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(54) **INTEGRATED MULTI-RAIL IMAGING SYSTEM**

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(57) **ABSTRACT**

The imaging system can comprise a plurality of elongated rails, a scanhead assembly, and a small animal mount assembly. The scanhead assembly is selectively mounted onto a first rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the first rail. The small-animal mount assembly is selectively mounted onto a second rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the second rail. The second rail being mounted relative to the first rail such that the longitudinal axis of the second rail is at an angle to the longitudinal axis of the first rail. The imaging system can also comprise a needle injection assembly that is selectively mounted onto the third rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the third rail. The third rail being mounted relative to the second rail and the first rail such that the longitudinal axis of the third rail is substantially coaxial to the longitudinal axis of the first rail.

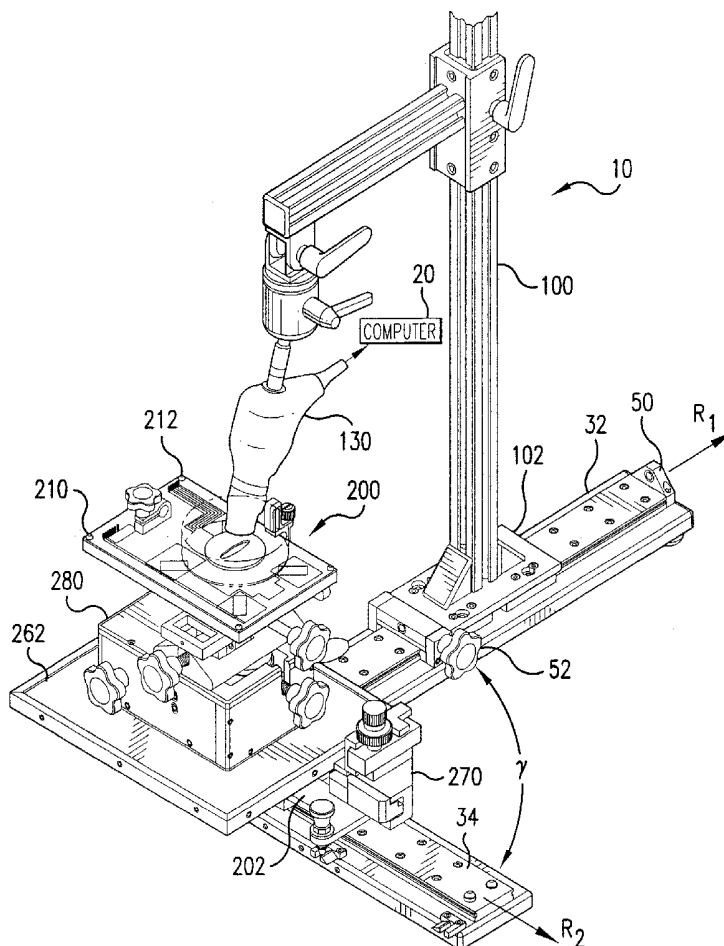
(21) Appl. No.: **11/541,096**

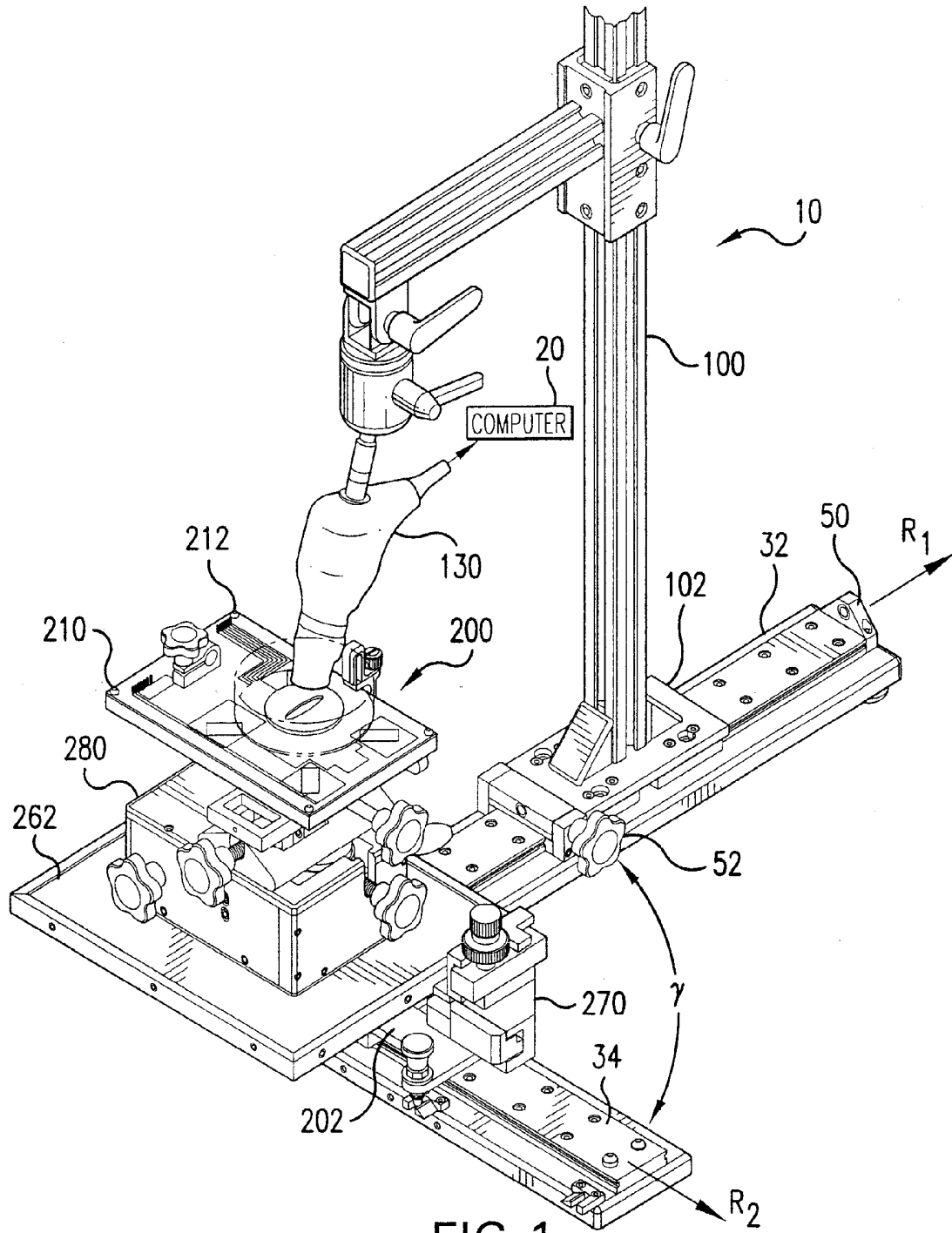
(22) Filed: **Sep. 29, 2006**

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(60) Provisional application No. 60/417,167, filed on Oct. 10, 2002. Provisional application No. 60/468,959, filed on May 9, 2003. Provisional application No. 60/417,185, filed on Oct. 10, 2002. Provisional application No. 60/468,960, filed on May 9, 2003.





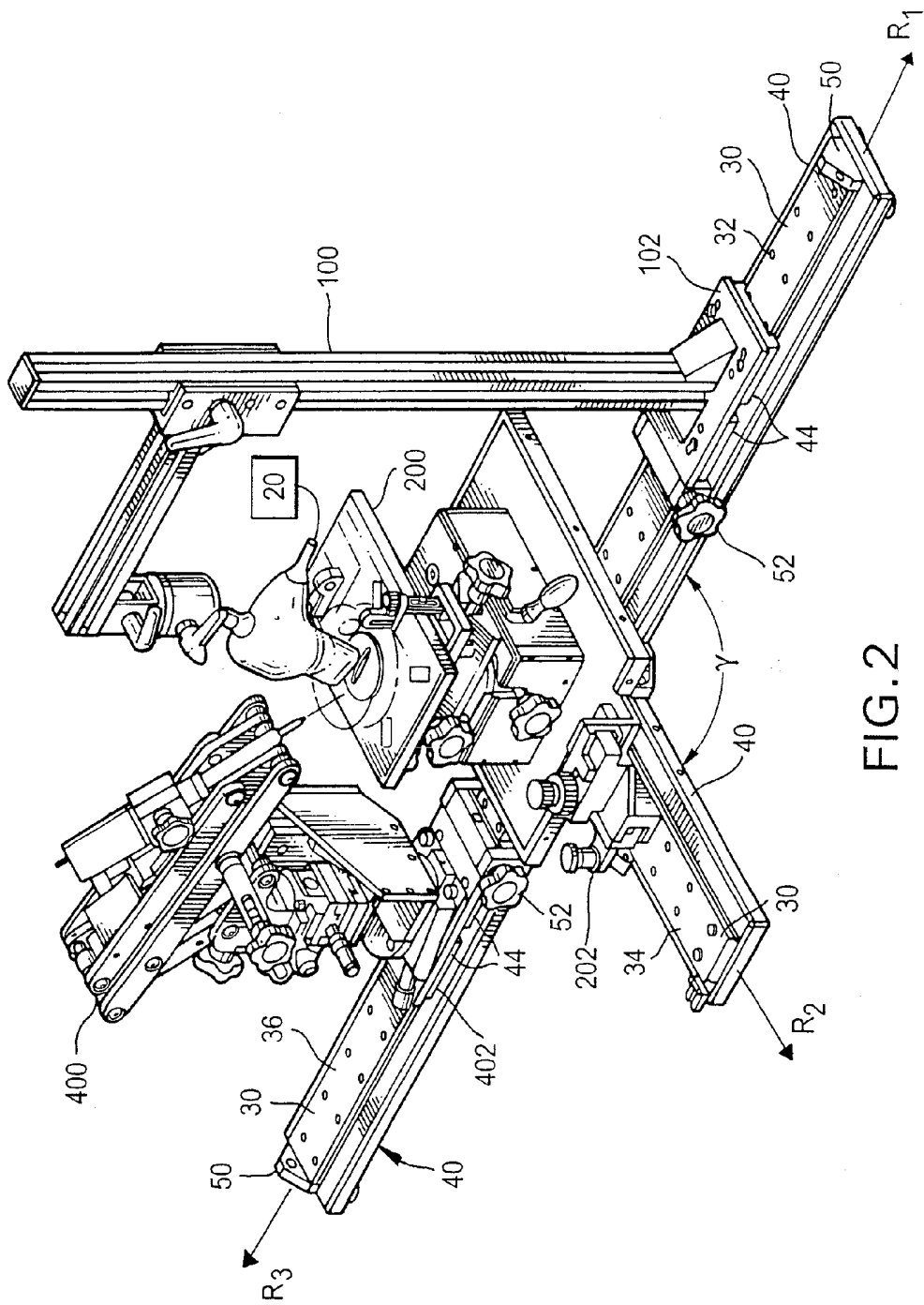
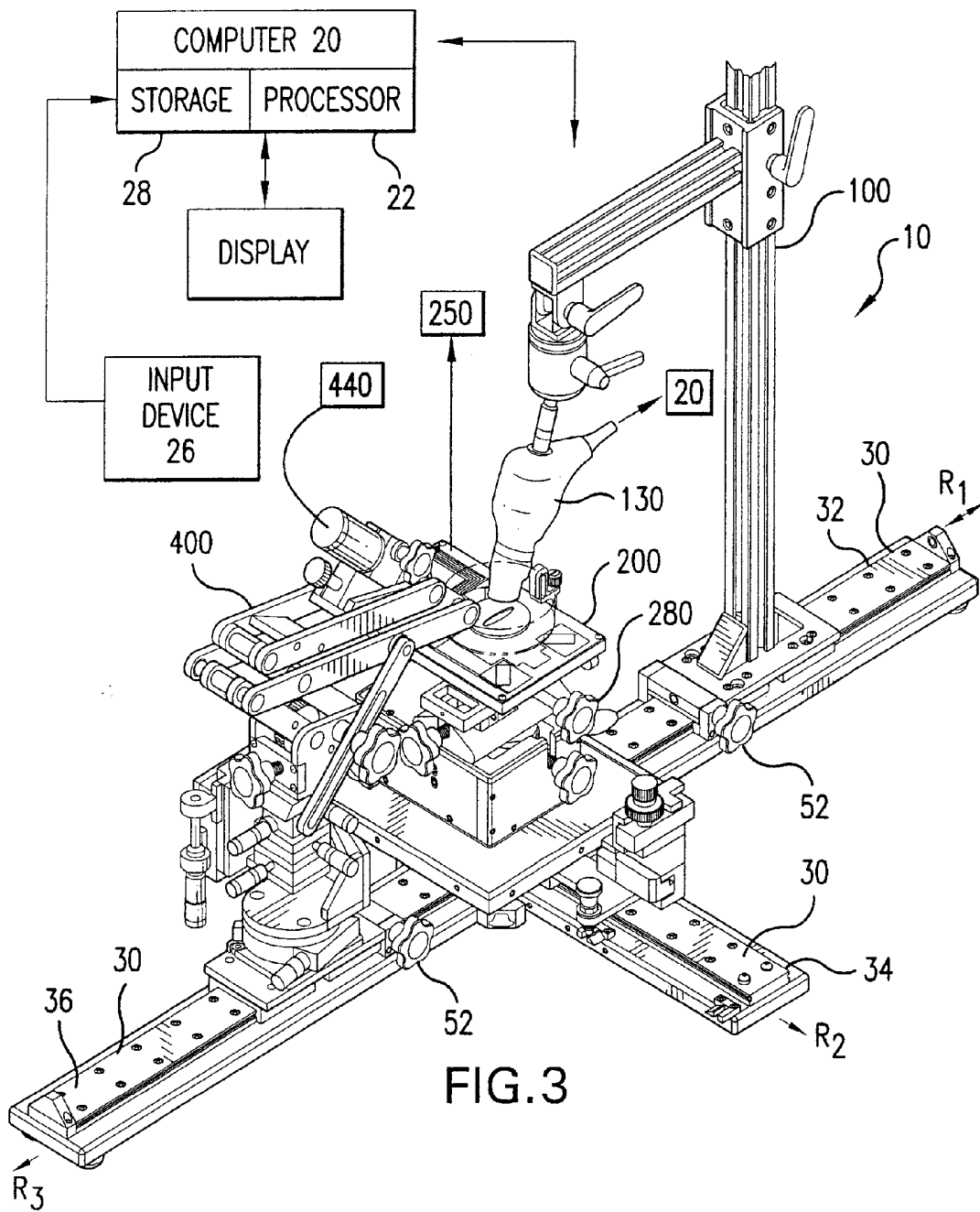


