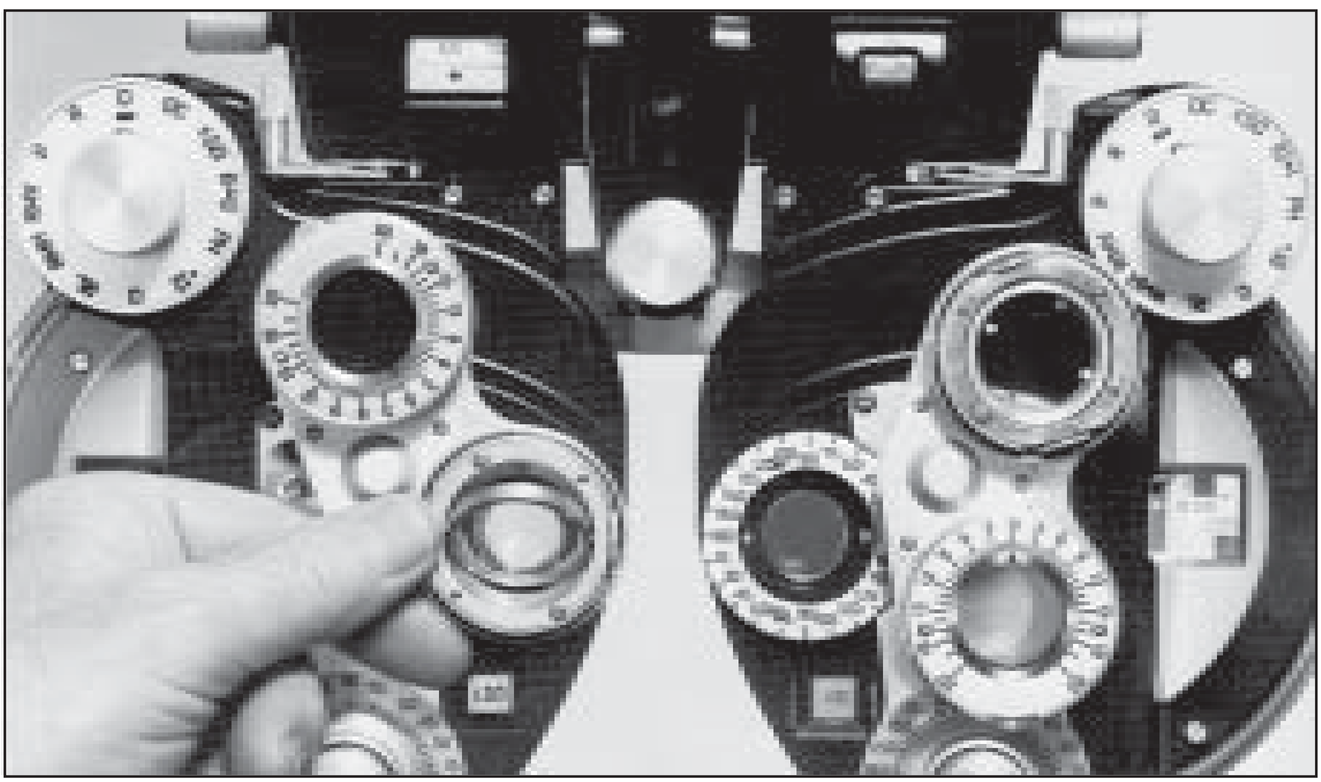


Figure 13 – Cross cylinder unit before right eye in axis check position..

* The usual power of the Cross Cylinder is ±0.25D, but other powers (±0.37D and ±0.50D) are available.

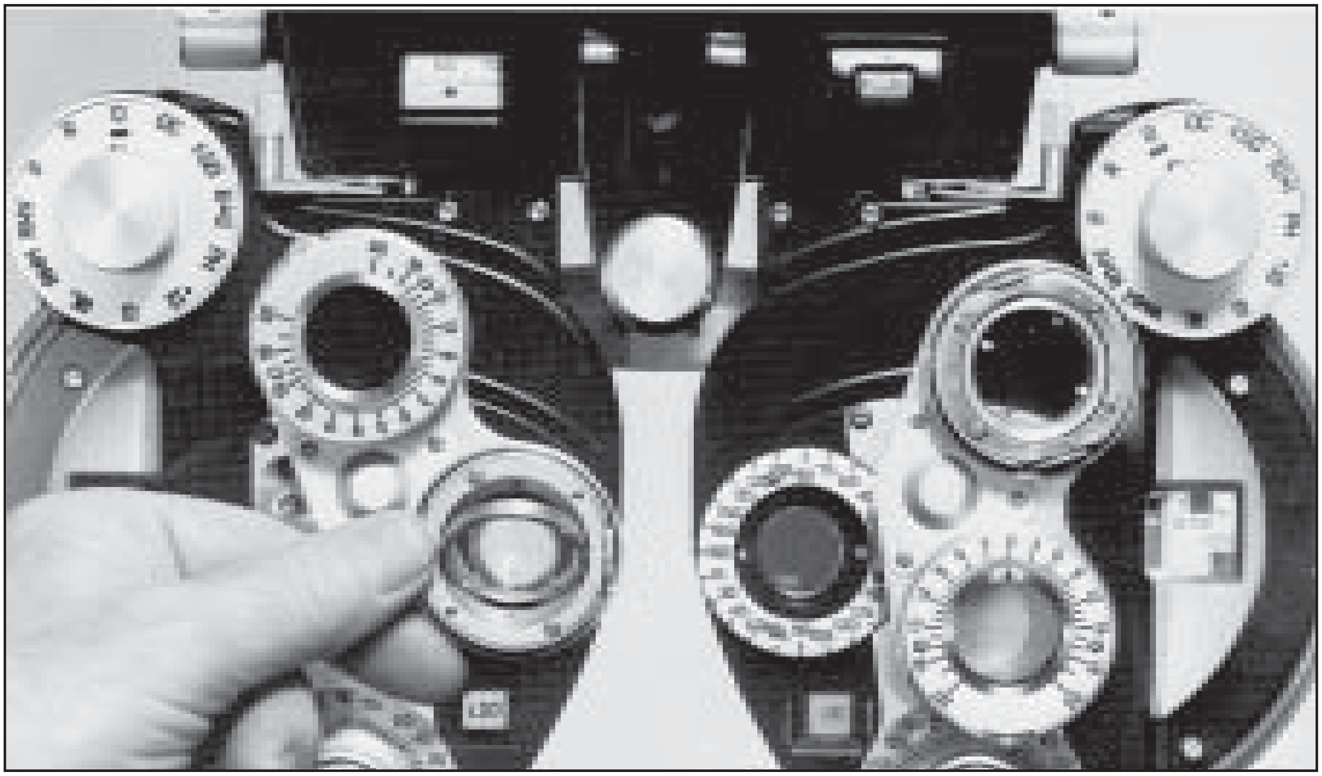


Figure 14 – Cross cylinder unit flipped from position 1 to position 2.

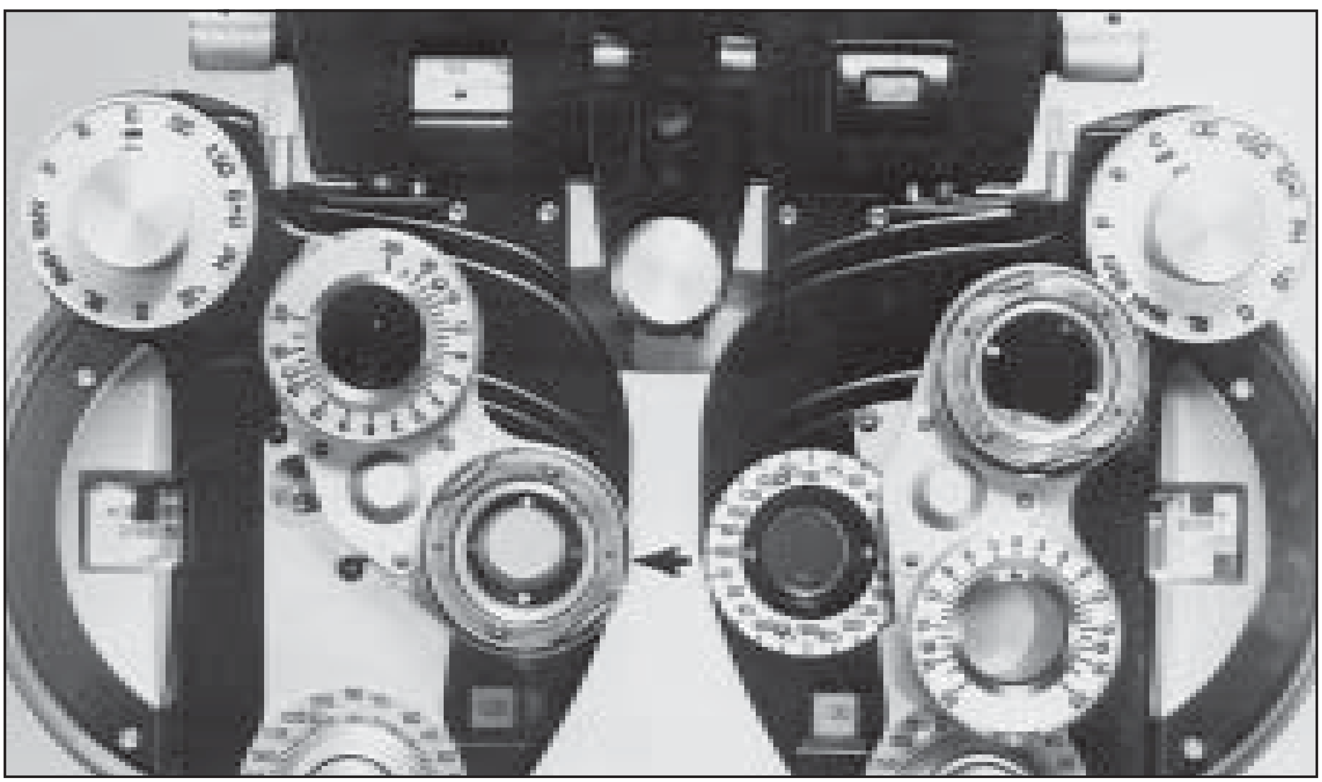


Figure 15 – Cross cylinder unit in power check position.

9. If the vision is better (less blurred) in one position, compared to the other, the minus correcting cylinder axis is rotated 5° to 10° toward the position of the red dots (in a plus cylinder PHOROPTOR, the correcting cylinder is rotated toward the position of the white dots) at which vision is better.

10. As the correcting cylinder axis is rotated, the Cross Cylinder axis is automatically rotated the same amount. Repeat Steps 7 and 8 until the final "end-point" is reached. This end-point is reached when the position of the correcting cylinder axis is such that flipping the Cross Cylinder from Position 1 to 2 makes the vision equally blurred.

Checking the Power

1. The Cross Cylinder unit is rotated 45° clockwise to the detent for Power Check position. Visual confirmation of this position is when the red dots, as well as the letter "P" (for Power) are parallel to the correcting minus cylinder axis (see Figure 15, p. 12).

2. While the patient is viewing (monocularly) two or three letters on the smallest line readable, the Power Check is performed by flipping the knurled knob from Position 1 to Position 2, and the patient asked, as before, whether the vision is better (or worse) in Position 1 compared to Position 2.

3. If vision is better (less blurred) with the red dots parallel to the minus correcting cylinder axis, the correcting cylinder power is increased. (Of course, in a plus cylinder PHOROPTOR, the opposite is true.)

4. If vision is better with the red dots perpendicular to the minus correcting cylinder axis, the correcting cylinder is reduced. (In a plus cylinder PHOROPTOR, the opposite is true.)

5. The final end-point is obtained — i.e. the correcting cylinder power is correct — when the vision is impaired equally when the Cross Cylinder lens is flipped from Position 1 to 2.

Usually, it is necessary to change the correcting cylinder power by only 0.25D. However, when it is found that the correcting cylinder power must be changed 0.50D or more, the sphere should be modified by 0.25D more plus, or less minus, for every 0.50D increase of correcting minus cylinder power—and vice versa, the sphere power modified by 0.25D less plus, or more minus, for every 0.50D decrease of the correcting minus cylinder power.

Although our discussion and illustrations have been concerned with determining the correction for the right eye, it should be understood that the same procedure is used for the left eye.

Pinhole Disc

The pinhole (PH) disc, which is in the PHOROPTOR Auxiliary Dial, is used in subjective refraction to reduce the retinal diffusion circles, especially in cases of subnormal vision (see Figure 16, below). It is helpful in determining whether a patient's vision may be improved by lenses.

It is essential that the acuity chart be well illuminated and that patients align their eye so they see through the pinhole.

If a patient with poor visual acuity sees better when looking through the pinhole, the indication is that their poor vision is due to a refractive error and the proper lenses should provide vision as good as that obtained with the pinhole.

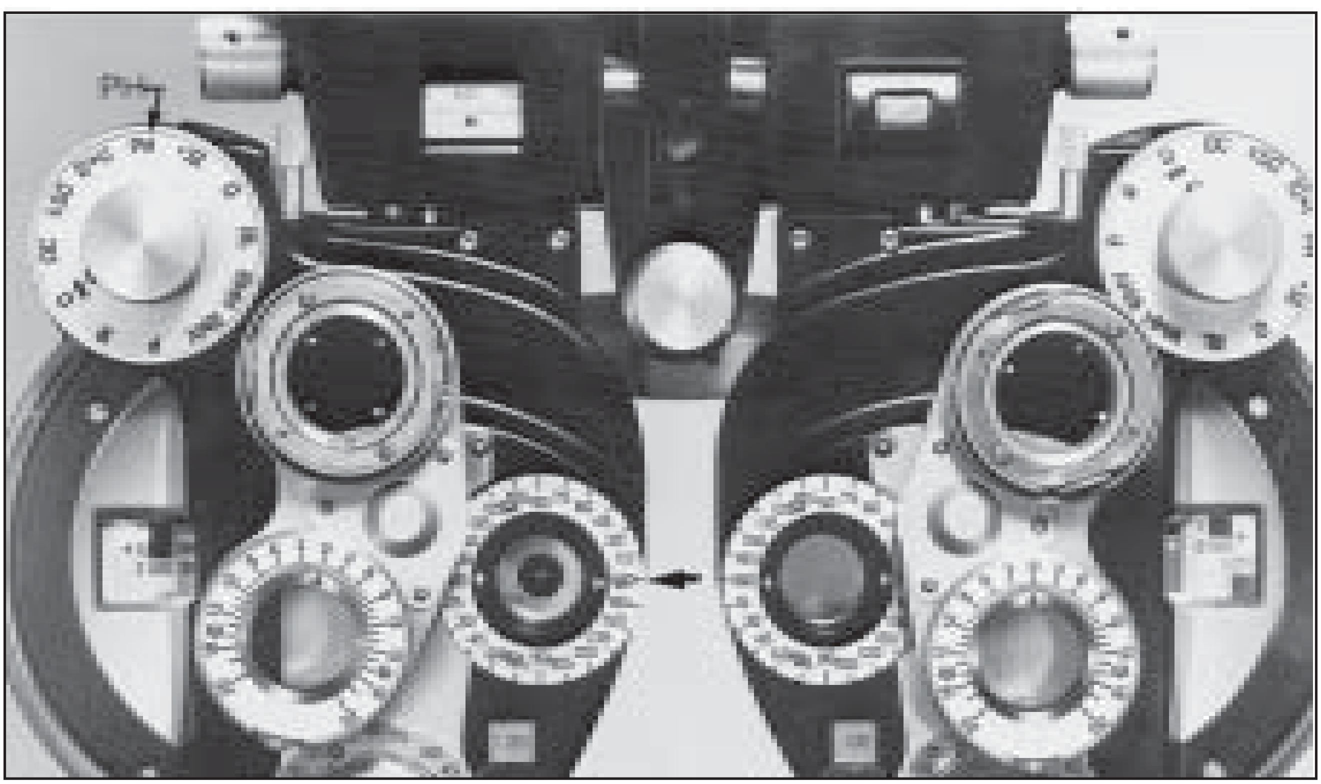


Figure 16 – Pinhole disc (PH) from auxiliary dial in place.

If the poor visual acuity is due to amblyopia, disease, or opacities of the ocular media, there is usually no improvement or even a reduction in acuity occurs with the pinhole.

Hence, the Pinhole Disc is very useful as a quick screening test to determine whether the reduced visual acuity is optical or nonoptical — that is, whether or not a refractive correction will improve the vision.

V. Near Point Refraction

Methods of Determining Amplitude of Accommodation

1. Push-Up: With the distance correction converged for Near in the PHOROPTOR, the patient is asked to report a blur on a fine print target as it is gradually moved closer from the usual reading distance of 16 inches (see Figure 17, below). The distance at which the print blurs is expressed in diopters. Both monocular and binocular results should be recorded.

If the patient is too presbyopic to read the target at 16 inches, plus sphere power is added until the print is clear and this additional power subtracted from the push-up results.

2. Minus Sphere Test: A small print target is placed at 16 inches, and minus spheres of increasing power are added gradually to the distance correction until the patient reports the first blurring. The amplitude of accommodation is determined by adding the minus power, taken as a plus, to 2.50D, the accommodative demand for the target distance. The test should be made both monocularly and binocularly. If patient is too presbyopic to read the print at 16 inches with the distance correction, add auxiliary + 2.50D spheres. The minus sphere that can then be overcome indicates the amplitude of accommodation.

Use of the Amplitude of Accommodation Data

It has been established that one can read or do prolonged close work comfortably when one has at least twice the amount of accommodation required for near point tasks. Hence, if one's work, and length of one's arms, require near point seeing at 16 inches (2.50D), one should have an amplitude of accommodation of 5.00D or more. When the amplitude becomes 4.00., (one-half being 2.00D), an add of +0.50D is indicated for reading at 16 inches (2.50D). An amplitude of only 2.00D requires an add of + 1.50D in order to leave patients with the half (1.00D) of their accommodation in reserve. That is, the amount of the add for near should be such as to require patients to use only half of their amplitude of accommodation and keep half of their amplitude in reserve.

