AMERICAN
LENSOMETER
JUNIOR
IMPROVED MODEL

By American Optical Company

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Model M603

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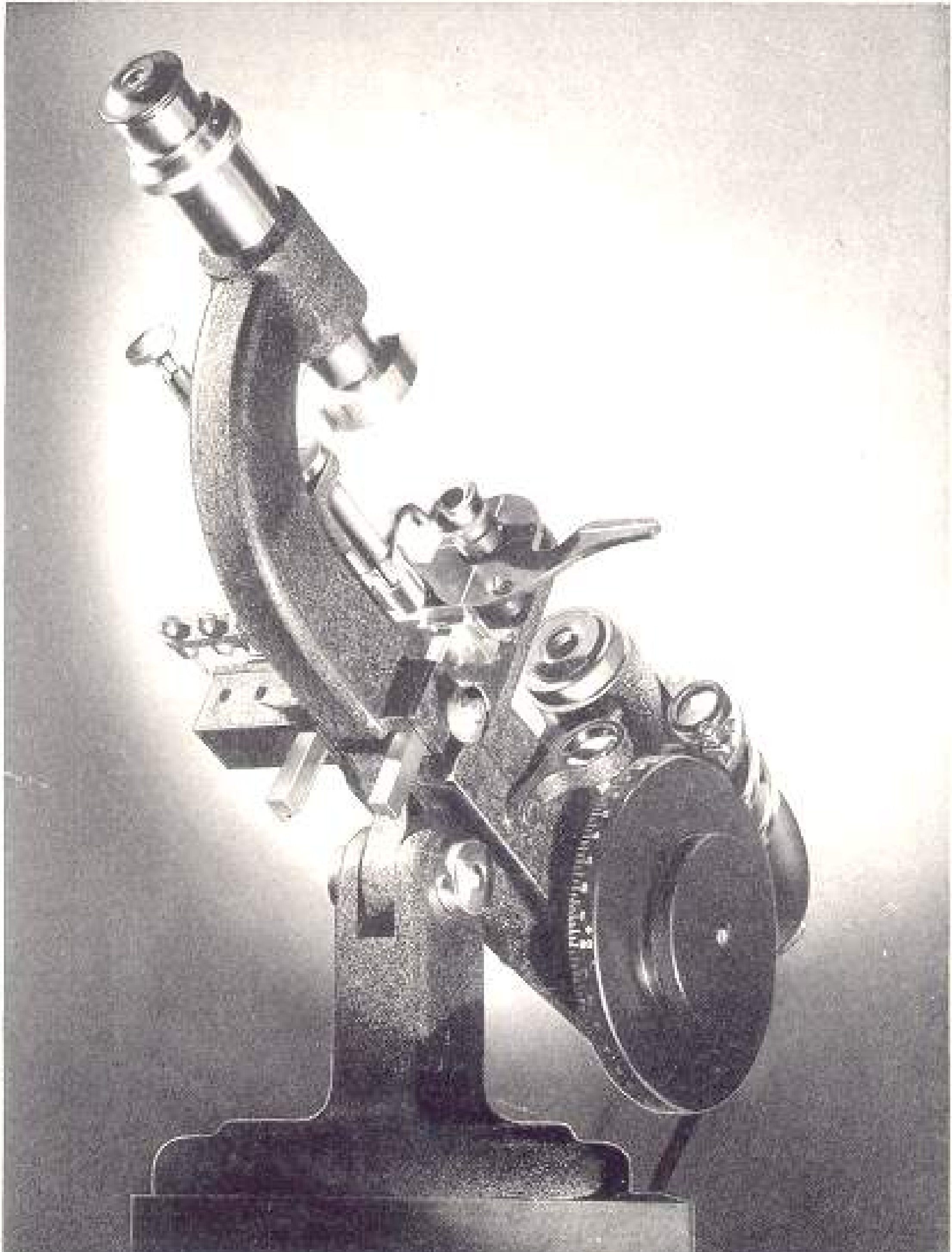

Pat. Pend.

THE IMPROVED LENSOMETER JUNIOR

MODEL 605

CONTENTS

Foreword

Determining the focal strength and the axis of an optical lens has been a favorite occupation with men of science since the 11th century. Alhazen the Arabian, Roger Bacon the Englishman, Giovanni the Venetian; these are but a few of the many who turned the brilliancy of their minds to lens measurement.

Many methods have been used—some crude and some adequate enough . . . but in 1914 a new instrument lay ready for production in the laboratories of American Optical Company which was to revolutionize the entire conception of lens measuring accuracy.

The new instrument, the Lensometer, was the result of more than ten years intensive research. Hitherto lenses had been tested by the neutralization and curvature methods—methods which had been effective enough in their time but

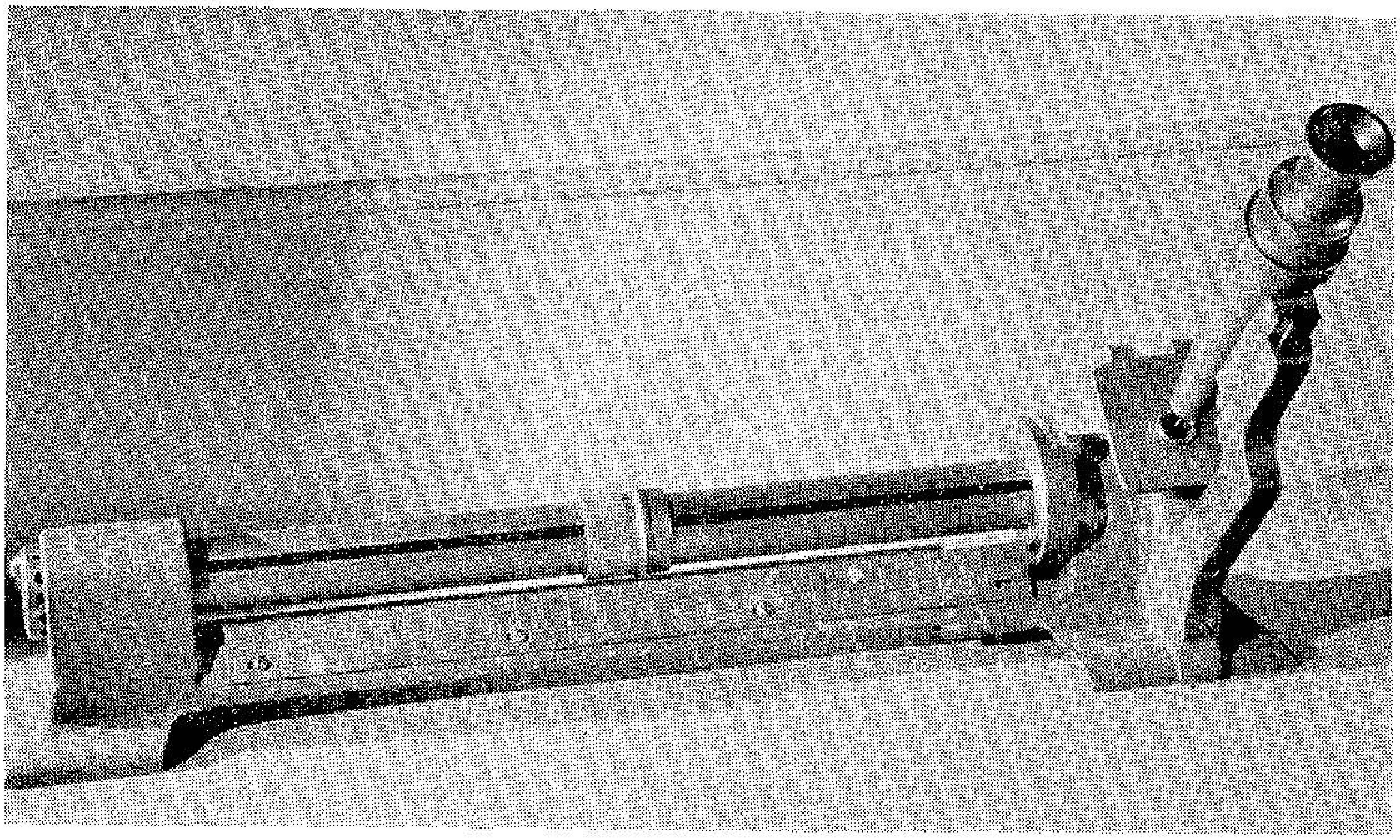

Fig. 2. The Original Lensometer

which were hopelessly out-dated from the moment that the Lensometer was brought out.

For here was an instrument, the findings of which were accurate to the minutest detail, an instrument that not only prescribed but also proved. Nevertheless, for all its advantages over other methods, testing and improvements went on in the AO laboratories until late in 1916 when the instrument was brought out.

