Aug. 31, 1937. E. L. ROBERTS 2,091,936

OPTOMETROSCOPE

Filed Jan. 15, 1936 2 Sheets-Sheet 1

Fig. 1.

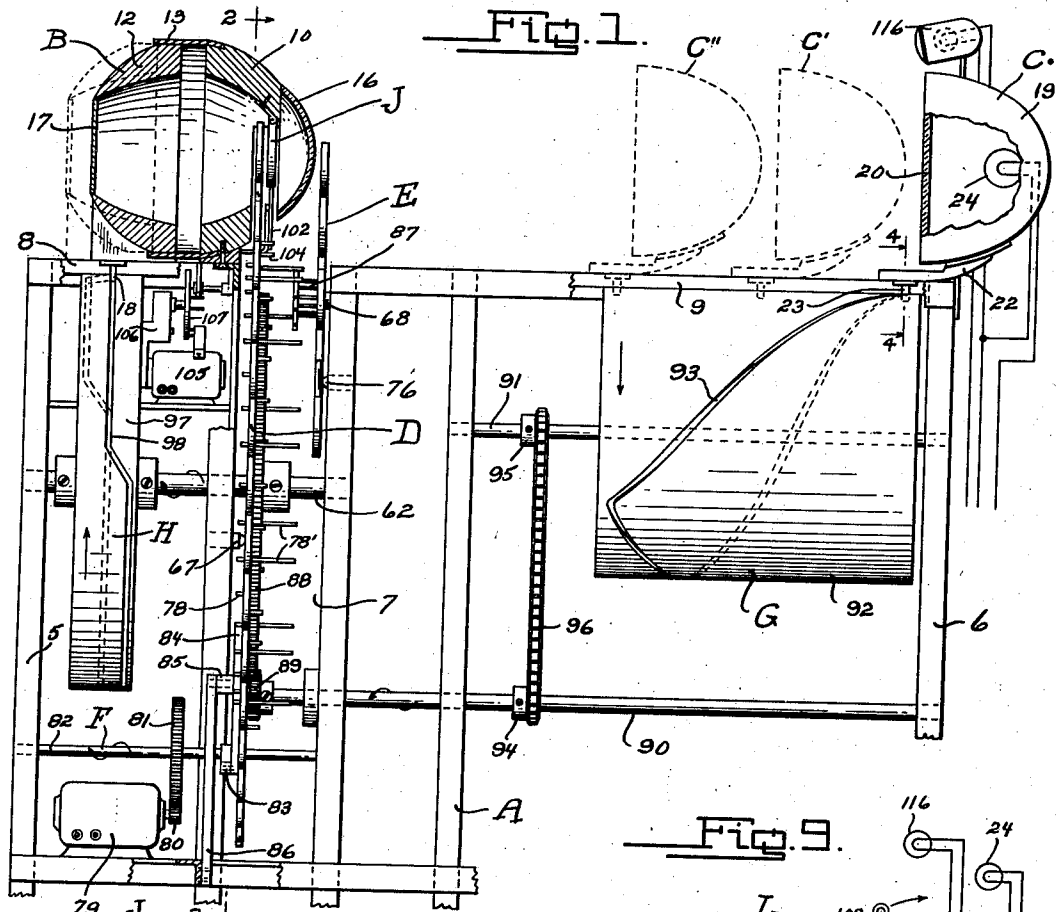


Fig. 9.

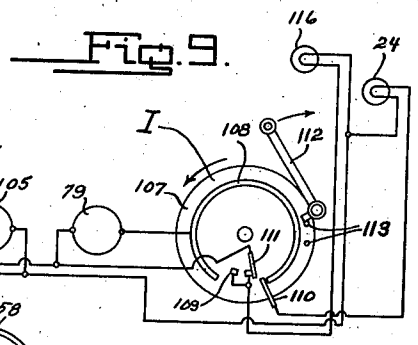
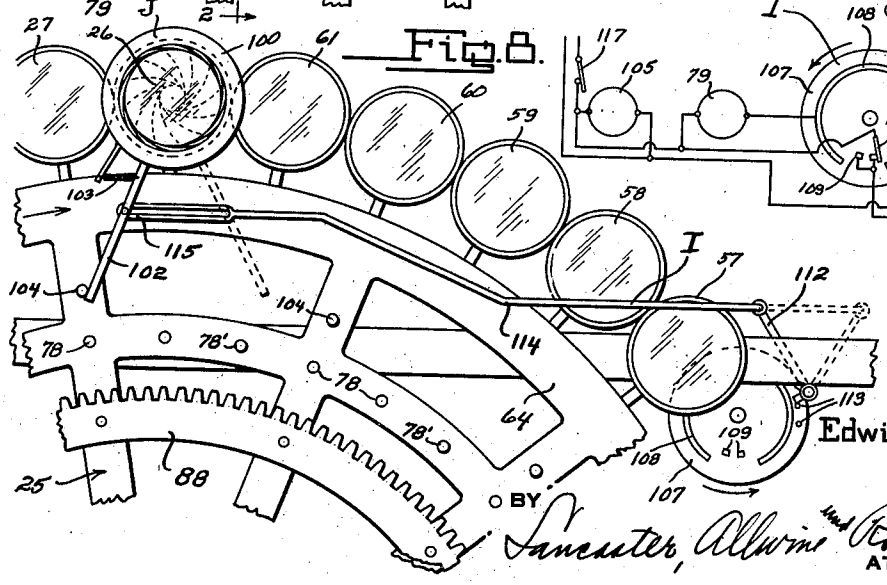


Fig. 8.