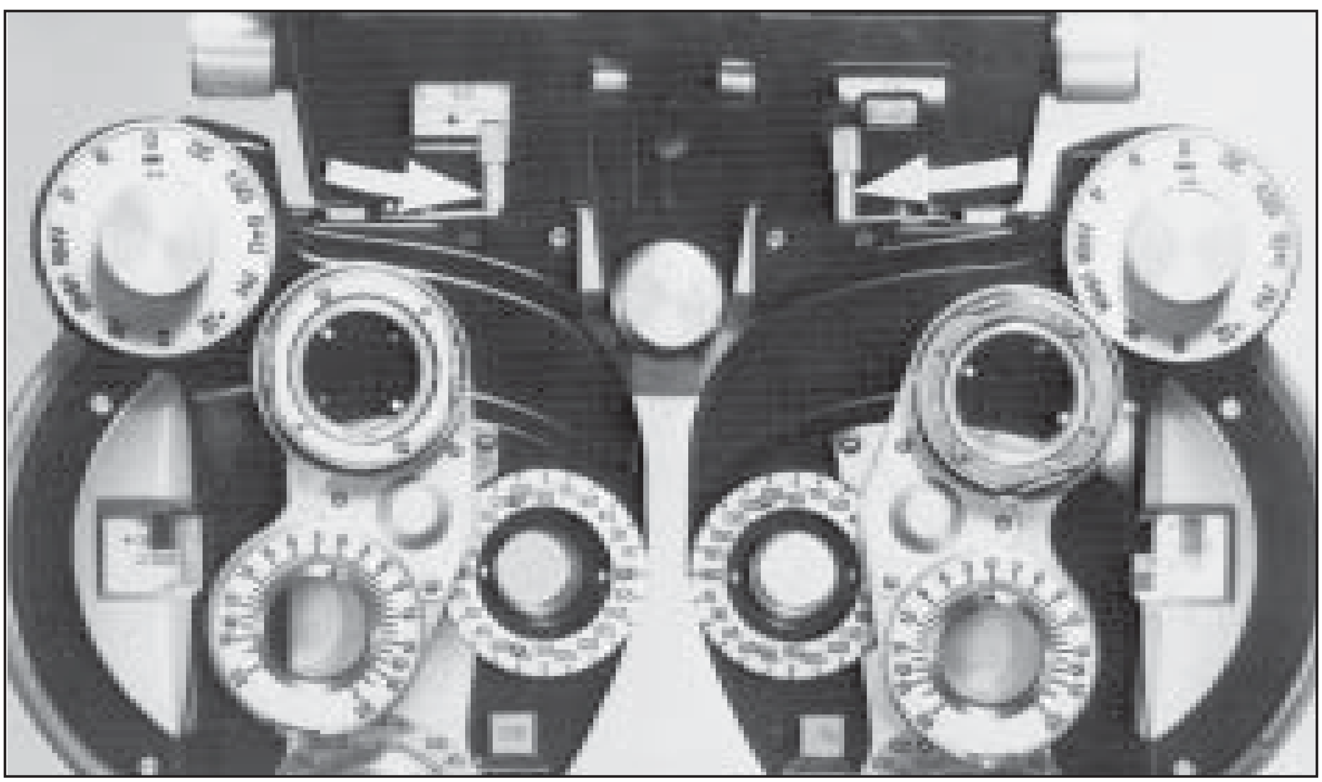


Figure 17 – PHOROPTOR converged for near point tests (note position of vergence levers).

Dynamic Cross Cylinder Test

To determine the near point conjugate to the patient's retina while he or she is using the amount of accommodation they "prefer" to use:

1. A "grid" target consisting of horizontal and vertical fine lines is positioned at the near point testing distance, i.e. 13, 14, 16 or 20 inches (see Figure 18, below).

2. The distance correction (sph. and cyl.) is in position before the patient's eyes, and if the astigmatism at the near point is fully corrected, the horizontal and vertical lines will appear equally clear, or equally blurred in presbyopia. In the latter case, an approximate correction for the presbyopia should be added. If the horizontal and vertical lines do not appear equally clear, the cylindrical correction should be changed until both appear equally clear, just as in the subjective astigmatic test for distance.

3. When the horizontal and vertical lines appear equally clear (or are made to appear so by adjusting the power of the cylinder), the pair of 0.50D Cross Cylinders in the Auxiliary Dial, with the minus axis vertical, are added in the PHOROPTOR to the lenses before the patient's eyes (see Figure 19, p. 16). These Cross Cylinders have the optical effect of creating an Interval of Sturm*, and patients, by adjusting their accommodation, indicate which portion of the Interval of Sturm they prefer to see.

4. If patients accommodate exactly for the distance of the target, the horizontal and vertical lines of the grid target appear equally clear. That is, the posterior (vertical) focal line of the Interval of Sturm is dioptrically as far behind their retina as the anterior (horizontal) focal line is in front and the circle of least confusion is on their retina. Hence, when the vertical and horizontal lines appear equally clear, the indication is the patient can accommodate easily for the near test and needs no "add" for near.

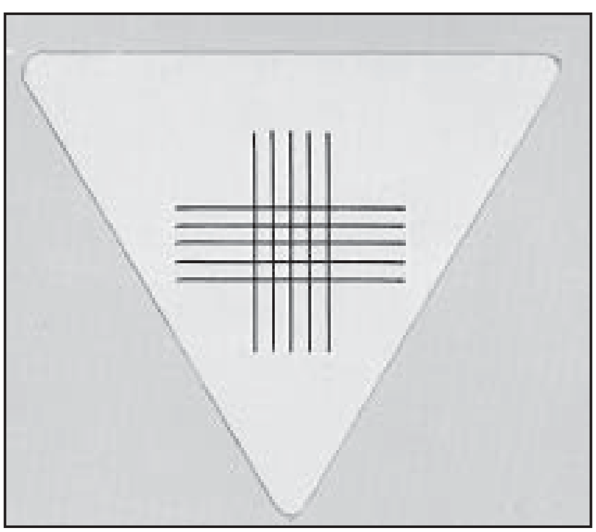


Figure 18 – Grid target for dynamic cross cylinder tests.

* **Interval of Sturm** – The focal interval or distance between the anterior and posterior focal lines in an astigmatic system.

5. If the vertical lines should appear clearer , the indication is that the patient has over-accommodated for the test distance (see Figure 20, p. 16). That is, they have exerted their accommodation to place the posterior focal line nearer their retina, adding minus sphere power until the horizontal lines appear as clear as the vertical line measures the amount of over-accommodation.

6. When the horizontal lines appear clearer than the vertical, the indication is that the patient has under-accommodated for the test distance (see Figure 21, p. 16). That is, the anterior focal line is nearer their retina, adding plus sphere power until the vertical lines appear just as clear as the horizontal lines measures the amount of underaccommodation.

The above (horizontal lines clearer) is the usual finding in presbyopia, and the amount of plus sphere necessary to add in order to make the horizontal and vertical lines appear equally clear agrees with the "add" found by leaving half the amplitude of accommodation in reserve.

With normal findings in non-presbyopic cases it is necessary to add +0.25 to +0.50D sphere (monocularly) to equalize the clearness of the horizontal and vertical lines. That is, most non-presbyopes prefer to relax their accommodation when given the opportunity — as is implied in the usual question: "Which lines appear clearer, the vertical or the horizontal?"

This form of questioning has been found to give more definitive answers than asking the patient to state when the horizontal and vertical lines appear equally clear.

Variations and Refinements of the Dynamic Cross Cylinder Test

1. **Monocular Tests** — Each eye is tested separately while the other eye is occluded.

2. **Binocular Tests** — The test is conducted while binocular vision and fusion of the test target is maintained. Lens powers are added before each eye simultaneously.

3. **Dissociated Tests** —This is essentially a monocular test, instead of covering (occluding) one eye, vertical diplopia is introduced by the 6 Base Up Auxiliary Dial lens before the right eye and the patient's attention directed alternately to the upper and then the lower target while the horizontal and vertical lines of the grid target are equalized as before outlined.

The binocular finding is normally slightly less than the monocular findings, but when it is markedly less, or when it is greater than the monocular findings, some anomaly of the accommodation — convergence relationship is indicated.

Some practitioners with little experience using this test comment that patients have difficulty in reporting which lines are clearer or when the lines are equally clear. This is usually due to indecisive patients and to misunderstanding of the examiner's questions.

In such cases, it is helpful to make large, rather than small, changes in the spherical powers added so the patient can readily discern a difference and then employ the "method of-limits' — i.e., the spherical power which just makes the vertical lines and then the horizontal lines clearer.

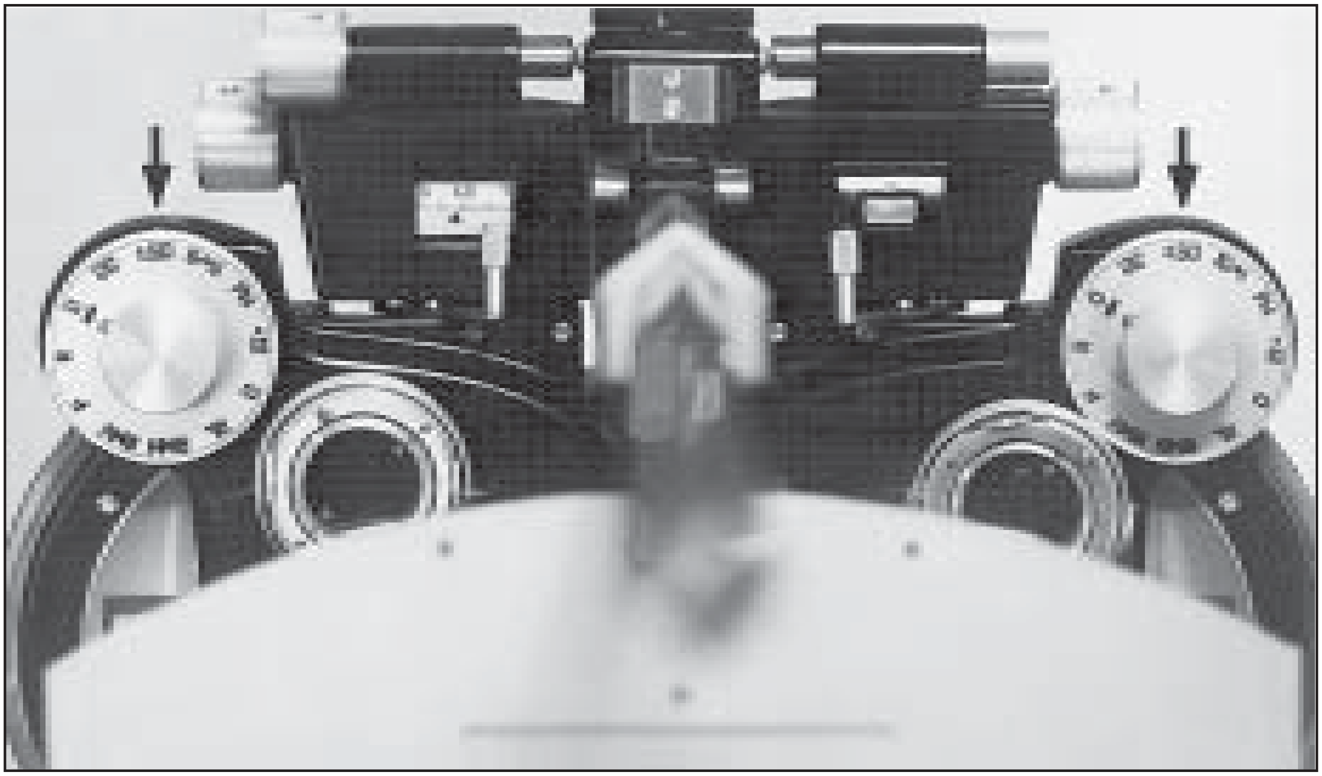


Figure 19 – Auxiliary dial cross cylinders in place.

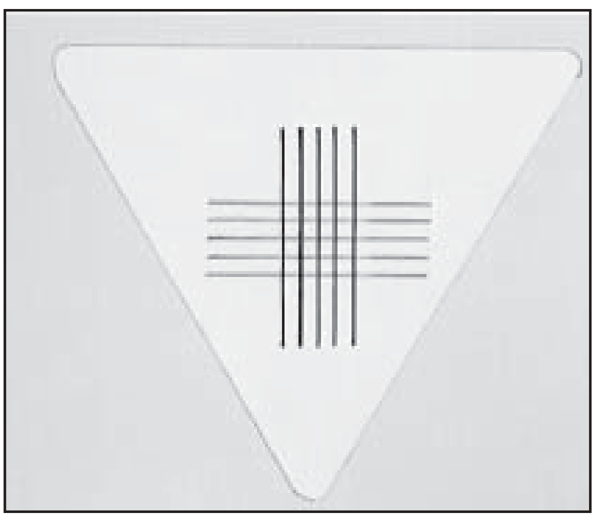


Figure 20 – Grid target with vertical lines clearest.

Figure 21 – Grid target with horizontal lines clearest.

Another procedure is to vary the distance of the test card when the patient is indecisive. For example, with the target at 16 inches and a tentative “add” in place, the patient first reports one set of lines and then the other appear clearer. Bringing the target closer, for example to 13 inches (requiring 0.50D more accommodation), should result in the horizontal lines appearing clearer, and bringing the card farther away to 20 inches (requiring 0.50D less accommodation) should make the vertical lines appear clearer. Smaller movements of the card, requiring accommodation changes of 0.25D or less, may be tried to determine the dioptric range which effects a reversal of the lines appearing clearer. The advantages of this test are:

1. Patients can usually discern changes in the clearness of lines more readily than changes in the legibility of letters.

2. The patient’s accommodation seems to be less variable.

3. It provides findings which are usually in agreement with other near point tests but which are often more definitive with respect to patient’s response.

Verification of Near Correction: "Method of Limits"

Finding the range through which fine print appears clear, monocularly and binocularly, is a verification of previous tests. The ranges should be equalized dioptrically rather than linearly.

The target of fine print is placed at the patient’s preferred reading distance and plus spheres, then minus spheres, are added in the PHOROPTOR until the limits of clear vision are ascertained. The add that results in equal dioptric ranges on either side of the preferred working distance leaves half the amplitude of accommodation in reserve.

Since the binocular amplitude of accommodation is normally greater than the monocular amplitudes, the add determined binocularly is slightly less than found monocularly. Clinical experience indicates that it is better to prescribe the smaller binocular add.

In unusual cases where monocular findings differ greatly from the usually slightly lower binocular ones, some anomaly of binocular vision may be indicated. Monocular testing also serves as a check of the distance correction. When the monocular amplitude seems greater for one eye, a recheck of the distance correction will often reveal that more plus (or less minus) sphere can be added for the eye having less amplitude of accommodation.

The factors involved in deciding upon separate distance and near corrections or multi-focals (bifocals or trifocals) will be discussed in a subsequent section.

VI. Factors in Multifocal Corrections

Prescribing Near Corrections

While population statistics provide tidy chronological scheduling for the inevitable onset and progression of presbyopia, clinicians know that both are unique for each of their patients and depend wholly upon that patient’s visual requirements and physiology. The clinician also knows that the patient’s case history is of paramount importance in the decisions relative to the amount of near addition, the kind of optical device selected, and the manner in which it will be fitted.

For the majority of habitual distance correction wearers, the multifocal is the obvious solution. Those patients who have not previously utilized distance correction however, often resist the multifocal solution. For them, single vision reading glasses and half eyes frequently prove more satisfactory; ultimately, however, many will resort to the multifocal.

When the practitioner has determined the distance Rx the reading add, and that a multifocal is appropriate, the following needs to be completed:

— Select the lens style and material

— Guide the selection of frame style and size

— Determine the position of the segment relative to the eye.

A wide variety of corrected curve multifocal constructions and sizes are available from which a design may be optimally matched to the patient’s needs. Tables 1 and 2 (pp. 18-19) list and describe these options in glass and hard resin, respectively.

Glass bifocals are made in two principal ways:

1. Both the cut-off style (see Figure 22, p. 20) and the round style (see Figure 22a, p. 20) are made by fusing segments of higher index glass into a finished concavity of the front convex surface of a major lens carrier of lesser refractive index. After fusing, a new single spherical front surface is generated and polished. The near power addition is a consequence of the segment’s relative index increment acting through the front air to glass and the internal glass to glass interfaces.

2. The Executive lens (see Figure 22b, p. 20) is the classic one-piece bifocal. Its near addition is a consequence of the greater, or steeper, curvature of the lower near lens portion — the segment.

In a real sense, all CR-39 resin bifocal lenses are one piece. The cut-off, round, and Executive lens styles (see Figures 22, 22a & 23, p. 20) are cast in glass molds which transfer, to the lenses, a finished front surface of the appropriate curvature and shape for the distance and near (segment) portions.

The cast resin progressive addition lenses (PAL) present important new multifocal prescribing opportunities. Unlike conventional bifocals or trifocals, which provide power for only two or three discrete distances, the PAL provides intermediate powers for viewing intermediate distances. With the PAL's, the patient is no longer confronted with the visual discontinuities encountered with conventional multifocals.

PAL's (see Figure 23a, p. 23) carry the distance correction with optical characteristics similar to those of a single vision corrected curve lens. Its lower, high acuity performance reading portion is connected, without interruption or demarcation lines, to the distance portion by a 10-12 mm long corridor whose power increases linearly from distance to near. PAL's, with their functional and cosmetic advantages, constitute legitimate alternatives to the conventional multifocal.