FIG. 2





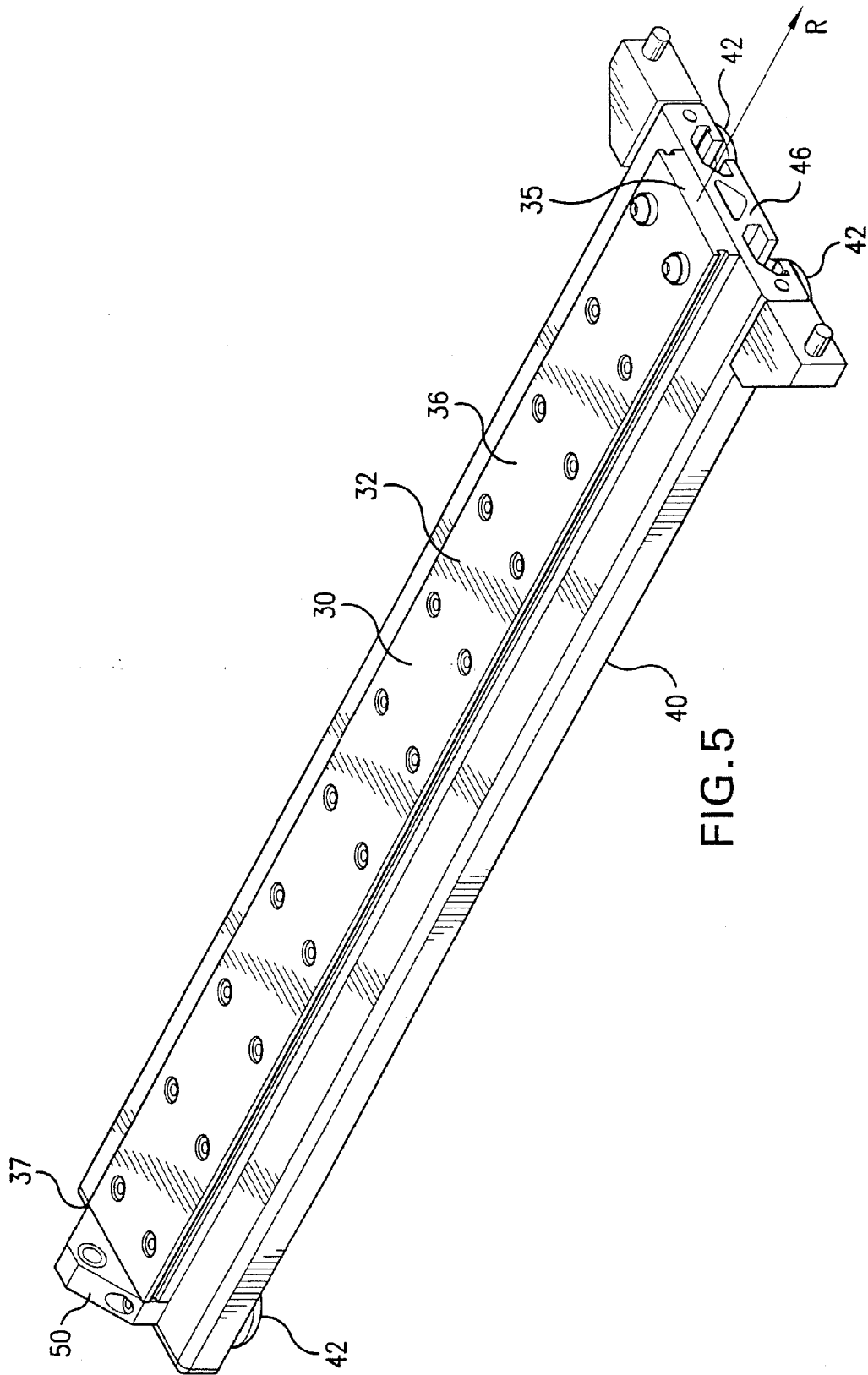


FIG. 5

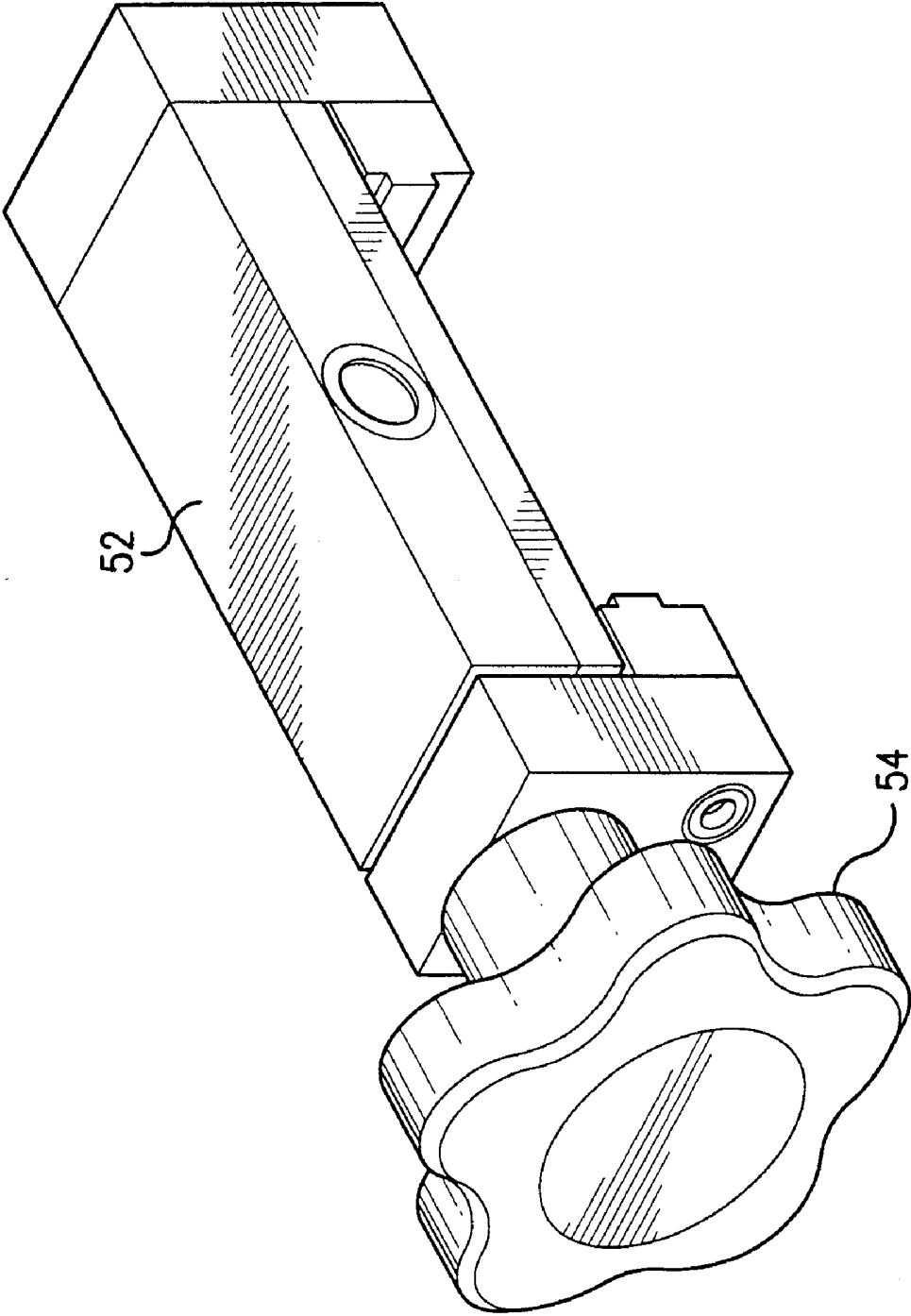


FIG. 6

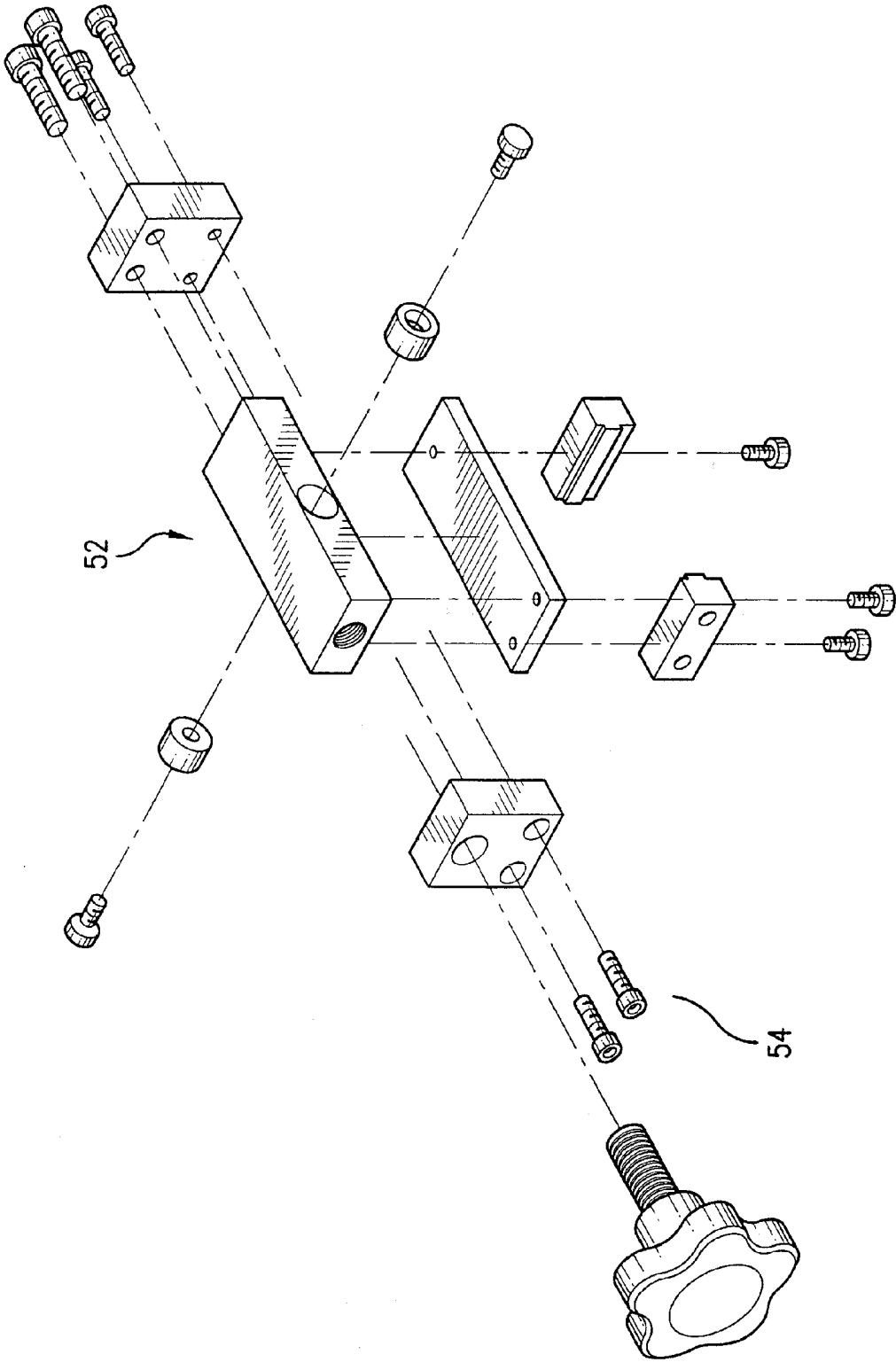


FIG. 7

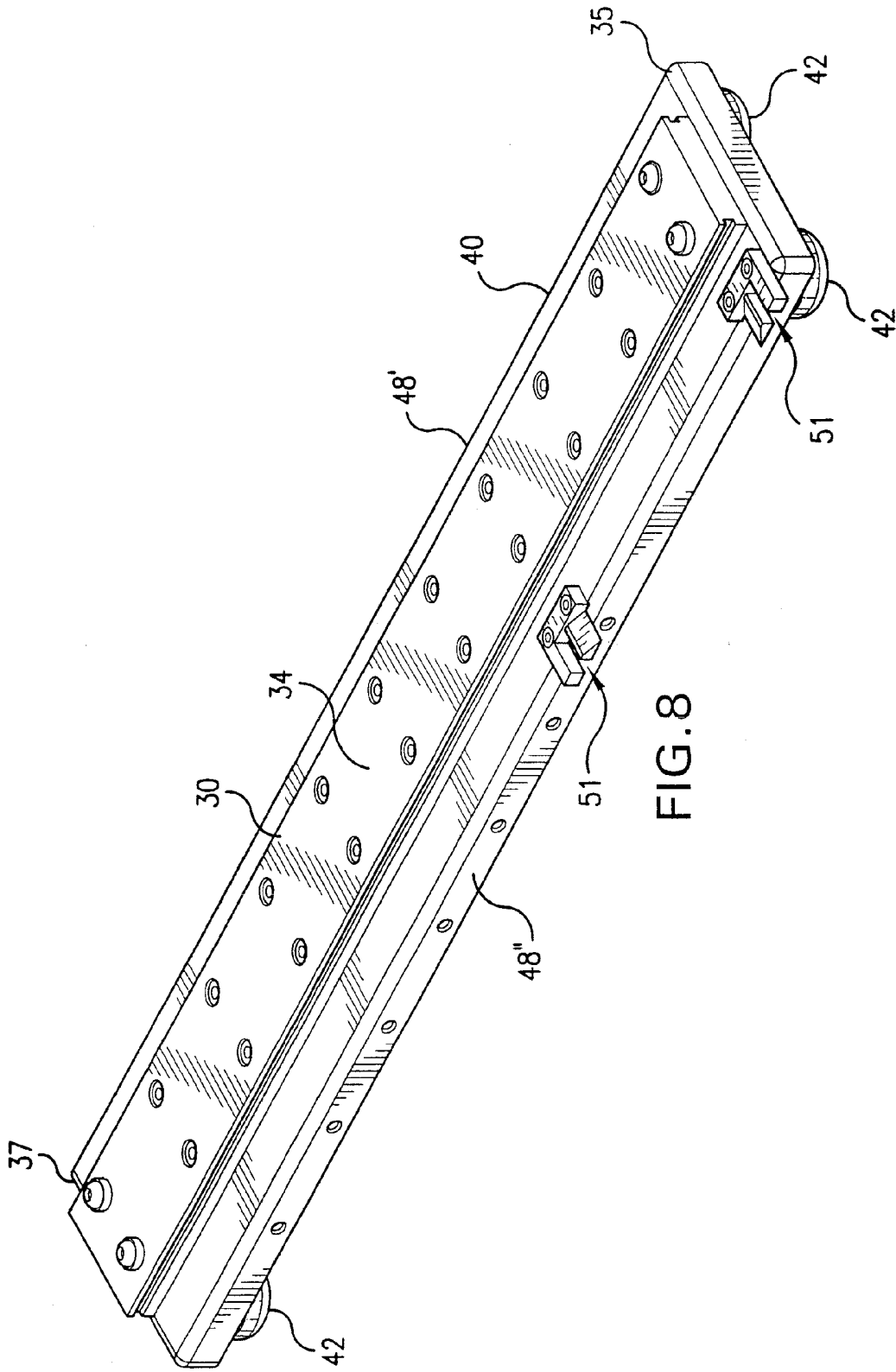
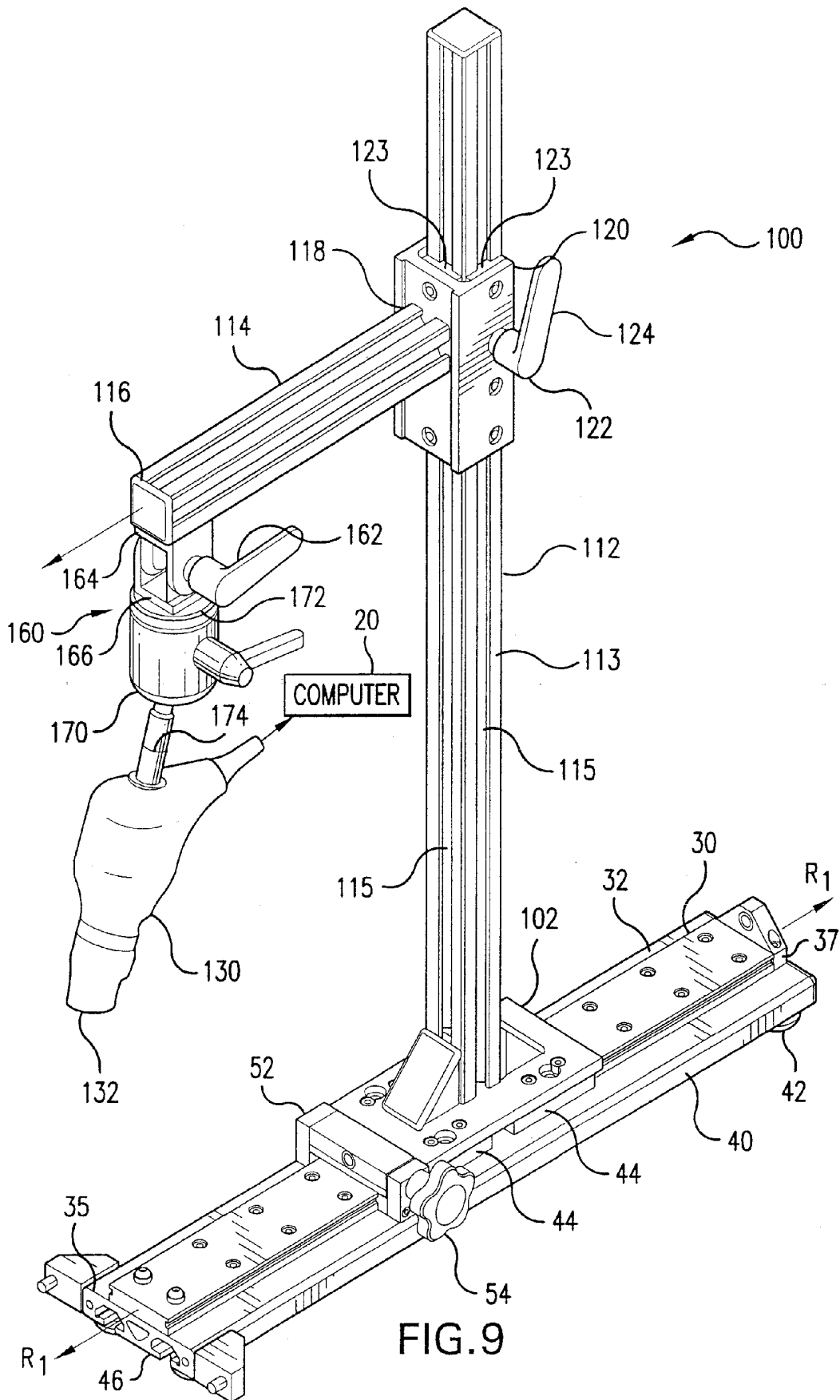


