May 26, 1959 A. NYMAN 2,888,516

LIGHT-TRANSMITTING APPARATUS

Original Filed June 18, 1951 5 Sheets-Sheet 1

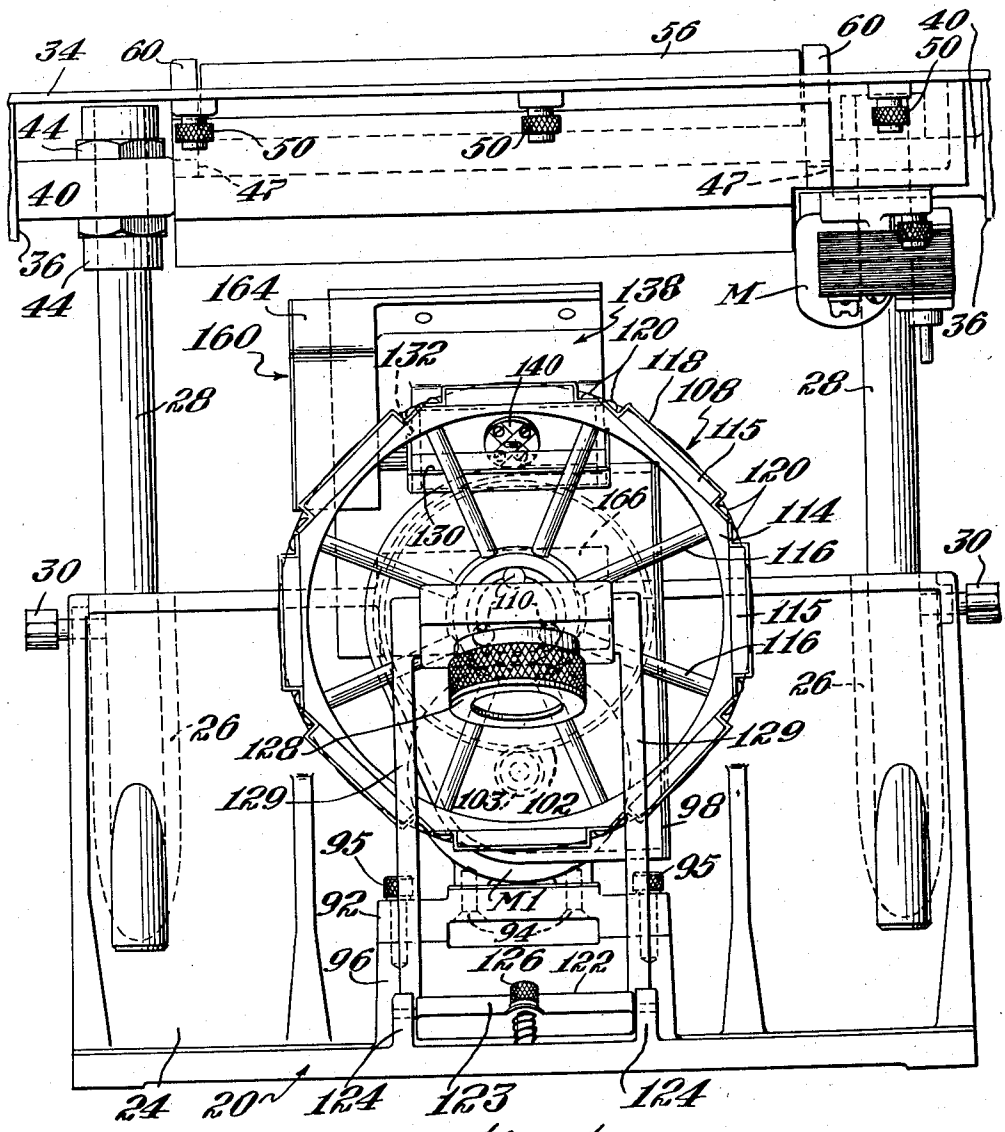


Fig. 1

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LIGHT-TRANSMITTING APPARATUS