Determining the Add

The appropriate add for a given patient depends upon: 1) the range of distances in which their near activities are executed; 2) the time intervals devoted to these activities; 3) the visual criticality of those activities; 4) the available amplitude of accommodation. In addition, factors such as ambient illumination, the patient's height and build, the near-activity posture, and the tools or instruments used, must be considered in the determination of add power. With patients wearing their distance correction, measurement is made in the spectacle plane of the add which, ideally, satisfies the determinants and factors just outlined. For relevance, the patient's reading or fixation target should be similar, in its acuity demands, to those they encounter in near activities. Conventional prescribing entails keeping 1/2 to 2/3 of the accommodative amplitude in reserve — unused — when the patient is operating in his near field. Longer intervals of continuous near point activity warrant larger reserves.

TABLE 1 – GLASS

					Lens Dimensions					
Style	Add Range	Blank Size	No. of Base Curves	Seg Form	Size A	Decentration B	GC to Seg Edge C	Seg Edge to Seg OC D	GC to Seg OC (C D) E	Trifocal Intermediate
Executive Onepiece Bifocal	+0.50 to +3.50	56 x 60	6		60 mm	0	3.0		3.0	
	+1.00 to +3.00	60 x 65	3		65 mm	0	3.0		3.0	
		60 x 70	1 (8.00 Base only)		70 mm		5.0		5.0	
Executive Onepiece Trifocal	+1.50 to +3.00	56 x 60	3		60 mm	0	3.0		3.0	7 x 60
Executive Double Segment	+0.75 to +2.00	56 x 60	2		60 mm				Reading Distance Intermediate	21 x 60 14 x 60 21 x 60
Super S Fused Bifocal	+0.75 to +3.50	65 mm	3	Flat Top	25	3.5	5.0	5.0	10.0	
		65 mm	3	Flat Top	28	3.5	5.0	5.0	10.0	
	+1.00 to +3.00	71 mm	3	Flat Top	25	6.0	5.5	5.0	10.5	
Super S Fused Trifocal	+1.50 to +3.00	65 mm	3	Flat Top	25	3.5	1.5	8.5	10.0	7 x 25
Kryptok Fused Bifocal	+0.75 to +3.50	65 mm	3	Round	22	0	5.0	17.0	16.0	

Table 3 (at right) provides a listing of occupations and their associated typical working ranges. Consider prescribing an add for Table 3's presbyopic barber who has 3.00 diopters of accommodative amplitude. If we wish to hold 2/3 in reserve, the nominal add indicated for this patient would be 2.50D (dioptric equivalent of 16") minus 1.00D (1/3 of 3.00D amplitude) or 1.50D. Additionally, consideration of all the factors outlined above should enter into the prescription decision.

TABLE 3

Occupation	**Working Range (Inches)**	**Occupation**	**Working Range (Inches)**
Housewife	16 - 34	Librarian	14 - 36
Secretary	16 - 26	Surgeon	14 - 24
Accountant	16 - 28	Pharmacist	18 - 34
Dentist	10 - 24	TV Repairman	10 - 20
Grocery Clerk	18 - 28	Plumber	12 - 26
Artist	16 - 24	Cosmetologist	10 - 18
Barber	14 - 18	Key Punch Operator	12 - 24
Butcher	24 - 28	Gas Station Attendant	18 - 34
Carpenter	16 - 26	Desk Worker	16 - 36
Sales Clerk	18 - 24	Lathe Operator	12 - 20
Watchmaker	6 - 24	Arc Welder	14 - 22
Architect	12 - 30		

TABLE 2 – CR39 Hard Resin

Style	Add Range	Blank Size	No. of Base Curves	Seg Form	Lens Dimensions: Size A	Decentration B	GC to Seg Edge C	Seg Edge to Seg OC D	GC to Seg OC (C D) E	Trifocal Intermediate
Executive Bifocal	+0.75 to +3.50	62 mm	6		62 mm	0	3.0		3.0	
S. Bifocal	+0.75 to +3.50	66 mm	5	Flat Top	25 mm	6.0	5.5	5.0	10.5	
	+1.00 to +3.00	75 mm	3	Flat Top	25 mm	6.0	5.5	5.0	10.5	
Aspheric Lenticular Cataract	+2.00 to +3.50 (1/2D steps)	66 mm (40 mm spot)	9	Round	22 mm	0	2.0	11.0	12.0	
Aspheric Cataract (Full Field)		63 mm	13	Round	22 mm	0	2.0	11.0	13.0	
ULTRA-VUE PC-26	+1.00 to +3.00	75 mm	3		15 to 26 mm					
High Add "D" Bifocal	+4.00 6.00 9.00 12.00 15.00 18.00	58 mm	3	Round	22 mm	0	4.0	11.0	15.0	

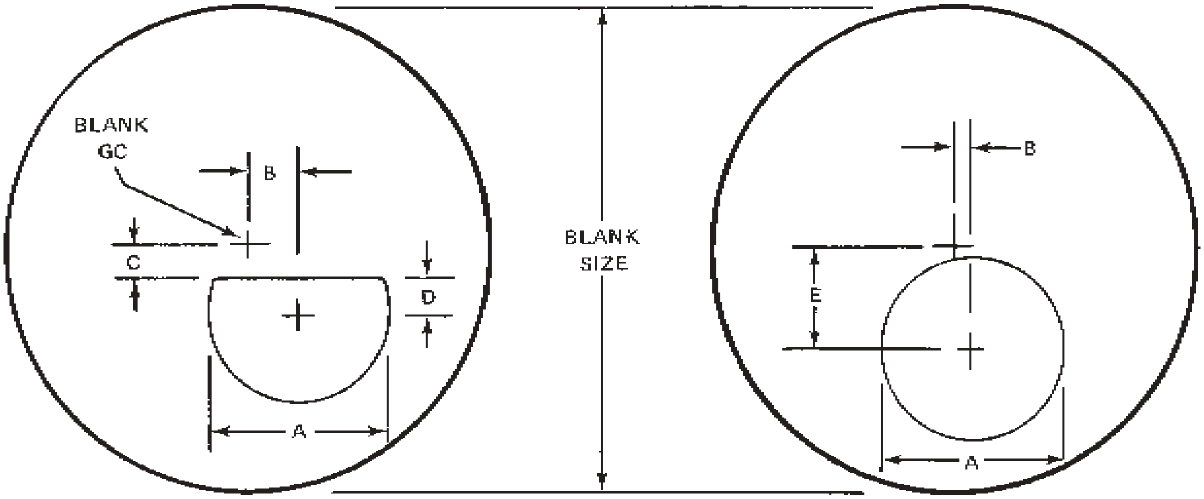


Figure 22 – "S" and super "S" Flat Top (Cut-Off)

Figure 22a – Round

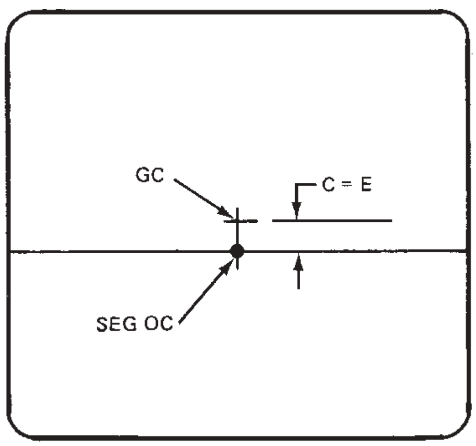


Figure 22b – EXECUTIVE (Glass)

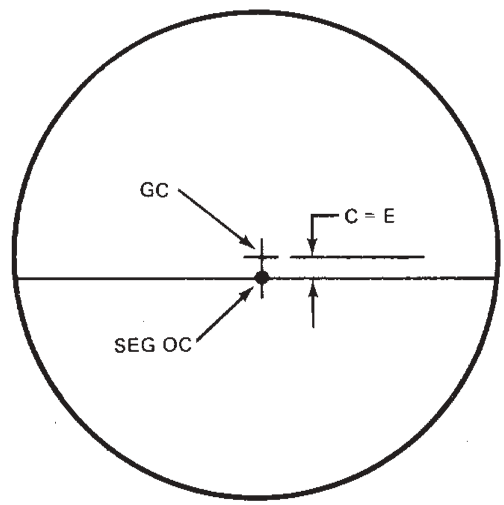


Figure 23 – EXECUTIVE (CR39)

Determining the Add for a New Visual Distance

A patient may change his work or acquire new interests which necessitate a near correction for a new working distance. If it is not possible or convenient to make the necessary measurements, the new add can be estimated by determining the dioptric difference between the new and original working distances.

Assume that a +2.00D add has been satisfactory for 16 inches, and that the patient now requires a new correction for near work at 10 inches. The dioptric difference between 10 inches (4.00D) and 16 inches (2.50D) is + 1.50D. It follows that an additional + 1.50 add is required and, therefore, the new add is 2.00D plus 1.50D, or 3.50D.

This procedure assures the use of the same amount of accommodation for both the original and new working distances. Table 4 (p. 22) provides a convenient means for determining new additions for various working distances.

Optical Factors in Bifocal Selection

Base Curves: For a given set of lens design criteria, the greater the number of base curves available in the lens series, the better "corrected" is that series. The consequence of a larger number of base curves is that correction, or minimization of peripheral aberrations, in accordance with the designer's criteria, may be more optimally achieved for any given prescription.

Optical Centers: The optical centers (OC) of Executive lens distance and near portions may be made to coincide on the dividing line between distance and near, thereby avoiding any image jump. For specific phorometric considerations however, options for alternate OC locations for distance, relative to the near segment, are open. The Executive lens is unique in that almost all lateral decentrations are possible without sacrifice of binocularly superimposed near fields. The advantages afforded by near fields, limited only by the frame eyewire dimensions, are self-evident. Because of one-piece construction, such spectacles are devoid of perceptible color aberration.

One might conclude, from the greater utilization of cutoff type multifocal segments than round segments, that the former provide greater advantages (see Figures 22 and 22a, p. 20). The round segment, nevertheless, is not without virtue. It offers freedom from the positional restrictions imposed by the fixed orientation and decentration of the cut-off segment in its blank. The cosmetic advantage of the round segment, generally less visible than the cut-off, should not be overlooked.

The round segment's major disadvantage is related to the fact that the optical center (OC) is located at its geometric center. As the visual axis passes from distance into near, it enters not only at the segment's narrowest width, but it encounters the segment's maximum vertical prismatic effect. The resulting abrupt object displacement, or image jump, can prove troublesome. By contrast, when the visual axis enters the cut-off segment, it enters through a wide "aperture," and at a point whose distance from the segment's OC and its consequential base down prismatic effect is less than half that of a round segment of equal dioptric power.

It follows, then, that for the hyperopic multifocal wearer, whose distance lens introduces base-up prism, the round segment minimizes total prism encountered (object displacement), as compared to the cut-off type, but maximizes abrupt prism change (image jump). For the myope, the round segment maximizes prism encountered but minimizes abrupt prism change.

Object Displacement

The prism power present at any point of the lens is directly dependent upon the dioptric power of the lens and the distance of that point from the optical center (OC). In units of prism diopters, prism power is the product of the distance from the OC, in centimeters, and the power of the lens or segment. The visual axis of an eye, when passing through any point of the lens, other than the OC will be deviated, and the "direction" or projection of the eye will differ from the actual path of the visual axis into the object field; the discrepancy in the object plane is referred to as "object displacement."

Object displacement occurs when the visual axis is lowered, as in reading, from the distance OC. A plus correction produces a base up prismatic effect, whereas a minus correction imposes a base down effect at the reading level. In general, patients are either unaware of, or readily adapt to, object displacement as long as the displacements are equal for the two eyes. Small unequal vertical object displacements — vertical imbalance — may produce asthenopic symptoms.

Image Jump

Image jump is that abrupt object displacement occurring at the top of the segment as a consequence of the resultant prismatic contributions of the distance lens and the segment. As discussed earlier, the Executive lens will produce no image jump for any distance-near power combinations. Similarly, the PAL, with its continuity of distance-to-near dioptric power, will produce no image jump.

For minus distance prescriptions, the cut-off bifocal will produce a minimum of object displacement and image jump, as compared to the round segment. In prescribing for hyperopes, object displacement may be minimized through the use of round segments, but should be used with caution, since the increased image jump — relative to the cut-off type — may be less tolerable.

Segment Size

The vocational and avocational visual requirements dictate segment size, as well as style, for any given patient. Clearly, the engineer, draftsman, and typist require a larger near field than do the homemaker or bus driver. The near field of view, afforded by any given segment size is significantly affected by the vertex distance, pupil size and shape, the distance correction, and the working distance. Larger vertex (fitting) distances, larger pupils, higher plus distance corrections, and shorter working distances, all act to minimize the effective near fields afforded by any given segment size.

While the Executive lens and the cut-off segment may be mutually exclusive optimum solutions for the draftsman and golfer, respectively, consider the presbyopic patient who is both draftsman and golfer. Analogous examples abound and point to the observation that not only will a given segment style and size not suit all patients, but that it may not meet all of the needs of a given patient. Multiple prescription of multifocals for a given patient is a realistic approach to satisfy their diverse visual needs. As discussed earlier, the clinician knows that the optimum selection(s) of multifocal(s) can only be made on the basis of a detailed assessment of that patient's work and play activities.

Fitting Factors

Segment Height

One of the more frequent frustrations confronting both patient and practitioner is the failure to optimally position the segment height. Clearly, the bifocal intended primarily for distance use must be fitted lower than that prescribed primarily for near work. Round segments are generally fitted 1 to 1 -1/2 mm higher than cut-off or Executive lens styles since the visual axis enters the former at its narrowest aperture, thereby affording a narrower near field than do other styles.

Surely, the "general rule" would prove irrelevant for many patients, including the young accommodative esophore or esotrope for whom the segment top might reside above the geometric center of the eyewire. Ultimately, the segment height depends upon the patient's needs and fitting parameters as dictated by frame selection, segment style, physiognomy, posture, and head tilt. For the first-time multifocal wearer, selection of a frame with adjustable bridge pads can seem providential. Further, the eyewire vertical size (B dimension) should be large enough to assure vertically adequate near fields.

Table 4 – For Determining the Proper Addition for New Working Distances

Working Distances (Inches)											
8"	10"	12"	13"	14"	16"	18"	20"	22"	26"	32"	40"
5.00D	4.00D	3.25D	3.00D	2.75D	2.50D	2.25D	2.00D	1.75D	1.50D	1.25D	1.00D
4.75	3.75	3.00	2.75	2.50	2.25	2.00	1.75	1.50	1.25	1.00	.75
4.50	3.50	2.75	2.50	2.25	2.00	1.75	1.50	1.25	1.00	.75	.50
4.25	3.25	2.50	2.25	2.00	1.75	1.50	1.25	1.00	.75	.50	
4.00	3.00	2.25	2.00	1.75	1.50	1.25	1.00	.75	.50		
3.75	2.75	2.00	1.75	1.50	1.25	1.00	.75	.50			
3.50	2.50	1.75	1.50	1.25	1.00	.75	.50				
3.25	2.25	1.50	1.25	1.00	.75	.50					
3.00	2.00	1.25	1.00	.75	.50						
2.75	1.75	1.00	.75	.50							
2.50	1.50	.75	.50								
2.25	1.25	.50									
2.00	1.00										
1.75	.75										
1.50	.50										

Procedure

1. Locate the column for the working distance used in prescribing.
2. Move down to the entry for the prescribed addition.
3. Move horizontally to the column for any other desired working distance.
4. Read the new addition.

Fitting a PAL entails positioning the major reference point over the pupil center, or slightly below, when the patient is looking directly ahead (see Figure 23a, below) .

The majority of patients require that the segments of the two lenses be positioned at the same level. This condition should not, however, be assumed to be universal since there are many patients whose facial asymmetry requires not only differential lateral lens positioning but also differential vertical placement of the segment tops.

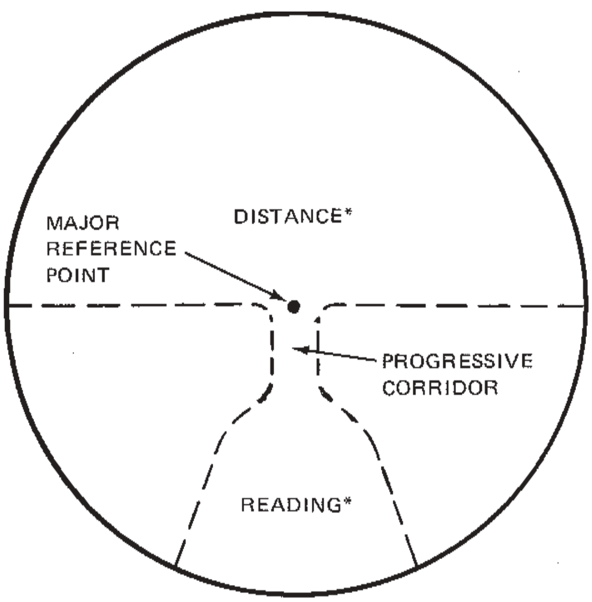


Figure 23a – PAL
(Areas contained by dashed boundaries are free of surface aberration.)

Segment Decentration

In fitting multifocals (other than Executive lenses) segments must be decentered nasally in order that the two near monocular fields maximally overlap. This will occur when the segments' OCs coincide with the visual axes' intercepts in the eyewire plane. Where the distance correction is plano or moderately minus, literal application of this procedure works well. If, however, the distance correction is plus or high minus, with near-point convergence, substantial base out or in prism, respectively, is incurred. The stress induced by such prism is potentially troublesome and may require additional segment decentration, in or out, in order to neutralize all or part of that prism present in the converged near-point posture.