FIG. 8



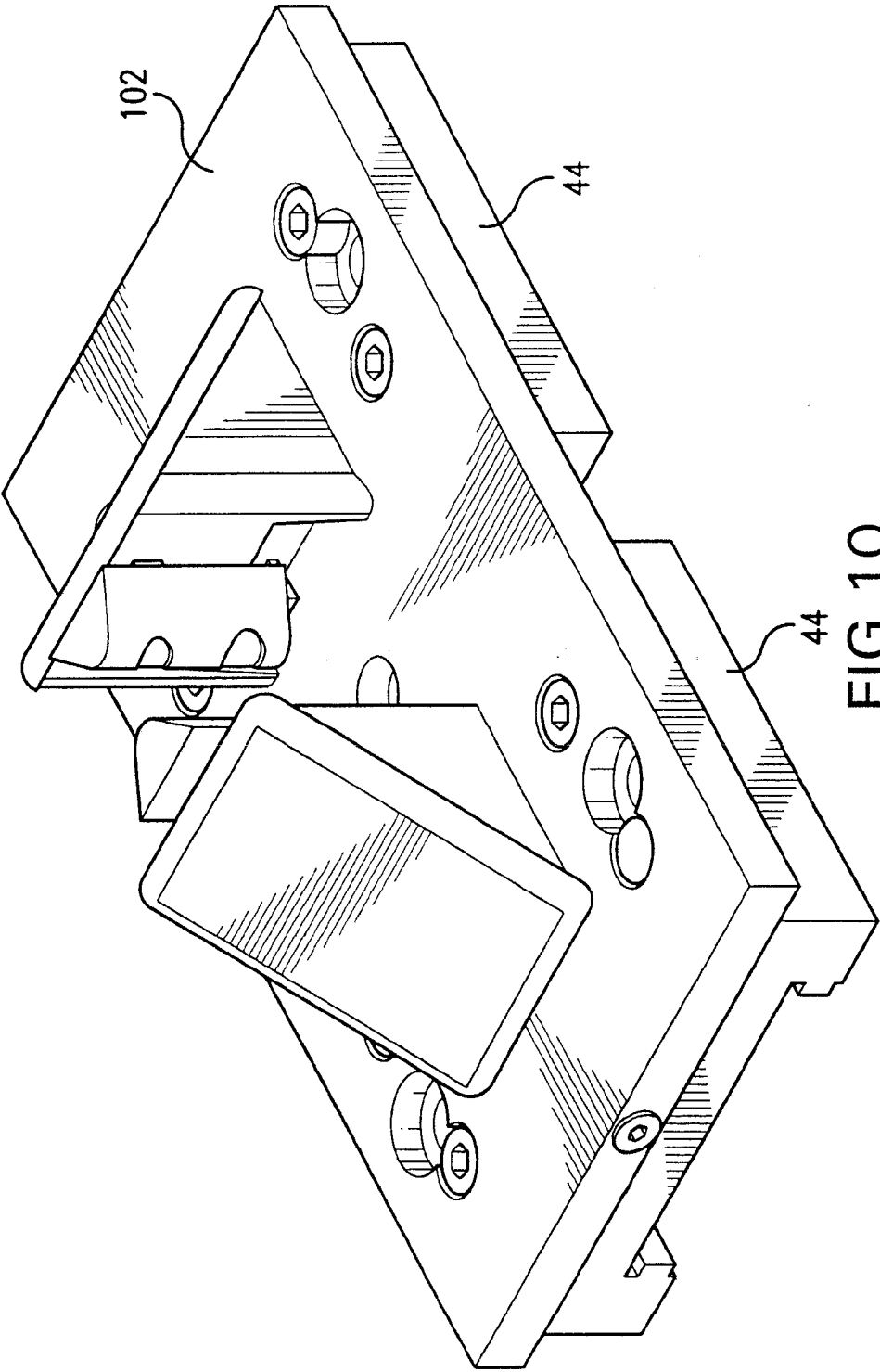


FIG. 10

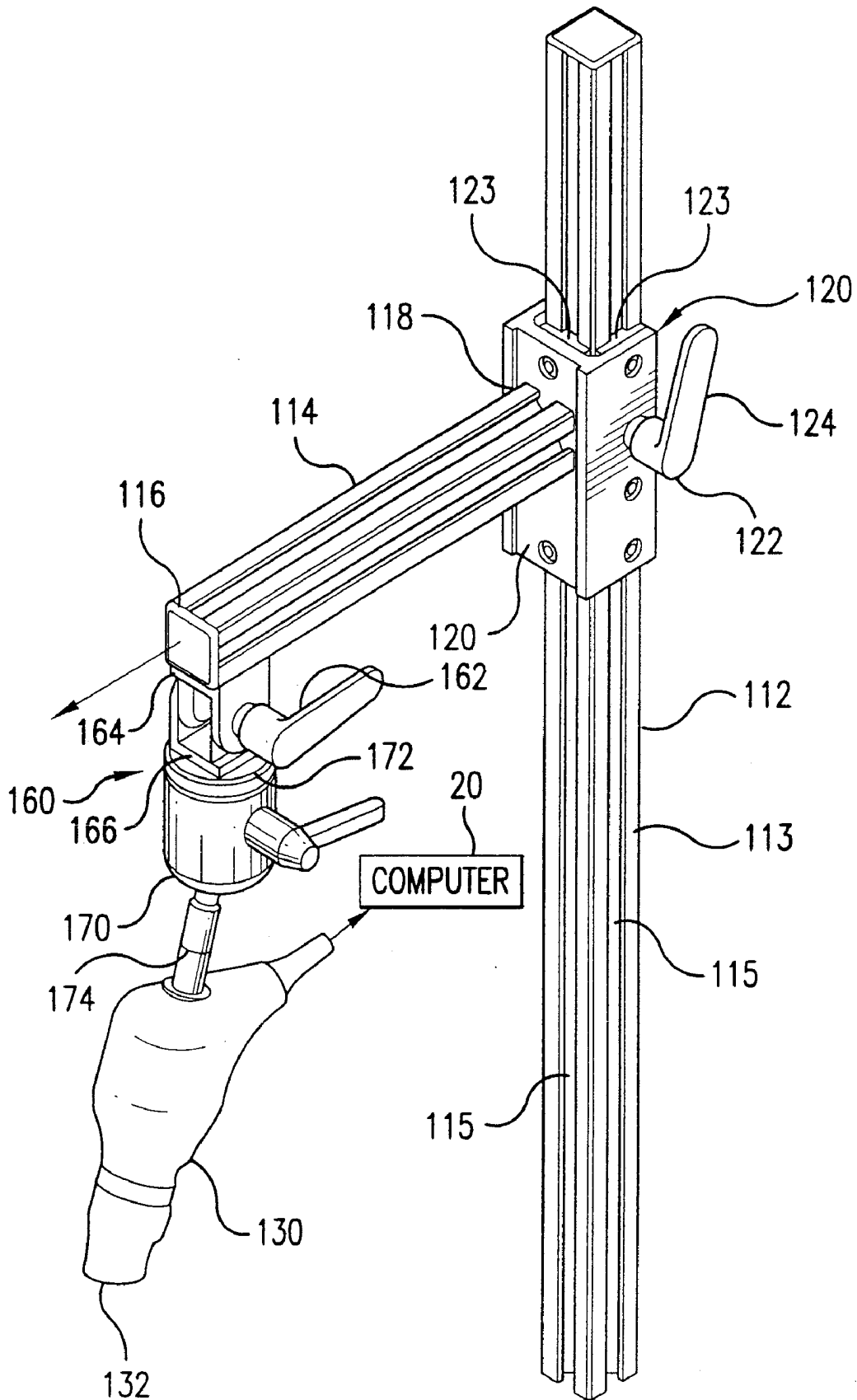


FIG 11

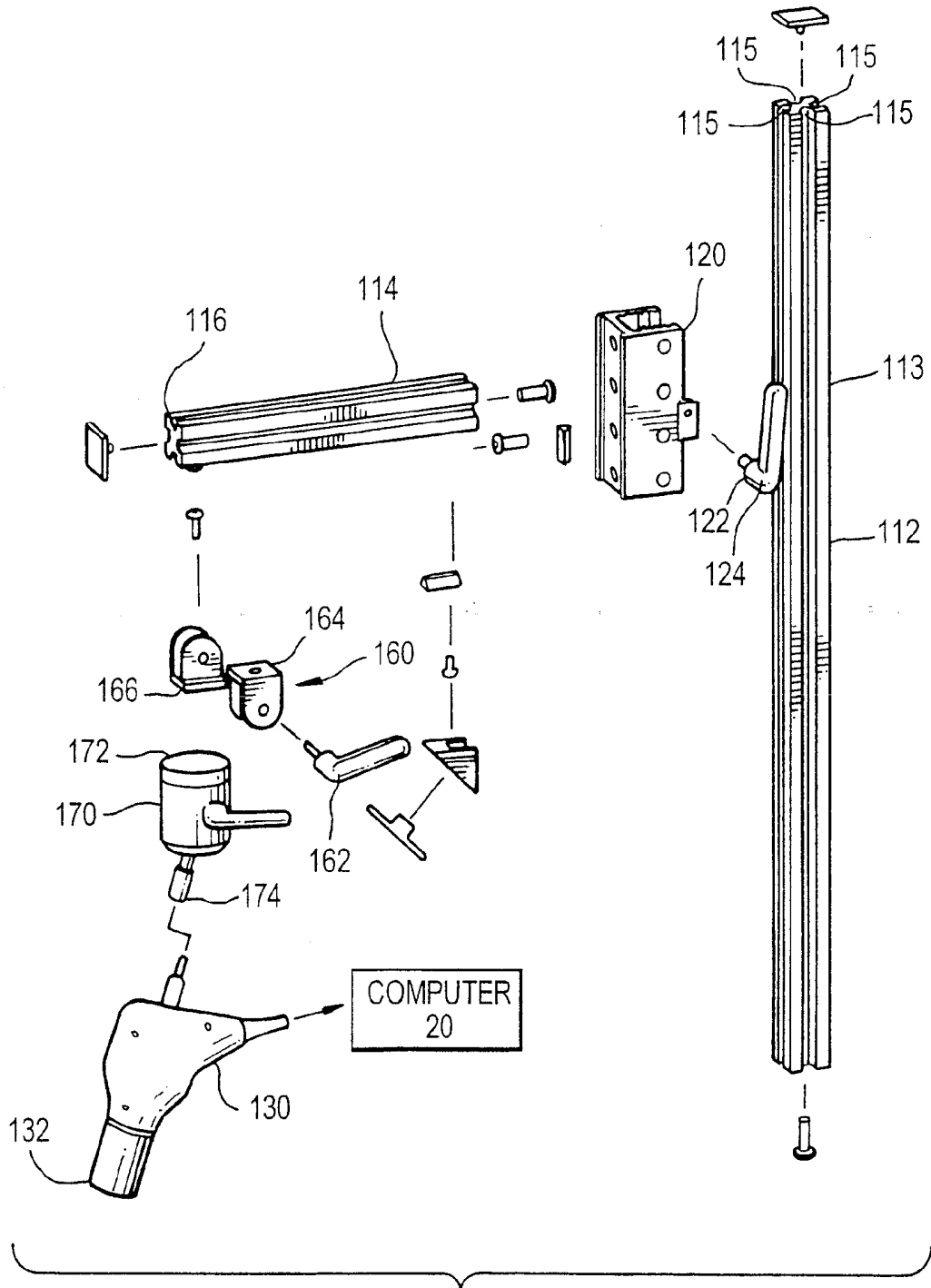


FIG. 12

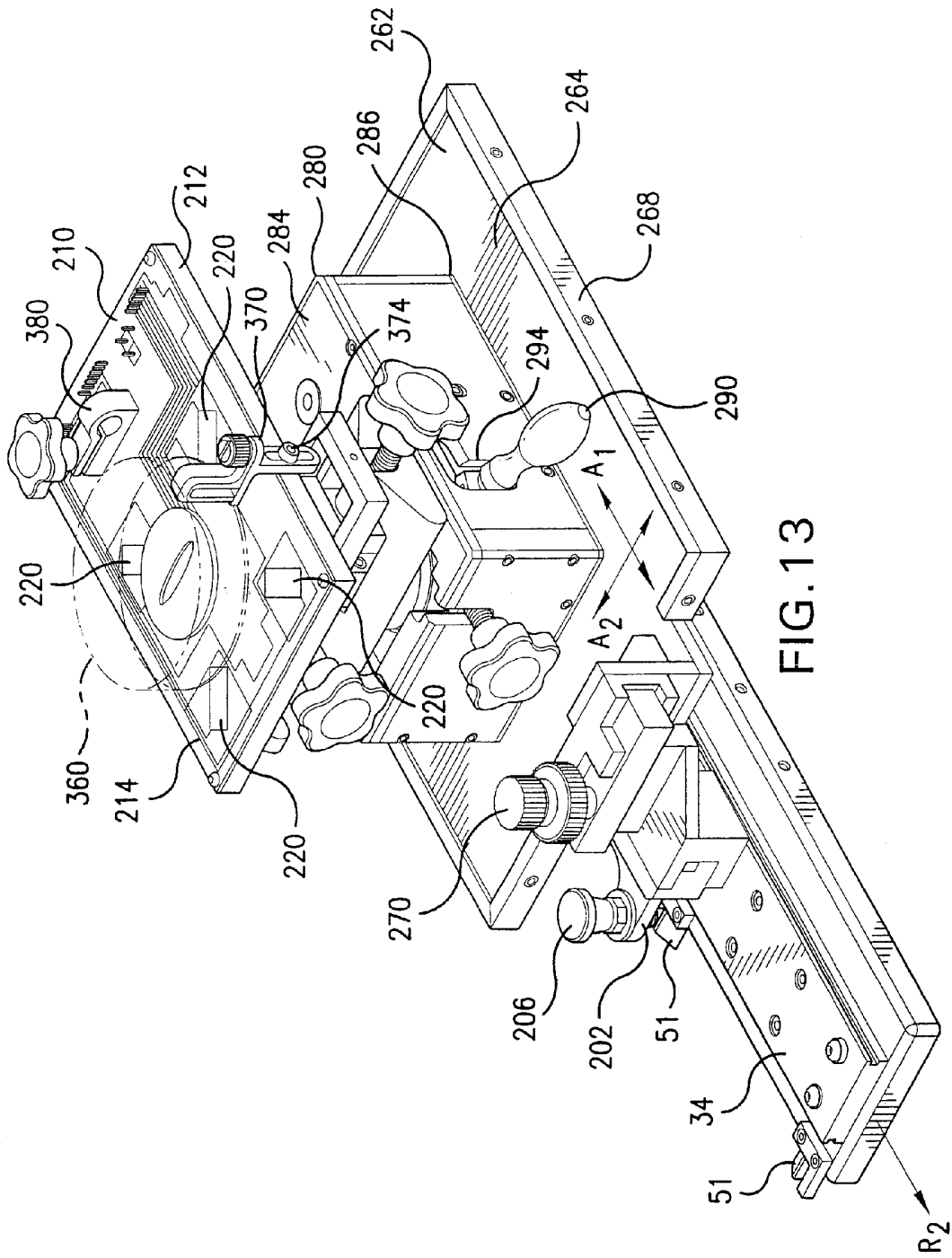


FIG. 13

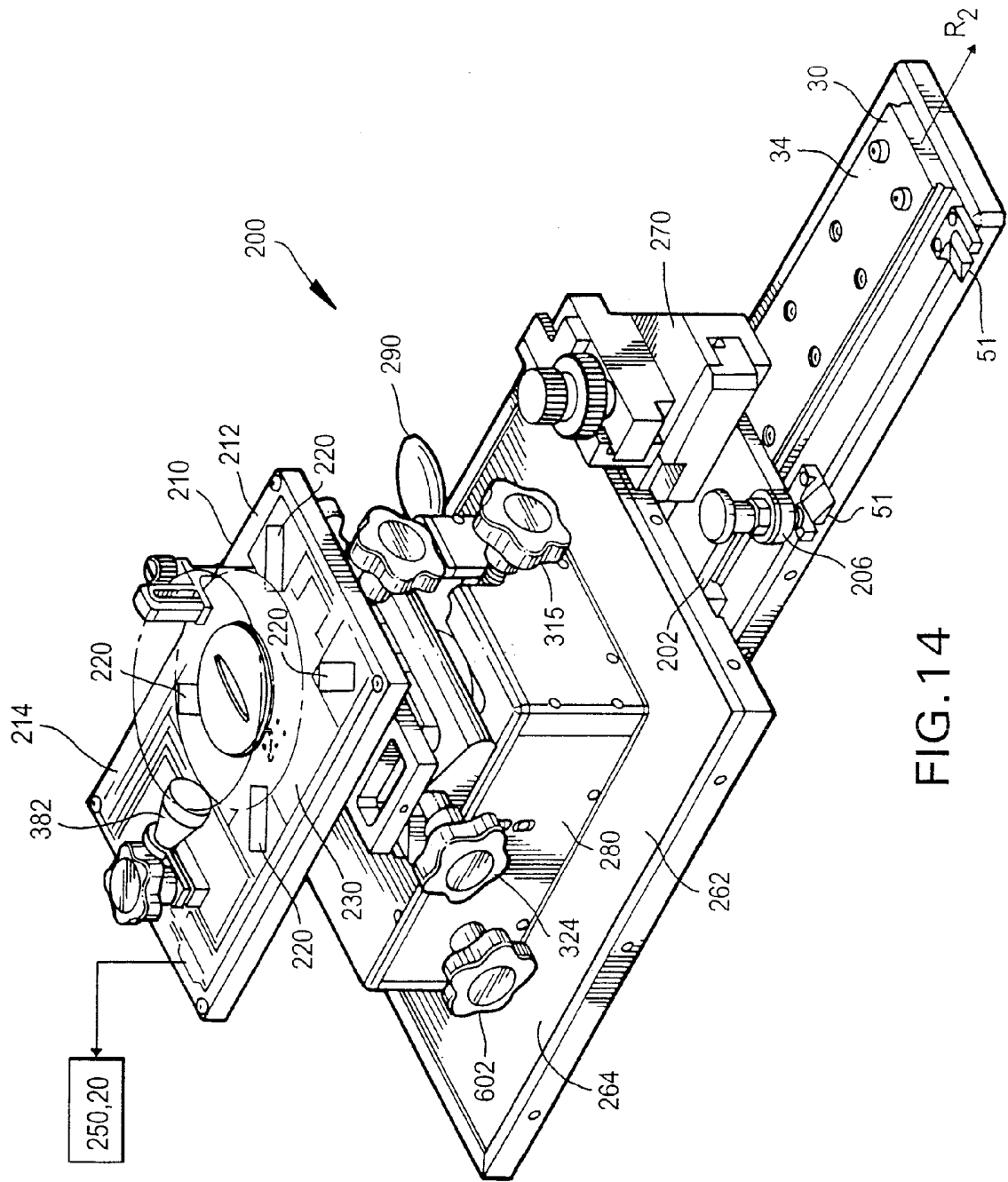


FIG. 14

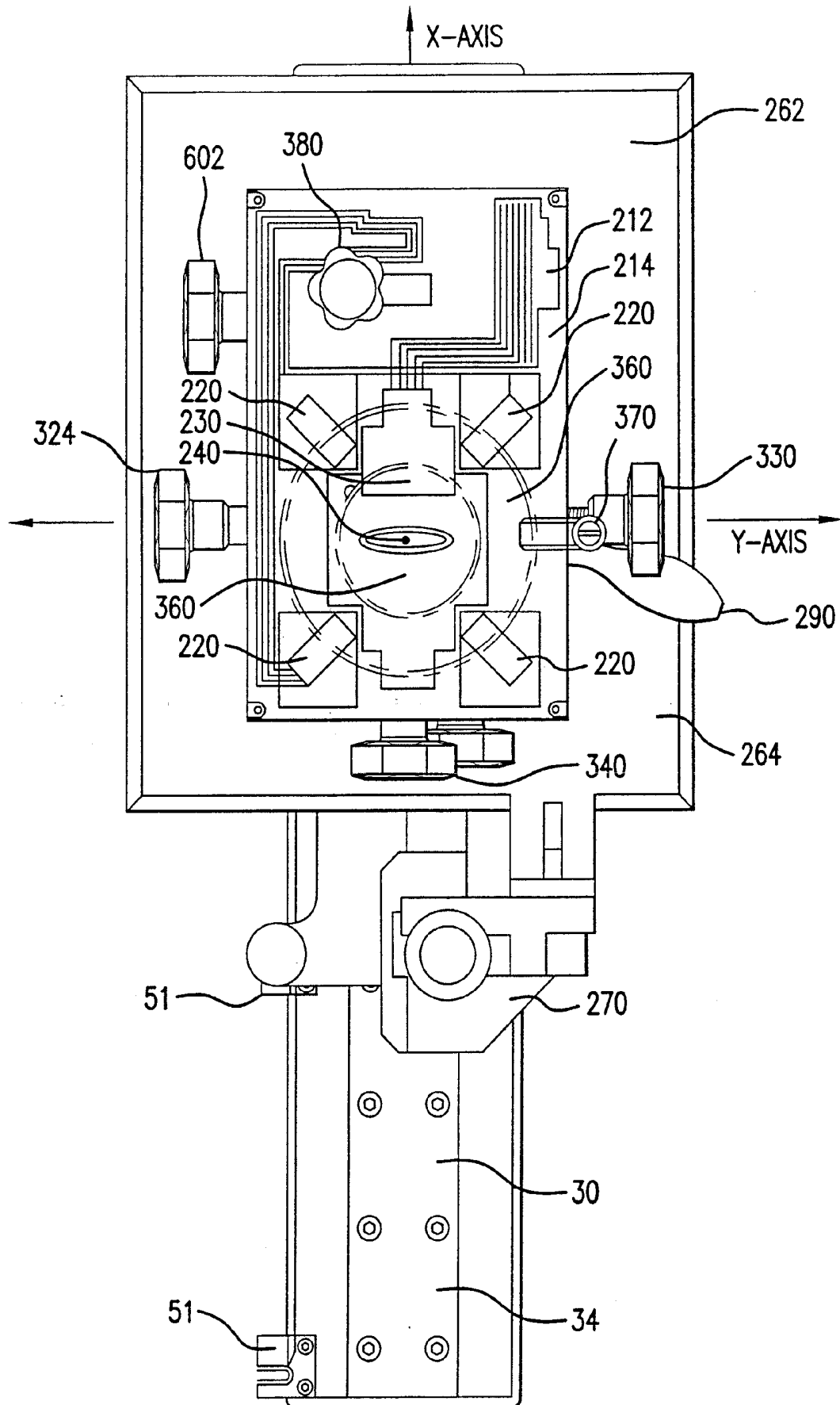


FIG. 15

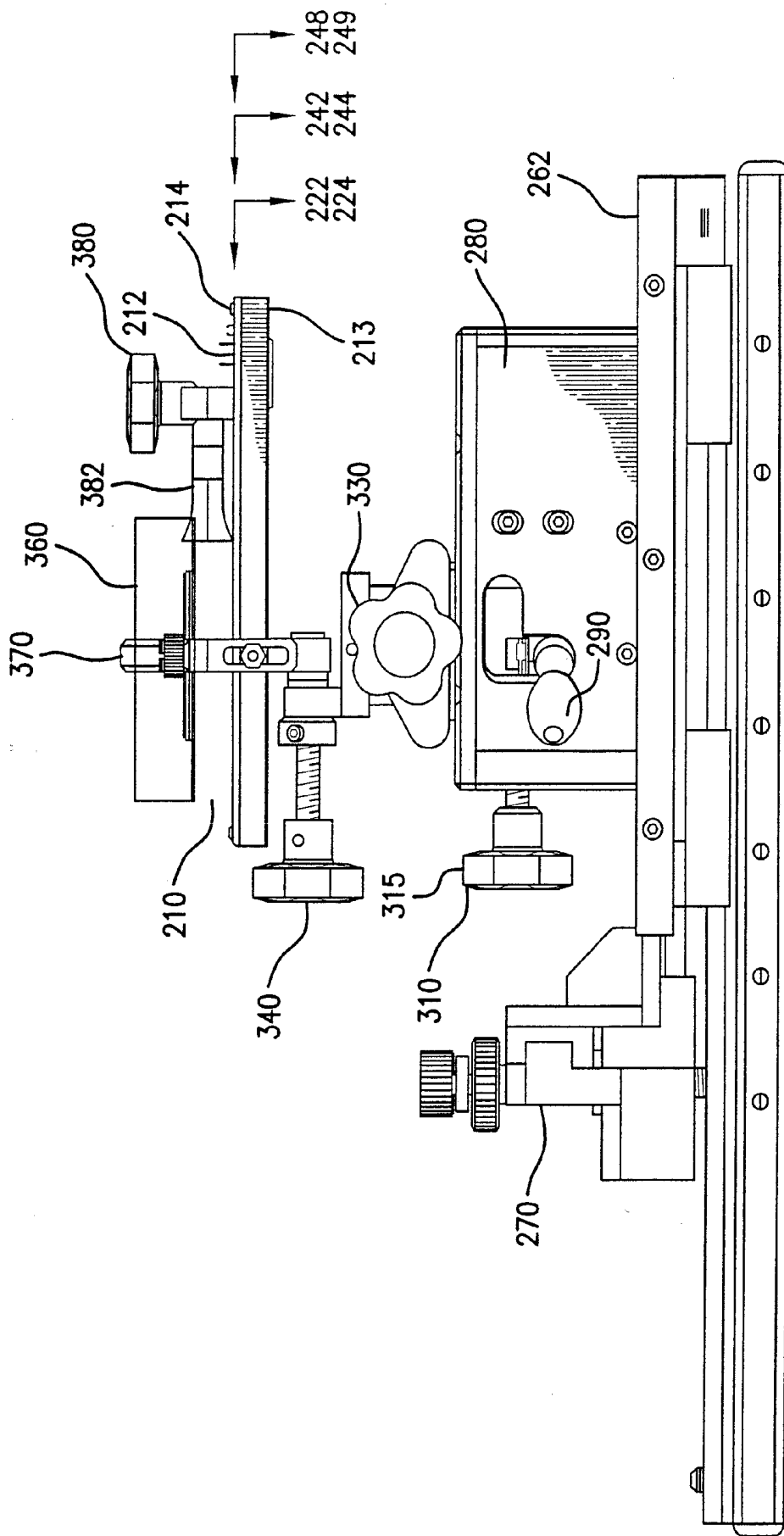


FIG. 16

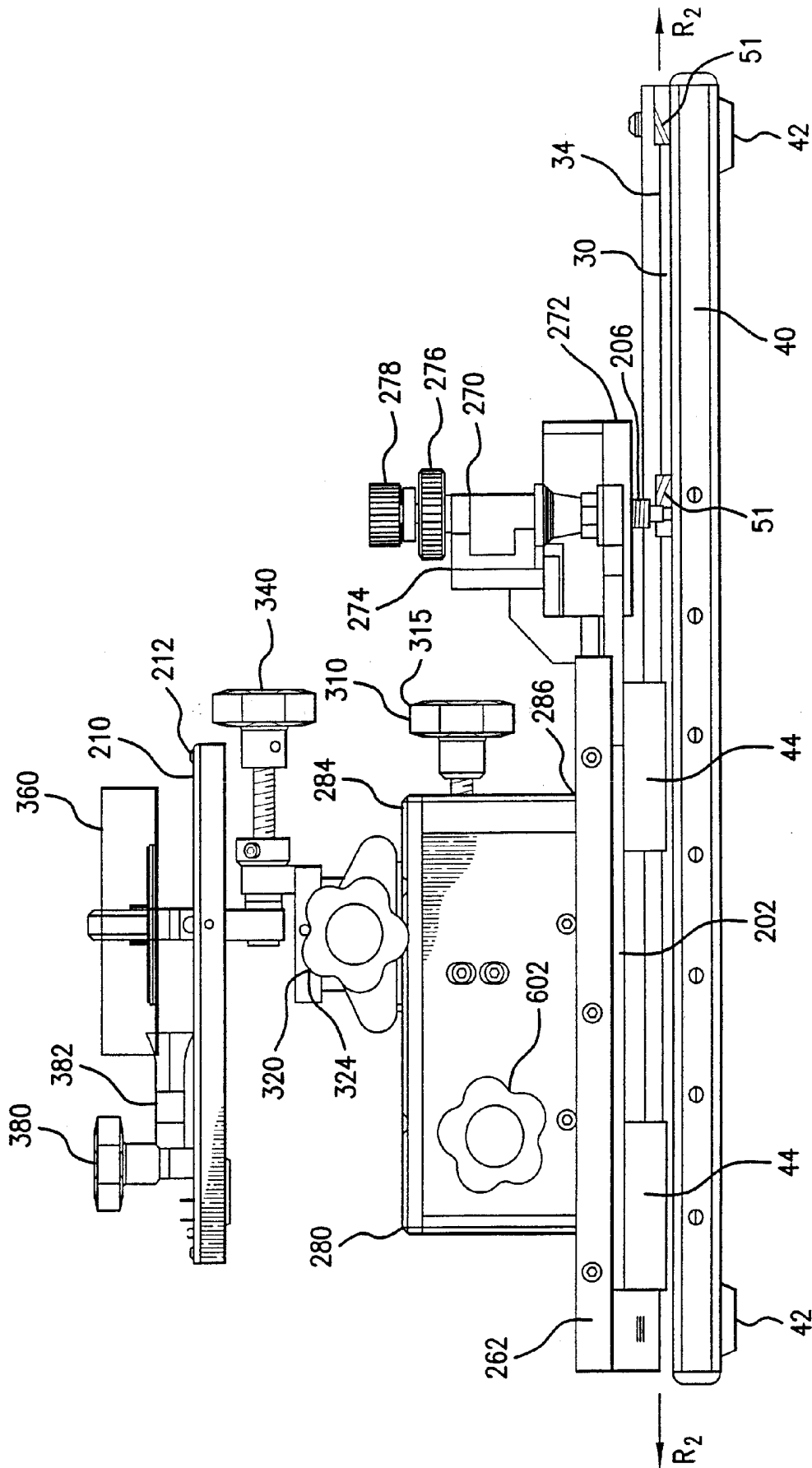


FIG. 17

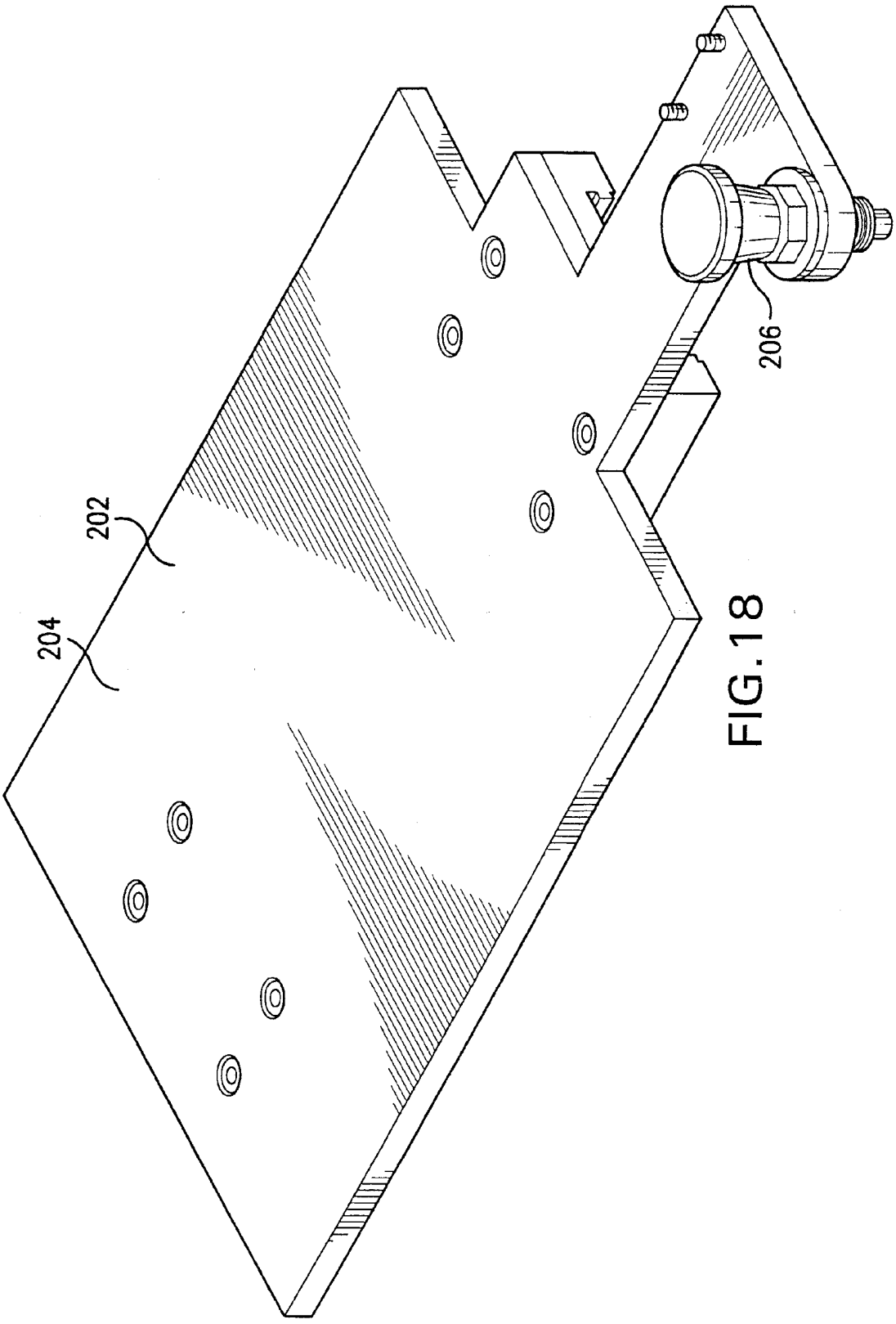


FIG. 18

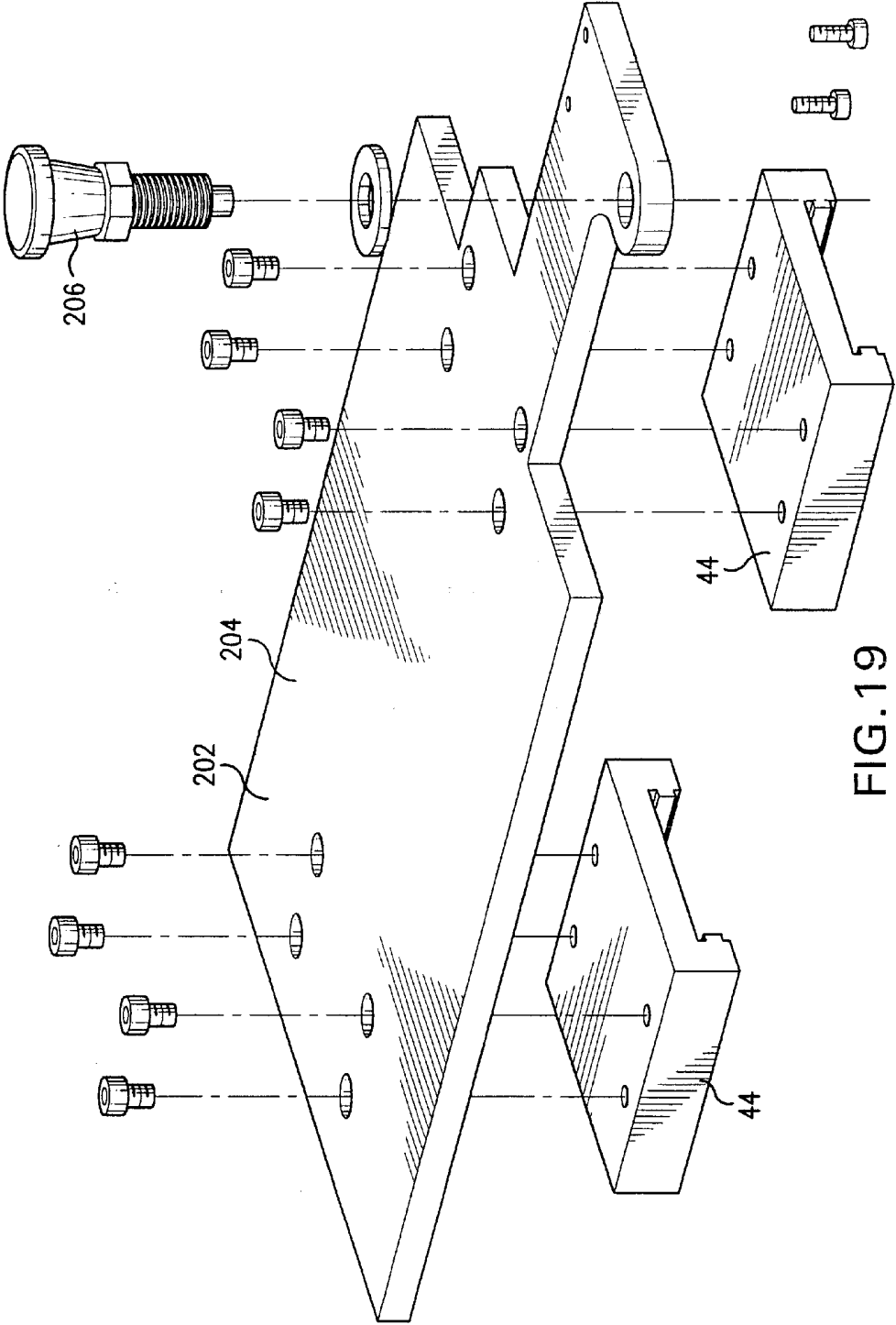


FIG. 19



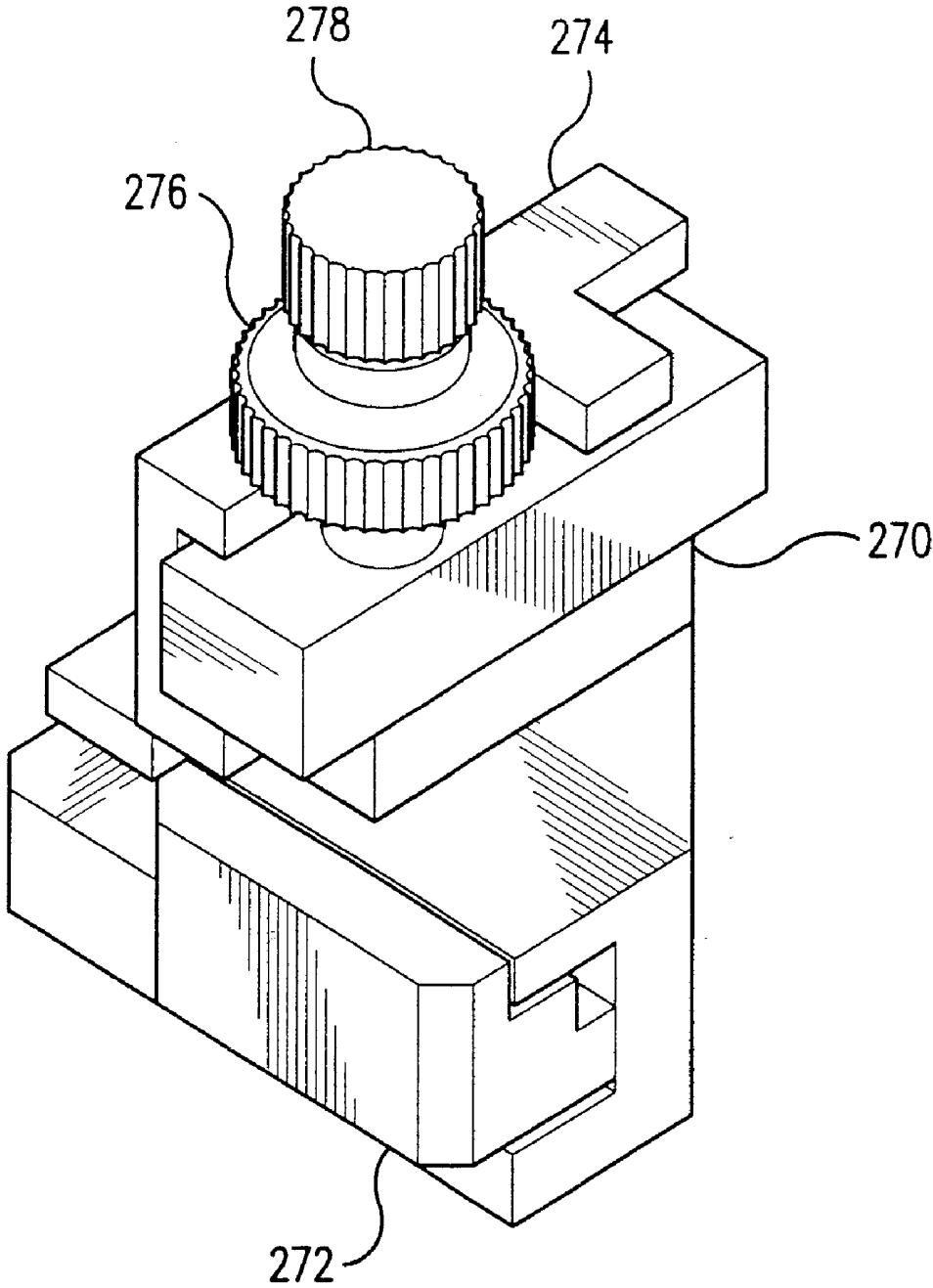


FIG. 21

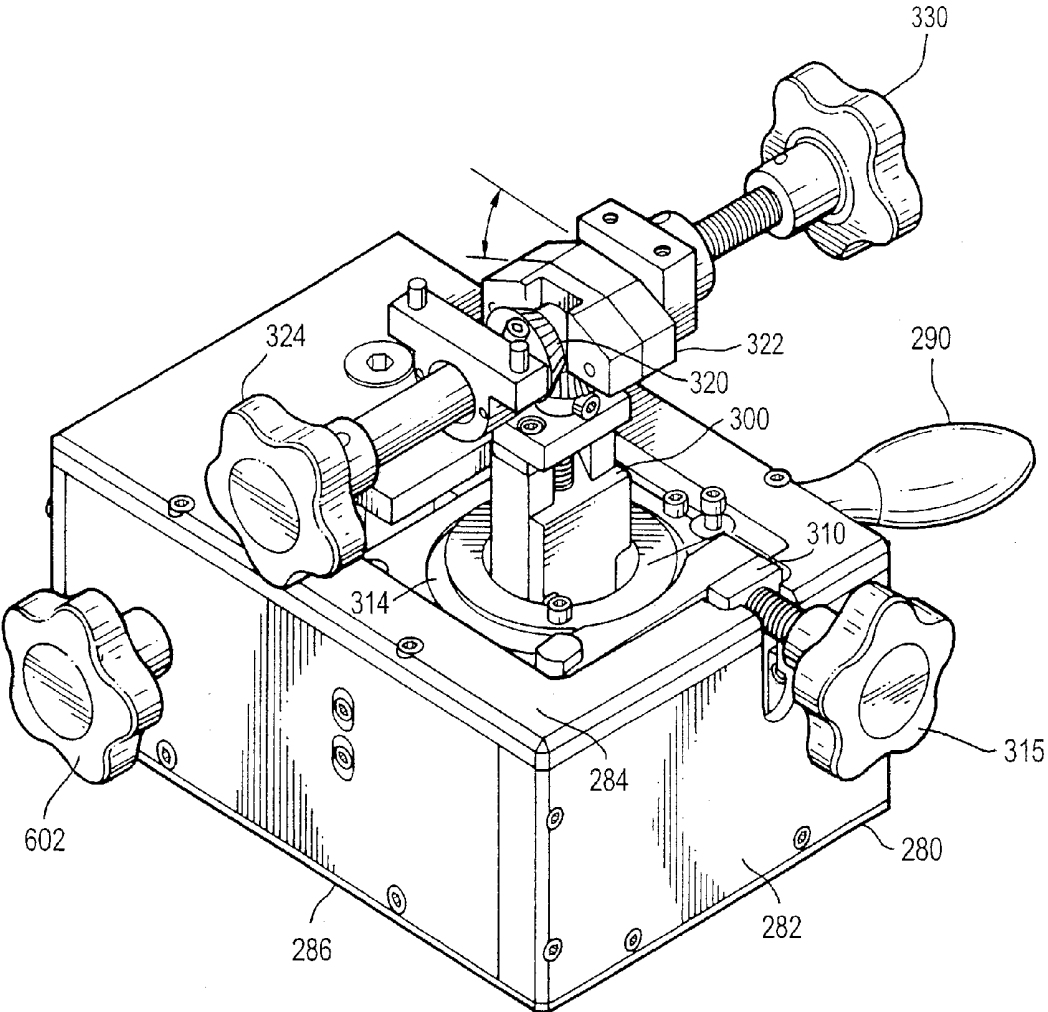


FIG.22

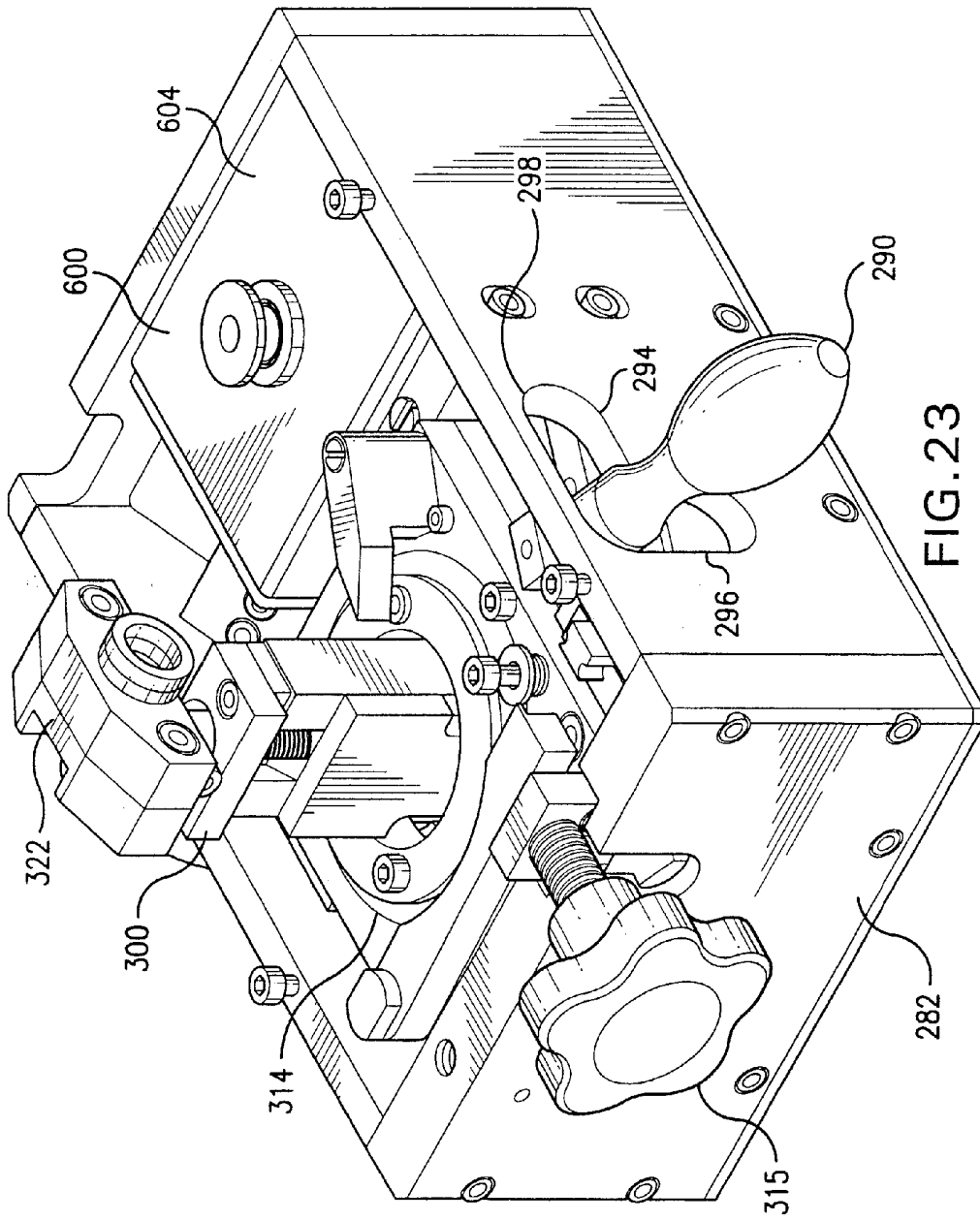


FIG. 23

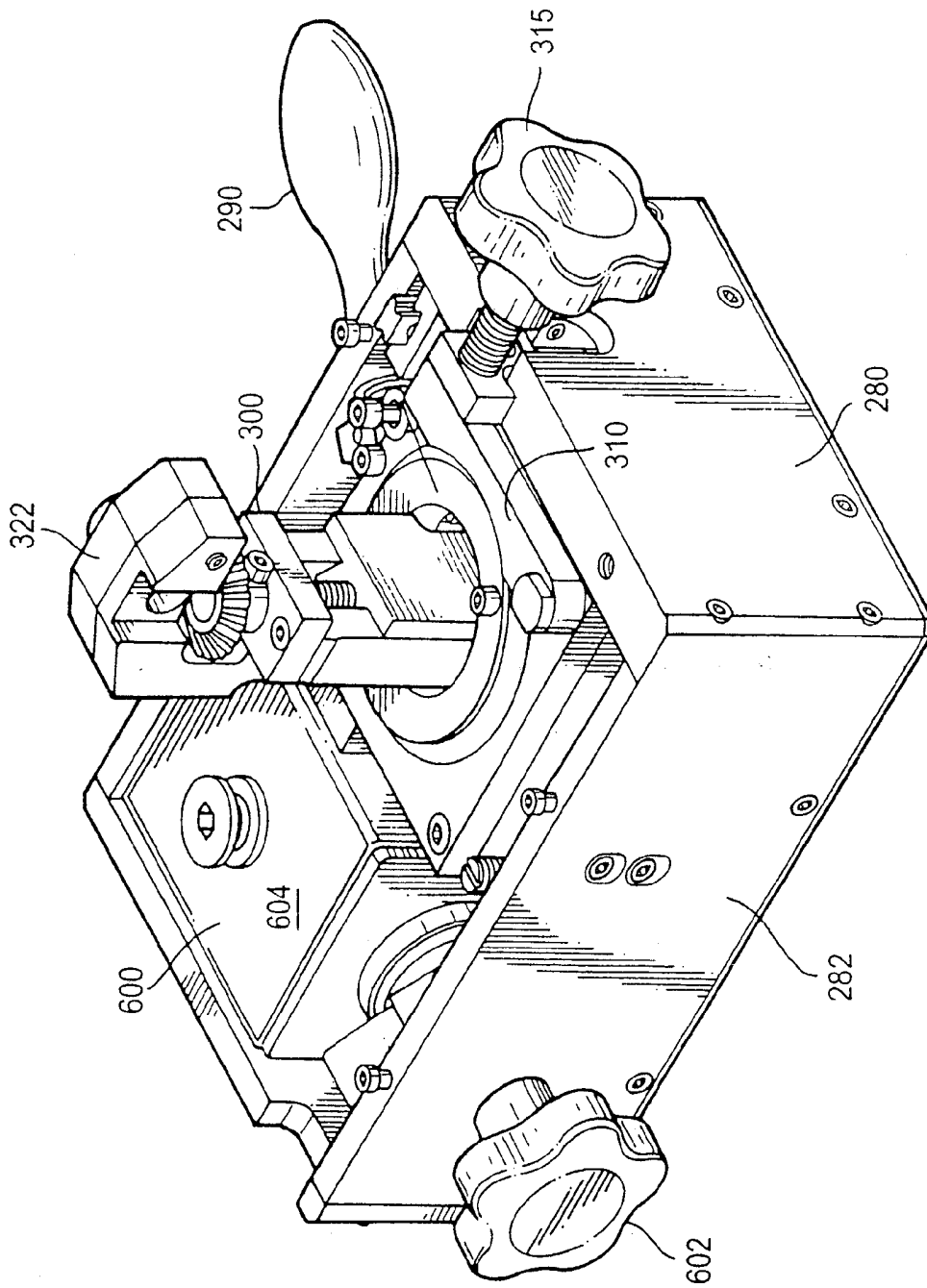


FIG. 24

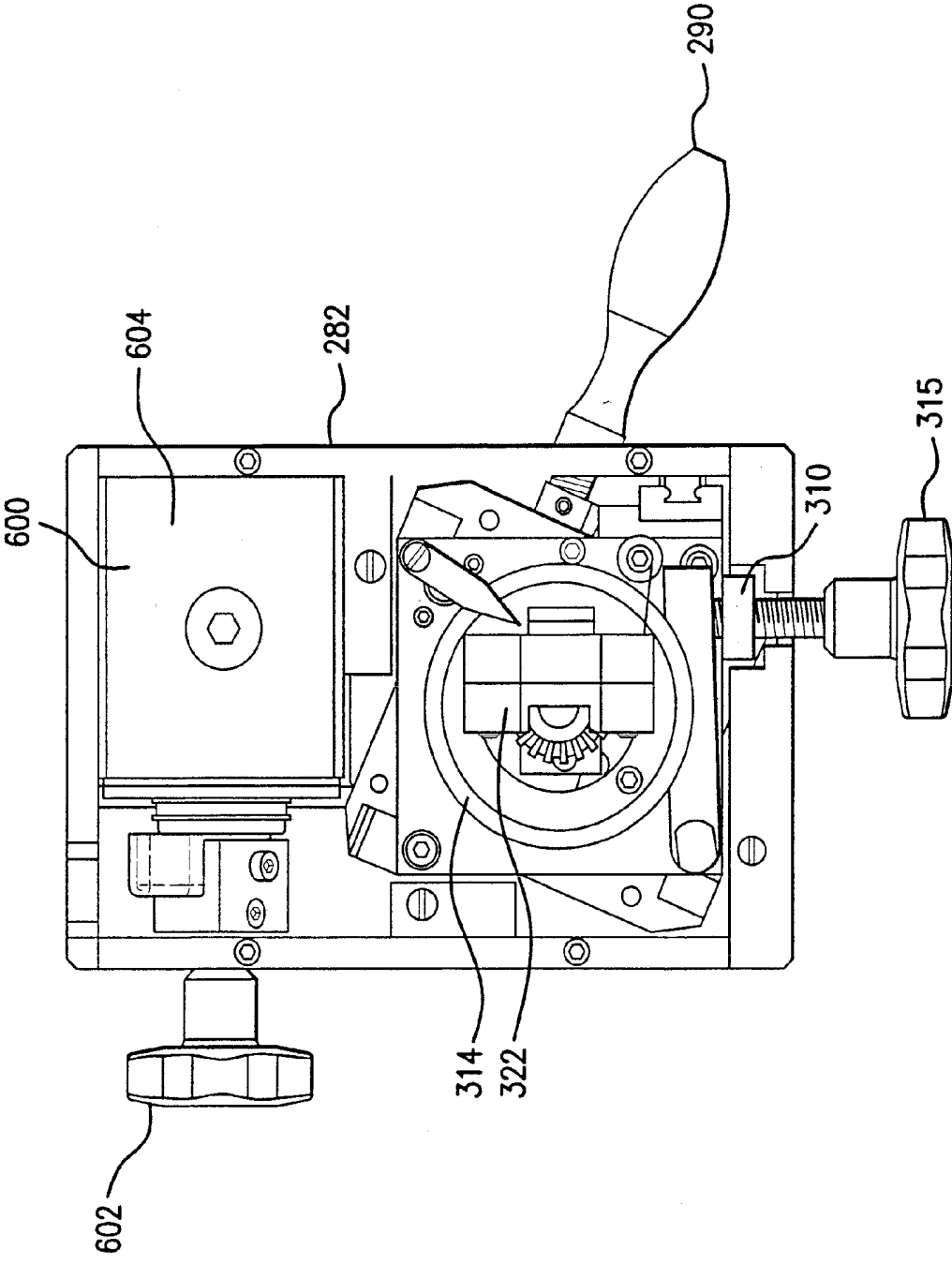


FIG. 25

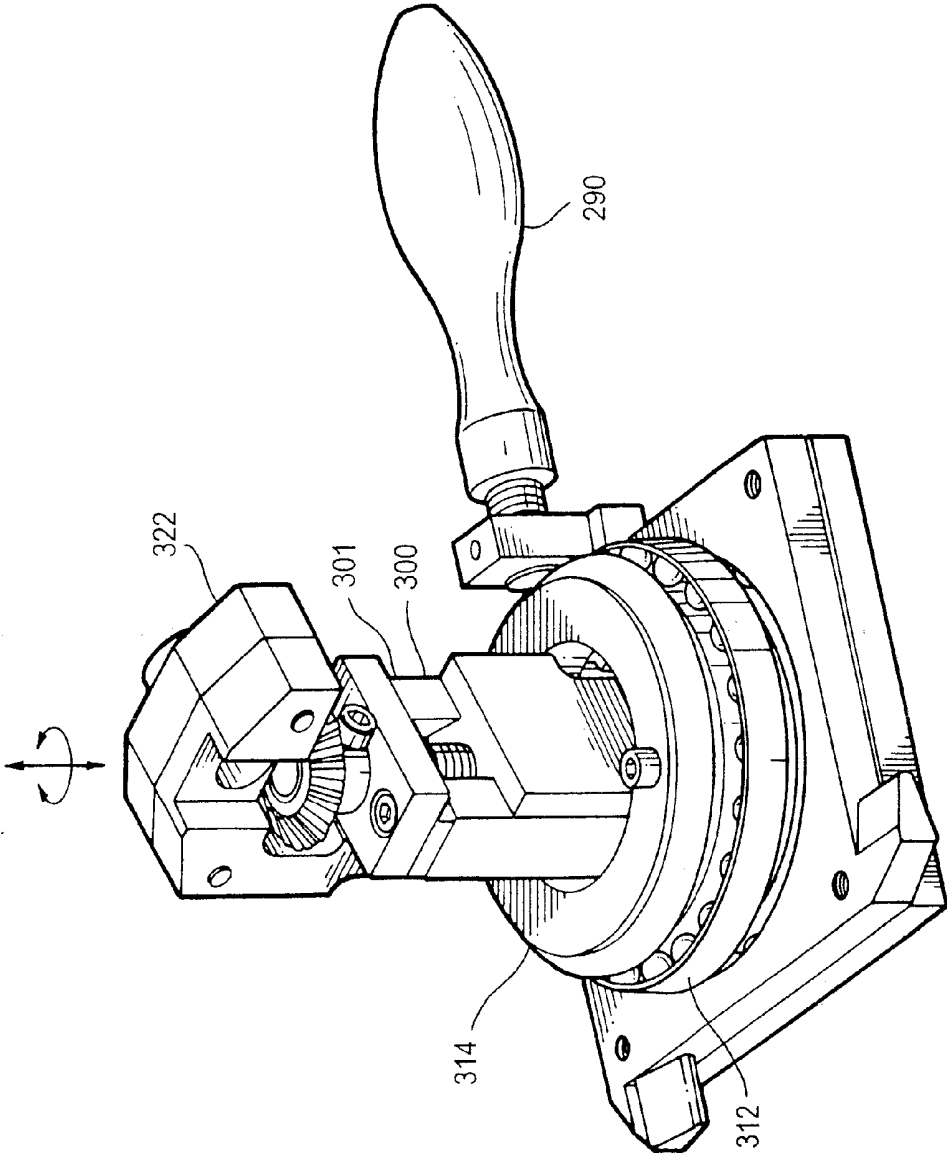


FIG. 26

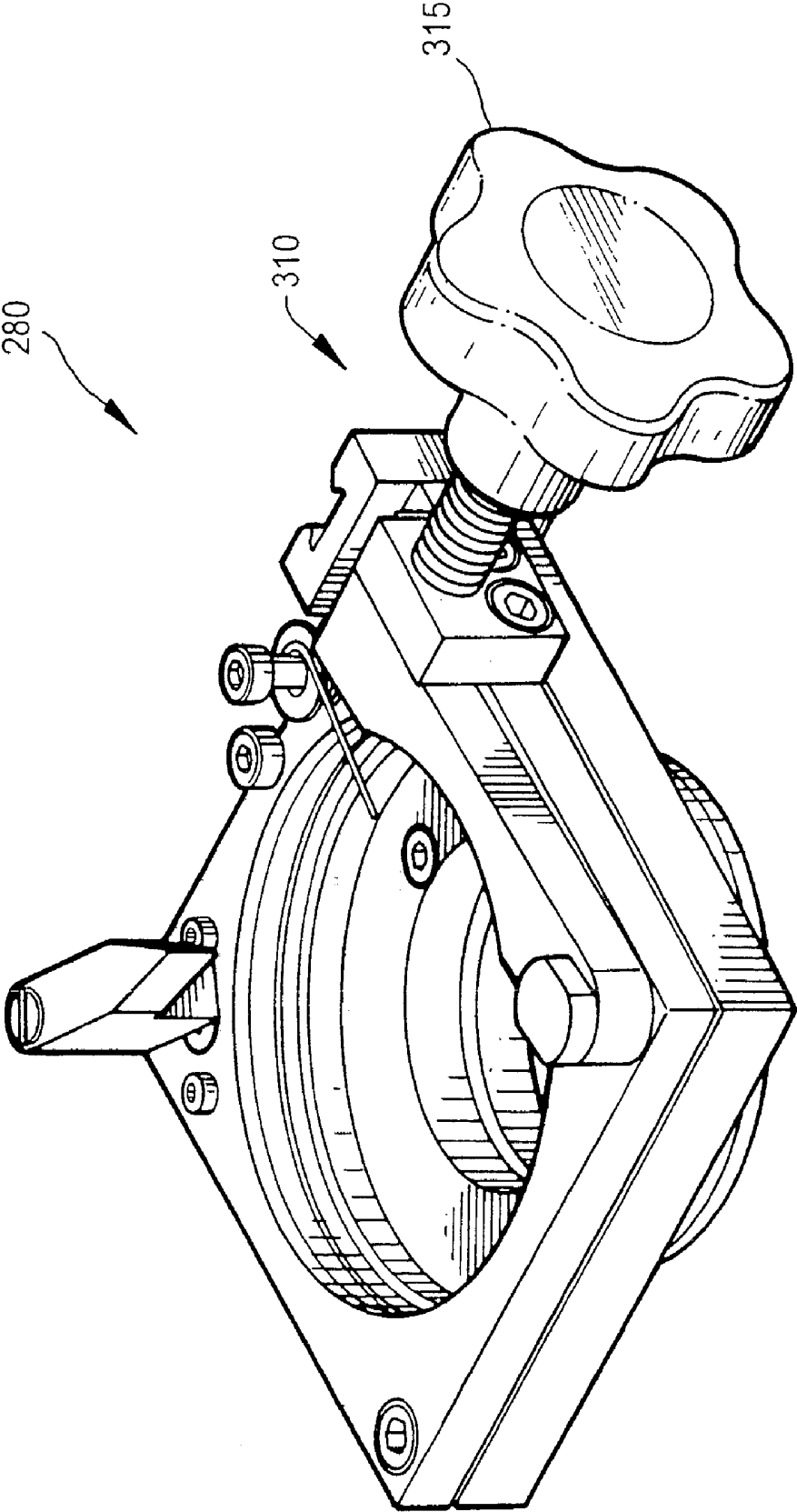


FIG. 27

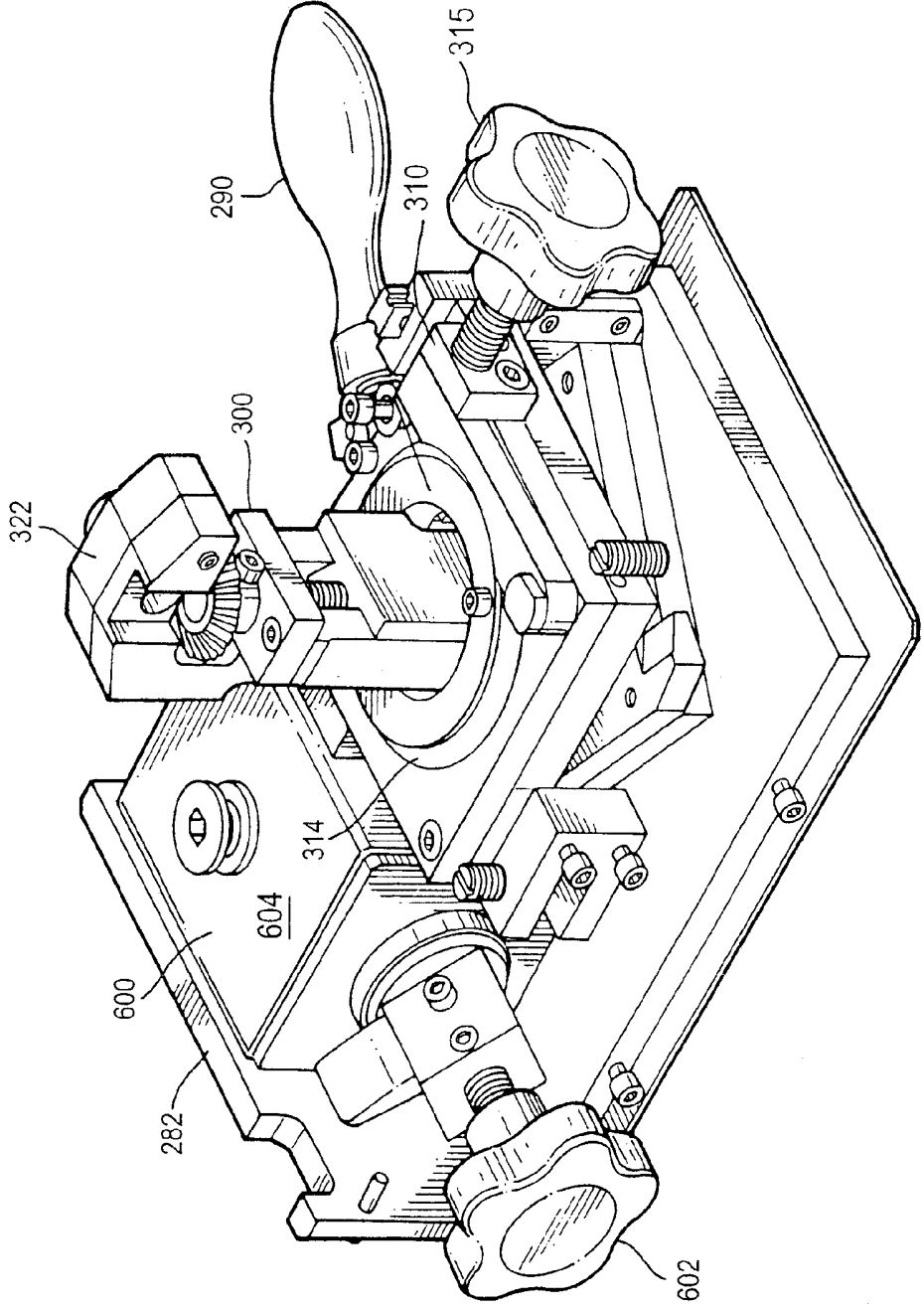


FIG. 28

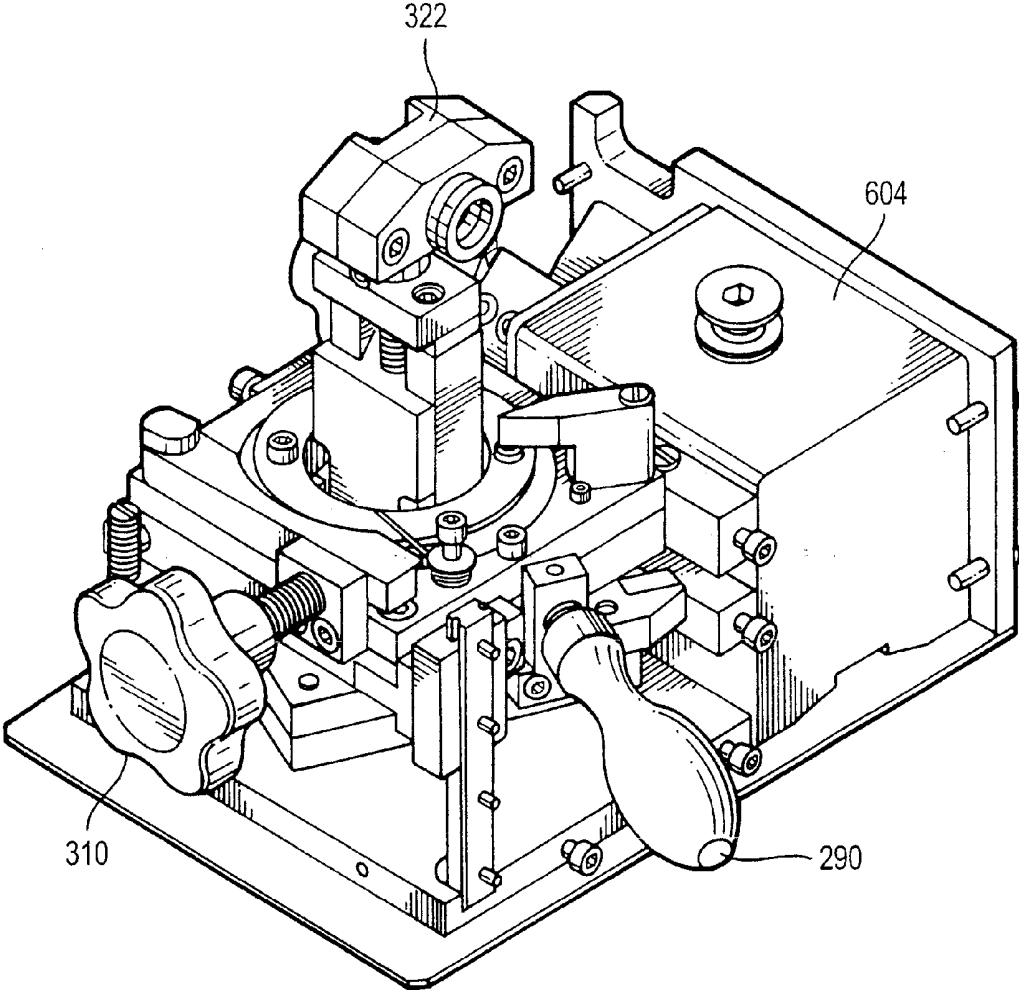


FIG.29



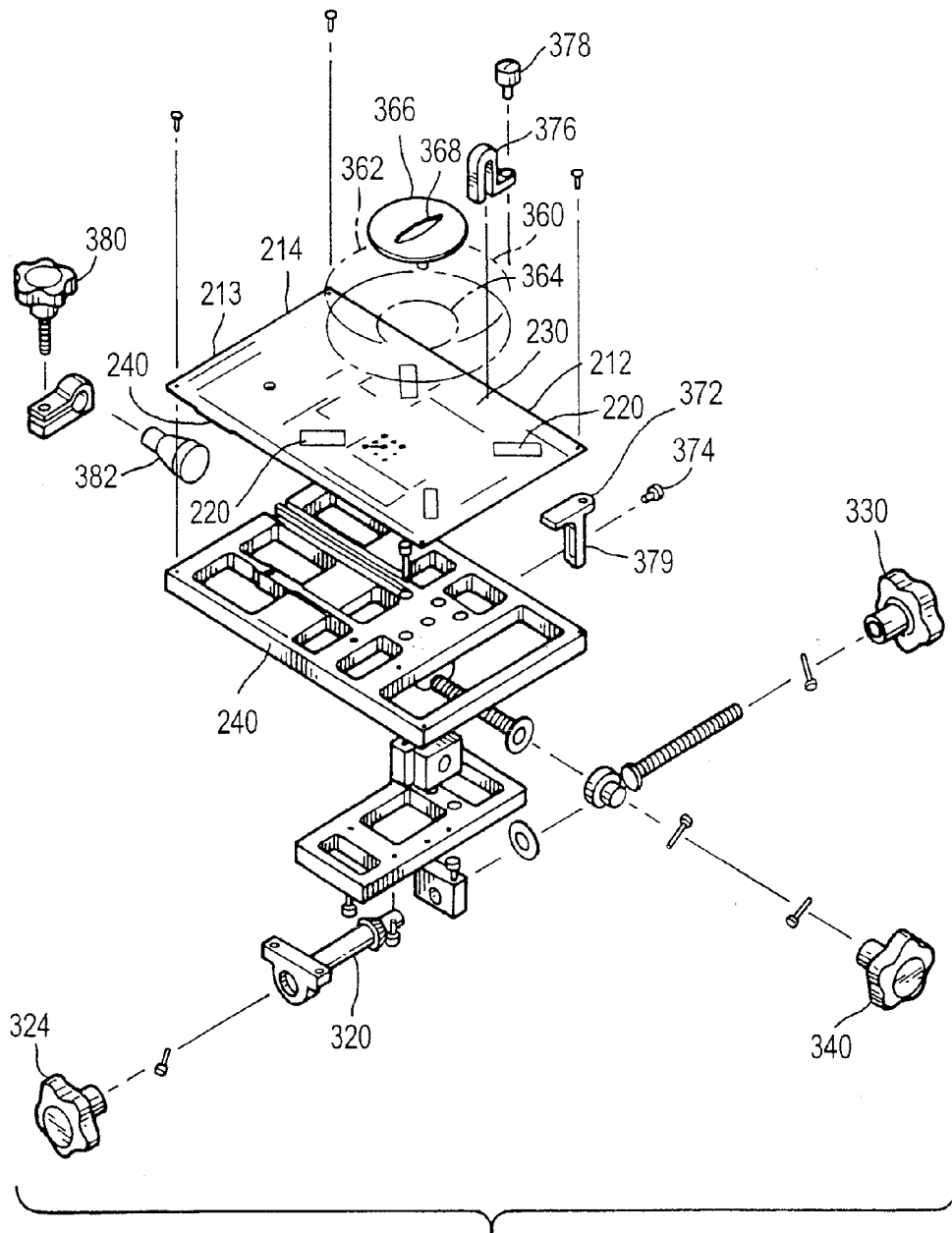


FIG.31



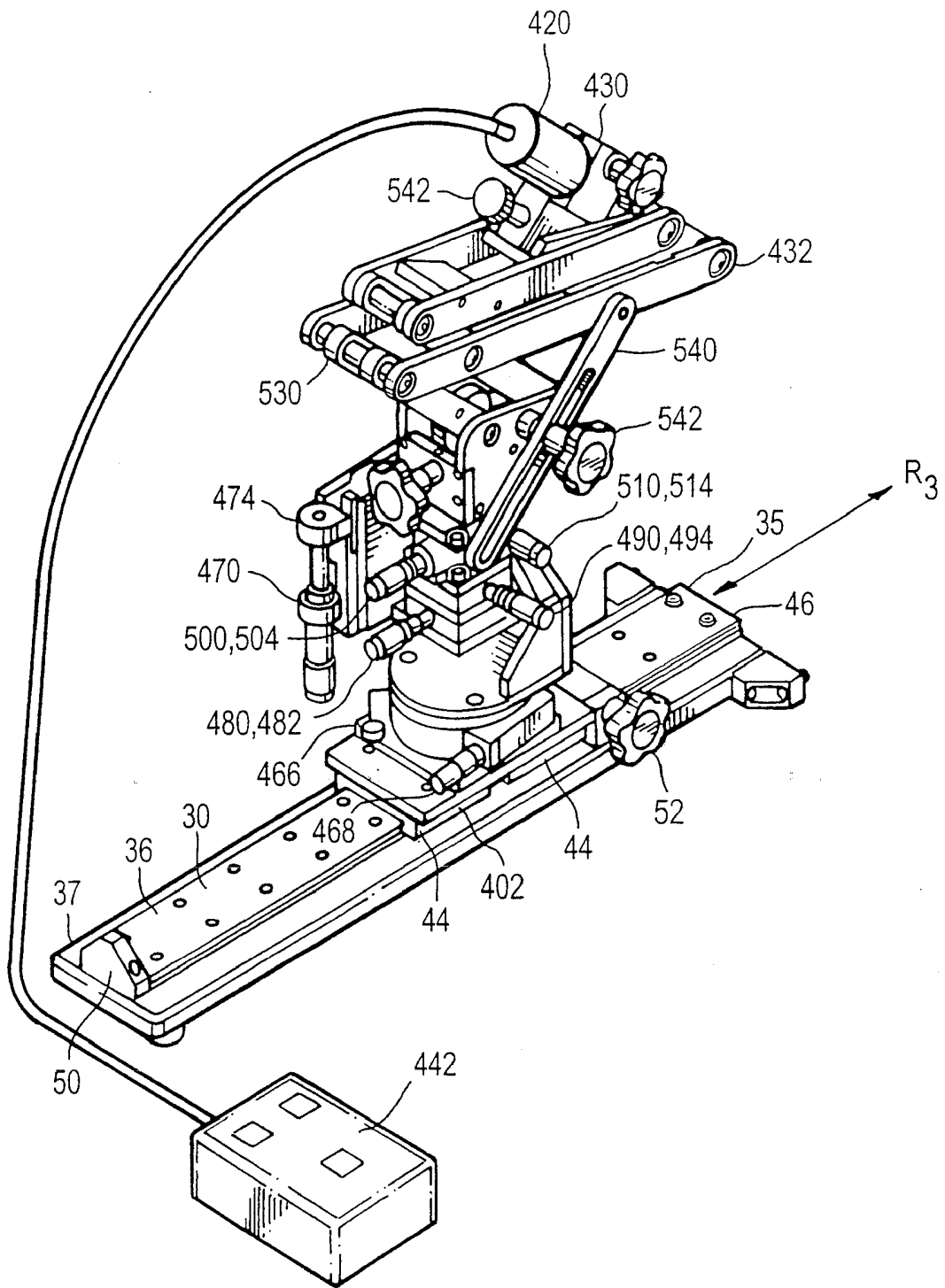


FIG. 33

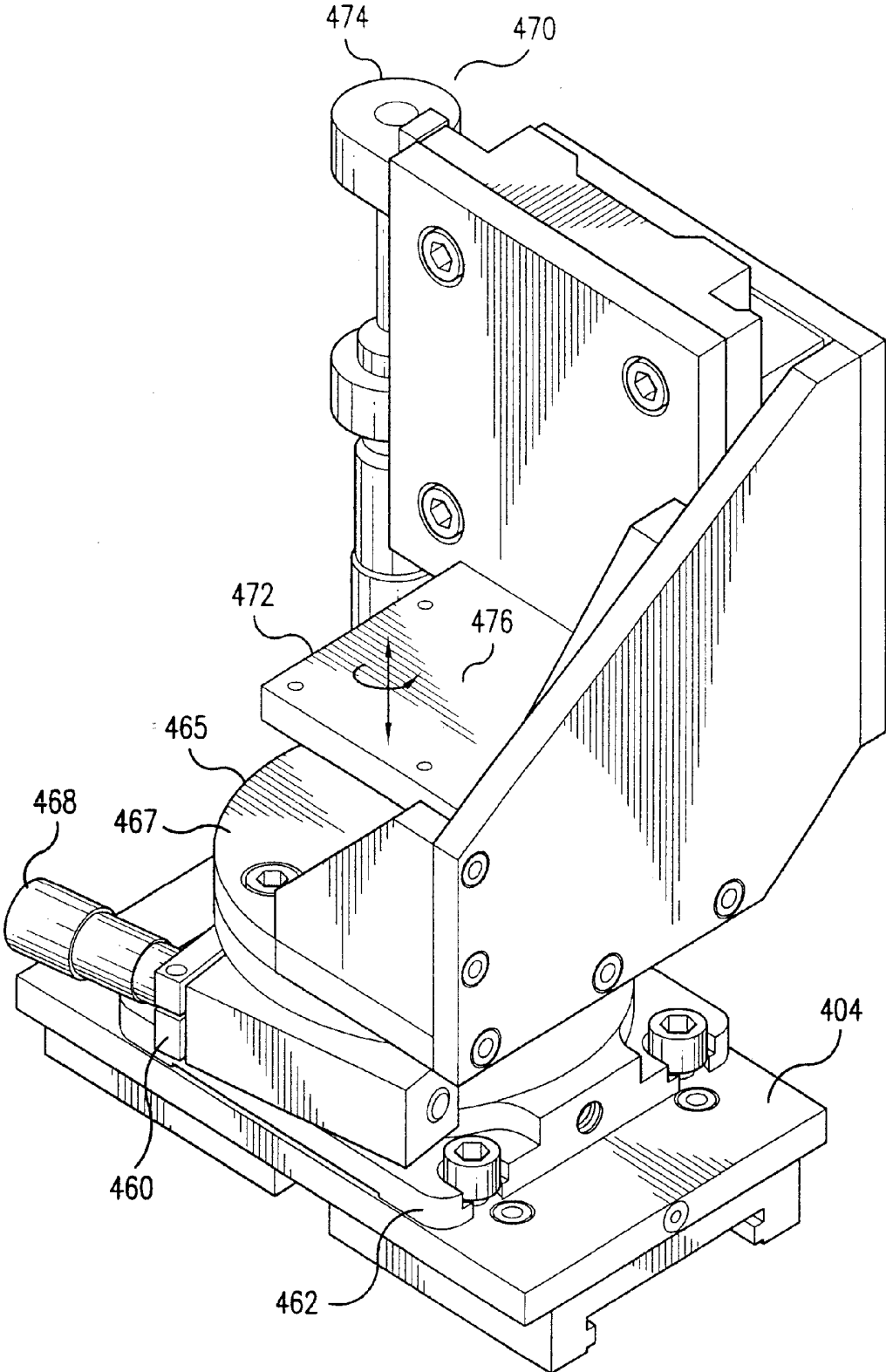


FIG. 34

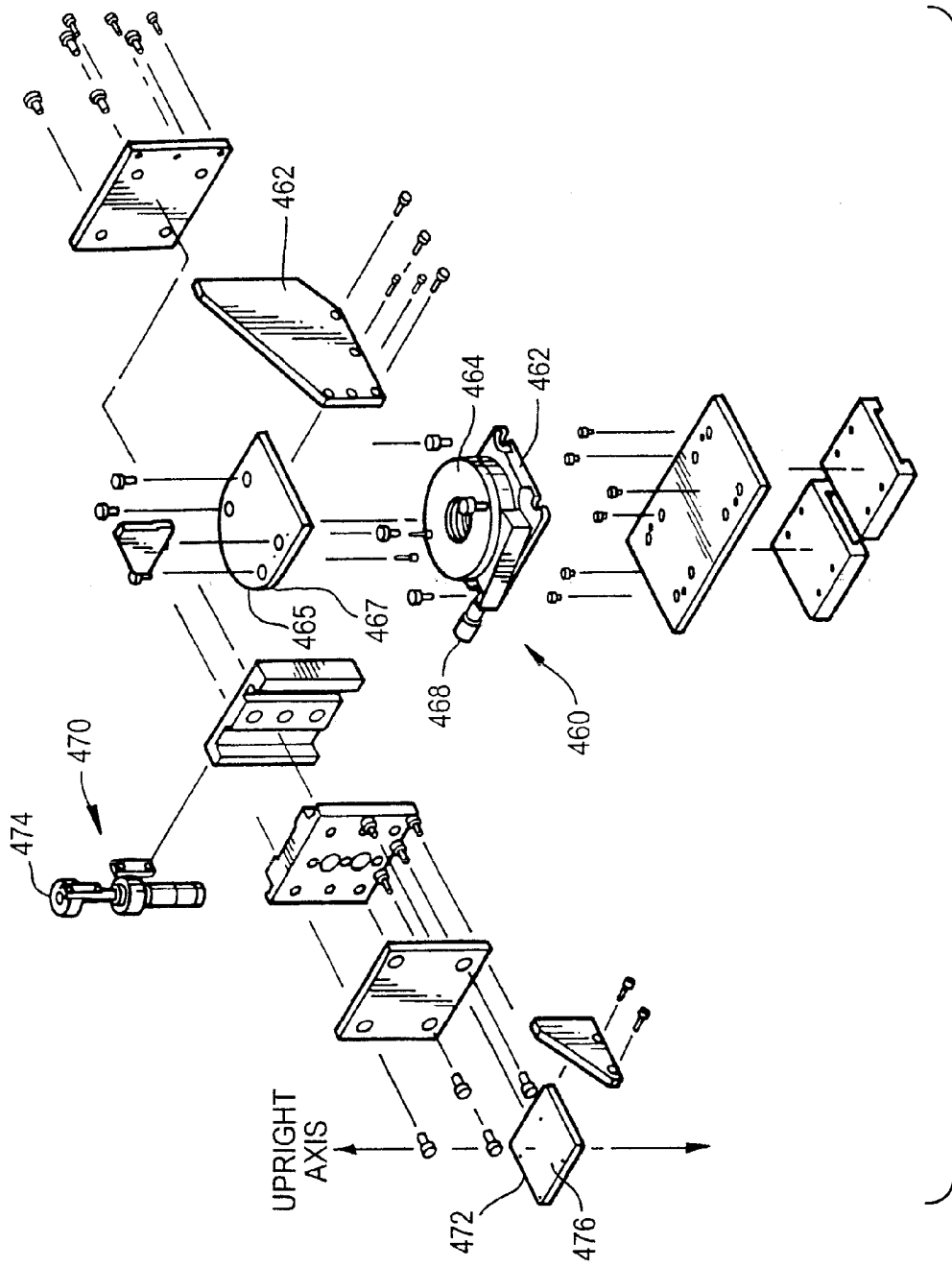


FIG. 35

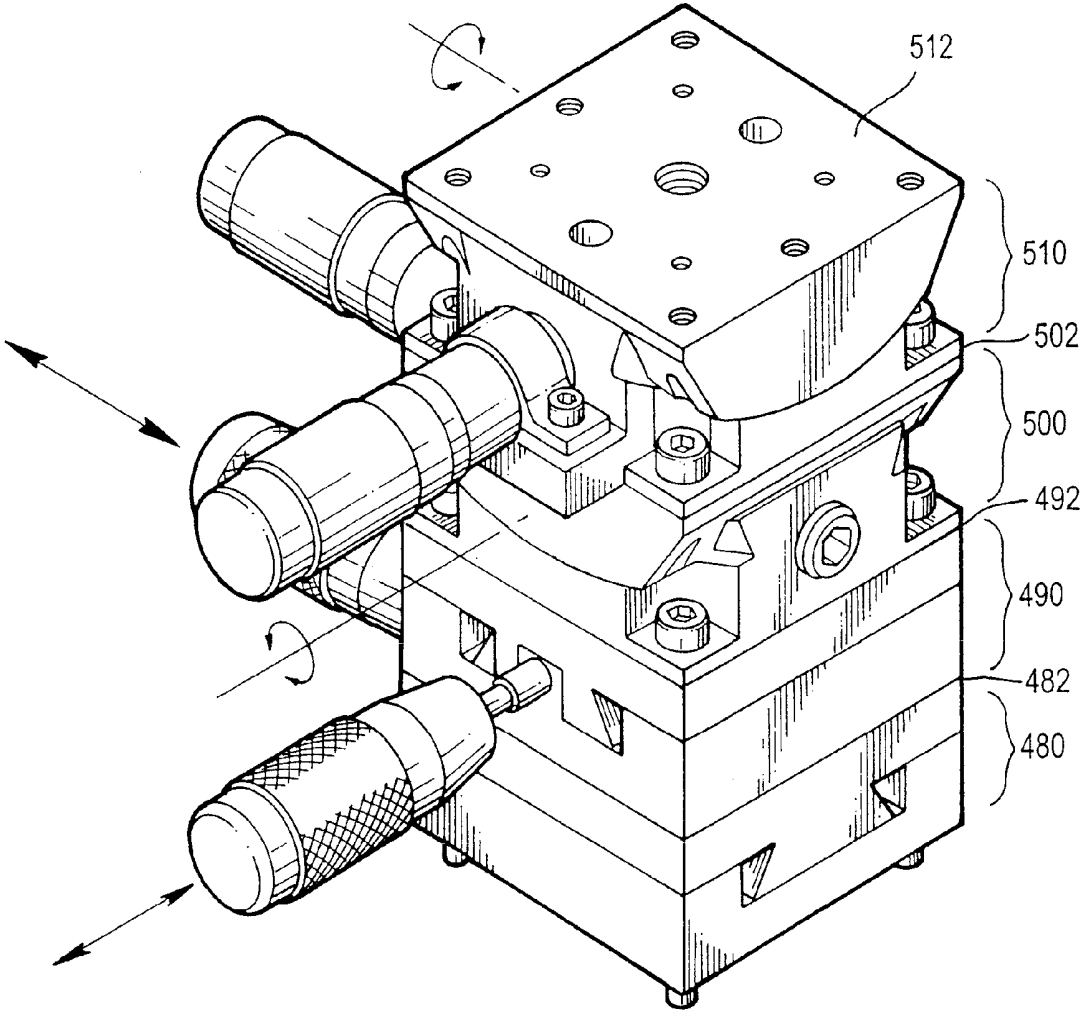


FIG.36

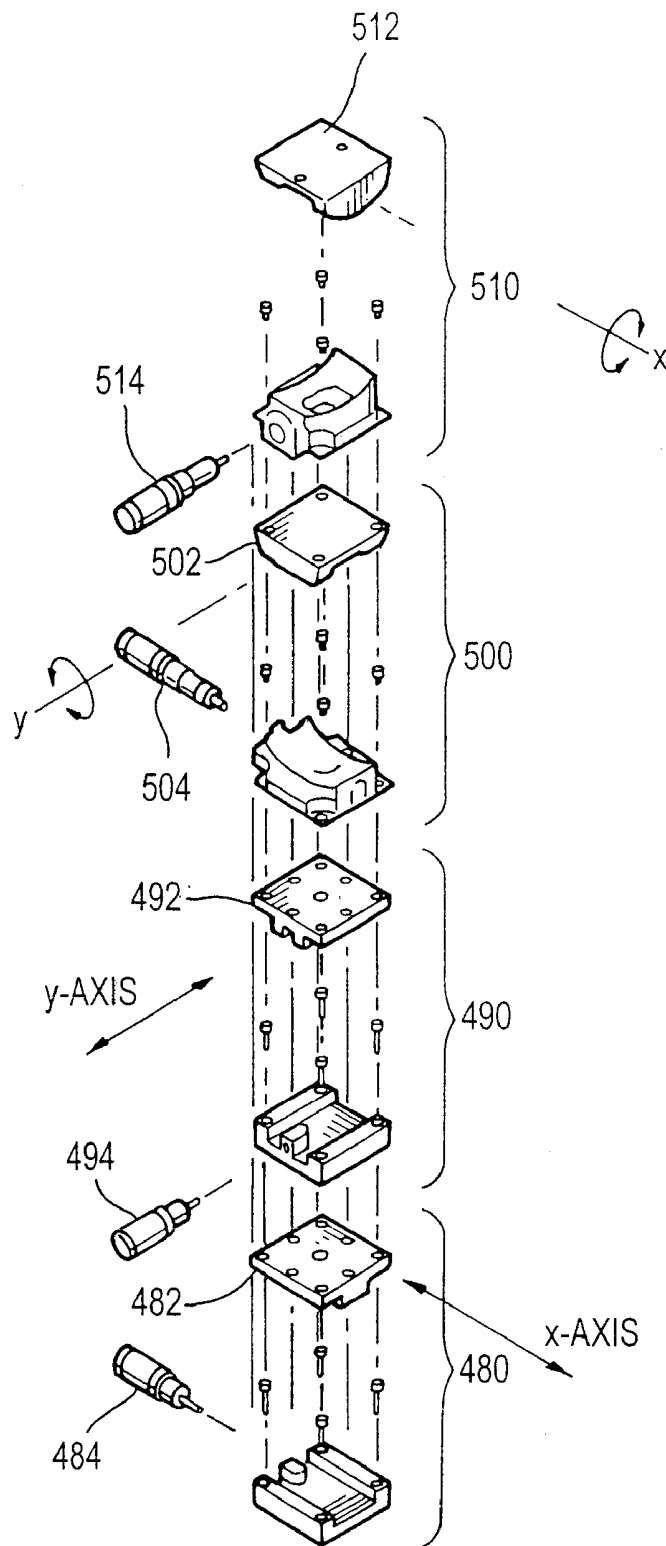


FIG.37

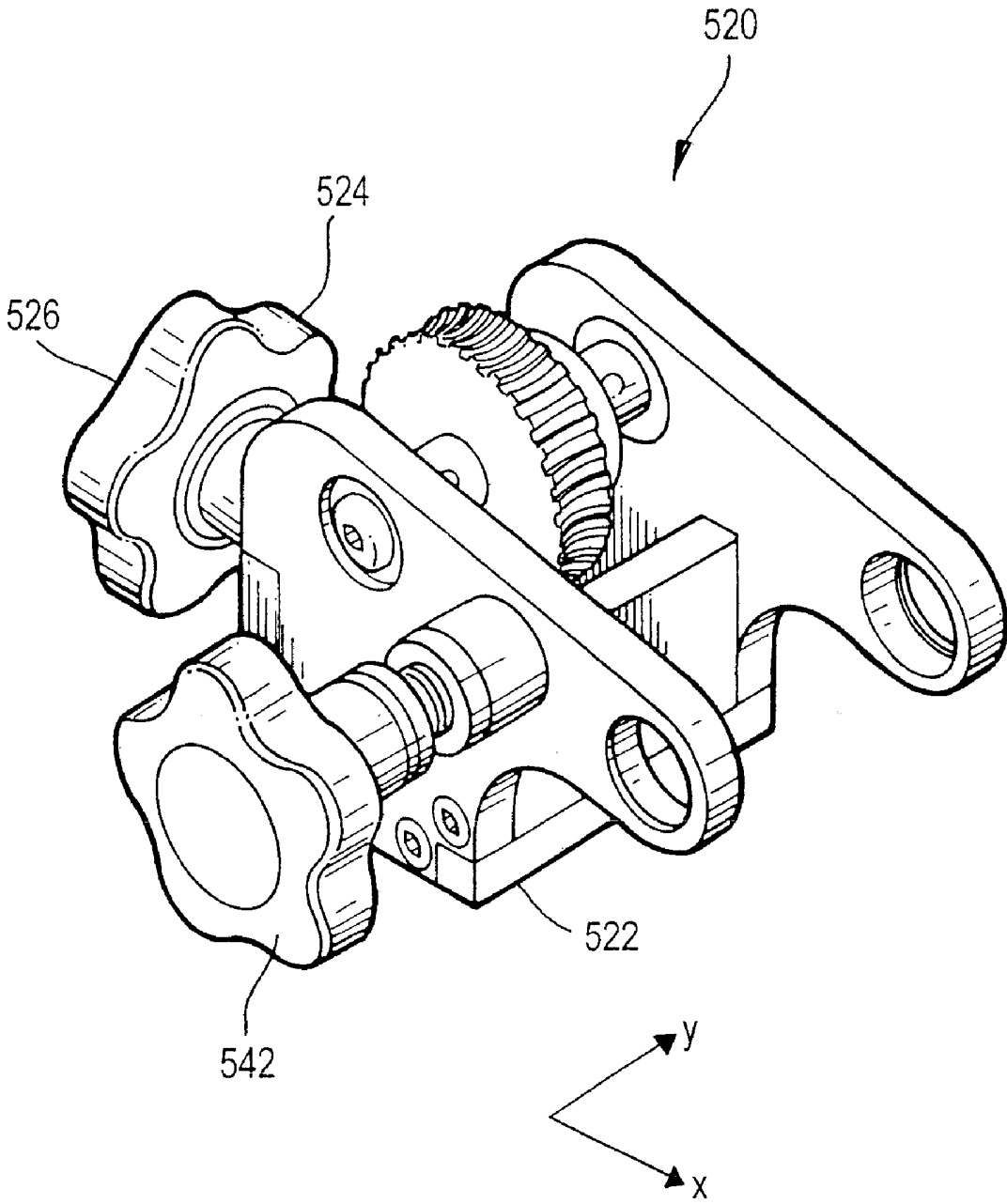


FIG.38

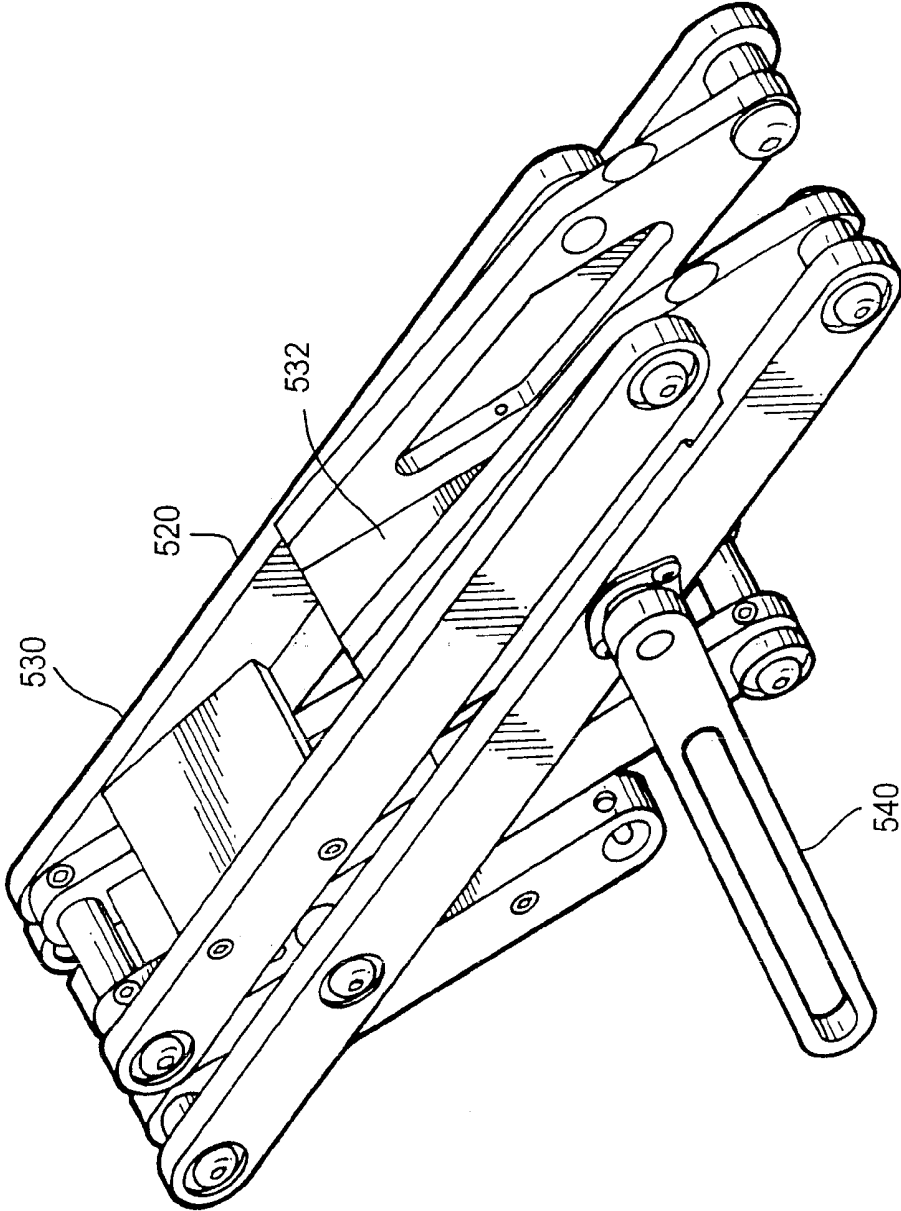


FIG. 39

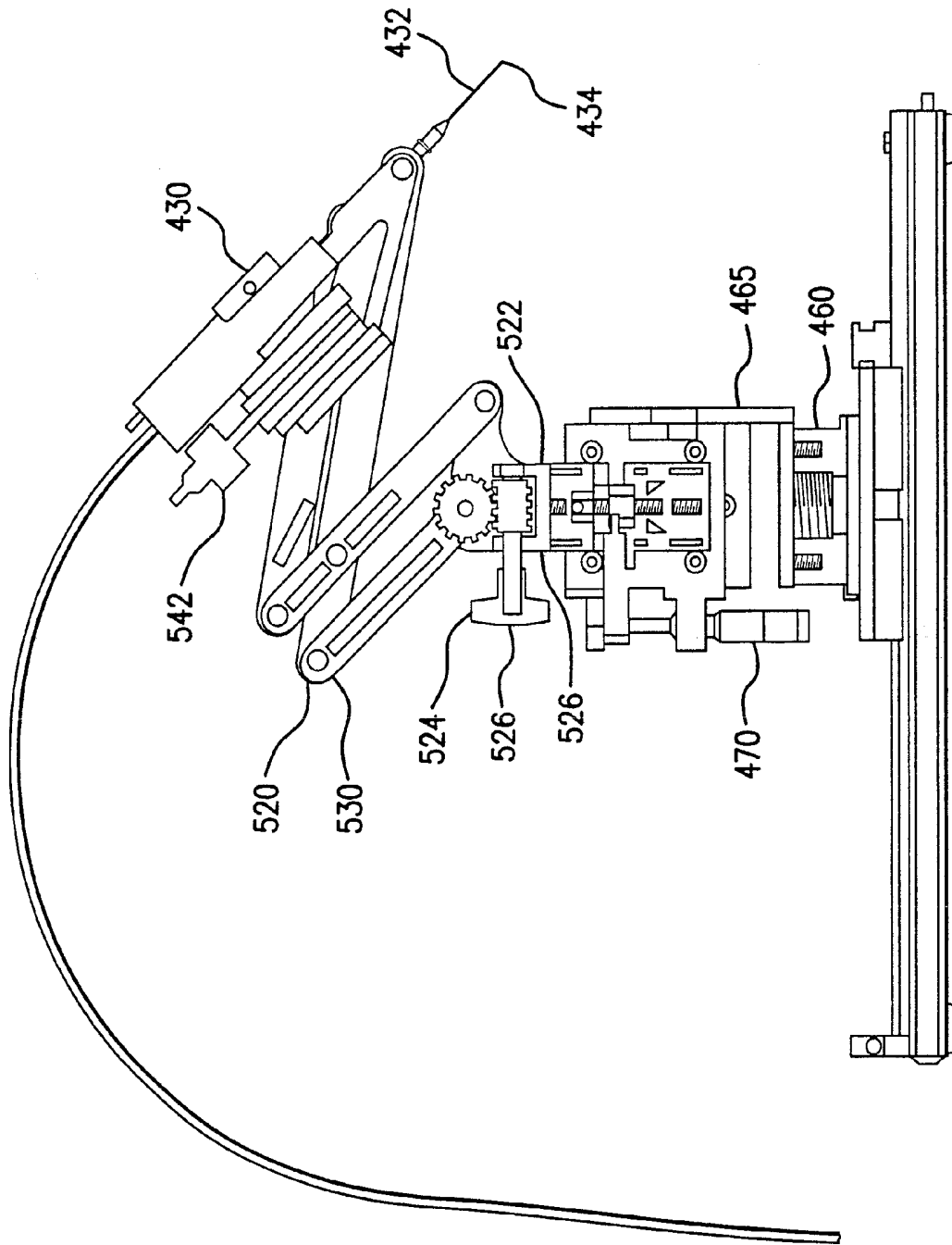


FIG. 40

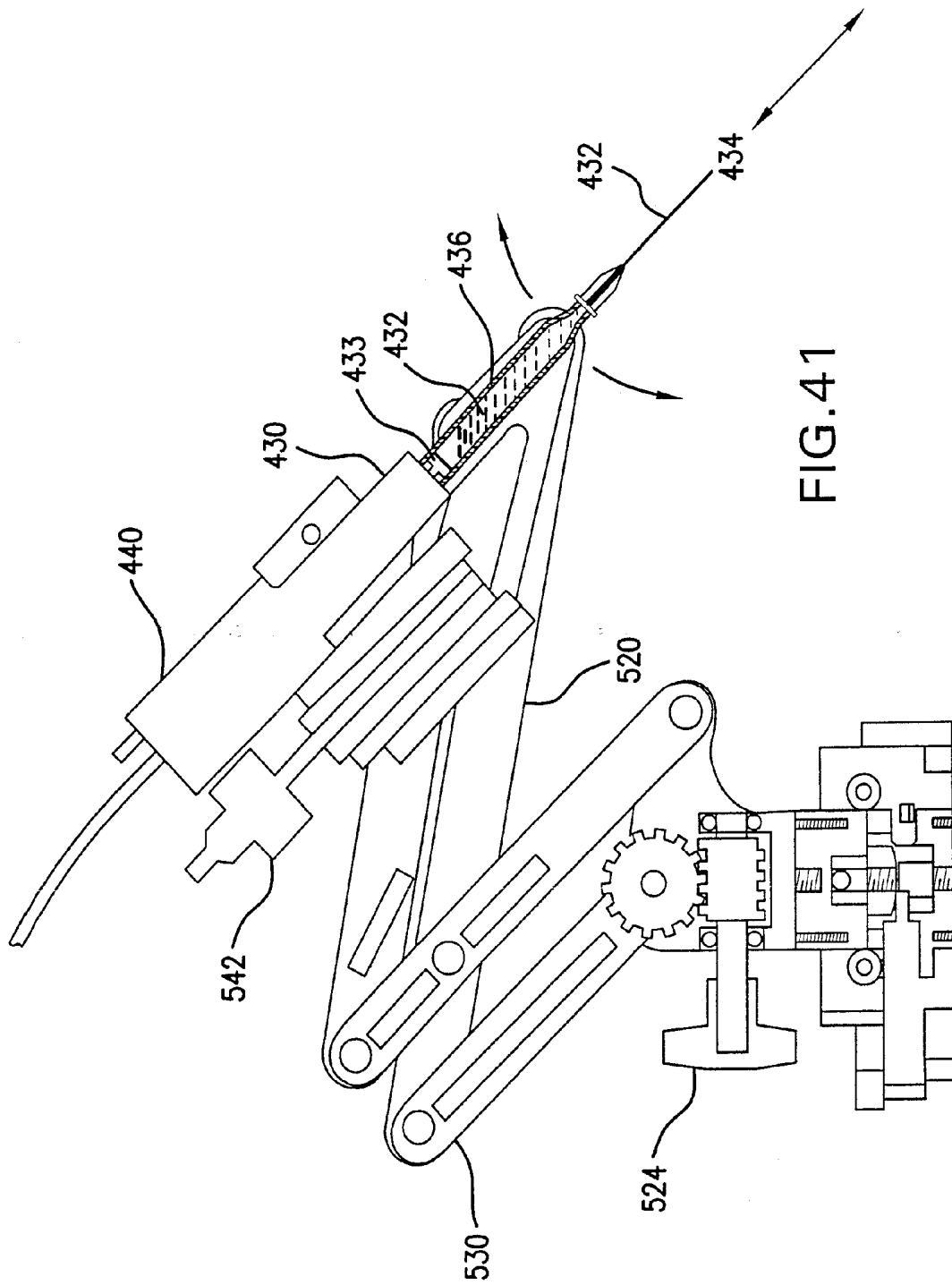


FIG. 41

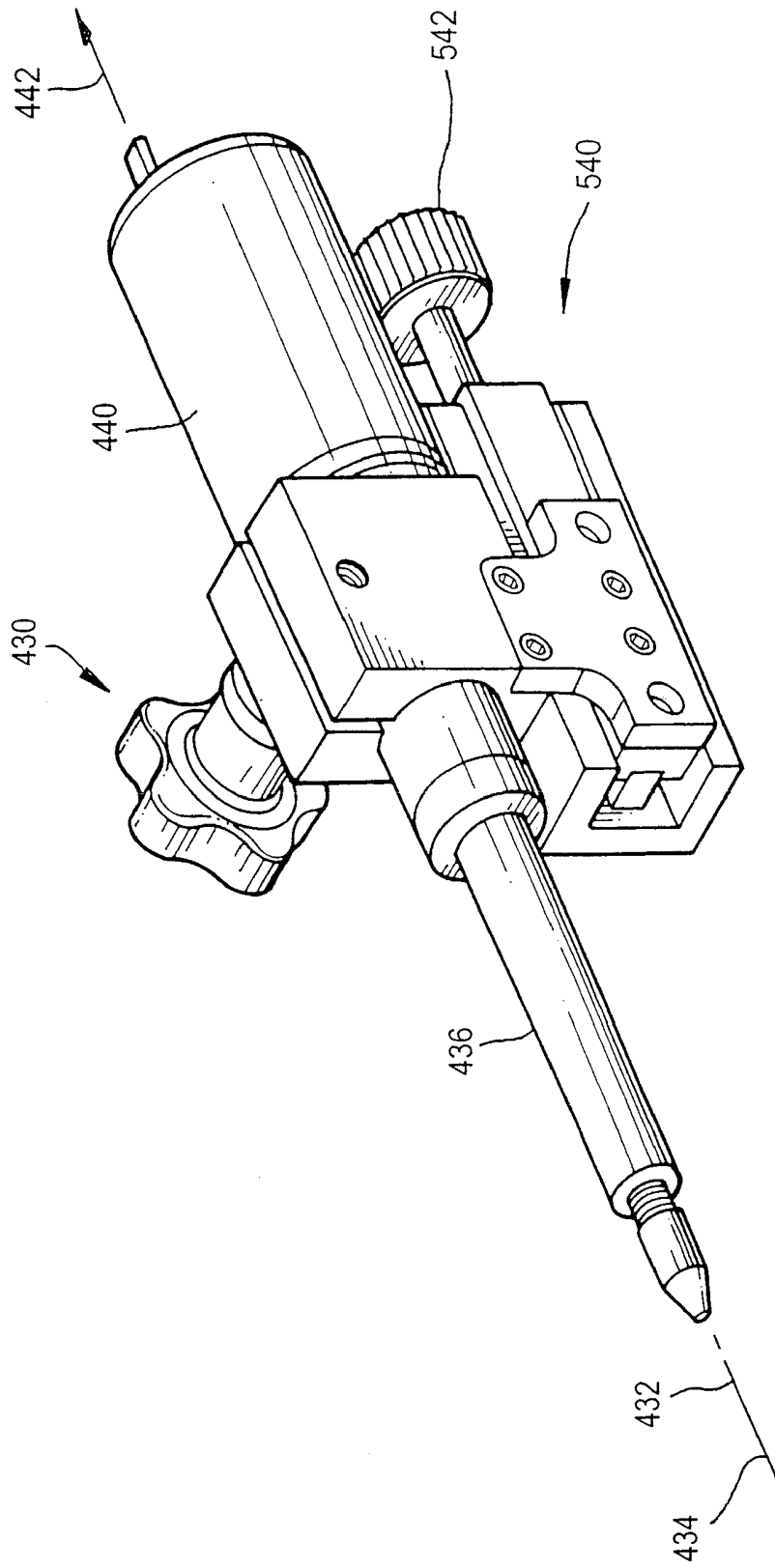


FIG. 42

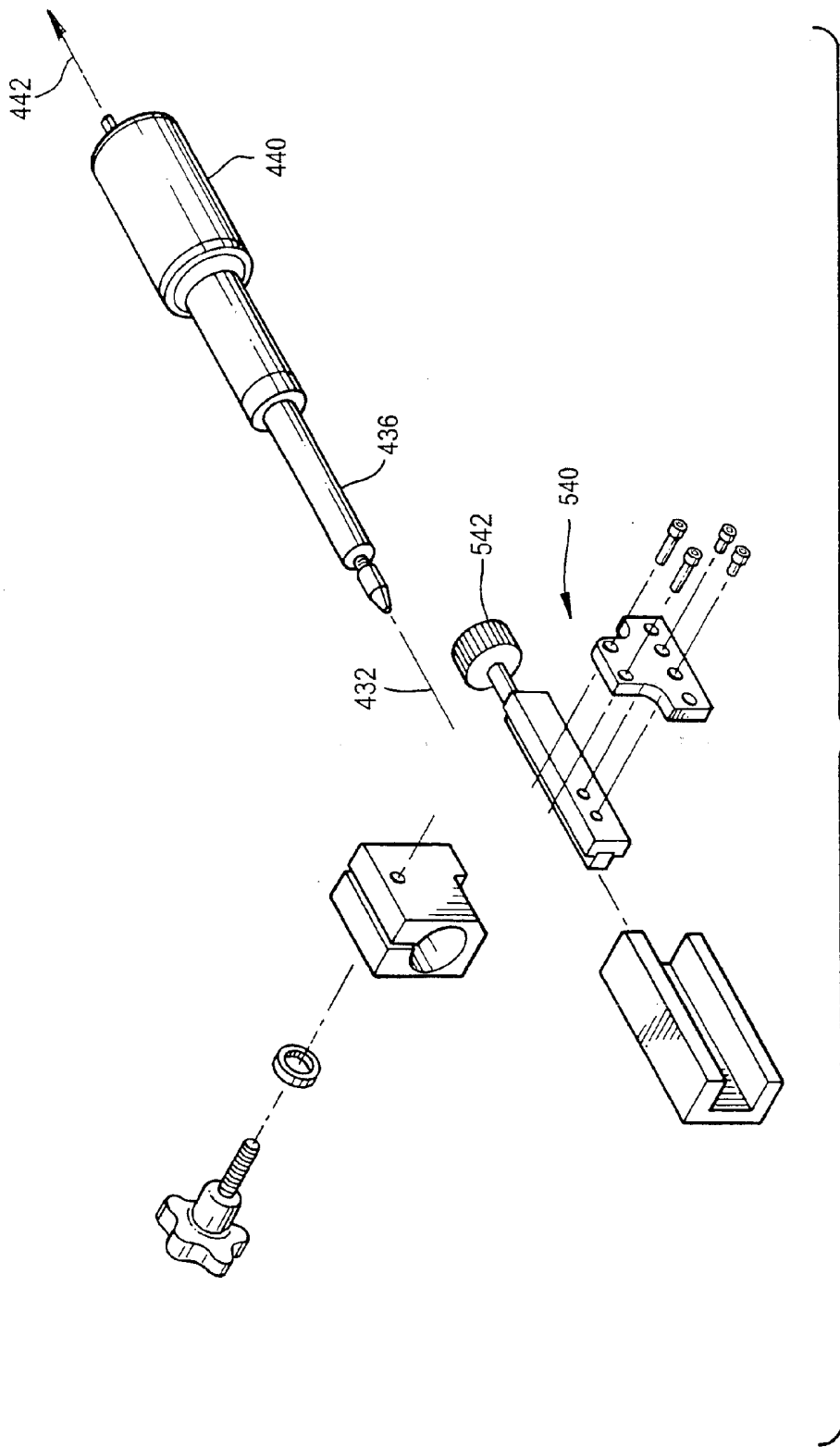


FIG. 43

## INTEGRATED MULTI-RAIL IMAGING SYSTEM

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of U.S. Provisional Application No. 60/417,167, entitled "GUIDED INJECTED RAIL SYSTEM," (attorney docket No. 00518-0008), filed on Oct. 10, 2002; U.S. Provisional Application No. 60/468,959, entitled "GUIDED INJECTION RAIL SYSTEM," (attorney docket No. T00518-0008-USP2), filed on May 9, 2003; U.S. Provisional Application No. 60/417,185, entitled "SMALL ANIMAL SURGICAL INTERVENTION PLATFORM," (attorney docket No. T00518-0009), filed on Oct. 10, 2002; and U.S. Provisional Application No. 60/468,960, entitled "SMALL ANIMAL SURGICAL INTERVENTION APPARATUS," (attorney docket No. T00518-0009-USP2), filed on May 9, 2003, all of which are incorporated in their entirety in this document by reference.

