

# #7

## Example Provisional Patent Application (PPA)

In due course, this Provisional patent application (PPA) was re-written and filed as a utility (non-provisional) patent application in the U.S. Patent Office. The patent was eventually granted as **US Patent No. 8,534,655**

*The following example is provided for educational purposes only in connection with **ELG's Practical Guide to PROVISIONAL PATENT APPLICATIONS for the Cost-Conscious Inventor.***

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## QUICK ACTION WOODWORKING VISE

### BACKGROUND OF THE INVENTION

Woodworking workbenches have traditionally employed a vise or vises for gripping workpieces. The vises utilized have taken many different forms which suit a wide array of woodworking tasks. Face vises, mounted on the front or long face of the workbench may be in the form of a twin screw face vise with the screws coupled by a chain or where the screws are independent. They also take the form of cast iron Emmert style vises which have pivoting jaws to accept tapered or irregular shaped work or the quick action Record style of vise which typically have a central screw combined with two laterally displaced guide rods. Another form of face vise is the leg vise which utilizes a screw mounted in one of the workbench legs with a vertically displaced fulcrum arm which accepts a peg installed in a hole to match the thickness of the work being secured. Face vises may also be in the form of the Scandinavian style shoulder vise which has a vise screw installed in a bench block mounted at the end of the bench and typically supported by an additional leg. The vise jaw is open to three sides so it has the ability to clamp work that would be difficult to clamp in the other style of vises.

Vises may also be found mounted to the end of the bench in the form of a tail vise. Typically the tail vise includes a dog which may be used to clamp work flat on the bench top between a corresponding bench dog mounted in various holes in the top of the bench. Many of the previously described face vises may be mounted on the end of the bench to function as a tail vise. The twin screw vise for example may be mounted on the end of the bench and be the same width as the bench top. If provisions are made in the vise jaw to accept bench dogs then the vise can function as a tail vise and still operate as a face vise mounted in the end or tail vise position.

All of the aforementioned vises excel at some tasks and have deficiencies which have to be overcome. Twin screw vises offer drop through clamping of large objects without racking since pressure is applied on both sides of the workpiece. The chain operated twin screw vise may have an external chain which detracts from the aesthetics of the work bench. The chain operated twin screw vises do not have quick action and have to be laboriously cranked in and out. The screws also require grease to work freely which may soil the workpiece if contacted. Independent operated twin screw vises also do not have quick action and require each screw to be operated while maintaining a grasp on the workpiece with the operators other hand. The iron style face vises may have quick action and are easy to install but the central screw and guide rods prevent drop through clamping. The vise jaws may rack if the work is not centered and the quick action nut may clog with dirt and sawdust preventing proper action. Some vises require the actuation of a lever to enable quick action

which makes them difficult to operate and the screw requires grease which may soil the workpiece. Leg vises excel at clamping work to the front face of the bench and have great holding power due to the long fulcrum arm. They do not have quick action and a peg must be moved in the fulcrum arm each time a different thickness workpiece is clamped. The fulcrum arm is very near the floor and requires considerable bending to change. The Scandinavian style shoulder vise requires the vise to be designed into the bench since it requires an additional leg. They do not have quick action and the bench block and vise screw extending outward from the front of the bench can be awkward to move around. Traditional tail vises are aesthetically pleasing and work well but they are very difficult to install, do not have rapid action and may sag when extended.

Typically, all screw actuated vises operate with clockwise rotation of the clamp handle which ergonomically speaking may not be ideal for all operators. Left handed people in particular may find that clockwise operation is not the best direction of rotation for them.

### SUMMARY OF THE INVENTION

The present invention improves prior art vises by providing a vise mechanism which is very versatile and can be configured into any of the vise forms previously described. Additionally the vise of the present invention has quick release that occurs automatically when unclamped and utilizes clamp shafts which do not require any lubrication for operation. The twin clamp shafts allow work to be clamped anywhere in the vise jaws without racking and the vise may be simply configured to clamp with clockwise or counter-clockwise rotation of the clamp handle to suit the operator. It may be constructed to appear as a traditional 18<sup>th</sup> century twin screw vise with wooden vise jaws, handles and clamp hubs or as a traditional leg vise with a single wooden vise handle and wooden jaw. It may also be configured into a quick action shoulder style vise, while not traditional in appearance, has aesthetic appeal and a more streamlined appearance with a single wooden handle and clamp hub.

The present invention vise operates smoothly and precisely without sagging or screw "chatter" common on quick action screw operated vises. It is simple and easy to install and adjust and clamping force can be limited for delicate work. The vise may be configured in any width desired and utilize one or two clamping handles. The vise jaw has a small amount of skew (approximately 2 degrees in either direction for example) which allows slightly out of square work to be clamped. The front vise jaw may be configured to allow it to swivel considerably (up to 10 degrees in either direction for example) which allows tapered or irregular objects to be firmly clamped. The vise may also be configured, using a single clamp shaft, into an enclosed tail vise with quick action and simple installation. The tail vise is visually appealing with a

very narrow slot in the bench top and a wooden clamp hub and handle.

In accordance with the teachings of the present invention, a vise is provided which includes a pair of spaced housings secured to the underside of the workbench top. A pair of parallel clamp shafts is received in holes in the respective housings and is free to slide in and out of the housings. The clamp shafts pass through holes in the laterally-extending rear vise jaw which is secured to the workbench top. The clamp shafts further pass through holes in the movable front vise jaw and are fixed to clamp hubs which transfer motion from the clamp handles into the clamp shafts. Means are provided to allow the front vise jaw to swivel and allow tapered objects to be clamped.

Pinions, which freely slide on the clamp shafts, are contained within the housings and convert rotational movement from the clamp shafts into linear movement by means of a corresponding rack. The linear motion actuates a bridge which slides against a laterally fixed wedge causing the bridge to displace a locking element which clutches and moves the clamp shafts to affect clamping. The linear motion from one clamp shaft is transferred through a rack and pinion to the other clamp shaft through a transfer bar and to the corresponding rack and pinion in the other housing. In this way, either clamp handle can be used to actuate the vise and both clamp shafts operate in unison when clamping. The vise may also be configured to utilize only one clamp hub and handle if desired.

Adjustment screws located in each housing allow the clamping action of each clamp shaft to be quickly and easily synchronized. The wedge and bridge pair can be reversed to allow clamping to occur with a clockwise rotation of the clamp handle or a counter-clockwise rotation of the clamp handle. When the clamp handle is in the un-clamped position the clamp shafts are free to move in and out of the housing, independent from one another, thus allowing the front vise jaw to be quickly positioned against the workpiece, whether straight or tapered, with one hand while the other hand is free to actuate the clamp handle and secure the workpiece.

One of the housings may be rotated 180° relative to the other to provide outward clamping force on one clamp shaft and inward clamping force on the other clamp shaft to allow clamping of a workpiece outside of the clamp shafts. This allows the vise to be utilized as a leg or shoulder vise.

It is an object of the present invention to provide a vise for a workbench which is mounted to the underside of the workbench top and has two clamp shafts projecting forward through the movable front vise jaw, typically made of wood, into the clamp hubs and handles that may be turned to rotate the clamp shafts to clamp a workpiece. The visual appearance of the vise may be made to look like a typical 18<sup>th</sup> century twin screw vise which many find appealing.

It is another object of the present invention to provide a vise for a workbench, wherein the vise has

quick action and yet is adapted to clamp tapered or odd shaped workpieces.

It is another object of the present invention to eliminate clamping screws which may sag and requires the application of grease which can soil a workpiece and collects saw dust and dirt.

It is yet another object of the present invention to provide a vise for a workbench featuring "drop through" clamping of relatively large workpieces.

It is yet another object of the present invention to provide a vise in which the distance between the clamp shafts can be set to the operator's preference.

It is a further object of the present invention to provide a vise in which the direction of the clamping action can be changed from clockwise rotation to counter clockwise rotation of the clamp handle to suit the operator. In addition the position of the handle in the unclamped state can be adjusted to allow better ergonomics and remains in that position.

It is a still further object of the present invention to provide a vise which is easy to install and also has the ability to easily synchronize the clamping motion of the clamp shafts. In addition the clamping force can be limited to suit the work at hand.

It is another object of the present invention to provide a vise in which the direction of the clamping force applied to one clamp shaft is opposite to the direction of the clamping force in the other clamp shaft to allow clamping outside of the clamp shafts as required for a leg or shoulder style vise.

It is yet another object of the present invention to provide a vise which can function as an enclosed quick action tail vise using a single clamp shaft, housing and associated components.

These and other objects of the present invention will become apparent from a reading of the following description, taken in conjunction with the enclosed drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a first embodiment showing the vise of the present invention configured as a face or end vise with two handles, with the workbench top, rear vise jaw and moveable front vise jaw shown in phantom for clarity.

FIG. 2 is a partial right section view of a first embodiment of the vise of the present invention taken along line 1-1 in FIG. 1.

FIG. 3 is a partial perspective exploded view of a first embodiment of the vise of the present invention showing the clamp shaft assembly to the clamp hub through the moveable front vise jaw shown in phantom for clarity.

FIG. 4 is a partial perspective exploded view of a first embodiment of the vise of the present invention showing the mechanism which provides clamping action.

FIG. 5 is a perspective illustrative view of a first embodiment of the vise of the present invention which shows the relationship of the locking element to the clamp shaft when the clamp shaft is rotated.

FIG. 6 is a perspective illustrative view of prior art locking elements which shows the relationship of the locking element to the clamp shaft when the clamp shaft is rotated.