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Fig. 2.

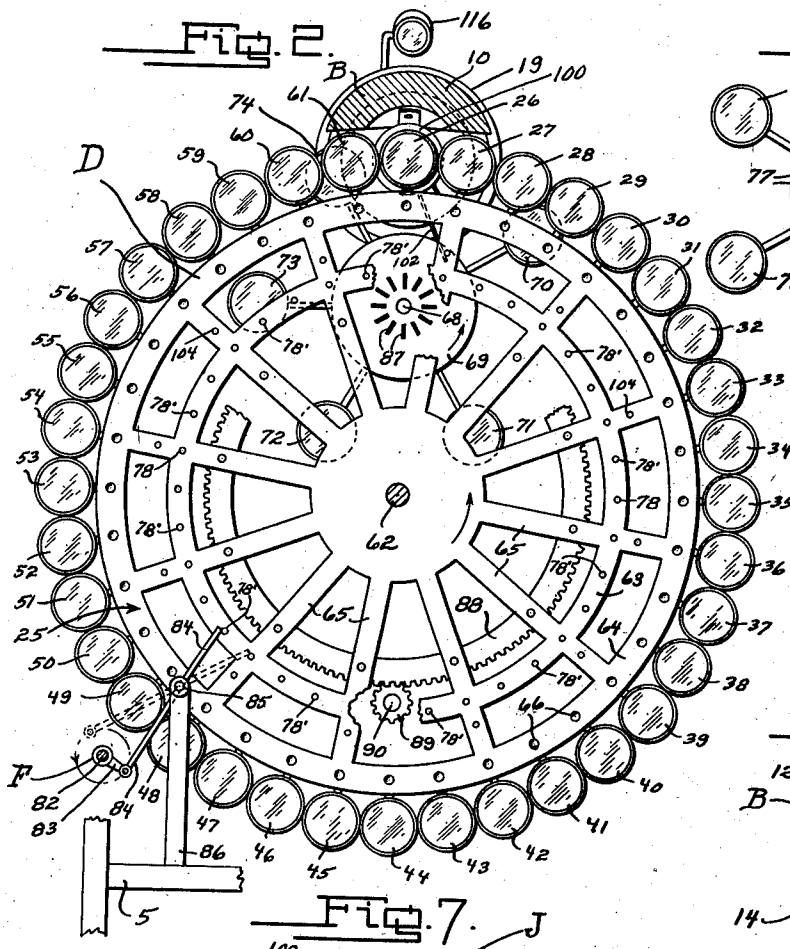


Fig. 5.

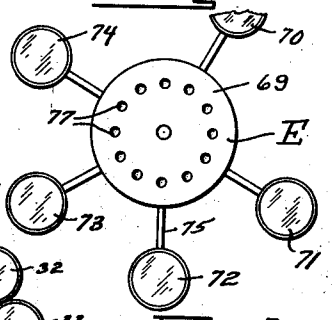


Fig. 4.

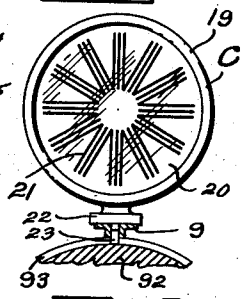


Fig. 3.

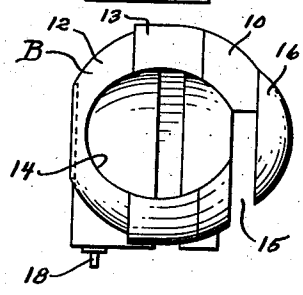


Fig. 7.

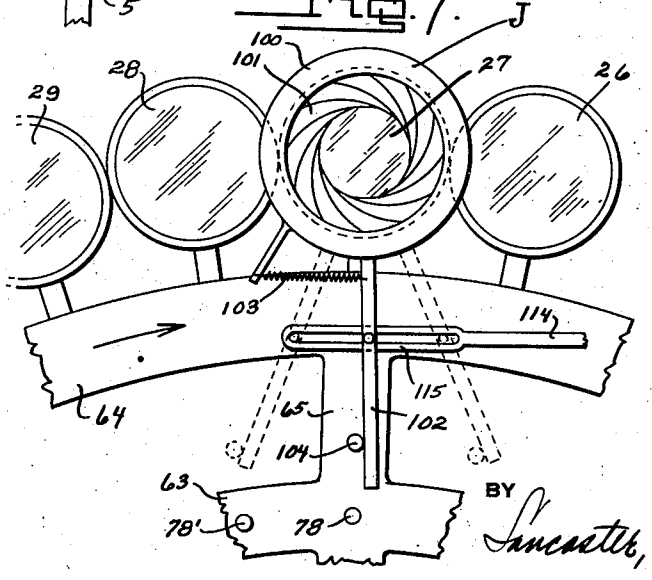
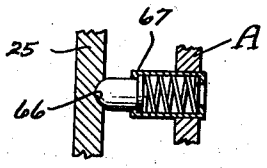


Fig. 6.



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Patented Aug. 31, 1937 2,091,936

UNITED STATES PATENT OFFICE

2,091,936

OPTOMETROSCOPE

Edwin Lee Roberts, Nashville, Tenn.