### BACKGROUND OF THE INVENTION

#### [0002] 1. Field of the Invention

[0003] The present invention relates to a small-animal imaging system, and more particularly to a multi-rail imaging system for maintaining a desired image plane during an imaging session.

#### [0004] 2. Description of the Prior Art

[0005] Over the past few years researchers in disciplines as diverse as neuroscience, developmental biology, genetics, and oncology have struggled with the challenge of injecting microliter and nanoliter quantities of fluid into discrete regions of organ systems. With the development and launch of ultrasound biomicroscopy (UBM) technology in the small animal imaging marketplace, the capacity to non-invasively observe, in real-time, the position of a needle or probe relative to an organ became a reality. One disadvantage with present positioning systems for animals is that straightforward repeatability of position with different animals is not possible.

[0006] For example, during injections procedures, a common problem has been the challenge of aligning a needle guidance device, which injects very small quantities of fluid, with a UBM scanhead device. Micromanipulation of both devices is necessary to help ensure that the injector needle of the needle guidance device lies within the same plane as the ultrasound scanhead so that the operator can guide the needle to the organ of interest. Consequently, this is a laborious and time-consuming process, which is aggravated by the need to move both devices away from an animal handling device, upon which a small animal is mounted, when a different animal is to be scanned. Current systems use independent, non-integrated, positioning methods for the various devices used in the imaging session.

[0007] Much information and expertise is available on the sequence and the manipulation of the mouse genome. Because of the similarity between the mouse and human genomes, the mouse is used as a model for understanding human gene function, and a model for many human disease processes. Manipulations permitted by guided injection technique facilitate experiments to further the understanding of genome function, the functional stages of organ devel-