FIG. 7 is a partial top plan view of a first embodiment showing the vise of the present invention in the unclamped state and configured for clamping by clockwise rotation of the clamp handle.

FIG. 8 is a partial top plan view of a first embodiment showing the vise of the present invention in the unclamped state and configured for clamping by counter - clockwise rotation of the clamp handle.

FIG. 9 is a partial rear illustrative view of a first embodiment showing the vise of the present invention and the relationship of applied handle force to the centerline of the clamp shaft.

FIG. 10 is a partial plan illustrative view of a first embodiment showing the vise of the present invention, with the bridge in the clamped position shown in phantom lines, which shows the direction of the clamping force, the angle of the wedge and bridge and the direction of motion during clamping.

FIG. 11 is a partial perspective exploded view of a second embodiment of the vise of the present invention configured as a single handle vise showing the clamp shaft assembly to the clamp hub through the moveable front vise jaw shown in phantom for clarity.

FIG. 12 is a partial perspective exploded view of a second embodiment of the vise of the present invention showing the mechanism which provides clamping action.

FIG. 13 is a perspective view showing a third embodiment of the vise of the present invention configured as a face or end vise with two handles and a swivel front jaw, with the workbench top, rear vise jaw and moveable front vise jaw shown in phantom for clarity.

FIG. 14 is a partial perspective exploded view of a third embodiment of the vise of the present invention showing the clamp shaft assembly to the clamp hub through the moveable front vise jaw.

FIG. 15 is a partial horizontal section view showing a third embodiment of the vise of the present invention and showing the moveable front vise jaw in a swiveled position.

FIG. 16 is a partial front illustrative view of a third embodiment of the present invention showing the swivel mechanism in the unlocked position.

FIG. 17 is a partial front illustrative view of a third embodiment of the present invention showing the swivel mechanism in the locked position.

FIG. 18 is a partial perspective exploded view of a fourth embodiment of the vise of the present invention configured as a single handle swivel jaw vise showing the clamp shaft assembly to the clamp hub through the moveable front vise jaw.

FIG. 19 is a perspective view of a fifth embodiment of the vise of the present invention configured as a leg vise with the moveable front vise

jaw, bench leg and partial bench top shown in phantom for clarity.

FIG. 20 is a partial perspective exploded view of a fifth embodiment of the vise of the present invention showing the clamp shaft assembly to the clamp hub through the moveable front leg vise jaw shown in phantom for clarity.

FIG. 21 is a partial right side view showing a fifth embodiment of the vise of the present invention in the unclamped state and configured for clamping by clockwise rotation of the clamp handle.

FIG. 22 is a partial right side view showing a fifth embodiment of the vise of the present invention in the unclamped state and configured for clamping by counter - clockwise rotation of the clamp handle.

FIG. 23 is a perspective view showing a sixth embodiment of the vise of the present invention configured as a shoulder vise with the moveable front shoulder vise jaw, fixed rear vise jaw and partial bench top shown in phantom for clarity.

FIG. 24 is a partial perspective exploded view of a sixth embodiment of the vise of the present invention showing the clamp shaft assembly to the clamp hub through the moveable front shoulder vise jaw and rear fixed vise jaw shown in phantom for clarity.

FIG. 25 is a partial top plan view showing a sixth embodiment of the vise of the present invention in the unclamped state and configured for clamping by clockwise rotation of the clamp handle.

FIG. 26 is a partial top plan view showing a sixth embodiment of the vise of the present invention in the unclamped state and configured for clamping by counter - clockwise rotation of the clamp handle.

FIG. 27 is a perspective view showing a seventh embodiment of the vise of the present invention configured as an enclosed tail vise.

FIG. 28 is a partial perspective view showing a seventh embodiment of the vise of the present invention with the partial bench top and apron shown in phantom for clarity.

FIG. 29 is a partial perspective exploded view showing a seventh embodiment of the vise of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIGS. 1, 2 and 4, the vise of the present invention comprises generally two clamp shafts 12 and 12' which are parallel to one another and have a keyway along most of their length and slide freely through the flanged plain bearings 47 and 47' located in front holes in housings 11 and 11' and through pinions 16 and 16', locking elements 17 and 17', through springs 20 and 20', through washers 43 and 43' and through flanged plain bearing 47 and 47' located in the rear holes of housings 11 and 11'. Flanged plain bearings 47 and 47' are constructed of an ultra high molecular weight polyethylene material to provide low friction to prevent stick - slip and provide good durability. The Flanged plain bearings 47 and 47' may also be made of Acetal,

Polytetrafluoroethylene, Bronze or any other suitable material depending on the application. Generally speaking the further apart the clamp shafts 12 and 12' are spaced the lower the friction coefficient must be for the material used in flanged plain bearings 47 and 47'. Clamp shafts 12 and 12' are prevented from being pulled out of housings 11 and 11' by retaining rings 24 and 24' which are housed in grooves machined near the ends of clamp shafts 12 and 12'. Clamp shafts 12 and 12' are constructed of mild carbon steel and are case hardened to provide a wear resistant surface, eliminate the need for oil lubrication and allow locking elements 17 and 17' to securely grab clamp shafts 12 and 12' as described later. Housings 11 and 11' are securely and distally mounted to the underside of a typical workbench top 46 using lag screws (not shown) or other appropriate fasteners, fastened through the mounting holes and slots provided in housings 11 and 11'. Housings 11 and 11' are constructed of ductile cast iron to provide strength. Pins 28 and 28' are press fit into corresponding holes in transfer bar 18 and pins 28 and 28' fit freely into suitable holes in racks 15 and 15' thus allowing racks 15 and 15' to freely rotate about pins 28 and 28'. Racks 15 and 15' engage pinions 16 and 16' through rectangular holes in bridges 13 and 13'. Transfer bar 18 is allowed to freely move while being constrained between the workbench top 46 and the housings 11 and 11'. With reference to FIGS. 1, 2 and 3, Clamp shaft 12 passes through a clearance hole in fixed rear vise jaw 45, wave spring 21 and washer 43 and through a circular hole and horizontal slot each bored part way through moveable front vise jaw 44 and into a close fitting bored hole in clamp hub 36. Retaining ring 24 is installed in a groove machined in clamp shaft 12 and retains wave spring 21 against clamp shaft 12. Clamp shaft 12 is securely affixed to clamp hub 36 by split pin 25 installed through a hole perpendicular to the close fitting bored hole in clamp hub 36 and into the cross hole in clamp shaft 12. Washer 43 fits tightly into the bored hole and has enough clearance to clamp shaft 12 to allow clamp shaft 12 to swivel slightly (approximately 2° for example) within the close fitting slot. Thus washer 43 locates moveable front vise jaw 44 laterally but allows moveable front vise jaw 44 to swivel slightly to accept slightly tapered work. Similarly, clamp shaft 12' passes through a clearance hole in fixed rear vise jaw 45, wave spring 21' and washer 43' and through a large circular hole and horizontal slot each bored part way through moveable front vise jaw 44 and into a close fitting axially bored hole in clamp hub 36'. Retaining ring 24' is installed in a groove machined in clamp shaft 12' and retains wave spring 21' against clamp shaft 12'. The horizontal slot in moveable front vise jaw 44 is very close fitting in the vertical direction to help stabilize moveable front vise jaw 44 when a workpiece is clamped high in the moveable front vise jaw 44 or dogs are utilized in moveable front vise jaw 44 for clamping work on the bench top. Wave springs 21 and 21' apply spring pressure between retaining

rings 24 and 24' installed in grooves in clamp shafts 12 and 12' and through washers 43 and 43' and into the rear face of moveable front vise jaw 44 pulling clamps hubs close to the front face of moveable front vise jaw 44. The combination of the horizontal slot in moveable front vise jaw and the spring action from wave springs 21 and 21' give compliance in the moveable front vise jaw 44 to allow moveable front vise jaw 44 to swivel slightly (approximately 2° for example ) so that slightly tapered or irregular workpieces may be effectively secured. In addition, this compliance allows for wood movement in the bench top 46, especially if vise 10 is located in the end position which would typically have higher expansion and contraction due to cross grain. Further, the compliance in moveable front vise jaw 44 allows for clamps shafts that are not perfectly parallel and also takes up tolerance between the clamp hubs 36 and 36' so all clamping action is directed towards clamping, creating quicker clamping action (generally within 45° of handle movement). Clamp shaft 12' is securely affixed to clamp hub 36' by split pin 25' installed through a hole perpendicular to the close fitting bored hole in clamp hub 36' and into the cross hole in clamp shaft 12'. Handles 34 and 34' slide within each clamp hub 36 and 36' perpendicular to the longitudinal axes of clamp shafts 12 and 12' and retained by knobs 35 and 35'. To facilitate ease of construction of moveable front vise jaw 44 and fixed rear vise jaw 45, a centrally located hole is provided in the end of clamp shafts 12 and 12' to allow the use of blind hole spotter 33 as shown in FIG. 2. With the blind hole spotter 33 installed in the centrally located hole of clamp shaft 12 or 12', the clamp shaft 12 or 12' may be slid forward to mark the clamp shaft 12 or 12' center location into moveable front vise jaw 44 and fixed rear vise jaw 45, greatly simplifying the hole and slot locations and simplifying construction of vise 10.

