

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
17 November 2005 (17.11.2005)

PCT

(10) International Publication Number
WO 2005/109065 A1

(51) International Patent Classification⁷: **G02B 7/02**

(21) International Application Number:
PCT/US2005/011953

(22) International Filing Date: 8 April 2005 (08.04.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/829,751 22 April 2004 (22.04.2004) US

(71) Applicant (for all designated States except US): **EASTMAN KODAK COMPANY** [US/US]; 343 State Street, Rochester, NY 14650-2201 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **BEDZYK, Mark, D.** [US/US]; 20 Landmark Lane, Pittsford, NY 14534 (US).

(74) Common Representative: **EASTMAN KODAK COMPANY**; 343 State Street, Rochester, NY 14650-2201 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

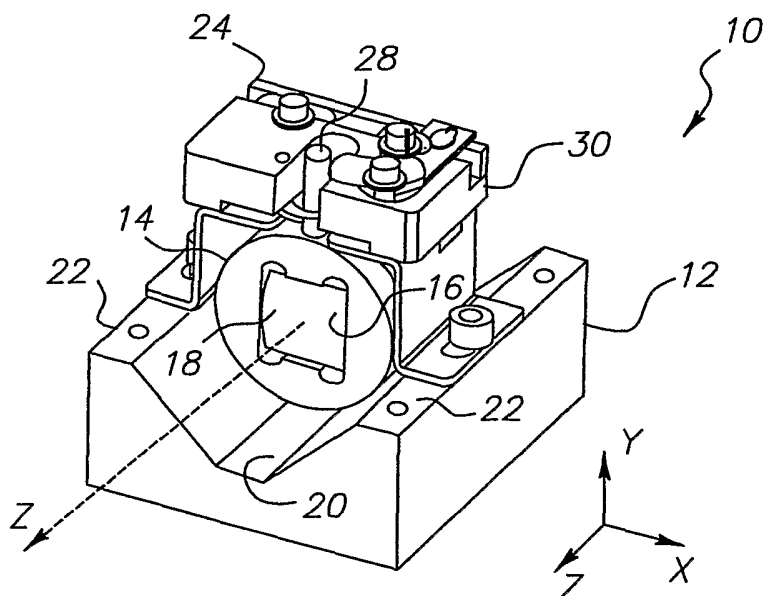
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: **ADJUSTABLE MOUNT FOR CYLINDRICAL LENS**



(57) Abstract: A positioning device disposes an optical component with respect to an optical axis. The positioning device has a lens carrier (14) for housing the lens (18) or other optical component, a mount (12) supporting the lens carrier along the optical axis, the lens carrier movable within the mount in at least one direction. An extended member is coupled to the lens carrier for setting the position of the carrier within the mount. A movable cam urges the extended member to effect movement in the at least one direction.

ADJUSTABLE MOUNT FOR CYLINDRICAL LENS

FIELD OF THE INVENTION

This invention generally relates to a device for adjustably mounting an optical element in an optical system; and, in particular, to mounting a
5 cylindrical lens that is independently adjustable an optical axis, in an optical system such as in a laser printer.

BACKGROUND OF THE INVENTION

The positioning of a lens, mirror or similar optical element (hereafter "lens") involves spatially locating such element within six degrees of
10 freedom. The lens is located translationally relative to each of three orthogonal axes directions generally designated as the x(scan), y(cross-scan), and z(beam path) axes directions. The lens is also located rotationally relative to three rotational directions, generally designated as the θ_x , θ_y , and θ_z directions, corresponding to angular rotation, respectively, about each of the x, y, and z axes.

15 Monolithic spherical lenses having one curved surface provide power magnification in two orthogonal directions, x and y, and focus parallel rays at a focal point corresponding to the center of curvature of the lens surface. Such lenses are used in laser printers, for example, for controlling beam spot size, convergence and focusing. Correct positioning of such spherical lenses in the x, y
20 translational and θ_x , θ_y rotational directions assures alignment of the focal point and center of the lens relative to an incident beam of light coincident with the z axis. Correct location of the lens along the z axis serves to assure proper focusing of an imaged object. Considerations for locating conjugate and composite spherical lens elements are similar.

25 Monolithic cylindrical lenses having one curved surface provide magnification in only one direction, x or y, and focus parallel rays to a line or lens cylinder axis parallel to the other direction, y or x respectively. Cylindrical lenses are used in laser printers, for example, for beam shaping, such as for controlling x-direction or y-direction elliptical beam spot size. Cylindrical lenses may be
30 manufactured to have a planar surface opposite the curved surface which is generally parallel to the x-y plane. Such a lens can, thus, be located in the θ_x and θ_y rotational directions by orienting the x-y planar surface normal to the incident

beam z axis direction. Variations in positioning in the non-magnification direction (i.e. variations in the y direction for magnification in the x direction, and vice versa) are not critical in many applications. Thus, once correct orientation of the x-y planar surface is established, locational precision is needed only in the x or y magnification translational and θ_z rotational directions. Location in the z direction is left adjustable for focusing purposes.

Conventional mounts for multiple degree-of-freedom positioning of optical elements nest multiple structural components for independent relative movement, one with respect to the other, to achieve the required translational and/or rotational positioning. For example, U.S. Patent No. 4,652,095 (Mauro) describes an arrangement of three nested stages, each having a table shiftable along rails in a respective x, y, or z translational direction by a threaded rod movable against the force of an opposing spring. The stages are nested, with the optical element mounted for movement with the table of the first stage, the first stage mounted for movement with the table of the second stage, and the second stage mounted for movement with the table of the third stage. U.S. Patent No. 3,596,863 (Kasperek) shows an arrangement of nested flexural pivots, each providing a respective θ_x , θ_y , and θ_z rotational adjustment. Other examples of nested optical element mounting arrangements are given in U.S. Patent Nos. 3,204,471 (Rempel); 4,077,722 (Bicskei); 4,099,852 (Kobierecki et al.); and 4,655,548 (Jue).

Mounting arrangements that provide multiple degree of freedom lens positioning, without nesting, are shown in U.S. Patent Nos. 3,989,358 (Melmoth) and 4,408,830 (Wutherich). U.S. Patent No. 3,989,358 provides independent x and y translational adjustments by micrometer spindles that are moved against knife-edges, displaced 90 degrees circumferentially about a lens retaining ring. U.S. Patent No. 4,408,830 provides x, y, and x-y translational adjustments by moving inclined faces of screw-driven cradle elements against corresponding angled corners of a rectangular lens retainer.

As a general observation, conventional devices for achieving six-degree-of-freedom positioning of optical elements tend to be unduly complex and costly. Moreover, when used for mounting cylindrical lenses in optical systems

like those of laser printers or the like, precise machining utilized to ensure correct positioning in critical directions is wasted when applied also for non-critical ones. In general, prior art mounts seek to avoid the exertion of any torque directly on the lens itself. See, for example, U.S. Patent No. 4,909,599 (Hanke et al.)

5 A number of innovative solutions have been proposed for cylindrical lens mounting without undue complexity. For example, commonly-assigned U.S. Patent No. 5,194,993 (Bedzyk) discloses an inexpensive lens mount for positioning a cylindrical lens or similar optical element in an optical system like that of a laser printer, wherein six degree-of-freedom positioning is achieved
10 with a minimum of nesting, taking advantage of physical characteristics of the lens, and employing a push-pull mechanism for applying a biasing torque on the lens, against which adjustments in the x or y axis magnification direction and θ_z rotational direction are made. As another example, commonly-assigned U.S. Patent No. 5,220,460 (Bedzyk) discloses a lens mount that applies a biasing
15 torque against the lens in the θ_z rotational direction. Yet another example is given in commonly-assigned U.S. Patent No. 5,210,648 (Bedzyk). U.S. Patent No. 5,210,648 discloses the use of a V-shaped channel track as a base for an adjustable mount, with the V-channel providing alignment along the optical axis. A carrier contains the lens itself, providing suitable orientation in x-y directions and θ_x and
20 θ_y rotation, and movable along the V-channel for positioning adjustment along the z-axis. An extended bracket provides the θ_z rotational adjustment.