opment, the differentiation of stem cells, and facilitate testing of new interventions for models of human disease. Ultrasound imaging can be used to generate a high resolution, cross sectional image in real-time so the imaging system can be operated while a needle is introduced into the small animal that gives the operator immediate accurate feedback for positioning of the needle tip in the target space. However, there is a need for providing a system to provide for quick manipulation of imaging apparatus and, if used, injection apparatus, around a sequence of different animals in a time efficient manner.

[0008] There is a further need for a mounting table for handling of small animals, such as mice, rats, rabbits, and the like, in both a minimally stressful and time efficient manner during the course of an imaging session. Control of the animal's physiological condition is of paramount concern, but doing so in an environment that permits the movement of the immobilized subject in a variety of positions to maximize the success of placing the animal within the imaging plane of the imaging apparatus. Further complicating these procedures is the fact that some protocols necessitate that the embryos of pregnant animals be externalized from the abdomen to provide for improved imaging resolution.

[0009] To date, no device serves each of the needs outlined to enable the safe and effective delivery of anaesthesia to small animals, the physiological monitoring of the immobilized subject, the capacity for a range of motion, and the ability to successfully externalize embryos on a specialized table.

### SUMMARY

[0010] The imaging system of the present invention allows for productive imaging of small-animals. In one example, the imaging system can include a plurality of elongated rails, a scanhead assembly, and a small animal mount assembly. In another example, a needle injection assembly is also included in the imaging system.