But 1916 and 1917 were precarious years for the new creation. Men's minds were overwhelmingly occupied by the turn of events in Europe and after approximately 100 machines had been sold, manufacture was discontinued. The new impetus came, after the war had ended. There now arose a greater need than ever for an unerring measuring device to provide accuracy and uniformity in lens prescription. The Lensometer was the answer.

During these early years when the principles of the Lensometer were little more than theories to the profession, the American Optical Company spared neither time nor expense in presenting its features to the optical world. Delegates who had been well grounded in its workings were sent out to give demonstrations and explanations.

Since then the story of the Lensometer has been one of development and improvement. New devices have been added until today the instrument is, without doubt, the most precise type of instrument for its purpose in existence. And what is just as important, its cost has been brought within the reach of all practitioners.

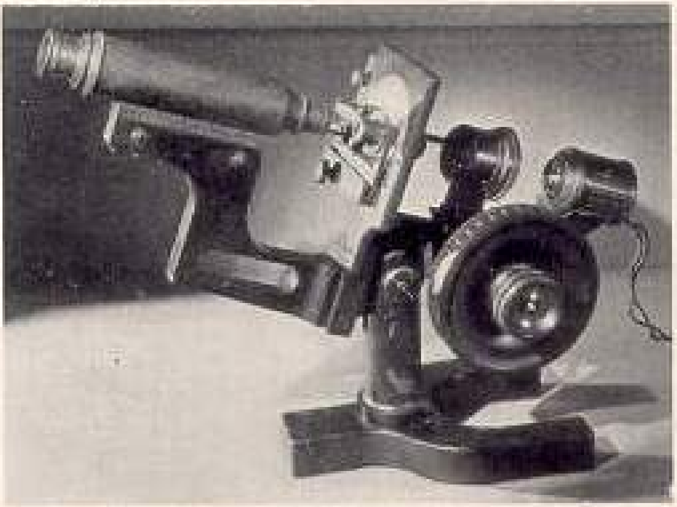

Fig. 3. One of the early models

The Lensometer is now made for American Optical Company by its affiliate, the Spencer Lens Company, which is internationally famous for the quality and merit of its products. The Lensometer has the double advantage of adding Spencer skill and experience in building scientific precision instruments to American Optical skill and experience in the design and construction of precision ophthalmic instruments.

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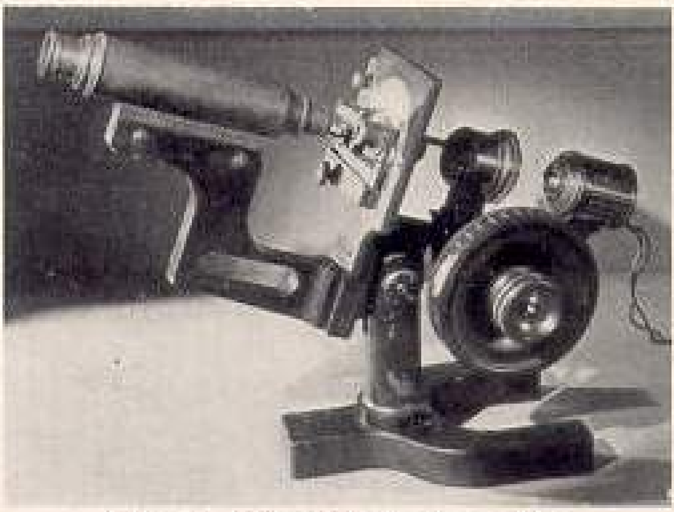

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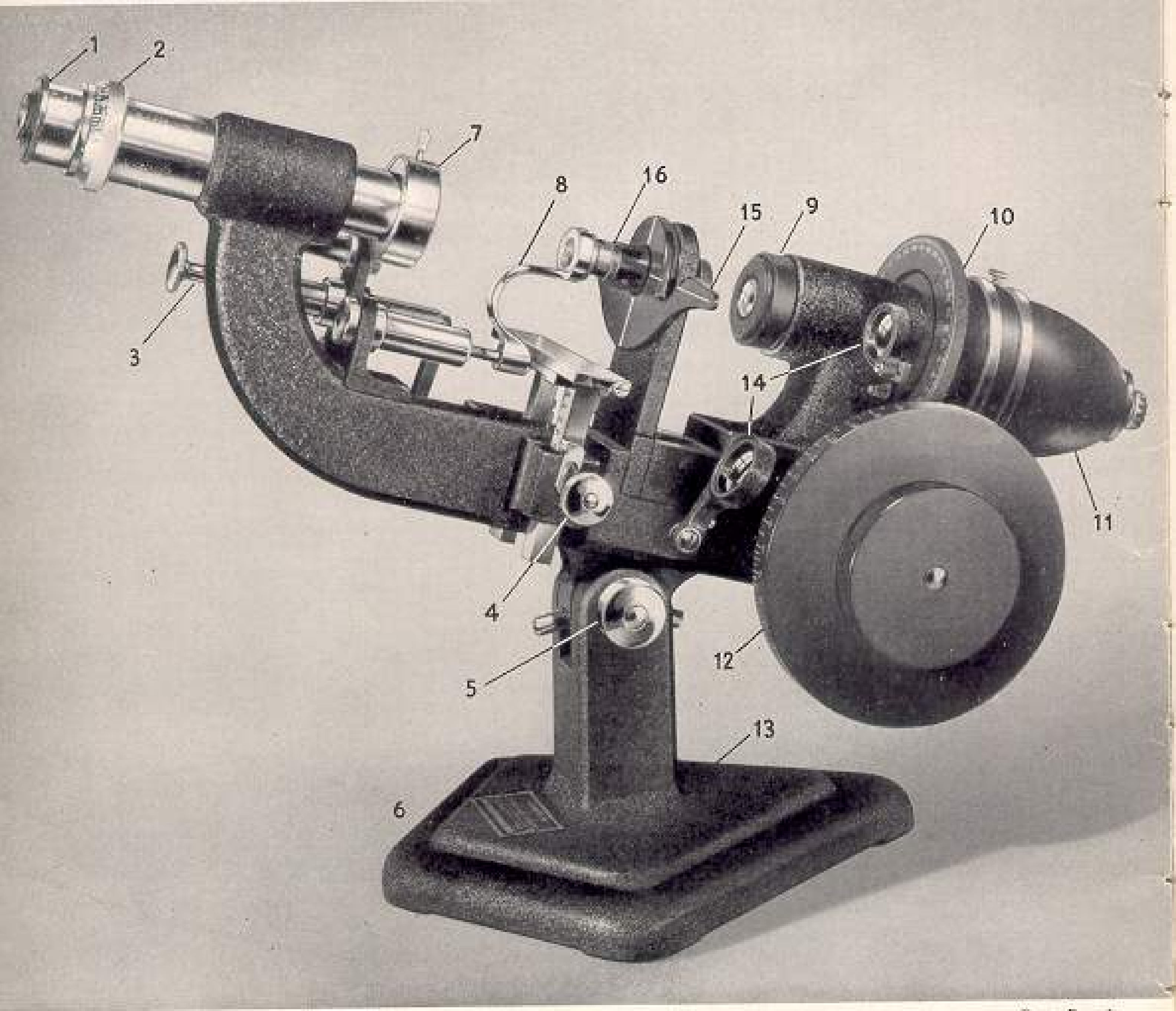


Fig. 4. Illustration showing major parts of Lensometer

The operation of the Lensometer is not a difficult matter, yet for accurate results, it is essential that the correct method be used. We suggest that the reader familiarize himself with the instrument before proceeding further:

The Instrument

1. Adjustable eye piece.
2. Wide range prism measurer, indicates prismatic power and direction of prism.
3. Lens marker—for centering and axis marking (practically automatic).
4. Aligning device—*rack* and pinion operated—permits extra-fine adjustment.
5. Adjustable for height.
6. Modern design for strength and beauty.
7. Auxiliary prism holder—for measuring bifocal segments and extra-strong prismatic powers.
8. New lens holder—natural hold.
9. Clear and substantial target.
10. Protractor wheel—clearly defined axis marker.
11. Standard lamp in bakelite housing.
12. Power wheel—graduated readings in fractional diopters between +20 and −20.
13. Sturdy construction—durable finish.
14. Magnifying attachments—give more accurate readings.
15. Lens aligning plate. The geometrical axis of the lens should be aligned with the 0—180 line of this plate.
16. Lens positioning tube.