Application January 15, 1936, Serial No. 59,291

20 Claims. (Cl. 35—17)

The present invention relates to a machine or apparatus which may be termed an optometroscope, and the primary object of the invention is to provide a machine for use in teaching the science of optics to show how one sees clearly at different distances when the eye is emmetropic and how one sees clearly at different distances with the aid of lenses when the eye is not emmetropic or is ametropic.

A further object of the invention is to provide an apparatus for demonstrating by mechanical means, different conditions of the eye as respects accommodation and refractive powers.

A further object is to provide apparatus of this character for demonstrating the different focal conditions of eyes such as emmetropia, presbyopia, hyperopia, astigmatopia and myopia.

A further object resides in the construction of a machine of this character which will also demonstrate a normal pupil's contraction to light.

Other objects and advantages of the invention will be apparent from the following detailed description, taken in connection with the accompanying drawings and in which drawings:—

Figure 1 is a view part in side elevation and part in longitudinal section of the machine.

Figure 2 is a vertical fragmentary section on line 2—2 of Figure 1.

Figure 3 is a view in side elevation of the eye.

Figure 4 is a fragmentary section on the line 4—4 of Figure 1 and showing the object in elevation.

Figure 5 is a plan view of the auxiliary lens carrier.

Figure 6 is a fragmentary detail sectional view through one of the yieldable stops or keepers for holding the lens carriers in proper alignment in the eye.

Figure 7 is an enlarged fragmentary detail view showing the means for contracting the iris during the demonstrations.

Figure 8 is an enlarged fragmentary detail view showing the means for contracting the iris at the end of each cycle of operation of the machine to demonstrate the pupil's contraction to light.

Figure 9 is a wiring diagram of the electrical arrangement.

Referring to the drawings in detail and wherein like reference character designate corresponding parts throughout the several views, the machine or apparatus comprises a frame A upon which is mounted an eye B and an object C which is arranged for movement toward and from the eye in the axis of the eye. Associated with the eye B is a main lens carrier D and an auxiliary lens carrier E, the lens carrier D having movement imparted thereto with an intermittent motion by the drive means F. A cam means G is provided for imparting movement to the object C, while a cam means H acts to shorten and lengthen the eye on its anteroposterior axis. Mechanism I is provided for contracting the iris J which is in the form of an iris diaphragm, to demonstrate the pupil's contraction to light.

The frame A is preferably constructed from angle iron and embodies a front section 5 and a rear section 6 which are connected in spaced apart relation by their lower portions providing a vertical upwardly opening space 7. Provided at the top of the front section 5 is a trackway 8 which aligns longitudinally with a similar trackway 9 provided at the top of the rear section 6. These trackways 8 and 9 may be formed from two pieces of angle iron as shown in Figure 4 and provide guides for the eye B and object C respectively.

Referring now to the construction of the eye B, the same consists of a hollow, substantially hemispherical anterior, or fixed section 10, and a hollow, substantially hemispherical posterior or movable section 12 telescopically associated with the section 10 by a band 13 serving to close the space between the sections when the sections are moved apart. These sections 10 and 12 are preferably formed of aluminum, and an opening 14 is formed in one side of the eye as shown in Figure 3. The anterior section 10 is secured to the frame section 5 at the rear end of the trackway 8 and is provided with a transverse slot 15 which is disposed above the frame opening 7. Secured to the outer or front end of the eye section 10 is a clear, transparent window 16 of concavo-convex form and having a greater curvature than the section 10. This window 16 forms the cornea of the eye. Mounted in the outer end or rear of the eye section 12 is a screen 17 which may be of lightly frosted glass and upon which the image is made. This screen 17 forms the retina of the eye and permits the image to be seen from the rear of the eye as a transmitted one, and thru the opening 14 in the side of the eye as a reflected one. The posterior eye section 12 is arranged to be guided in the trackway 8 in its movement toward and from the anterior eye section 10 and is provided with an operating pin or lug 18 which projects downwardly through the trackway for engagement with the cam means H whereby the length of the eye may be varied on the anteroposterior axis of the eye. Thus the eye will have three lengths in the demonstrations; a normal length for use in demonstrating emmetropia, presbyopia and astigmatopia; a shortened eye for use in hyperopia (far sightedness); and a lengthened eye for use in myopia (near-sightedness). Figures 1 and 3 show the eye in its normal length and from which length it will be seen that the section 10 may be moved toward the section 12 for shortening the eye, and

also away from the section 12 as shown in dotted lines in Figure 1 for lengthening the eye.

The object C, which is arranged for guided movement toward and from the eye B on the trackway 9, may be in the form of an electric light embodying a reflector 19 having a plate glass lens 20 upon which words, lines, pictures or any desired indicia may be delineated as indicated at 21 in Figure 4. The reflector 19 has a supporting arm 22 which is provided with a pin or lug 23 which projects downwardly through the trackway 9 for engagement with the cam means G whereby the object may be moved forwardly and backwardly in the axis of the eye B. Figure 1 shows by full and dotted lines, the three positions of the object as moved by the cam means G. An electric lamp 24 is mounted in the rear of the reflector 19 so that the rays of light are directed toward the eye B which focuses the object indicia 21 on the screen or retina 17.