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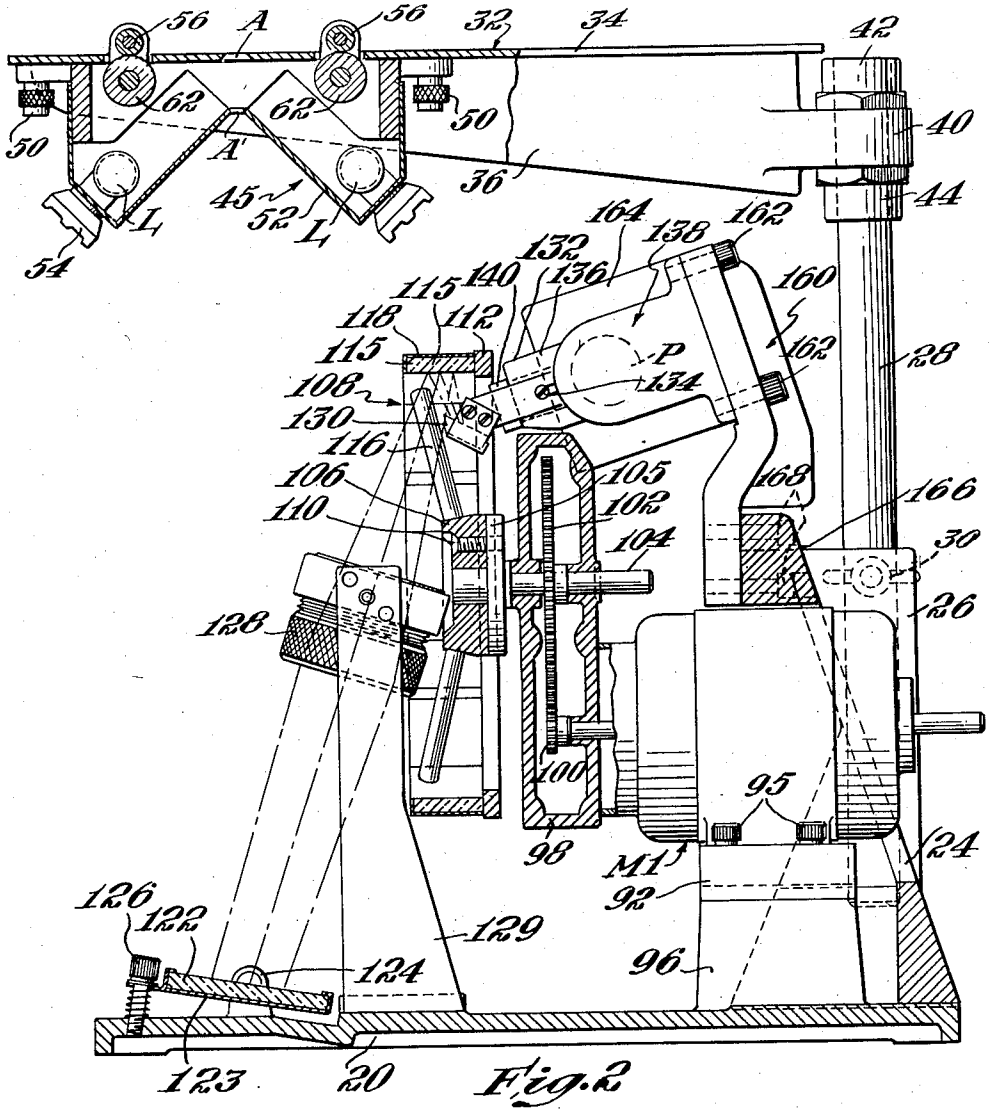


Fig. 2

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LIGHT-TRANSMITTING APPARATUS

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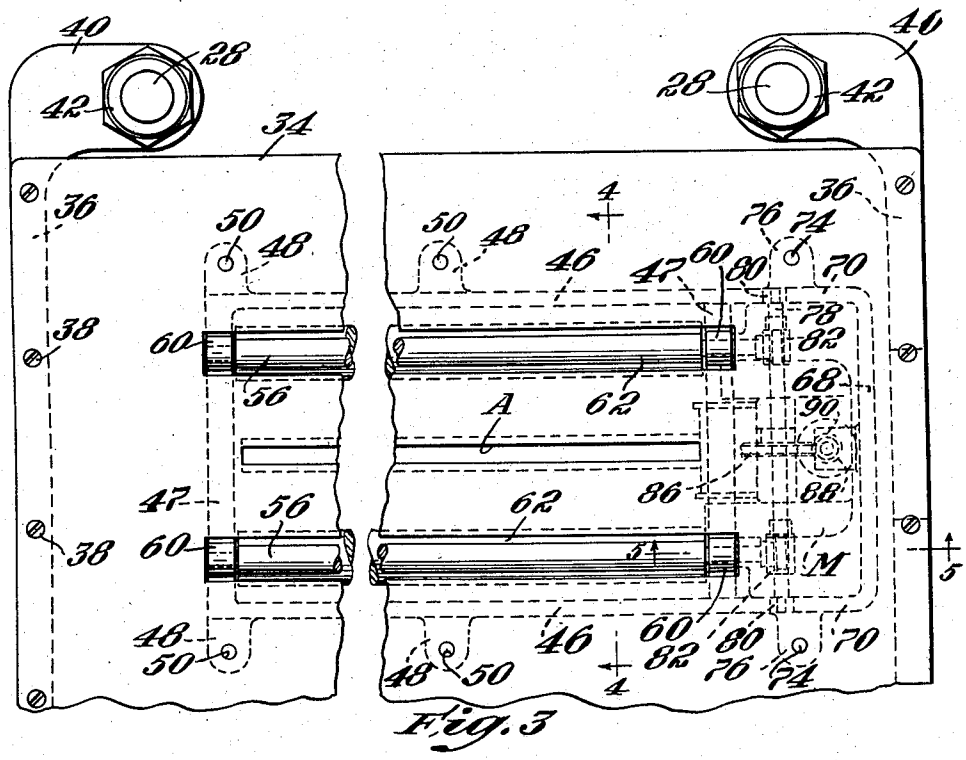


