May 15, 1923. 1,454,950

J. M. BOYLE

OPTICAL SYSTEM

Filed Oct. 15, 1918 9 Sheets-Sheet 1

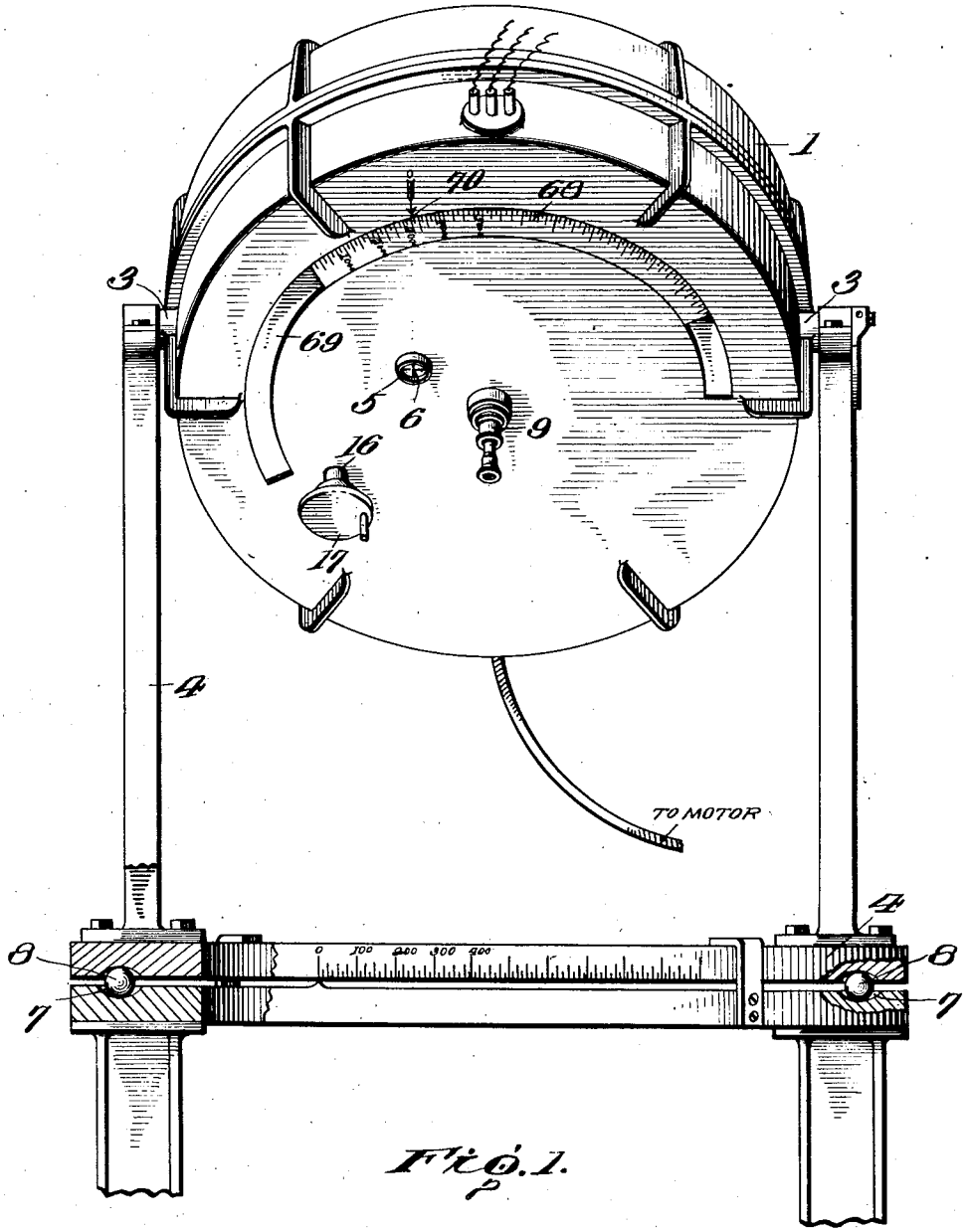


Fig. 1.

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James M. Boyle.

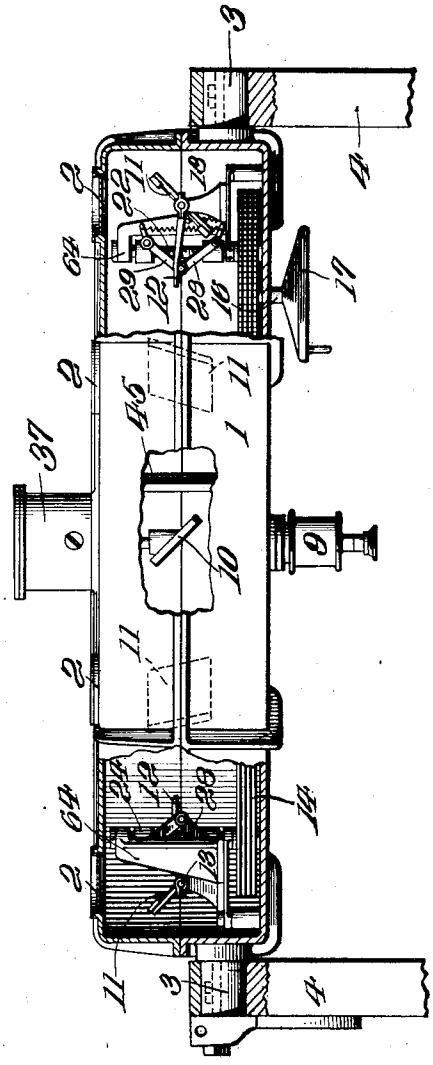
May 15, 1923. **1,454,950**

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Filed Oct. 15, 1918 9 Sheets-Sheet 2

Fig. 2.