The main lens carrier D is rotatably mounted in the well or open space 7 of the frame A and embodies a flat carrier wheel or disc 25 upon the peripheral edge of which is mounted in contacting relation, an annular series of thirty six focusing lenses 26 to 61 inclusive. The carrier disc 25 is fixed upon a horizontal shaft 62 suitably journaled in the frame A whereby the lenses 26 to 61 will move through the slot 15 in the eye B so as to successively align axially with the eye. While the carrier disc 25 may be of various shapes, in the example shown, it is formed with inner and outer rims 63 and 64 respectively, and twelve radially arranged spokes 65 spaced equidistantly apart. Provided in one face of the outer rim 64, one for each of the thirty six focusing lenses, is an annular series of rounded depressions 66 into which a spring urged keeper 67 as shown in Figure 6 engages for holding the focusing lenses in axial alignment in the eye.

The auxiliary lens carrier E is also mounted in the well or open space 7 of the frame A as upon a stub shaft 68 carried by the rear frame section 6. This carrier E is freely rotatable upon the stub shaft 68 and embodies a carrier disc 69 upon which a series of five focus correcting lenses 70 to 74 inclusive are mounted as by radial arms 75. These lenses 70 to 74 are arranged to travel just in front of the window or cornea 16 of the eye and when axially aligning with the eye are releasably retained in position by means of a spring urged keeper 76 engaging in depressions 77 provided in the carrier disc 69. As will be noted in Figure 5, there are twelve of these depressions 77 spaced equal degrees apart. As will also be observed in Figure 5, the lenses 71 and 74 are spaced 90 degrees from the lens 70, while the lenses 71 to 74 are spaced 60 degrees apart. The auxiliary lens carrier E is adapted to be rotated with an intermittent movement for aligning the focus correcting lenses with the eye, by the main lens carrier D in a manner to be later described.

Provided in equally spaced apart relation about the inner rim 63 of the carrier disc 25 is a series of thirty six drive pins 78 which project for a short distance from the front face of the disc to be engaged by an operating member of the drive means F whereby the lens carrier D is moved 10 degrees each movement and thus successively aligns the focusing lenses 26 to 61 in the eye.

The drive means F for imparting intermittent movement to the lens carrier D preferably embodies an electric motor 79 having a pinion 80 meshing with a gear 81 fixed on a drive shaft 82 journaled in the lower portion of the frame A. Secured to the shaft 82 is a crank arm 83 to which is pivotally connected as at one end, a lever 84 having its intermediate portion slidable in a pivoted fulcrum block 85 journaled in a suitable support 86. The outer or free end of this lever 84 is arranged to engage the drive pins 78 and rotate the lens carrier D with an intermittent movement whereby the focusing lenses carried thereby will stop for short periods of time in the eye B. This manner of imparting movement to the carrier D by the lever 84 and pins 78 also causes the beginning and ending of each movement of the carrier D to be somewhat slower than during the intermediate portion of the movement.

Movement is imparted to the auxiliary lens carrier E at properly timed intervals by the main lens carrier D through the provision of twelve actuating pins 78′ arranged in equally spaced apart relation about the inner rim 63 of the carrier disc 25 and projecting from the rear face of the disc for engagement with twelve L shaped pins 87 projecting from the carrier disc 69. These actuating pins 78′ are preferably provided by extending certain of the drive pins 78 through the carrier disc 25, and for the purpose of clearness, the pins providing both drive and actuating pins have been designated as 78′ in Figure 2. The auxiliary lens carrier E is rotated 30 degrees each rotary movement of 10 degrees of the main lens carrier D.

Referring now to the means G for imparting movement to the object C, this means operates to shift the object to three positions along the trackway 9 such as has been illustrated by the full and dotted line showings in Figure 1 whereby the object is disposed at different distances from the eye B. This means G preferably comprises a ring gear 88 secured to the rear face of the carrier disc 25 and meshing with a pinion 89 fixed upon one end of a shaft 90. Fixed upon a shaft 91 directly beneath the trackway 9 is a cam drum 92 provided with an endless cam groove or slot 93 into which the pin 23 extends whereby movement is imparted to the object C. Secured to the shaft 90 is a sprocket wheel 94, while secured to the shaft 91 is a sprocket wheel 95, and a drive chain 96 is trained over these sprocket wheels for imparting rotation to the shaft 91 from the shaft 90. The sprocket wheels 94 and 95 are of the same size so that the speed of the shafts 90 and 91 will be equal. The speed ratio of the ring gear 88 to the pinion 89 will be twelve to one, whereby the shaft 90 will be rotated 120 degrees for each 10 degrees of rotation of the main lens carrier D by the drive means F. Since the sprocket wheels 94 and 95 are alike, the cam drum 92 will also be rotated 120 degrees for each 10 degrees' rotation of the lens carrier D.

The cam groove or slot 93 is of such shape or pitch that when the drum 92 is rotated in the direction of the arrow in Figure 1, the first 120 degrees of rotation will move the object C from its rear most position as shown in full lines to the intermediate position as at C′; the next 120 degrees of rotation will move the object from the intermediate position C′ to the fore most position C″; and at the next 120 degrees of rotation the object will move rearward for its full length of travel to its starting position. Since the main lens carrier moves 10 degrees each time the cam drum 92 moves 120 degrees, it will be seen that a

different focusing lens 26 to 61 aligns in the eye for each of the three positions of the object and that the cam drum makes twelve revolutions for each single revolution of the lens carrier D. Thus the object C assumes three positions twelve times during one complete rotation of the lens carrier D.

