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(54) Title: MAGNIFYING STEREOSCOPIC VIEWER (57) Abstract A magnifying stereoscopic viewer (10), and illuminator (11). The viewer has a viewing surface (37) at which enlarged virtual images of an object (23) outside the viewer can be seen from a viewing plane (25). The viewer optics include zoom-type projection lens systems (51). The viewing surface preferably is a mirror which can be adjusted, and the viewer positioned, so that the apparent distance of the virtual images from the exit pupils is substantially equal to the distance directed to the object from the exit pupils. The direct view line (87) can pass through a neutral density filter (38) so that the brightness of the object as seen along such line is not greatly different from that of the virtual images. The illuminator has a mechanism (100-110) for moving the viewer to focus on the object. A series of changeable reticles (130) and filters (164) are in the illuminator.		

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MAGNIFYING STEREOSCOPIC VIEWERBACKGROUND OF THE INVENTIONField of the Invention

This invention pertains to magnifying stereoscopic optical devices generally useful in the manner of stereomicroscopes. More particularly, it pertains to a rear projection magnifying stereo viewer.

General Review of the Art and the Problems Thereof

Stereoscopic microscopes, having binocular eyepiece lens systems, are well known. They are used in many ways including in scientific and medical research, industrial manufacturing and inspection procedures, forensic and pathological analyses, and surgical procedures, to name only a few. The uses fall generally into two categories, namely, those where the object of interest is merely passive and is magnified for better viewing of its detail features, and those where the object is both magnified and actively manipulated or acted upon by the user of the microscope or by others. The latter uses include use in surgical procedures and use in industrial manufacturing operations, and it is in such kinds of uses that this invention has particular utility.

Conventional microscopes have short eye relief eyepiece lens systems which require that the human eye be placed close to the eyepiece in a small exit pupil area (commonly

1 about 5 mm. in diameter) in order that the full magnified
virtual image of the object of interest can be seen.
Extended use of such microscopes is very tiring, even when
the eyepiece is disposed to minimize user neck and back
5 strain. The viewing requirements of conventional
microscopes, and the impact of their side effects, are
especially difficult where the microscopes are used by
persons who act upon the object being viewed, as in surgical
procedures or in the manufacture of small electronic
10 devices; in these applications, the microscope user may be
obliged to shift his view from the microscope eyepiece to
the work directly at hand, and in so doing his eyes must
reaccommodate in terms of eye focus or aperture or both.
The accommodation process requires time and, if repeated
15 frequently, induces eyestrain. In some cases, natural
accommodation for direct viewing, as compared to
microscope viewing, of the object may be prevented if direct
viewing can be achieved only through prescription corrective
lenses which interfere with efficient use of a microscope.

20 The surgical procedures of radial keratotomy and
intraocular lens placement present useful examples of the
problems and limitations of conventional stereoscopic
microscopes. Those surgical procedures most commonly are
performed while the surgeon views the surgical location
25 through a microscope. Because of light losses in the
microscope optics, as well as for other reasons, the image
seen by the surgeon in the microscope is dimmer than the
image he would see when looking directly at the surgical
area. Thus, in shifting his view between the microscope and
30 a direct view, the surgeon's eyes must accommodate for the
significant differences in image brightness. Also, the
image viewed through the microscope commonly is seen at an
apparent distance from the eye which is much different from
the direct distance from the eye to the surgical area.
35 Thus, in shifting his view between the microscope and the

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1 surgical area, the surgeon's eyes must also reaccommodate
for distance. Also, the presence of the microscope may
prevent the surgeon from viewing the surgical area unless he
moves his head away from the narrowly defined head placement
5 required for effective use of the microscope. These
circumstances obviously induce eyestrain and muscle strain
and also loss of time which can be critical.

It is well known that spectacles interfere with
efficient use of microscopes. It is for this reason that
10 microscopes used in surgery are equipped with binocular
eyepieces which are individually or relatively adjustable so
that a surgeon who normally wears spherical-correcting
(distance-correcting) spectacles can adjust the eyepieces to
compensate for his uncorrected vision characteristic. The
15 difficulties presented to such a surgeon in shifting his
view of the surgical area from direct to microscope viewing
are apparent. If the surgeon's uncorrected vision
characteristic includes astigmatism, involving a cylindrical
curvature in his corrective lenses, he cannot compensate for
20 that condition by adjustment of the microscope eyepieces
which are adjustable only in a distance (spherical) sense.
It is for such reasons that skilled surgeons experienced in
procedures requiring use of surgical microscopes often are
forced to limit, if not abandon, their surgical practices
25 when they reach the age where they must wear corrective
spectacle lenses if they cannot use contact lenses.

Rear projection magnifying stereoscopic viewing devices
are known for use in viewing stereo photographs, stereo
positive or negative film transparencies, and other two-
30 dimensional stereo-image creating things. Such devices
commonly are known as microstereoscopes. In such devices,
the photographs and the like are placed below the objectives
in a predetermined relation to the optical elements of the
device; such viewing devices are not usable for viewing
35 objects outside the structures of the devices. It is known,

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1 in the context of such devices, to arrange the optical
elements so that a user can be located a substantial but
predefined distance from the nearest structure of the device
and can have his head located anywhere within a much larger
5 area than is pertinent to efficient use of a stereoscopic
microscope.

SUMMARY OF THE INVENTION

The present invention addresses and effectively
10 overcomes the user-related limitations of stereoscopic
microscopics which were noted above. It provides an optical
device which can be used in substantially all applications
where stereoscopic microscopes now are used, but which has
all of the "user-friendly" properties of long eye relief,
15 large viewing area rear projection viewers, together with
further benefits and advantages not found either in such
stereoscopic viewers or in stereoscopic microscopes. While
optical devices according to this invention have utility in
many applications, including all of those noted above
20 concerning microscopes, they are perceived to have
particular utility in surgical applications, and it is in
that latter utility and application that the invention is
described in detail.

Generally speaking, this invention provides a
25 stereoscopic magnifying viewer characterized by the absence
of eyepiece lenses. The viewer includes magnifying lens
means which include an objective lens assembly focusable
upon an object outside the viewer. The viewer also includes
viewing surface means, a frame, and mounting means for
30 mounting the lens means and the viewing surface means to the
frame. The mounting means mounts the lens and viewing
surface means in that order along an optical axis of the
viewer in such relation to each other to define left and
right optical axes in the viewer between the objective lens
35 assembly and an external exit pupil, and also to define in a

1 viewing plane at the exit pupil stereoscopically related
left and right viewing areas. The viewing areas are defined
to be centered substantially 2.5 inches apart and to be
substantially greater than 5mm in diameter without overlap
5 so that, by placing his eyes in the viewing areas, a user
can visually observe, via the viewing surface means,
enlarged stereoscopic virtual images of an object outside
the viewer upon which the objective lens assembly is
focused. The lens means is arranged so that the distance
10 from the viewing plane to the virtual images along the
optical axes is a substantial portion of the distance
directly to the object from the viewing plane. Thus, a user
of the viewer can efficiently shift his view between the
virtual images and the object.

15 A presently preferred embodiment of the viewer has a
folded optical axis and a field lens system located above a
viewing mirror which comprises the viewing surface means. A
user can position the viewer to place the viewing mirror
just to the side of his line of direct vision to the object
20 so that minimal eye movement is involved in shifting between
views of the object and the virtual image. Also, the
viewing mirror preferably is surrounded by a neutral density
filter to cause the object, when viewed directly through the
filter, to have about the same apparent brightness as the
25 virtual images as seen via the viewing mirror. This feature
reduces the need for brightness reaccommodation as a user
shifts his view from the viewing mirror to direct viewing of
the object. Further, the viewer preferably is used with a
cooperatively defined illuminator to which the viewer is
30 mounted. The focus of the viewer objective lens assembly on
the object can be obtained by moving the viewer on the
illuminator; preferably such movement is power driven in
response to operation of a foot control provided for the
user of the viewer. Also, the presently preferred viewer
35 includes an auto-focusing zoom lens system for control of

1 the magnification factor afforded by the viewer; the zoom
lens system can be power operated and controlled through the
foot control.

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1 DESCRIPTION OF THE DRAWINGS

The features and advantages of the viewer as noted above, and also other features and advantages of the viewer, are more fully set forth in the following detailed
5 description of a presently preferred viewer having utility in connection with surgical procedures. That description is presented with reference to the accompanying drawings in which:

FIG. 1 shows use of a presently preferred magnifying
10 stereoscopic viewer by a surgeon in an operation on an eye of a patient on an operating table;

FIG. 2 is a side elevation view of the viewer and associated illuminator shown in FIG. 1;

FIG. 3 is a rear elevation view of the viewer and
15 illuminator shown in FIG. 2 and also shows the way in which other optical devices can be mounted to the illuminator for use concurrently with use of the viewer;

FIG. 4 is an enlarged elevation view, partially in cross-section, of the interior of the viewer and shows
20 certain of the optical elements of the viewer;

FIG. 5 is a view of the viewer taken substantially along line 5-5 in FIG. 4;

FIG. 6 is an enlarged fragmentary cross-section view taken substantially along line 6-6 in FIG. 5;

25 FIG. 7 is an enlarged fragmentary cross-section view taken substantially along line 7-7 in FIG. 5;

FIG. 8 is a fragmentary elevation view of the reverse side of the zoom drive mechanism shown in FIG. 4;

FIG. 9 is an elevation view of the zoom drive cam drum;

30 FIG. 10 is a vertical elevation view, partially in cross-section, of the interior of the illuminator shown in FIGS. 2 and 3;

FIG. 11 is a cross-section view taken substantially along line 11-11 in FIG. 10 with certain elements omitted
35 for clarity of illustration;

1 FIG. 12 is a cross-sectional elevation view, taken toward the left from the right of FIG. 10 showing the power drive mechanism for focusing of the viewer;

5 FIG. 13 is a cross-sectional elevation view taken substantially along line 13-13 in FIG. 11 showing the lamp and stand-by lamp carrier in the illuminator;

 FIG. 14 is a cross-sectional plan view, taken along line 14-14 in FIG. 10 of the tilt drive mechanism for the illuminator and viewer;

10 FIG. 15 is an enlarged cross-section view taken along line 15-15 in FIG. 14; and

 FIG. 16 is a side elevation view of another magnifying stereoscopic viewer according to this invention.

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1 DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

FIG. 1 shows a stereoscopic magnifying viewer 10 in use with a cooperatively arranged illuminator 11 in the course of the performance by a surgeon 12 of a surgical procedure on an eye of a patient 13 supported on an operating table 14. The illuminator is supported above the patient's head by a support arm 15 carried on a pedestal 16 at the side of the operating table. Viewer 10 is carried by the illuminator.

10 The support arm and pedestal assembly are not, per se, part of this invention. A possible support arm and pedestal assembly 17 is a Zeiss surgical microscope support, Model S3B, which includes in its pedestal controls and mechanisms for power operation of several adjustments of the support itself and of a commercially available binocular stereo surgical microscope. The operation of some of the different power functions of the microscope support and of the microscope can be initiated and controlled by the surgeon via a foot control assembly 18 coupled to the microscope support. As set forth below, certain of the power driven functions and adjustments provided in the viewer and the illuminator, notably the zoom or magnification adjustment functions of the viewer and the basic focus function of the viewer optics upon the surgical area (object), preferably are initiated and controlled via the microscope support assembly 17 and its foot-actuated control accessory 18. The foot control can be used to cause the viewer to be moved in X and Y directions across and along the operating table.

Another presently preferred embodiment of a viewer according to this invention is an industrial, rather than surgical, stereoscopic magnifying viewer. The industrial viewer can include all of the features of the surgical viewer, but usually it does not. Therefore, description of the presently preferred surgical viewer 10, and its

1 associated illuminator 11 necessarily pertains to the industrial viewer.

FIG. 2 is a side elevation view of the viewer 10 and illuminator 11 shown in FIG. 1, whereas FIG. 3 is a rear
5 view of the illuminator and viewer as seen from the side opposite from the side at which surgeon 12 is located (see FIG. 1). A mounting arrangement 20 is carried at the upper end of the illuminator for coupling the illuminator securely to support arm 15 of the microscope support assembly 17. A
10 manually operable tilt adjustment mechanism 21, shown in greater detail in FIGS. 14 and 15, is part of the connection of the illuminator mounting arrangement. The tilt adjustment is operable to cause the illuminator, and the viewer mounted to the illuminator, to pivot left or right as
15 seen in FIG. 2 about a pivot point defined by the tilt adjustment mechanism.