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Filed Oct. 15, 1918 9 Sheets-Sheet 3

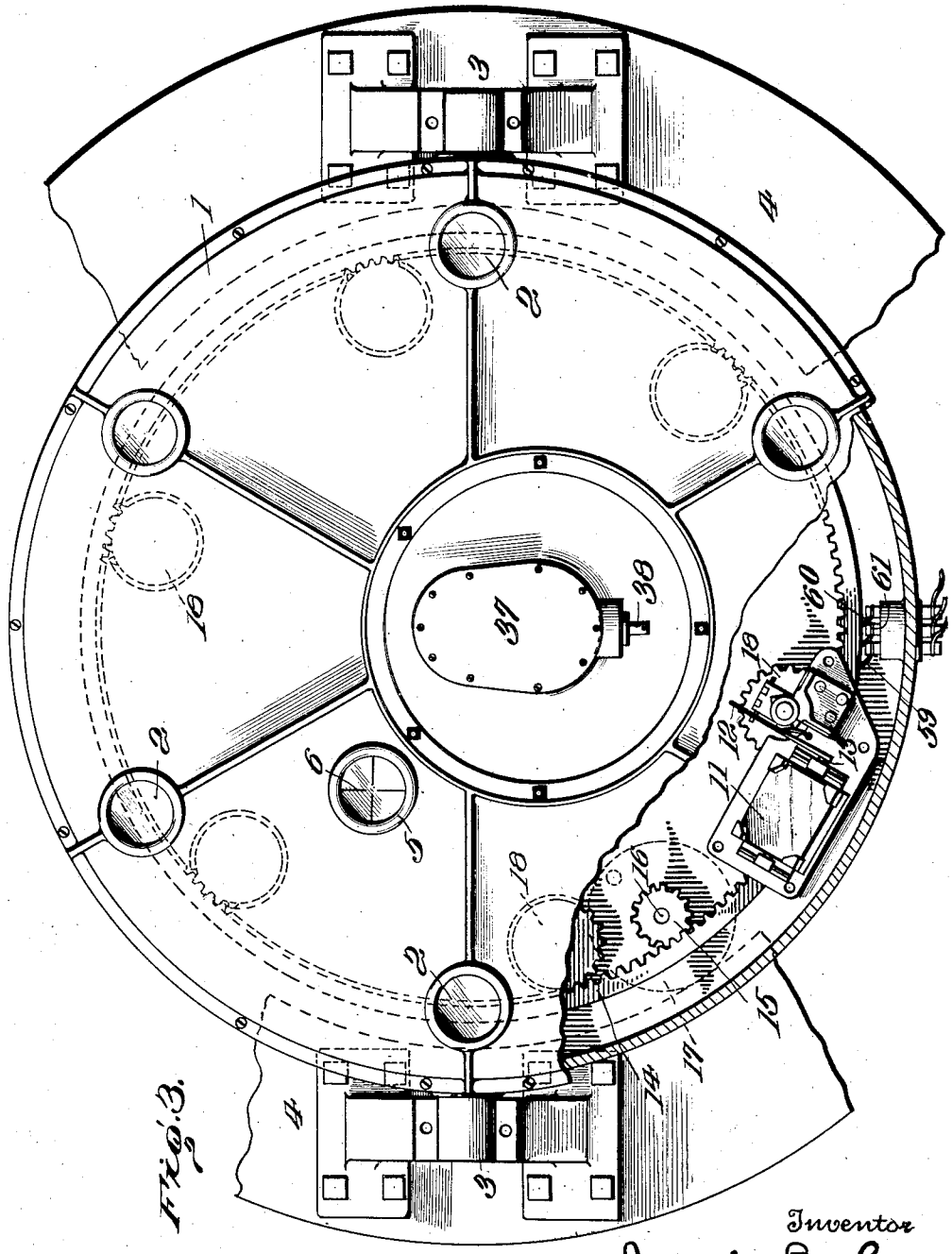


Fig. 3.

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Filed Oct. 15, 1918 9 Sheets-Sheet 4