Referring now to the means H for shortening and lengthening the eye B, this means embodies a cam drum 97 fixed on the shaft 62 upon which the lens carrier D is mounted so as to have its peripheral surface movable directly beneath the trackway 8. Provided in the peripheral face of the cam drum 97 is an endless cam groove or slot 98 into which the pin 18 extends whereby upon rotation of the cam drum the posterior eye section 12 will be moved toward and from the fixed anterior eye section 10. Since the cam drum 97 is fixed on the shaft 62, this cam drum will be rotated for 10 degrees each movement with the lens carrier D.

Figure 1 shows the eye in its normal length and from which position the eye section 12 may be moved toward the eye section 10 for shortening the eye on its anteroposterior axis in demonstrating axial hyperopia, and also moved away from the eye section 10 for lengthening the eye on its anteroposterior axis in demonstrating axial myopia. The cam groove 98 is of such shape that from a starting position of the cam drum 97 as in Figure 1, for 80 degrees of rotation of the cam drum the eye is held at normal length; then through 10 degrees of rotation is shortened and held in this shortened length for 80 degrees of rotation of the cam drum; then through 10 degrees of rotation is returned to normal length and held in normal length for 110 degrees of rotation of the cam drum; then through 10 degrees of rotation is lengthened and held in this lengthened position for 50 degrees of rotation of the cam drum; and then through 10 degrees of rotation returned to the normal length starting position.

The iris J preferably consists of an iris diaphragm such as used upon photographic cameras and embodies an annular casing 100 mounted in the slot 15 of the eye between the focusing lenses and the cornea or window 16. Mounted within the casing 100 are the usual blades 101 controlled by the operating lever 102 which extends downwardly at the rear of the carrier disc 25. Swinging movement of the lever 102 serves to open and close the blades 101 of the iris, and a coil spring 103 normally swings the lever in one direction opening the iris to dilate the pupil.

The iris J is adapted to be adjusted to three sizes, corresponding to the three positions of the object C. That is, when the object is in its rear most position, the pupil is most widely dilated as in Figure 8; when in its intermediate position, the pupil is moderately contracted as in Figure 7; and when in its foremost position, the pupil is most contracted. The means for operating the iris to contract the pupil consists of a series of twelve pins 104 one projecting rearwardly from each spoke 65 of the carrier wheel 25 at a location between the rims 63 and 64 of the wheel. These pins 104 successively engage the lever 102 as shown in Figure 7 for operating the iris, and after the iris has been contracted, the end of the lever slips off of the pin and is returned by the spring 103 so that the iris is opened and the pupil dilated. This contracting and dilating of the pupil occurs for each three lenses 26 to 61 aligned in the eye, or twelve times during one complete cycle of the machine.

A mechanism I is also provided for demonstrating the pupil's contraction to light, and this demonstration occurs at the end of each cycle of operation. This mechanism I also serves to control operation of the electric motor 79 whereby the machine stops for a short interval while this demonstration is performed. Suitably mounted in the front frame section 5 is a small electric control motor 105 which, through suitable speed reduction gearing 106 rotates a contact wheel 107 on which is provided a long contact segment 108 and two short spaced apart contact segments 109. Arranged to coact with the long contact 108 is a contact arm 110, while arranged to coact with the short contacts 109 is a contact arm 111. When demonstrating the pupil's contraction to light, the iris J is operated twice, and a light is thrown on the eye each time the iris is contracted.

To operate the iris twice, a bell crank lever 112 as shown in Figures 8 and 9 is mounted adjacent the contact wheel 107, and two spaced apart pins 113 carried by the contact wheel act to rock the bell crank lever two times and exert two pulls upon a link 114 having a pin and slot connection 115 with the iris operating lever 102. As will be observed, the pin and slot connection 115 permits operation of the iris by the pins 104. Mounted in any preferred location so as to direct its light beam through the cornea or window 16 is an electric lamp 116 which lights each time the iris is operated for contracting the pupil.

Referring particularly to Figure 9, the contact wheel 107 is shown in a position where the circuit has just been broken to the drive motor 79 and the object lamp 24 by the long contact segment 108 moving out of engagement with the contact arm 110; the contact arm 111 is just being engaged by one of the short contact segments 109 for completing the circuit to the lamp 116; and one of the pins 113 is contacting the short arm of the bell crank lever 112 for operating the iris J to contract the pupil as the light 116 is thrown on the eye. Upon closing the control switch 117, it will be seen that the motor 105 will run constantly and through the contact wheel 107 will control circuits to the motor 79 and lamps 24 and 116. The contact wheel 107 will make slightly less than one revolution for each complete revolution of the lens carrier D since during the degree of rotation of the contact wheel, equal to the spacing between the ends of the long arcuate contact 108, the lens carrier D is at rest with focusing lens 26 in alignment in the eye.