With reference to FIGS. 2 and 4, keys 26 and 26' slide freely in keyways in shafts 12 and 12' and in corresponding keyways in pinions 16 and 16' and transmits rotational movement of shafts 12 and 12' into pinions 16 and 16' while allowing translational movement of shafts 12 and 12' into and out of housings 11 and 11'. Bridges 13 and 13' have a centrally located rectangular hole which fits freely around pinions 16 and 16' and racks 15 and 15' and have one edge which is perpendicular to the longitudinal axes of clamp shafts 12 and 12' and an opposite edge which is at a slight angle relative to the previously described edge. The angled edges of bridges 13 and 13' are in contact with the identically angled edges of wedges 14 and 14' which are free to move longitudinally in pockets in housings 11 and 11' but are constrained from moving laterally. The edges of bridge 13 and 13' that are perpendicular to clamp shafts 12 and 12' are in contact with locking elements 17 and 17'. Racks 15 and 15' freely fit into the rectangular hole of bridges 13 and 13' and engage pinions 16 and 16'. Racks 15 and 15' may be machined with a very small lip on each end to better

locate racks 15 and 15' vertically in the rectangular hole in bridges 13 and 13', otherwise racks 15 and 15' are held in vertical location by pinions 16 and 16' and the close lateral fit of racks 15 and 15' within the rectangular hole of bridges 13 and 13'. The rectangular hole in bridges 13 and 13' keep pinions 16 and 16' in alignment with racks 15 and 15' by nesting pinions 16 and 16' and racks 15 and 15' within the rectangular hole and converts the lateral motion of racks 15 and 15' into longitudinal motion by means of the wedging action created by the angled edges of wedges 14 and 14' acting against the corresponding angled edges of bridges 13 and 13'. Bridges 13 and 13' also function to limit the rotation of pinions 16 and 16' in order to prevent pinions 16 and 16' from running off the end of racks 15 and 15' by contacting the pinions 16 and 16' teeth at the end of travel. Bridges 13 and 13' are constructed of low carbon steel and are case hardened to eliminate galling between bridges 13 and 13' and wedges 14 and 14' and between bridges 13 and 13' and locking elements 17 and 17'.

Rotary motion from clamp shaft 12 is transferred to pinion 16 through key 26 and is converted to translational motion by means of rack 15 which is engaged with pinion 16. The translational motion of rack 15 is transferred to rack 15' through pins 28 and 28' which are press fit into transfer bar 18. The translational motion from rack 15' is converted back to rotary motion by means of pinion 16' which is engaged with rack 15'. The rotary motion from pinion 16' is transferred to clamp shaft 12' through key 26'. In this way, clamp shafts 12 and 12' are thus allowed to operate in unison when clamping and the motion of all elements contained in housings 11 and 11' occur simultaneously and in synchronicity.

Transfer bar 18 may be fashioned to any specific length to give the desired center to center distance of clamp shafts 12 and 12' and correspondingly any desired length of moveable front vise jaw 44. It will be apparent to those skilled in the art that transfer bar 18 may also be constructed so as to be adjustable in length by use of bolted connections, multiple mounting holes or other suitable means.

In the unclamped state, bridges 13 and 13' are positioned by racks 15 and 15' at their shortest longitudinal width against wedges 14 and 14' at their shortest longitudinal width allowing locking elements 17 and 17' to contact release adjusting screws 23 and 23' by means of spring pressure from springs 20 and 20' bearing against housing 11 and 11' and locking elements 17 and 17'. Locking elements 17 and 17' are thus held perpendicular to clamp shafts 12 and 12' allowing clamp shafts 12 and 12' to freely pass through locking elements 17 and 17' and therefore moveable front vise jaw 44, which is fixed to clamp shafts 12 and 12', is free to be positioned against the workpiece whether square or slightly tapered.

Once moveable front vise jaw 44 is positioned against a workpiece, clamping begins as follows: Rotation of handle 34 is transferred through clamp hub 36 into split pin 25 and into clamp shaft 12 and

again transferred to pinion 16 through key 26 and its corresponding keyway in pinion 16 and clamp shaft 12. Rotation of pinion 16 is transferred into linear motion by engaging rack 15 which causes bridge 13 to translate identically. As the angled edge of bridge 13 translates against the corresponding angled edge of wedge 14 it is forced rearward against locking element 17 on a line which is radially displaced from the center of locking element 17 thus creating a moment about the center of locking element 17 and causing it to lock onto clamp shaft 12. Further rotation of handle 34 and thus clamp shaft 12 causes clamp shaft 12 to displace rearward to enable clamping. The motion transfer from transfer bar 18, previously described, causes identical clamping action to occur in clamp shaft 12' through identical movements of rack 15', pinion 16', bridge 13' and locking element 17'. Clamping may be initiated by rotation of either clamp handle 34 or 34'.

Locking elements 17 and 17' translate longitudinally with the shaft but always maintain a planar relationship with bridges 13 and 13' by rotating about shafts 12 and 12' while locking elements 17 and 17' are simultaneously locking against shafts 12 and 12' as depicted in FIG 5. The use of soft low carbon steel in locking elements 17 and 17' combined with case hardened steel in clamp shafts 12 and 12' allow locking elements 17 and 17' to securely grip clamp shafts 12 and 12' even though there is relative movement between clamp shafts 12 and 12' and locking elements 17 and 17'. Prior art locking elements such as disclosed in U.S. Pat. # 4,057,239 issued on Nov. 8, 1977, do not have relative motion between the locking element and the shaft as shown in FIG. 6 and require flats, or other suitable means, machined into the shaft and locking element so that the locking element and shaft turn in unison. The unique motion and combination of case hardened steel in clamp shafts 12 and 12' and soft low carbon steel in locking elements 17 and 17' of the current invention allows the locking elements 17 and 17' to transmit the rotational clamping force and the translational clamping motion without being keyed to the shaft and without requiring a helical ramp or other complicated means used in prior art. The motion of locking elements 17 and 17' allow the centrally located hole and the periphery of locking elements 17 and 17' to be circular, greatly simplifying construction. Since locking elements 17 and 17' rotate freely about clamp shafts 12 and 12', locking elements 17 and 17' wear evenly about the entire circumference of the hole in locking elements 17 and 17' thereby increasing the durability of the part significantly.

Synchronization and adjustment of the clamping action between the corresponding clamp shafts 12 and 12' is accomplished by means of clamp adjusting screws 22 and 22' which are threaded into housings 11 and 11' and bear against wedges 14 and 14'. By threading the clamp adjusting screws 12 and 12' in or out, Wedges 14 and 14' are advanced or retracted against bridges 13 and 13' which in turn are advanced

or retracted against locking elements 17 and 17'. This adjustment causes the clamping action to be respectively advanced or delayed which allows the two clamp shafts to be precisely and simply synchronized. The clamp adjusting screws 22 and 22' also allows compensation for wear and tolerances in manufacturing. An additional benefit of clamp adjusting screws 22 and 22' is that by retracting the screws significantly the maximum clamping force may be reduced to allow clamping of delicate or fragile workpieces. When clamp adjusting screws 22 and 22' are advanced or retracted, locking elements 17 and 17' may not release from clamp shafts 12 and 12' properly due to the altered angular relationship of locking element 17 and 17' to clamp shafts 12 and 12'. A perpendicular relationship of locking elements 17 and 17' to clamp shafts 12 and 12' is required to unlock locking elements 17 and 17' from clamp shafts 12 and 12'. To allow for proper release of locking elements 17 and 17', release adjusting screws 23 and 23' are threaded into housings 11 and 11' and contact locking elements 17 and 17' at their periphery. Release adjusting screws 23 and 23' are advanced against locking elements 17 and 17' when in the unclamped state until locking elements 17 and 17', with the aid of spring pressure from springs 20 and 20', release from clamp shafts 12 and 12' by attaining a perpendicular relationship to clamp shafts 12 and 12'. Jam nuts 32 and 32' are tightened against housings 11 and 11' to prevent release adjusting screws 23 and 23' from inadvertently moving after they are adjusted.

Vise 10 can be configured to clamp with clockwise rotation of clamp handles 34 and 34' or with counter-clockwise rotation of clamp handles 34 and 34'. When bridges 13 and 13' and wedges 14 and 14' are oriented as shown in FIG. 7, clockwise rotation R1 or R2 of clamp handle 34 or 34' enables clamping forces F1 and F2 to be applied to clamp shafts 12 and 12' and translational force F3 to be applied through transfer bar 18. To configure vise 10 to clamp with counter-clockwise rotation of clamp handles 34 and 34', bridges 13 and 13' and wedges 14 and 14' are simply removed from housings 11 and 11' rotated 180° about a longitudinal axis and re-installed into housings 11 and 11' as depicted in FIG. 8. Counter-clockwise rotation R3 or R4 of clamp handle 34 or 34' enables clamping forces F3 and F4 to be applied to clamp shafts 12 and 12' and translational force F5 applied through transfer bar 18.

With reference to FIGS. 9 and 10, the clamping force C, handle force F, and total clamp travel T, may be changed in vise 10 by changing the angle  $\alpha$  of the contacting surfaces between bridges 13 and 13' and wedges 14 and 14' and by changing the number of teeth on racks 15 and 15'. The clamp force C and total clamp travel T for angle  $\alpha$  of wedges 14 and 14' and bridges 13 and 13' and for number of rack teeth  $N_r$  of racks 15 and 15' may be determined from the following formulas:

$$C = \left( \frac{Fd}{p} \right) \cot \alpha \quad \text{and:}$$

$$T = \beta \left( \frac{\pi r}{180} \right) \tan \alpha \quad \text{where:}$$

C = Clamping force applied through clamp shafts 12 and 12' and moveable front vise jaw 44 to clamp workpiece.