To fixate at near, the visual axes converge and intercept the eyewire planes at points whose inset from the distance OC depends upon: 1) interpupillary distance; 2) rear lens vertex to center of rotation (CR) distance; 3) fixation distance; 4) distance correction. Through a plano lens fitted 27 mm from the CR, a 64 mm PD patient, fixating an object at 16" (from the eye) would produce a 1.9 mm visual axis inset for each eye. If this patient was a 4 diopter myope, as Table 5 (p. 23) indicates, his or her bifocal segment insets would be 1.7 mm each in order to maximize coincidence of monocular fields. When reading, this patient will encounter 0.68 prism diopters, base in, for each eye (0.17 cm x 4 diopters = 0.68 prism diopters). In the unlikely event

TABLE 5

For working distance of 16", the table indicates, in millimeters, decentration in of segments to achieve overlapping monocular fields.

Distance Lens Power	Mid-bridge-to-pupil Distance with Eyes in Primary Distance Gaze				
	28	30	32	34	36 (mm)
+14D	2.5	2.6	2.8	3.0	3.2
+12D	2.3	2.5	2.6	2.8	3.0
+ 8D	2.0	2.2	2.3	2.5	2.6
+ 4D	1.8	2.0	2.1	2.2	2.3
Plano	1.6	1.8	1.9	2.0	2.1
− 4D	1.5	1.6	1.7	1.8	1.9
− 8D	1.4	1.5	1.6	1.7	1.8
−12D	1.3	1.4	1.5	1.6	1.7
−16D	1.2	1.3	1.4	1.5	1.5
−20D	1.1	1.2	1.3	1.4	1.4

that this prism portends difficulty for the patient, it might be neutralized by reducing the amount of segment decentration in. In the case cited, a lesser decentration in (less than 1.7 mm) would have the effect of introducing base out prism due to the segment.

Had this patient been a 4 diopter hyperope, at the near point, he or she would encounter 0.84 prism diopters (0.21 x 4) base out for each eye. Increasing the segment decentration in would introduce base in prism, thereby offsetting the base out prism due to the distance lens. If this patient required a 2 diopter add, in order to completely neutralize the 0.84 base out distance-induced prism, the total decentration in for each from the distance OC eye would be

$$6.3 \text{ mm } (0.21 \text{ cm} + \frac{084}{200.})$$

An appreciation of the foregoing is important in order that prism-based problems may be anticipated and dealt with in prescribing. The clinician, however, knows that of greater importance than simplistic numbers, is the patient's case history.

If, as a pre-presbyope, the patient had been wearing a strong single vision minus or plus distance correction, and asymptomatically handled the prism encountered, there is little motivation to alleviate that distance induced prism in his or her new bifocal. Moreover, additional segment decentration, designed to neutralize this prism, may present new, unwelcome, adaptation demands. If, indeed, appreciable decentration, beyond that incorporated in the lens blank, is appropriate, the Executive is ideal in that for all possible decentrations, binocular field overlap is always provided.

Decentration, or inset of the PAL reading portion, is accomplished by the laboratory's routine rotation of the symmetrical semifinished blank (see Figure 23a, p. 22) — 10° counterclockwise for the right eye and 10° clockwise for the left eye. The resulting inset, 14 mm down from the major reference point, is approximately 2.5 mm for each eye.

Trifocals

The trifocal, in addition to the distance and near power corrections of the bifocal, includes a third intermediate region whose power is a proportion of the lower reading segment. Available in the one-piece Executive lens, as well as the cut-off style, the intermediate segment is 7 mm high (see Figures 23b and 24, below). Double segments are also available , where a second separate segment is located high in the distance portion (see Figure 24a, p. 24). The second, upper segment may be of the same power as the lower segment or of a power intermediate to the distance and lower segment.

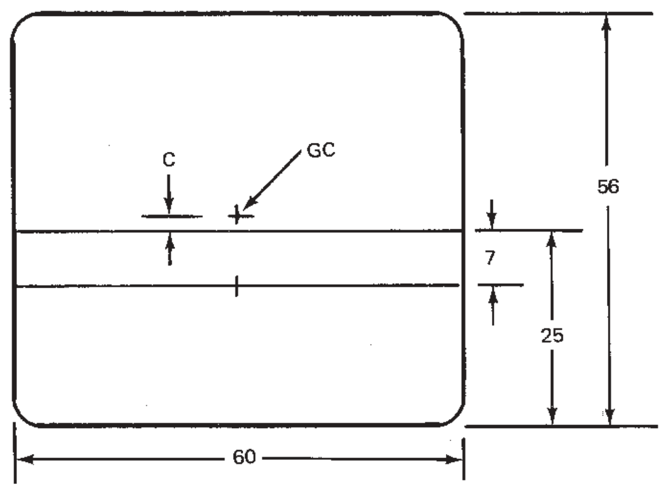


Figure 23b – EXECUTIVE Trifocal

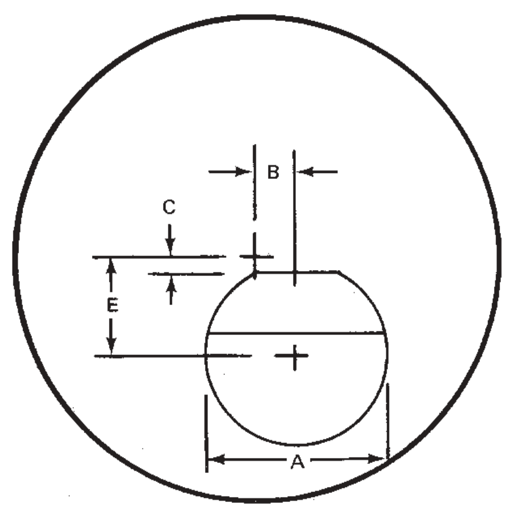


Figure 24 – Super "S" Trifocal

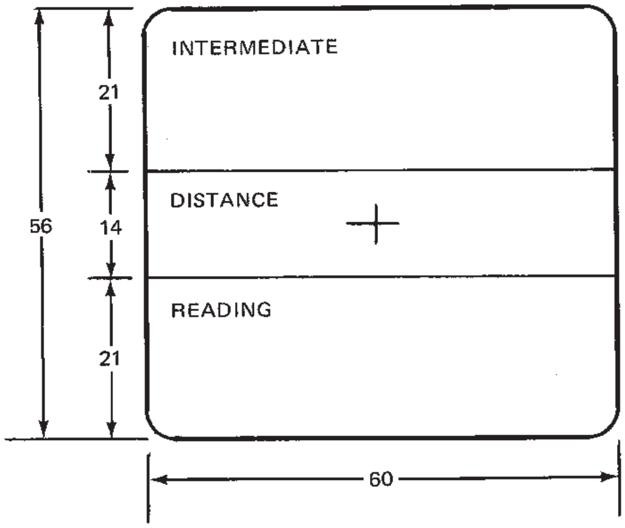


Figure 24a – EXECUTIVE Double Segment.

In glass, the fused cut-off style trifocal is made similarly to the bifocal, except that a second segment component, of a refractive index intermediate to those of the major distance lens and the near segment, is employed. For the Executive lens, a third curvature is incorporated on the front surface. For all CR39 resin trifocal lens styles, the casting molds simply provide a third curvature which is transferred to the resin trifocal lens.

Prescribing Trifocals

With increasing age and the progressive depletion of accommodation reserves, the advancing presbyope may, by complaint, indicate a need, unsatisfied by bifocals, for the same visual performance in the intermediate range that he or she enjoys for both distance and near.

In general, trifocals find application when the total add requirement is 1.50D and greater. Typical trifocal candidates may have recently received their increased bifocal add: 2.00D for a 16" working distance. They have 1.00D amplitude of accommodation and, therefore, hold 0.5D in reserve at the near point. Through the segment they can see as close as 13" by using their reserve, while if they relax their accommodation, they can see out to 20". Through the distance upper they may be able to see as close as 40" through full use of their accommodative amplitude. It follows, then, that within the range from 20" to 40" the unhappy patient suffers blurred vision.

These patients may be better served by a trifocal with a 2.00D add in the lower segment and a 1.00D add in the intermediate segment. Through the distance portion they can see clearly up to 40" by using their 1.00D of accommodation. Through the intermediate they can now see clearly throughout the range of 40" to 20" by appropriate exercise of their accommodative amplitude (none to full). Through the lower segment of 2.00D add by similar exercise of accommodation, they may see clearly within the range of 20" to 13". The trifocals, therefore, afford these patients clear vision throughout the range extending from distance to 13 inches.

In determining the style, size, and height of the trifocal segment, the same fitting considerations discussed earlier for bifocals are relevant—perhaps even more critical for achieving comfort and efficiency.

At the risk intrinsic to "general rules" standard practice places the top of the lower segment at the same height as a cut-off bifocal segment. This will bring the upper edge of the upper segment in line with, or slightly below, the lower pupil margin. The dispenser's failure to fit the trifocal high enough is probably the chief cause of rejection by patients; these patients cannot comfortably get into the reading segment. The use of a frame with adjustable pads is especially prudent when prescribing trifocals.

Presbyopes hope to continue the visual efficiency and comfort which they enjoyed in earlier years. Few of us happily accept the compromises associated with age. However, too many become unnecessarily resigned to visual performance in restricted ranges. Optimal matching, from a wide variety of modern multifocal aids, with the needs of prebyopes, can help them enjoy what they once knew as "youthful vision."

VII. Muscle Balance Test with the PHOROPTOR Refracting Instrument

Prism Dissociation Method

6 △ U means this amount of prism is Base Up before this patient's right eye (see Figure 25, p. 26). The purpose is to create diplopia (double vision) while the patient is viewing a spot of light (muscle light), a horizontal row of letters, or a single letter. Tests may be made for both Distance and Near.

A prism refracts (bends) incoming light toward its base. However, on looking through a prism, objects are seen displaced away from the prism base.

Hence, the patient's right eye with the 6 △ Base Up sees objects lower than objects seen with the other eye.

The patient's response as to the relative lateral position of the two targets seen indicates the type of lateral (horizontal) phoria — i.e. if the lower (R.E.) target appears to the left of the upper (L.E.) target, exophoria is indicated; if the lower target appears to the right of the upper target, esophoria is indicated; when the upper and lower targets appear one directly above the other, orthophoria is indicated.

The rotary prisms (see Figure 26, p. 26) are used to measure the amount of the lateral phoria: Base In power (see Figure 27, p. 27) corrects, or measures, exophoria; while Base Out power (see Figure 28, p. 27) corrects, or measures, esophoria. The amount and position of the Base of the lateral prism power which aligns (places one above the other) the double images is a measure of the horizontal phoria.

To measure the vertical phoria, remove the 6 △ Base Up before the right eye and insert 10 △ I (see Figure 29, p. 28) in the

PHOROPTOR Auxiliary Dial which indicates this amount of Base In prism before the patient's left eye. The purpose is to create horizontal diplopia while the patient is viewing a spot of light (muscle light), a vertical row of letters, or a single letter. The test may be made for both Distance and Near.

Since objects viewed through a prism appear displaced away from its base, the patient's left eye will see the left target while the right eye sees the right target.

The patient's response as to the relative vertical position of the two targets indicates the type of vertical phoria (hyperphoria) — i.e., if the right target appears lower than the left, a right hyperphoria is indicated; if the left target appears lower than the right, a left hyperphoria is indicated.

The amount of vertical prism power introduced by the rotary prisms to make the two targets appear to be on the same level measures the amount of the vertical phoria: Base Down power (see Figure 30, p. 28) before the Right Eye corrects Right Hyperphoria, Base Down power (see Figure 31, p. 29) before the Left Eye corrects Left Hyperphoria.

This technique of measuring heterophoria is known as the Prism Dissociation Method or the von Graefe Method. In comparison to the Maddox Rod technique, it may be said that the stimuli to each eye remains practically equal, but displaced with Prism Dissociation; whereas the Maddox Rod does not displace, but it distorts and impairs the acuity of the object seen by eye before which the Maddox Rod is placed.

NOTE: Prisms have some inevitable distortion. There are some colored fringes around the object seen through a prism and, also, straight lines will appear curved. These distortions are more marked for higher prism powers, but they do not affect the results of the tests.

Maddox Rod Method

In the PHOROPTOR Auxiliary Dials, there are four Maddox Rods which are identified, as follows:

RMH means Red Maddox (Rod) Horizontal (see Figure 32, p. 29).

RMV means Red Maddox (Rod) Vertical (see Figure 33, p. 30).

WMH means White Maddox (Rod) Horizontal (see Figure 34, p. 30).

WMV means White Maddox (Rod) Vertical (see Figure 35, p. 31).

The purpose of having both Red and White Maddox Rods is to facilitate those practitioners who prefer Red Maddox Rods, and those who prefer the White Maddox Rods, as well as those who want to use both Red and White Maddox Rods.

The Maddox Rods, like the Dissociating Prisms, are used in the tests for heterophoria. The patient fixates a spot of light (muscle light) which must be bright enough to be seen through the Maddox Rod.

The spot of light viewed through the "Vertical" Maddox Rod appears as a horizontal streak of light and, viewed through the "Horizontal" Maddox Rod, the spot of light appears as a vertical streak.

The horizontal streak (either red or white) seen through the Maddox Rod by one eye and the spot of light viewed directly by the other eye are the test conditions for eliciting the vertical phorias.

If the patient sees the horizontal streak running through (on the same level) as the muscle light, no vertical phoria is indicated. If the patient sees with his right eye the horizontal streak below the muscle light, Right Hyperphoria is indicated or, if the streak appears above, Left Hyperphoria is indicated.

On the other hand, if the patient sees with his left eye the horizontal streak below the muscle light, Left Hyperphoria is indicated or, if the streak appears above, Right Hyperophoria is indicated.

The vertical streak (either red or white) seen by one eye and the muscle light seen by the other eye constitute the test conditions for horizontal (lateral) phoria.

When the patient sees the vertical streak running through the muscle light, no lateral phoria is indicated.

If the patient sees with his or her right eye the vertical streak to the right of the muscle light, esophoria is indicated or, if the streak appears to the left, exophoria is indicated.

If the patient sees with his or her left eye the vertical streak to the left of the muscle light, esophoria is indicated or, if the streak appears to the right, exophoria is indicated.

In each of the above instances, the amount of the separation between the streak and the muscle light is measured by the amount of prism power (with the Rotary Prisms) which is necessary to align the streak and the spot of light — keeping in mind that:

BASE OUT prism measures (or corrects) ESOPHORIA;

BASE IN measures (or corrects) EXOPHORIA:

BASE DOWN, R.E. (or BASE UP, L.E.) measures R. HYPERPHORIA;

BASE DOWN, L.E. (or BASE UP, R.E.) measures L. HYPERPHORIA.

NOTE: There are many variations in the techniques that may be used:— some consistently use the Red Maddox Rods before the patient's right eye, some consistently use the White Maddox Rods before the patient's left eye; some use alternately the Maddox Rod before the right and left eyes; some use both Maddox Rods, one before each eye, i.e. horizontal before right eye with vertical before left eye and/or vice versa.

Fusional Amplitudes

Some refractionists measure the fusional amplitudes for distance and for near on every patient. This practice provides the examiner with experience in the findings on many normals so he or she will be more familiar with the typical findings on abnormal, i.e. those patients having a significant heterophoria for which their fusional amplitudes are inadequate.

With the refractive correction before the patient's eyes and while fixating a vertical line of letters, the Rotary Prisms are moved into place before each of the patient's eyes (see Figure 36, p. 32).

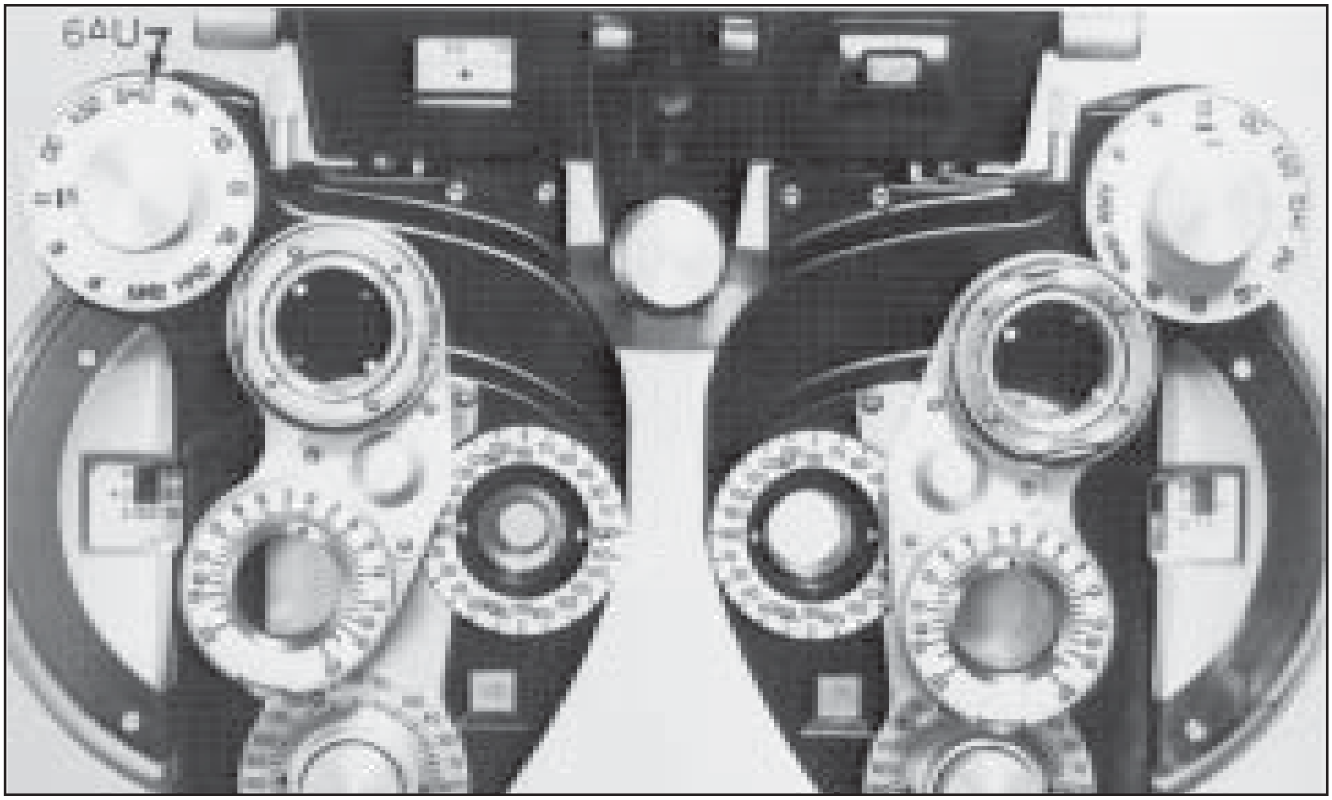


Figure 25 – Auxiliary Dial 6 △ Base UP Before Patient's Right Eye.