The illuminator has an optical axis 22 along which light from the illuminator is directed to an object area 23 below the illuminator. Viewer 10 has an optical axis 24
20 (actually a pair of optical axes, i.e., left axis 24L and right axis 24R) which originate outside the structure of the viewer at object area 23 and which terminate in a viewing plane 25 also located externally of the structure of the viewer. Viewing plane 25 is the general location at which a
25 user of the viewer, such as surgeon 12, places his eyes 26 to observe enlarged, erect, right-reading virtual images of an object to be viewed and located in object area 23. As can be seen in FIG. 2, the structure and geometry of the viewer and the illuminator are cooperatively related so that
30 the viewer optical axes 24 and the illuminator optical axes 22 substantially intersect at object area 23.

FIG. 3 illustrates the capability for use with illuminator 11 and viewer 10 of additional optical accessories which preferably are carried by the illuminator.
35 Thus FIG. 3 shows a short eye relief binocular stereo

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1 microscope 28 mounted to the lower portion of the
illuminator housing via a dovetail connection 29.
Microscope 28 has optical axes 30 which converge at object
area 23. Microscope 28 can be used in combination with
5 viewer 10 so that a surgical assistant (represented by eye
31 in FIG. 3) can obtain an enlarged stereoscopic view of
object area 23 as needed. Viewer 10 is considered to be
located at a 12 o'clock position relative to illuminator 11.
Stereomicroscope 28 is mounted to the illuminator at either
10 the three o'clock or nine o'clock position, the nine
o'clock position being shown in FIG. 3. FIG. 3 also shows
the use with the illuminator and viewer of an optical
recording accessory, such as a video camera 33 or a still
camera, as desired. The video camera is carried on a
15 recording accessory adaptor 34 which is mounted to the lower
end of the illuminator housing via a second dovetail
connection 29 so that the recording accessory adaptor is
disposed at the three o'clock position as illustrated in
FIG. 3. Accessory adaptor 34 has an optical axis 35 which
20 intersects object area 23.

As will be apparent from the following description,
illuminator 11 can be defined to receive a second magnifying
stereo viewer 10 at the six o'clock position relative to the
viewer which is shown in FIG. 2. It is also possible to
25 mount some other optical accessory, or some other device
such as a surgical laser, to the illuminator at the six
o'clock position relative to the viewer illustrated in FIG.
2.

As shown generally in FIGS. 4 and 5, viewer 10
30 incorporates a magnifying lens system which includes
suitable mirrors at appropriate locations along optical axes
24L and 24R. The magnifying lens system effectively
terminates at a viewing surface which has a long eye relief
characteristic and with which viewing plane 25 is associated
35 in a way defined by the magnifying lens system. The viewing

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1 surface is that externally observable element of the viewer
to which a user of the viewer looks from the viewing plane
to observe enlarged left and right stereoscopically related
virtual images created by the magnifying lens system.
5 Preferably, as is the case in presently preferred viewer 10,
the viewing surface is a flat mirror 37 carried in the
central portion of a glass plate 38 which is hingeably
mounted at 39 to a housing 40 of the viewer. Mirror 37 is
so disposed on glass plate 38 that when the mirror is
10 adjusted for use of the viewer, the mirror crosses both of
optical axes 24R and 24L below a high gain, rear projection
diffuser 41. Left and right magnified virtual images of
object 23 are presented in the plane of diffuser 41 by an
exit field lens 42. The exit field lens preferably is
15 provided as a fresnel lens disposed immediately above
diffuser 41 and mounted in a frame 43 which also carries
diffuser 41.

Some might refer, inexactly, to element 41 as a screen.
In the context of this invention, such terminology is not
20 correct. A screen is a viewing surface which most commonly
is used with a large viewing volume, such as the audience
space of a motion picture theater, where the desired purpose
of the surface is to enable the image to be seen about
equally well from all locations in the viewing volume. A
25 diffuser, on the other hand, places the viewing location in
a relatively narrow range of possible places. It will be
seen that this invention involves the later circumstance, so
that element 41 of viewer 10 is a diffuser.

It will be appreciated, particularly from the following
30 description pertinent to FIG. 16, that mirror 37 is the
presently preferred form of the viewing surface provided in
a magnifying stereoscopic viewer according to this
invention; it is the mirror to which a user of the viewer
looks to observe enlarged left and right virtual images of
35 object 23 upon which the magnifying lens system of the

1 viewer is focused. As more clearly developed in the
description pertinent to FIG. 16, it is within the scope of
this invention that the viewing surface can be provided as a
rear projection diffuser similar to diffuser 41 but located
5 at a position generally corresponding to the position of
mirror 37 in viewer 10. The reasons why a mirror is
preferred as a viewing surface are discussed in conjunction
with the description pertinent to FIG. 16.

As shown best in FIG. 4, the magnifying lens system of
10 viewer 10 includes two parallel objective lens systems 45
disposed respectively along optical axes 24L and 24R. Lens
systems are carried in an objective lens mount 46 at the
lower end of viewer housing 40. Each objective lens system
includes an iris diaphragm mechanism 47 which is manually
15 operable by a user of the viewer via an actuating lever 48
which projects through a slot 49 in the objective lens mount
in a known manner. A single objective lens system, used
off-axis in association with optical axes 24L and 24R, could
be used in viewer 10 but is less preferred than the
20 provision of the twin objective lens systems 45. The
provision on each optical axis 24L and 24R of an individual
objective lens system dedicated to that optical axis enables
optimization of the optics of the viewer's objective lens
arrangement.

25 Within the housing of viewer 10 each optical axis
passes through a field lens assembly 50 and a projection
zoom lens system 51 to first and second folding mirrors 52
and 53 respectively, and thence to diffuser 41 with its
associated field lens. Proceeding from its objective lens
30 system to its field lens assembly 50, each optical axis
encounters first a flat mirror 55 and then a roof mirror 56.
A real image (represented at 58 in FIG. 4) is presented in
each field lens assembly 50, and it is this real image which
is further magnified by the adjacent zoom lens system and
35 projected to diffuser 41 as a virtual image.

1 A zoom lens system 51 is provided in viewer 10 along
each of the two optical axes of the viewer. Each zoom lens
system includes upper and lower movable lens sets 58 and 59
carried respectively in upper and lower movable lens mounts
5 60 and 61. The projection zoom lens systems are defined so
that the magnified virtual images observable at diffuser 41
are magnified 5 to 20 times the size of the object upon
which objective lens systems 45 are focused. Optical axes
24L and 24R converge, proceeding upwardly in the viewer, at
10 the location in the viewer at which the zoom lens systems
are located. The zoom lens systems are operated in
synchronism with each other according to a program defined
by a cylindrical zoom cam 63 disposed centrally between the
projection lens systems and rotatable about an axis which
15 corresponds substantially to the bisector of the included
angle between the optical axes through the projection zoom
lens systems. Each of the mounts 60 and 61 of each zoom
lens system is supported for movement along the respective
optical axis in response to rotation of drive cam 63. Thus,
20 each of movable mounts 60 and 61 is journaled about a
cylindrical guide bar 65 disposed parallel to the respective
optical axis adjacent the drive cam. Also, on the opposite
side of the respective axis, each of mounts 60 and 61
carries a pair of rollers 66. The rollers are captively
25 engaged with the opposing inner surfaces of a guide rail
composed of an adjacent surface of a viewer base plate 54
and of a flanged rail member 68 connected to the base plate
(see FIG. 7).

As shown best in FIGS. 7 and 8, each of lower zoom lens
30 mounts 60 is coupled to a lower cam follower sleeve 69 and
each of upper zoom lens mounts 61 is coupled to an upper cam
follower sleeve 70. The coupling of mounts 60 to cam
follower sleeve 69 is similar to the coupling of mounts 61
to cam follower sleeve 70, and thus only the coupling of the
35 former mounts to cam follower 69 is described in detail; it

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1 will be understood that this description is equally applicable to the coupling of lens mounts 61 to upper cam follower sleeve 70.

Lower cam follower sleeve 69 encircles cam drum 63. At its rear, i.e., adjacent base plate 54 of viewer 10, sleeve 69 carries a cross-arm 71. The cross-arm extends laterally of the axis of rotation of the cam beyond the adjacent zoom lens guide bars 65. Adjacent each of its outer ends the cross-arm defines a slot 72. Slots 72 on each guide bar are coaxially aligned in a plane perpendicular to the axis of rotation of the drive cam. A pin 73 carried by the adjacent one of lower zoom lens mounts 60 is snugly yet slidably received within the corresponding one of slots 72. The fit of each pin 73 in its cooperating slot 72 is sufficiently snug that there is no significant play or lost motion between the cross-arm and pin 73 laterally of the slot as the cross-arm is driven along the length of the cam. However, motion of pins 63 relatively along slots 72 occurs freely, thereby providing motion accommodation of the pins relative to the cross-arms, the need for which is due to the fact that guide bars 65 are not parallel to the axis of rotation of the zoom cam drum.

As shown in FIG. 7 (see also FIG. 9) cam follower sleeve 69 cooperates with cam drum 63 via a follower pin 75 affixed to sleeve 69 to project into and to closely cooperate with a cam program groove 76 defined in the outer surface of the cam drum. Follower sleeve 70 cooperates with the cam drum via a similar pin and a second programming groove 77. The programming grooves extend for about 540°, (i.e., about 1-1/2 turns) about the circumference of the cam drum. Grooves 76 and 77 are cooperatively defined relative to each other to cause zoom lens sets 58 and 59 to move conjointly in the desired relationship along optical axes 24L and 24R to provide the desired zoom function throughout the desired magnification range (preferably 5X to 20X) in

1 viewer 10 and to keep the virtual images properly focused at
all times. The programming grooves are defined in the
periphery of cam drum 63 to compensate for the fact that the
zoom lens sets do not move parallel to the axis of rotation
5 of the cam drum.

Cam drum 63 is driven about its axis of rotation by a
reversible zoom drive motor 78 which is connected to the
upper end of the cam drum and is suitably mounted to the
base plate of the viewer; the base plate is the principal
10 structural frame of the viewer. It is preferred that
operation of the zoom drive motor is initiated and
controlled by the surgeon via foot control accessory 18 of
microscope support assembly 17.

FIGS. 4, 5 and 6 also illustrate a manual drive
15 mechanism for the zoom lens system as an alternate to the
power drive afforded by motor 78. In such an alternate
drive arrangement for the zoom lens system, a gear 79 is
secured to a lower mounting shaft 80 of the cam drum for
cooperation with a worm 81. The worm 81 is in turn secured
20 to a shaft 82 which is rotatably supported on the same
portion of the internal structure of the viewer which
carries a lower bearing for the cam drum. Shaft 82 extends
through a front face 83 of viewer housing 40 below rear
projection diffuser 41 where the shaft carries a manually
25 operable drive wheel or knob 84. A user of the viewer can
readily operate the zoom function of the viewer from his
viewing location.

It is also within the scope of this invention that both
power and manually operated drive mechanisms can be provided
30 within the viewer for operating the zoom lens system. If
both power and manually operated zoom drive arrangements are
provided, then the manually operated arrangement would
necessarily differ somewhat from the manually operated
arrangement described above. For example, rather than use a
35 worm on the manually driven shaft, the worm may be replaced

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1 by a bevel gear cooperating with a suitable gear carried by
the lower support shaft for the cam drum. The manually
driven shaft carrying the bevel gear could be spring loaded
so that the normal condition of the bevel gear is disengaged
5 from the gear carried by the cam drum shaft. To operate the
manual drive arrangement, a user of the viewer would simply
push on knob 84 to move the bevel gear into cooperation with
other gear and then operate the manual drive by turning the
knob.

10 The optical elements within viewer 10 are arranged to
cause left and right exit pupils, represented in FIG. 5 by
exit pupil 86, to be defined in viewing plane 25. Each exit
pupil is approximately 2-1/2 inches in diameter as compared
to the 5mm. exit pupil typically afforded by stereoscopic
15 microscopes. The left and right exit pupils, as defined in
viewing plane 25, are centered about 2-1/2 inches apart,
which distance is the average interpupillary distance in
humans. The left and right exit pupils are so defined in
viewing plane 25 that they do not overlap. Thus, a user of
20 viewer 10 can position his left and right eyes anywhere in
viewing plane 25 within that range of positions which causes
his left eye to be within the left exit pupil and his right
to be within the right exit pupil. When the viewer's head
is so positioned, he can observe suitably magnified virtual
25 images by looking at viewing mirror 38 in which he sees a
reflection of the left and right stereoscopically related
enlarged virtual images of the object of interest at area
23. The user of the viewer is not required to hold his head
virtually motionless at a narrowly defined, i.e., 5mm
30 diameter, location close to an eyepiece. Rather, the user
can sit comfortably back from the viewing mirror with his
head positioned in any comfortable attitude consistent with
the location of his left and right eyes in the viewing plane
within the left and right exit pupils. So long as the
35 viewer's eyes are positioned in the viewing plane within the

1 exit pupil areas, the user can observe an enlarged stereoscopic view of the object of interest.