F = Handle force applied at distance d from clamp shafts 12 or 12' centerline to point of force application on Handle 34 or 34'.

d = Distance from clamp shafts 12 or 12' centerline to point where handle force F is applied on handle 34 or 34'.

p = Pitch line radius of pinions 16 and 16'.

$\alpha$  = Angle of contacting surfaces of bridges 13 and 13' and wedges 14 and 14' relative to a perpendicular line to the longitudinal axes of shafts 12 and 12'.

T = Total clamp travel distance of clamp shafts 12 and 12' when clamp handle 34 or 34' is rotated through the maximum allowed angular rotation  $\beta$ .

$\beta$  = Maximum angular rotation of clamp handle 34 or 34'. The maximum rotation of clamp handle 34 or 34' is limited by the number of teeth on racks 15 and 15' and the number of teeth on pinions 16 and 16' and may be calculated from the following formula:

$$\beta = \left[ (N_r - 1) \left( \frac{360}{N_p} \right) \right] - \cos^{-1} \left( \frac{r - 0.049}{r} \right)$$

where:

$N_r$  = Number of teeth on racks 15 and 15'

$N_p$  = Number of teeth on pinions 16 and 16'

r = Outside radius of pinions 16 and 16'

Assuming handle force F remains constant, as angle  $\alpha$  is decreased clamp force C increases and total clamp travel T decreases. Correspondingly as angle  $\alpha$  is increased, clamp force C decreases and total clamp travel T increases. Assuming handle force F remains constant, vise 10 can thereby be configured, by increasing angle  $\alpha$  on bridges 13 and 13' and wedges 14 and 14', to clamp highly compressible materials with more total clamp travel T and less clamp force C applied to moveable front vise jaw 44 and thus less clamp force applied to the workpiece being clamped. Vise 10 may also be configured, by decreasing angle  $\alpha$  on bridges 13 and 13' and wedges 14 and 14', to clamp highly dense materials with less total clamp travel T and more clamp force C applied to moveable front vise jaw 44. Total clamp travel T may be increased by adding teeth to racks 15 and 15' effectively lengthening racks 15 and 15'. Adding teeth to racks 15 and 15' increases the maximum angular rotation of clamp handles 34 and 34' and thus increases total clamp travel T. Total clamp travel T may be decreased by subtracting teeth from racks 15 and 15' effectively shortening racks 15 and 15'. Subtracting teeth from racks 15 and 15' decreases the maximum angular rotation of clamp handles 34 and 34' and thus decreases total clamp travel T.

The structure of a second embodiment shown in FIGS. 11 – 12 is functionally identical to that of FIGS. 1 – 10. Reference numerals for functionally identical structure carry postscripts a in FIGS. 11 – 12.

In this arrangement, a single clamp handle 34a, clamp hub 36a and knobs 35a is utilized. This configuration may be necessary when the center to center distance of clamp shafts 12a and 50 are close enough in proximity to interfere with each other and hinder operation of vise 10. All structure associated with clamp shaft 12a is identical to structure detailed previously in the first embodiment. Since a single handle only is used in this embodiment, clamp shaft 50 is constructed without a keyway or a cross hole and has two distally spaced grooves machined into the forward most area of clamp shaft 50. The rearmost groove of clamp shaft 50 accepts retaining ring 24a'. Wave spring 21a' bears against retaining ring 24a' and applies spring pressure through washer 43a' and against the rear face of compliance ring 49. Clamp shaft 50 protrudes slightly through compliance ring 49 and is retained with retaining ring 24a' installed in the forward most groove machined in clamp shaft 50, bearing against the forward most washer 43a'. Compliance ring 49 is installed into a circular pocket milled into single handle moveable front vise jaw 60 and secured with wood screws 48. A decorative cover plate 61 is fastened to single handle moveable front vise jaw 60 with wood screws 48 to provide an attractive appearance. Compliance ring 49 allows the high clamping forces of vise 10 to be applied directly to single handle moveable front vise jaw 60 and not through screws or other means which may fail under load. The slot milled into compliance ring 49 also provides compliance to single handle moveable front vise jaw 60 in the same manner as described in the first embodiment.

With reference to FIG. 12, clamp shaft 50 does not rotate and thus does not require a pinion 16, key 26, 40 or rack 15 as described in the first embodiment. Spacer 75 is installed on shaft 50 between front flanged plain bearing 47a' and locking element 17a' to retain front flanged plain bearing 47a'. Spacer 75 is constructed of plastic such as Polyvinyl chloride and has sliding clearance to allow rotation and translation. Since a rack 15 as described in the first embodiment, is not required with clamp shaft 50, bridge 59 is constructed with a reamed hole to accept pin 28a' instead of a rectangular hole. Bridge 59 is allowed to freely rotate about pin 28a'. Otherwise bridge 59 is identical to bridge 13a. All rotational clamping motion is applied through clamp shaft 12a and the motion of clamp shaft 50 is translational only. All clamping and release functions are identical to the first embodiment. Clamp shaft 50, clamp hub 36a, handle 34a and knobs 35a may be positioned on the right or left side of single handle moveable front vise jaw 60.

The structure of a third embodiment shown in FIGS. 13 – 17 is functionally identical to that of FIGS. 1 – 10. Reference numerals for functionally

identical structure carry postscripts b in FIGS. 13 – 17.

In this configuration, moveable front vise jaw 72 is able to swivel to enable tapered objects or irregular shaped objects such as carvings or guitars while maintaining good contact between clamp hubs 36 and 36' and moveable front vise jaw 72. With reference to FIGS. 13, 14 and 15, clamp shaft 12b passes through a clearance hole in moveable front vise jaw 72 and through swivel base 38, wave spring 21b, lock ring 37 and swivel ring 39 and into clamp hub 36b. Similarly, Clamp shaft 12b' passes through a clearance hole in moveable front vise jaw 72 and through compensator base 40, wave spring 21b, washer 43b and compensator ring 41 and into clamp hub 36b'. Compensator base 40 and swivel base 38 are rigidly mounted within circular pockets in moveable front vise jaw 72 using wood screws 27 and 27'. When mounted, compensator base 40 and swivel base 38 are flush with the outer surface of moveable front vise jaw 72. Each clamp hub 36b and 36b' is fixed on the end of its respective clamp shaft 12b and 12b' with spring pins 25b and 25b' or other appropriate means. Handles 34b and 34b' slide within each clamp hub 36b and 36b' perpendicular to the longitudinal axes of clamp shafts 12b and 12b' and retained by knobs 35b and 35b'.

Clamp shaft 12b passes through a circular hole in swivel ring 39 and is allowed to freely rotate. Lock ring 37 is held in firm contact with swivel ring 39 by spring force from wave spring 21b acting against retaining ring 24b which is housed within a groove in clamp shaft 12b. Clamp hub 36b is allowed to freely rotate against swivel ring 39 and is kept in close contact by spring force from wave spring 21b. Two pivot pins 42, coaxially located on either side of clamp shaft 12b, pass through holes in swivel ring 39 and swivel base 38. Pivot pins 42 are retained on the outside by the circular pocket in moveable front vise jaw 44 and on the inside by clamp shaft 12. Once mounted swivel ring 39 stands proud of the front face of moveable front vise jaw 44 so that when moveable front vise jaw 72 is swiveled a prescribed arc in either direction, clamp hub 36b does not contact the front face of moveable front vise jaw 72 as depicted in FIG. 15.

With reference to FIG. 16, when lock ring 37 is rotated until stop tab 2 contacts horizontal member of swivel base 38, openings in lock ring 37 align with swivel stops 4 on swivel base 38 allowing swivel base 38 and moveable front vise jaw 72, since it is firmly affixed to swivel base 38, to freely swivel about pivot pins 42 in either direction. The swivel angle is limited (for example, to 10° arc) by swivel stops 4 on swivel base 38 contacting the bottom of machined pockets in swivel ring 39.

With reference to FIG. 17, when lock ring 37 is rotated until stop tab 3 contacts the horizontal member of swivel base 38, the openings in lock ring 37 are not aligned with swivel stops 4 on swivel base 38 thus preventing swivel base 38 and moveable front vise jaw 72 from swiveling. Thus moveable front vise



jaw 72 is held essentially parallel to fixed rear vise jaw 45 to allow more control when clamping square work. Moveable front vise jaw 72 is not held firmly parallel to fixed rear vise jaw 45 and is allowed a small degree of movement (for example, 1° arc) so that slightly tapered work may be clamped firmly without the need to rotate lock ring 37 to the unlocked free swivel position. It may be apparent to those skilled in the art that swivel stops 4 could be replaced with set screws threaded into holes in swivel base 38 thus allowing adjustment of movement of moveable front vise jaw 72 when lock ring 37 is rotated to prevent swiveling of moveable front vise jaw 72 as described previously.