Fig. 3

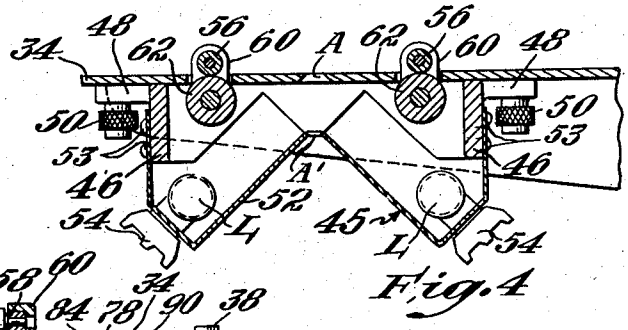


Fig. 4

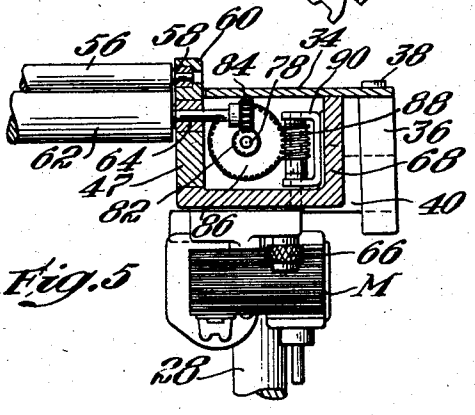


Fig. 5

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LIGHT-TRANSMITTING APPARATUS

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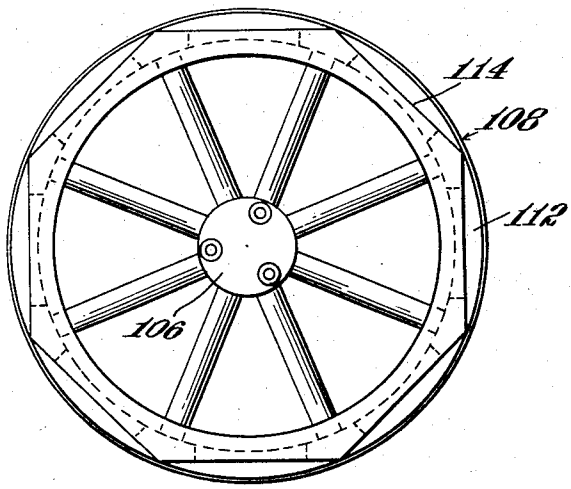