Objective lens systems 45 are not adjustable in terms of focal length. Focusing of the viewer upon an object of
5 interest is achieved by locating the objective lens assemblies the proper distance from the object of interest. How this is accomplished will be set forth below in the description of illuminator 11.

The optics of viewer 10 are so defined that the
10 distance along optical axis 24 from viewing plane 25 to rear projection diffuser 41 via mirror 37, for most useful operating positions of the viewer, is substantially equal to the direct distance between the exit pupils and object area 23. This means that when a surgeon, for example, uses
15 viewer 10 in the course of performing a surgical operation and views the operation site through the viewer, the apparent distance from his eyes to the enlarged virtual images seen in mirror 37 is substantially equal to the true distance between his eyes and the surgical site. Therefore,
20 if the surgeon desires to shift his line of view from a line along optical axis 24 to a direct line of sight (represented in FIG. 5 by line 87), the surgeon experiences virtually no need for reaccommodation of his eyes for distance in shifting his gaze between the viewer virtual images and the
25 object. Thus the surgeon, for example, can look back and forth between the true surgical site and the enlarged view of the surgical site as often as he pleases, each view coming into focus virtually instantaneously. In this further way, use of viewer 10 reduces fatigue and strain in
30 the user and increases the user's efficiency in performing the operation or procedure of interest at the object area.

Viewing mirror 37 preferably is carried in the central portion of a glass plate which is defined as a neutral density filter. It is preferred that when the viewer 10 is
35 in use, plate 38 is angularly adjusted relative to the

1 viewer housing to cause the user's direct line of sight 87
(see FIGS. 2 and 5) from exit pupils 86 to the object area
to pass through a portion of plate 38 which is not covered
by viewing mirror 37. Thus, in looking from the viewing
5 mirror to the actual object along line 87, the viewer's line
of sight passes through the neutral density filter of plate
38. The result is that the brightness of the true object
seen along line 87 is approximately the same as the
brightness of the virtual images seen via mirror 37. In
10 shifting their gaze between the enlarged virtual images and
the true object, the eyes of a user of the viewer need not
reaccommodate for brightness. In this further way, viewer
10 is constructed to maximize the flexibility and comfort of
a user and to optimize the efficiency with which the user
15 performs the tasks of interest at the object area.

As noted above, the connection of plate 38 with mirror
37 to housing 40 is via a hinge connection 39. The hinge
connection is not a loose connection; rather, it is a stiff
connection which makes it possible for the user, with modest
20 force, to adjust the position of the plate angularly
relative to the viewer housing, and in which the plate
maintains its adjusted position once the user removes his
hands from the plate.

The brightness of the virtual images seen by a user in
25 mirror 37 can be adjusted by user operation of the iris
diaphragm mechanisms 49 incorporated within objective lens
systems 45 of the viewer, or by the use of suitable neutral
density filters in illuminator 11. In this way, a user of
the viewer can adjust the brightness of the virtual images
30 in any way desired relative to the brightness of the true
object, whether or not the true object is seen through a
margin of plate 38.

Illuminator 11 shown in FIGS. 10 through 13 is
supported from overhead by support arm 15 of microscope
35 support assembly 17. The illuminator in turn provides

1 support for viewer 10. The illuminator also provides the
source of illumination of object area 23 upon which viewer
10 is focused; it also as incorporates additional
accessories, such as reticles and filters, for use with the
5 viewer. As previously noted, the illuminator can also
provide support for other optical accessories, such as a
stereo microscope, a television or still camera, or a
surgical laser which can be used, as appropriate, with
viewer 10.

10 Illuminator 11 has a substantially closed housing 90
composed of a top plate 91, a bottom plate 92, a movable
front side plate 93 with which viewer 10 is associated, a
back side plate 94 and left and right end plates 95 and 96,
respectively (see FIG. 11). The front and rear surfaces of
15 the illuminator converge toward each other proceeding
downwardly along the height of the illuminator, as shown
best in FIGS. 12 and 13. The front plate 93 of the
illuminator housing is heavy relative to the back plate 94.
The front plate occupies the majority of the front surface
20 area of the illuminator housing and is vertically movable
relative to the remaining structure of the illuminator
housing. The base plate of the viewer is adapted to be
connected directly to the illuminator front plate,
preferably by a single large-headed projection carried by
25 the base plate of the viewer and cooperating with a suitable
slot in an upper portion of the illuminator front plate and
also by screws adjacent the lower margin of the illuminator
front plate (see FIG. 12). As shown in FIG. 11, the side
edges of the illuminator front plate 93 are beveled, as at
30 97, so that the entire illuminator front plate is the male
element of a dovetail sliding connection, the female
elements of which are defined adjacent the front left and
right corners of the illuminator housing as by elements 98
and flanges 99 along the edges of end plates 95 and 96. A
35 pair of identical racks 100 are secured to the inner surface

1 of the front plate parallel to and adjacent to the beveled dovetail surfaces 97 (see FIG. 11). Each rack cooperates with a gear 101. Gears 101 are affixed to a common shaft 102 which is disposed parallel to the illuminator front plate within the illuminator housing. The opposite ends of shaft 102 are rotatably mounted in suitable bearings 103 which are in turn mounted in bearing carriers 104 suitably affixed to the illuminator end plates 95 and 96.

Adjacent one of its ends within the illuminator housing 10 (the right end as seen in FIG. 11), shaft 102 also carries a worm gear 105 which is in turn engaged with a worm 106. The worm is mounted to the upper end of a vertically disposed rotatable shaft which is suitably supported in the illuminator and to which is mounted a driven gear 108 which is meshed with a drive gear 109. The drive gear is affixed to the output shaft of a focus drive motor 110 which is suitably supported within the illuminator housing. Operation of focus drive motor 110 preferably is initiated and controlled by surgeon 12 via foot accessory 18 of microscope support assembly 17 (see FIG. 1). Motor 110 is reversible. It is apparent, therefore, that when motor 110 is operated, shaft 102 is turned in one direction or other to cause the illuminator front plate, and viewer 10 mounted to it, to be moved up or down along the viewer optical axis 24 which is parallel to the illuminator front plate. In this way, the viewer is moved bodily along its optical axis relative to the illuminator (typically the viewer is only roughly positioned by adjustment of support arm 15) to cause the objective lens system 45 of the viewer to focus upon the desired object in object area 23 and to cause the viewer objective lens system to create a real image 58 at the entrance pupil in each of the projection lens assemblies 50 within viewer 10.

As shown in FIG. 11, the bearing carriers associated with focusing mechanism shaft 100 are mounted at coaxially

1 aligned openings 112 in the upper front corners of the illuminator end plates. It was noted above that, if desired, illuminator 11 can be defined to mount a pair of viewers 10. Accordingly, the illuminator rear plate 94 is
5 removably mounted to rear flanges 113 of the end plates and the end plates define additional apertures 114 at mirror image locations of apertures 112; apertures 114 are closed by standby bearing carriers 115 or dummies of them. Thus, illuminator 11 can readily be adapted for use with a second
10 viewer by removing rear plate 94, by substituting for it a duplicate of front plate 93 (with dovetail keeper strips 98) and by the addition to the illuminator of a second focus drive mechanism composed of equivalents of elements 100 through 110 as described above.

15 Illuminator 11 includes a light source and means for projecting light from that source in a focused beam to object area 23. Accordingly, a projection lens assembly 118, which includes a series of projection lenses suitably mounted in a support tube 119, is mounted to the bottom
20 plate 92 of the illuminator in alignment with optical axis 22 of the illuminator. Support tube 119 extends below the housing bottom plate. As shown in FIG. 10, above the upper end of the projection lens support tube, optical axis 22 passes through a field lens 120 to a mirror 121 from which
25 the optical axis proceeds laterally through the filament 122 of a lamp 123. The lamp is a component of a light source 124 which also includes a concave reflector 125 located on optical axis 22 behind the lamp. A collector lens 126 is disposed across the optical axis for directing light
30 reaching it directly from the filament and indirectly from mirror 125 to the field lens via mirror 121. An infrared absorbing filter 127 is disposed across the optical axis between lens 126 and mirror 121. If desired, mirror 121 can be a photopic dichroic mirror, i.e., a cold mirror which
35 allows infrared radiation to pass through it and which

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1 reflects visible light along the optical axis to the field lens. Also, the reflector mirror 125 located behind lamp 123 can be and preferably is a cold mirror which passes infrared radiation through it to a chimney 128 carried by
5 the housing left end plate 95 behind the mirror. Lens 126, mirror 121 and field lens 120 are arranged to define a real image of filament 122 in the plane of a reticle wheel 130 which is disposed normal to optical axis 22 immediately below field lens 120 so that a portion of the reticle wheel
10 extends across the optical axis.

Inasmuch as viewer 10 is an embodiment of this invention adapted for use in connection with surgical procedures, illuminator 11 includes means which enables lamp 123 to be changed quickly in the event that it should burn
15 out in the course of a surgical procedure. Accordingly, as shown in FIGS. 10 and 13, illuminator 11 includes a standby lamp 132 which, with primary lamp 123, is supported on a carrier plate 133. Each of lamps 123 and 132 is disposed centrally behind a corresponding aperture 134 through the
20 carrier plate. The opposite vertical edges of the carrier plate are received in cooperating ones of a pair of rail members 135 which are mounted at their upper ends to illuminator top plate 91 adjacent an opening 136 through the top plate. The carrier plate extends through opening 136 to
25 its upper end which is configured as a handle 137. In the event that primary lamp 123 burns out, handle 137 is grasped so that the carrier plate can be pulled upwardly to raise carrier plate 133 in the rails sufficiently to place the filament of standby lamp 132 on optical axis 122. Each lamp
30 has its terminal pins engaged in a suitable socket 139; respective ones of a pair of conductive contact elements 140 are other components of each socket and are conductively coupled to respective ones of the lamp terminal pins via the socket. Contact members 140 are disposed to either side of
35 the corresponding lamp near the rail members. One of a pair

1 of conductive spring contact members 141 is suitably carried
in a non-conductive manner by each rail for engagement with
the adjacent one of whichever pair of contact members 140 is
associated with the lamp having its filament disposed on
5 optical axis 22. Hot and common power conductors are
connected to respective ones of contacts 141 to provide
energization of the lamp disposed on the optical axis upon
closure of an ON-switch (not shown) for the illuminator.

A notch is formed in one of the edges of carrier plate
10 133 adjacent the filament location of each of lamps 123 and
132. A hole 143 is formed through the adjacent rail 135 to
register with the notch associated with the lamp which is
positioned at the illuminator optical axis. A retractable
detent pin 144 is extendable through hole 143 into registry
15 with the adjacent carrier plate notch to lock carrier plate
in either its upper (primary) or its lower (standby)
operative positions relative to the illuminator housing. As
shown in FIG. 11, detent pin extends through the adjacent
illuminator end plate 95 where it carries a manually
20 engageable knob 145. Pin 144 is biased by a spring 146 into
detenting engagement with one or the other of the marginal
notches of lamp carrier plate 133.

In the event that primary lamp 123 should burn out
during the course of use of illuminator 11, the standby lamp
25 can be brought into operative position within the
illuminator simply by pulling on knob 145 to disengage the
inner end of detent pin 144 from the carrier plate notch
adjacent the primary lamp and then by pulling upwardly on
the handle at the upper end of carrier plate 133. In this
30 way, the standby lamp is moved into operative position and
is automatically brought into the lamp energization circuit.
When the standby lamp has been brought to the appropriate
place, it is secured there as the detent pin snaps into
engagement with the lower detent notch under the urging of
35 bias spring 146. Similarly, the carrier plate can be

1 removed from the illuminator by once again disengaging
detent pin 144 from the lower detent notch and pulling the
entire carrier plate out of the illuminator through opening
136. In this way, the burnt out lamp can be replaced and
5 the lamp carrier reinserted into the illuminator.

The opening 136 in the illuminator top plate through
which the lamp carrier plate extends preferably is circular.
A light and heat deflecting shroud 148 is carried by the
upper end of lamp carrier plate 133 below handle 137 and
10 above the illuminator top plate when the lamp carrier is in
its primary rather than standby position within the
illuminator. Accordingly, air heated by operation of the
operative lamp can flow upwardly out of the illuminator
through opening 136 past shroud 148. Further cooling of
15 light source 124 is provided by a cooling fan 149 (see FIG.
10) located below the lowermost position of the lamp carrier
plate and driven by a motor 150 suitably mounted to the
illuminator bottom plate. Ambient air is drawn into the
interior of the illuminator by fan 149 through an air inlet
20 opening 151 formed through the adjacent illuminator side
wall 95 adjacent the lower end of the illuminator housing.