With reference to FIGS. 13, 14 and 15, clamp shaft 12b' passes through a slot in compensator ring 41 and is allowed to freely rotate and translate laterally within the confines of the aforementioned slot. Compensator ring 41 is held in firm contact with clamp hub 36b' by spring force from wave spring 21b' acting against retaining ring 24b' which is housed within a groove in clamp shaft 12b'. Two pivot pins 42', coaxially located on either side of clamp shaft 12b', pass through holes in compensator ring 41 and compensator base 40. Pivot pins 42' are retained by press fit into appropriately sized holes in compensator ring 41. Once mounted, compensator ring 41 stands proud of the front face of moveable front vise jaw 72 so that when moveable front vise jaw 72 is swiveled an arc limited by contact of swivel ring 39 to swivel base 38 as described previously, clamp hub 36b' does not contact the front face of moveable front vise jaw 72. When moveable front vise jaw 72 is swiveled in either direction about pivot pins 42, clamp shaft 12b' is allowed to translate within the slot in compensator ring 41 thus allowing for the arc created by moveable front vise jaw 72. The slot in compensator ring 41 also allows for any variation in distance between housings 11b and 11b' caused by any seasonal wood movement in bench top 46.

The structure of a fourth embodiment shown in FIG. 18 is functionally identical to that of FIGS. 1 - 10. Reference numerals for functionally identical structure carry postscripts c in FIG. 18.

In this configuration, moveable front vise jaw 72 is able to swivel identically to the previous embodiment of FIGS. 13 - 17 and a single clamp handle 34c, clamp hub 36c and knobs 35c is utilized. This configuration may be necessary when the center to center distance of clamp shafts 12c and 50c are close enough in proximity to interfere with each other and hinder operation of vise 10. All structure associated with clamp shaft 12c is identical to structure detailed previously in the previous embodiment of FIGS. 13 - 17. Since a single handle only is used in this embodiment, clamp shaft 50c is constructed without a keyway or a cross hole and has two distally spaced grooves machined into the forward most area of clamp shaft 50c as previously described in the second embodiment of FIGS. 11-12. Clamp shaft 50c passes through a clearance hole in moveable front vise jaw

72c and through compensator base 40c, wave spring 21c', washer 43c' and single handle compensator ring 76. The rear most groove of clamp shaft 50c accepts retaining ring 24c'. Wave spring 21c' bears against retaining ring 24c' and applies spring pressure through washer 43c' and against the rear face of single handle compensator ring 76. Clamp shaft 50c protrudes slightly through single handle compensator ring 76 and is retained with retaining ring 24c' installed in the forward most groove machined in clamp shaft 50c, bearing against washer 43c'. Compensator base 40c is rigidly mounted within a circular pocket in moveable front vise jaw 72c using wood screws 27c'. When mounted, compensator base 40c is slightly lower than the outer surface of moveable front vise jaw 72c.

Clamp shaft 50c' passes through a slot in single handle compensator ring 76 and is allowed to freely rotate and translate laterally within the confines of the aforementioned slot. Single handle compensator ring 76 is held in firm contact with washer 43c' by spring force from wave spring 21c' acting against front retaining ring 24c' which is housed within a groove in clamp shaft 50c. Two pivot pins 42c', coaxially located on either side of clamp shaft 12c', pass through holes compensator base 40c and into holes in single handle compensator ring 76. Pivot pins 42c' are retained by a press fit into the appropriately sized holes in single handle compensator ring 76. Once mounted, single handle compensator ring 76 remains within the front face of moveable front vise jaw 72 whether swiveled fully or not, so that the entire assembly may be concealed by decorative cover plate 61 mounted to moveable front vise jaw 72c with wood screws 27c. When moveable front vise jaw 72c is swiveled in either direction about pivot pins 42c', clamp shaft 50c is allowed to translate within the slot in single handle compensator ring 76 thus allowing for the arc created by moveable front vise jaw 72c. The slot in single handle compensator ring 76 also allows for any variation in distance between housings 11c and 11c' (not shown) caused by any seasonal wood movement in bench top 46.

The structure of a fifth embodiment shown in FIGS. 19 - 22 is functionally identical to that of FIGS. 1 - 10. Reference numerals for functionally identical structure carry postscripts d in FIGS. 19 - 22.

In this configuration, vise 10 is constructed as a leg vise where clamping of the workpiece is done above clamp shaft 12d. In a typical leg vise the lower fulcrum arm is held immobile by a pin inserted in a hole in the fulcrum arm and pressed against the workbench leg while the upper vise screw is tightened causing the upper portion of the vise jaw to secure the workpiece. In this arrangement vise 10 is mounted vertically as show in FIG. 19 and the lower housing 11d' is rotated 180° relative to the upper housing 11d. In this way, the upper clamp shaft 12d will pull moveable leg vise jaw 53 inward toward workbench leg 58 while clamp shaft 50d will push moveable leg vise jaw 53 outward from workbench

leg 58 when handle 34d is rotated, thus creating a net inward force applied above clamp shaft 12d to effect clamping.

With respect to FIG. 19 the elements contained in housings 11d and 11d' are identical to the elements 5 previously described in FIG. 12 for a single handle vise with the only difference being that housing 11d' is rotated 180° relative to housing 12d. Both housings 11d and 11d' are firmly mounted to the inside face of bench leg 58 with bolts, screws or other suitable 10 fasteners (not shown). Workbench leg 58 is constructed of suitably sized wood securely fastened together in the form of a "U" section to provide needed stiffness and to conceal housings 11d and 11d' for aesthetic reasons. Transfer bar 18d and 15 elements contained within housings 11d and 11d' are contained on one side by the rightmost inner side of workbench leg 58 in a similar fashion as previously described in the configuration of FIGS. 1 - 10. The upper clamp shaft 12d protrudes through a clearance 20 hole in the front member of workbench leg 58 and lower clamp shaft 50d also protrudes through a clearance hole in the front member of workbench leg 58.

With reference to FIG. 20 upper clamp shaft 12d 25 passes through moveable leg vise jaw 53 and is secured to clamp hub 36d with split pin 25d installed through cross hole in clamp hub 36d and upper clamp shaft 12d. Clamp hub 36d, handle 34d, knobs 35d, washer 43d, wave spring 21d and retainer 24d 30 function identically to the first embodiment previously described in FIG. 3. Lower clamp shaft 50d passes through compliance ring 49d, washer 21d and wave spring 43d with retaining ring 24d' installed in the forward most groove machined in 35 lower clamp shaft 50d to retain compliance ring 49d from coming off the end of lower clamp shaft 50d. Compliance ring 49d is retained on the other side by washer 21d' and retaining ring 24d' installed in a second groove slightly rearward of the forward most 40 groove. Compliance ring 49d is securely installed, with the slot oriented vertically, in a circular pocket machined in moveable leg vise jaw 53 with wood screws 48d. The use of compliance ring 49d allows for easy assembly and preserves the appearance of the 45 front face of moveable leg vise jaw 53 since all mounting hardware is hidden on the rear side of moveable leg vise jaw 53. Compliance ring 49d also provides compliance to moveable leg vise jaw 53 in an identical fashion to the first embodiment described 50 in FIGS. 1 - 10. Contained in a pocket and very near the floor, in the lower most portion of moveable leg vise jaw 53 is a wheel 56 mounted on axle 55. Springs 54 mounted in holes on both sides of wheel 56 apply downward pressure on axle 55 which is 55 retained from falling out of moveable leg vise jaw 53 by split pins 57 installed in holes under axle 55. Spring pressure from springs 54 push against axle 55 and thus cause wheel 56 to apply pressure against the floor which counteracts the weight of moveable leg 60 vise jaw 53 so moveable leg vise jaw 53 is easy to move in and out when in the unclamped state.

Vise 10 can be configured to clamp with clockwise rotation of clamp handle 34d or with counter-clockwise rotation of clamp handle 34d. When bridges 13d and 59d and wedges 14d and 14d' are oriented as shown in FIG. 21, clockwise rotation R1 of clamp shaft 12d enables clamping force F1 to pull upper clamp shaft 12d in toward workbench leg 58, creating translational force F2 to be applied through transfer bar 18d which creates fulcrum arm force F3 to push lower clamp shaft 50d away from workbench leg 58. Transfer bar 18d rotates slightly about pins 28d and 28d' since the movements of clamp shafts 12d and 50d are 180° out of phase. To configure vise 10 to clamp with counter-clockwise rotation of clamp handle 34d, bridges 13d and 59d and wedges 14d and 14d' are simply removed from housings 11d and 11d' rotated 180° about a longitudinal axis and re-installed into housings 11d and 11d' as depicted in FIG. 22. Counter-clockwise rotation R2 of clamp shaft 12d enables clamping force F4 to pull upper clamp shaft 12d in toward workbench leg 58, creating translational force F5 to be applied through transfer bar 18d which creates fulcrum arm force F6 to push lower clamp shaft 50d away from workbench leg 58. Transfer bar 18d rotates slightly about pins 28d and 28d' since the movements of clamp shafts 12d and 50d are 180° out of phase.

The structure of a sixth embodiment shown in FIGS. 23 - 26 is functionally identical to that of FIGS. 1 - 10. Reference numerals for functionally identical structure carry postscripts e in FIGS. 23 - 26.

In this arrangement, vise 10 is constructed as an adaptation of a Scandinavian shoulder vise where clamping of the workpiece is done to the right of clamp shaft 12e. In a typical Scandinavian shoulder vise the vise screw is held in a cantilevered arm mounted to a vise block which is firmly attached to the workbench top. In this arrangement vise 10 is mounted horizontally under bench top 46e as show in FIGS. 23 and 24 and the left most housing 11e' is rotated 180° relative to the right most housing 11e. In this way, the right most clamp shaft 12e will pull moveable shoulder vise jaw 51 inward toward fixed rear shoulder vise jaw 52 while left most clamp shaft 50e will push moveable shoulder vise jaw 51 outward from rear fixed shoulder vise jaw 52 when handle 34e is rotated, thus creating a net inward force applied to the right of clamp shaft 12e to effect clamping. The operation and function of this configuration is identical to that of the arrangement of FIGS. 19 - 20 except vise 10 is mounted horizontally under workbench top 46e, clamp shafts 12e and 50e protrude through clearance holes in rear fixed shoulder vise jaw 52 and the workpiece is clamped to the right of right clamp shaft 12e. It will be apparent to those skilled in the art that vise 10 may also be mounted to the right end of workbench top 46e with clamp shaft 12e to the left of clamp shaft 50e and the workpiece clamped to the left of clamp shaft 12e.