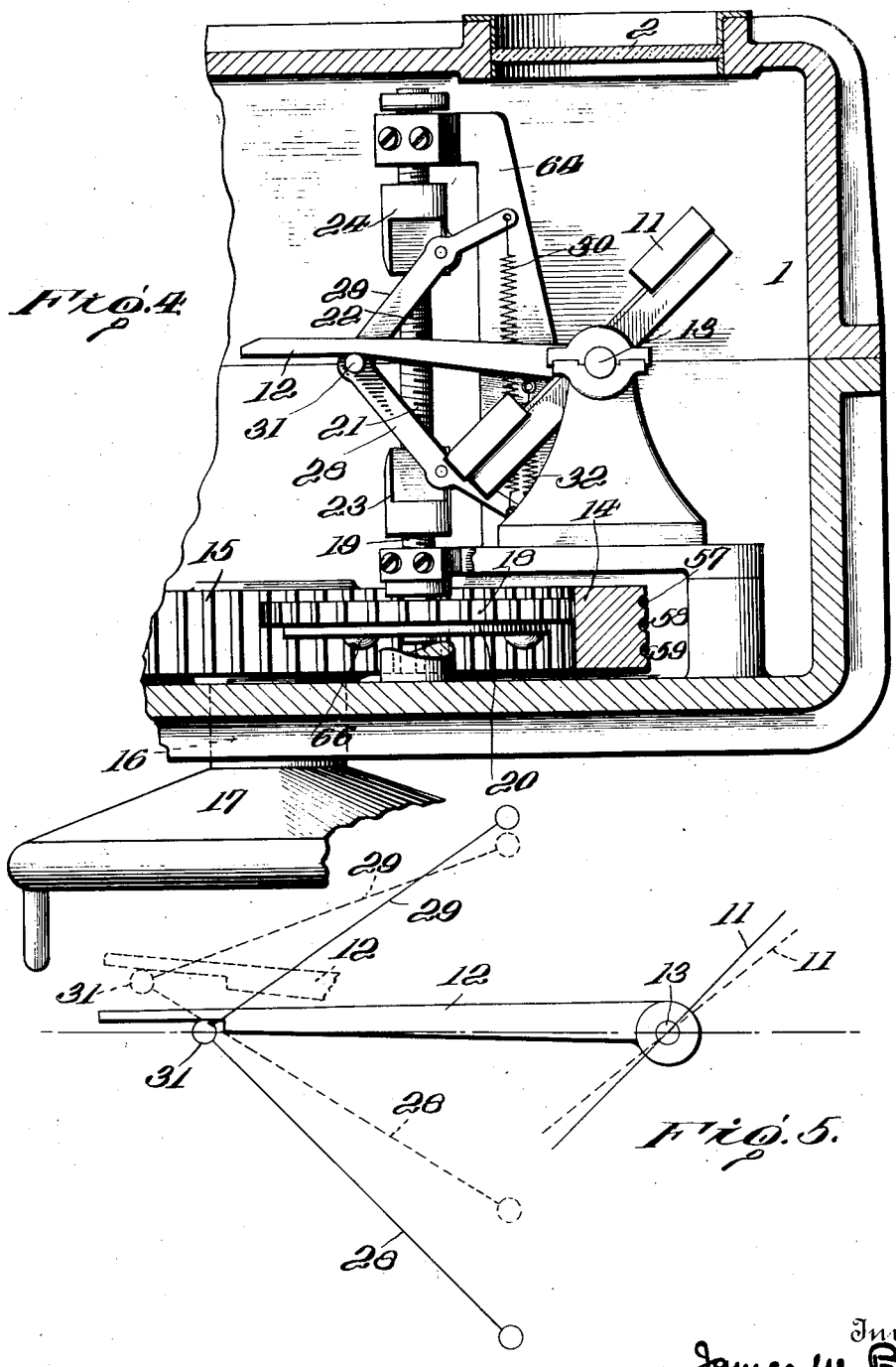


Fig. 4.

Fig. 5.

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May 15, 1923. 1,454,950

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Filed Oct. 15, 1918. 9 Sheets-Sheet 5

Fig. 6.

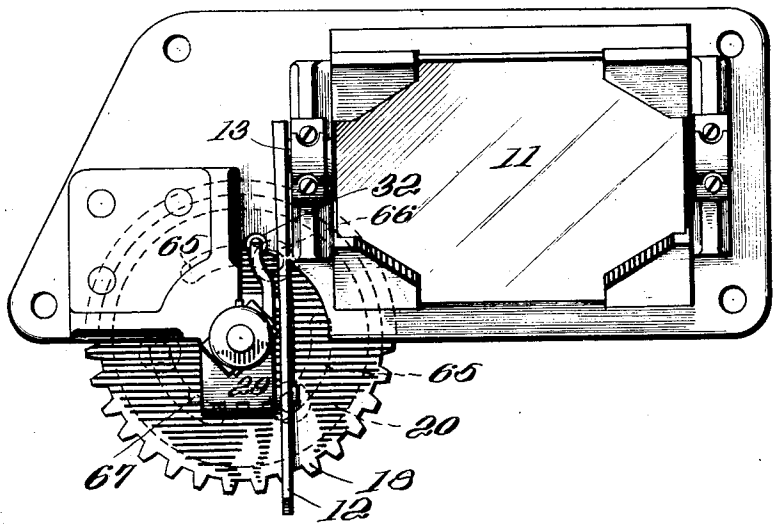
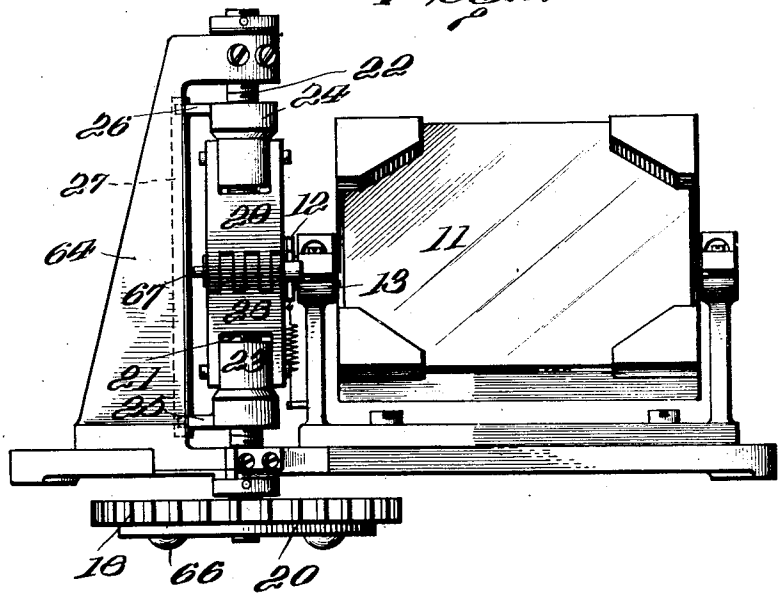


Fig. 7.



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May 15, 1923. 1,454,950

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Filed Oct. 15, 1918 9 Sheets-Sheet 6