As before stated, the machine, which may be termed an optometroscope, is designed for use in teaching to demonstrate how one sees clearly at different distances when the eye is emmetropic and how one sees clearly at different distances with the aid of lenses when the eye is ametropic. In the demonstrations, five different refractive conditions are shown. First emmetropia is demonstrated to show that an eye that is normal as respects accommodation and refraction, such as in a young person of say twenty-five years, sees clearly at all distances without the aid of glasses. Second, presbyopia is demonstrated to show that the same eye as shown in the first demonstration but which is now fifty years old, sees distant objects just as clearly as it did at the age of twenty-five, but must have glasses for near vision. It also show that not only is it necessary to have a glass for near vision, but that any glass for

distant vision causes a blurring. Third, hyperopia is demonstrated to show that such an eye needs a glass for both far and near vision, or needs a glass to wear at all times. It is also shown that nature can correct this defect, at least temporarily, but at the expense of great nerve energy. Fourth, astigmatopia is demonstrated to show that such an eye needs a glass to wear at all times. It is also shown that nature can do nothing whatever towards correcting the trouble. Fifth, myopia is demonstrated to show that nature can do nothing to correct this irregularity and that this eye must have a glass to be worn all the time.

The eye B has three lengths used in the demonstrations, a normal length being used in emmetropia, presbyopia and astigmatopia, a shortened eye in hyperopia, and a lengthened eye in myopia.

In using the machine, Figures 1 and 2 show the machine in a starting position with the object C in its primary or distant position, the lens **26** in position in the eye B, the eye in its normal length, and the iris J wide open dilating the pupil. The object lamp **24** is lighted making the image of the object **21** appear on the screen or retina **17**. The lever **84** then imparts a 10 degree rotary movement to the lens carrier D whereby the object C moves up to the intermediate position C'; lens **27** moves into the eye and takes the place of lens **26**, and the pupil is partially contracted as in Figure 7. While the lever **84** is moving to engage the next pin **78**, the lens carrier D, object C, and lens **27** will remain for a short period of time in this relation. With the next movement of the lever **84**, the lens **28** moves into the eye, the object moves up to the third or near position C'', and the pupil is most contracted. With the next movement of the lens carrier D by the lever **84**, the object C returns to its primary or distant position, lens **29** moves into the eye, and the pupil dilates to its primary size by the iris operating lever **102** slipping off of one of the pins **104**. Thus is completed the first demonstration of the twelve that will constitute one cycle of operation of the machine.

In demonstration one, the lenses **26**, **27** and **28** are all clear and a sharp image is made on the retina **17** for all three positions of the object because this demonstration shows a normal eye in a young person say of twenty-five years. Such a person still has the power of accommodation and can focus the eye to fit it for seeing distinctly objects at different distances from the eye.

In demonstration two, using lenses **29**, **30** and **31**, this shows a person say fifty years old with a normal eye. With lens **29** the image is clear because the object is in its primary or distant position indicating that the person is looking at a distance and the eye needs no accommodation. With lens **30** the image is not quite clear because the object has been moved up to the intermediate position which requires more accommodation than a normal eye at this age has. With lens **31** the image is less clear because the object is still closer and requires much accommodation such as the eye is unable to give.

In demonstration three, lenses **32**, **33** and **34**, and also auxiliary lens **70** are used. This represents the same eye as used in demonstration two in which the eye has lost its power of accommodation, that is, the power to focus for different distances. Science must then be called upon to help nature, and that is done by the auxiliary lens carrier E. All work done by the lenses **26** to **61** passing through the eye demonstrates nature's work, while that done by the lenses **70** to **74** passing in front of the eye demonstrates the work of science, or man's work. As lens **32** moves into the eye, lens **70** is moved into position in front of the eye thus blurring the image because this eye has normal vision and hence needs no correction for distance. As lens **33** moves into the eye and lens **70** remains in front of the eye, the object moves up to the intermediate position and the image is still somewhat blurred. Then, as lens **34** moves into the eye, with lens **70** still in front of the eye, the object moves up to the near position and the image is clear.

These two demonstrations two and three show that a normal eye of fifty years must have a lens before it for clear near vision but must not have a lens before it for distant vision. At the end of each of the twelve demonstrations, the object of course moves back to its primary or distant position and the pupil dilates.

The next or fourth demonstration shows a hyperopic eye, or one in which the eye is shorter than normal. So, at the end of demonstration three, lens **34** moves out of the eye and lens **35** moves into the eye, the auxiliary lens **70** is moved from in front of the eye and no auxiliary lens takes its place, the object moves back to its primary position, and the eye becomes shortened by the action of the cam drum H. The machine is now ready for demonstration four.

In demonstration four, lenses **35**, **36**, and **37** are used and show a hyperopic eye which is not aided by excessive accommodation and not aided by science, that is, by the use of an auxiliary lens. Hence, all three lenses **35**, **36** and **37**, for all positions of the object, show the image somewhat blurred.

In demonstration five, still showing a hyperopic eye, and using lenses **38**, **39** and **40**, here nature comes to the rescue and through excessive accommodation, thus gives clear vision for all three of the lenses **38**, **39** and **40**.

In demonstration six, still showing a hyperopic eye, and using lenses **41**, **42**, and **43**, here nature is relieved of the duty of aiding by excessive and nerve-racking accommodation and science comes to the rescue. As lens **41** moves into the eye, auxiliary lens **71** is placed in front of the eye and remains there while lenses **42** and **43** are in the eye so that the image is clear for all three positions of the object. As this demonstration ends and lens **44** moves into the eye, auxiliary lens **71** is removed from in front of the eye, and the object moves back to its primary position, the eye is lengthened by the action of the cam drum H and assumes its normal size or length to prepare for demonstration seven.