Fig. 6

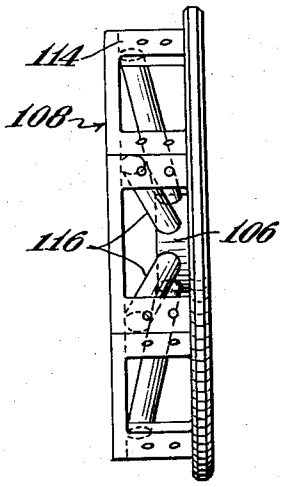


Fig. 7

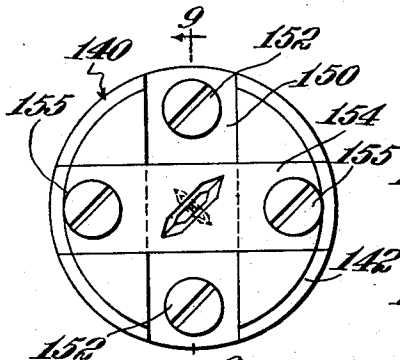


Fig. 8

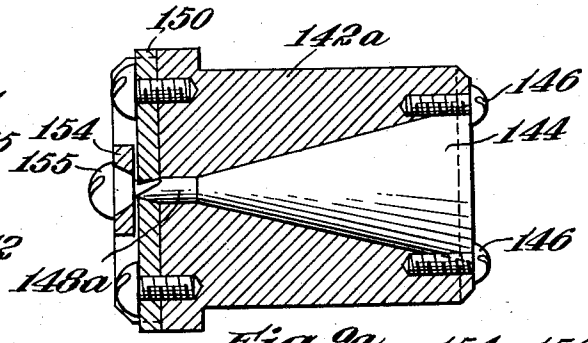


Fig. 9a

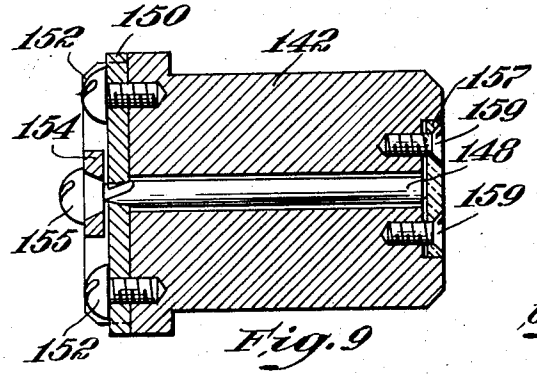


Fig. 9

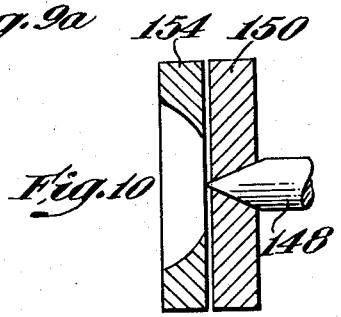


Fig. 10

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LIGHT-TRANSMITTING APPARATUS

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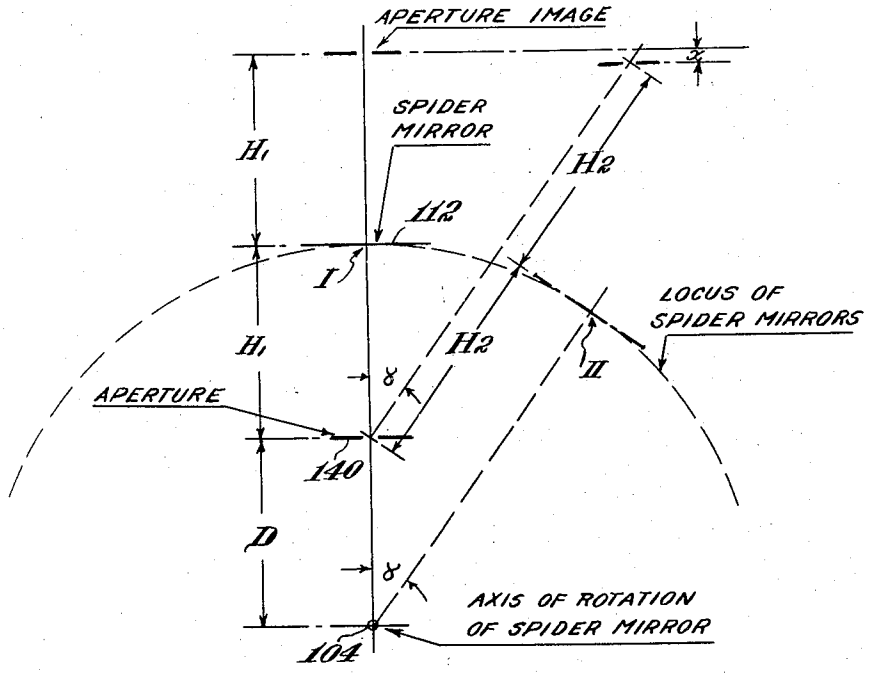


Fig. 11

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2,888,516

LIGHT-TRANSMITTING APPARATUS

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Original application June 18, 1951, Serial No. 232,221, now Patent No. 2,750,443, dated June 12, 1956. Divided and this application February 11, 1953, Serial No. 336,373

10 Claims. (Cl. 178—7.6)

This application is a division of my copending application Serial No. 232,221, now United States Patent No. 2,750,443, issued June 12, 1956.

This invention relates to a device for collecting light throughout a wide arc, and more particularly to an aperture assembly for collecting the light and directing it to a photocell or other device. The invention is especially applicable to scanning apparatus where light is continuously collected from different angles.

Objects of the invention are to provide optical apparatus which collects light equally well at various angles of approach throughout a wide angle without moving the collector and more particularly to direct light from various points of a sheet through the aperture of a photocell or the like without moving either the sheet or the cell. According to the present invention the apparatus comprises a light-transmitting element of a material having a high index of refraction one end of the element being in the form of a wedge together with means for directing light into the aforesaid end throughout an arc extending transversely of the apex of the wedge.

The light directing means may comprise a mirror movable throughout an arc extending transversely of the apex of the wedge.

In a more specific aspect the apparatus comprises an aperture assembly including an opaque member having an opening therein characterized in that the aforesaid wedge extends into the opening so that light rays in planes normal to the edge of the wedge over a wide incident angle are directed through the opening. The opening is preferably in the form of a slot extending lengthwise of the apex of the wedge. In the preferred embodiment the aperture assembly comprises two opaque members each of which has a slot therein, the members being arranged with the slots lying adjacent each other in angular relationship so that the widths of the slots form the respective dimensions of the aperture, the wedge end of the light-transmitting element extending through the rear slot.