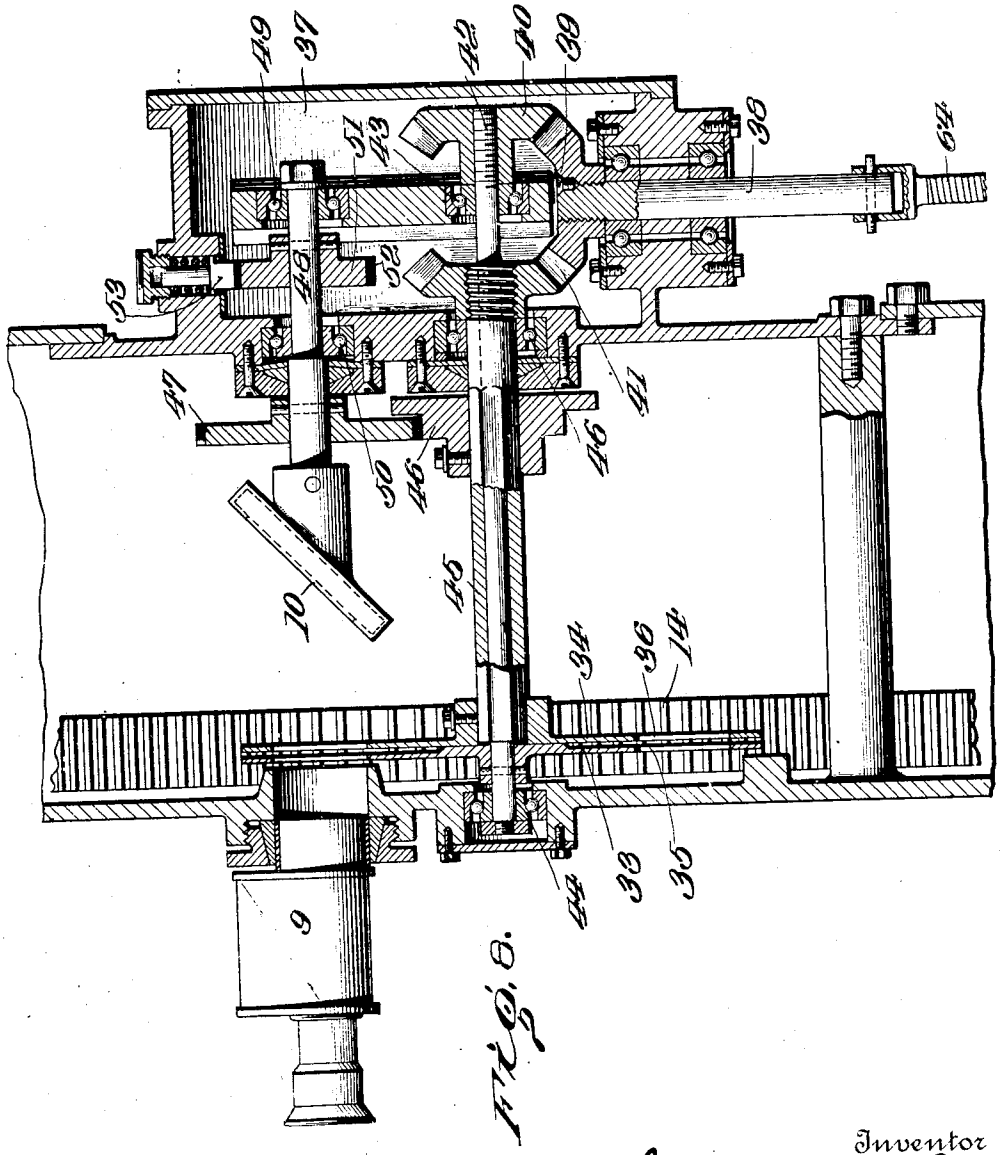


FIG. 6.

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May 15, 1923. 1,454,950

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OPTICAL SYSTEM

Filed Oct. 15, 1918 9 Sheets-Sheet 7

Fig. 9.

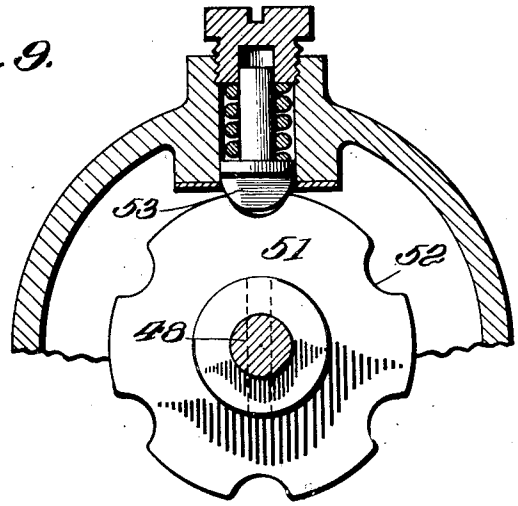
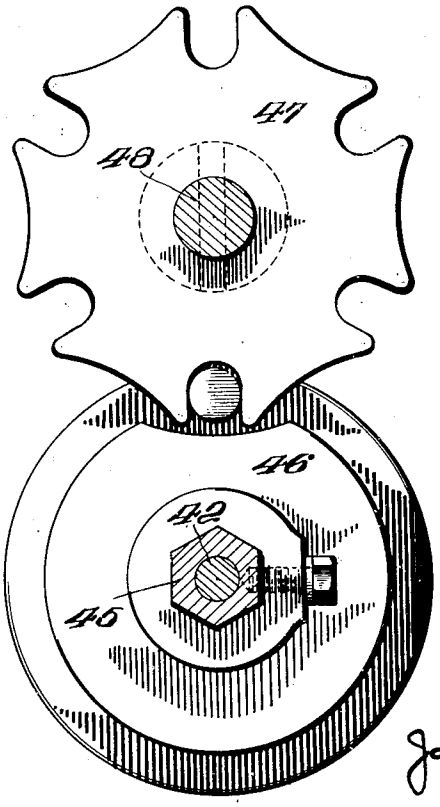


Fig. 10.



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May 15, 1923. 1,454,950

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Filed Oct. 15, 1918 9 Sheets-Sheet 8

FIG. 11.

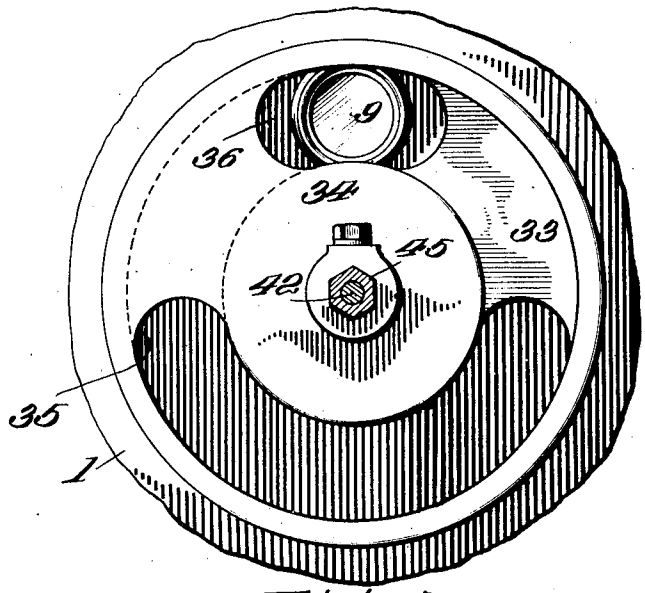
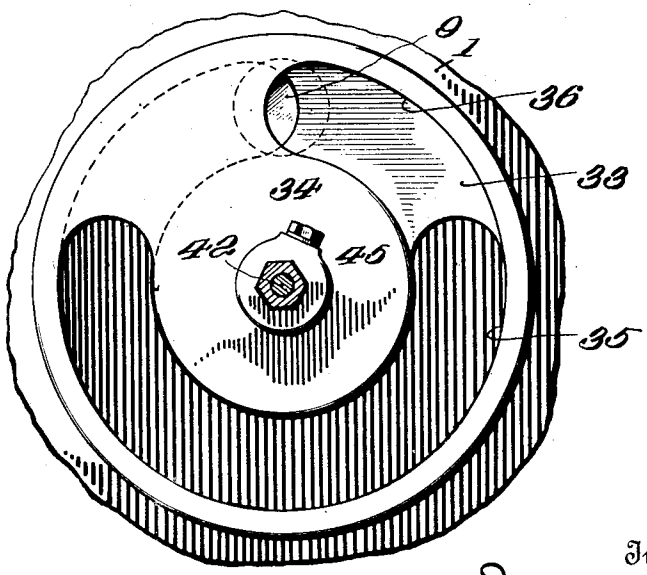


FIG. 12.