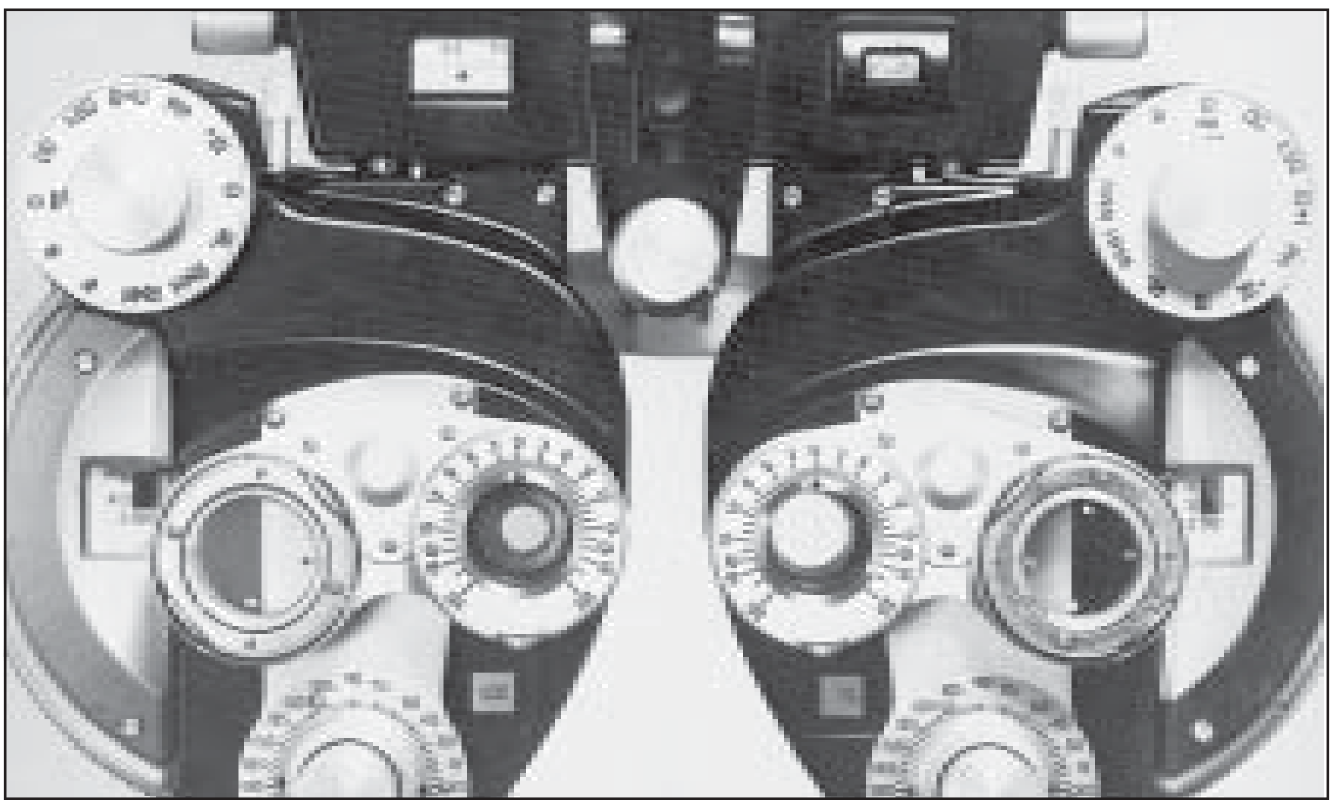


Figure 26 – Rotary Prism Units in Place.

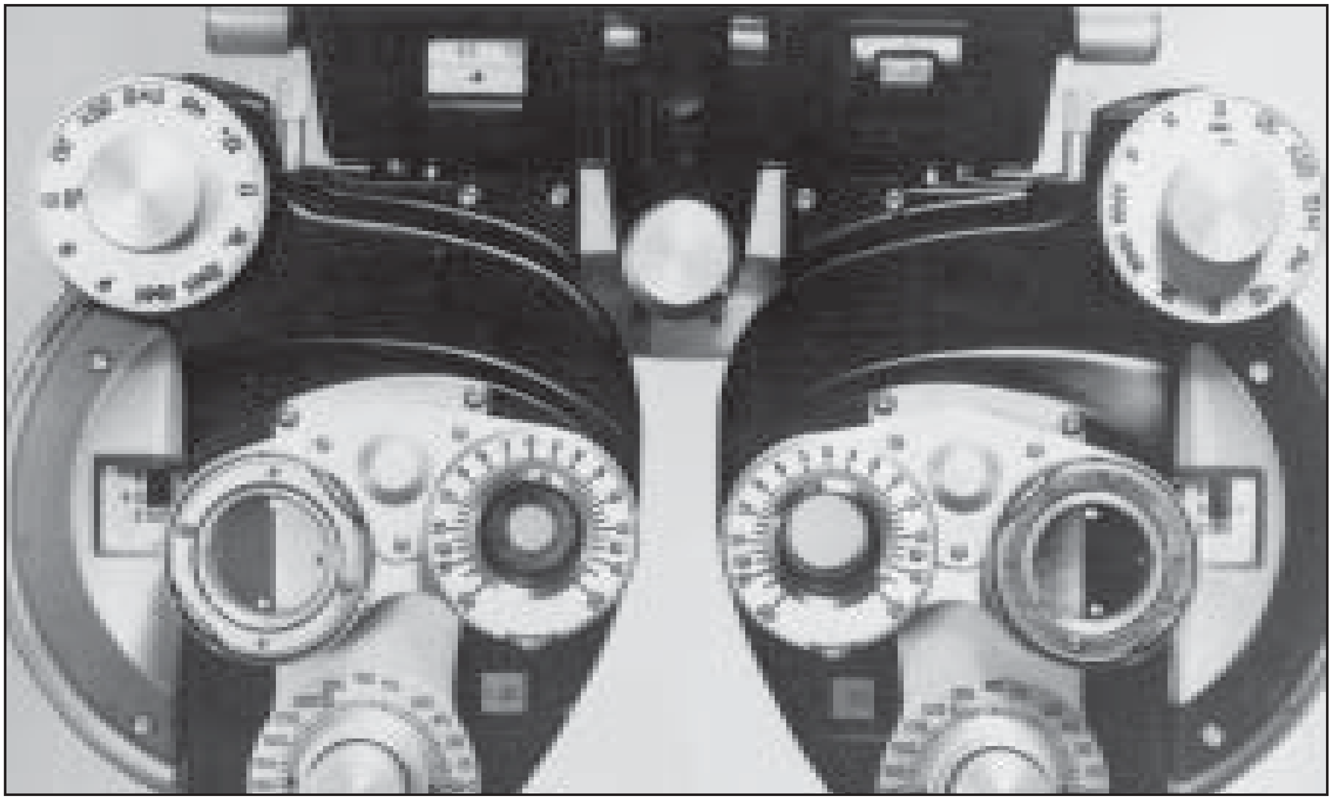


Figure 27 – Rotary Prism Units Showing Base IN Power Before Both Eyes.

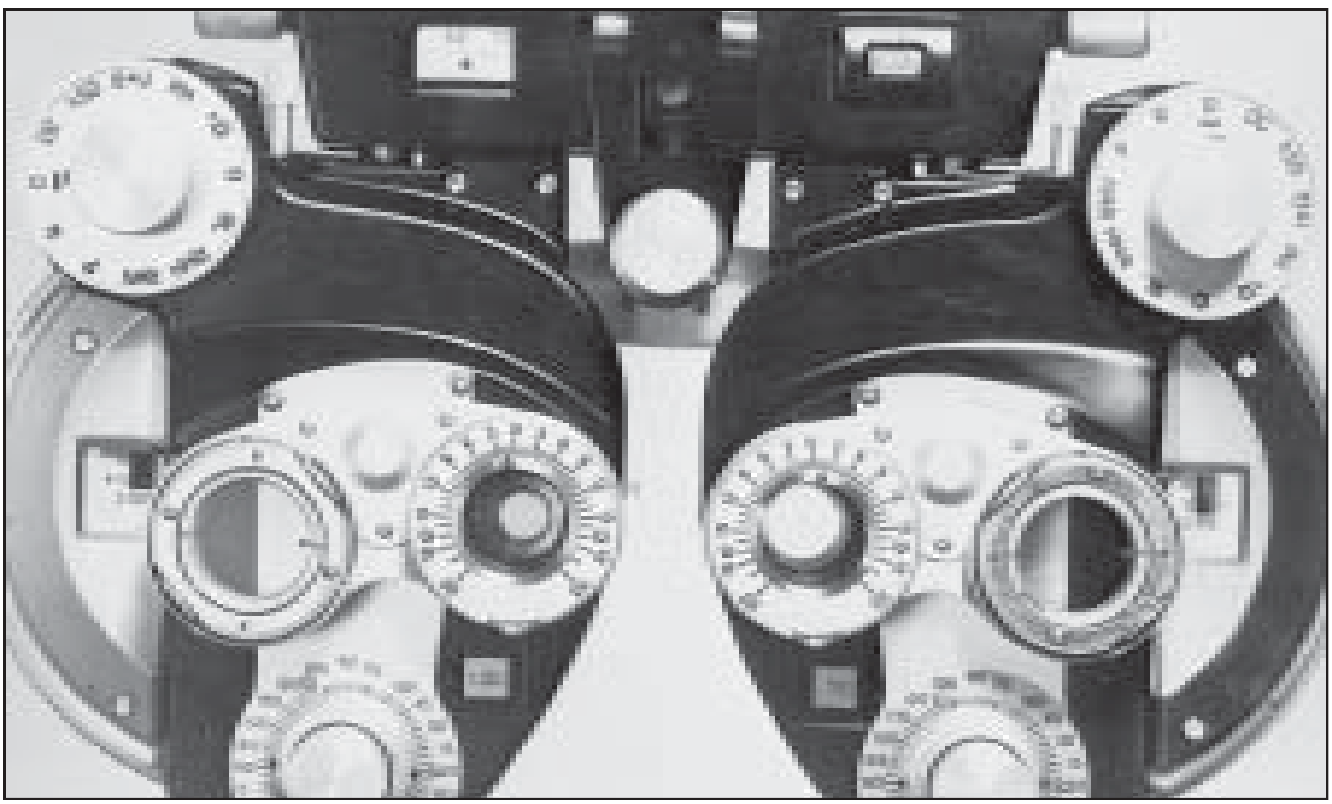


Figure 28 – Rotary Prism Units Showing Base OUT Power Before Both Eyes.

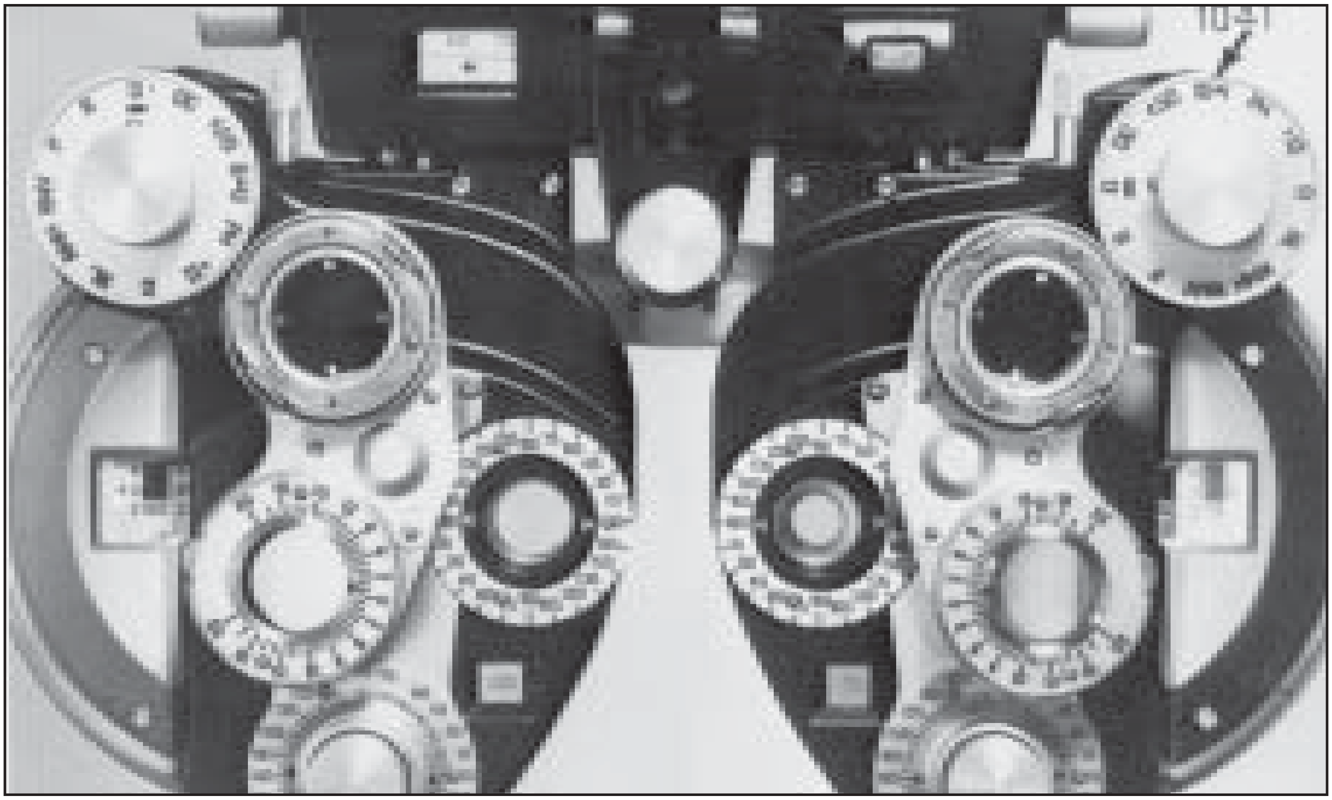


Figure 29 – Auxiliary Dial 6 △ Base IN Before Patient's Right Eye.

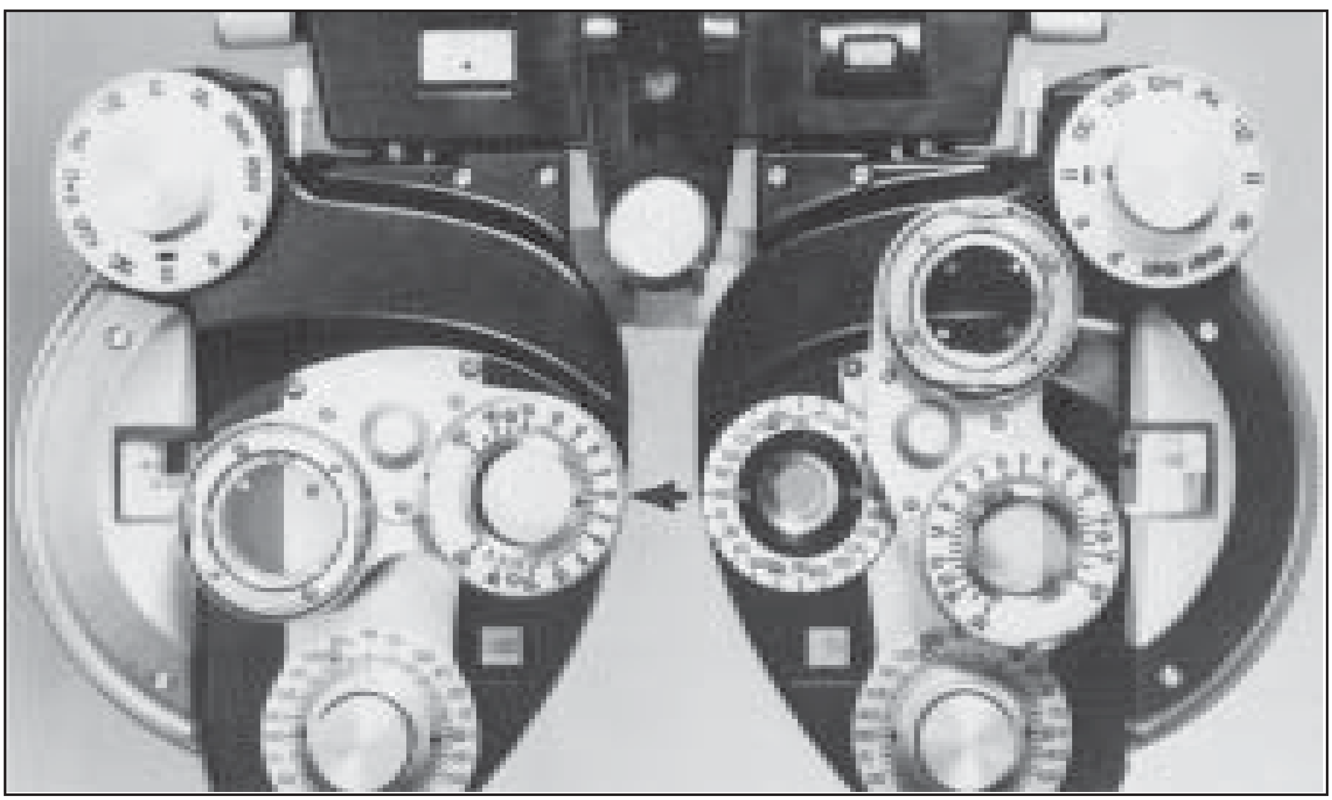


Figure 30 – Rotary Prism Showing Base DOWN Power Before Right Eye.