 While the solutions offered in U.S. Patent Nos. 5,194,993; 5,220,460; and 5,210,648 enable precision adjustment of lens positioning for all six degrees of freedom, the accessibility needed to make these adjustments can be
25 a practical constraint in some situations, particularly for designs requiring compact packaging of pre-scan optical components. For example, the adjustable mount of U.S. Patent No. 5,210,648 requires access to adjustment screws from both the front and the top of this unit. The adjustable mounts of U.S. Patent Nos. 5,220,460 and 5,194,993 require access for adjustment from both the front and
30 sides.

Thus it can be seen that there would be advantages to the design of an adjustable lens positioning mount having adjustments for z and θ_z positions accessible from a single direction.

SUMMARY OF THE INVENTION

5 It is an object of the present invention to provide an adjustable lens mount having adjustments for z positioning and θ_z rotation accessible from a single direction. With this object in mind, the present invention provides a positioning device for disposing an optical component relative to an optical axis, the positioning device comprising:

- 10 (a) a carrier for housing the optical component;
(b) a mount supporting the carrier along the optical axis, wherein the carrier is movable within the mount in at least one direction;
(c) an extended member coupled to the carrier for setting the
15 position of the carrier within the mount; and
(d) a movable cam for urging the extended member to effect movement in at least one direction.

It is a feature of the present invention that it employs cam movement to provide high resolution rotational adjustment of a lens.

20 It is an advantage of the lens mount of the present invention that it provides suitable positioning in x , y and rotational θ_x and θ_y directions, allowing the z and coarse and fine θ_z rotation adjustments to be performed by turning adjustment screws on one side of the lens mount.

It is a further advantage of the present invention that it provides an
25 apparatus that can be kept in place as part of an optical apparatus or can be used as a removable fixture for adjustment and potting of the optical components.

It is a further advantage of the apparatus of the present invention that it requires precision manufacture only for specific components, allowing low-cost fabrication of the lens mount itself.

30 These and other objects, features, and advantages of the present invention will become apparent to those skilled in the art upon a reading of the

following detailed description when taken in conjunction with the drawings wherein there is shown and described an illustrative embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing
5 out and distinctly claiming the subject matter of the present invention, it is believed that the invention will be better understood from the following description when taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a perspective view showing an adjustable lens mount according to the present invention;

10 Figure 2 is a front plan view showing the relationship of adjustable lens mount components to the optical axis;

Figure 3 is a cutaway side view showing components of Figure 2;

Figure 4 is a top view of the alignment tool showing the positioning housing of the adjustable lens mount;

15 Figure 5 is a partially exploded view showing how the alignment tool is seated on the adjustable lens mount;

Figure 6 is a top view showing the mechanical components used for adjustment along the z axis;

20 Figure 7 is a bottom view of mechanical components for adjustment along the z axis;

Figure 8 is a perspective view showing adjustment screws on the top of the positioning housing of the present invention;

Figure 9 is a front plan view showing how θ_z rotation of the lens carrier is achieved using a pin;

25 Figure 10 is a perspective view showing components used for coarse θ_z adjustment;

Figure 11 is a top view showing the mechanical components used for coarse θ_z adjustment;

30 Figure 12 is a top view showing the mechanical components used for fine θ_z adjustment; and

Figure 13 is a top view showing an arrangement of mechanical components that can be used for effecting translation along the z-axis in an alternate embodiment.

DETAILED DESCRIPTION OF THE INVENTION

5 The present description is directed in particular to elements forming part of, or cooperating more directly with, apparatus in accordance with the invention. It is to be understood that elements not specifically shown or described may take various forms well known to those skilled in the art.

10 A typical optical system of the type to which the invention finds application includes an optical head for projecting a beam of laser light along an optical beam path coincident with a z axis direction. The beam is modulated in accordance with information received from an image signal generating circuit, and scanned line-by-line in an x axis (scan) direction by means of a rotating polygon onto a photosensitive film or other similar receiving medium. The medium is in
15 turn moved in an y axis (cross-scan) direction by means of a rotating drum or the like. A start-of-scan detector controls the timing of the light beam modulation. Optical elements, including cylindrical lenses, are positioned between the optical head and the mirrored multiple facets of the polygon to control beam shaping, focusing and direction. Other optical elements, located between the polygon and
20 the drum, correct for differences in beam focus due to the f - θ condition and focus the image in the cross-scan direction to avoid objectionable banding artifacts due to facet out-of-plane wobble and pyramid angle errors. Additional details concerning the functioning and operation of laser printers of this type are given in U.S. Patent Nos. 5,184,153 (Daniels et al.); 4,397,521 (Antos et al.); 4,796,962
25 (DeJager et al.); 4,982,206 (Kessler et al.); and 4,921,320 (DeJager et al.)

Referring to Figure 1, there is shown an adjustable lens mount 10 of the present invention, in perspective view. Adjustable lens mount 10 is designed to locate a lens 18 for use in shaping the elliptical form of a scanning beam in either the x or y direction and for controlling its position on the optical
30 axis (the z axis) and controlling its rotation along the z axis, θ_z . Lens 18 shown in Figure 1 is mounted with its focus in the y axis; however, those skilled in the art

can readily appreciate that the same principles apply for a lens having focus in the x axis direction.

Adjustable lens mount 10 has a base 12 elongated in the z-axis direction and a lens carrier 14 including a central optical opening 16 that is concentric with the z axis. Base 12 has flat rails 22 on either side of a V-shaped track 20. V-shaped track 20 has an upwardly-opening channel that extends longitudinally in the z direction. Flat rails 22 also extend longitudinally in the z direction. In a preferred embodiment, V-shaped track 20 and flat rails 22 are formed to have uniform lateral cross section along the length of base 12.

Lens carrier 14 is configured for adjustable movement translationally in the z axis direction and rotationally in the θ_z direction within V-shaped track 20. Lens carrier 14 is a generally cylindrical body, shown within a positioning housing 24 that provides the various z and θ_z adjustment mechanisms described subsequently. Ideally, the body of lens carrier 14 and V-shaped track 20 in which it is seated are dimensioned, configured, and adapted so that the center of optical opening 16 coincides with optical axis z when lens carrier 14 is seated within base 12. Lens carrier 14 acts as an optical component housing, configured to mount lens 18, or other suitable optical device, substantially in parallel to the x-y plane of the optical system, so that x, y, and θ_x and θ_y positioning is automatically effected when lens carrier 14 is seated within V-shaped track 20 on base 12. Referring to the front view of Figure 2 and to the side sectional view of Figure 3 taken from reference line A-A in Figure 2, the positional relationship of lens carrier 14 with respect to optical axis z and the orthogonal x and y axes is shown. A cylindrical lens axis 26 of lens 18 lies along optical axis z in this embodiment. A pin 28, aligned with the radius of rotation of lens carrier 14, cooperates with adjustment components in positioning housing 24 to effect both z-axis and θ_z adjustment, in a manner described subsequently.

Fitted on the top of positioning housing 24 is an alignment tool 30, as shown more clearly in the top view of Figure 4 and removed from position in the partially exploded perspective view of Figure 5. Mechanisms of alignment tool 30 are used to perform the linear z position adjustment and both coarse- and

fine- θ_z rotational adjustments. In the embodiment shown, alignment tool 30 seats securely in place atop positioning housing 24 by means of pins 34 that engage holes 36 in a bracket 32. This arrangement enables removal of alignment tool 30 after adjustments are complete. However, alignment tool 30 may be kept in
5 position in the optical apparatus, allowing later adjustments to be more easily made. Bracket 32 is itself secured to base 12 by mounting bolts 38 through threaded bores 76 on flat rails 22; of course, other arrangements for bracket 32 mounting could be used, as is well known to those skilled in the optical component mounting arts.