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May 15, 1923. 1,454,950

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Filed Oct. 15, 1918 9 Sheets-Sheet 9

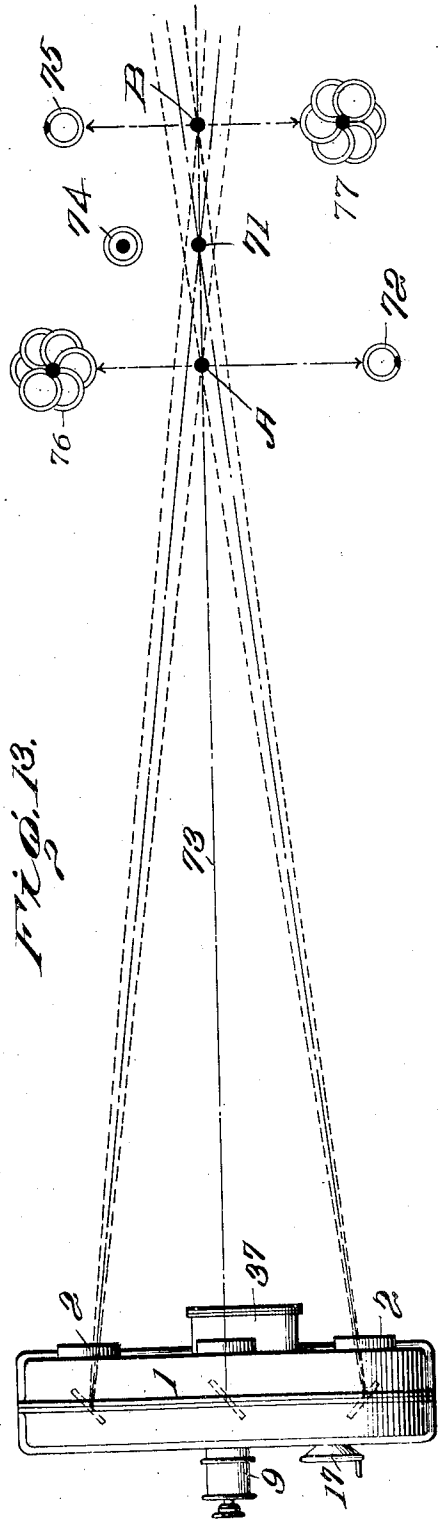


Fig. 13.

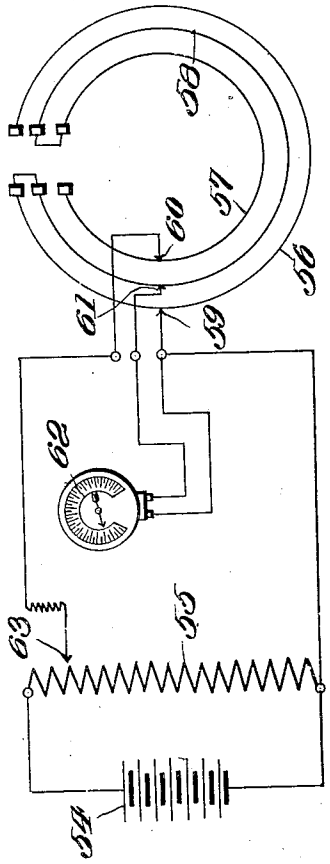


Fig. 14.

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Patented May 15, 1923. 1,454,950

UNITED STATES PATENT OFFICE.

JAMES M. BOYLE, OF THE UNITED STATES ARMY.

OPTICAL SYSTEM.

Application filed October 15, 1918. Serial No. 258,241.

(FILED UNDER THE ACT OF MARCH 3, 1883, 22 STAT. L., 625.)

To all whom it may concern:

Be it known that I, JAMES M. BOYLE, Major, Ordnance Dept., U. S. A., a citizen of the United States, resident of New York city, New York, and stationed at Washington, D. C., have invented an Improvement in Optical Systems, of which the following is a specification.

The invention described herein may be used by the Government, or any of its officers or employees in prosecution of work for the Government, or by any other person in the United States, without payment of any royalty thereon.

The present invention relates to an improvement in optical systems and more particularly to a system in which successive images of an object may be made visible in such a manner as to appear either in stereoscopic or in spherical stereoscopic relief. While it is contemplated that an optical system of this character may be readily adapted to various uses, the particular embodiment hereinafter described is intended to be used more especially in connection with determining the range of a moving target.

It has been found that range finders of the well known short base type are impracticable in anti-aircraft fire due to the rapid change of position of the target and the difficulty of retaining it in the field in such a manner that accurate readings of range can be taken. Similarly, various systems of fire control based upon other methods of range finding have also proven inadequate when measured in terms of direct hits in proportion to the number of shots fired.

One object of the present invention, as applied to the particular problem of anti-aircraft fire control, is to provide a range finding device which may be readily oriented and adjusted to conform to changes in the direction and range of rapidly moving targets.

A further object of the invention is to provide a range finding device in which the proper adjustment for reading of the true range may be indicated by the stereoscopic clearness of the image of said target instead of by coincidence or super-position only of one image over another, as in the case of range finders now in common use.

For the purpose of attaining the first of the objects above set forth, the optical system hereinafter described is preferably mounted to be rotatable about its own central vertical axis as well as tiltable on an axis normal thereto. This permits tilting of the device for adjustment to elevation as well as movement of rotation for adjustment to azimuth.

To produce an image of a target in stereoscopic distinctness, my improved optical system contemplates the use of a plurality of reflector or light ray transmitting systems arranged to cooperate optically with a single reflector centrally arranged with respect thereto, spherical stereoscopic relief being produced ordinarily by the use of more than two systems co-operating with a single reflector. When applied to range finding, the optical system may include a suitable telescope arranged in collimation with the centrally disposed reflector. By rapidly and intermittently rotating this reflector, a series of images of an object or target in the field is transmitted in rapid succession to the telescope. Where the interval between images is made small enough, it is contemplated that persistence of vision and persistence of memory will facilitate an illusion of stereoscopic effect as soon as the extensions of the optical axis of the several reflector systems have been made to intersect by means of suitable adjusting mechanism in a plane cutting the target or an image of the target and normal to the extension of the central axis of the optical system, said plane being hereinafter referred to as the target plane.