Illuminator 11 includes the capability of projecting to
object area 23 a focused image of a suitable reticle
arrangement. In the context of surgical procedures, a
25 useful reticle arrangement might be a grid of lines along
which an ophthalmologist would make incisions in the human
eye in the course of performing a radial keratotomy
procedure. Thus, before such an operation, the
ophthalmologist could lay out the precise arrangement of
30 incisions to be made during a radial keratotomy procedure
and could have a suitable reticle transparency constructed
for use in the illuminator during the particular procedure
of interest. More commonly however, if the illuminator is
used regularly by an ophthalmologist for such surgical
35 procedures, the illuminator can include a series of

1 reticles from which the ophthalmologist can select the
reticle arrangement suitable, or most suitable, for the
procedure at hand. These benefits and advantages of
illuminator 11 are provided in the context of reticle wheel
5 130 which, as noted before, is disposed normal to optical
axis 22 below field lens 120 at the location where the field
lens focuses a real image of lamp filament 122. The reticle
wheel extends partially across the optical axis below the
field lens. As shown best in FIG. 11, a plurality of
10 openings 154 are provided through the reticle wheel at
regularly spaced locations inwardly from the periphery of
the wheel at such positions that the openings can be
centered on optical axis 22. A suitable glass element or
optical transparency carrying a suitable reticle grid is
15 carried in each of openings 154. While twelve openings 154
are shown in reticle wheel 130, any suitable number of
openings can be provided. The same is true with respect to
filter wheel 164.

The reticle wheel has an axis of rotation 155 which is
20 parallel to optical axis 122 at the location of the field
lens, the reticle wheel has a central hub 156 to which a
driven bevel gear 157 is mounted. Hub 156 and bevel gear
157 are mounted for rotation about a shaft 158 which defines
axis 155. Driven bevel gear 157 is meshed with a drive
25 bevel gear 159 carried at the inner end of a reticle drive
shaft 160 which extends through illuminator housing end wall
96 where it is coupled to a reticle actuator knob 161.
Thus, a user of the illuminator need rotate knob 161 to turn
the reticle wheel to place a desired reticle at the focus of
30 field lens 120 on illuminator optical axis 22. The image of
the selected reticle will be projected on the object of
interest in object area 23 during use of the illuminator.

Illuminator 11 also includes a filter wheel 164 which
is or can be physically identical to reticle wheel 130 and
35 which is located immediately below the reticle wheel for

1 rotation about axis 155. Suitable colored, neutral density
or other filter elements can be mounted in the openings
formed through the filter wheel. The filter wheel is
secured to the lower end of shaft 158 which, as described
5 above, forms the axle about which the reticle wheel is
rotatable. Shaft 158 is rotatably mounted in suitable
brackets within the illuminator and carries at its upper end
a driven gear 165 which is meshed with a drive gear 166
carried on the lower end of a filter drive shaft 167 which
10 extends through the illuminator top plate. A manually
engageable filter drive knob 168 is secured to the upper end
of shaft 167 outside the top of the illuminator.

It will be understood that, if desired, reticles can be
carried in filter wheel 164, and filters can be carried in
15 reticle wheel 130.

As shown in FIGS. 10, 14 and 15, illuminator 11 is
coupled to support arm 15 of microscope support assembly 17
through connection 20 which includes a manually operable
tilt adjustment mechanism. The tilt adjustment mechanism
20 can be operated to cause the illuminator to swing about a
pivot axis located closely above the illuminator top plate
and parallel to the plane of the illuminator front plate.

As shown in FIG. 15, a mounting flange 170 is defined
at the lower end of a pivot bracket 171. The pivot bracket
25 is affixed to the illuminator top plate, as by bolts passed
through flange 170. A pivot pin 172, which defines the
pivot axis for the illuminator, passes rotatably through
bracket 171 above flange 170 and is connected at its
opposite ends to a hollow hanger housing 173. The upper end
30 of the hanger housing carries a fitting 174 suitable for
releasable engagement in a cooperating device carried at the
outboard end of microscope support arm 15 (see FIG. 1). The
tilt adjustment mechanism is operated by manually turning a
tilt drive knob 175 located outside the hanger housing and
35 connected inside the housing to a drive bevel gear 176.

1 Gear 176 is meshed with a driven bevel gear 177 which is
secured on an upper shaft 178 which is rotatably mounted in
the hanger housing for rotation about an axis which is
perpendicular to the axis about which the drive knob is
5 rotatable. A corresponding one of a pair of drive gears 179
is affixed to shaft 178 adjacent each of its opposite ends.

Each drive gear 179 is meshed with a driven gear 180
which is fixed to the adjacent end of a second shaft 181
also rotatably mounted in the hanger housing parallel to
10 shaft 178. The central portion of shaft 181 is externally
threaded to cooperate with an internally threaded nut 182
which defines diametrically opposed outwardly projecting
cylindrical projections 183 which are engaged in a yoke
configuration defined at the upper end of pivot bracket 171.
15 Thus, as knob 175 is turned, shaft 181 is turned by the
cooperation of gears 176, 177, 179 and 180. As shaft 181
rotates, nut 182 is prevented from rotation with the shaft
by virtue of the cooperation of its projections in the yoke
configuration at the upper end of the pivot bracket.
20 Accordingly, nut 182 moves axially along shaft 181 as the
shaft turns. Axial motion of the nut produces angular
motion of the pivot bracket about pin 172, thereby providing
the desired tilting movement of the illuminator to which the
lower end of the pivot bracket is securely affixed.

25 Another viewer 190 according to this invention is shown
in FIG. 16. Viewer 190 is shown with its input optical axis
191 directed to an object 192 to be presented in magnified,
stereoscopically-related virtual images at a viewing surface
193 of the viewer. Viewer 190 has objective lens means 194
30 which cooperate with internal optics (not shown) to cause
the desired stereoscopically-related, left and right
virtual images to be presented at the viewing surface. The
optics within viewer 10 cause those virtual images to be
observable at left and right exit pupils 195 located in a
35 viewing plane 196 spaced from the viewing surface as shown

1 in FIG. 16. As with viewer 10 described above, exit pupils
195 are centered approximately 2-1/2 inches apart and
preferably have non-overlapping diameters substantially
greater than 5 mm up to about 2-1/2 inches. The optical
5 elements within viewer 190 include, if desired, suitable
zoom lens systems together with optical elements for
projecting the real image developed by objective lens
assembly 94 on the viewing surface and for folding the
optical axis of the viewer suitably to enable presentation
10 of the magnified virtual images at the viewing surface.

The viewing surface of viewer 190 preferably is defined
by a high gain rear projection diffuser similar to diffuser
41 of viewer 10 and with which may be associated a fresnel
lens similar to lens 42 of viewer 10. Viewers 10 and 190
15 have the common feature that they provide a long eye relief
characteristic, i.e., there is a substantial distance
between the viewing plane and the virtual images to be
viewed. However, viewer 190 does not include a mirror, with
the result that a user of viewer 90 must look directly to
20 the diffuser where the virtual images are presented rather
than indirectly to such diffuser via a mirror like mirror 37
of viewer 10. Therefore, as seen from an inspection of FIG.
16 as compared to FIG. 5, for example, the apparent distance
between viewing plane 196 and viewing surface 193 for viewer
25 190 is not substantially equal to the distance from the
center of the exit pupils in viewing plane 196 direct to
object 192. However, the distance from viewing plane 196 to
the viewing diffuser is a substantial portion of the
distance along a direct sight line from the viewing plane to
30 the object, and so distance reaccommodation of a user's eyes
is minimized as he shifts his gaze between direct and
enlarged views of the object. Thus, while viewer 190
presents considerable advantages over conventional
stereoscopic microscopes having short eye relief eyepieces
35 and very small exit apertures, it is believed that viewer 10

1 represents a greater advance over the state-of-the-art than viewer 190. That is, while both viewers 10 and 190 are within the scope of this invention, viewer 10 is presently preferred because it has the capability of causing the
5 virtual images seen via mirror 37 to appear to be the same distance from the observer as the object upon which the viewer is focused. This characteristic of viewer 10 means that, in shifting his eyes between the viewing surface and the real object, the eyes of a user of viewer 10 do not need
10 to significantly reaccommodate for distance. Also, as distinguished from the case with viewer 10, when user of viewer 190 shifts his line of sight between viewing surface 193 and object 192, his eyes may also need to undergo substantial reaccommodation for brightness.

15 Also, viewers 10 and 190 provide the advantage that a user of the viewer can wear any corrective spectacles he may desire, including spectacles for correcting for astigmatism.

An industrial version of viewer 10, for example, might include a fixed magnification projecting lens system
20 rather than a variable magnification, i.e., zoom projection lens system.

The preceding description of a presently preferred and other embodiments of this invention has been set forth for purposes of illustration and exposition rather than for
25 purposes of limitation or precise definition of all forms in which this invention may be embodied. The preceding description is not an exhaustive catalog of all arrangements by which this invention can be embodied. The foregoing descriptions and the accompanying drawings directed to one
30 skilled in the art to which the invention pertains and are to be read as exemplary and supportive of the broad scope of this invention consistent with the fair meaning of the following claims.

1 WHAT IS CLAIMED IS:

1. A stereoscopic magnifying viewer comprising
 - A. magnifying lens means including an
5 objective lens assembly focusable upon an object outside the viewer,
 - B. viewing surface means,
 - C. a frame, and
 - D. mounting means mounting the lens means and the
10 viewing surface to the frame in that order along an optical axis in such cooperative relation to each other 1) to define left and right optical axes in the viewer between the objective lens assembly and an exit pupil and 2) to define in a viewing plane
15 at the exit pupil left and right, stereoscopically related viewing areas a) which are centered substantially 2.5 inches apart, b) which are substantially greater than 5mm. in diameter and do not overlap, and c) at which a user can visually
20 observe, via the viewing surface means, enlarged stereoscopic virtual images of an object outside the viewer upon which the objective lens assembly is focused,
 - E. the lens means being defined so that the distance
25 from the viewing plane to the virtual images along the optical axes is a substantial portion of the distance directly to the object from the viewing plane, whereby a user of the viewer can efficiently shift his view between the virtual images and the
30 object.
2. Apparatus according to claim 1 wherein the object is a three-dimensional object.
- 35 3. Apparatus according to claim 2 wherein the viewing

1 surface means comprises a mirror.

4. Apparatus according to claim 3 including a rear
projection diffuser at which the virtual images are
5 generated, the mirror being located along the optical axes
between the diffuser and the viewing plane so that the
virtual images are observable from the viewing areas via the
mirror.

5. Apparatus according to claim 4 wherein the position
10 of the mirror relative to the diffuser is user-adjustable
for adjustment of the location of the viewing plane and the
viewing areas relative to the diffuser.

6. Apparatus according to claim 3 including means for
15 positioning the mirror relative to the viewing areas so that
the mirror is disposed proximally adjacent lines directly
from the viewing areas to the object.

7. Apparatus according to claim 6 wherein the mirror
20 is carried on a transparent plate inwardly of an edge of the
plate, and the means for positioning the mirror is operable
to cause lines direct to the object from the viewing areas
to pass through a portion of the plate not occupied by the
mirror.

25

8. Apparatus according to claim 7 wherein said portion
of the plate defines a filter.

9. Apparatus according to claim 8 wherein the filter
30 is a neutral density filter.

10. Apparatus according to claim 9 wherein the filter
is defined to cause the object when viewed directly
therethrough to have an apparent brightness substantially
35 the same as the brightness of the virtual images when viewed

1 via the mirror.

11. Apparatus according to claim 3 including means operable for adjusting the brightness of the virtual images.

5

12. Apparatus according to claim 2 wherein the magnifying lens means includes zoom lens means operable for altering the magnification of the object as imaged at the virtual images.

10

13. Apparatus according to claim 12 including power means for operating the zoom lens means.

14. Apparatus according to either one of claims 12 or 13 including manually operable means for operating the zoom lens means.

15. Apparatus according to claim 12 wherein the zoom lens means is located in that portion of the viewer in which the optical axis is composed of left and right axes and comprises left and right zoom lens systems, in which the left and right axes are not parallel to each other, and including means common to the left and right zoom lens systems for operating those systems in synchronism.

25

16. Apparatus according to claim 15 wherein each zoom lens system includes, as corresponding elements, at least one movable lens, and the means common to the zoom lens systems comprises a movable cam member, a movable cam follower operatively engaged with the cam member, and means coupling the cam follower to the corresponding movable lenses for moving said lenses along the respective optical axes in response to movement of the cam follower.

17. Apparatus according to claim 1 including means

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1 mounting the viewer for movement thereof toward and away
from the object in a plane parallel to the viewer optical
axis as defined at the objective lens assembly.