10 In general, adjustments for z and θ_z positioning will be made following a certain order, as described following. However, in practice, the adjustments described subsequently could be made in any order, depending on the requirements of the optical apparatus design.

Mechanism for z-Axis Adjustment

15 With the apparatus of the present invention, the first adjustment typically made is the linear z-positioning adjustment, which sets the relative position of lens carrier 14 along the optical axis (z axis), within V-shaped track 20. Initially, the z-position of lens carrier 14 is approximately measured, and positioning housing 24 mounted, so that this adjustment need only provide a more
20 exacting positioning to about +/- 0.031 inches in a preferred embodiment.

Referring now to Figures 6 and 7, there are shown top view and bottom views, respectively, of components of alignment tool 30 that urge lens carrier 14 backwards or forwards along the z axis by applying force to pin 28. The top view representation of Figure 6 is simplified to show components that
25 provide z adjustment motion, excluding other mechanical components for simplicity. A z-adjustment pinion 40 cooperates with a gear 42 in rack-and-pinion fashion to shift the position of a z-positioning plate 44, a linkage that pivots about a pin 46, mounted to alignment tool 30. This action causes the edge surface of a slot 48 in z-positioning plate to press against the side of pin 28, thereby forcing
30 lens carrier 14 to move in the z-direction, that is, along V-shaped track 20. The gear ratio, pivot pin 46 placement, and dimensioning of z-positioning plate 44 contact surfaces are configured to suit the required adjustment resolution and

range. In a preferred embodiment, for example, a 1 degree rotation of z-adjust pinion 40 causes an approximately 0.00046 inch movement of lens carrier 14 along the z axis.

Figure 7 shows the operation of alignment tool 30 for z-axis positioning from a bottom view, with lens carrier 14 and other components removed for clarity. Figure 8 shows the position of alignment tool 30 components from a rear view (relative to Figure 1). It can be observed that the gear-and-pinion arrangement of the embodiment shown is advantaged for positive engagement and mechanical robustness; however, other mechanisms could be used for this adjustment, such as a coupling using friction, for example.

Mechanism for Coarse θ_z Adjustment

The front plan view of Figure 9 shows the simple mechanism by which θ_z adjustment is performed using adjustable lens mount 10 of the present invention. As noted above, pin 28 is fitted within lens carrier 14, to be substantially aligned with a radius from the z-axis. Movement of pin 28 in the x-direction as shown causes rotation of lens carrier 14 about the z axis. This same type of x-direction movement is used for moving pin 28, first for coarse θ_z adjustment, then for fine θ_z adjustment.

Referring to the partially exploded view Figure 10 and the top view of Figure 11, there is shown the overall mechanism for coarse θ_z adjustment. An eccentric cam 50, secured by a clamping screw 52, is positioned using a pin 54 to effect approximate angle θ_z adjustment. Eccentric cam 50 does this by setting a coarse position for a θ_z cam 56, a type of drive member that provides a contact surface 72 against which pin 28 locates. Rotating eccentric cam 50 within a hole 58 positions θ_z cam 56, thereby adjusting the position of pin 28. A spring force F_s , or similar type of loading force, is applied to load pin 28 against θ_z cam 56. The mechanism for applying spring force is shown more clearly in Figure 8. A spring 60 applies force by means of a loading lever, which pivots on a pivot pin 64. In a preferred embodiment, coarse θ_z adjustment rotates lens carrier 14 to within about ± 0.15 degrees of the final fine θ_z adjustment. The dotted outline in Figure 11 represents, in somewhat exaggerated form, the range of motion of θ_z cam 56 over

the adjustment range of eccentric cam 50. When coarse θ_z adjustment is complete, clamping screw 52 is tightened to hold eccentric cam 50 in position.

Mechanism for Fine θ_z Adjustment

Once the coarse θ_z adjustment has been performed, the fine θ_z adjustment can be made, using the mechanism shown in Figure 12. The rack and pinion arrangement of a fine θ_z adjust pinion 66 and gear rack member 68, mechanically coupled to θ_z cam 56 at a pivot point 70, causes θ_z cam 56 to pivot about eccentric cam 50. Curved contact surface 72 of θ_z cam 56 provides the slight movement necessary over an arc A for precision adjustment against pin 28.

10 The curvature dimensions of arcuate contact surface 72 in this embodiment can be designed to provide the needed range of motion and resolution needed for fine adjustment over the full travel path of θ_z cam 56. The dotted-line representation in Figure 12 shows, in outline form, the θ_z fine adjustment mechanism at extremes of travel over arc A. (Here, the term "arc" is understood in its most general

15 geometrical sense, as a smooth curve joining two points; arc A need not be a circular arc.) In a preferred embodiment, for example, a 1 degree rotation of fine θ_z adjust pinion 66 causes a lens carrier 14 rotation on the order of approximately 0.0023 degrees. It must be observed that contact surface 72 need not be arcuate; in practice, however, some amount of curvature is typically advantageous to allow

20 fine adjustment at the needed resolution, particularly when making adjustments manually.

While the apparatus of the present invention allows precise adjustment in z and θ_z , these adjustments are not wholly independent of each other. Because of this, the following sequence is typically followed for making

25 adjustments using adjustable lens mount 10 of the present invention:

- (1) Make linear z -axis positioning adjustment;
- (2) Make coarse θ_z adjustment; and
- (3) Make fine θ_z adjustment.

As with other types of optical systems where there is some interaction between

30 mechanical mounting components, it may be necessary to repeat one or more adjustments as needed.

Once the fine θ_z adjustment is complete, lens carrier 14 can be locked into place using a locking screw 74, as shown in Figure 8. Lens carrier 14 can then be potted in place against base 12 using conventional techniques well known in the optical arts, allowing the removal of both bracket 32 and alignment tool 30. Optionally, bracket 32 may be kept in place, allowing removal of alignment tool 30. Or, the complete adjustable lens mount 10 apparatus may be kept in place to facilitate subsequent readjustment. Pin 28 may be attached to lens carrier 14 or may be removable. For example, pin 28 may be threaded.

Alternate Embodiment for Fine z-axis Adjustment

While the preceding description gives detailed information on the use of θ_z cam 56 for effecting fine θ_z adjustment, a slight rearrangement of alignment tool 30 components allows this same type of adjustment mechanism to be used for z-axis adjustment as well. Referring to the top view of Figure 13, it can be observed that specific components of alignment tool 30 have been rotated 90 degrees in the x-z plane for use in effecting precision z-axis translation of lens carrier 14. Here, a z-position cam 57 operates in a similar manner to θ_z cam 56 for urging pin 28 in the z-axis direction. Correspondingly, a fine z-adjust pinion 67 operates in a manner similar to fine θ_z adjust pinion 66, described with reference to Figure 12, for making the adjustment. Fine z-adjust pinion 67 cooperates with a gear rack member 69, mechanically coupled to z-position cam 57 at a pivot point 71, causing z-position cam 57 to pivot about eccentric cam 51. A contact surface 73 of z-position cam 57 provides the slight movement necessary for precision z-axis adjustment against pin 28.

Adjustable lens mount 10 could be used for various types of optical components other than cylindrical lenses, including a range of refractive or reflective optical devices. The apparatus of the present invention can use components fabricated from a range of materials, selected for specific requirements of the optical system. While rack-and-pinion mechanisms are particularly advantaged for providing controlled motion of θ_z cam 56 and z-positioning plate 44 when adjusted from above, other types of mechanical device could be used, such as friction-based or belt-driven devices. Cam action, because

it converts rotational movement to linear movement, is particularly well suited for making adjustments manually. While θ_z cam 56 provides a drive member that is advantaged for manual high-resolution adjustment, other types of components could be used as the drive member for urging pin 28 to effect corresponding rotational motion of lens carrier 14. For example, automated actuators, such as various types of electromechanical or piezoelectric actuators, could alternately be used for adjusting the position of pin 28 to effect θ_z rotation, either using θ_z cam 56 or using some other device that provides a suitable contact surface. A simple adjustment screw could be used for providing linear motion against positioning pin 28; however, such an arrangement requires at least some access space from the side of adjustable lens mount 10. Loading force holding pin 28 against the contact surface of θ_z cam 56 can be provided in a number of ways, such as using an arrangement of springs, magnets, or other components. Pin 28 can be some other type of extended member that allows some amount of rotation of lens carrier 14 within base 12.