For the purpose of illustration a typical embodiment of the invention is shown in the accompanying drawings in which:

Fig. 1 is a front elevation view of a facsimile scanner;

Fig. 2 is a side elevation view of the scanner shown in Fig. 1;

Fig. 3 is a partial plan view of the copy table;

Fig. 4 is a partial section on lines 4—4 of Fig. 3;

Fig. 5 is a partial sectional view on lines 5—5 of Fig. 3;

Fig. 6 is a front elevation view on the spider and mirror assembly;

Fig. 7 is a side elevation view of the spider and mirror assembly;

Fig. 8 is a front elevation view of one construction of the aperture assembly;

Fig. 9 is a sectional view on lines 9—9 of Fig. 8;

Fig. 9a is a sectional view similar to Fig. 9 of an alternate construction of aperture assembly;

Fig. 10 is an enlarged partial sectional view showing the details of the aperture plates; and

Fig. 11 is a schematic diagram illustrating the principle of operation of the scanner.

As is best shown in Figs. 1 and 2 the embodiment of an optical scanner chosen for the purposes of illustration is supported upon a base 20 having a bracket 24 cast integrally therewith so that the bracket extends upwardly from the rear of the base. The bracket 24 has bosses 26 positioned at either end thereof wherein are carried respectively two vertically disposed columns 28 which telescope respectively in apertures in the bosses being secured in adjusted position by means of thumb screws 30.

Upon the upper ends of the columns 28 is carried a copy table 32, which has an upper copy guiding surface 34, each side of which is reinforced by a respective rib 36 being attached thereto by means of screws 38. At the rear end of each rib 36 is an integrally cast finger or tab 40 which is turned inwardly and provided with an aperture for engaging the upper end of a respective column 28. The table 32 is held in position by two pairs of nuts 42 and 44 which engage threads cut in the ends of the columns 28 so that nuts are positioned respectively above and below the tabs 40.

As is shown in Figs. 3 and 4, the surface 34 of the copy table 32 is provided with three transverse slots. The center slot A, which forms an elongated optical aperture whose function will be described in detail below, is brightly illuminated from the bottom of the table by means of two tubular electric lamps L which are preferably of the fluorescent type. The lamps L are enclosed in a lamp housing 45 which is suspended beneath the table 32. The housing 45 consists of a substantially rectangular frame having two opposed side members 46 which are provided with a plurality of apertured tabs 48. Connecting members 47 extend between the ends of the side members 46 to complete the frame. A plurality of knurled headed screws 50 engage the corresponding tab apertures and thread into the bottom of the table so that the housing 45 is secured to the table 32. A sheet metal enclosure 52, which is shaped like an inverted V as is best shown in Fig. 4, is attached to the frame side members 46 by screws 53. Suitable electrical elements of conventional design such as the sockets and connectors designated generally by the numeral 54 are located at the lower end of each of the legs of the housing to accommodate the respective lamps L. A slotted aperture A' is positioned at the apex of the enclosed legs where it is in vertical alignment with the table aperture A.

The lamp housing 45 also supports two pair of copy feed rolls which are located in the outer slots in the table on either side of the aperture A. The upper driven roll 56 is carried upon a shaft which is journaled in bearings 58 as is shown in Fig. 5. Each bearing 58 is pressed into an aperture in a respective boss 60 which projects upwardly through the slotted apertures in the table from the connecting members 47 of the lamp housing 45. The shaft of the lower driving roll 62 is journaled in bearings 64 pressed in apertures in the opposed connecting members 47 immediately below the bosses 60.

Both pairs of feed rolls are driven at the same speed by means of an electric motor M which is suspended from the bottom of the housing 68 of a reduction gear unit by means of the knurled screws 66. The gear reduction unit comprises a shaft 78 whose ends are journaled in bearings 80 (Fig. 3) pressed in the housing ends 70. The shaft 78 carries two worms 82 which engage gears 84 carried on the ends of the respective shafts of the lower feed rolls 62. Interposed between the worms 82 is a driving gear 86 which mates with a worm gear 88 carried

upon the shaft of the motor M between the arms of a V-shaped bracket 90 secured to the side wall of the gear reduction unit housing 68.

As is best shown in Figs. 1 and 2 the base of a second motor M1 is attached to a spacer 92 by flat headed screws 94. The spacer 92 is in turn fastened by screws 95 to a boss 96 cast integrally with the base 20. The end bell of the motor M1 has fastened thereto a housing 98 for a reduction gear unit which includes a pinion 100 secured to the end of the motor shaft. The pinion 100 mates with a gear 102 carried upon a shaft 104 journaled in the walls of the housing 98. The end of the shaft 104 extends through the front housing wall and carries a disc 105 which is secured to the hub 106 of a spider 108 by means of three screws 110.

As is shown in Figs. 6 and 7, the spider 108 consists of a structure which may be either cast or fabricated in the form of an octagonal rim 114 having a flange 112. Eight equally spaced integral spokes 116 cant outwardly from the hub 106 to the respective junctions between adjacent flat portions of the octagonal rim 114. A plurality of mirrors 115 (Fig. 1) are carried upon the respective flat portions of the rim portion 114 being secured thereto with their reflecting surfaces directed inwardly by associated brackets 118 which are attached to the spider 108 by means of screws 120.