Vise 10 can be configured to clamp with clockwise rotation of clamp handle 34e or with counter-

clockwise rotation of clamp handle 34e. When bridges 13e and 59e and wedges 14e and 14e' are oriented as shown in FIG. 25, clockwise rotation R1 of clamp shaft 12e enables clamping force F1 to pull right most clamp shaft 12e in toward rear fixed shoulder vise jaw 52, creating translational force F2 to be applied through transfer bar 18e which creates fulcrum arm force F3 to push left most clamp shaft 50e away from fixed rear shoulder vise jaw 52. Transfer bar 18e rotates slightly about pins 28e and 28e' since the movements of clamp shafts 12e and 50e are 180° out of phase. To configure vise 10 to clamp with counter-clockwise rotation of clamp handles 34e, bridges 13e and 59e and wedges 14e and 14e' are simply removed from housings 11e and 11e' rotated 180° about a longitudinal axis and re-installed into housings 11e and 11e' as depicted in FIG. 22. Counter-clockwise rotation R2 of clamp shaft 12e enables clamping force F4 to pull right most clamp shaft 12e in toward rear fixed shoulder vise jaw 52, creating translational force F5 to be applied through transfer bar 18e which creates fulcrum arm force F6 to push left most clamp shaft 50e away from fixed rear shoulder vise jaw 52. Transfer bar 18e rotates slightly about pins 28e and 28e' since the movements of clamp shafts 12e and 50e are 180° out of phase.

The structure of a seventh embodiment shown in FIGS. 27 - 29 is functionally identical to that of FIGS. 1 - 10. Reference numerals for functionally identical structure carry postscripts f in FIGS. 27 - 29.

In this configuration, vise 10 is constructed as an adaptation of a tail vise where clamping of the workpiece is done on top of workbench top 74 between workbench dog 69 and tail vise dog 64 as shown in FIG. 27. Tail vise dog 64 slides on a dovetail machined into dog block 63 allowing tail vise dog 64 to slide up and down to accommodate different thicknesses of work and can be fully retracted below the surface of workbench top 74 when not in use. Tail vise dog 64 and dog block 63 are located within a narrow slot machined through workbench top 74. Workbench dog 69 may be installed in spaced holes to accept varying lengths of work clamped between workbench dog 69 and tail vise dog 64. Movement of dog block 63 and tail vise dog 64 to effect clamping is accomplished by rotating handle 34f with associated knobs 35f which causes rotation of clamp hub 36f which is located outside of tail vise apron 70 which is firmly affixed to workbench top 74.

With respect to FIGS. 28 and 29, clamp shaft 12f is held at one end by a close fit clearance hole in pillow block bearing 67 which is securely mounted to the underside of workbench top 74 with screws or other appropriate fasteners (not shown). The other end of clamp shaft 12f is contained within a close fitting clearance hole bored into tail vise apron 70. Clamp shaft 12f is thus allowed to freely rotate within the confines of the close fitting clearance holes in pillow block bearing 67 and tail vise apron 70. Clamp shaft 12f is prevented from sliding laterally to the left by clamp hub 36f which is secured to clamp shaft 12f

by split pin 25f installed in cross holes machined in the end of clamp shaft 12f. Clamp shaft 12f is prevented from sliding laterally to the right by shaft collar 68 which is firmly clamped to clamp shaft 12f and is located on the inboard side of tail vise apron 70 with a slight clearance to allow suitable retention while allowing free rotation.

Plate 62 is mounted to housing 11f by flat head machine screws 65 and nuts 66 installed in mounting holes and slots on housing 11f. Dog block 63 is fastened to the top side of plate 62 using flat head machine screws 65 installed in tapped holes in the bottom of dog block 63. Plate 62 retains the elements found within housing 11f and transfers motion to dog block 63. Housing 11f is free to translate along shaft 12f when in the unclamped state thus allowing tail vise dog 64 to be quickly positioned against the workpiece to be secured. Plate 62 is located with a small amount of clearance from the underside of workbench top 74 so housing 11f is free to move laterally while being restrained from rotation about clamp shaft 12f by the protrusion of dog block 63 into the slot machined through workbench top 74. Dog block 63 is kept slightly below the top surface of workbench top 74 and has a dovetail machined at a slight forward angle on one side (2 to 4 degrees for example). A corresponding dovetail machined into tail vise dog 64 allows tail vise dog 64 to slide freely on dog block 63 with spring force from spring plunger 71 installed in threaded hole in dog block 63 providing frictional retaining force so tail vise dog 64 remains at any height setting the operator desires. The slight forward angle of dog block 63 similarly angles tail vise dog 64 so that a component of clamping force is directed downward toward the workbench top 74 thus keeping the workpiece to be clamped in firm contact with workbench top 74.

The structure located within housing 11f function in a similar manner to the first embodiment of FIGS. 1 - 10. Tail vise transfer bar 73 does not connect to any other elements and is only long enough to cover the rectangular hole in bridge 13f. Transfer bar 73 is kept from rotating about pin 28f by use of liquid retaining compound commonly used for retention purposes or alternatively pin 28f could also be press fit into suitable holes in transfer bar 73 and rack 15f.

Clamping of a workpiece is accomplished as follows: Tail vise dog 64 is adjusted vertically to accommodate the thickness of the workpiece to be clamped and one side of the workpiece is placed against bench dog 69. With the vise in the unclamped state tail vise dog 64 is slid within the slot in workbench top 74 until it contacts the workpiece on the opposite side from bench dog 69. Counter-clockwise rotation of handle 34f causes similar rotation in clamp shaft 12f which creates relative motion between shaft 12f and housing 11f as previously described in the first embodiment of FIGS. 1 - 10. Since clamp shaft 12f is retained from moving laterally as previously described, housing 11f, plate 62, dog block 63 and tail vise dog 64 translate toward bench dog 69 thus clamping workpiece between

bench dog 69 and tail vise dog 64. Clamping can be accomplished with clockwise rotation of handle 34f by simply removing bridge 14f and wedge 13f from housing 11f and rotating 180° about a longitudinal axis and re-installing into housing 11f as described in the first embodiment of FIGS. 1 – 10.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of structures differing from the types described above.

While the invention has been illustrated and described as embodied in a woodworking vise, it is

not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

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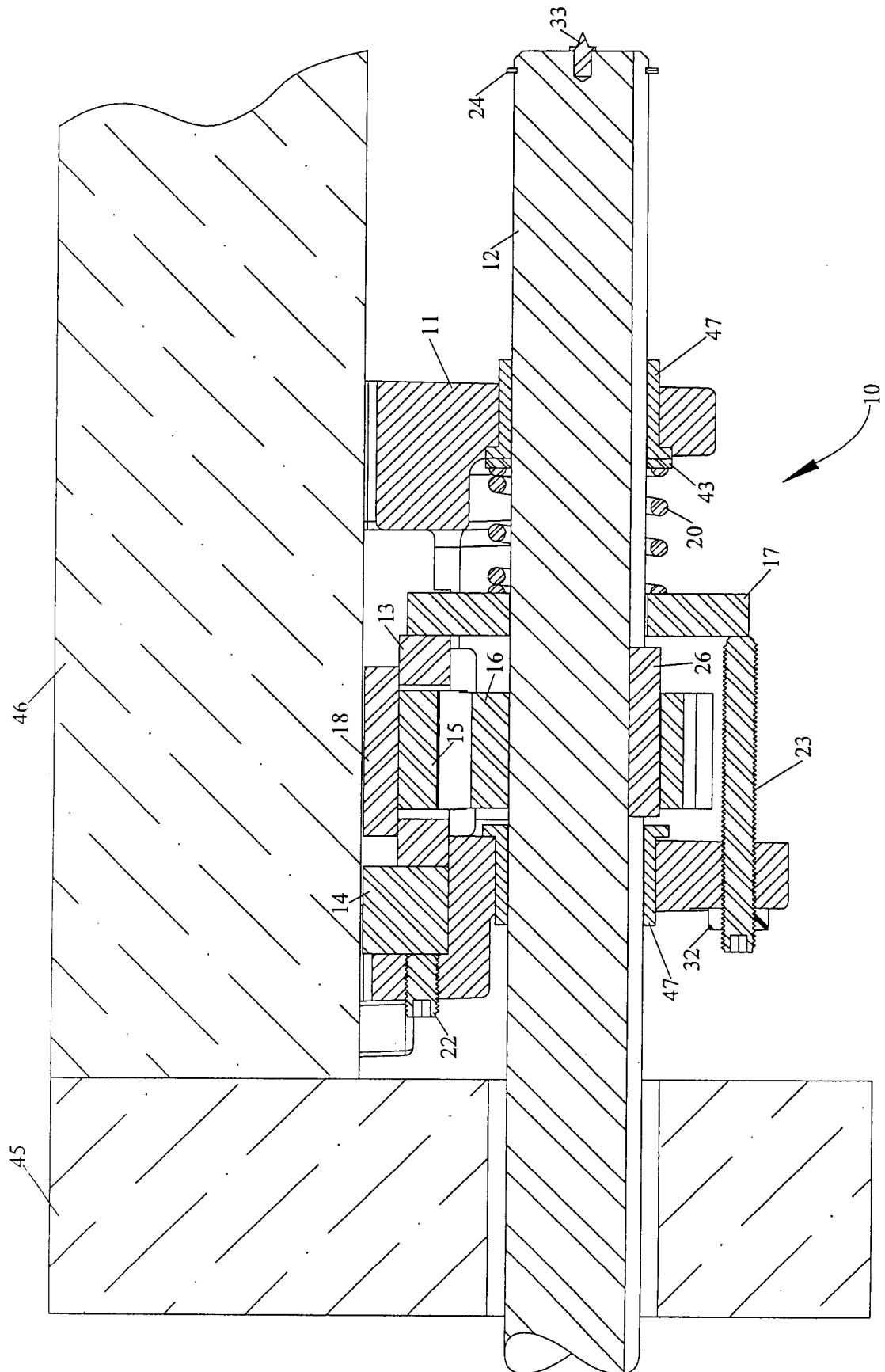