It can be appreciated that the apparatus of the present invention provides an adjustable mount for an optical component that allows adjustments relative to the optical or z axis to be made from one side of the mount. Thus, the apparatus of the present invention is advantaged for equipment in which spacing constraints limit the options for adjustment access. It can be appreciated that the adjustments needed can be provided manually or can be effected using a motor or other automated apparatus.

Thus, what is provided is an apparatus and method for mounting a cylindrical lens or other optical component, independently adjustable in position along or rotationally about an optical axis, in an optical system like that of a laser printer.

PARTS LIST

10	adjustable lens mount
12	base
14	lens carrier
16	optical opening
18	lens
20	V-shaped track
22	flat rails
24	positioning housing
26	cylindrical lens axis
28	pin
30	alignment tool
32	bracket
34	pin
36	hole
38	mounting bolt
40	z-adjust pinion
42	gear
44	z-positioning plate
46	pin
48	slot
50	eccentric cam
51	eccentric cam
52	clamping screw
54	pin
56	θ_z cam
57	z-position cam
58	hole
60	spring
64	pivot pin
66	fine θ_z adjust pinion
67	fine z-adjust pinion

- 68 gear rack member
- 69 gear rack member
- 70 pivot point
- 71 pivot point
- 72 contact surface
- 73 contact surface
- 74 locking screw
- 76 bore

CLAIMS:

1. An adjustable mount for positioning an optical component relative to an optical axis comprising:
 - (a) a carrier for housing said optical component;
 - 5 (b) a mount supporting said carrier along said optical axis, wherein said carrier is movable within said mount in at least one direction;
 - (c) an extended member coupled to said carrier for setting a position of said carrier within said mount; and
 - (d) a movable cam for urging said extended member to
10 effect movement in said at least one direction.
2. An adjustable mount according to claim 1 wherein said at least one direction is substantially orthogonal to said optical axis.
- 15 3. An adjustable mount according to claim 1 wherein said at least one direction is substantially parallel to said optical axis.
4. An adjustable mount according to claim 1 wherein said cam comprises an arcuate surface for contact with said extended member.
20
5. An adjustable mount according to claim 1 wherein said mount comprises an outwardly opening V-channel.
6. An adjustable mount according to claim 1 wherein said
25 carrier is substantially cylindrical.
7. An adjustable mount according to claim 1 further comprising an adjustment gear pivotally hinged to said cam for controlling cam movement over an arc.

8. An adjustable mount according to claim 1 further comprising a spring applying a force to load said extended member against said cam.

5 9. An adjustable mount according to claim 1 wherein said extended member is removably attached to said carrier.

10. A positioning device for disposing an optical component rotationally about an optical axis, said positioning device comprising:

10 (a) a carrier for housing said optical component, said carrier supported along said optical axis and rotatable about a center of rotation substantially coincident with said optical axis;

(b) an extended member coupled to said carrier and extending away from said optical axis for setting the rotation angle of said carrier;
15 and

(c) a drive member comprising a movable contact surface for urging said extended member in a direction substantially orthogonal to said optical axis, thereby adjusting said angle of said carrier about said optical axis.

20 11. A positioning device according to claim 10 wherein said drive member comprises a cam.

12. A positioning device according to claim 10 wherein said contact surface of said cam is arcuate.

25 13. A positioning device according to claim 10 wherein said carrier is supported within an outwardly opening V-channel.

30 14. A positioning device according to claim 10 wherein said carrier is substantially cylindrical.

15. A positioning device according to claim 11 further comprising an adjustment gear pivotally hinged to said cam for controlling cam movement over an arc.

5 16. A positioning device according to claim 10 further comprising a spring applying a loading force to said extended member against said contact surface.

10 17. A positioning device according to claim 10 further comprising:

(d) a linear movement plate pivotally hinged to an adjustment gear, said linear movement plate having said contact surface for urging said extended member in a direction along said optical axis, thereby moving said carrier linearly with respect to said optical axis.

15 18. A positioning device according to claim 10 wherein said drive member comprises a piezoelectric actuator.

20 19. A positioning device according to claim 10 wherein said drive member comprises an electromechanical actuator.

20. A positioning device according to claim 10 wherein said extended member is removably attached to said carrier.

25 21. A positioning device for disposing an optical component rotationally about an optical axis, said positioning device comprising:

(a) a carrier for housing said optical component, said carrier supported along said optical axis and rotatable about a center of rotation substantially coincident with said optical axis;

30 (b) an extended member coupled to said carrier and extending away from said optical axis for setting a rotation angle of said carrier; and

(c) a movable cam for urging said extended member in a direction substantially orthogonal to said optical axis, thereby adjusting said angle of the carrier about said optical axis.

5 22. A positioning device according to claim 21 wherein said surface of said cam in contact with said extended member is arcuate.

 23. A positioning device according to claim 21 wherein said carrier is supported within an outwardly opening V-channel.

10

 24. A positioning device according to claim 21 wherein said carrier is substantially cylindrical.

 25. A positioning device according to claim 21 further
15 comprising an adjustment gear pivotally hinged to said cam for controlling cam movement over an arc.

 26. A positioning device according to claim 21 further
comprising a spring for forcing said extended member against said cam.

20

 27. A positioning device according to claim 21 further comprising:

 (d) a linear movement plate pivotally hinged to an adjustment gear, said linear movement plate having a z-axis contact surface for
25 urging said extended member in a direction along the optical axis, thereby moving said carrier linearly with respect to said optical axis.

 28. A positioning device according to claim 21 wherein said extended member is removably attached to said carrier.

29. A positioning device for disposing an optical component at a linear position along an optical axis and rotationally about said optical axis, the positioning device comprising:

5 (a) a carrier for housing said optical component, said carrier supported along said optical axis and rotatable about a center of rotation substantially coincident with said optical axis;

(b) an extended member coupled to said carrier and extending away from said optical axis for setting a rotation angle of said carrier;

10 (c) a movable cam disposed for urging said extended member in a direction substantially orthogonal to said optical axis, thereby adjusting said angle of said carrier about said optical axis; and

(d) a linear movement plate pivotally hinged to an adjustment gear, said linear movement plate having a contact surface for urging said extended member in a direction along said optical axis, thereby moving said
15 carrier linearly with respect to said optical axis.

30. A positioning device according to claim 29 wherein said cam contact surface is arcuate.

20 31. A positioning device according to claim 29 wherein said carrier is supported within an outwardly opening V-channel.

32. A positioning device according to claim 29 wherein said carrier is substantially cylindrical.

25 33. A positioning device according to claim 29 further comprising a rack-and-pinion adjustment mechanism for controlling position of said cam.

30 34. A positioning device according to claim 29 further comprising a spring for forcing said extended member against said cam.

35. A positioning device for disposing an optical component at a linear position along an optical z axis and rotationally about said optical z axis, said positioning device comprising:

5 (a) a carrier for housing said optical component, said carrier supported along said optical z axis and rotatable about a center of rotation substantially coincident with said optical z axis;

(b) an extended member coupled to said carrier and directed away from said optical axis, said extended member rotatable in an x-y plane for adjusting a rotation angle of said carrier about said optical z axis and movable in a
10 z direction for adjusting a linear position of said carrier along said optical z axis; and

(c) a positioning housing comprising:

(i) a rotational angle cam disposed for urging said
15 extended member in a direction within said x-y plane, thereby adjusting said angle of said carrier about said optical z axis; and
(ii) a linear positioning cam comprising at least a first
z-axis contact surface for urging said extended member
in a direction substantially parallel to said optical z axis.