5 18. Apparatus according to claim 17 wherein the viewer
mounting means includes an illuminator operable for
illuminating the object, viewer support means in the
illuminator for supporting the viewer in the illuminator,
and means for moving the support means in the viewer.

10

19. Apparatus according to claim 18 wherein the
illuminator includes reversible power means operable for
moving the viewer support means.

15 20. Apparatus according to claim 1 including an
illuminator adapted to be connected to the viewer in a
predetermined relation of the viewer to the illuminator, and
wherein the illuminator includes a light source and lens
means for directing light from the source to the object.

20

21. Apparatus according to claim 20 wherein the
illuminator lens means defines an illuminator optical axis,
and said predetermined relation of the viewer to the
illuminator is one which causes the viewer and illuminator
25 optical axes to substantially intersect.

22. Apparatus according to claim 21 including view
focus means comprising means operable for moving the viewer
relative to the illuminator while maintaining said
30 predetermined relation of the viewer to the illuminator.

23. Apparatus according to claim 20 wherein the
illuminator includes means associated with the light source
for projecting an image of a selected reticle to the object.

35

1 24. Apparatus according to claim 20 wherein the
illuminator includes means for mounting to the illuminator,
separately from but in a selected relation to the viewer, an
optical device in such manner that the device optics are
5 directed toward the object.

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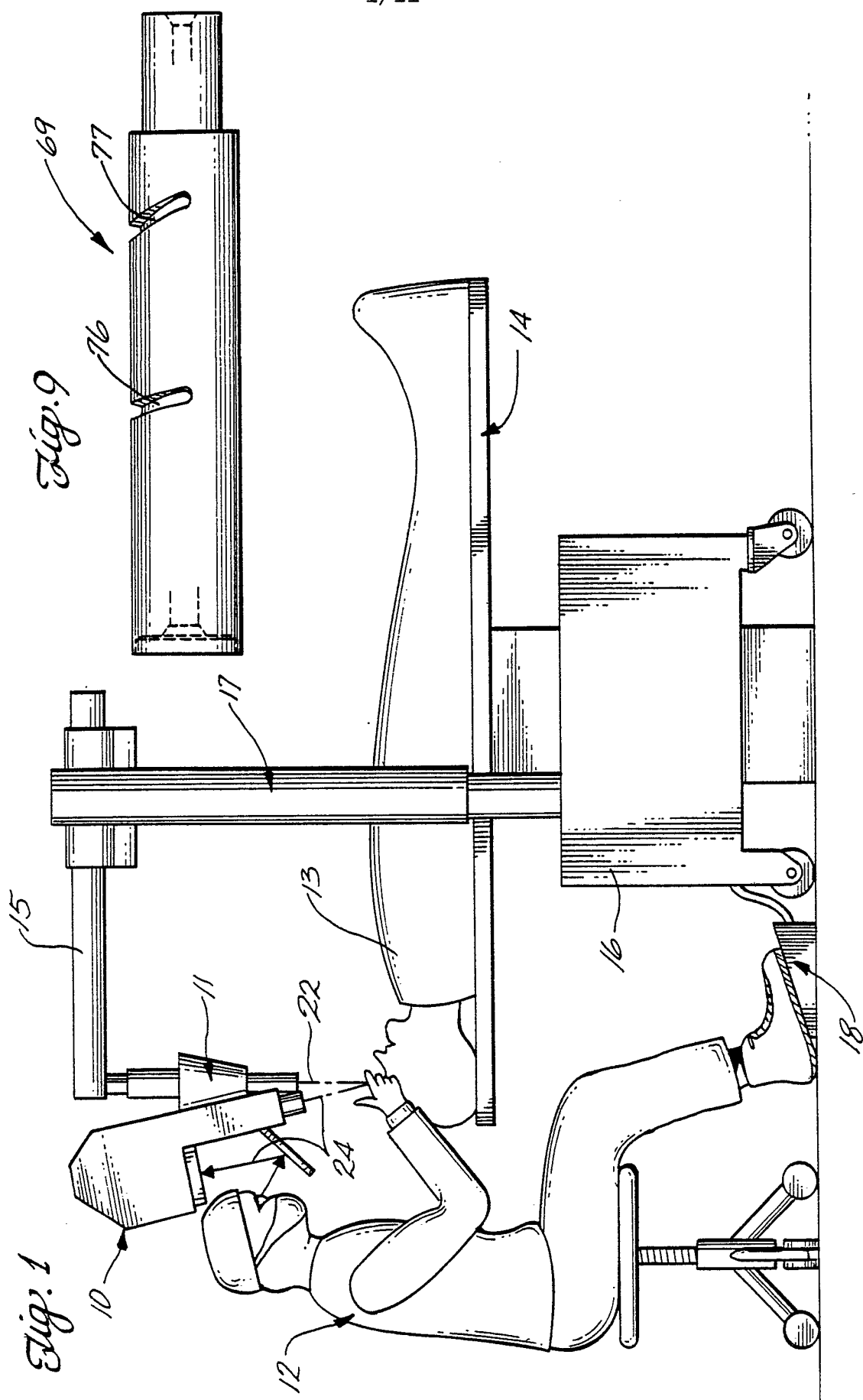


Fig. 3

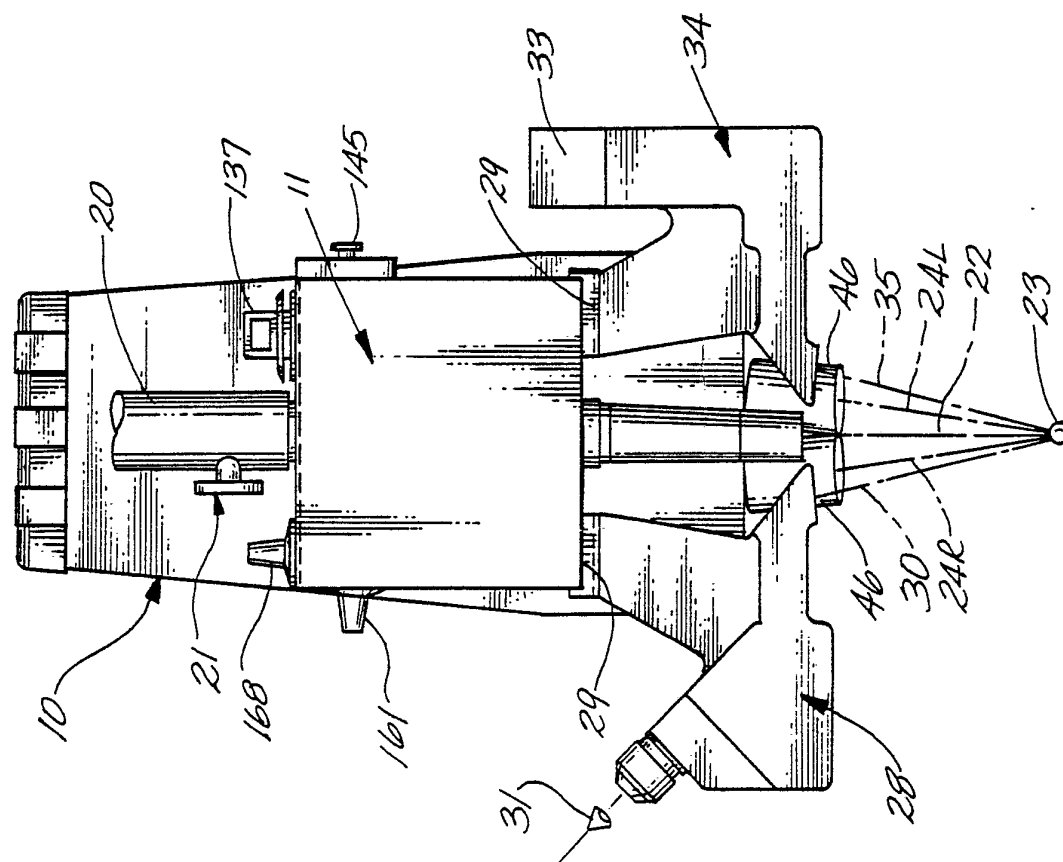
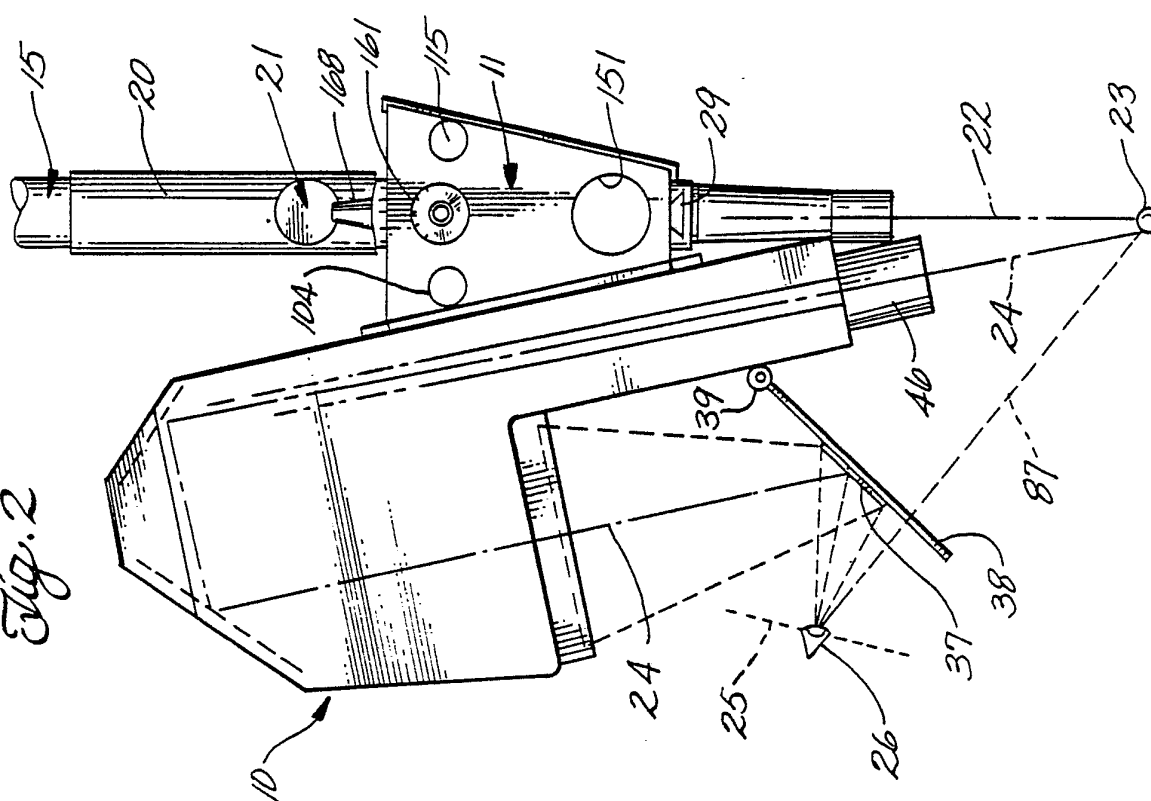