The Functions Of the Lensometer

THE AO Lensometer was designed to provide a reliable and accurate measuring device for all ophthalmic lenses; to place in the hands of the refractionist and the dispenser an instrument that measures with a minimum of effort and time the actual refractive effect of a given lens as it is used. In simple terms it enables him to determine the focal strength and axis of any optical lens.

With it, allowances and all other errors that are possible through calculations, are eliminated; with it, the refractionist can determine the focal power of a fragment of any broken lens that he is called upon to replace; and what is just as important, in all cases of doubt the optical practitioner can take the combination (or succession) of lenses in the test case and read the exact effective power of the combination.

The Lensometer determines:—

1. The effective power of spheres;
2. The effective power of cylinders;
3. The effective power of compound lenses;
4. The power of prisms;
5. The direction of prismatic power;
6. The axes of cylindrical lenses;
7. The center of lenses; and
8. The power of bifocal segments.

The Principles of the Lensometer

The Lensometer has been many times called an optical sentinel and that, in brief, is exactly what it is. By a combination of a telescopic lens system, a standard lens system and a target, it reverses the optical order and makes the eye the object rather than the target.

In other words, for the purpose of the test the target becomes the eye, and the eye the target. Its underlying

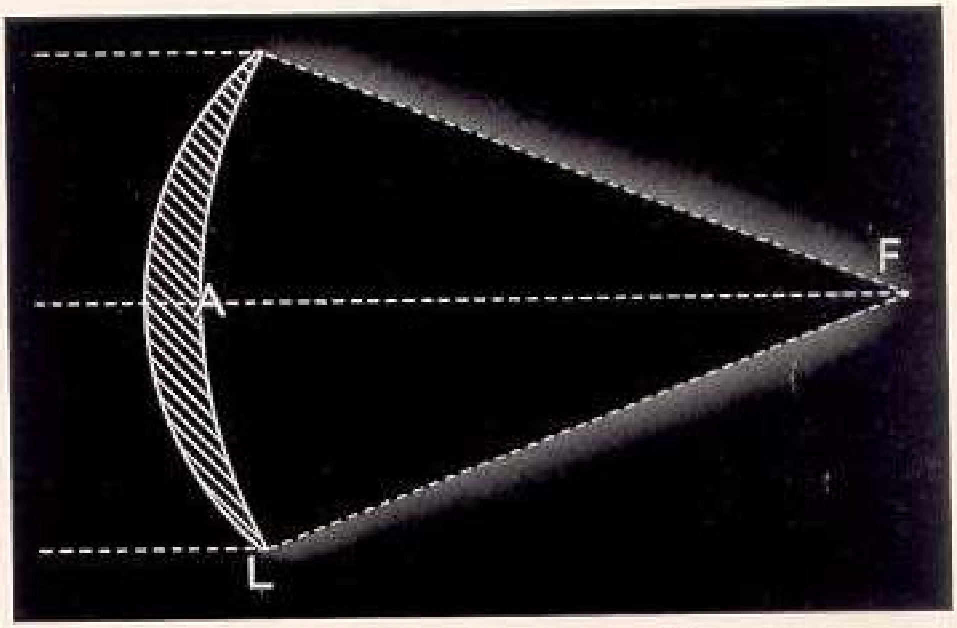


Fig. 5. 1/AF denotes power of lens

principle is the conversion of optical power into linear measure. The focal length of the lens is accurately determined and translated into diopters. This is accomplished by the use of a standardized lens and the graduated scale.

The unit of optical measurement used is the diopter. The diopter, by definition, represents the power of any lens bringing distant parallel light to a focus at one meter from the lens. Thus, also, the meter was chosen as the unit of linear measurement.

Hence in the above illustration L designates a lens with its focus at F. The back focal length is AF. The reciprocal of this focal length in meters or 1/AF denotes the power of that lens. From the above we derive the following formulae, in which D is the power of the lens in diopters and F the back focal length in meters: $D = 1/AF$ or $AF = 1/D$.

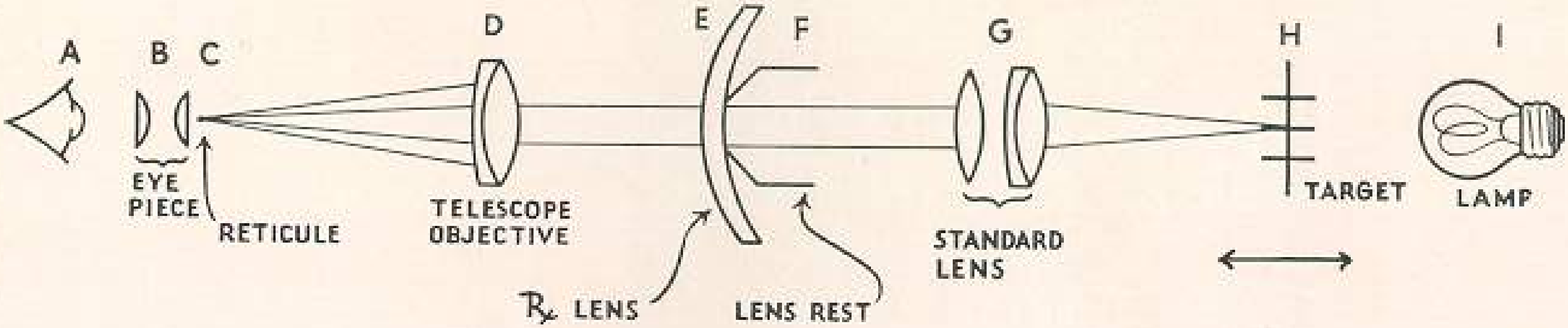


Fig. 6. Diagram showing a cross section of the Lensometer Junior with an ophthalmic lens set up in position to be tested

Also, since by definition the power of a lens bringing distant light to a focus at one meter is said to be one diopter; a lens bringing it to a focus at ½ meter is said to be 2 diopters; one bringing it to focus at ¼ meter is said to be 4 diopters, it can be seen by the following diagram that the linear distance as measured in diopters varies inversely as to the diopters in a geometric progression.

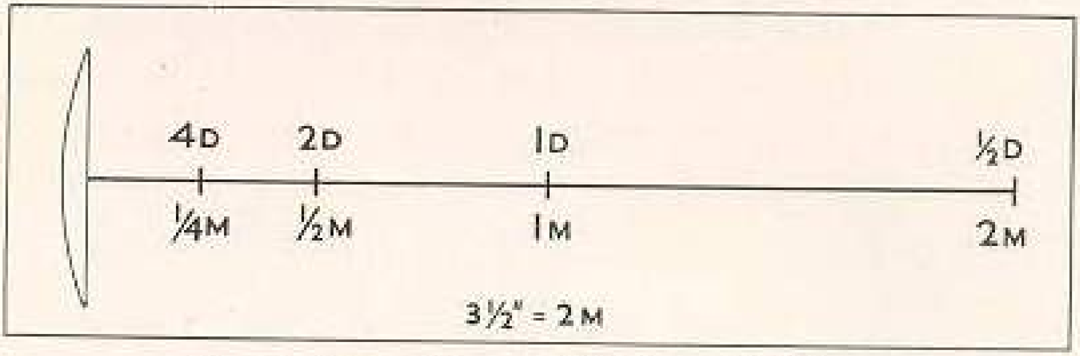


Fig. 7. In this diagram, M is Meter; D, Diopter

Since it was unwieldly to measure in actual whole meters and to transform the geometric progression into a uniform scale, the telescopic lens system and the fixed positioning tube with the adjustable standardized lens were incorporated into the instrument. The telescopic system makes distant vision possible on so small an instrument. The standardized lens projects the image plane of the target into the required back focal distance of the lens being tested.

For those who are interested in the mechanics of the Lensometer, the optical system is explained below. See figure 6.

The observer's eye (A) is placed at the exit pupil of the telescopic system, which is composed of an adjustable eyepiece (B) and a telescopic objective. The eyepiece is focused on a reticule (C) to compensate for any errors there may be in the observer's eye.

The telescopic objective (D) is so adjusted to bring the images of distant objects to a focus on the reticule (C). This optically places the eye of the observer as the distant object toward which the spectacle lens (E) is turned.

The positioning tube (F) is adjusted and set with lock screws for holding the ophthalmic lens (E) at the required distance from the laboratory adjusted standard lens (G).

In this way the image plane of the target (H) is projected into the required back focal distance from the ocular surface of the lens under test (E). The positioning tube (F) is so adjusted that the ocular surface of the lens (E) is held in the principal focal plane of the standard lens (G).