20

36. A positioning device according to claim 35 wherein movement of said rotational angle cam is effected by rotation of an adjustment pinion.

25 37. A positioning device according to claim 35 wherein movement of said linear positioning cam is effected by rotation of an adjustment pinion.

38. A positioning device according to claim 35 wherein said
30 positioning housing is removable from said carrier following adjustment.

39. A method for disposing an optical component rotationally about an optical axis, comprising:

- (a) seating said optical component within a carrier;
- (b) supporting said carrier along said optical axis;
- 5 (c) providing a rotational control member outwardly extended from said carrier; and
- (d) setting a position of said rotational control member by:
 - (i) applying a loading force in a direction orthogonal to said optical axis to force said rotational control member
 - 10 against a contact surface; and
 - (ii) moving said contact surface to urge said rotational control member against said loading force, thereby adjusting an angle of the carrier about said optical axis.

15 40. A method for disposing an optical component according to claim 39 wherein the step of moving said contact surface comprises the step of moving a cam.

20 41. A method for disposing an optical component according to claim 39 wherein the step of applying said loading force comprises the step of extending a spring.

25 42. A method for disposing an optical component according to claim 39 wherein the step of moving said contact surface comprises the step of adjusting a pinion.

43. A method for disposing an optical component linearly along an optical axis, comprising:

- (a) seating said optical component within a carrier;
- (b) supporting said carrier along said optical axis;
- 5 (c) providing a linear position control member outwardly extended from said carrier; and
- (d) urging said linear position control member in a direction substantially parallel to said optical axis by pivoting a movable plate about a pivot point, said movable plate having at least one contact surface for moving said
- 10 linear position control member.

1/7

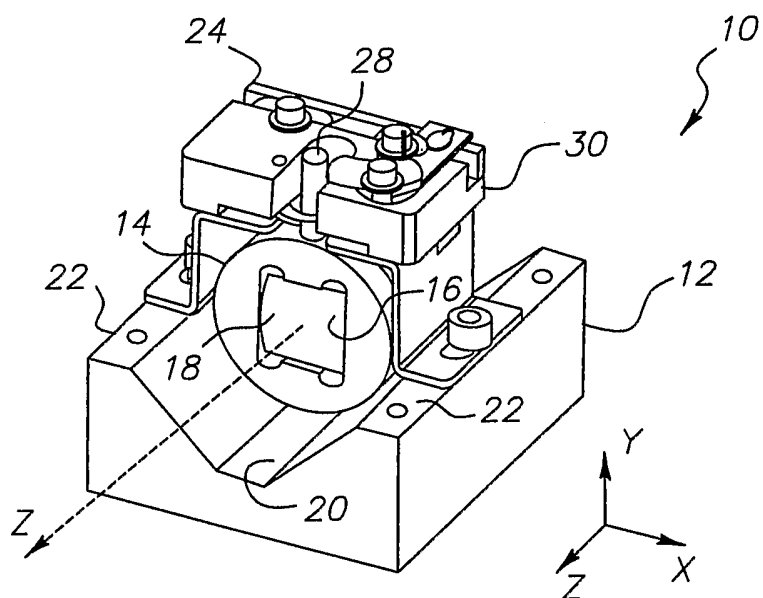


FIG. 1

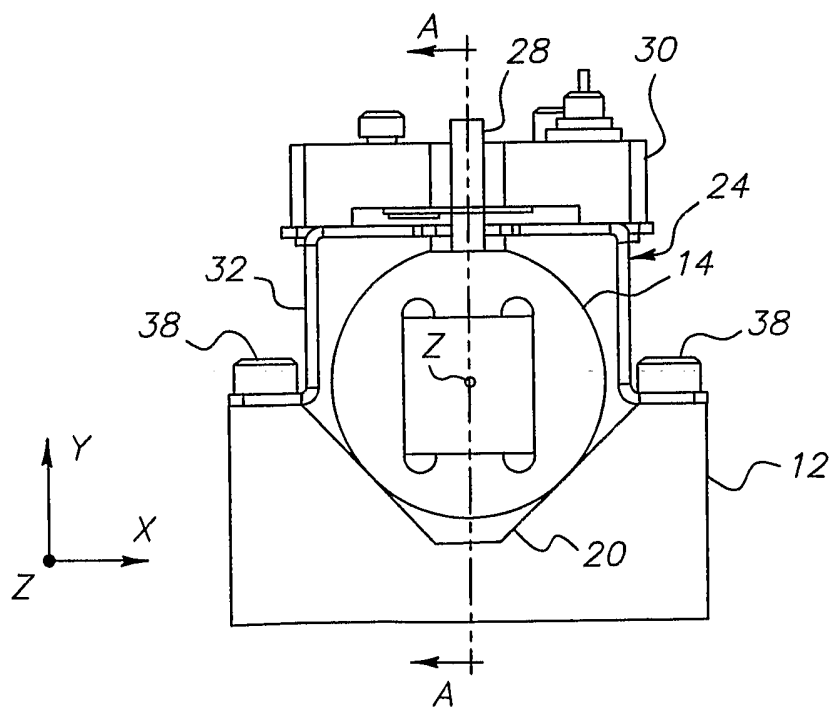
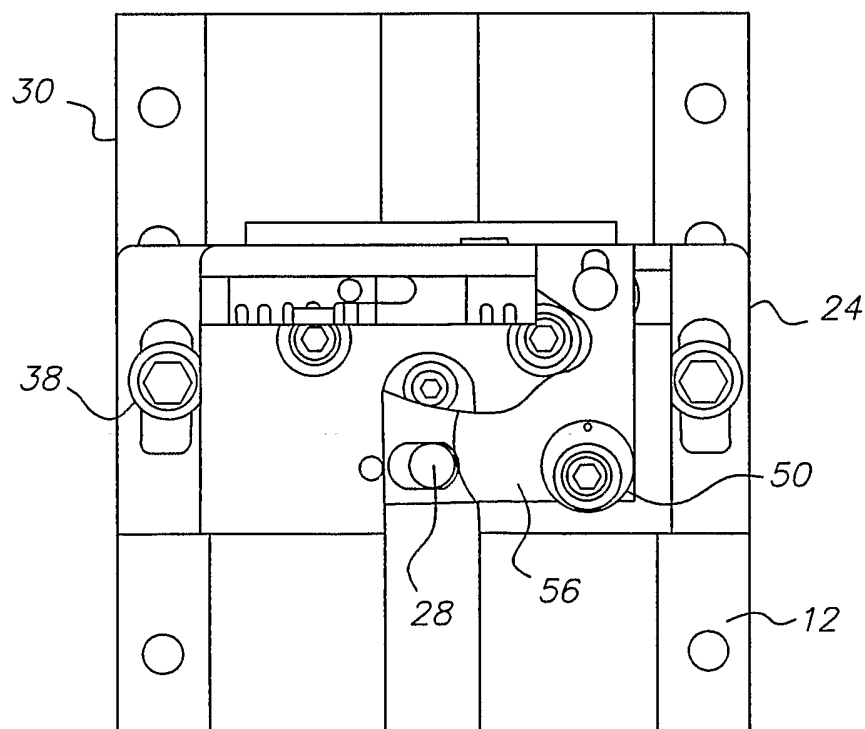
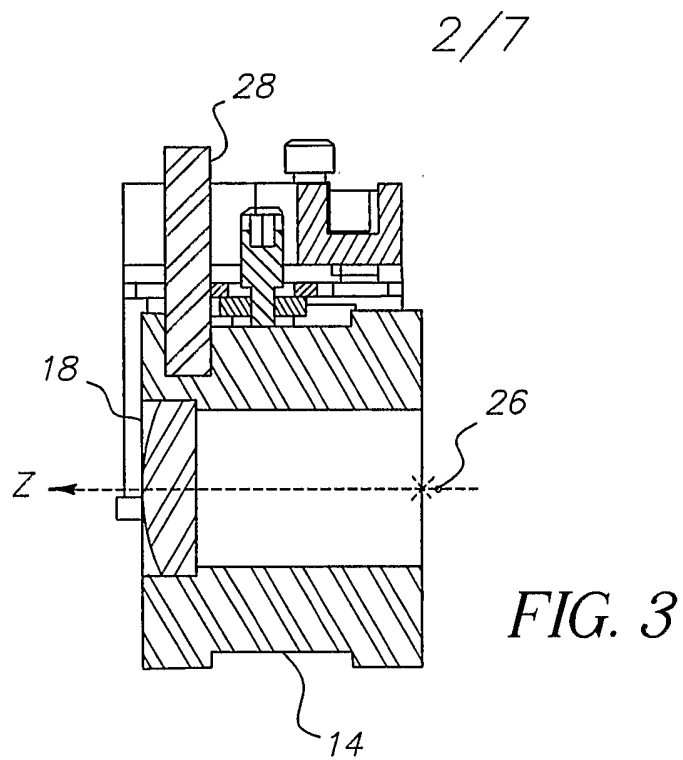