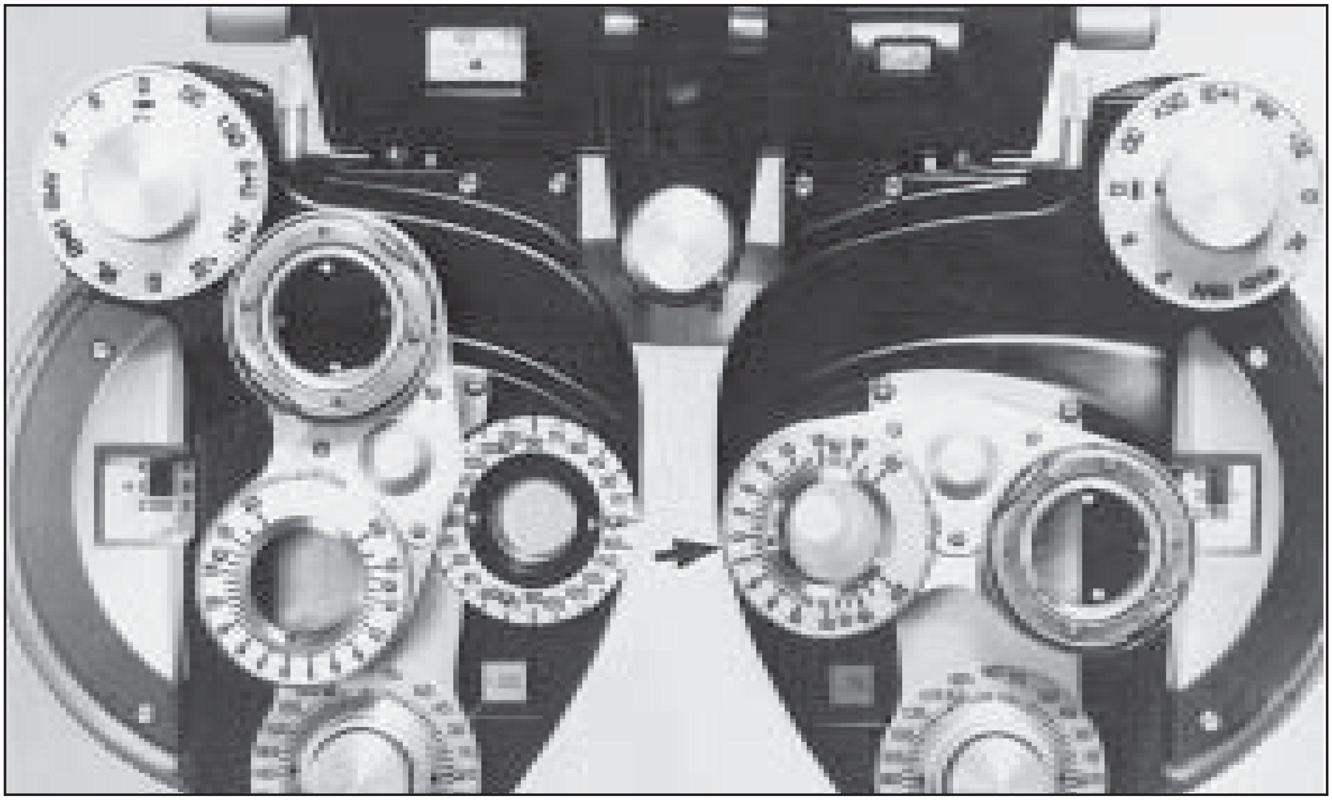


Figure 31 – Rotary Prism Showing Base DOWN Power Before Left Eye.

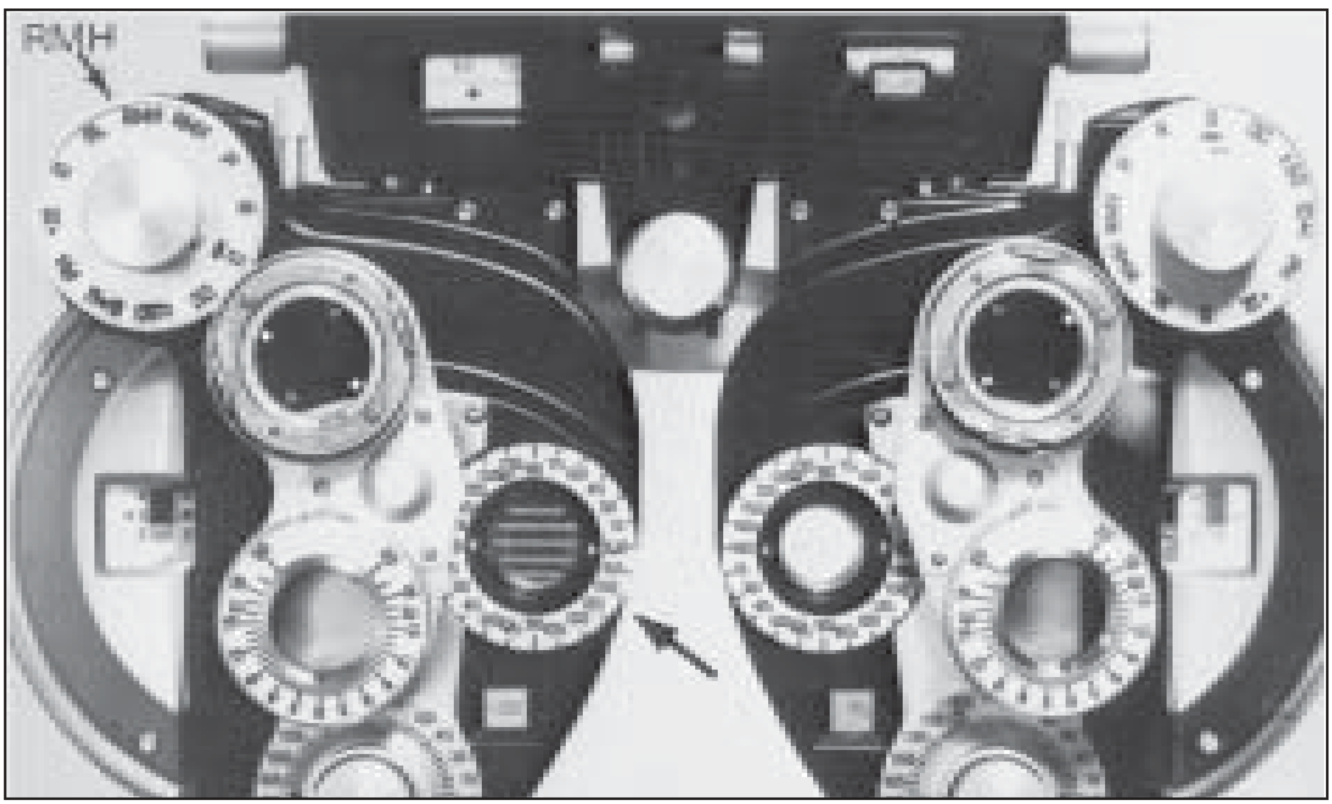


Figure 32 – Auxiliary Dial "RMH" (Red Maddox Horizontal) in Place.

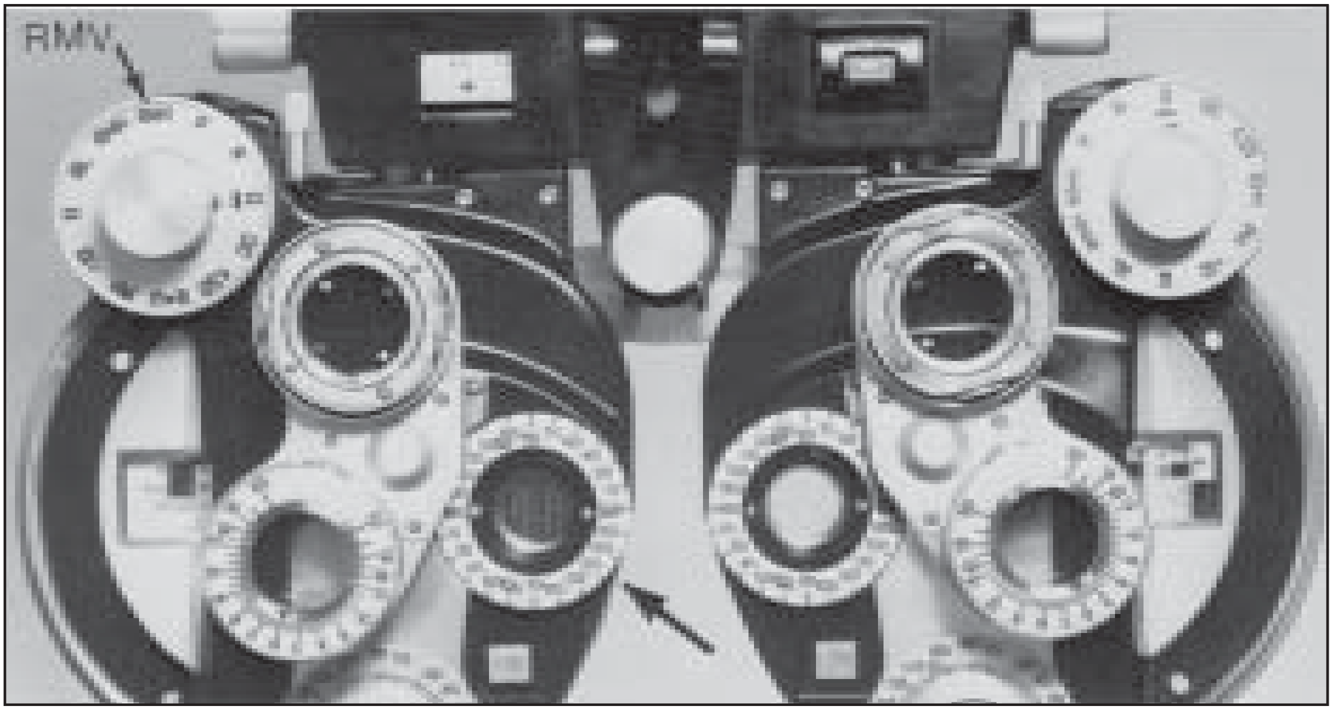


Figure 33 – Auxiliary Dial "RMV" (Red Maddox Vertical) in Place.

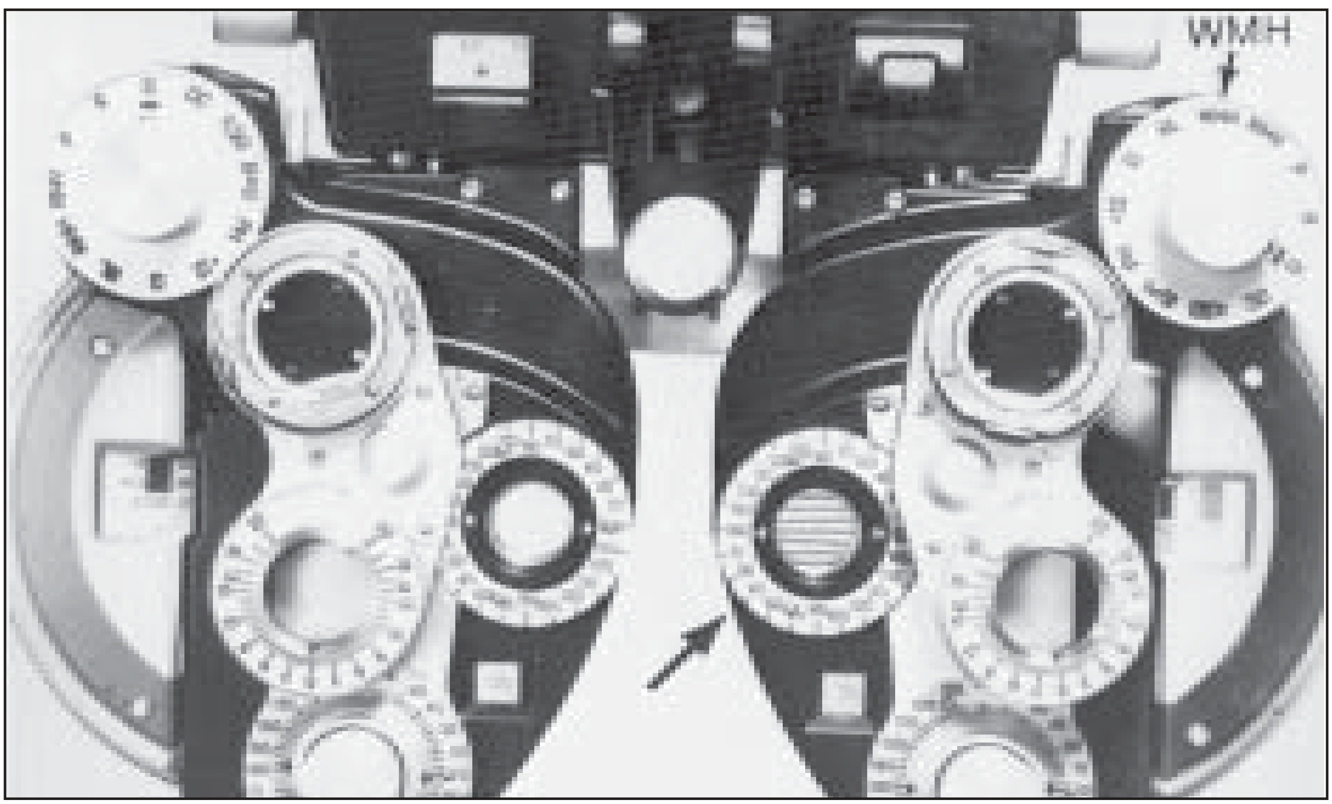


Figure 34 – Auxiliary Dial "WMH" (White Maddox Horizontal) in Place.

Positive Fusional Amplitudes

Convergence is measured by the amount of BASE OUT prism that can be overcome before fusion is broken, as evidenced by the patient seeing double (diplopia) (see Figure 37, p. 32). The prism power is introduced gradually, approximately the same amount before each eye. The patient is asked to report when the letters begin to BLUR; when they BREAK (separate) into two lines of letters, and when they RECOVER back into one line of letters. When patients use Accommodative Convergence to aid their Fusional Convergence, they report that the target (letters) become blurred before breaking into two images. After doubling has occurred, the BASE OUT prism power is gradually reduced until the two images appear to unite— i.e. fusion is regained. These three findings are termed: BLUR, BREAK and RECOVERY points, respectively. The Convergence Amplitudes are usually taken first.

Negative Fusional Amplitudes

With the refractive correction in place while the patient again fixates the vertical line of letters, the Rotary Prisms are used to measure the Negative Fusional Amplitudes (Divergence) by gradually adding before each eye, BASE IN prism power (see Figure 38, p. 33).

The BLUR, BREAK and RECOVERY points are measured by the amount of BASE IN prism power necessary to cause blurring, doubling and recombination of the fixated target. The BLUR and BREAK points are usually produced simultaneously or the BLUR will precede the BREAK point by a very small amount of prism power since accommodation is not stimulated by the divergence effort.

Vertical Fusional Amplitudes

These are usually very much smaller in amount than either of the lateral fusional amplitudes.

The Rotary Prisms are turned (rotated) to provide BASE UP and BASE DOWN before the dominant eye — usually the right eye (see Figure 39, p. 34). It is not necessary to have the Rotary Prisms before each eye because only a small amount of power is involved — except in cases of significant hyperphoria — and, also, the impulses for fusion are binocular even though only one eye is given the stimulus for diplopia. The fixation target should now be a Horizontal line of letters.

The measurements are best taken and recorded as "+V.D. and -V.D.': meaning + and - vertical divergence. The former (+V.D.) is the amount of BASE DOWN prism power before the eye (or BASE UP before the left eye) and the latter (-V.D.) is the amount of BASE UP prism power before the right eye (or BASE DOWN before the left eye) that can be overcome before fusion is broken. There is no BLUR point finding, as in the case of the lateral fusional amplitudes, since accommodation is not involved.

These measurements of Prism Convergence and Prism Divergence, as well as the Vertical Fusional Reserves (or amplitudes) require only a few minutes and, while the majority of patients will be found to have normal amplitudes, the few patients who reveal abnormal findings might otherwise be overlooked (or neglected).