In demonstration seven, using lenses **44**, **45** and **46**, this shows an astigmatopic eye and as nature cannot correct this condition and science has not corrected, the image is blurred for all positions of the object. With the eye still at its normal length, as lens **47** moves into the eye, auxiliary lens **72** moves in front of the eye for the beginning of demonstration eight.

In demonstration eight, using lenses **47**, **48** and **49**, here science corrects the vision for distance and the eye's normal accommodation fits it for proper focus so that the image is clear for all positions of the object.

In demonstration nine, using lenses **50**, **51**, and **52**, another but different kind of astigmatopia from that of demonstrations seven and eight is

shown, and without the aid of science vision is blurred for all distances.

In demonstration ten, using lenses **53**, **54** and **55**, here science comes to the rescue and auxiliary lens **73** is placed in front of the eye for correcting distant vision and then nature uses normal accommodation and gives clear vision for all positions of the object. As lens **56** moves into the eye, the auxiliary lens **73** is moved from in front of the eye, and the eye is lengthened from its normal length by the action of the cam drum H to prepare for demonstration of a myopic eye.

In demonstration eleven, using lenses **56**, **57** and **58**, and showing a myopic eye, here nature cannot correct this condition and when the object is in its primary or distant position, the image is blurred. As the object moves up toward the eye, the image is a little clearer but is blurred for all proper distances from the eye. If the object is brought up very close, the image will be fairly clear and a much better way than so doing is to let science correct this condition of nearsightedness caused by elongation of the axis of the eye as shown in demonstration twelve.

In demonstration twelve, using lenses **59**, **60** and **61**, here auxiliary lens **74** is placed before the eye to correct distant vision and then by normal accommodation nature makes the object clear for all distances.

At the end of the twelve demonstrations, constituting one cycle of the machine, as the lens **61** is removed from the eye; lens **74** removed from in front of the eye; lens **26** moved into the eye; the eye returned to its normal length; and the object returned to its primary distant position, the long contact segment **108** disengages contact arm **110** thus breaking the electrical circuit to the drive motor **79** and the object lamp **24** to prepare the machine for demonstrating the pupil's contraction to light. During this demonstration, the light **116** is shown two times upon the eye by the contacting of the short segments **109** with the contact arm **111**, and each time the light is thrown on the eye, the iris J is operated by the bell crank lever **112** and contracts the pupil. After this demonstration, the long segment **108** again engages contact arm **110** and the machine is again prepared for demonstration one.

Thruout the description wherever the term eye has been used with reference to the structure B, the same should be read to mean a simulation of an eye.

From the foregoing it will be seen that a novel machine or apparatus has been disclosed for demonstrating by mechanical means, various conditions of the eye as respects accommodation and refractive powers.

Changes in detail may be made to the specific form of the invention as herein shown and described, without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. In a machine of the class described, a simulation of an eye having a retina, a plurality of lenses, and means associating the lenses with the eye for focusing images on the retina.

2. In a machine for demonstrating different focal conditions of the human eye as respects accommodation and refractive powers, a simulation of an eye having a retina, and a lens system associated with the eye for displaying images on the retina in accordance with whether the eye is emmetropic or is ametropic.

3. In a machine of the class described, a simulation of an eye having a retina, a series of connected lenses for successive alignment in the eye for focusing an image on the retina with some of the images in and some out of focus, and a second series of lenses associated with the first mentioned lenses for bringing certain of the images to a proper focus on the retina.

4. In a machine of the class described, a simulation of an eye having a retina, a series of focusing lenses movable through the eye, means for successively aligning the lenses in the eye, an object focused on the retina by said lenses, a series of correcting lenses movable in front of the eye, and means for aligning the correcting lenses with certain of the focusing lenses when the latter are in alignment in the eye.

5. In a machine of the class described, a simulation of an eye having a retina, a series of focusing lenses movable through the eye, means for successively aligning the lenses in the eye for displaying images on the retina, an object movable toward and from the eye in timed relation to movement of said lenses, timing mechanism for the object, and a series of correcting lenses movable in front of the eye in alignment with certain of the focusing lenses.

6. In a machine of the class described, a simulation of an eye having a retina, a series of focusing lenses for successive alignment in the eye, an object movable toward and from the eye in timed relation to movement of the lenses, timing mechanism for the object, an iris in the eye opened and closed in timed relation to movement of the object, timing mechanism for the iris, and a series of correcting lenses movable in front of the eye in alignment with certain of the focusing lenses.

7. In a machine of the class described, a simulation of an eye having a retina, a series of focusing lenses movable through the eye, means for moving the lenses with an intermittent movement for successively aligning the lenses in the eye, an object movable with a stop motion toward and from the eye, an iris in the eye, means for varying the iris pupil in accordance with the position of the object, a series of correcting lenses movable in front of the eye, and means for aligning the correcting lenses with certain of the focusing lenses.

8. In a machine of the class described, an adjustable simulation of an eye having a retina, a series of focusing lenses movable with an intermittent movement through the eye, an object movable with a stop motion toward and from the eye, an iris in the eye, means for operating the iris in accordance with the position of the object, a series of correcting lenses movable in front of the eye in alignment with certain of the focusing lenses, and means for varying the length of the eye on the anteroposterior axis of the eye.