FIG. 2



3/7

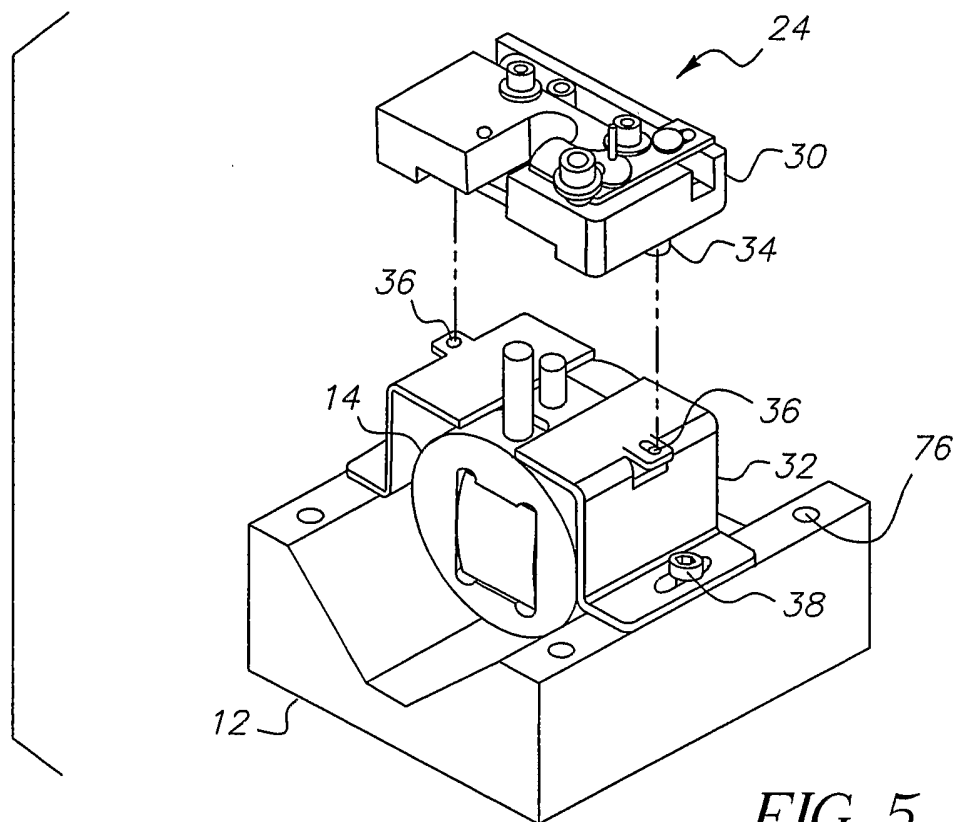


FIG. 5

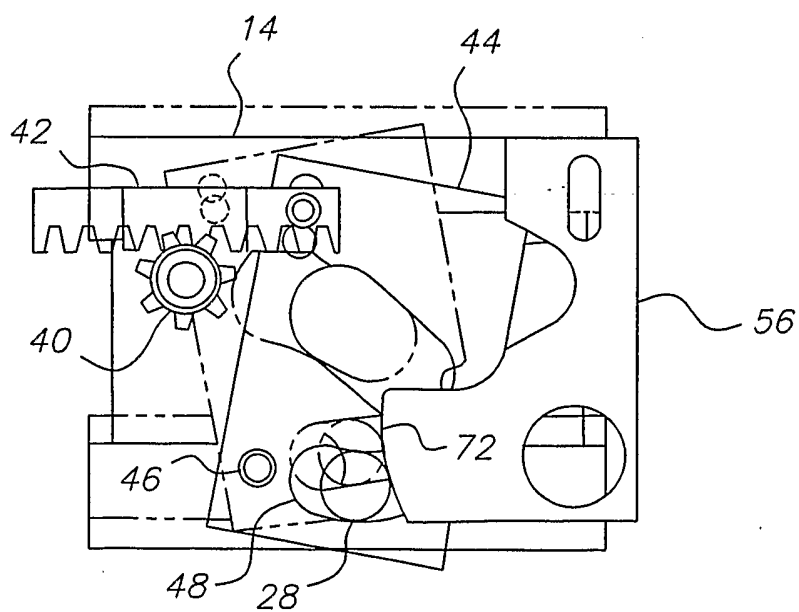


FIG. 6

4/7

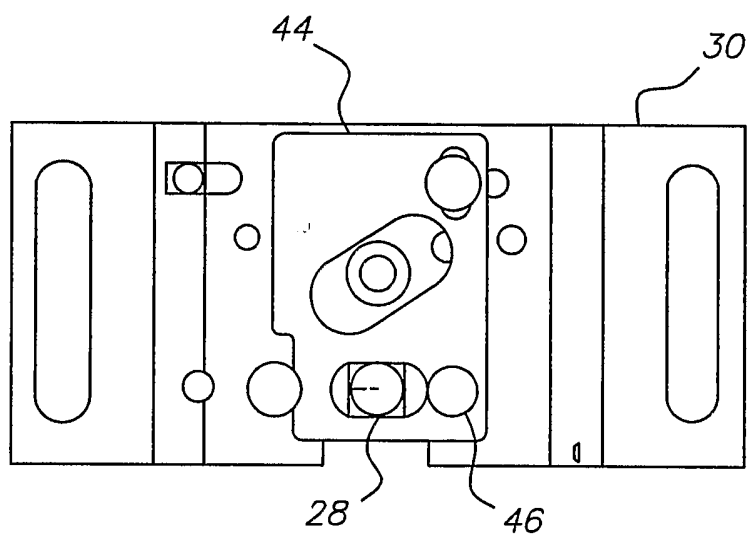


FIG. 7

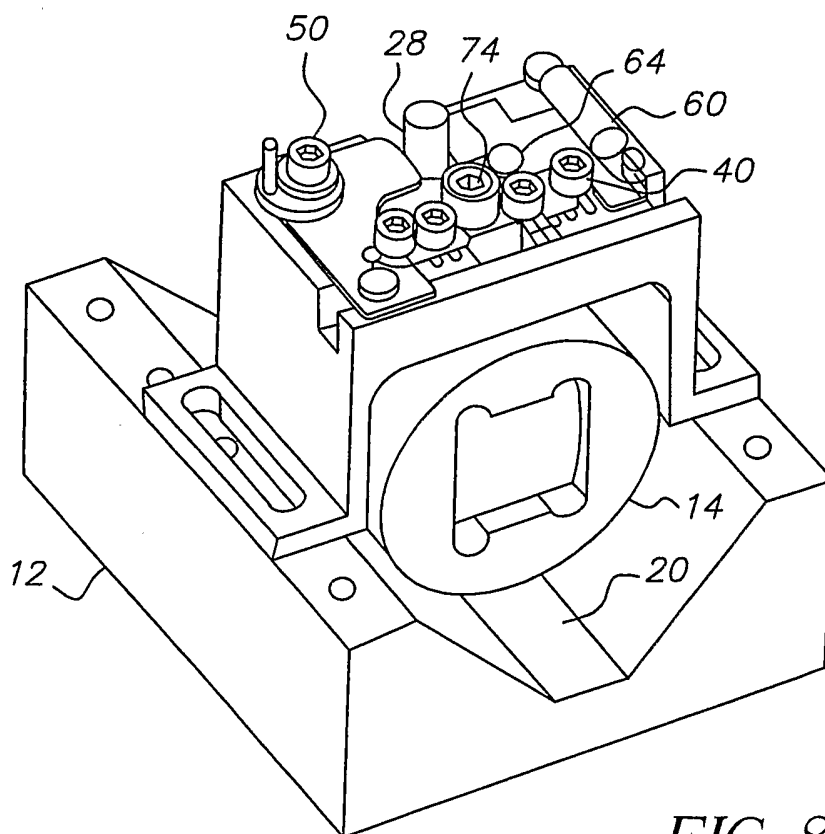