Thus, from any book on Geometrical Optics we can find an equation for the distance (X) from this point to the image of the target. If we let (X^1) equal the distance of the target from the other focal plane of the standard lens (G) and (F) the equivalent focal length of the standard lens (G) we get

$$XX^1 = F^2.$$

Then by transposing we get

$$X^1 = F^2 (1/X) \text{ or } F^2D.$$

from which it can be seen that the reciprocal of the back focus of the lens (F) is read as a linear term X^1 in units depending for the units of length upon the value (F).

Now the equivalent focal length of the standard lens is somewhat less than 0.05 meters but for ease in calculation we will assume

$$F = 0.05, \text{ then}$$

$$X^1 = \frac{0.0025}{X} \text{ or } 0.0025D$$

where D is effective power of lens (E) in diopters.
It is thus seen that each diopter means 2.5 mm movement of the target, and for 0.01 D a movement of 0.025 mm.

The standard lens (G) must be accurate. Consequently, it is made adjustable in power by a slight change in the separation between a weak positive element and another strong over achromatized positive element. After accurately adjusting the power, the two lens cells are sealed at the required separation.

The precision of the protractor on the Lensometer is tested by means of a marked plano cylinder set face up, then face down. The average readings will then give the 180° point regardless of the actual axis of the cylinder. (It is advisable to have the cylinder within ten degrees of 180° for ease in figuring).

The power is so adjusted that readings made with each Lensometer agree with the values as certified by the United States Bureau of Standards for our Primary Standard Lens Set.

Operation of the Lensometer

a. Preliminary Adjustment

The instrument should always be adjusted to the eye of the examiner before lenses are analyzed. This adjustment is accomplished as follows:

Turn the graduated power wheel until the zero position is directly opposite the arrow on the indicator. While looking at the eyepiece, rotate it until the circulars of the reticule are sharp and clear as in figure 8A. If the instrument has been properly adjusted the squares and bands of light on the target will be sharply defined as in figure (8B).

Fig. 8A—Reticule

Fig. 8B—Target

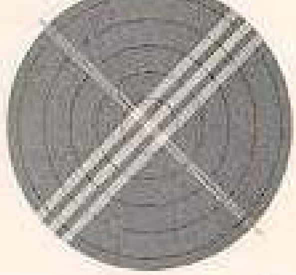


Fig. 8C—Reticule and Target combined

Superimposed on the reticule a clear image of the combined reticule will be seen as in figure 8C.

With the instrument set correctly for the operator's eye, we are ready to proceed with any of the tests outlined on the following pages.

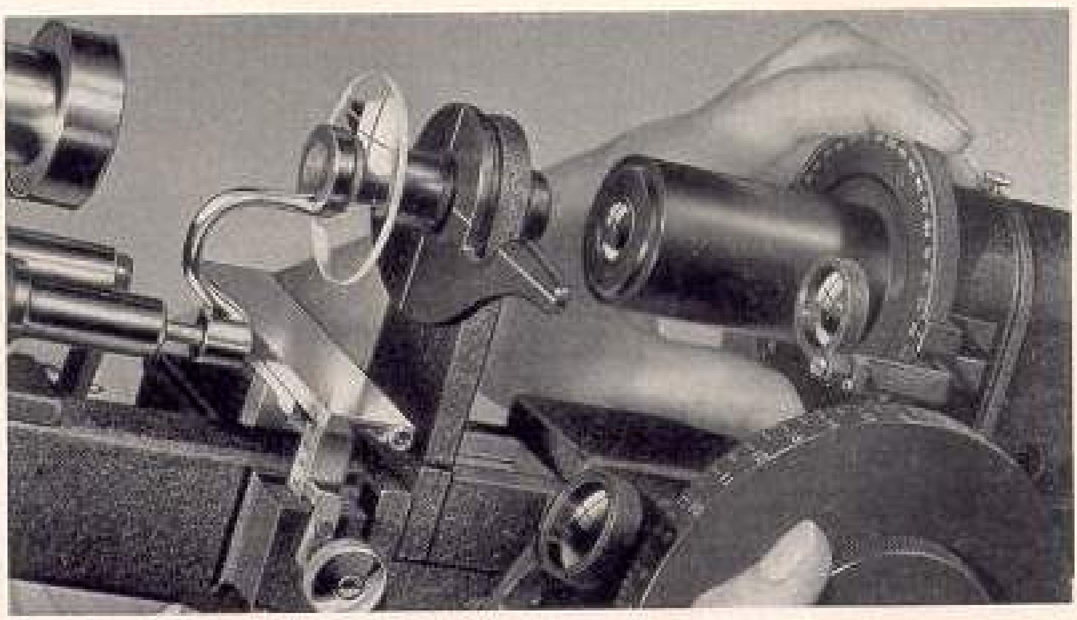


Fig. 9. Section showing proper position of lens being examined

b. Analyzing Spherical Lenses

Insert the lens to be tested with the back or ocular surface against the lens positioning tube (See Fig. 9).

While looking through the eyepiece, revolve the graduated power wheel until the squares are fairly distinct as in Figure 10A. Then move the lens until it is centered. This is indicated by the squares falling within the circle engraved on the reticule of the eyepiece as in Figure 8C.

Next, the power wheel is moved away from the operator, causing the squares to be blurred slightly as in Figure 10B then the power wheel is slowly turned *toward* the operator until the squares are sharp as in Figure 8C. Do not turn the power wheel back and forth by small amounts, because the most rapid and accurate settings are made as described. If you wish to verify the findings, repeat the entire operation.

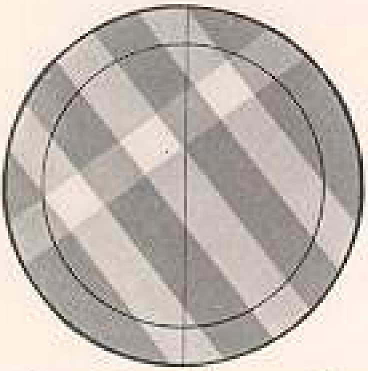


Fig. 10A—Normal image decentered

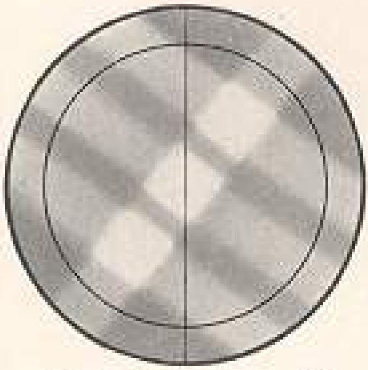


Fig. 10B—Sphere out of focus; No cylinder

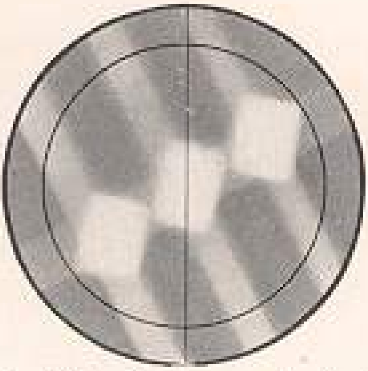


Fig. 11A—Sphere and cylinder out of focus; Axis off

The power of the sphere can be read directly from the graduated wheel—white numerals indicating plus power, and red numerals indicating minus power.

c. Analyzing Plano Cylinders

Set the power wheel at zero and insert the lens to be tested with the ocular surface against the lens positioning tube, so that the geometrical axis of the lens is on the 0-180° line. The appearance of the target will be similar to that shown in Figures 11A or 11B. While looking through the eyepiece, turn the protractor on the instrument until the single line comes into focus and becomes a bright band of light. See illustration 11C. The axis of the cylinder is indicated on the protractor.

Now rotate the power wheel until the three lines come into focus, as in Fig. 11D, carefully turning the power wheel until the sides of the rectangles are very sharp.

The power of the cylinder can now be read directly from the power wheel—positive if white, negative if red.

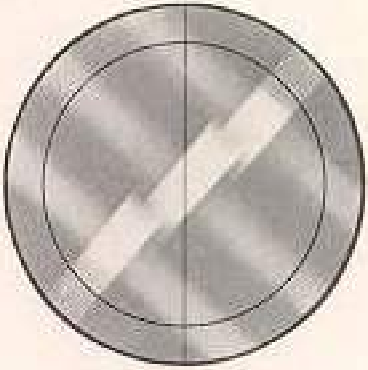


Fig. 11B—Sphere in focus; Axis off

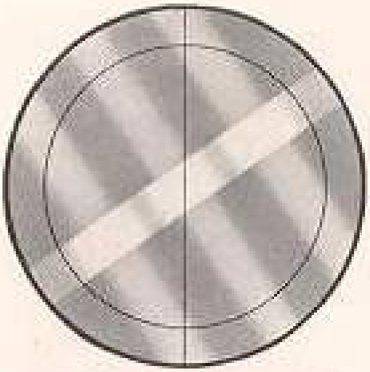


Fig. 11C—Sphere in focus; Axis correct

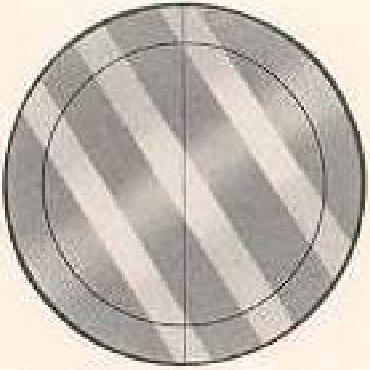


Fig. 11D—Cylinder focused

d. Analyzing Sphero Cylinders

Place the lens w'th its ocular surface against the positioning tube of the instrument or in other words with the front surface of the lens towards the operator.