A stationary mirror 122 is pivotally mounted upon the base 20 directly below the aligned apertures A and A'. The mirror 122 is secured in a bracket 123 journaled in two bosses 124 extending upwardly from the base 20 so that it can be adjusted by means of a spring biased adjusting screw 126 to impinge light rays coming from the subject copy adjacent the table aperture A upon the particular spider mirror 115 which is positioned in the top portion of its travel about the axis of the shaft 104. A conventional converging lens system is mounted in the optical barrel 128 which is supported between two spaced brackets 129 extending upwardly from the front portion of the base 20 so that the lens system is interposed in the optical path between the stationary mirror 122 and the top spider mirror 115.

A second stationary mirror 130 (Fig. 2) is supported by means of a bracket 132 within the rim 114 of the spider 108 directly beneath the position occupied by the top spider mirror 115. The ends of the bracket 32 are provided with slots through which pass screws 134 engaging threaded apertures in the sides of a boss 136 extending from a phototube housing 138 whereby the position of the mirror can be adjusted with respect to the surfaces of the spider mirrors 115.

A light sensitive device such as the photocell P is mounted in a horizontal position within the hollow light tight housing 138. Light rays reflected from the mirror 130 are admitted into the housing 138 through an aperture 140 secured in the boss 132. The structural details of one form of the aperture assembly can best be seen in Figs. 8 through 10 wherein the numeral 142 designated as a flanged cylindrical member or barrel having an axially disposed passage or aperture extending therethrough. A rod 148 of a material, such as sapphire, having a high index of refraction is inserted in the passage. One end of the rod 148 is ground in the shape of a wedge with diverging surfaces of equal area having an included angle of approximately 40° as is shown in Fig. 10. The wedge shaped end of the rod 148 extends beyond the end of the barrel 142 through a V-shaped slot milled or otherwise cut in a strap 150 at an angle of 45° to the longitudinal axis of the strap as is shown in Fig. 8. The strap 150 is recessed in a groove in the flanged end of the barrel 142 being secured therein by means of screws 152 which engage threaded apertures in the flange. A second similarly slotted strap 154 is fastened to the flanged end of the barrel 142 by screws 155 so that the slot therein lies adjacent and at an angle of 90° to the slot in the recessed strap 150. The depth of the groove in the end of the barrel 142 is made slightly greater than the thickness of the strap 150 so that a clearance is provided between the straps 150 and 154 into which clearance the apex of the wedge end of the rod 148 extends as is shown in Fig. 10. The rod 148 is held in position by means of a transparent plate 157 which is secured in a recess in the end of the barrel 142 by means of screws 159.

As is best shown in Fig. 8 the edge of the wedge end of the rod 148 is arranged parallel with the axis of the slot in the bottommost strap 150 so that light rays normal to the edge impinge upon the wedge over a great angle of incidence approaching 120° without appreciable loss of aperture area, that is, as shown in Fig. 11, the rod 148 is so positioned that as each mirror swings across the light path, from the position II in Fig. 11 to a corresponding position on the other side of the vertical, the light enters the wedge first on one side and then on the other. The effective dimensions of the aperture are determined by the width of the slots in the straps 150 and 154.

A modification of the aperture assembly is shown in Fig. 9*a* wherein the grooved straps 150 and 154 and the wedge shaped end of the sapphire rod are similar in construction to those described in detail heretofore. The rod 148*a* is foreshorted and abuts the small end of a truncated cone 144 of a light transmitting material such as "Lucite" which is secured in a tapered aperture in the barrel 142*a* by means of screws 146.

The aperture barrel 142 is mounted in the boss 136 with the axis of the groove in the outside strap 154 perpendicular to the optical axis of lens 128 and parallel to the reflecting surface of the top spider mirror 115 in its median position so that the wedge at the end of the rod 148 will receive incident light through a very wide angle on either side of the aperture axis.

The housing 138 for the photocell P is secured to the face of a bracket 160 (Fig. 2) by means of screws 162. The bracket 160 is in turn attached to the horizontal boss 166 on the top of the rear base bracket 24 by means of screws 168. The end of the housing 138 is provided with a flange to which is fastened a side plate 164 (Fig. 1). The side plate 164 has mounted on its inner surface a conventional socket (not shown) so that the photocell P is readily taken from the housing 138 by removing the plate.

The copy is placed upon the top of the table 32 and manually inserted between the two pair of feed rolls 56 and 62 with the surface to be scanned towards the table surface 34. The energization of the motor M drives both pair of feed rolls, as described heretofore, so that the subject copy moves by the aperture slot A in the table surface 34. Light rays from the lamps L are reflected from the portion of the copy adjacent the aperture A, down through the opening A', in the lamp enclosure 45 to impinge upon the stationary mirror 122. The rays are then reflected from the mirror 122 through the converging lens system in the barrel 128 to impinge upon the mirror 115 which is positioned at the top of the path of travel and thence to the stationary mirror 130 which directs the rays through the aperture 140 to impinge on the light sensitive electrode of the photocell P.