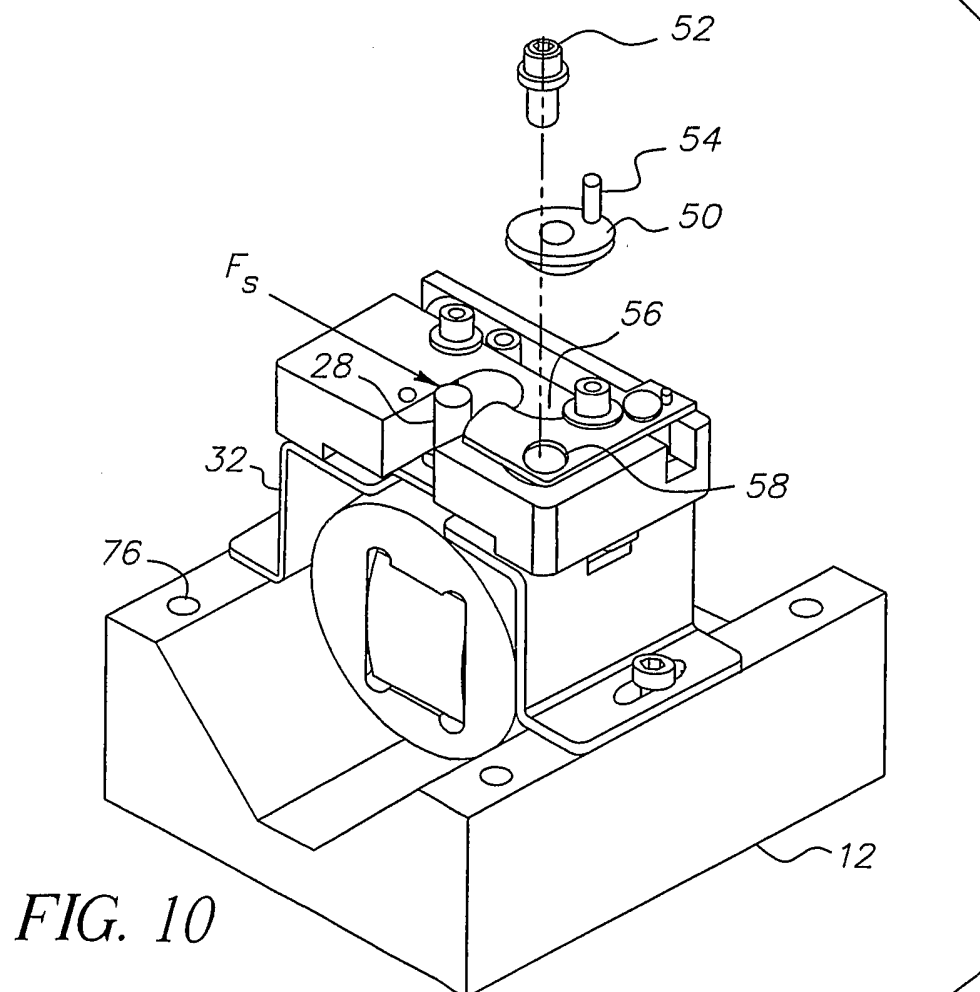
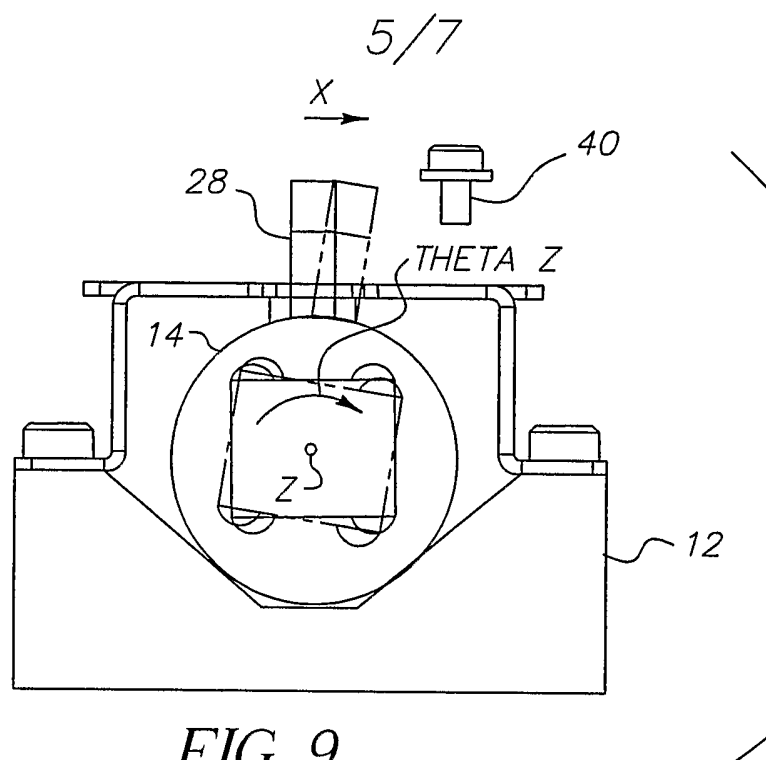
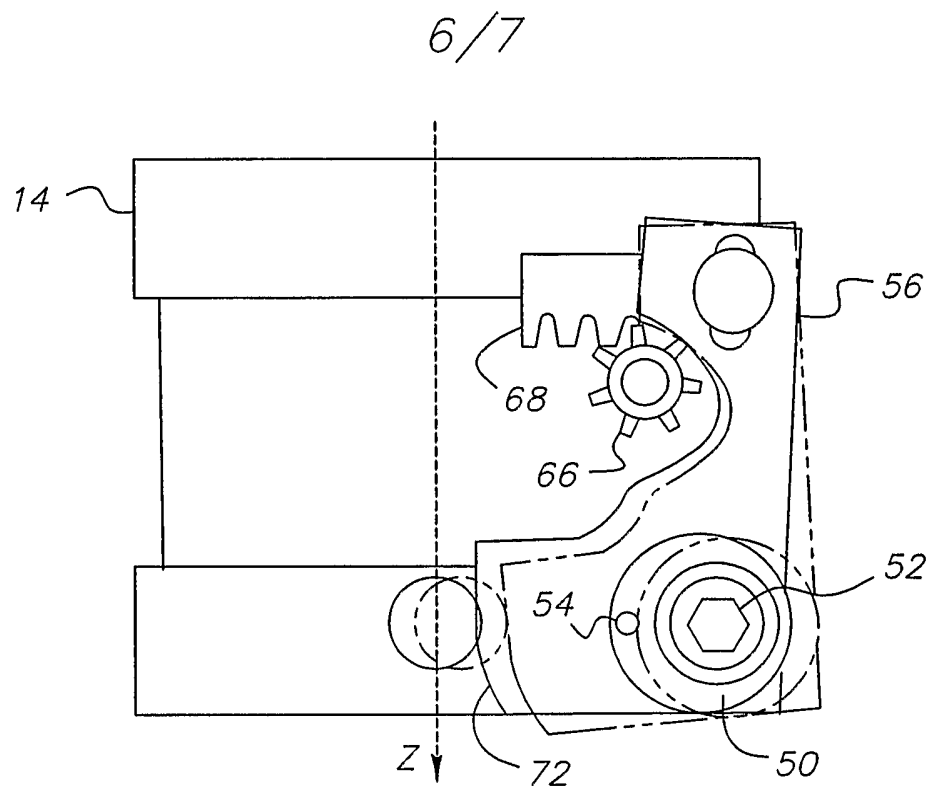
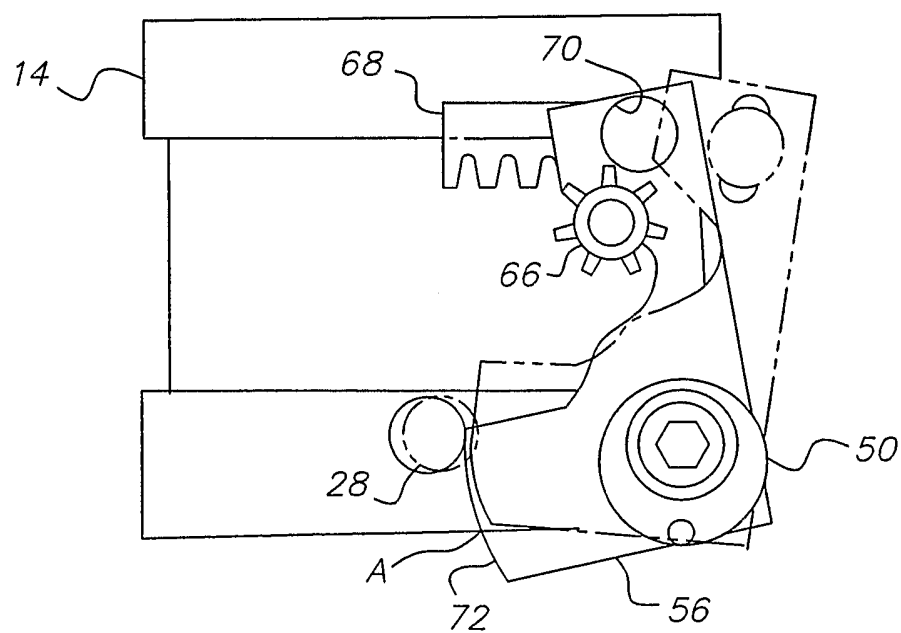
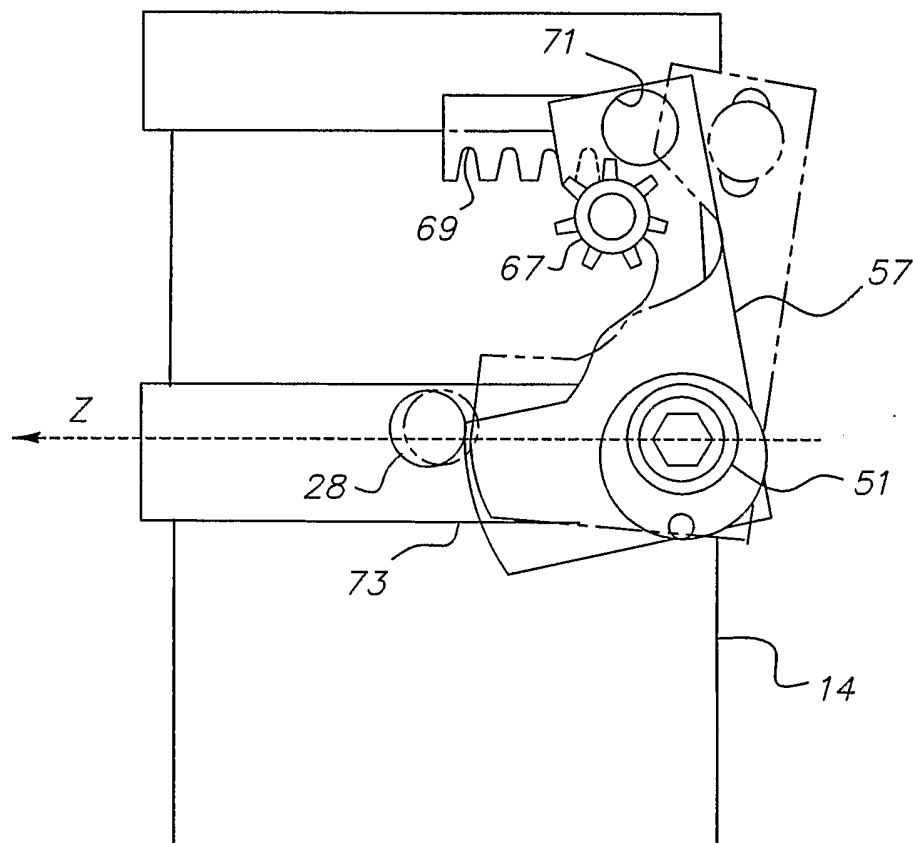