When used as a range finder, the present optical system is supplemented by a calibrated scale adapted to co-operate with the circumferential light ray transmitting or reflector systems in such a manner as to indicate, in any desired unit of linear measurement, the distance to the target which corresponds in each case to the angular relation between extensions of the optical axes of the circumferential light ray transmitting or reflector systems.

The same information as to range may conveniently be disclosed at a point distant from the range finding instrument itself by

a suitable electrical device adapted to produce variations in resistance corresponding to increments of movement of the calibrated range scale, said variations in resistance being in turn translated into terms of linear measurement by reference to a suitably calibrated scale.

One embodiment of my invention as applied to a range finder for use in anti-aircraft fire control is illustrated in the drawings accompanying the present application, in which—

Figure 1 is a general view showing the bottom of the instrument and the range scale in perspective and as assembled upon a mount, parts of which are in vertical section.

Figure 2, an elevation with portions in vertical section and portions broken away illustrating details of the mechanism for tilting the reflectors.

Figure 3 is a top plan view with a portion broken away to disclose part of the distance indicating and reflector tilting mechanism.

Figure 4 is a detail of the reflector tilting mechanism and a portion of the mechanism for translating the increment of deflection into terms of linear measurement.

Figure 5 illustrates diagrammatically the operation of means for multiplying the increment of deflection of the reflectors to such a degree that by properly calibrated scales, the movement may form the basis for measurements in linear units.

Figures 6 and 7 are details showing a type of reflector and mechanism associated therewith.

Figure 8 is a view partly in vertical section of the mechanism for intermittently rotating a central reflector and means for continuously rotating a shutter.

Figures 9 and 10 show details of the intermittent reflector movement.

Figures 11 and 12 show details of the shutter.

Figure 13, indicates diagrammatically the anticipated appearance of the field when the target is between the range finder and the point of intersection of extensions of the optical axes of the reflecting mirror systems, when the target is at said points and when it is beyond said point, and

Figure 14 is a diagrammatic representation of electrically operated means for providing readings at a distance from the observation point.

Referring to Figures 1 and 2, the optical system or range finding device may comprise a housing 1, provided with a plurality of apertures or windows 2 preferably arranged equi-distant from a common center and uniformly spaced from each other. A pair of axial trunnions 3, projecting from opposite sides of housing 1 support said housing in a suitable frame 4, in such a manner that the housing may be tilted about its horizontal axis. Another opening 5 may be provided at a convenient place and equipped with cross hairs 6 and otherwise adapted to serve as a finder.

In Figure 1, the housing is shown mounted in such a manner that the supporting frame 4 may be freely rotated, preferably on roller bearings. This movement, together with the tilting permits practically universal adjustment of the optical system, as to direction, within the normal requirements of a device of the character under consideration. The mounting may comprise a suitable track 7 adapted to receive ball bearings 8 or other suitable rolling contact members interposed between said track and the frame and supporting the latter.

A suitable telescope 9 is attached to the housing 1 in such a manner that its optical axis is normally parallel to and arranged to intercept lines of rays reflected through suitable light-ray transmitting or reflector systems including a reflector 10, Figure 2, which is mounted and operated in housing 1 in a manner hereinafter to be described. Figure 2 discloses reflectors 11, also included in the reflector systems, pivotally mounted adjacent to the windows 2, in such a manner that images of objects or targets appearing in the field may be transmitted in succession from said reflectors to the centrally located reflector 10. Any suitable optical or mechanical optical arrangement or light-ray transmitting system may be employed for bending the pencils of light extending from the object or target through the reflector systems to the eye of the observer, which bending may be translated into terms of distance to the image by the motion controlling mechanisms of the bending devices employed. In the present case, the pencils of light are bent by synchronously tilting the reflectors 11, said tilting means being more clearly shown in Figures 3, 4, 5, 6 and 7. In each case, the reflector 11 is deflected by a lever arm 12 attached to a lug 13, co-axial with and fixed to the reflector, and means for operating said lever arm from the exterior of housing 1, as shown in Figure 2. For this purpose, a relatively large gear or scale gear 14 mounted co-axially with the optical axis of the telescope 9, and with the common center of the circumferentially placed reflectors 11 and is arranged to mesh with a gear 15 mounted on a shaft 16, Figure 3, said shaft extending through the wall of the housing and carrying a hand wheel 17 conveniently positioned outside the housing.

At suitable intervals corresponding to the circumferential intervals between the reflectors 11, gears 18 mesh with the scale gear 14 and each drives a shaft 19 on which it is loosely mounted, movement of said shaft be-

ing imparted through a plate 20 fixed thereto and normally fastened to said gear by means of adjustment slots 65 positioned to engage screw studs 66 threaded in the gear 18. This arrangement of parts is intended to facilitate the adjustment of the reflectors 11 to positions effecting accurate intersection of extensions of their optical axes. The shaft 19 may be journaled in a suitable bracket 64' conveniently mounted in the housing 1 and is provided with oppositely threaded portions 21 and 22 of different gauge, cooperating respectively with nuts 23 and 24 which may conveniently be retained against motion of rotation without affecting their freedom of longitudinal movement by projecting members 25 and 26 engaging a slot or guide 27 of the bracket 64, Figure 7. A pair of cooperating toggle arms 28 and 29 are pivoted respectively to the nuts 23 and 24 at one end, the opposite ends being connected by means of a hinge pin 67 having an extension 31. A spring tension member 30 may be interposed between the separated opposite ends of the toggle arms 28 and 29 in such a manner as to normally tend to draw said ends toward each other.

As shown in Figures 3, 4, 5, 6, and 7, the extension 31 of hinge pin 67 at the junction of the arms 28 and 29, yieldingly engages one face of lever arm 12 and is adapted to deflect the free end of said arm against tension of a spring 32. When shaft 19 is rotated, the nuts 23 and 24 are moved longitudinally thereon, one of said nuts being displaced to a greater extent than the other on account of their different thread gauges. The nut which moves the greater distance will carry its toggle arm through a correspondingly larger displacement than that of the other arm. However, both are pivotally mounted and are hinged together so that the arm of less movement will swing on its pivot and yield to the arm of greater movement, thus swinging the hinge joint and the hinge pin extensions 31 out of normal zero position. This movement of hinge pin extension 31 effects an equivalent deflection of the lever arm 12.