It will be evident that as the spider 108 is rotated by the motor M1, the image band or strip of light reflected from the copy adjacent the aperture A as described above, moves across the wedge at the end of the sapphire rod 148 of the aperture 140 i.e. the photocell P in effect "sees" successive elemental areas of the copy. By correlating the rate of advance of the copy with the rotational speed of the spider 108, each spider successive mirror 115 reflects light rays from sequential transverse elements of the copy so that the photocell P receives light from successive areas of sequential transverse elements of the subject copy i.e. the copy is scanned by the photocell.

A schematic diagram is shown in Fig. 11 wherein for clarity and simplicity the stationary mirrors **122** and **130** and the spider mirrors other than the one of immediate concern have been omitted. In the diagram the aperture and the spider mirror bear the designations **140** and **112** respectively as employed previously heretofore. With the mirror **112** in the uppermost position designated I, the image of the aperture **140**, appears to be at a distance behind the mirror surface equal to H^1 i.e. the distance between the mirror surface and the aperture. The distance between the aperture **140** and the axis of rotation of the mirror spider about the shaft **104** is designated D. If there is a stationary mirror between the rotating mirror and the axis (such as **130** in Figs. 1 and 2) D is the distance between the axis and the virtual image of the aperture behind the stationary mirror, and if there is no such stationary mirror D is the actual distance as in Fig. 11. It will be evident that H^1+D is equal to the radius of rotation of the spider mirrors.

If the mirror **112** is rotated clockwise through an angle to a position designated II, the aperture image is also moved through the same angle to a position which appears to be a distance behind the mirror surface equal to H^2 i.e. the distance from the aperture **140** to the mirror surface. During such rotation the aperture image deviates from a straight line by a distance designated x i.e. the effective location of the aperture changes with the rotation of the mirror **112** so that the light rays coming from the copy through the lens system **128** cannot be maintained in focus upon the aperture.

From the geometry of the diagram it will be evident that the following relation holds for any value of a:

$$X=2D(1-\cos a)(H/D-\cos a)$$

Further it can be shown both experimentally and mathematically that for any given maximum value a of the angle of rotation of the spider mirror, by making the ratio H/D equal to cosine of a the deviation x is minimized so that the defocusing can be kept within reasonable limits without the necessity of using special and expensive lens systems.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. Optical facsimile apparatus comprising a support for facsimile copy, a light-transmitting element of a material having a high index of refraction, one end of the element being in the form of a wedge, and a mirror movable throughout an arc extending transversely of the wedge for reflecting an image of said copy on said wedge end from various points on said arc and means to move said mirror thereby to move the image of said copy across the wedge, said wedge having at least two light transmitting surfaces substantially equal in area and converging in an apex directed toward said arc intermediate the ends thereof so that said wedge presents a substantially constant area to light received from different points on said arc.

2. Optical facsimile apparatus comprising a support for facsimile copy, a light-transmitting element of a material having a high index of refraction, one end of the element being in the form of a wedge, and a projector including a converging lens for focusing an image of said copy on said wedge and a mirror movable throughout an arc extending transversely of the wedge for reflecting an image of said copy on said wedge end from various points on said arc, and means to move said mirror thereby to move the image of said copy across the wedge.

3. Optical facsimile apparatus comprising a support for facsimile copy, an aperture assembly for receiving light over a wide incident angle comprising an opaque member having a slot therein, and a light-transmitting element of a material having a high index of refraction, one end of said element being in the form of a wedge which extends into said slot, and a projector including a converging lens for focusing an image of said copy on said members and a mirror movable throughout an arc extending transversely of the wedge for reflecting an image of said copy on said members thereby, and means to move said mirror to move the image of the copy across said member whereby light rays in planes normal to the edge of said wedge over a wide incident angle are directed through the aperture, said wedge having at least two light transmitting surfaces substantially equal in area and converging in an apex approximately bisecting said wide angle so that said wedge presents a substantially constant area to light rays received from different directions within said incident angle, and said slot defining one transverse dimension of light rays falling on said wedge.

4. Optical facsimile apparatus comprising a support for facsimile copy, an aperture assembly for receiving light over a wide incident angle comprising two opaque members each of which has a slot therethrough, said members being arranged with the slots lying adjacent each other in angular relationship so that the widths of the slots form the respective dimensions of the aperture, and a light-transmitting element having a high index of refraction, one end of said element being in the form of a wedge which extends into said slot, and a projector including a converging lens for focusing an image of said copy on said members and a mirror movable throughout an arc extending transversely of the wedge for reflecting an image of said copy on said members, and means to move said mirror thereby to move the image of the copy across said members whereby light rays in planes normal to the edge of said wedge over a wide incident angle are directed through said aperture, said wedge having at least two light transmitting surfaces substantially equal in area and converging in an apex approximately bisecting said incident angle so that said wedge presents a substantially constant area to light rays received from different directions within said wide angle, and said slots defining the two transverse dimensions of light rays falling on said wedge.