1. Bring to sharp focus the single line of the target by slowly and simultaneously rotating in either direction the power and protractor wheels. When the single line is focused, then the reading on the power wheel indicates the spherical power and the protractor wheel reading indicates the axis of the plus or minus cylinder. The sign of the cylinder is determined by the second setting.

2. Now focus the three lines of the target by rotating only the power wheel. This gives the second reading. The cylinder is equal to the dioptric difference between the second and first reading. The cylinder power is plus when the power wheel has to be turned towards the operator for the second reading and it is minus when the power wheel has to be rotated away from the operator for the second setting.

Sphere = First reading single line
Axis = Protractor reading of first setting.
Cylinder = Second reading minus first reading

Examples.

1. First reading: Power wheel +2.50 D
Protractor wheel 85°

Second reading: Power wheel +1.00 D
Sphere = +2. 50 D
Cylinder = +1.00 − (+2.50) = −1.50 ax 85°
Rx = +2.50 −1.50 ax 85°

2. First reading: Power wheel +1.25 D
Protractor wheel 150°

Second reading: Power wheel −0.50 D
Sphere = +1.25 D
Cylinder = −0.50 − (+1.25) = −1.75 ax 150°
Rx = +1.25 − 1.75 ax 150°

3. First reading: Power wheel −1.37 D
Protractor wheel 17°

Second reading: Power wheel −2.00D
Sphere = −1.37 D
Cylinder = −2.00 − (−1.37) = −0.62D ax 17°
Rx = −1.37 −0.62 ax 17°

e. Prisms and Decentration

With the improved Lensometer Junior, it is a simple matter to decenter lenses to obtain a predetermined amount of prismatic power, without the use of tables or any calculations whatsoever.

Assume a spherical lens is to be decentered 3.00 prism diopters at 45°. First, place the lens with its ocular surface against the positioning tube, and after focusing with the power wheel align it for geometrical center. The target will then appear as in Figure 8C. Then set the prism axis scale on the telescope tube (see Figure 12) at 45° and move the lens on the positioning tube until the center square of the target is on the third circle of the reticule and exactly in line with the dark axis line of the reticule, which has now

Fig. 12. Prism measuring device

been set at 45°. The target will then appear as in Figure 13. It will be noted that each circle on the reticule represents 1.00 prism diopter. Without changing the position of the lens, mark it with the centering device to denote the amount and direction of decentration necessary to produce that prismatic power. If the prism to be checked exceeds 5.00

prism diopters, insert an auxiliary prism in front of the telescope tube, as in Figure 18. Generally, a 5° prism from the trial case will answer the purpose.

f. Verifying Finished Lenses

Spheres. Set the graduated wheel to the prescription value and insert the lens against the positioning tube. If the images are sharp, as in Fig. 8C, the lens is correct. If the wheel has to be turned, say, 0.12 Diopter to bring the image to a sharp focus, then the lens is incorrect by that amount.

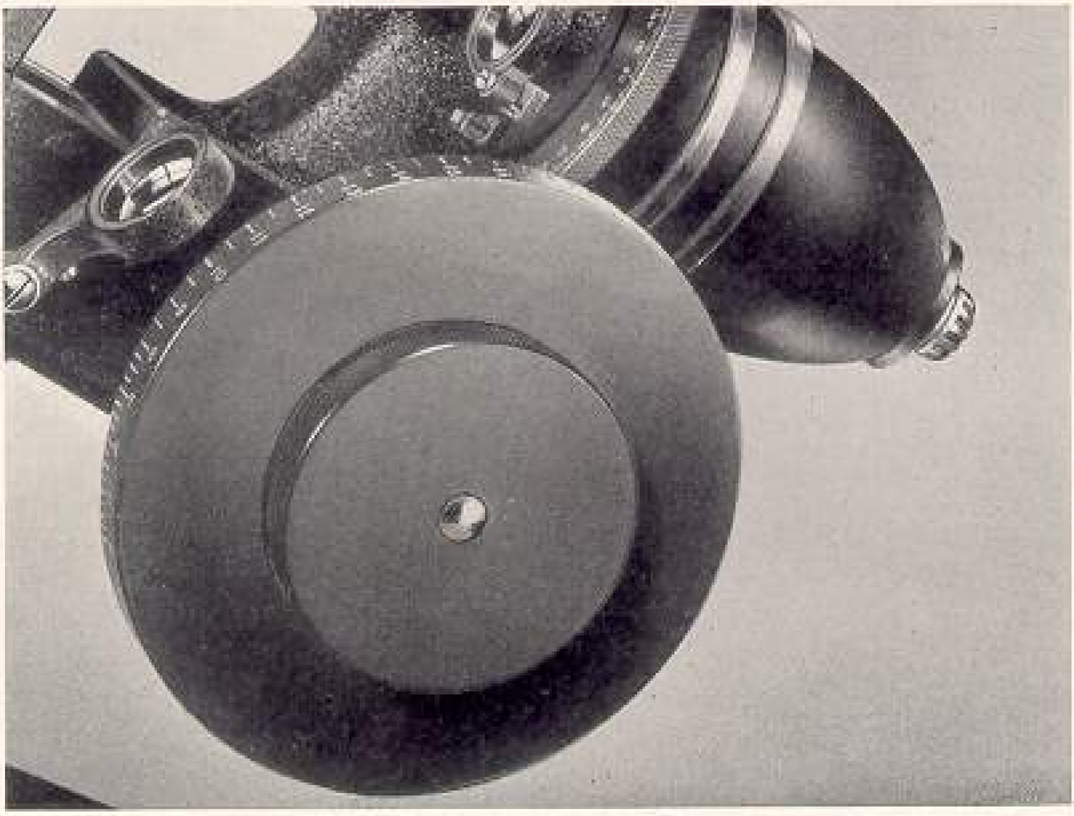


Fig. 12A. Power Wheel

Cylinders. To verify a cylinder set the power wheel to 0.00, and the axis wheel to indicate the axis on the Rx. Place the lens on the positioning tube, with the geometrical axis horizontal and perfectly aligned on the 0-180° line. The image as seen should be three rectangles, extending along the same line as in Figure 11C, with faint bands extending out of each rectangle but sharply defined on their sides. This tests the cylinder for absence of power along the axis.

Next, move the graduated wheel to the cylindrical power appearing on the Rx. The rectangles and ribbons should be parallel to each other and should be sharply defined along their former indistinct direction as in Figure 11D.

Sphero-Cylinders. Set the power wheel according to the spherical power appearing on the Rx; also set the small power indicator on this wheel at the same position. The rest of the operation is the same as for cylinders, always taking the spherical power instead of zero power as a starting point, and the sum of the spherical and cylinder powers for the second reading. The difference between the first and second readings represents the cylindrical power of the lens.

g. Prismatic Power

To determine if a lens has been properly decentered, set the power and the axis wheels at their proper positions and place the lens on the positioning tube with the geometrical center and, in the case of a cylinder, with the axis perfectly

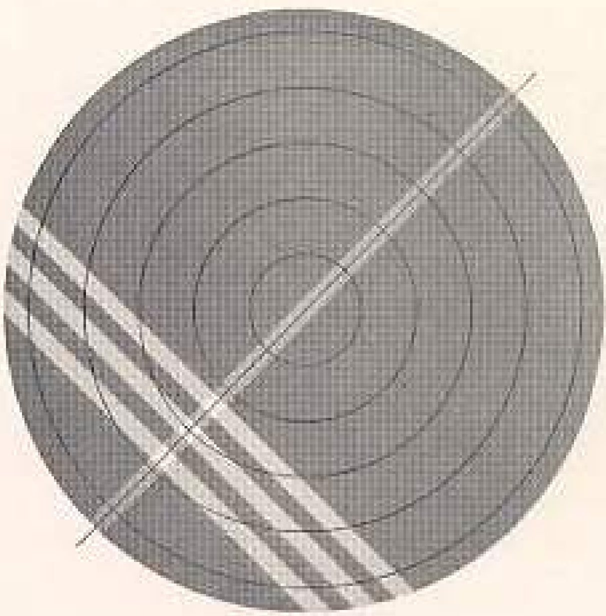


Fig. 13. Target showing power of three prism diopter

aligned. Next turn the prism axis scale to the correct position. The image in the case of a decentered sphere should be as in Fig. 13.

h. Alignment of Spectacles

This is a simple attachment supplied on every Lensometer Junior of the improved model by which the alignment of a pair of spectacle lenses, mounted and ready to deliver, can be checked for alignment of axes and prismatic power. Often lenses that have been properly surfaced are cut or edged off axis or with the wrong amount of decentration. Also there is a possibility of perfectly surfaced and edged lenses being improperly mounted in a frame, either because the frame is out of "true", or because the drilled holes are not correctly positioned, or for various other reasons. As it is essential that the finished work comply in full with the specifications on the Rx, every job should be checked on the Lensometer before delivery to the patient.