Fig. 2



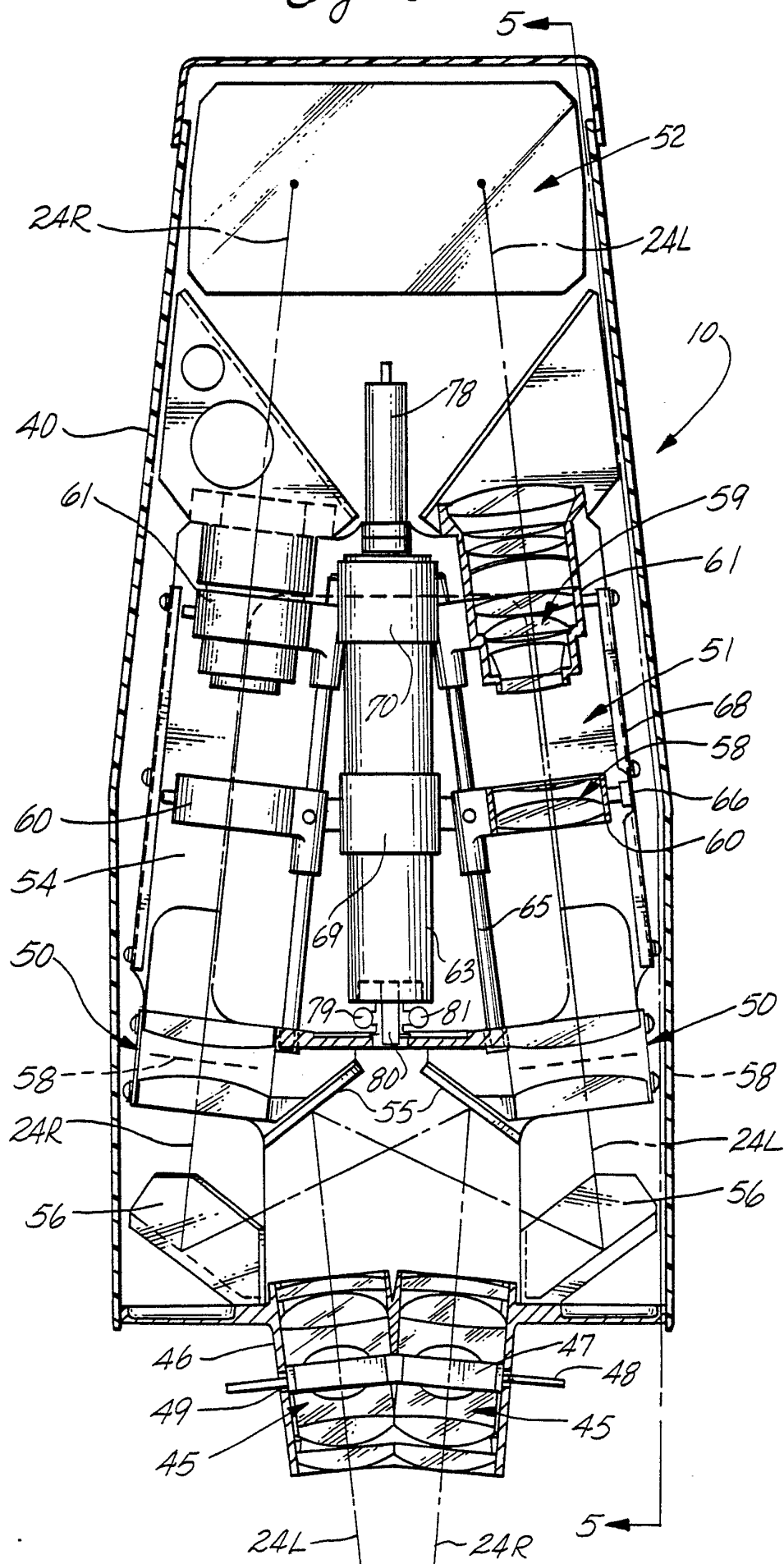
3/11
Fig. 4

Fig. 5

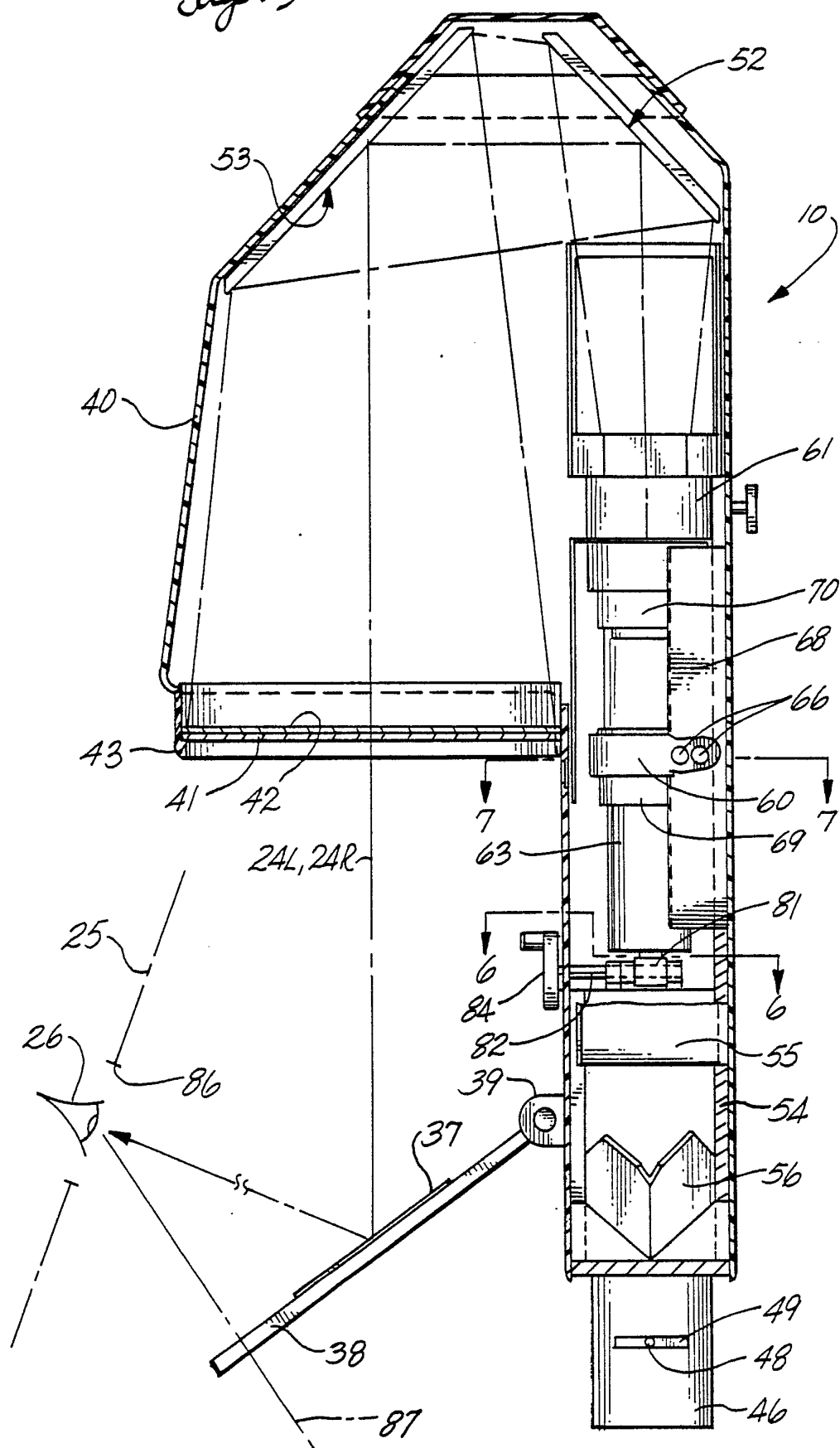


Fig. 6

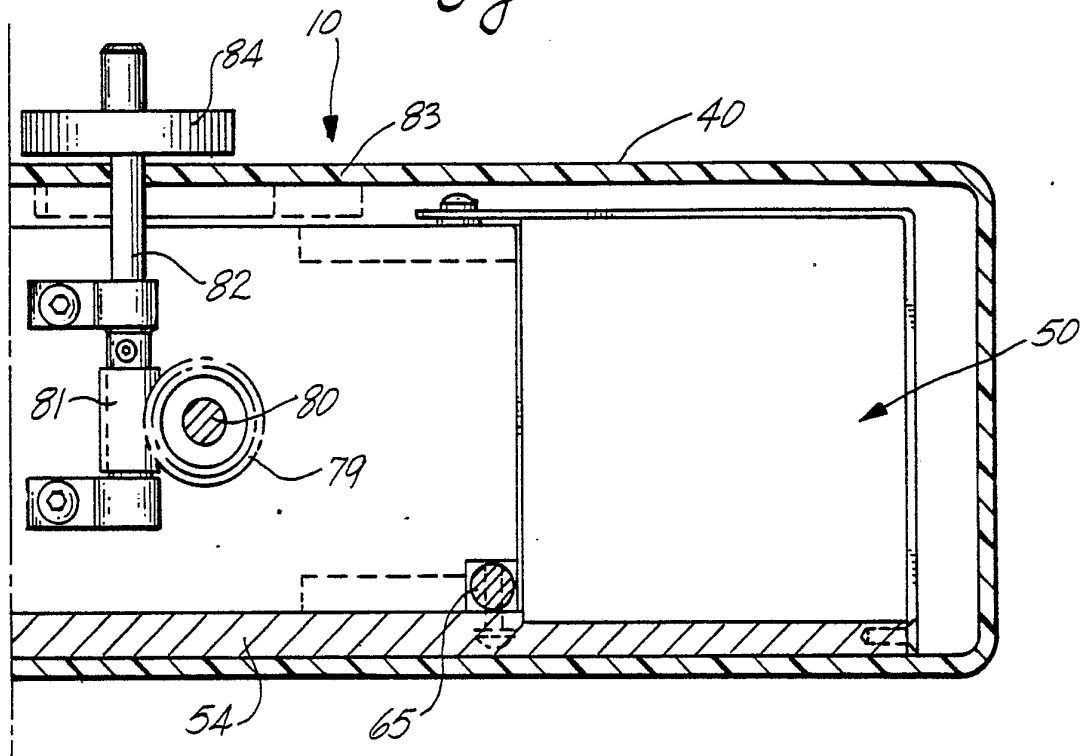
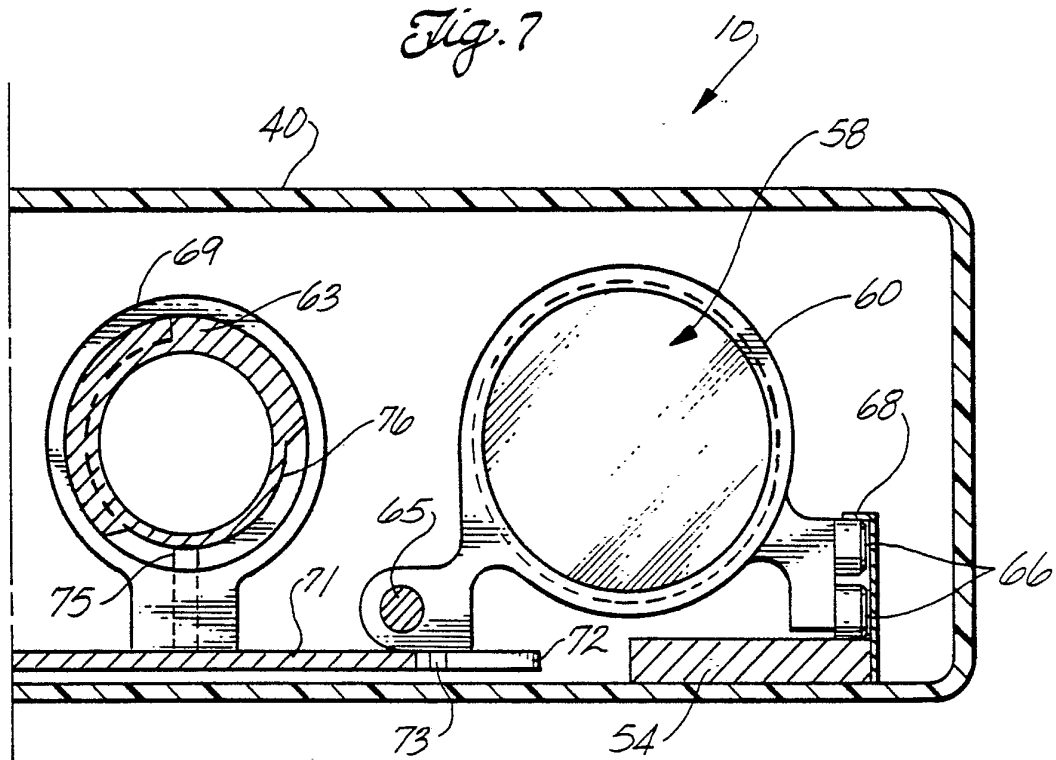
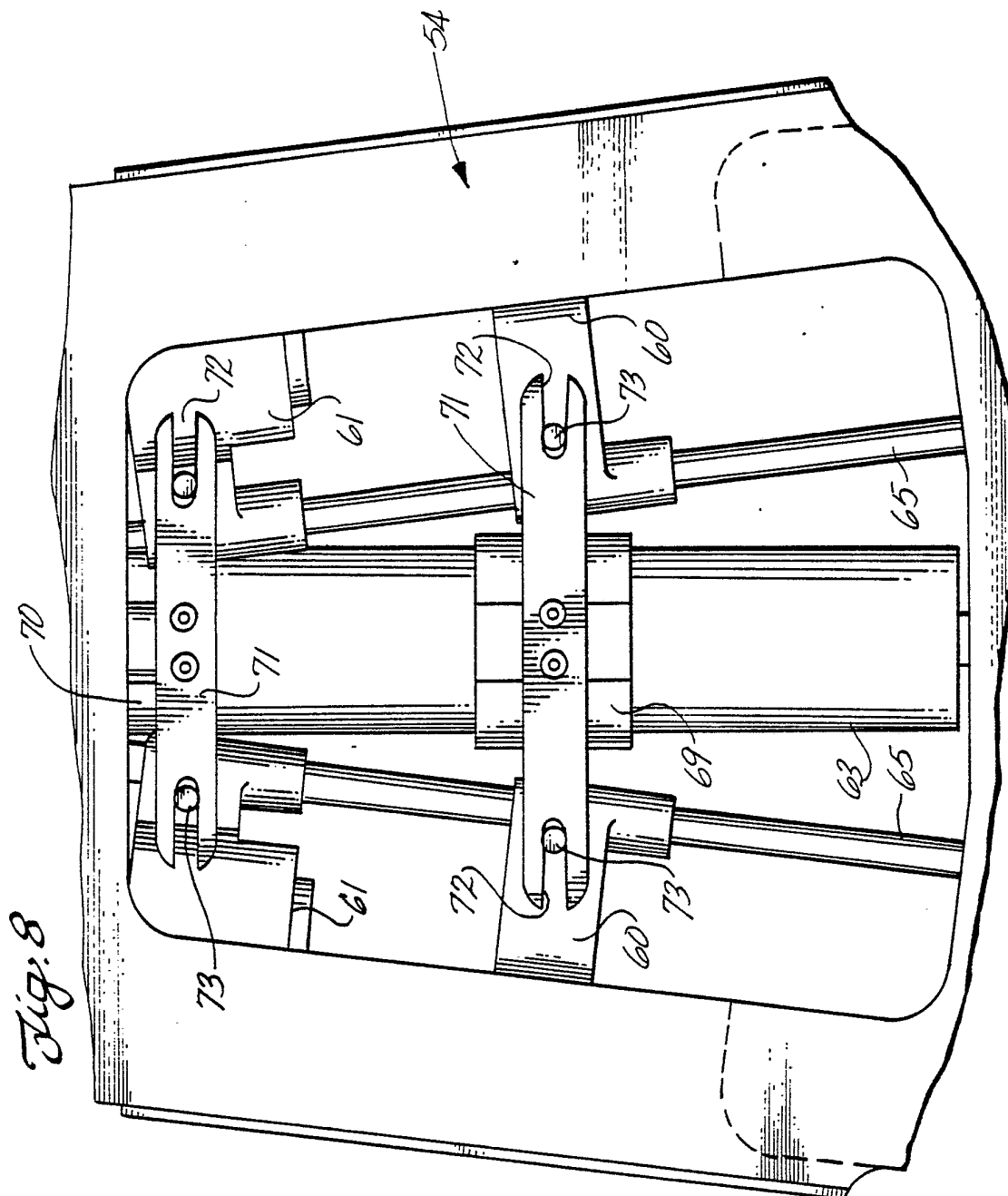