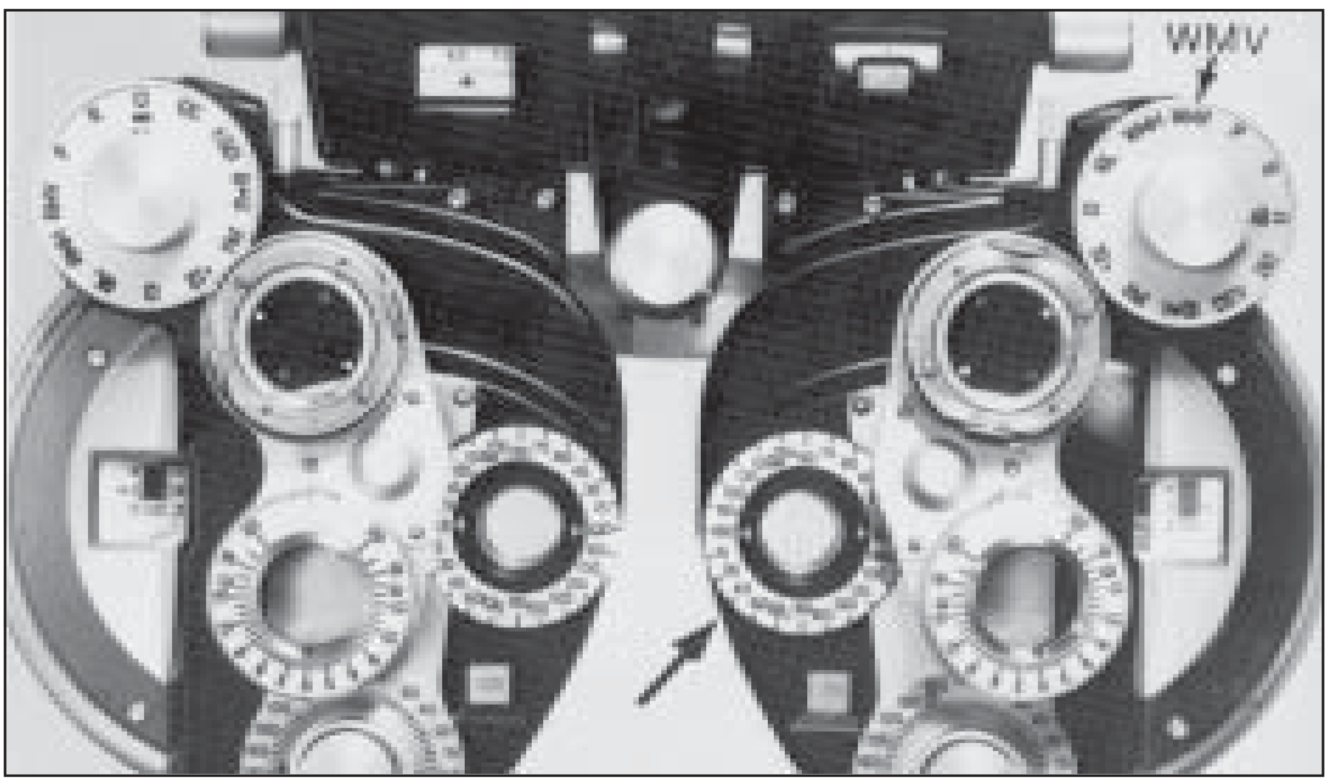


Figure 35 – Auxiliary Dial "WMV" (White Maddox Vertical) in Place.

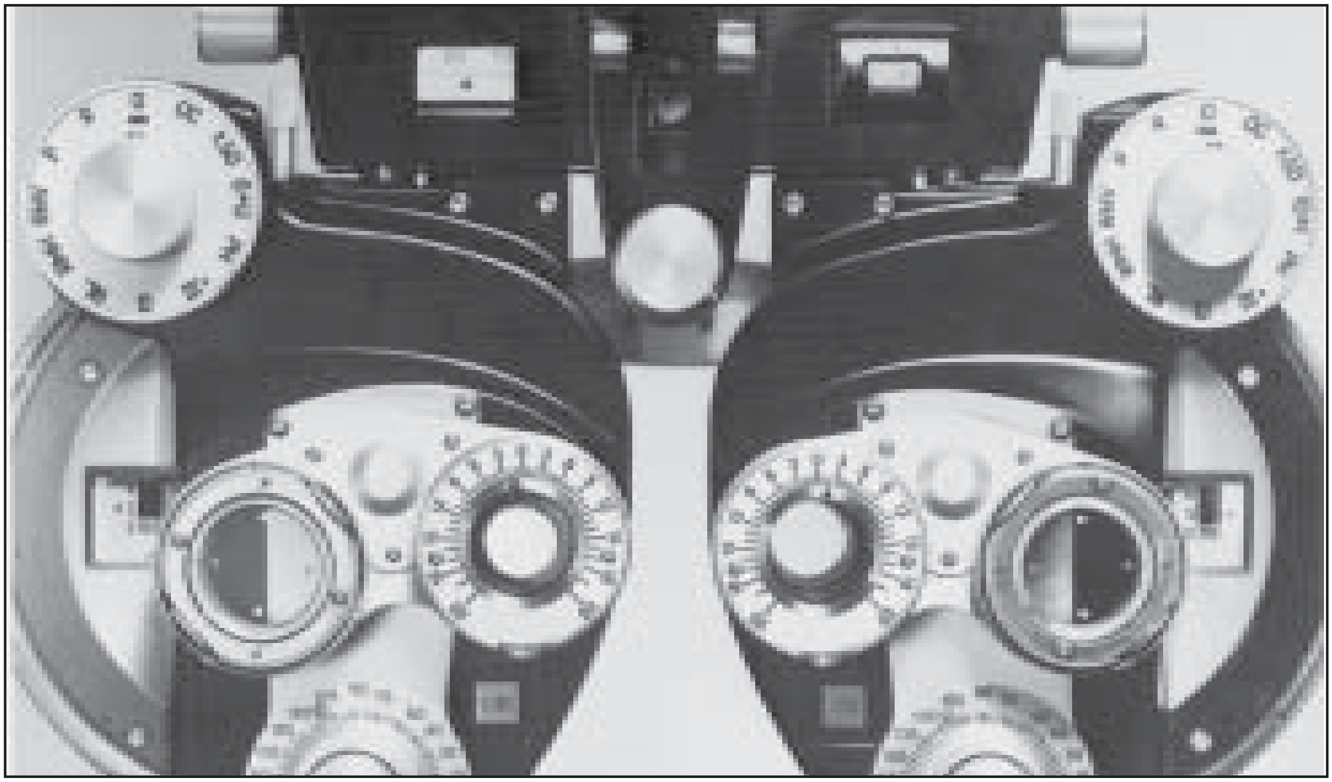


Figure 36 – Rotary Prism Units in Place.

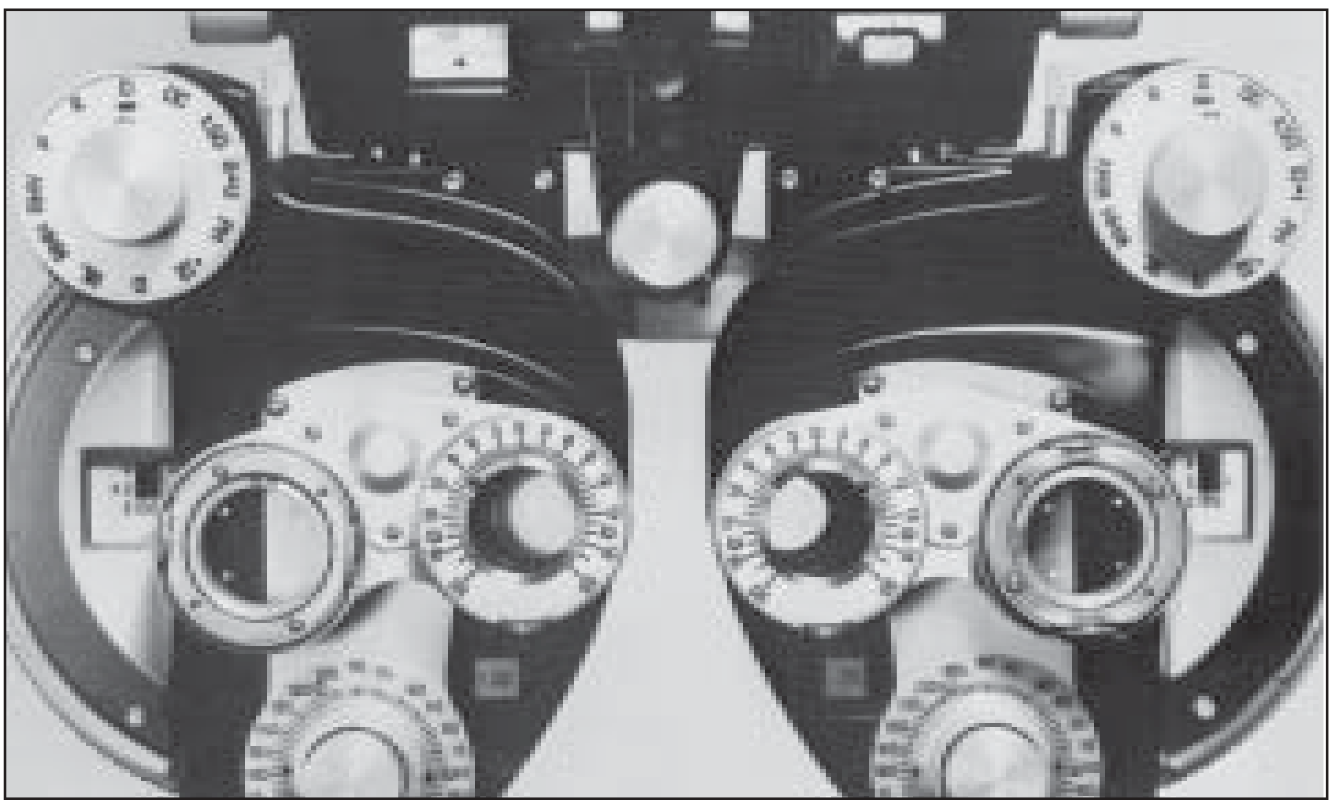


Figure 37 – Rotary Prism Units Showing BASE OUT Prism Power.

Interpretation of Findings

By routinely measuring the Fusional Amplitudes on every patient — most of them with no significant heterophoria — refractionists soon begin to establish norms for their particular technique and their unique office set-up.

It has been demonstrated that Fusional Amplitudes are influenced by the amount and degree of peripheral fusional stimuli present in the fixation area, by the speed (or slowness) with which the prism power is changed, by the directions given to the patient, and by the patient's motivation to fuse as long as possible. Hence, clinicians should establish for themselves what is normal for their testing conditions and procedures. They will then be able to recognize cases which fall outside the normals for their particular setup.

In general, the Convergence Amplitudes will be found to be normally twice those of the Divergence Amplitudes for both distance and near, while the Vertical Amplitudes will be equally small for both distance and near.

The chief value of the Fusional Amplitudes is in cases of significant heterophoria—when one is trying to decide whether a prismatic element should be incorporated in the refractive correction.

The Fusional Amplitudes provide an indication as to whether patients have adequate reserves to compensate for their heterophoria. For example, one patient may have 8 △ exophoria for distance and 16 △ exophoria for near. If they can overcome this divergence tendency and still have greater than twice the prism convergence amplitude compared to the divergence amplitude, they will not usually complain of discomfort. On the other hand, if their convergence amplitude is only equal to, or less than, their divergence amplitude there are likely to be reports of discomfort and some BASE IN prism power in their glasses will be of assistance.

Likewise, if patients measure 1 △ or 2 △ R. hyperphoria, but can overcome (before diplopia) 4 △ or 5 △ BASE DOWN and BASE UP before the right eye, they are not likely to have discomfort, since their amplitudes are more than adequate to compensate for their deviation. However, if they can overcome only 1 △ or 2 △ BASE UP before the right eye while it requires 5 △ to 6 △ BASE DOWN before the right eye to break fusion, the chances are that the patient has some discomfort resulting from this imbalance and a vertical prism (i.e. R.E. 1 △ or 2 △ BASE DOWN) will bring relief.

As in the case of refractive corrections, there are many factors to consider in deciding upon the amount of the prism to prescribe. A similar statement applies: "Give the minimum amount to relieve the symptoms and to provide encouragement to the fusion faculty."

As indicated, the vertical fusional amplitudes are much less than the lateral amplitudes, so a hyperphoria of 1 △ or 2 △ may cause discomfort, whereas a lateral phoria of 4 △ or 5 △ may not cause discomfort. When a vertical phoria accompanies a significant lateral phoria, it is best to correct first, just the vertical phoria as the lateral fusional amplitudes may improve to adequately compensate for the lateral phoria.

In the young (pre-presbyopes) with significant exophoria and inadequate fusional amplitudes, it is possible that some convergence training may improve the fusional amplitudes. However, in cases of hyperphoria and in cases of esophoria, improvement in the fusional amplitudes by means of orthoptic training is much more difficult.

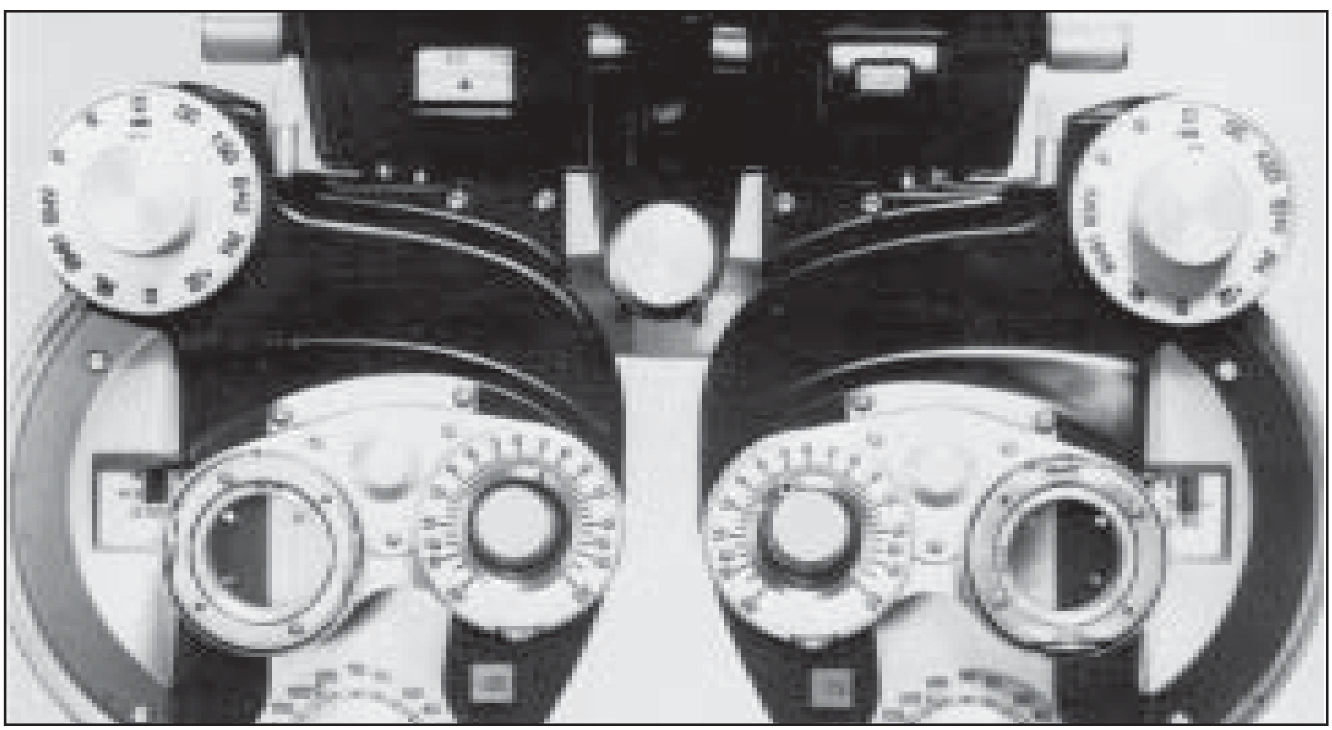


Figure 38 – Rotary Prism Units Showing BASE in Prism Power.

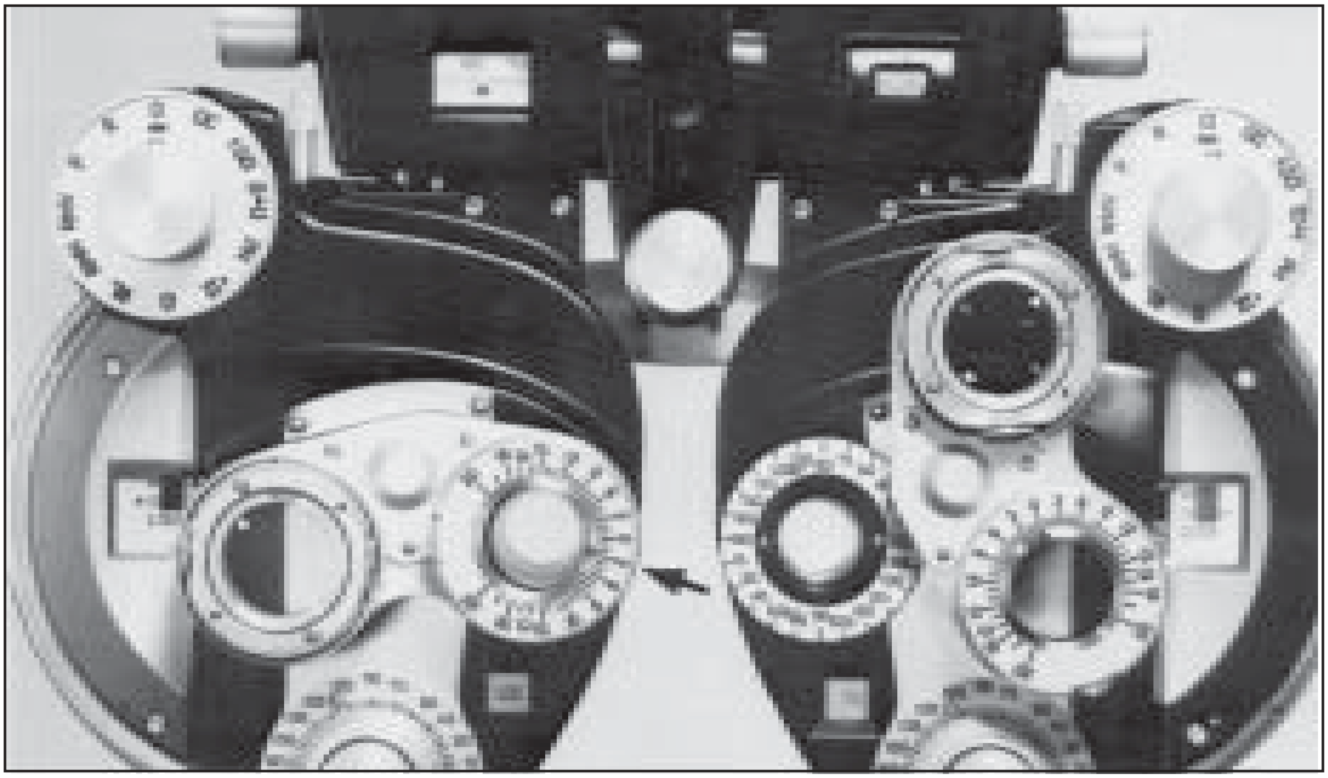


Figure 39 – Rotary Prism Unit Before Right Eye to Provide Vertical Prism Power.