When not in use, the aligning device should be in its lower position, as in Figure 9. When it is desired to check a mounted prescription, the device can be raised, as in Figure 15 and the mounting placed thereon.

Fig. 14. Magnifying attachment for protractor and power wheel

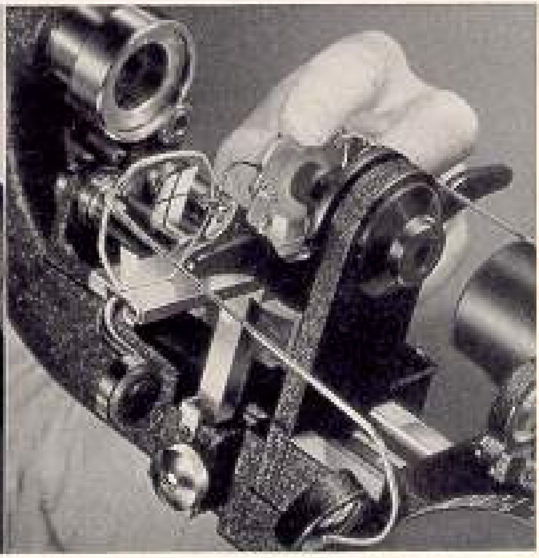


Fig. 15. Position of spectacles on aligning device

To check such work, set the power wheel, the axis scale, and the prism scale in their proper positions and check one lens. Then move the aligning device to the right or left and check the other lens, being careful not to change the up and down position of the device.

Any discrepancy in the alignment of the finished Rx can readily be located and corrected before the work is sent out.

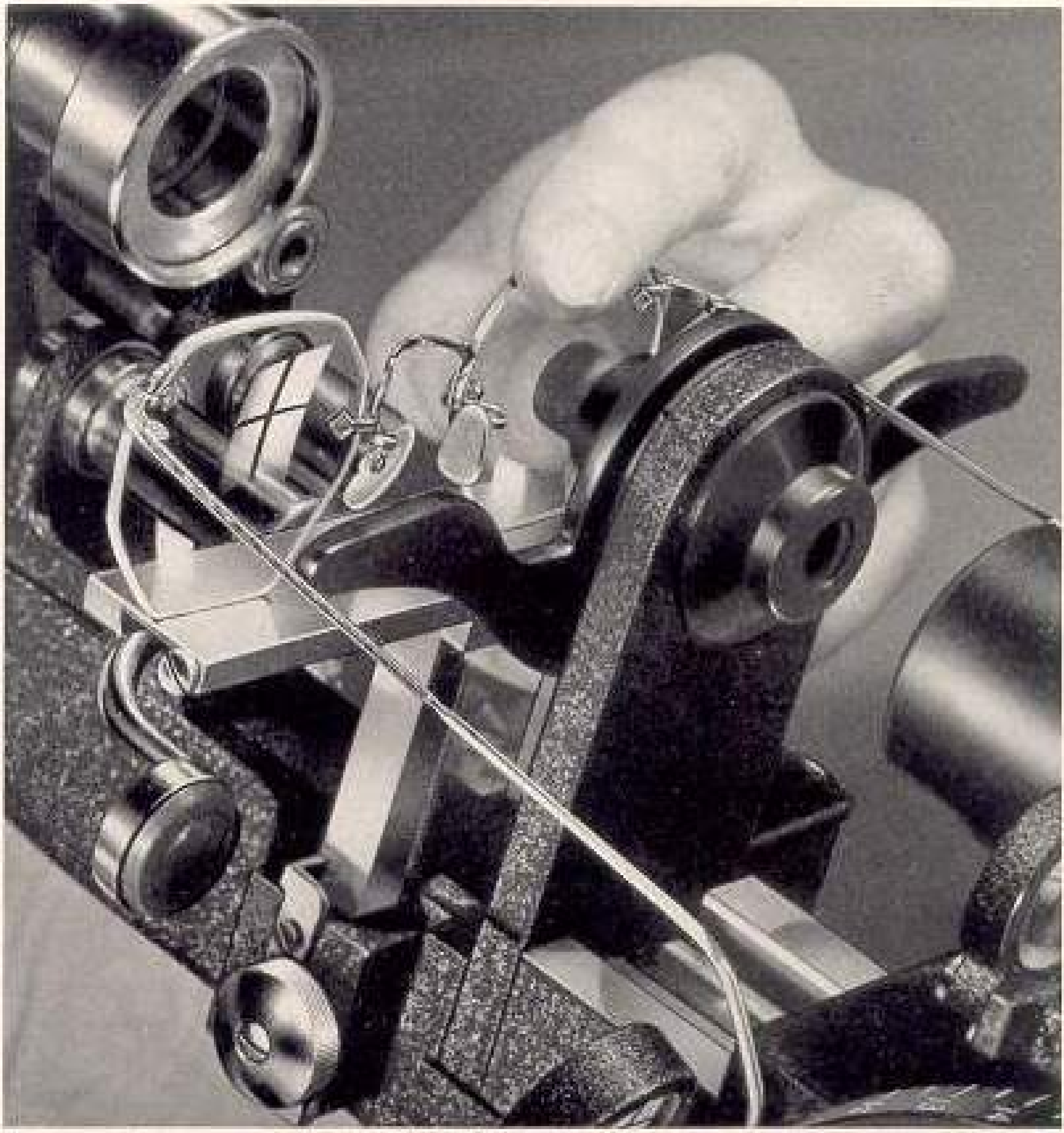


Fig. 16. Close up of aligning device

i. Bifocal Additions

To measure the addition of fused bifocals with the segment on the convex side, it is necessary that we reverse the usual procedure—that is, we must measure this addition from the convex, instead of from the concave, side. If we measured from the concave side, the segment would be away from the positioning tube by an amount equal to the thickness of the glass of the distance lens, at the segment. This thickness of glass moves the segment a small distance away from the positioning tube, a very small distance, but enough to give erroneous readings.

The procedure for reading bifocals with front segments is as follows:

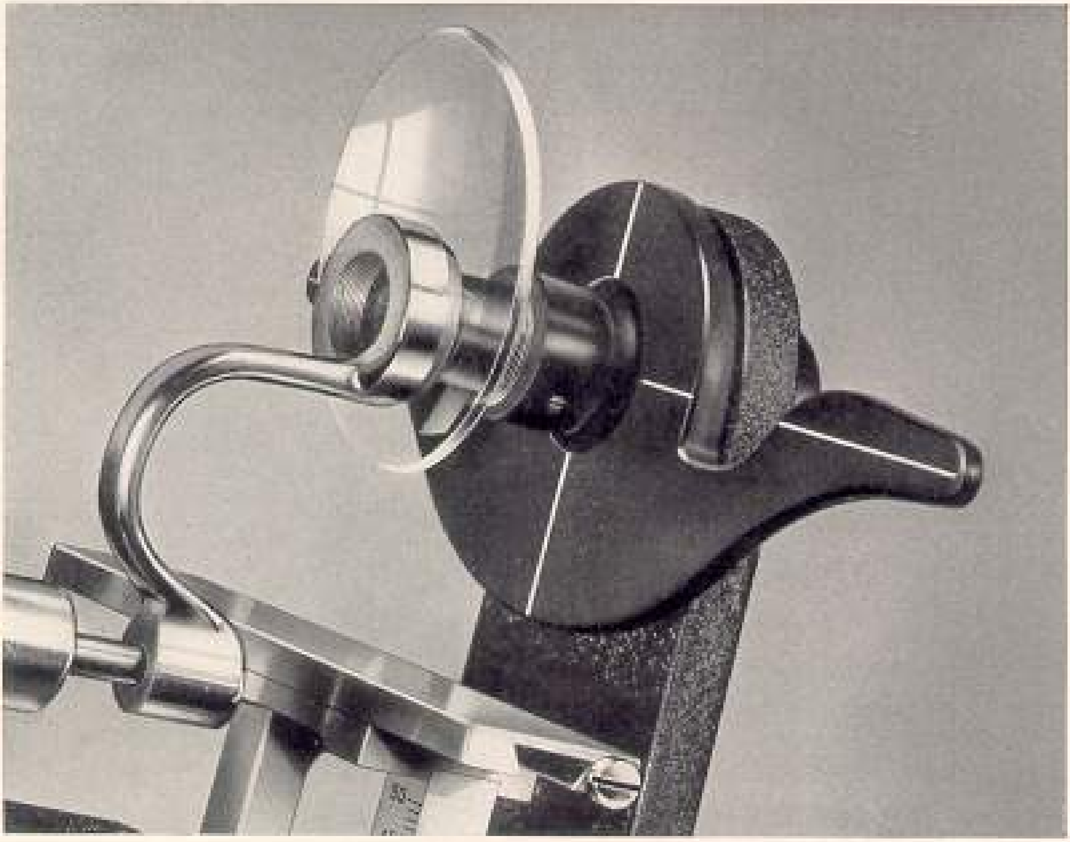
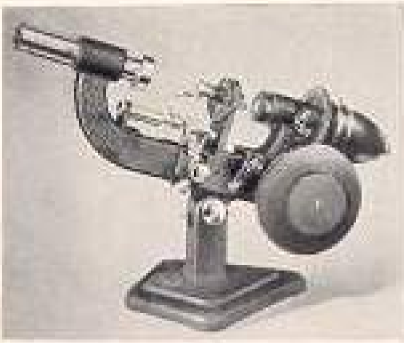


Fig. 17. Bifocal lens being tested

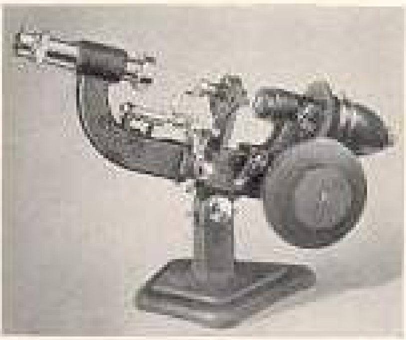
The distance power is to be measured in the usual manner with the concave surface of the lens against the lens positioning tube.

To get the "add", two measurements should be taken, both with the *convex* side of the lens against the tube. First, measure the power through the center of the lens. Next, move the reading segment so that a point, about 5mm below the dividing line of the lens, is on the lens positioning tube. The reason for this is that the average reading position of the individual is 5mm below the dividing line.

Then measure the power, inserting prisms in the prism holder of the Lensometer when necessary to bring the target to the center of the reticule. The difference between the two readings is the power of the addition. This method, however, is to be used only in obtaining the power of the addition.



M603
Lensometer, without prism measurer and without marking device . . . $180.00*



M603A
Lensometer, same as M603 but including prism measurer $200.00*

M603B
Lensometer, same as M603 but including both prism measurer and marking device $225.00*

M603X
Magnifying attachment for power wheel . . $7.00

M603Y
Magnifying attachment for axis wheel . . $6.00

*Price does not include either M603X or M603Y Magnifying attachments

Western prices slightly higher

Questions Answered

The purpose of this book is to acquaint the reader with the principles and the operation of the Lensometer. It should be read carefully. However, for those who desire the salient features of this instrument in condensed form we have prepared a series of questions and answers that may clear up some points.

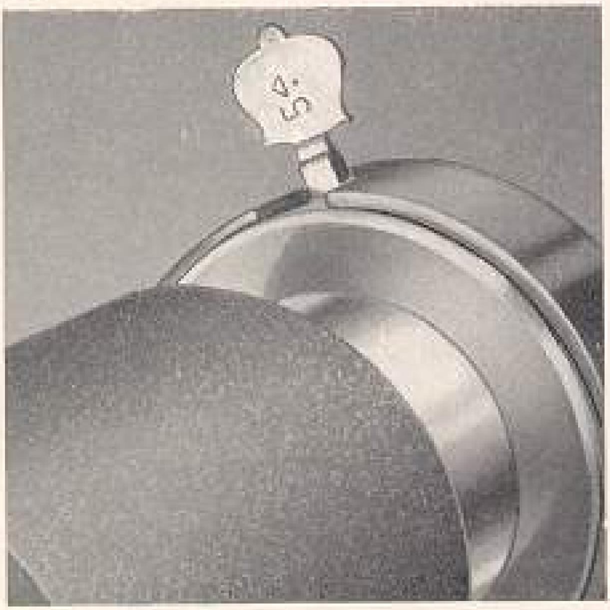


Fig. 18. Auxiliary prism holder

1. *How is information, that the Lensometer gives, of value?*
It shows the effective power (also called vertex refraction) of any lens quickly and accurately and illustrates the separation error of neutralization lens.

2. *What determines the effect of a lens on the eye?*
The distance behind or in front of the cornea at which the lens produces a focus.

3. *Does the distance from the cornea change the effect of a lens?*
Yes. Increasing the distance strengthens the power of a positive lens and weakens the effect of a negative lens.

4. *Why don't we measure the power from the cornea?*
People wear glasses at different distances from the cornea, so the same lens would be marked differently for various people.

5. *Will the Lensometer measure any form lens?*
Yes, all Ophthalmic lenses.

6. *Is the Lensometer difficult to operate?*

No. One of its chief features is its simplicity and ease of operation. A novice in the knowledge of optics would be able to verify Rx. lenses after being instructed in its use.

7. *Does the Lensometer require much attention?*

No. Its construction is such that cleanliness and ordinary care will preserve it indefinitely.

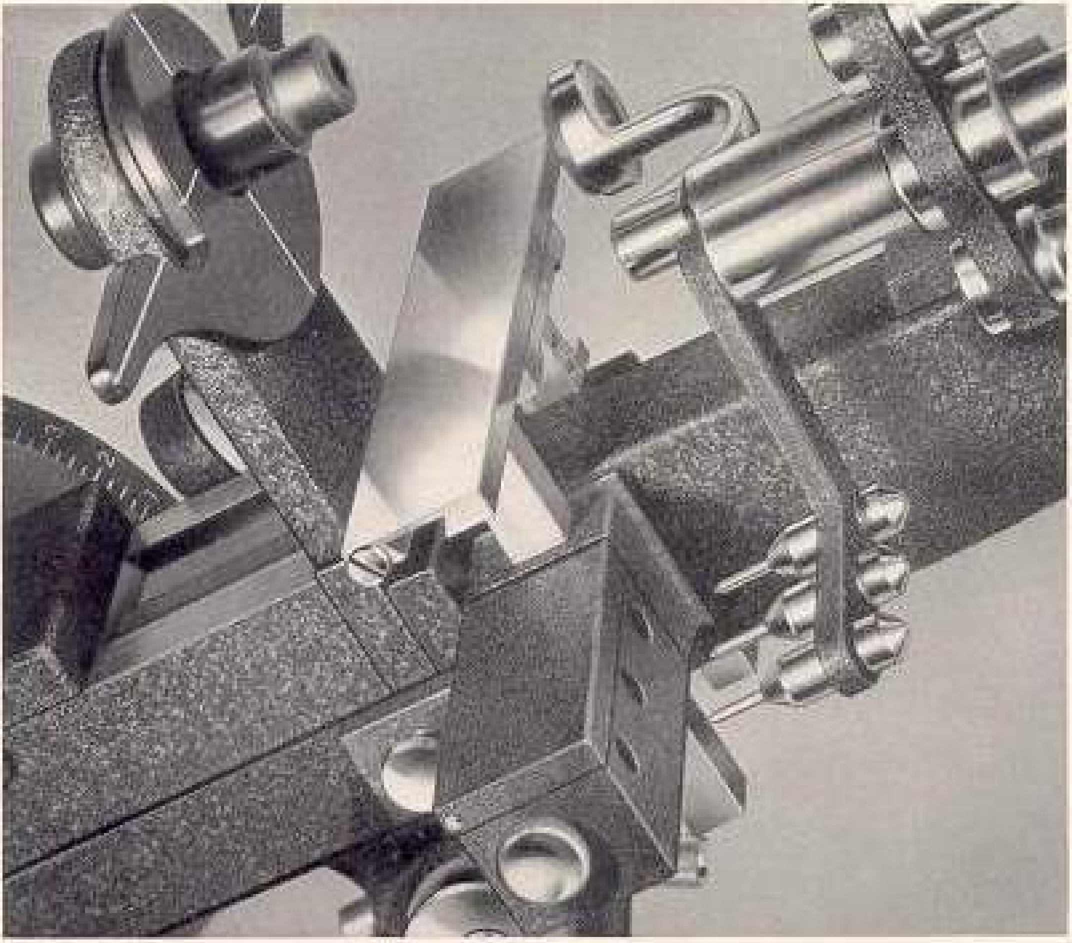


Fig. 19. Position of marking device when not in use

8. *Is its upkeep expensive?*

No. Only a bad accident or introduction of emery into moving parts could lead to the necessity of repair.