FIG. 2

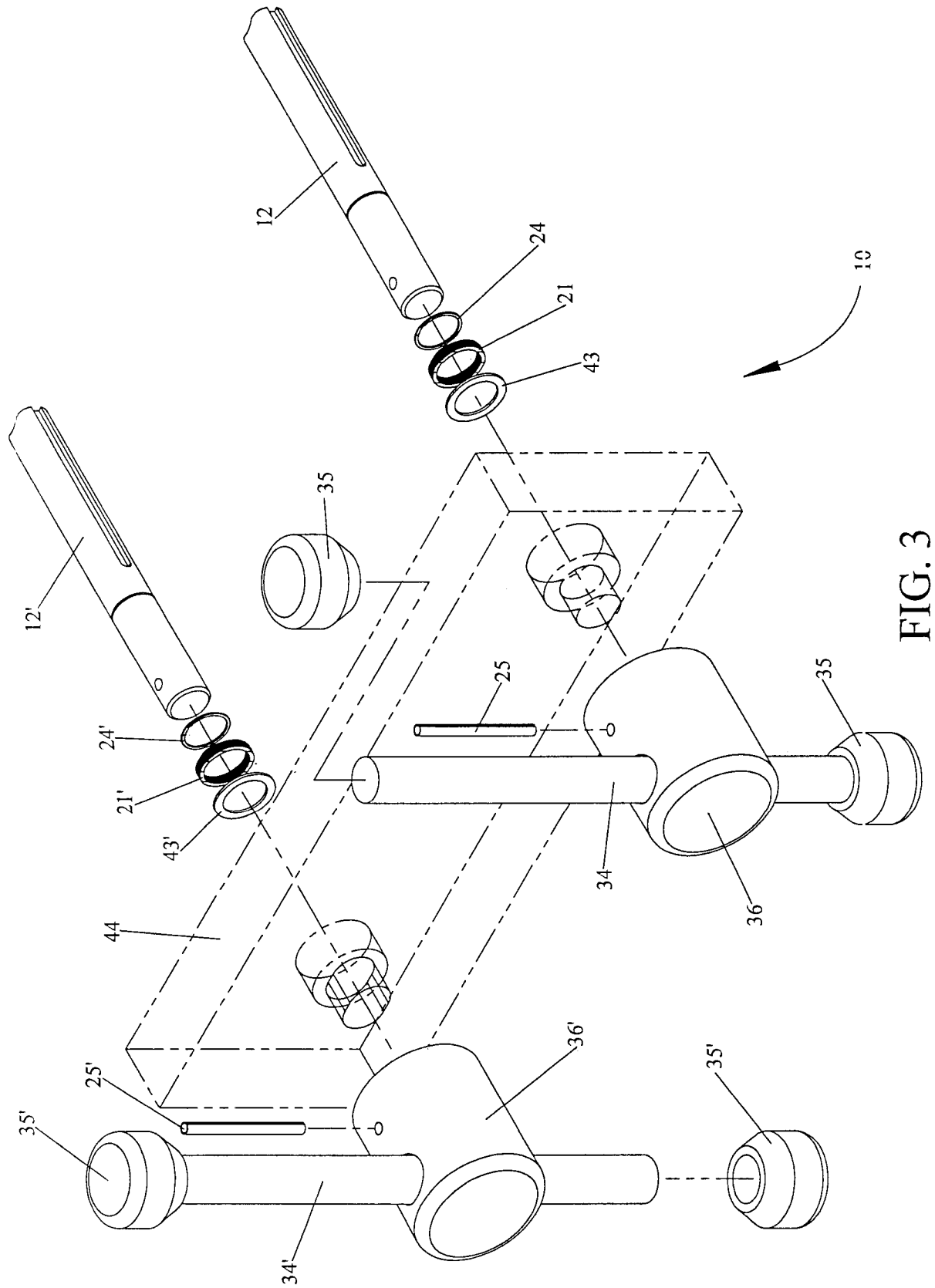


FIG. 3

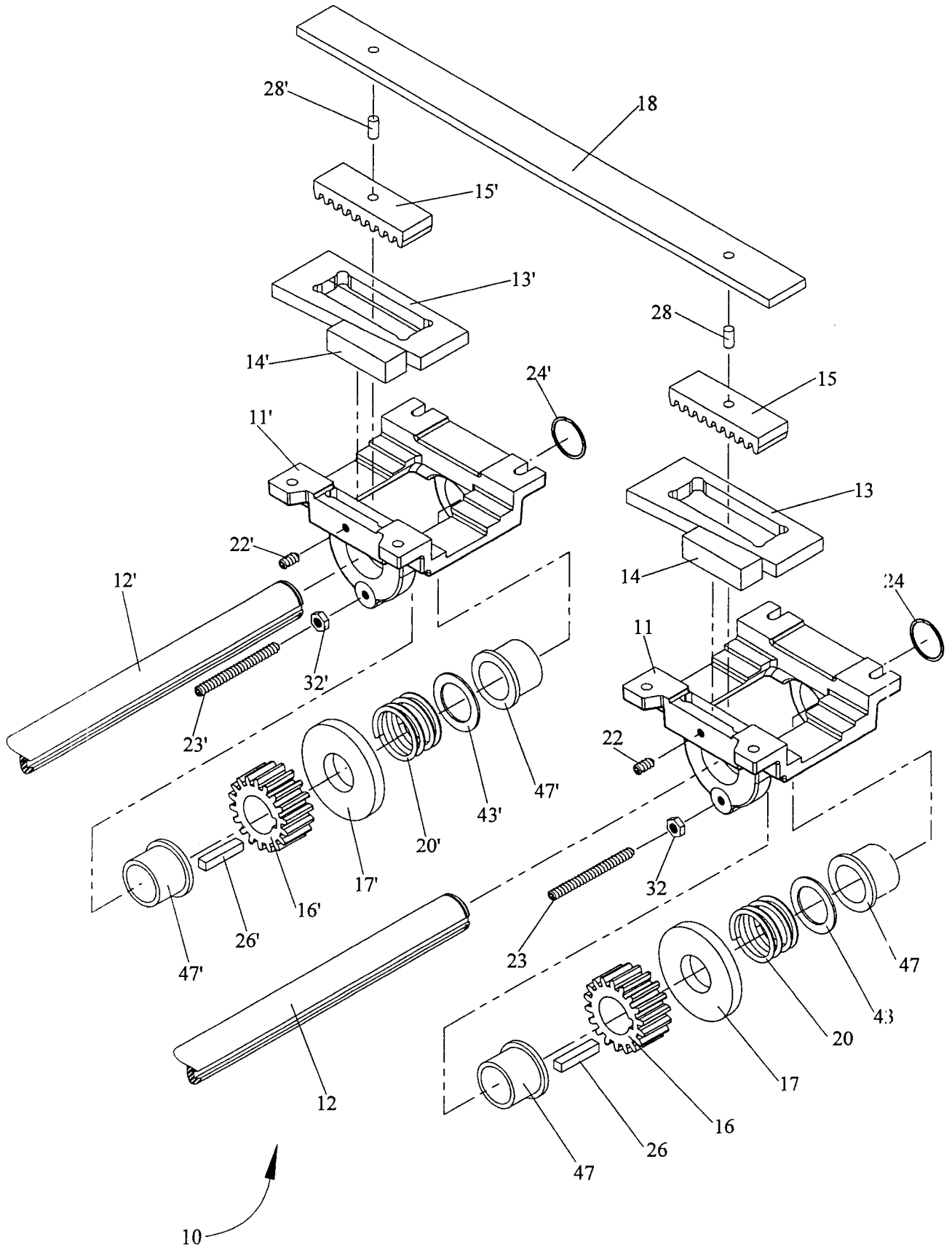


FIG. 4



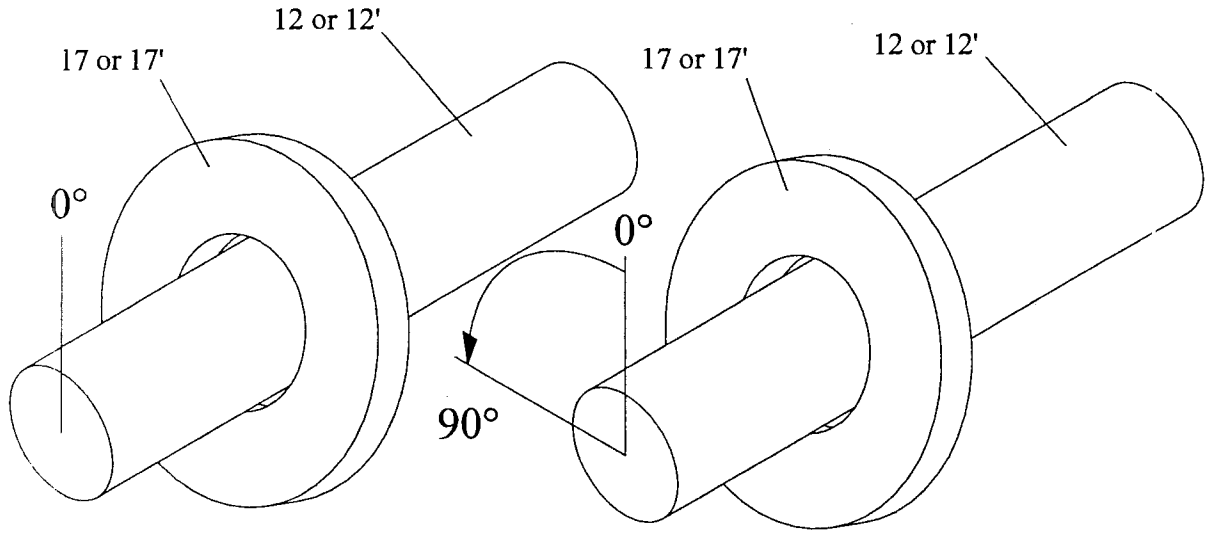