Fig. 7





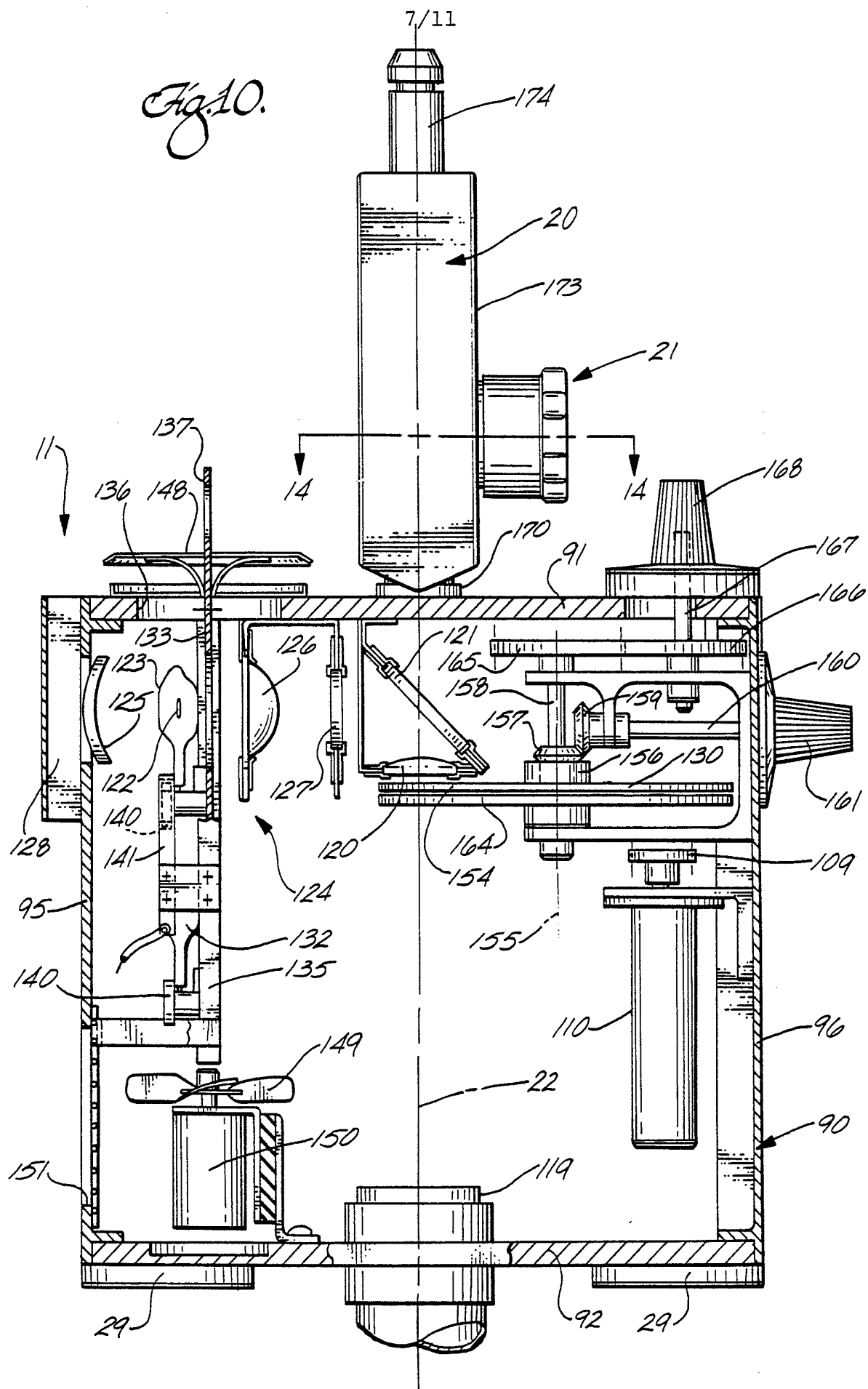
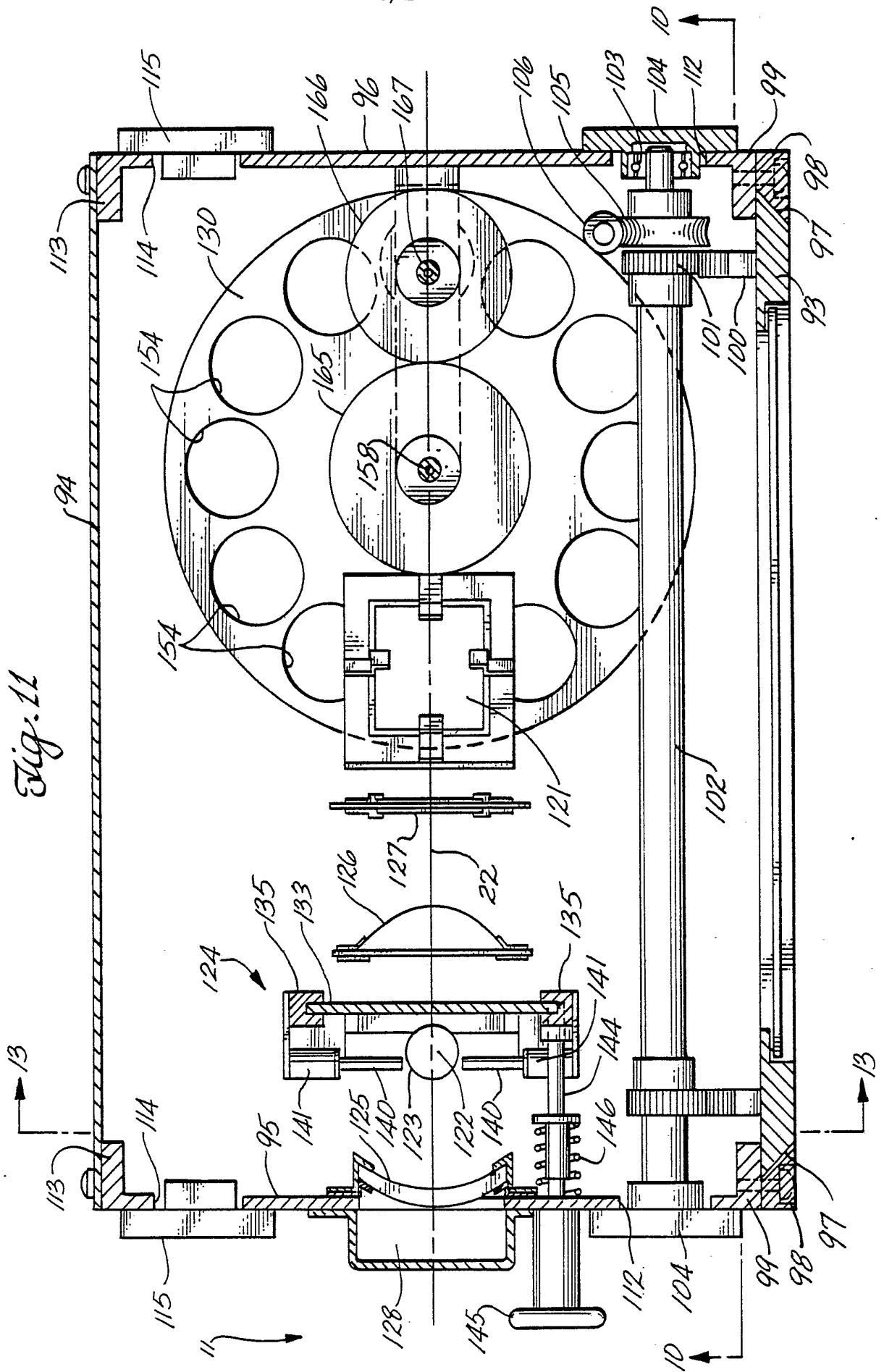
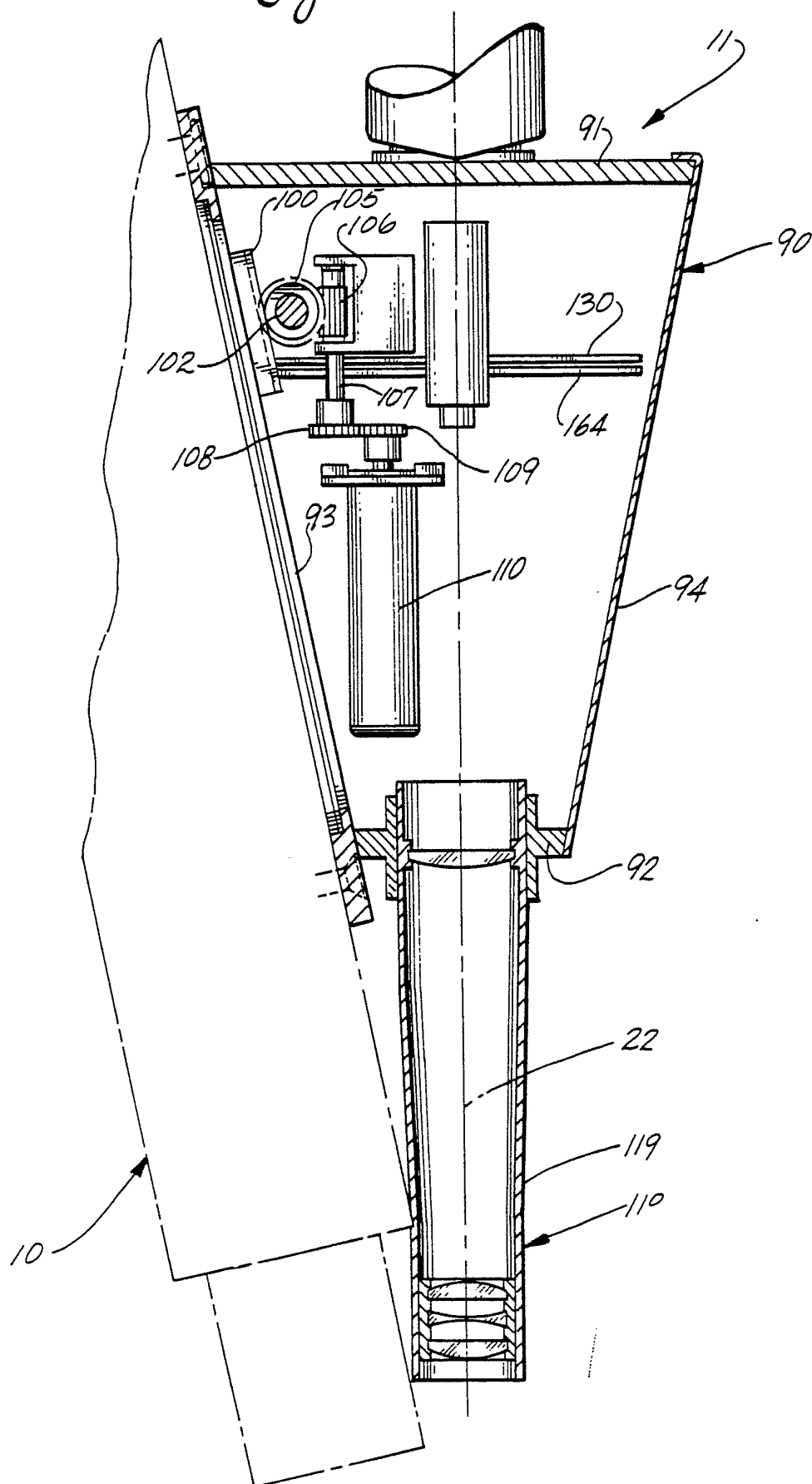