9. In a machine of the class described, an adjustable simulation of an eye embodying relatively movable anterior and posterior sections, means for moving one of the sections toward and from the other section, a screen at the rear of the posterior section, a series of lenses movable with an intermittent movement through the anterior section, an object movable toward and from the eye on the axis thereof, an iris mounted in the anterior section, means for operating the iris, and a second series of lenses movable with an intermittent movement in front of the eye into alignment with certain lenses of said first mentioned series.

10. In a machine of the class described, a simulation of an eye having a retina, groups of lenses movable through the eye and successively aligned therein, an object movable toward and from the eye and spaced different distances from the eye for each lens of the groups, a series of lenses movable in front of the eye, and means for successively aligning the lenses of said series with the lenses of certain of said groups of lenses when the latter are aligned in the eye.

11. In a machine of the class described, a frame, a simulation of an eye mounted on the frame and adjustable on its anteroposterior axis, a main lens carrier rotatably mounted on the frame and provided with a series of annularly arranged lenses movable through the eye with an intermittent movement, an auxiliary lens carrier rotatably mounted on the frame and provided with a series of annularly arranged lenses movable in front of the eye when certain of the lenses on the main lens carrier are aligned in the eye, an object movable on the frame toward and from the eye, and means for moving the object toward and from the eye.

12. In a machine of the class described, a frame, a simulation of an eye embodying an anterior section fixed on the frame and a posterior section movable toward and from the anterior section, a rotary lens carrier having a series of annularly arranged lenses movable through the eye, means for imparting rotation to the lens carrier with an intermittent movement, a second rotary lens carrier having a series of lenses for aligning in front of the eye, means for imparting rotation to the second lens by the first mentioned lens carrier, an object movable toward and from the eye, means for imparting movement to the object with a stop motion, an iris, and means for contracting the iris in accordance with the position of the object.

13. In a machine of the class described, a frame, an adjustable simulation of an eye, a rotary main lens carrier having an annular series of lenses movable through the eye, drive means for imparting intermittent movement to the lens carrier for successively aligning the lenses in the eye, a rotary auxiliary lens carrier having lenses movable in front of the eye, means for rotating the auxiliary lens carrier in a timed relation to the main lens carrier, an object movable toward and from the eye, means for imparting movement to the object whereby the object is moved in steps toward the eye and from the eye in a single movement, an iris, and means on the main lens carrier for operating the iris.

14. In a machine of the class described, a frame, a simulation of an eye having a movable section and a fixed section having a slot, a rotary main lens carrier having an annular series of lenses movable through said slot, an annular series of drive pins on the carrier, drive means embodying an operative lever engageable with the pins for imparting intermittent rotary movement to the lens carrier, a rotary auxiliary lens carrier having a series of lenses movable in front of the eye, coacting pins on the lens carriers for imparting rotation to the auxiliary lens carrier from the main lens carrier, an object, operating means between the object and main lens carrier for moving the object toward and from the eye in timed relation to movement of the lens carriers, an iris having an operating arm, and pins on the main lens carrier for engaging the operating arm for contracting the iris.

15. In a machine of the class described, a frame, an adjustable simulation of an eye, a rotary main lens carrier having an annular series of lenses movable through the eye, drive means for intermittently imparting rotation to the carrier, a cam drum rotatable with the carrier for adjusting the eye, an auxiliary lens carrier movable by the main lens carrier and embodying lenses movable in front of the eye, an object movable toward and from the eye, a second cam drum for imparting movement to the object, and drive means between the main lens carrier and said second cam drum.

16. In a machine of the class described, a frame, a simulation of an eye embodying an adjustable section, a rotary lens carrier having an annular series of lenses movable through the eye, drive means for imparting intermittent rotary movement to the lens carrier, cam means movable with the lens carrier for imparting movement to said adjustable eye section, an auxiliary lens carrier movable by the first mentioned lens carrier and having lenses movable in front of the eye, an object movable toward and from the eye, cam means operatively connected to the first mentioned lens carrier for imparting movement to the object, an iris operated by said rotary lens carrier, means for controlling operation of said drive means, and a second means for operating said iris independently of the rotary lens carrier.

17. In a machine of the class described, an adjustable simulation of an eye having a retina, a series of focusing lenses movable with an intermittent movement through the eye, a series of correcting lenses movable in front of the eye and co-acting with certain of the focusing lenses, an object movable toward and from the eye in timed relation to said lenses, an iris contracted in timed relation to said lenses, a drive means, a control means for the drive means, and means operable by the control means for contracting the iris upon stopping of said drive means by the control means.

18. In a machine of the class described, an adjustable simulation of an eye, a lens carrier having a series of lenses movable through the eye, an object movable toward and from the eye, a second lens carrier having lenses movable in front of the eye, drive means for the lens carrier, an iris operated in timed relation to the lenses, a control means for the drive means, a lamp for directing a light beam on the eye, a second iris operating means, and means operable by the control means for stopping the drive means and twice operating the iris and lighting said lamp at the end of each cycle of operation of said lens carriers.

19. In a machine of the class described, a simulation of an eye having a screen, an object movable toward and from the eye, a lens system embodying movable lenses for focusing the object on the screen, an iris contracted in accordance with the position of the object, drive means for the lens system, a control means for the drive means, and means operable by the control means for contracting the iris after each cycle of operation of the lens system.

20. In a machine for demonstrating different refractive conditions of the eye, an eye member formed to resemble the human organ of sight and adjustable on its anteroposterior axis, an object movable toward and from the eye, and lenses movably associated with the eye for focusing the object on the retina.

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