9. *What are the special advantages of the Lensometer?*

Measures lenses as worn.
Eliminates possibilities of error.
Saves time.
Saves labor.

Fig. 20. Marking the lens

10. *Why does the instrument weigh so much?*

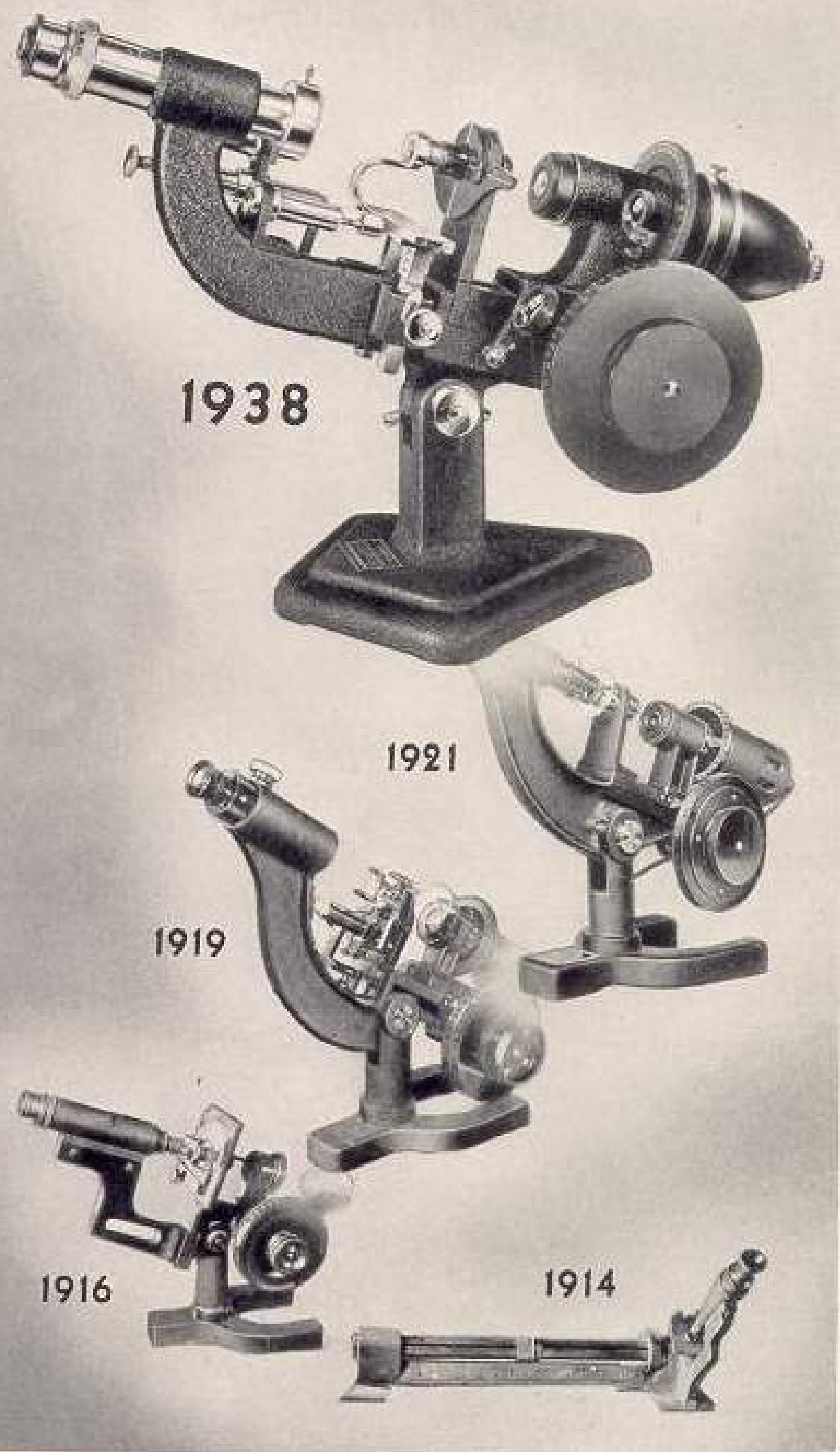
It is necessary in an instrument which will measure such minute displacements, to have the proper amount of metal in girder type construction, in order to insure permanence of adjustment. Solid substantial construction and weight make minute adjustments permanently accurate.

11. *Why is a double pinion gear used?*

The pinion gear must be accurate and remain so permanently, so the movable gear was devised. This is under continuous strong spring tension with reference to the keyed gear. It automatically adjusts for both rack and pinion wear.

12. *Why are the pinion shaft and bearings so large?*

Experience has proved that even with great care, an instrument used as frequently as the Lensometer will receive many accidental knocks. A small pinion shaft will bend and destroy the accuracy of the instrument.


1938
1921
1919
1916
1914

13. *What is the advantage of the adjustable inclination stand?*

The eye and body working under physical strain is conductive to carelessness and error.

The Lensometer can be adjusted to a comfortable and proper position which is an aid to efficiency.

14. *What advantage is the large lamp house?*

This instrument takes a standard intermediate base lamp, obtainable from any larger dealer in electric lamps.

15. *How is the effective power of lens being verified known to be the same as lens used in test lens frame?*

Test lens frame with lenses used in testing the eye may be inserted in Lensometer and measured in effective power to verify the test lenses.

Conclusion

The history of the Lensometer has been one of steady progress. It was designed and developed to meet the requirements of a profession that was exacting in its needs, precise in its findings.

In the preceding pages something of the background, utility, and mechanics of the Lensometer has been outlined briefly. American Optical Company believes that the years of research given to the Lensometer have been justified. It is proud of the part it has played in the pioneering and development of the instrument.

6. Read the axis of the cylinder from the axis wheel.

Measurement of Prisms.

1. Place the ocular side of the lens against the positioning tube.

2. Focus the target, and locate the central bright area (where the single bright line crosses the middle line of the three bright lines) with respect to the black circles of the reticule. This position indicates the prism power that is effective at the point of the lens located at the center of the positioning tube. Each black circle represents one prism diopter. The direction of the base-apex line of the prism is located by turning the straight black line of the reticule until it goes through the central bright area, and then reading the angle from the prism measuring device near the eyepiece.

3. If the prism power exceeds 5^{Δ} it is necessary to use an auxiliary prism lens in the holder at the end of the telescope in order to bring the target back into the field of view.

Measurement of Bifocal Adds.

1. Place the front surface of the lens against the positioning tube.

2. Measure the power through the center of the lens.

3. Move the segment area up on the positioning tube and measure the power again.

4. The bifocal addition is the difference between these two readings.

HOW TO USE A LENSOMETER

Preliminary Adjustment.

Set the power wheel at zero and look through the eyepiece at the target. Adjust the eyepiece, if necessary, until both the black circles and lines of the reticule and the bright lines of the target are sharp and clear.

Measurement of Spheres.

1. Place the ocular side of the lens against the positioning tube of the instrument. Let the lens rest on the lens alignment table and be held in place by the lens holder.

2. Rotate the power wheel until the bright lines and squares of the target become sharp and clear. To locate the optical center of the lens, move the lens until the center of the black reticule line coincides with the center of the middle light square.

3. Read the power of the lens from the power wheel. White numbers and lines indicate plus power, red numbers and lines indicate minus power.

Measurement of Sphero-Cylindrical Lenses.

1. Place the ocular side of the lens against the positioning tube.

2. Rotate the power wheel and the axis wheel until the single bright line of the target is straight, sharp and clear.

3. Read the power from the power wheel. (First Reading.) Take this as the power of the sphere.

4. Without changing the position of the axis wheel, rotate the power wheel until the three bright lines are sharp and clear; then read the power again. (Second Reading.)

5. The difference between the second and the first readings is the cylinder. It is plus if the second reading indicates more plus or less minus, that is, if the top of the wheel has been turned toward the operater for the second reading. The cylinder is minus, if the second reading indicates less plus or more minus, that is, if the top of the wheel has been turned away from the operator.