As illustrated diagrammatically in Figure 5, the position of the parts indicates that toggle arm 28 has moved a greater distance than toggle arm 29, and has therefore carried the hinge pin extension 31 to the dotted line position, thus also deflecting the lever arm 12, which in turn tilts the reflector 11 about its pivot 13.

Figure 8 illustrates, in detail, suitable mechanism for intermittently rotating the centrally positioned mirror 10 in such a manner that its reflecting surface may be directed to intercept rays or images reflected from the mirrors 11 in succession and to transmit the same into the telescope 9 through the opening of a suitable shutter. Such a shutter may conveniently comprise discs 33 and 34 having openings 35 and 36 respectively arranged to register for open position adjacent to the objective of telescope 9 during a portion of the rotation of the discs 33 and 34 which turn in opposite directions.

Power may be supplied to operate the shutter and intermittent mirror moving mechanism by any suitable means, here shown as a driving shaft 38, journaled in an extension 37 of the housing 1 and provided with a bevelled gear 39 which meshes with two other bevelled gears 40 and 41 respectively. Bevelled gear 40 is mounted at one end of a solid shaft 42 journaled at 43 and 44, preferably on roller bearings, and passing through a hollow shaft 45. This solid shaft 42 carries at one end the shutter disc 33 having the slotted portion 35 arranged to pass opposite the objective end of telescope 9. Bevelled gear 41 is attached to one end of the hollow shaft 45, which is journaled at 46, preferably on roller bearings in the housing 1 and the shaft partially encloses and is free to rotate around solid shaft 42 in the opposite direction. Disc 34 is attached to one end of said hollow shaft 45 adjacent to disc 33 and has the slotted opening 36 cooperating with the slotted opening 35 in disc 33 to permit intermittently the passage of light rays reflected from mirror 10 to the telescope 9.

For intermittently rotating mirror 10, the hollow shaft 45 may carry a driver 46 operatively mounted with respect to a driven gear 47, Figure 10, which in turn is fixed to a shaft 48 journaled at 49 and 50 and having at one end the mirror 10 secured thereto in any suitable manner, said driver and driven member being adapted to constitute an intermittent movement timed and adjusted to permit images to be reflected into the objective of the telescope when the shutter is in open position and to move the reflecting surface of the central mirror from collimation with one mirror 11 to the next mirror 11 during the ray-intercepting period of the shutter movement. Suitable means for insuring positive stop and reducing backlash in the intermittent movement may be provided. For this purpose, a collar 51 is fixed to shaft 48, said collar having at intervals on its periphery a series of recessed portions 52 arranged to engage a yielding detent 53, Figure 8, coincident with the period of rest of the mirror 10, or during each of its image reflecting periods.

Suitable means are provided for facilitating the reading of range directly from the range finding instrument, and may include a range scale 68, preferably calibrated in meters, Figure 1, and inscribed on a surface of the scale gear 14, said scale being positioned to be visible through an aperture 69

in the housing 1, and movable with respect to an index or zero point 70 inscribed on the housing at an appropriate place with respect to the scale 68 and the aperture 69. Or the scale may be inscribed on a fixed portion of the device and a suitable index member may be attached to the large gear and adapted to cooperate with said fixed scale to indicate readings in any desired unit of measure.

Where it is desired to present readings of range at a point distant from the instrument, and simultaneously with operation thereof, suitable means may be provided for translating the increment of movement of the scale gear 14 into terms of resistance variation in an electrical circuit, which in turn may be indicated directly on a scale adapted to give readings in any desired unit of measurement. One embodiment of such a system is diagrammatically shown in Figure 14, wherein a suitable electrical current may be supplied from any convenient source, such as a battery 54. A potentiometer resistance 55 may be interposed in the circuit of which a portion is carried on the large gear 14 and includes the conductors 56 and 57 between which is interposed another resistance member 58. Suitable contacts 59 and 60, Figure 3, may be provided adjacent to said conductors and a contact 61 adjacent said resistance member whereby the varying degrees of resistance afforded by the resistance member 58 for the different effective lengths thereof interposed in the circuit due to turning of the large gear 14 by the operator, may be indicated on a suitable dial 62, which is preferably calibrated to read in terms of yards or meters. If the parts are properly adjusted, this reading will be identical and simultaneous with the reading on the scale 68 forming part of the gear 14. For the purpose of re-establishing a true zero on dial 62 in case of variation from the instrument reading due to variation in the amount of electromotive force in the circuit, suitable means is provided for changing the position of contact of a terminal 63 of the derived circuit along the potentiometer resistance 55.

In operation, the intermittently rotatable reflector or mirror 10 and the continuously rotatable shutter discs may be actuated by the mechanism heretofore described for the purpose. To drive said mechanism, the shaft 38 may conveniently be rotated by a flexible shaft 64′ driven by suitable motive power, such as that of a motor or by hand if necessary. The observer may then direct the apertures or windows 2 in the general direction of the target which is readily located by means of the finder 5. The observer then places his eye at the eye-piece of the telescope and sees an image or images of the object reflected from the intermittently rotating mirror 10. The image or images may be perceived in more or less stereoscopic distinctness depending on the proximity to actual intersection in the target plane of the extensions of the optical axes of the several reflecting systems, an image of the distant object or target being actually reflected to the eye of the observer separately and successively by each of the radially disposed mirrors 11 through the functioning of the intermittently moving central mirror 10 and the compound shutter, but apparently producing a constantly visible image or field due to the observer's persistence of vision and memory.

Referring to Figure 13, it is assumed that extensions of the optical axes of the reflector systems converge at 71. If the target under these conditions is at A, it is contemplated that the image transmitted through the uppermost window 2 to the eye of an observer who is looking through the telescope will be relatively positioned as indicated in a diagrammatic field 72, or toward the bottom of said field the combined images being illustrated at 76.

If the target is in the vertical plane, normal to the axis 73 and containing the point of convergence 71 of the extensions of the optical axes of the reflector systems, then the position of the images transmitted through all of the windows will be as shown in the diagrammatic field 74.