FIG. 8



*FIG. 11**FIG. 12*

7/7

*FIG. 13*

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US2005/011953

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 210 648 A (BEDZYK ET AL) 11 May 1993 (1993-05-11) cited in the application column 4, line 67 - column 9, line 47; figures 1-6	1-43
A	US 5 220 460 A (BEDZYK ET AL) 15 June 1993 (1993-06-15) cited in the application column 4, line 38 - column 7, line 65; figures 1-4	1-43
A	US 5 194 993 A (BEDZYK ET AL) 16 March 1993 (1993-03-16) cited in the application column 3, line 53 - column 8, line 39; figures 1-8	1-43

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *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 when the document is taken alone
- *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

Date of the actual completion of the international search

12 September 2005

Date of mailing of the international search report

26/09/2005

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Sarnecki, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US2005/011953

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5210648	A	11-05-1993	US 5194993 A 16-03-1993
		DE 69215208 D1 19-12-1996	
		DE 69215208 T2 22-05-1997	
		EP 0558735 A1 08-09-1993	
		JP 6502936 T 31-03-1994	
		WO 9306515 A1 01-04-1993	
		DE 69211327 D1 11-07-1996	
		DE 69211327 T2 02-01-1997	
		EP 0558743 A1 08-09-1993	
		JP 6502935 T 31-03-1994	
		WO 9306514 A1 01-04-1993	
		US 5220460 A 15-06-1993	
US 5220460	A	15-06-1993	US 5194993 A 16-03-1993
		DE 69211327 D1 11-07-1996	
		DE 69211327 T2 02-01-1997	
		EP 0558743 A1 08-09-1993	
		JP 6502935 T 31-03-1994	
		WO 9306514 A1 01-04-1993	
		DE 69215208 D1 19-12-1996	
		DE 69215208 T2 22-05-1997	
		EP 0558735 A1 08-09-1993	
		JP 6502936 T 31-03-1994	
		WO 9306515 A1 01-04-1993	
		US 5210648 A 11-05-1993	
US 5194993	A	16-03-1993	DE 69211327 D1 11-07-1996
		DE 69211327 T2 02-01-1997	
		DE 69215208 D1 19-12-1996	
		DE 69215208 T2 22-05-1997	
		EP 0558735 A1 08-09-1993	
		EP 0558743 A1 08-09-1993	
		JP 6502935 T 31-03-1994	
		JP 6502936 T 31-03-1994	
		WO 9306514 A1 01-04-1993	
		WO 9306515 A1 01-04-1993	
		US 5220460 A 15-06-1993	
		US 5210648 A 11-05-1993	