Fig. 11

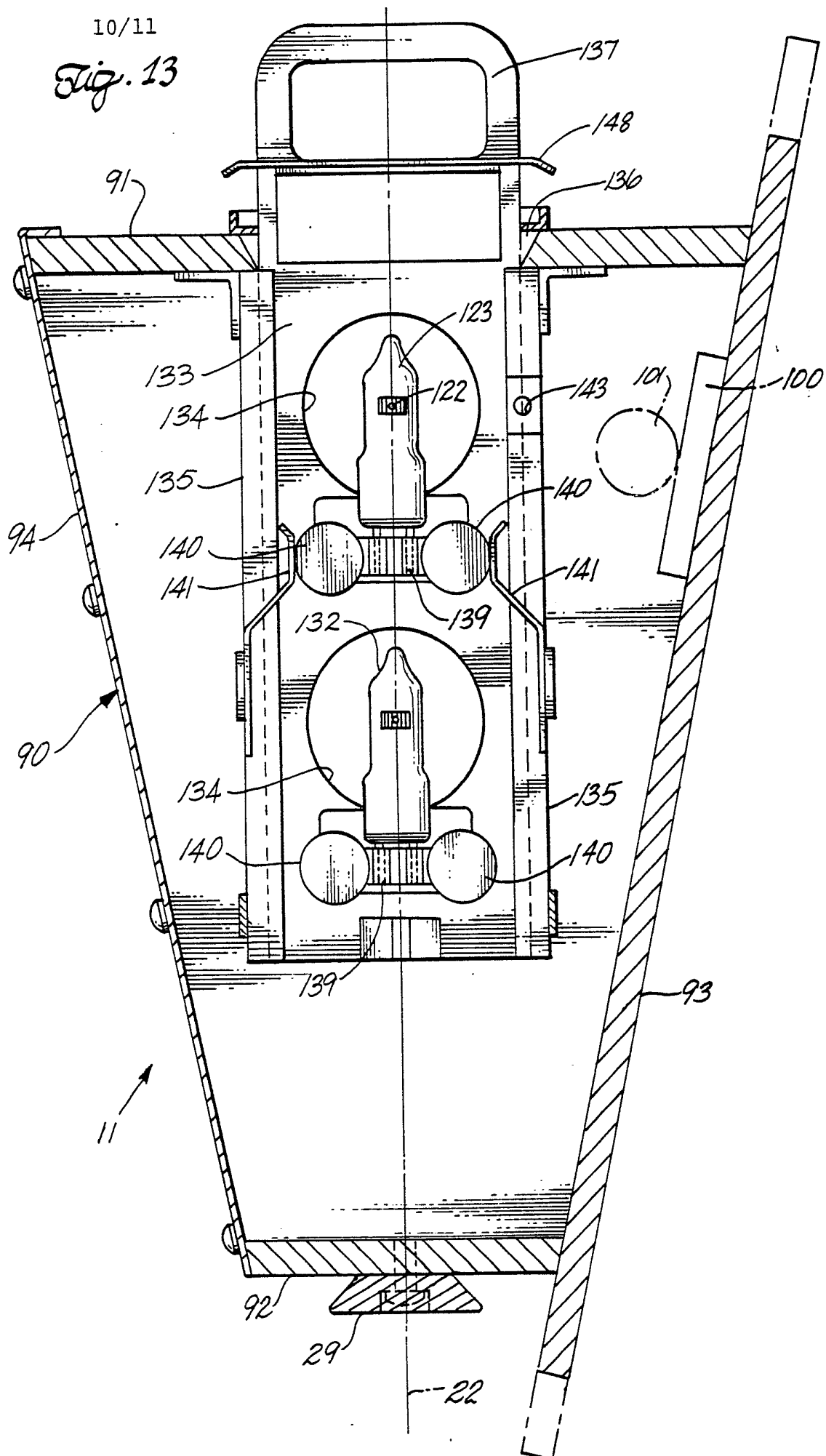


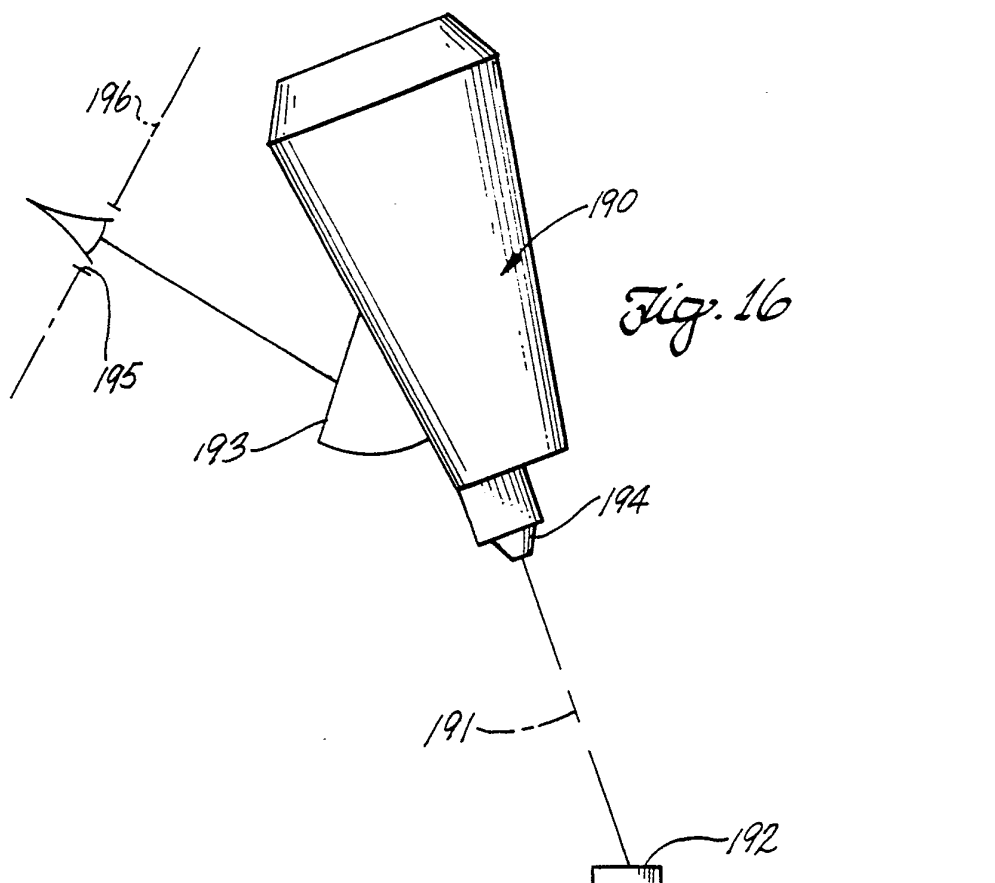
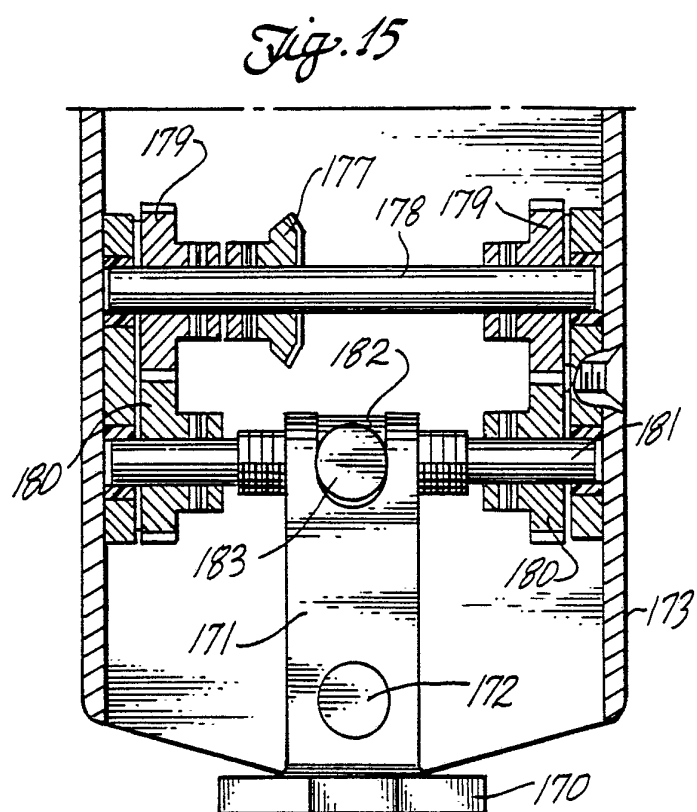
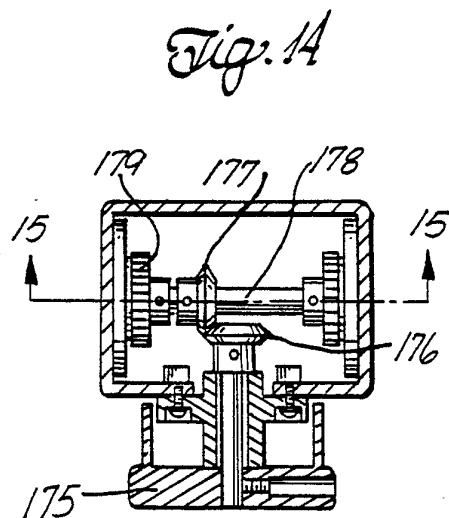
9/11
Fig. 12



10/11

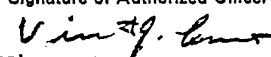
Fig. 13





INTERNATIONAL SEARCH REPORT

International Application No PCT/US86/00785

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC (4): G02B 27/22, 27/14		
US CL: 350/130		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
U.S.	350/130, 131, 174, 507, 508, 511, 512, 515, 516, 517, 519, 521, 523, 528	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category [*]	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
X	Jena, Review No. 4, Paper 219-222, 1974,	1, 2
Y	"The plastival 50 microstereo projector of VEB Carl-Zeiss Jena," by Lehr and Bonnke, Int Cl ² G02B 21/22, USPO 350-9. See the entire document.	1-6, 11-17, 20, 21, 23, 24
Y	US,A, 4,012,109 (Freeman) 15 March 1977 See the entire document.	1-6, 11-17, 20, 21, 23, 24
Y	US,A, 2,891,444 (Ewald) 23 June 1959 See the entire document.	1-6, 11-17, 20, 21, 23, 24
Y	US,A, 3,405,991 (Seedhouse) 15 October 1968 See Figures 1 and 2.	12-16
Y	GB,A, 2059095A 15 April 1981 (Freeman) See Figure 1 and Abstract (57).	20, 21, 23, 24
A	US,A, 4,531,816 (Baumgartel) 30 July 1985	
A	US,A, 4,518,231 (Muchel) 21 May 1985	
A	US,A, 4,363,532 (Weber) 14 December 1982	
[*] Special categories of cited documents: ¹⁵ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ²	Date of Mailing of this International Search Report ²	
19 May 1986	08 JUL 1986	
International Searching Authority ¹	Signature of Authorized Officer ²⁰	
ISA/US	 Vincent J. Lemmo	

Category *	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No ¹⁸
A	US,A, 4,235,509 (Takabayashi) 25 November 1980	
A	US,A, 3,510,202 (Boughton) 5 May 1970	

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☒ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE ¹⁰

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers because they relate to subject matter ¹² not required to be searched by this Authority, namely:

2. ☒ Claim numbers 22 because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out ¹³, specifically:

The claim is unclear because concurrent "moving" and "maintaining" between viewer and illuminator are claimed.

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING ¹¹

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.