[0011] The plurality of elongated rails can include a first rail, a second rail, and, if used, a third rail. Each rail has a proximal end, a spaced distal end, and a longitudinal axis. In one exemplary configuration, the proximal end of the first rail is positioned proximate a first edge of the second rail intermediate the proximal end and distal end of the second rail such that the longitudinal axis of the first rail is at an angle to the longitudinal axis of the second rail. In another exemplary example, the proximal end of the third rail is positioned proximate a second edge of the second rail intermediate the proximal end and distal end of the second rail such that the third rail and the first rails are on opposite sides of the second rail. In this example, the longitudinal axis of the third rail is substantially coaxial to the longitudinal axis of the first rail.

[0012] The scanhead assembly is selectively mounted onto the first rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the first rail. The small-animal mount assembly is selectively mounted onto the second rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the second rail. The needle injection assembly is selectively mounted onto the third rail and is constructed and arranged for

movement in a linear bi-directional manner along the longitudinal axis of the third rail.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0013] These and other features of the preferred embodiments of the invention will become more apparent in the following detailed description in which reference is made to the appended drawings wherein:

[0014] FIG. 1 is a perspective view of one embodiment of a small-animal imaging system of the present invention, showing a scanhead assembly mounted onto a first rail and a small-animal mount assembly mounted onto a second rail.

[0015] FIG. 2 is a perspective view of an alternative embodiment of a small-animal imaging system of the present invention, showing a scanhead assembly mounted onto a first rail, a small-animal mount assembly mounted onto a second rail, and a needle injection assembly mounted onto a third rail.

[0016] FIG. 3 is a schematic view of the small-animal imaging system of FIG. 2.

[0017] FIG. 4 is a side view of the small-animal imaging system of FIG. 2.

[0018] FIG. 5 is a perspective view of a first or third rail of the present invention.

[0019] FIG. 6 is a perspective view of a movable stop.

[0020] FIG. 7 is an exploded view of the movable stop of FIG. 6.

[0021] FIG. 8 is a perspective view of an embodiment of the second rail of the present invention showing two spaced fixed stops.