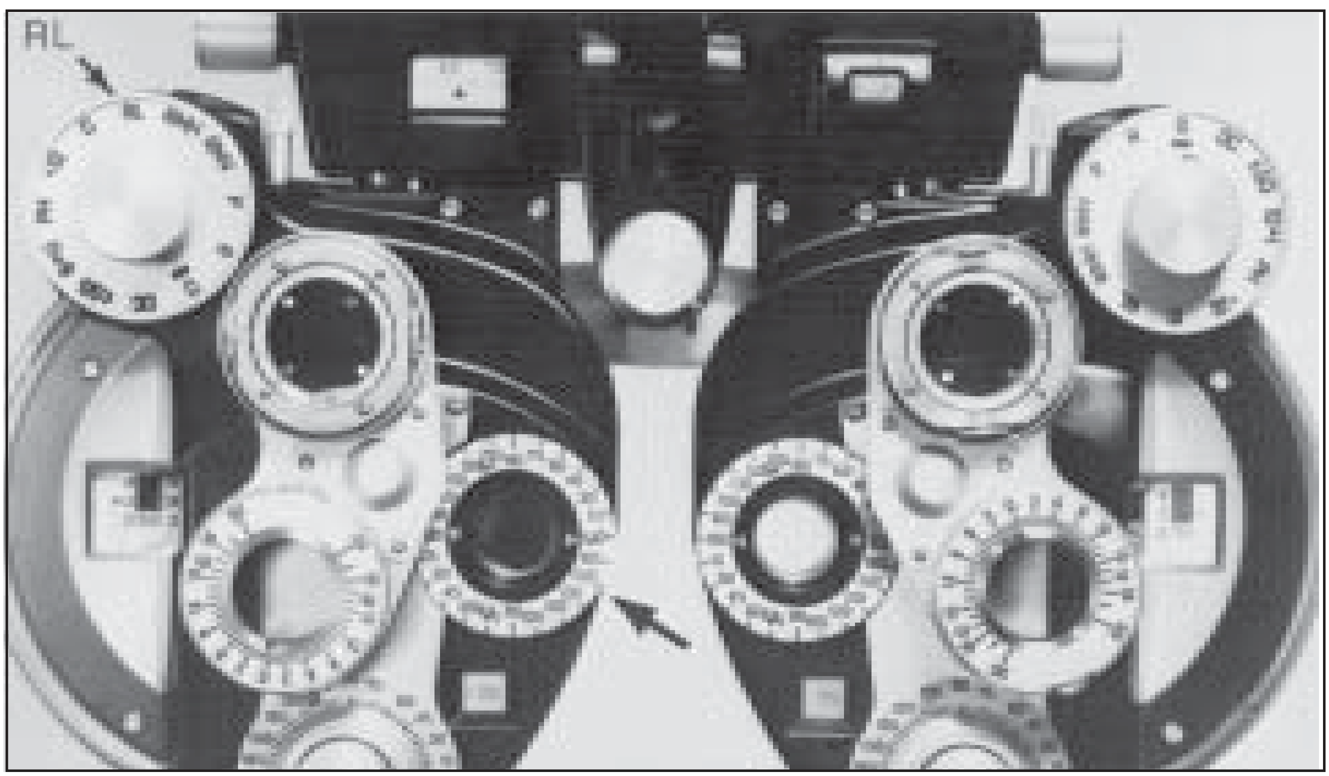


Figure 40 – Red Lens (RL) in Auxiliary Dial Before Patient's Right Eye.

Red Glass Test

To test the quality of binocular vision (or fusion), a red glass or Red Lens (RL) (see Figure 40, p. 34) is placed before one eye while both eyes, with ametropia corrected, view a small spot of white light (muscle light). If the patient reports:

1. The light appears single and pink in color — indicating good quality binocular vision.

2. The light appears doubled, one white and one red— indicating poor quality binocular vision. The amount measured by the Rotary Prisms and direction of separation of the two lights indicates the degree and nature of the heterophoria.

3. The light appears single and red in color — indicating poor binocular vision and suppression of the eye which does not have the red glass.

4. The light appears single and white in color — indicating poor binocular vision and suppression of the eye which does have the red glass.

Variations of the test may include the use of prisms to determine the amount of fusional amplitudes — i.e. the "stress" that can be tolerated while the fused pink-color light remains single, or prisms may be used to determine the correction for heterophoria.

Practitioners differ in their judgement as to the amount of illumination present in the refracting room while this test is conducted. Optimum room illumination is about 2 to 5 foot candles. Obviously, the room illumination should not be so high that the muscle light, especially when dimmed by the red glass, cannot be seen. On the other hand, when the room is completely dark, the test is most critical — i.e. demands excellent binocular vision, since peripheral stimuli to fusion is eliminated.

VIII. Prescribing the Right (or Best) Correction

While the measuring of the refractive error is a science, the prescribing of a correction is an art.

Although prescribing exactly what has been measured may give the best visual acuity, it may not be the most comfortable (to the patient) and, hence, not the most efficient.

It is most important to consider the patient's Chief Complaint and prescribe a correction which will relieve or minimize his or her complaint without introducing new difficulties.

Sometimes, it is best (clinically) to build up to the full correction by making gradual changes in the patient's correction. It is difficult to lay down hard and fast rules, but a consideration of the patient-as-a-person will most often result in satisfaction.

Changes of 1.00D sphere or cylinder from a patient's previous correction are often about all that can be tolerated by sensitive individuals. In many cases a change of 0.50D is all that can be tolerated.

The above statements include those patients who have reasonably good visual acuity with their old glasses, but have complained of localized ocular discomfort (asthenopia). Not included are young children who have never worn glasses, but have a convergent strabismus which is corrected by +5.00D (or more) spheres. Also, an exception is the recently operated cataract patient who requires + 10.00D to + 15.00D spheres. In these latter cases, as nearly as possible to the full correction should be given.

There is always a certain amount of change in the patient's spatial localization with every new optical correction. Young people usually adjust more quickly to these changes than do older patients. Despite an increase in visual acuity, the patient may reject new glasses if the new distortions in space perception are intolerable. This occurs more with cylindrical changes than with spherical changes, especially, if the cylinder axes are oblique.

The advice to patients as to whether to wear their new glasses constantly, or just for distance seeing, or for near point tasks, must be emphasized.

If the patient's Chief Complaint is primarily that of blurred distance vision, there is no point in insisting that the glasses should be used for near vision. Likewise, if the patient's complaint is solely that of blurred near point vision, there is no need to advise that the glasses be worn constantly.

In beginning presbyopia patients, who need primarily some plus sphere power, but there is also a small astigmatic error, it is usually best not to prescribe the cylinder correction. The plus spherical power will enable them to read without introducing the meridional distortion of cylindrical power.

One good overall criterion is to prescribe, especially at first, the minimum amount of correction which relieves the chief complaint and gives good visual acuity. The patient should be advised that only a partial correction is given at first so he or she will become adjusted to it easily. More nearly the full correction may be given as time progresses and the need arises.

More complaints arise from prescribing too much, rather than too little. People do not want their visual habits changed radically unless, of course, there is a lot to gain—such as the need for better acuity or relief from discomfort. In such cases, it is necessary to explain to patients that their visual habits, to which they have become accustomed, must be changed in order to gain the desired advantage of clearer vision and/or relief from discomfort.

Fortunately, in most cases, patients will be found to have remarkably similar refractive errors, or need similar refractive changes, in both eyes. The relatively few patients who have unequal (anisometropic) refractive errors, or who require unequal refractive changes, are the ones who require more careful consideration.

In those patients with unequal refractive errors, the most practical method is to consider each case individually, since the judgement of what to prescribe will depend upon the patient's age, nature of previous corrections, symptoms, visual acuity, muscle balance, occupation, hobbies, general physical and nervous condition.

Older people who have never worn glasses, despite a marked difference in the visual acuity of each eye and manifest lack of good binocular coordination, but who now complain primarily of blurred vision for close work, may be best served by an equal add for near, leaving them with the same inequality of visual acuity to which they have been accustomed.

On the other hand, young people who have yet to decide on their life's work should not be deprived of good vision in each eye and encouragement toward better binocular vision, including stereopsis, without some attempt being made to correct even a large degree of anisometropia.

With the present-day emphasis on good vision in each eye to meet certain academic, industrial, civil service or military visual standards, every effort should be made — or, at least, offered to young people who would fail to meet these standards if a full refractive correction for each eye is not given.

IX. Glossary of Terms Frequently Used in Refraction

ACCOMMODATION: The adjustment, by the ciliary muscle, of the focus of the eye for clear vision at different distances.

ALTERNATING VISION: The use of the eyes alternately, but not together.

AMBLYOPIA: Impaired visual acuity not correctable by refractive means and not due to obvious pathological conditions.

AMETROPIA: The refractive condition in which, with accommodation at rest, parallel rays of light do not come to a clear focus on the retina— i.e. a refractive error.

ANISOMETROPIA: The refractive condition in which the ametropia of one eye differs from that of the other.

ASTHENOPIA: A general term used to include those subjective symptoms of "eyestrain" arising in or around the eyes resulting from the use of the eyes.

ASTIGMATISM: A condition of the eye in which different meridians have different refractive powers, such that rays of light from a point of an object are not brought to a point focus in the eye and, as a result, the image formed is blurred. Cylindrical lenses are used to correct astigmatism.

BINOCULAR VISION: The object viewed with both eyes is seen as a single object, although there are two images, one in each eye.

CATARACT: An opacity or loss of transparency of the crystalline lens or its capsule.

COMPOUND HYPEROPIC ASTIGMATISM: An error of refraction in which the focus of each principal meridian is behind the retina, one farther behind than the other, when the accommodation is at rest.

COMPOUND MYOPIC ASTIGMATISM: In this error of refraction, the focus of each principal meridian is in front of the retina, one farther in front than the other.

CONVERGENCE: The rotation of the eyes necessary to bring the images of a near object on the fovea of each eye. SEE FUSIONAL AMPLITUDE.

CORNEA: The anterior surface of the eyeball which is a transparent lens that contributes the greater portion of the refractive power of the eye.

CORNEAL ASTIGMATISM: That part of the total astigmatism of the eye which is produced by the difference in the radii of curvature of the cornea.

CYCLOPLEGIA: A pathological or artificially induced (by drugs) paralysis of the ciliary muscle and power of accommodation, usually accompanied by dilated pupils.

DIOPTER: (D.) The unit of measure of lens power. A lens with one diopter of refractive power will bring parallel rays of incident light to a focus at a distance of one meter. The power of a lens is expressed as the reciprocal of the focal length, when the latter is measured in meters—e.g., 1 D. = 1 m.; 2D = 1/2 m.; 3D = 1/3 m.; 0.50D. = 2 m; 0.25D. = 4 m; etc.

DIPLOPIA: (DOUBLE VISION) When one object appears as two, due to the fact that its images are not on corresponding retinal areas, double vision occurs because such images cannot be fused to a single mental picture.

DIVERGENCE: The ability to adjust the pointing of the eyes to a more distant object. SEE ALSO FUSIONAL AMPLITUDE.

EMMETROPIA: The ideal condition, in which there is no refractive error.

ESOPHORIA: A lateral deviation of the visual axes inward when the fusion is suspended or broken.

EXOPHORIA: A lateral deviation of the visual axes outward when the fusion is suspended or broken.

FOVEA: A small depression or pit in the central retinal area in which visual acuity is most sensitive or greatest.

FUSION: The combination of the two separate images upon the two retinas into a single visual impression.

FUSIONAL AMPLITUDE: The measure of a subject's capacity to maintain binocular vision when similar objects seen by the two eyes are displaced relative to each other by mechanical or optical means. It is a measure of the subject's ability to overcome obstacles to binocular vision.

HETEROPHORIA: Any deviation of the visual axes of the eyes when fusion is suspended or broken.

HYPEROPIA (or HYPERMETROPIA): Commonly called far-sightedness; a refractive error in which the light rays tend to focus behind the retina, when accommodation is at rest.

HYPERPHORIA: A vertical deviation of the visual axes when fusion is suspended or broken: Right hyperphoria (RH) when the right visual axis deviates upward; Left hyperphoria (LH) when the left visual axis deviates upward.

INTERVAL OF STURM: The linear or dioptric distance between the two focal lines (anterior and posterior) of an astigmatic eye or optical system.

LENS: The lens of the eye (crystalline) is a nearly spherical, transparent body suspended just behind the iris. Its shape and thickness are changed by the contraction and relaxation of the ciliary muscle. It is by this mechanism that the eye is able to change its focus.

MIXED ASTIGMATISM: In this refractive condition, the focus of one meridian is in front of the retina (myopic) while the focus of the other meridian, at right angles to the first, is behind the retina (hyperopic).

MONOCULAR VISION: Vision which involves only one eye, the other eye being absent or covered, or its image mentally suppressed.

MUSCULAR APPARATUS: This apparatus consists of two groups of muscles, intra-ocular and extraocular. The intra-ocular muscles regulate the size of the pupil and control the focusing of images upon the retina. The extra-ocular muscles support and move the eyes.

MYOPIA: Commonly called nearsightedness; a refractive error in which the light rays are brought to a focus in front of the retina.

NEUROMUSCULAR CONDITION: The functional condition of the ocular muscles and the nervous connections by means of which the coordination of the eyes is effected are included jointly under the term neuromuscular condition .

NYSTAGMUS: An involuntary, regular and usually rapid repetitive movement or rotation of the eye.

OCULAR ROTATIONS: All movements of the eyeball in its socket are spoken of as rotations. Usually, there are no limitations of movement in any direction such as would occur, for example, in case of paralysis.

OPHTHALMOMETER: An ophthalmic instrument for measuring the anterior curvatures of the cornea— thus indicating the amount of the corneal astigmatism.

OPTIC NERVES: The two complex bundles of nerve fibers connecting the light-sensitive layers of the two retinas with the visual areas and centers in the brain.

ORTHOPHORIA: The ideal condition of muscular balance in which the visual axes are parallel when either eye is fixing a distant object and the other eye is covered, or fusion is otherwise suspended.

PERIPHERAL FUSIONAL MOVEMENTS: Fusional movements of the eyes which occur in response to stimuli affecting the peripheral retina even when the subject is not aware of such stimuli.

PHOTOPHOBIA: An abnormal sensitivity or intolerance of light.

PRESBYOPIA: A reduction in the amplitude of accommodation occurring normally with age and requiring a plus lens addition (ADD) for adequate vision at near.

PUPIL: The aperture or opening in the center of the iris through which light is admitted into the eyeball. Its size is varied by the papillary muscles.

REFRACTION: The bending of the rays of light by a lens, or other means. Commonly used to describe the process or technique of measuring the refractive errors of the eyes.

REFRACTIVE APPARATUS: The optical system of the eye, which includes the cornea, pupil and lens. Its function is to produce images upon the retina.

REFRACTIVE ERRORS: See HYPEROPIA, MYOPIA, ASTIGMATISM .

RETINA: The light sensitive surface or film upon which images are formed by the refractive apparatus. The retina is connected directly with the brain by the fibers of the optic nerves.

RETINOSCOPY: The objective measurement of the refractive error of the eye by the use of a Retinoscope which determines the conjugate focus of the retina by the interpretation of the movement of the light reflex in the patient's eye relative to the motions made by the examiner

SENSORY DIVISION: That portion of the nervous apparatus which receives visual impressions upon the retina and transmits them through the optic nerves to the visual areas and centers in the brain.

SIMPLE HYPEROPIC ASTIGMATISM: In this refractive error, the rays of light passing through one meridian of the eye, which is the axis of the astigmatism, are brought to a focus at the retina, while those passing through the meridian at right angles to the first are brought toward a focus behind the retina. The image formed on the retina is blurred when accommodation is at rest.

SIMPLE MYOPIC ASTIGMATISM: In this refractive error, the rays of light passing through one meridian of the eye, which is the axis of the astigmatism are brought to a focus at the retina, while those passing through the meridian at right angles are brought to a focus in front of the retina. The image formed on the retina is blurred.

STEREOPSIS: The binocular impression of solidity or depth resulting from the mental interpretation of slight differences (disparities) in the patterns of the images of the two eyes.

STRABISMUS: Commonly called squint or crossed eyes; a manifest muscular imbalance in which the visual axes of the eyes do not intersect at the object fixated.

SUPPRESSION: The blocking of vision of one eye without apparent structural or physical cause—psychological blocking. This may occur when clear binocular vision is difficult or impossible, and monocular vision is preferred.

VISUAL ACUITY: The sharpness of vision of an eye. It is commonly determined by noting the smallest size of letters which the subject can read correctly at a distance of twenty feet. According to the Snellen notation, 20/20 is "normal" or standard vision.

VISUAL EFFICIENCY: Capacity of the visual apparatus to perform its functions effectively. It covers not only visual acuity, but all the functions of vision. Often eyes with defects function effectively in spite of the defects because of the capacity for compensation.

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