If the target is beyond the point 71, or at B, the image transmitted through the upper window 2 will be relatively positioned as indicated in the diagrammatic field 75, or toward the top of the field.

In the first case, or position A, the field as seen through the bottom window will disclose the target image toward the top and the images, as seen through the remaining windows, will be similarly off center, thus producing, during rapid rotation of the central reflector, an illusion in which the outside edges of the field will appear to rotate about the target. When however, the target is in the plane in which the optical axes of the several reflecting systems intersect, the image will always appear in the same position in the field and the fields themselves will necessarily appear to be superposed. Then the target will appear in stereoscopic relief and there will be no appearance of rotation of the field edges.

By operating the hand wheel 17, and thereby the large gear 14, the operator may control the direction of the extensions of the optical axes of the several reflecting systems until they do actually converge in the plane of the object, or target plane whereupon the image will appear in stereoscopic or spherical stereoscopic relief, depending on the number and relative positions of the reflecting mirrors 11. At this point, the reading for range may be taken either from the scale

68 forming a part of the instrument itself, or from the scale 62 operated through an electrical circuit in the manner heretofore described.

It is contemplated that the intermittently rotating mirror 10 may operate at a high rate of speed and that it shall be so adjusted that an image may be reflected therefrom into the telescope simultaneously with the period of rest of said mirror in which position the slots of the discs 33 and 34 are in open position. The succeeding movement of rotation causes the discs to act as a shutter and at the same time causes the mirror 10 to rotate to image reflecting position with respect to the next succeeding mirror 11 of the series.

As above set forth, the mechanism provided for tilting the mirrors is adapted to move them simultaneously and uniformly by means of the large gear 14 which meshes with each of the individual drive gears 18 of the several mirrors 11. It is contemplated that this angular movement of the mirrors shall be, as nearly as possible, free from lost motion and capable of registering very minute changes in position all of which will be simultaneous and uniform. The degree of tilting of the mirrors is an angular displacement from which the range may readily be computed in accordance with well known mathematical principles, and the degree of tilting is proportionate to the amount of rotation of the large gear 14, this relation being expressed in terms of linear measurement indicated by means of the range scale.

It is contemplated that the optical system hereinabove described is capable of adaptation to various uses not necessarily associated with range finding. Furthermore, it is contemplated that various parts hereinabove described may be replaced by functional equivalents without departing from the domain of the invention. For example, any suitable device may be employed to translate angular displacement of the reflectors into terms of linear measurement disclosed on a scale; various forms of intermittent movements and shutters may be employed in place of the ones shown and described, and other obvious substitutions and equivalents will readily occur to one skilled in the art to which the present invention relates.

I claim as my invention:

1. In an optical system, the combination of a reflector, means adapted to transmit thereto a succession of images of an object arranged to produce the effect of a single image in stereoscopic relief, and means co-operating with said image transmitting means to indicate the distance of the object when its image appears in stereoscopic relief.

2. A range finder having means for presenting a composite image of a series of successive images of a target and means co-operating with said image presenting means to indicate the distance of the target.

3. In an optical system, a plurality of light ray transmitting members adjustable as to their angles of inclination, a reflector co-operating therewith and means for rotating said reflector about an axis angularly disposed with respect to the plane of its reflecting surface.

4. In an optical system, a plurality of light ray transmitting members adjustable as to their angles of inclination, a reflector co-operating therewith and means for rotating said reflector intermittently about an axis angularly disposed with respect to the plane of its reflecting surface.

5. In an optical system, a plurality of light ray transmitting members, a rotatable reflector co-operating therewith and adapted to rotate intermittently about an axis angularly disposed with respect to the plane of its reflecting surface, and a shutter interposed in the path of light rays reflected from said rotatable reflector.

6. In an optical system, a plurality of light ray transmitting members arranged at both sides of a common axis and a rotatable reflector having its axis of rotation co-incident with the common axis of the plurality of light ray transmitting members and passing through its own effective reflecting surface.

7. In an optical system, a plurality of light ray transmitting members arranged at both sides of a common axis and an intermittently rotatable reflector having its axis of rotation co-incident with the common axis of the plurality of light ray transmitting members and passing through its own effective reflecting surface.

8. In an optical system, a plurality of light ray transmitting members and a single reflector co-operating therewith and adapted to rotate about an axis passing through its reflecting surface and extending in the same direction as the axis of the pencil or beam reflected thereby.

9. In an optical system, a plurality of light ray transmitting members and a single reflector co-operating therewith and adapted to rotate about an axis angularly disposed with respect to the plane of its reflecting surface.

10. In an optical system, a plurality of tiltable reflectors arranged about a common axis and a rotatable reflector having its axis of rotation co-incident with the common axis of the plurality of reflectors.

11. In an optical system, a plurality of light ray transmitting members arranged about a common axis and movable to varying relative angular positions with respect to said common axis and a rotatable reflec-

tor having its axis of rotation co-incident with the common axis of the plurality of light ray transmitting members.

12. In an optical system, a plurality of light ray transmitting members, a reflector rotatable intermittently to positions of collimation with the plurality of light ray transmitting members and means co-operating with said plurality of members to indicate the distance of the point of intersection of extensions of the optical axes of the light ray transmitting members.

13. A range finder having a plurality of light ray transmitting members, a centrally arranged reflector rotatable intermittently to positions of collimation therewith, means co-operating with said plurality of light ray transmitting members to indicate the distance of a target, and electrical means co-operating with said distance indicating means to provide distance readings at a point remote from the position of the range finder.

14. A range finder having a plurality of light ray transmitting members, a centrally arranged reflector rotatable intermittently to positions of collimation therewith, means for actuating the light ray transmitting members to vary the angular relation thereof with respect to the centrally arranged reflector, and electrically operated means co-operating with said reflector actuating means to indicate the extent of angular deflection of said reflectors.

15. A range finder having a plurality of light ray transmitting members, a centrally arranged reflector rotatable intermittently to positions of collimation therewith, means for actuating the light ray transmitting members to vary the angular relation thereof with respect to the centrally arranged reflector, and means associated with said light ray transmitting member actuating means to translate the angular deflection thereof into terms of variation in resistance in an electrical circuit.

Signed at Washington, D. C., this 3rd day of October, 1918.

JAMES M. BOYLE.

Witness:
JOHN W. THOMPSON.