[0022] FIG. 9 is a perspective view of the scanhead assembly mounted onto the first rail, showing a mount and a scanhead unit.

[0023] FIG. 10 is a perspective view of a base member of the scanhead assembly showing at least one carriage connected to the bottom of the base member.

[0024] FIG. 11 is a perspective view of an elongate upright member, a cantilever beam, and a scanhead orientation control mechanism of the scanhead assembly of FIG. 9.

[0025] FIG. 12 is an exploded view of the elongate upright member, the cantilever beam, and the scanhead orientation control mechanism shown in FIG. 11.

[0026] FIG. 13 is a perspective view of the small-animal mount assembly mounted onto the second rail.

[0027] FIG. 14 is a perspective view of the small-animal mount assembly of FIG. 13.

[0028] FIG. 15 is a top view of the small-animal mount assembly of FIG. 13.

[0029] FIG. 16 is a side view of the small-animal mount assembly of FIG. 13.

[0030] FIG. 17 is a side view of the small-animal mount assembly of FIG. 13.

[0031] FIG. 18 is a perspective view of a base member of a mount subassembly of the small-animal mount assembly shown in FIG. 13.

[0032] FIG. 19 is an exploded view of the base member shown in FIG. 18.

[0033] FIG. 20 is a perspective view of a planar platform of the mount subassembly.

[0034] FIG. 21 is a perspective view of a portion of a table orientation control mechanism of the mount subassembly.

[0035] FIG. 22 is a perspective view of a housing of an orientation control mechanism of the small-animal mount assembly, showing a portion of the orientation control mechanism.

[0036] FIG. 23 is a perspective view of a housing of an orientation control mechanism of the small-animal mount assembly, showing a portion of the orientation control mechanism.

[0037] FIG. 24 is a perspective view of a housing of an orientation control mechanism of the small-animal mount assembly, showing a portion of the orientation control mechanism.

[0038] FIG. 25 is a top view of the housing of the orientation control mechanism of FIG. 24.

[0039] FIG. 26 is a perspective view of a portion of the orientation control mechanism.

[0040] FIG. 27 is a perspective view of a portion of the orientation control mechanism.

[0041] FIG. 28 is a perspective view of a portion of the orientation control mechanism showing portions of the housing removed.

[0042] FIG. 29 is a perspective view of a portion of the orientation control mechanism showing portions of the housing removed.

[0043] FIG. 30 is a perspective view of a portion of the orientation control mechanism operatively connected to a table member.

[0044] FIG. 31 is an exploded view of FIG. 6.

[0045] FIG. 32 is a side view of one embodiment of the needle injection assembly mounted onto the third rail, showing an injector subassembly and a carriage subassembly.

[0046] FIG. 33 is a perspective view of the needle injection assembly of FIG. 28.

[0047] FIG. 34 is a perspective view of a rotation adjustment mechanism and a height adjustment mechanism of the carriage subassembly.

[0048] FIG. 35 is an exploded view of the rotation adjustment mechanism and the height adjustment mechanism of FIG. 34.

[0049] FIG. 36 is a perspective view of a first lateral adjustment mechanism, a second lateral adjustment mechanism, a first tilt adjustment mechanism, and a second tilt adjustment of the carriage subassembly.

[0050] FIG. 37 is an exploded view of the first lateral adjustment mechanism, the second lateral adjustment mechanism, the first tilt adjustment mechanism, and the second tilt adjustment mechanism of FIG. 36.

[0051] FIG. 38 is a perspective view of a portion of the articulating armature subassembly showing the mount member.

[0052] FIG. 39 is a perspective view of a plurality of cooperative arm members of the articulating armature subassembly.

[0053] FIG. 40 is a partial cross-sectional view of the needle injection assembly.

[0054] FIG. 41 is a partial cross-sectional view of a portion of the injector unit.

[0055] FIG. 42 is a perspective view of an injector unit of the injector subassembly.

[0056] FIG. 43 is an exploded view of the injector unit of FIG. 42.

#### DETAILED DESCRIPTION OF THE INVENTION

[0057] The present invention is more particularly described in the following examples that are intended as illustrative only since numerous modifications and variations therein will be apparent to those skilled in the art. Thus the embodiments of this invention described and illustrated herein are not intended to be exhaustive or to limit the invention to the precise form disclosed. They are chosen to describe or to best explain the principles of the invention and its application and practical use to thereby enable others skilled in the art to best utilize the invention. As used in the specification and in the claims, "a," "an," and "the" can mean one or more, depending upon the context in which it is used. The preferred embodiment is now described with reference to the figures, in which like numbers indicate like parts throughout the figures.

[0058] Referring to FIG. 1, one embodiment of an integrated multi-rail imaging system 10 of the present invention is shown. The imaging system includes a plurality of elongated rails 30, a scanhead assembly 100 selectively mounted onto a first rail 32 of the plurality of elongated rails, and a small-animal mount assembly 200 selectively mounted onto a second rail 34 of the plurality of elongated rails. In an alternative embodiment shown in FIGS. 2-4, the imaging system 10 can also include a needle injection assembly 400 that is selectively mounted onto a third rail 36 of the plurality of elongated rails.

[0059] As noted above, and as shown in the figures, the plurality of elongated rails 30 includes the first rail 32, the second rail 34, and, if the needle injection assembly 400 is used, the third rail 36. Each rail has a proximal end 35, a spaced distal end 37, and has a longitudinal axis R1, R2, and R3. Each rail 30 can be connected to an elongate support plate 40 by welding or by conventional fasteners, such as, for example, screws, bolts, or the like. Each support plate can have at least one damper member 42, such as, for example, rubber feet, connected to and extending from the bottom of the support plates to help reduce vibrations. The scanhead assembly 100, the small-animal mount assembly 200 and the needle injection assembly 400 each has a base member 102, 202, 402 that is constructed and arranged for movement in a reciprocal or otherwise gliding fashion upon their respective rails in a linear bi-directional manner, i.e., along the respective rail's longitudinal axis. As one will

appreciate, each base member has at least one carriage 44 connected to the bottom of the base member that is adapted to slide on the respective rail. In one embodiment, each rail can also have a fixed stop 50 connected to the distal end of the rail to limit the movement of the base member mounted thereto. In an alternative embodiment, the second rail can have a pair of fixed stops 51 connected to the second rail and defining two fixed end points for bi-directional travel of the base member 202.

[0060] In use, an end edge 46 of the support plate 40 that is connected to the first rail 32 is connected to a side edge 48' of the support plate that is connected to the second rail 34. The proximal end 35 of the first rail 32 being positioned adjacent the second rail 34 and between the proximal and distal ends 35, 37 of the second rail. In this configuration, the longitudinal axis of the first rail is at an angle with respect to the longitudinal axis of the second rail. In one embodiment, the angle  $\gamma$  is about and between 150 to 30 degrees. In another embodiment, the angle  $\gamma$  is about and between 130 to 60 degrees. In yet another embodiment, the angle  $\gamma$  is about and between 110 to 70 degrees. In another embodiment, the angle  $\gamma$  is about and between 95 to 85 degrees.

[0061] If used, an end edge 46 of the base plate 40 that is connected the third rail 36 is connected to a side edge 48" of the base plate of the second rail 34 (opposite to the side edge to which the first rail 32 is connected). The proximal end 35 of the third rail 36 being positioned adjacent the second rail and between the proximal end and distal end of the second rail such that the third rail 36 opposes the first rail 32. In this example, the distal ends of the respective first and third rails extend away from each other and the longitudinal axis of the first and the third rails are substantially co-axial. Thus, the respective longitudinal axis R1, R2, and R3 are fixed in a relative orientation with respect to one another to provide a common coordinate system.

[0062] The imaging system 10 of the present invention can also include at least one movable stop 52. Each movable stop 52 is constructed and arranged for movement in a reciprocal or otherwise gliding fashion upon their respective rails in the linear bi-directional manner, i.e., along the respective rail's longitudinal axis. In one example, one movable stop 52 is mounted to each respective rail intermediate the respective base member 102, 202, 402 and the proximal end of the rail. In another example, one moveable stop is mounted to each of the first and third rails.

[0063] Each movable stop 52 also has a stop clamping mechanism 54 that can selectively fix the position of the moveable stop relative to the rail member. As one will appreciate, the operator of the system can readily adjust the position of the movable stops by releasing the stop clamping mechanism, moving the movable stop to the desired position, and clamping the movable stop to the rail at a desired position with the stop clamping mechanism. A portion of the base member 102, 202, 402 can be selectively and releasably secured to a portion of one respective movable stop.

[0064] In one example, the portion of the base member and the portion of the movable stop are magnetized with an attractive polarity such that, when brought into proximity to each other, the respective portions of the base member and the moveable stop are attracted to each other. In another example, a second portion of each base member and a portion of the fixed stop are also magnetized with an

attractive polarity such that, when brought into proximity to each other, the second portion of the base member and the portion of the fixed stop are attracted to each other. Thus, in use, the base members can be selectively moved between the fixed stop and the moveable stop and can be releasably secured to the movable stop in the desired position. This allows one of the end points of travel of the base members to be selectively adjusted and allows the base members to be quickly moved away and brought back to the selected desired position, i.e., back to the selectable end point of travel.

#### Scanhead Assembly

[0065] Referring to the figures, the scanhead assembly 100 includes a mount 110 and a scanhead unit 130. The mount 110 includes the base member 102, an elongate upright member 112, a cantilever beam 114, and a scanhead unit orientation control mechanism 160. The upright member 112 is connected to and extends substantially normal to the base member 102 (which is mounted as described above to the first rail). The cantilever beam 114 has a first end 116 and a spaced second end 118. The second end 118 of the beam has a sleeve member 120 constructed and arranged for movement in a reciprocal or otherwise gliding fashion upon the exterior surface 113 of the upright member 112 in a linear bi-directional manner, i.e., along a longitudinal axis of the upright member. The longitudinal axis of the beam 114 is co-planar to the longitudinal axis of the first rail 32.

[0066] The sleeve member 120 of the beam also has a beam lock mechanism 122 for selectively mounting the sleeve member at a desired position. For example, in use, a handle 124 of the beam lock mechanism can be rotated to loosen the beam lock mechanism, the beam can be raised or lowered into the desired position, and the handle 124 of the beam lock mechanism 122 is rotated to selectively lock the beam into the desired position relative to the upright member 112. In one example, the exterior surface 113 of the upright member 112 defines at least one longitudinally extending groove 115 and the interior surface 121 of the sleeve member 120 has at least one male protrusion 123. The male protrusion is sized and shaped for complementary receipt within one groove 115 of the upright member. In one example, the male protrusion 123 extends at least partially along the length of the interior surface 121 of the sleeve member.

[0067] In one example, the scanhead unit 130 is an ultrasonic scan head. As one will appreciate however, other scanhead units can be used, such as, for example, an MRI scanhead, a CT scanhead, and the like. The scanhead unit 130 is electrically coupled to an external computer 20 for processing of the images. The scanhead unit 130 is operatively connected to the beam 112 of the scanhead assembly 100 in selective orientation by the scanhead unit orientation control mechanism 160. In one example, the scanhead unit orientation control mechanism comprises an angle control lock mechanism 162 and a ball joint lock mechanism 170. A proximal end 164 of the angle control lock mechanism 162 is connected to the beam proximate the first end 116 of the beam. A fixed portion of the angle control lock mechanism extends downwardly away from the beam along a substantially vertical axis. A distal end 166 of the angle control lock mechanism is connected to a proximal end 172 of the ball joint lock mechanism 170 and is constructed and

arranged for pivotal movement of the ball joint lock mechanism along an angle control lock plane defined by the co-planar longitudinal axis of the first rail and the beam. As one will appreciate, the angle control lock mechanism 160 can be moved between a locked position and an unlocked position.

[0068] A distal end 174 of the ball joint lock mechanism 170 is connected to the scanhead unit and is constructed and arranged for pivotal movement of the scanhead unit. As one will appreciate, the ball joint lock mechanism 170 allows the operative end 132 of the scanhead unit to be positioned at an angle with respect to the vertical axis of the angle control lock mechanism and with respect to the angle control lock plane. The ball joint lock mechanism 170 is moveable between a locked position and an unlocked position. When the ball joint lock mechanism 170 is locked at the desired angle, it will be appreciated that the operative end 132 of the scanhead unit 130 can be moved through an arc in a desired image plane by selectively unlocking the angle control lock mechanism 160 and moving the angle control lock mechanism along its fixed range of movement.

#### Small-Animal Mount Assembly

[0069] The small-animal mount assembly 200 of the present invention includes a table subassembly 210 and a mount subassembly 260. The table subassembly 210 includes a table member 212. The mount subassembly 260 includes the base member 202, which is mounted to the second rail 34 as described above, a planer platform 262, and a table orientation control mechanism 280 selectively positioned onto a portion of an upper surface 264 of the platform 262. The table orientation control mechanism 280 is constructed and arranged for adjusting the height, tilt and rotation of the operatively connected table member 212 relative to the upper surface 264 of the platform 262.

[0070] In one example, an operator selectable plunger lock mechanism 206 is connected to the edge of the base member 202. A portion of the plunger lock mechanism is constructed and arranged for selectively engaging a portion of a fixed stop 51 connected to the second rail. The plunger lock mechanism can include a spring mechanism for "locking" the plunger lock mechanism to the respective fixed stop until operator force is applied to the plunger lock mechanism 206. In use, the operator draws the plunger lock mechanism upward to separate the plunger lock mechanism from the respective fixed stop. The base member 202 can then be moved along the longitudinal axis of the second rail until it is selectively lock to the other fixed stop. In this example, one fixed stop 51 is positioned proximate the distal end of the second rail and the other fixed stop 51 is positioned intermediate the proximal and distal ends of the second rail.

[0071] In one example, the platform 262 is movably connected to the base member 202 by a platform adjustment mechanism 270. The platform 262 has a lower surface 266 that is opposed to the upper surface and defines a first axis A1 parallel to the longitudinal axis of the second rail and a second axis A2 normal to first axis. The platform can also have a raised edge 268 extending substantially about the periphery of the platform to help prevent the orientation control mechanism from falling from the upper surface 264 of the platform.

[0072] The platform adjustment mechanism 270 is constructed and arranged for moving the platform in a platform

plane defined by the respective first-axis and second-axis of the platform. A platform base 272 of the platform adjustment mechanism is connected to a portion of the top surface 204 of the base member and an adjustable armature 274 of the platform adjustment mechanism is connected to a portion of an edge of the platform 262. In use, rotational movement of a first control knob 276 of the platform adjustment mechanism moves the platform bi-directionally relative to the base member along the first axis of the platform. In the same manner, rotational movement of a second control knob 278 of the platform adjustment mechanism moves the platform bi-directionally relative to the base member along the second axis of the platform. As one will appreciate movement of the platform 262 relative to the base member forward or rearward along the respective first or second axis depends upon the direction the first or second control knob is moved. In one embodiment, the platform can be moved relative to the base member 202 between end points along each of its respective first and second axis less than and including about 100 mm. In another embodiment, less than and including about 80 mm. In yet another embodiment, less than and including about 60 mm. In another embodiment, less than and including about 50 mm.

[0073] In this example, the lower surface 266 of the platform can rest on the top surface 204 of the base member 202. Further, the upper and lower surfaces 264, 266 of the platform and the top surface 204 of the base member are positioned in parallel planes. A coating or sheet of low-friction material such as, for example, Teflon™ can cover the lower surface 266 of the platform or the top surface 204 of the base member 202. One skilled in the art will appreciate that other low-friction materials are contemplated. Thus, in use, the platform can be selectively moved in the first and second axis within the platform plane under the control of the platform adjustment mechanism 270. The low-friction coating allows this motion to take place with minimal friction.

[0074] The orientation control mechanism 280 includes a housing 282 having a top 284 and a bottom 286. In use, the bottom of the housing is disposed onto and can be selectively slid along the upper surface 264 of the platform 262. The upper surface of the platform can also be coated with low-friction material. This low-friction coating allows the operator to readily position the housing 282 of the orientation control mechanism onto a desired portion of the upper surface of the platform. The orientation control mechanism includes a magnetic lock 600 that is housed within the housing. Upon movement of a magnet control knob 602, which extends beyond the exterior of the housing, the magnetic lock 600 is movable from a retracted, non-engaged position, to an engaged position in which a magnet 604 is brought into attractive contact with the upper surface of the platform. As one will appreciate, when the magnetic lock is in the engaged position, the housing of the orientation control mechanism is fixed relative to the platform due to the attraction of the magnet and the platform. However, even if the magnetic lock 600 is in the engaged position, the housing can slide on the upper surface of the platform if sufficient force is exerted onto the housing or the connected table assembly.

[0075] The orientation control mechanism 280 further can comprise a coarse height mechanism 290, a rotation control mechanism 310, a fine height control mechanism 320, a first

tilt control mechanism 330, and a second tilt control mechanism 340. The coarse height mechanism is housed within the housing and is constructed and arranged for selective bi-directional movement of an upright shaft member 300 along an upright axis of the orientation control mechanism 280. The upright axis is substantially normal to the longitudinal axis of the second rail 34. Thus, upon movement of a lever control 290 of the coarse height mechanism, the shaft member 300 can be raised or lowered as desired between a top, extended, position and a lowered, contracted, position. To accommodate the movement of the lever control, the housing defines an "L" shaped slot 294 in one side having an upright portion 296 and a longitudinally extending portion 298 proximate the top of the housing. In the lowered position, the lever control is in lower portion of the upright portion of the slot. In order to raise the top 301 of the shaft member 300 to its top position, the lever control 292 is lifted upward the extent of the upright portion of the slot 294 and is then slid into and seated within the longitudinally extending portion of the slot.

[0076] The shaft member 300 of the orientation control mechanism can be rotated about the upright axis about a bearing 312 positioned within the housing 282. The rotation brake mechanism 310 is housed within the housing and is constructed and arranged for selectively engaging a brake surface 314 connected to the shaft member so that the shaft member can be fixed in a desired position about the upright axis. Thus, the shaft member can be rotated by applying a rotational force to the shaft such that the table member, which is operatively engaged to the shaft member, can be rotated about the upright axis until the table member is in the desired orientation. When the shaft member is positioned in the desired position, a brake knob 314, which extends beyond the exterior of the housing, of the rotation brake mechanism 310 can be selectively activated to selectively fix the shaft member in the desired position relative to the upright axis.

[0077] A movable cap 322 is operatively connected to the shaft member and can be selectively moved by the fine height control mechanism 320. The fine height control mechanism is constructed and arranged for selective bi-directional movement of the moveable cap relative to the top 301 of the shaft member 300 along the upright axis of the orientation control mechanism 280. Thus, upon movement of a height control knob 324 of the fine height mechanism, the cap 322 can be raised or lowered as desired. In one embodiment, the cap 322 can be moved relative to the top 301 of the shaft member between end points along the upright axis less than and including about 50 mm. In another embodiment, less than and including about 30 mm. In yet another embodiment, less than and including about 20 mm. In another embodiment, less than and including about 10 mm.

[0078] The table member 212 defines a table plane that further defines an x-axis and a y-axis. One will appreciate that the x and y axis of the table plane form a common coordinate system. The first tilt control mechanism 330 is operatively connected to the cap 322 and is constructed and arranged for selectively adjusting and securing the tilt of the table member 212 relative to the y-axis of the table plane. The second tilt control mechanism 340 is operatively connected to a bottom surface 213 of the table member 212 and is constructed and arranged for selectively adjusting and

securing the tilt of the table member relative to the x-axis of the table plane. A portion of the second tilt control mechanism 340 is mounted onto a top surface 332 of the first tilt control mechanism 330.

[0079] In this configuration, the first and the second tilt control mechanisms 330, 340 allow the table member 212 to be angled with respect to the respective y-axis and x-axis of the table plane. In one embodiment, the angle is less than and including about 60 degrees (i.e., +/-30 degrees). In another embodiment, the angle is less than and including about 45 degrees (i.e., +/-22.5 degrees). In yet another embodiment, the angle is less than and including about 30 degrees (i.e., +/-15 degrees). Thus, in operation, selective manipulation of the controls of the mount subassembly 260 by the operator allows the table member 212 to be oriented in a desired table surface plane.

[0080] The table member 212 has a top surface 214 that is disposed in the table surface plane. The table subassembly 210 can also comprise a plurality of ECG electrode contact pads 220, at least one grid of electronic heating elements 230, and/or at least one thermocouple 240. In one example, the plurality of ECG contact pads is operatively attached to the top surface 214 of the table member. Each ECG contact pad senses an ECG signal within a portion of a small animal that is secured against the ECG contact pad. Each ECG contact pad 220 is spaced from an adjacent contact pad and can be positioned so that each one of the feet/paws of the small animal can be selectively positioned against one of the ECG contact pads. In one example, the plurality of ECG contact pads comprises four ECG contact pads that are positioned in a spaced "X" configuration so that the respective feet of the small animal can be positioned in a splayed position. Each ECG contact pad 220 generates an ECG signal 222 representative of the sensed ECG. The ECG signal can be transmitted through an A/D converter (not shown) to a control apparatus 250 on ECG signal line 224. This ECG signal can be transmitted through an isolated ECG amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

[0081] The grid of electronic heating elements 230 is disposed onto the top surface 214 of the table member 212 and is electrically coupled to the control apparatus 250. The temperature of the top surface 214 of the table member can be adjusted via the control apparatus so that a small animal's temperature can be maintained within a desired range when the small animal is positioned onto the top surface 214 of the table member. If used, the thermocouple 240 is connected to the top surface of the table member and can be positioned such that a portion of the small animal overlies the thermocouple when the small animal is secured to the top surface 214. In one example, the thermocouple is positioned near the center of the top surface 214 of the table member 212 and is spaced from the at least one grid of electronic heating elements 230. The thermocouple 240 generates a temperature signal 242 representative of the sensed temperature of the small animal proximate the thermocouple. The temperature signal 242 can be transmitted through an A/D converter (not shown) to the control apparatus 250 on temperature signal line 244. This temperature signal can be transmitted through an isolated amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

[0082] The table subassembly 210 can also include a rectal temperature probe 246. The rectal temperature probe generates an internal temperature signal 248 representative of the sensed internal temperature of the small animal with the rectum of the small animal the thermocouple. The internal temperature signal 248 can be transmitted through an A/D converter (not shown) to the control apparatus on temperature signal line 249. This internal temperature signal can be transmitted through an isolated amplifier and digital or analog anti-aliasing filter (not shown) to remove noise and amplify the signal before processing.

[0083] In one example, if external embryonic imaging is desired, the table subassembly 210 can include a walled dish 360 and a dish support mechanism 370. The dish 360 has a peripheral wall 362 and defines an opening 364 in the bottom of the dish. The dish is formed of a substantially rigid material, such as, for example, a rigid plastic. A pliable membrane 366 defining a slit 368 is connected to the opening to form a moisture proof connection. In one example, in a relaxed position, the slit in the membrane is closed and is moisture proof. In a stretched position, the slit in the membrane is open. The pliable membrane can be a rubber membrane. In another example, the slit 368 in the membrane 366 is open in both the relaxed and stretched positions.

[0084] The dish 360 can be selectively held in position relative to the top surface 214 of the table member 212 by selective actuation of a dish support mechanism 370. The dish support mechanism has an arm member 372 and a fastener 374. The arm member has an upper portion 376 that is constructed and arranged for selectively clamping onto a portion of the wall 262 of the dish. As one will appreciate, the dish 260 can be removed by removing knurled screw 378. The arm member 372 has a lower portion defining an elongate slot 379. The fastener 374 passes through the slot 379 and can selectively secure the lower portion of the arm member to an edge of the table member. In use, the position of an attached dish can be adjusted by loosening the fastener 374, adjusting the dish 360 into the desired position, and tightening the fastener 374 to secure the dish 260 in the desired position.

[0085] In certain externalized procedures, the small animal is secured to the top surface 214 of the table member and the dish 260 is disposed onto the small animal such that the pliable membrane 366 is in the stretched open position with the "open" slit forming a moisture proof seal between the small animal and the dish. In this example, embryos can be passed through the slit in the rubber membranes and can be imaged in the dish while still attached to the small animal.

[0086] The table subassembly 210 can also include a clamp member 380 secured to a portion of the top surface 214 of the table member. In one example, the clamp member 380 is constructed and arranged for grasping a portion of a conical small animal mask 382 that is shaped and sized for fit with the snout of the small animal. The mask 382 is connected to at least one anaesthetic line that is coupled to an external anaesthetic source, not shown. In an alternative example, the clamp member 380 can selectively grasp a portion of the at least one anaesthetic line.

#### Needle Injection Assembly

[0087] Referring now to FIGS. 32-43, one embodiment of the needle injection assembly 400 is shown. The needle

injection assembly is constructed and arranged for operator control of a needle's insertion point, insertion depth, and angle of penetration. The needle injection assembly 400 further can be constructed and arranged for controlling a needle plunger 433 of the needle 432.

[0088] In one example, the needle injection assembly 400 includes the base member 402 (which is connected to the third rail 36 as described above), an injector subassembly 420, and a carriage subassembly 450. The injector subassembly 420 includes an injector unit 430 that has an elongated needle 432 operatively mounted therein. The needle 432 has a longitudinal length and a distal end 434. The carriage subassembly 450 is connected to the base member 402 and provides controls for setting the needle's insertion point in the small animal in a desired plane, which is typically the same plane as the scanhead unit is set up to image, i.e., the desired image plane. The carriage subassembly 450 also provides controls for pivoting the needle 432 so that the operator can set a desired angle of penetration to the needle's insertion point in the small animal. The carriage subassembly 450 can include a rotation adjustment mechanism 460, a height adjustment mechanism 470, a first lateral adjustment mechanism 480, a second lateral adjustment mechanism 490, a first tilt adjustment mechanism 500, a second tilt adjustment mechanism 510, and an articulating armature subassembly 530.