5. Optical scanning apparatus for a subject copy comprising a light pickup device, a mirror disposed at a distance from an axis of rotation, means for rotating the mirror about the axis, an optical system including a lens for causing light rays coming from the copy to impinge upon the mirror during a portion of its rotation about the axis, said optical system being arranged to image successively the consecutive elements of the copy upon the device, said device including aperture means comprising an opaque member having a rectilinear slot approximately in the plane of said axis and a light-transmitting element having a high index of refraction, one end of the element comprising a wedge extending into said slot, whereby light rays are directed through said aperture from throughout a wide incident angle, said wedge having at least two light transmitting surfaces substantially equal in area and converging in an apex approximately bisecting said incident angle so that said wedge presents a substantially constant area to light rays received from different directions within said wide angle, and said slot defining one transverse dimension of light rays falling on said wedge.

6. Optical scanning apparatus for a subject copy comprising a light pickup device, a mirror disposed at a distance from an axis of rotation, means for rotating the mirror about the axis, an optical system including a lens for causing light rays coming from the copy to impinge upon the mirror during a portion of its rotation about the axis, said optical system being arranged to image successively the consecutive elements of the copy upon the device, said device comprising masking means and a light-transmissive element, said masking means comprising two opaque members each of which

has a slot therethrough, said members being arranged with the slots lying adjacent each other in angular relationship, the rear slot being approximately in the plane of said axis, and said light-transmissive element having a high index of refraction, one end of the element comprising a wedge extending into said rear slot, whereby light rays are directed through said aperture from throughout a wide incident angle, said wedge having at least two light-transmitting surfaces substantially equal in area and converging in an apex approximately bisecting said wide angle so that said wedge presents a substantially constant area to light rays received from different directions within said wide angle, and said slots defining the two transverse dimensions of light rays falling on said wedge.

7. Optical apparatus comprising a light-transmitting element of a material having a high index of refraction, one end of the element being in the form of a wedge, and means for directing a moving beam of light into said end throughout an arc extending transversely of the apex of said wedge, said wedge having at least two light transmitting surfaces substantially equal in area and converging in an apex directed toward said arc intermediate the ends thereof so that said wedge presents a substantially constant area to light received from different points on said arc.

8. Optical apparatus comprising a light-transmitting element of a material having a high index of refraction, one end of the element being in the form of a wedge, and a mirror movable throughout an arc extending transversely of the apex of the wedge for directing light into said end, said wedge having at least two light-transmitting surfaces substantially equal in area and converging in an apex directed toward said arc intermediate the ends thereof so that said wedge presents a substantially constant area to light received from different points on said arc.

9. Optical scanning apparatus for a subject copy comprising a light sensitive device responsive to variations in light intensity, a mirror disposed at a distance from an axis of rotation, means for rotating the mirror about the axis, an optical system including a lens for causing light rays coming from the copy to impinge upon the mirror during a portion of its rotation about the axis, said optical system being arranged to image successively the consecutive elements of the copy upon the device, aperture means comprising an opaque member having a rectilinear slot approximately in the plane of said axis, and a light-transmitting element having a high index of refraction, one end of the element comprising a wedge extending into said slot, and directed toward a point intermediate the ends of said portion of mirror rotation, whereby light rays are directed through said aperture throughout a wide angle of rotation of said mirror.

10. Optical scanning apparatus for a subject copy comprising a light sensitive device responsive to variations in light intensity, a mirror disposed at a distance from an axis of rotation, means for rotating the mirror about the axis, an optical system including a lens for causing light rays coming from the copy to impinge upon the mirror during a portion of its rotation about the axis, said optical system being arranged to image successively the consecutive elements of the copy upon the device, aperture means comprising two opaque members each of which has a slot therethrough, said members being arranged with the slots lying adjacent each other in angular relationship, the rear slot being approximately in the plane of said axis, and a light-transmissive element having a high index of refraction, one end of the element comprising a wedge extending into said rear slot, and directed toward a point intermediate the ends of said portion of mirror rotation, whereby light rays are directed through said aperture thoughout a wide angle of rotation of said mirror.

References Cited in the file of this patent

UNITED STATES PATENTS

336,257	Palmer	Feb. 16, 1886
1,351,562	Foster	Aug. 31, 1920
1,663,308	Jenkins	Mar. 20, 1928
1,762,383	Booraem	June 10, 1930
1,883,971	Kryzanowsky	Oct. 25, 1932
2,089,588	Mihaly	Aug. 10, 1937
2,287,605	Dickson	June 23, 1942
2,338,748	Watkiss	Jan. 11, 1944
2,458,860	Kogel	Jan. 11, 1949