[0089] The rotation adjustment mechanism 460 is constructed and arranged for rotating portions of the carriage subassembly mounted thereon about an upright axis. In one example, the rotation adjustment mechanism includes a housing 462 that is connected to the top surface 404 of the base member 402. The rotation adjustment mechanism 460 further includes a conventional bearing 464 mounted within the housing that connects to and supports a frame member 465. The frame member 465 has a base 467 that is operatively connected to the bearing of the rotation adjustment mechanism. As one will appreciate, the frame member 465 can rotate about an upright axis extending normal to the longitudinal axis of the third rail and through the center of the bearing. The rotation adjustment mechanism 460 can include a rotation lock knob 466 for selectively locking the rotation of the frame member so that the amount of rotation of the frame member about the upright axis is limited. The rotation adjustment mechanism can also include a fine rotation adjustment control knob 468 that allows the operator to rotate the frame member through a limited angle about the upright axis after the rotation lock knob has been engaged. In one embodiment the limited angle is about and between 10 degrees (+/-5 degrees). In another embodiment, the angle is about and between 8 degrees (+/-4 degrees). In yet another embodiment, the angle is about and between 6 degrees (+/-3 degrees).

[0090] The height adjustment mechanism 470 is operatively connected to the frame member 465 and is constructed and arranged for raising portions of the carriage subassembly supported thereon along an upright axis. The height adjustment mechanism includes a platform 472 that can be selectively moved along an upright axis parallel to the upright axis of the rotation adjustment mechanism 460 between a top fixed end point and a bottom fixed end point. In use, rotation of the height adjustment knob 474 of the height adjustment mechanism moves the platform of the height adjustment mechanism bi-directionally relative to the

base 467 of the frame member along the upright axis. As one will appreciate, movement of the platform 472 upward or downward along the upright axis depends upon the direction the height adjustment knob 474 is moved. In one embodiment, the platform 474 of the height adjustment mechanism can be moved about a center point between fixed end points about and between +/-25 mm. In another embodiment, about and between +/-18 degrees. In another example, about and between +/-13 degrees.

[0091] The first lateral adjustment mechanism 480 is connected to and is mounted onto the top surface 476 of the platform 472. The second lateral adjustment mechanism 490 is connected to and mounts thereon a selectively movable top surface 482 of the first lateral adjustment mechanism 480. The first tilt adjustment mechanism 500 is connected to and mounts thereon a selectively movable top surface 492 of the second lateral adjustment mechanism 490. Similarly, the second tilt adjustment mechanism 510 is connected to and is mounted onto a selectively movable top surface 502 of the first tilt adjustment mechanism 500. The articulating armature subassembly 520 is operatively connected to a selectively movable top surface 512 of the second tilt adjustment mechanism 510.

[0092] The first lateral adjustment mechanism 480 is constructed and arranged for moving the top surface 482 of the first lateral adjustment mechanism relative to the platform 472 and parallel to an x-axis defined by the platform. This allows the top surface 482 of the first lateral adjustment mechanism 480 to shift toward or away from the proximal end of the third rail 36. In use, rotation of a first lateral adjustment knob 484 moves the top surface 482 of the first lateral adjustment mechanism 480 bi-directionally relative to the platform. Similarly, the second lateral adjustment mechanism 490 is constructed and arranged for moving the top surface 492 of the second lateral adjustment mechanism relative to the top surface 482 of the first lateral adjustment mechanism 480 and parallel to a y-axis defined by the platform (which is normal to the defined x-axis). This allows the top surface 492 of the second lateral adjustment mechanism to shift toward or away from the respective side edges of the third rail 36. In use, rotation of a second lateral adjustment knob 494 moves the top surface 492 of the second lateral adjustment mechanism bi-directionally relative to the top surface 482 of the first lateral adjustment mechanism. As one will appreciate, in another example, the second lateral adjustment mechanism 490 can be connected to and mounted onto the top surface 476 of the platform 472 and the first lateral adjustment mechanism 480 can then be connected to and mounted thereon the selectively movable top surface 492 of the second lateral adjustment mechanism 490.

[0093] The articulating armature subassembly 520 has a mount member 522 that is, in one example, connected to the top surface 512 of the second tilt adjustment mechanism 510. The mount member 522 of the articulating armature subassembly defines a mount plane that further defines an x-axis and a y-axis. One will appreciate that the x and y axis of the mount plane form a common coordinate system. In one example, the first tilt adjustment mechanism 500 is operatively connected to the top surface 492 of the second lateral adjustment mechanism 490 and is constructed and arranged for selectively adjusting and securing the tilt of the mount member 522 relative to and about the y-axis of the

mount member. The second tilt adjustment mechanism **510** is operatively connected to the top surface **502** of the first tilt mechanism **500** and is constructed and arranged for selectively adjusting and securing the tilt of the mount member **522** relative to the x-axis of the mount member.

[0094] In this configuration, the first and the second tilt adjustment mechanisms **500**, **510** allow the mount member **522** to be angled with respect to the respective y-axis and x-axis of the mount member. In one embodiment, the angle is less than and including about 40 degrees (i.e., +/-20 degrees). In another embodiment, the angle is less than and including about 20 degrees (i.e., +/-10 degrees). In yet another embodiment, the angle is less than and including about 10 degrees (i.e., +/-5 degrees).

[0095] One will appreciate that, in another example, the second tilt adjustment mechanism **510** can be connected to and mounted thereon a selectively movable top surface of the uppermost of the first or second lateral adjustment mechanisms. In this example, the first tilt adjustment mechanism **500** is connected to and is mounted onto the selectively movable top surface **512** of the second tilt adjustment mechanism **510**. The mount member of the articulating armature subassembly **520** would be operatively connected to the selectively movable top surface **502** of the first tilt adjustment mechanism.

[0096] The articulating armature assembly **520** includes a plurality of cooperative arm members **530** that are operatively connected to the mount member and can be moved by selective actuation of an armature control mechanism **524**. As one will appreciate, selective manipulation of the rotation adjustment mechanism **460**, the height adjustment mechanism **470**, the first lateral adjustment mechanism **480**, the second lateral adjustment mechanism **490**, the first tilt adjustment mechanism **500**, and/or the second tilt adjustment mechanism **510** allows the mount member **522** of the articulating armature assembly to be positioned into a desired mount plane defined by a plane extending through the mount member. The injector unit **430** of the injector subassembly **420** is operatively mounted within a seat **532** positioned at a distal portion **534** of the plurality of cooperative arm members such that the distal end **434** of the needle **432** extends beyond the plurality of cooperative arm members. As one will appreciate, the injector unit **430** is positioned in a needle plane that is normal to the mount plane of the mount member **522**.

[0097] The articulating armature assembly **520** is constructed and arranged for rotating the injector unit **430** about the distal end **434** of the needle in a desired needle plane that is normal to the desired mount plane. In operation, the desired needle plane is substantially coplanar to the desired image plane. As an armature control knob **526** is selectively rotated, the injector unit is between a first fixed end point in which the needle **432** is angled at a lower angle of penetration  $\theta$  relative to an upright axis to a second fixed end point in which the needle is angled at a higher angle of penetration  $\theta$  relative to the upright axis. Thus, the operator can selectively set the exact insertion point of the needle and, via manipulation of the control of the articulating armature assembly, can select, within the desired needle plane, a desired angle of penetration  $\theta$  of the needle into the subject small animal. The articulating armature assembly **520** also includes a position brake mechanism **540** that can be selectively

engaged to fix the plurality of cooperative arm members is a desired position. By "fixing" the plurality of cooperative arm members is the desired position, the operator can "fix" the desired angle of penetration  $\theta$  of the needle. By tightening knob **542** onto a portion of the mount member, the plurality of cooperative arm members can be selectively "locked" into position.

[0098] The injector subassembly **420** includes the injector unit **430** mounted thereon the seat **532** of the articulating armature assembly. In one example, the injector unit **430** includes a plunger **433**, a barrel **436**, and the elongate needle **432**. The plunger **433** is movable within a defined chamber **437** of the barrel **436**. A bore of the needle **432** is in communication with the chamber of the barrel. In use, the plunger **433** can be manually moved in a conventional manner to inject a desired amount of material into the subject small animal or to draw material thereinto the chamber of the barrel. In another example, the injector unit **430** also includes a conventional actuator **440** that is operatively coupled to the plunger **433**. In this example, the actuator **440** is also electrically coupled to a plunger control unit **442**. The user can actuate controls on the plunger control unit **442** to retract or extend the plunger of the injector unit a desired amount.

[0099] The injector subassembly further comprises a needle insertion mechanism **540** constructed and arranged for controlling the extension and the retraction of the injector unit **430** relative to the seat **532** of the plurality of cooperative arm members **530**. In use, rotation of a needle insertion control knob **542** of the needle insertion mechanism moves the injector unit **430**, and the attached needle, bi-directionally along the seat and along longitudinal axis of the needle **432**. As one will appreciate, insertion or retraction movement of the injector unit and the attached needle depends upon the direction the needle insertion control knob **542** is moved.

[0100] It will be appreciated that the combination of the releasable coupling between the movable/fixed stops and the base members of the respective assemblies and the respective rails allows for repositioning of the assemblies while maintaining alignment and relative positioning of the various components. The assemblies can be set up and aligned in their respective procedure positions and subsequently moved out of position to, for example, replace the small animal on the table member. The assemblies can then be returned to their procedure positions to and be aligned in the same manner as for the previous small-animal on the table member. In this manner, it will be recognized that the potentially time-consuming process of re-aligning the assemblies can be avoided.

[0101] Once the small-animal on the table member is imaged (and injected), a second small-animal can easily be introduced into the field of view with minimal adjustment to either the scanhead unit or, if used, the injector unit, by using the movable/fixed stops, since the small-animal mount assembly can slide out of the image plane on its own rail.

[0102] The imaging system **10** can also include the computer **20** having a system processor **22**. The processor **22** can be coupled to a display or monitor **24** and to a user input device **26**, such as a keyboard, mouse, or other suitable device. If the monitor **24** is touch sensitive, then the monitor **24** itself can be employed as the user input device **26**. A

computer readable storage medium **28** is coupled to the processor. As one will appreciate, the operation of the scanhead assembly **100**, table subassembly **210** of the small-animal mount assembly **200**, and, if used, the needle injection assembly **400** could be controlled by the computer **20**. As one skilled in the art will appreciate, the computer readable medium **28** can include hardware and/or software such as, by way of example only, magnetic disks, magnetic tape, optically readable medium such as CD ROM's, and semi-conductor memory such as PCMCIA cards. In each example, the medium **28** can take the form of a portable item such as a small disk, floppy diskette, cassette, or it can take the form of a relatively large or immobile item such as hard disk drive, solid state memory card, or RAM coupled to the processor **22**. It should be noted that the above listed example mediums **28** can be used either alone or in combination. The display **24** could be multipurpose and also serve as a screen for the imaging system **10**. Alternatively, the imaging system can have a separate screen.

[**0103**] Operation of the system begins by placing and securing the small animal onto the table member such that the small animal's paws are placed against the ECG pads. The rectal probe is inserted into the small-animal and the health parameters are monitored on the control apparatus **250** and/or the computer **20** throughout the imaging session. The respective controls of the mount subassembly of the small-animal mount assembly are selectively manipulated to place the table member in the desired table surface plane. In one example, the small-animal mount assembly can be moved on the second rail until the plunger lock mechanism **206** engages a portion of the fixed stop **51** positioned intermediate the proximal and distal ends on the second rail. Alternatively, the small-animal mount assembly can be moved until a portion of the base member contacts a portion of a previously set movable stop on the second rail. In this position, the table member of the small-animal mount assembly is in the imaging field of the scanhead unit.

[**0104**] Next, the mount of the scanhead assembly is positioned into a proximate procedure position on the first rail. In one example, the movable stop **50** is slid along and then secured onto the first rail at a desired procedure position that is within a few centimetres of the desired final procedure position of the mount. One will appreciate that fine adjustment to the position of the scanhead unit can be made through manipulation of the controls of the mount of the scanhead assembly. The mount of the scanhead assembly is moved into contact with the movable stop so that the desired image plane of the scanhead unit is positioned such that the image plane bisects the portion of interest in the small-animal.

[**0105**] As one will appreciate, when the imaging session is complete, the small-animal mount assembly and the imaging assembly can be moved away from the procedure positions on the first and second rails (toward the respective distal ends of the rails) while maintaining alignment and relative position of the small-animal mount assembly and the imaging assembly. Thus, the set image plane and the table surface plane will not change. A new small-animal can be positioned on the table member and the small-animal assembly and imaging assembly can be repositioned by relying upon the previous setting of the movable and/or fixed stops.

[**0106**] If the needle injection assembly is used, the injector unit is filled with the fluid to be injected. Next, the base member of the needle injection assembly is positioned into a proximate procedure position on the third rail. In one example, the movable stop is slid along and then secured onto the third rail at a desired procedure position that is within a few centimetres of the desired final procedure position of the base member. One will appreciate that fine adjustment to the position of the needle of the injection unit can be made through manipulation of the controls of the carriage subassembly. The base member of the needle injection assembly is moved into contact with the movable stop and the controls of the carriage subassembly are manipulated so that the needle can be placed in the desired needle plane, which can also be the set image plane of the scanhead unit. The carriage subassembly can also be manipulated to select the desired angle of penetration of the needle within the desired needle plane.

[**0107**] The needle is advanced into the subject small-animal at the needle's insertion point to a desired depth and the sample material is injected either manually or by using the plunge control unit. Typically, confirmation of injected material, such as fluid, can often be seen on the screen of the system as the tissue surrounding the distal end of the needle accommodates the extra volume. The needle can then be withdrawn and the procedure is complete.

[**0108**] Subsequently, the needle injection assembly, the scanhead assembly, and/or the small-animal mount assembly can be selectively moved away from their procedure positions. A new animal can be positioned onto the table member of the small-animal mount assembly and the needle injection assembly, the scanhead assembly, and/or the small-animal mount assembly can be repositioned by relying upon the previous settings of the movable/fixed stops. One will appreciate that the planes of the scanhead unit and the injector unit will remain co-planer.

[**0109**] It is contemplated that many other procedures can be done using the imaging system **10** of the present invention. The multi-rail design of the imaging system enables an operator to precisely align the needle of the needle injection assembly within the imaging plane of the scanhead unit of the scanhead assembly. The needle injection assembly, the small-animal mount assembly, and the scanhead assembly can then be moved back and forth along their respective rails **32**, **34**, **36** and be brought back to their original procedure positions without losing the alignment of the image plane or the co-planer alignment between the needle of the injector unit and the image plane of the scanhead unit.

[**0110**] It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. An imaging system for imaging portions of small-animals, comprising:

- a plurality of elongated rails, the plurality of elongated rails including a first rail and a second rail, each rail having a proximal end, a spaced distal end, and a longitudinal axis, the proximal end of the first rail positioned proximate a first edge of the second rail intermediate the proximal end and distal end of the second rail, the longitudinal axis of the first rail at an angle with respect to the longitudinal axis of the second rail;
- a scanhead assembly having a mount, the mount having a scanhead assembly base member that is selectively mounted onto the first rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the first rail; and
- a small-animal mount assembly having a mount subassembly, the mount subassembly having a mount assembly base member that is selectively mounted onto the second rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the second rail.
2. The imaging system of claim 1, wherein the plurality of elongated rails includes a third rail, the proximal end of the third rail positioned proximate a second edge of the second rail intermediate the proximal end and distal end of the second rail, the longitudinal axis of the third rail substantially coaxial to the longitudinal axis of the first rail.
3. The imaging system of claim 2, further comprising a needle injection assembly comprising an injection assembly base member that is selectively mounted onto the third rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the third rail.
4. The imaging system of claim 1, wherein the scanhead assembly further comprises a scanhead unit having an operative emitting end, the scanhead unit being electrically coupled to a computer.
5. The imaging system of claim 4, wherein the mount further comprises:
- an elongate upright member connected to and extending from the scanhead assembly base member, the upright member having an exterior surface and a longitudinal axis extending substantially normal to the scanhead assembly base member;
  - a cantilever beam having a first end and a spaced second end, the second end having a sleeve member constructed and arranged for linear bi-directional movement along the exterior surface of the upright member, the sleeve member having a beam lock mechanism for selectively securing the sleeve member at a desired position on the upright member; and
  - a scanhead unit orientation control mechanism connected to a portion of the first end of the beam and a portion of the scanhead unit, the scanhead unit orientation control mechanism constructed and arranged for positioning the emitting end of the scanhead unit in a desired image plane.
6. The imaging system of claim 1, wherein the small-animal mount assembly further comprises a table subassembly having a table member, the table member having a top surface, a bottom surface, and defining a table plane.
7. The imaging system of claim 6, wherein the mount subassembly further comprises:
- a planar platform having an upper surface and a lower surface and defining a first axis parallel to the longitudinal axis of the second rail and a second axis normal to the first axis, the platform further defining a platform plane defined by the first axis and the second axis; and
  - a platform adjustment mechanism constructed and arranged for moving the platform in the platform plane, the platform adjustment mechanism having a platform base and an adjustable armature, the platform base being connected to a portion of a top surface of the mount assembly base member and the armature being connected to a portion of an edge of the platform.
8. The imaging system of claim 7, wherein the lower surface of the platform overlies and rests on the top surface of the mount assembly base member.
9. The imaging system of claim 8, wherein the upper surface and the lower surface of the platform are coated with a low-friction material.
10. The imaging system of claim 8, wherein platform and the top surface of the mount assembly base member are positioned in parallel planes.
11. The imaging system of claim 7, wherein the mount subassembly further comprises a table orientation control mechanism selectively positioned onto a portion of the upper surface of the planar platform, the table orientation control mechanism constructed and arranged for adjusting the table plane of the table member.
12. The imaging system of claim 11, wherein the orientation control mechanism includes:
- a housing having a top and a bottom; and
  - a magnetic lock housed partially within the housing and having a movable magnet, the magnetic lock movable from a retracted, non-engaged, position to an engaged position in which the magnet is brought into attractive contact with the upper surface of the platform.
13. The imaging system of claim 11, wherein the orientation control mechanism includes:
- a bearing housed within the housing;
  - an upright shaft member engaged to the bearing such that the shaft member can be selectively rotated about an upright axis; and
  - a coarse height mechanism constructed and arranged for selective bi-directional movement of the upright shaft member along the upright axis.
14. The imaging system of claim 13, wherein the orientation control mechanism includes:
- a brake surface connected to the shaft member; and
  - a rotation control mechanism constructed and arranged for selectively engaging the brake surface.
15. The imaging system of claim 14, wherein the orientation control mechanism includes:
- a movable cap movably connected to an upper portion of the shaft member; and
  - a fine height control mechanism constructed and arranged for selective bi-directional movement of the movable cap relative to a top of the shaft member along the upright axis.
16. The imaging system of claim 15, wherein the orientation control mechanism includes:

- a first tilt control mechanism operatively connected to the top of the movable cap, the first tilt control mechanism having a top surface; and
- a second tilt control mechanism operatively connected to the top surface of the first tilt control mechanism and operatively connected to the bottom surface of the table member,
- wherein the first tilt control mechanism is constructed and arranged for selectively adjusting and securing the tilt of the table member relative to the y-axis of the table plane, and wherein the second tilt control mechanism is constructed and arranged for selectively adjusting and securing the tilt of the table member relative to the x-axis of the table plane.
17. The imaging system of claim 6, wherein the table subassembly includes: a control apparatus; and
- at least one ECG control pad, the at least one ECG control pad attached to the top surface of the table member and electrically coupled to the control apparatus, each ECG pad generating, to the control apparatus, an ECG signal representative of a sensed ECG of a portion of the small animal disposed thereon the ECG pad.
18. The imaging system of claim 17, wherein the table subassembly further includes
- at least one grid of electronic heating elements disposed onto the top surface of the table member.
19. The imaging system of claim 18, wherein the table subassembly further includes a thermocouple connected to the top surface of the table member and electrically coupled to the control apparatus, the thermocouple generating, to the control apparatus, a temperature signal representative of the temperature proximate the thermocouple.
20. The imaging system of claim 19, wherein the table subassembly further includes a rectal temperature probe electrically coupled to the control apparatus, the rectal temperature probe generating, to the control apparatus, an internal temperature signal representative of the sensed internal temperature of the small animal.
21. The imaging system of claim 6, wherein the table subassembly further includes:
- a dish having a peripheral wall;
- a dish support mechanism having an arm member and a fastener, the arm member having an upper portion and a lower portion, the upper portion of the arm member constructed and arranged for selectively clamping onto a portion of the wall of the dish, the lower portion of the arm member defining an elongate slot, wherein, in use, the fastener passes through the slot and selectively secures a portion of the lower portion of the arm member to an edge of the table member.
22. The imaging system of claim 6, wherein the table subassembly includes:
- a small animal mask shaped and sized for fit onto a portion of the snout of the small animal; and
- a clamp member secured to a portion of the top surface of the table member, the clamp member constructed and arranged for grasping a portion of the small animal mask.
23. The imaging system of claim 3, wherein the needle injection assembly further includes:
- an injector subassembly, the injector subassembly having an injector unit that has an elongated needle; and
- a carriage subassembly connected to the needle injection assembly base member, the injector unit connected to a portion of the carriage subassembly, the carriage subassembly constructed and arranged for positioning the needle in a desired needle plane.
24. The imaging system of claim 23, wherein the needle injection assembly includes an articulating armature assembly, wherein the articulating armature assembly includes a plurality of cooperative arm members that has a seat connected to a distal portion of the plurality of cooperative arm members, the injector unit being operatively mounted to the seat, and wherein the articulating armature assembly is constructed and arranged for rotating the injector unit about a distal end of the needle in the desired needle plane to a desired angle of penetration of the needle relative to an upright axis.
25. The imaging system of claim 24, wherein the injector subassembly further includes a needle insertion mechanism constructed and arranged for controlling the extension and retraction of the injector unit relative to the seat.
26. An imaging system for imaging portions of small-animals, comprising:
- a plurality of elongated rails, the plurality of elongated rails including a first rail and a second rail, each rail having a proximal end, a spaced distal end, and a longitudinal axis, the proximal end of the first rail positioned proximate a first edge of the second rail intermediate the proximal end and distal end of the second rail, the longitudinal axis of the first rail at an angle with respect to the longitudinal axis of the second rail;
- a scanhead assembly selectively mounted onto the first rail and constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the first rail; and
- a small-animal mount assembly selectively mounted onto the second rail and constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the second rail.
27. The imaging system of claim 26, wherein the plurality of elongated rails includes a third rail, the proximal end of the third rail positioned proximate a second edge of the second rail intermediate the proximal end and distal end of the second rail, the longitudinal axis of the third rail substantially coaxial to the longitudinal axis of the first rail.
28. The imaging system of claim 27, further comprising a needle injection assembly selectively mounted onto the third rail and constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the third rail.
29. An imaging system for imaging portions of small-animals, comprising:
- a plurality of elongated rails, the plurality of elongated rails including a first rail, a second rail, and a third rail, each rail having a proximal end, a spaced distal end, and a longitudinal axis, the proximal end of the first rail being positioned proximate a first edge of the second rail intermediate the proximal end and distal end of the second rail, the proximal end of the third rail being positioned proximate a second edge of the second rail

intermediate the proximal end and distal end of the second rail, the longitudinal axis of the third rail substantially coaxial to the longitudinal axis of the first rail and the first rail at an angle with respect to the longitudinal axis of the second rail;

a scanhead assembly having a scanhead assembly base member that is selectively mounted onto the first rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the first rail;

a small-animal mount assembly having a mount assembly base member that is selectively mounted onto the second rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the second rail; and

a needle injection assembly having an injection assembly base member that is selectively mounted onto the third rail and is constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the third rail.

**30.** The imaging system of claim 29, further comprising at least one moveable stop, each movable stop mounted onto one rail and constructed and arranged for movement in a linear bi-directional manner along the longitudinal axis of the rail, each movable stop having a stop clamping mechanism constructed and arranged for selectively fixing the position of the movable stop relative to the rail.

**31.** The imaging system of claim 30, wherein one moveable stop of the at least one moveable stop is mounted to the

first rail intermediate the proximal end of the first rail and the scanhead assembly base member mounted thereon the first rail.

**32.** The imaging system of claim 30, wherein one moveable stop of the at least one moveable stop is mounted to the first rail intermediate the proximal end of the first rail and the scanhead assembly base member mounted thereon the first rail.

**33.** The imaging system of claim 30, wherein the scanhead assembly further comprises:

a scanhead unit having an operative emitting end; and

means for orienting the operative emitting end into a desired image plane.

**34.** The imaging system of claim 30, wherein the small-animal mount assembly further comprises:

a table member defining a table plane; and

means for orienting the table member so that the table plane of the table member is positioned in a desired table plane.

**35.** The imaging system of claim 30, wherein the needle injection assembly further comprises:

a needle having a distal end and a longitudinal length; and

means for orienting the needle into a desired needle plane.

\* \* \* \* \*

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摘要(译)

成像系统可包括多个细长导轨，扫描头组件和小动物安装组件。扫描头组件选择性地安装在第一轨道上，并且构造和布置成沿第一轨道的纵向轴线以线性双向方式运动。小动物安装组件选择性地安装在第二轨道上，并且构造和布置成沿着第二轨道的纵向轴线以线性双向方式运动。第二轨道相对于第一轨道安装，使得第二轨道的纵向轴线与第一轨道的纵向轴线成一角度。成像系统还可以包括针注射组件，该针注射组件选择性地安装在第三轨道上，并且构造和布置成沿着第三轨道的纵向轴线以线性双向方式运动。第三轨道相对于第二轨道和第一轨道安装，使得第三轨道的纵向轴线基本上与第一轨道的纵向轴线同轴。