FIG. 5

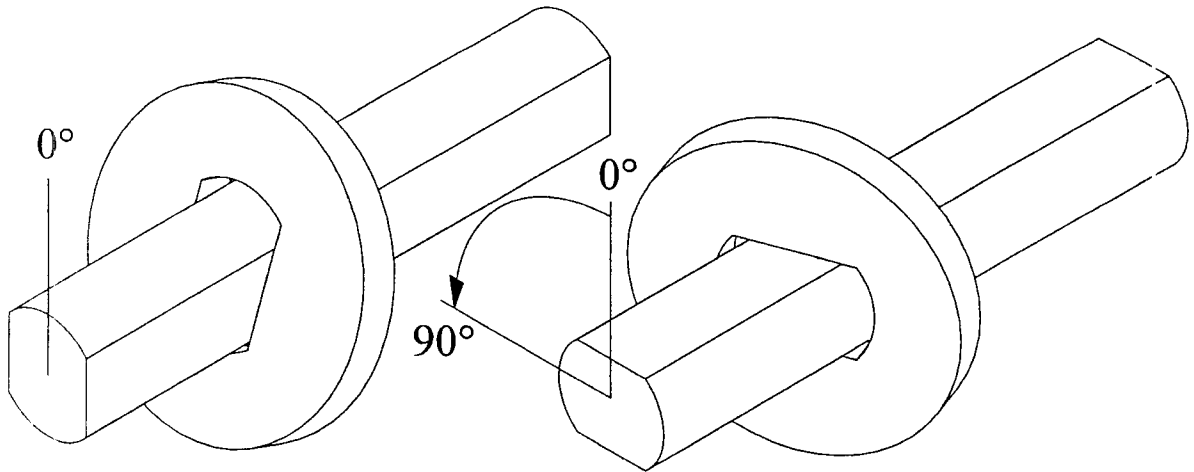


FIG. 6

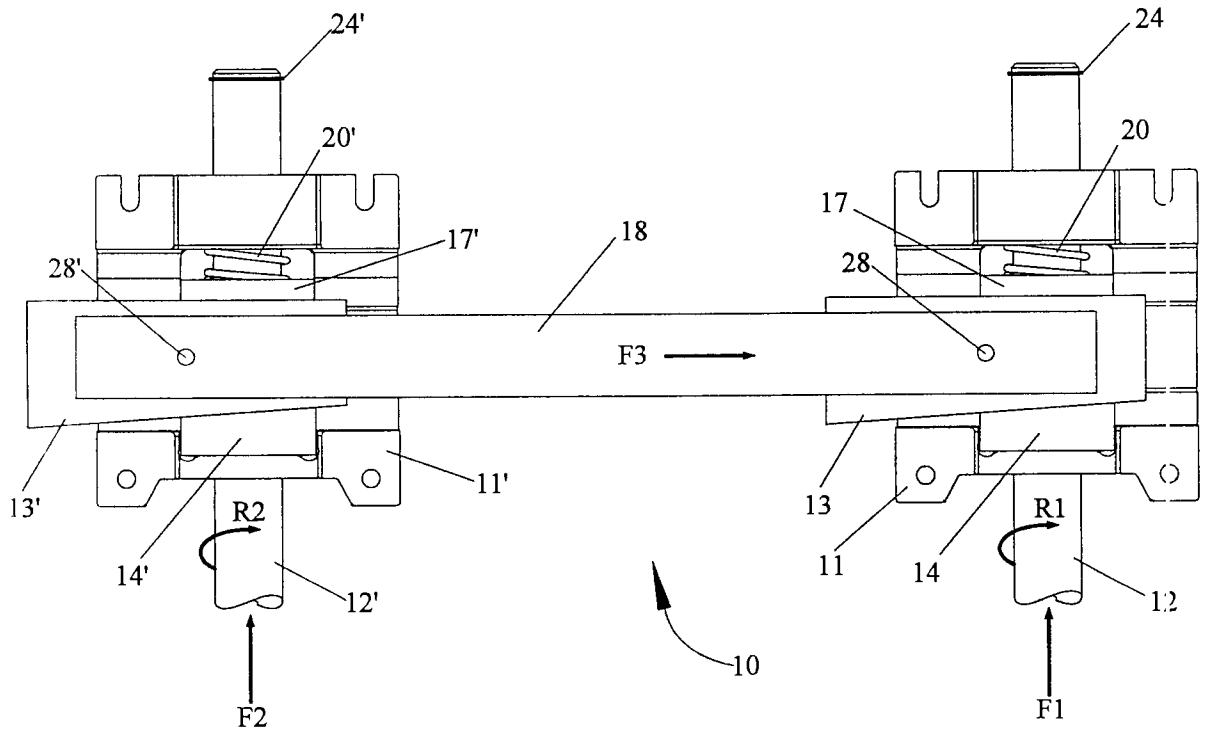


FIG. 7

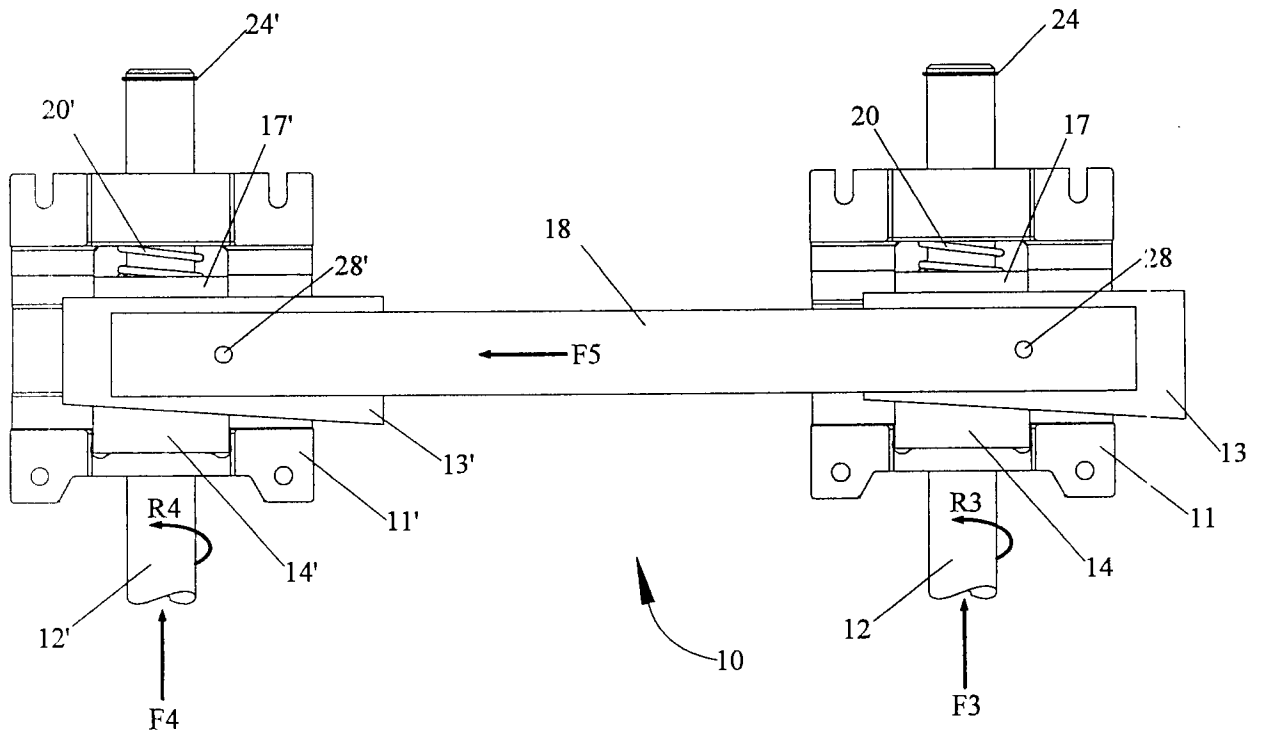


FIG. 8

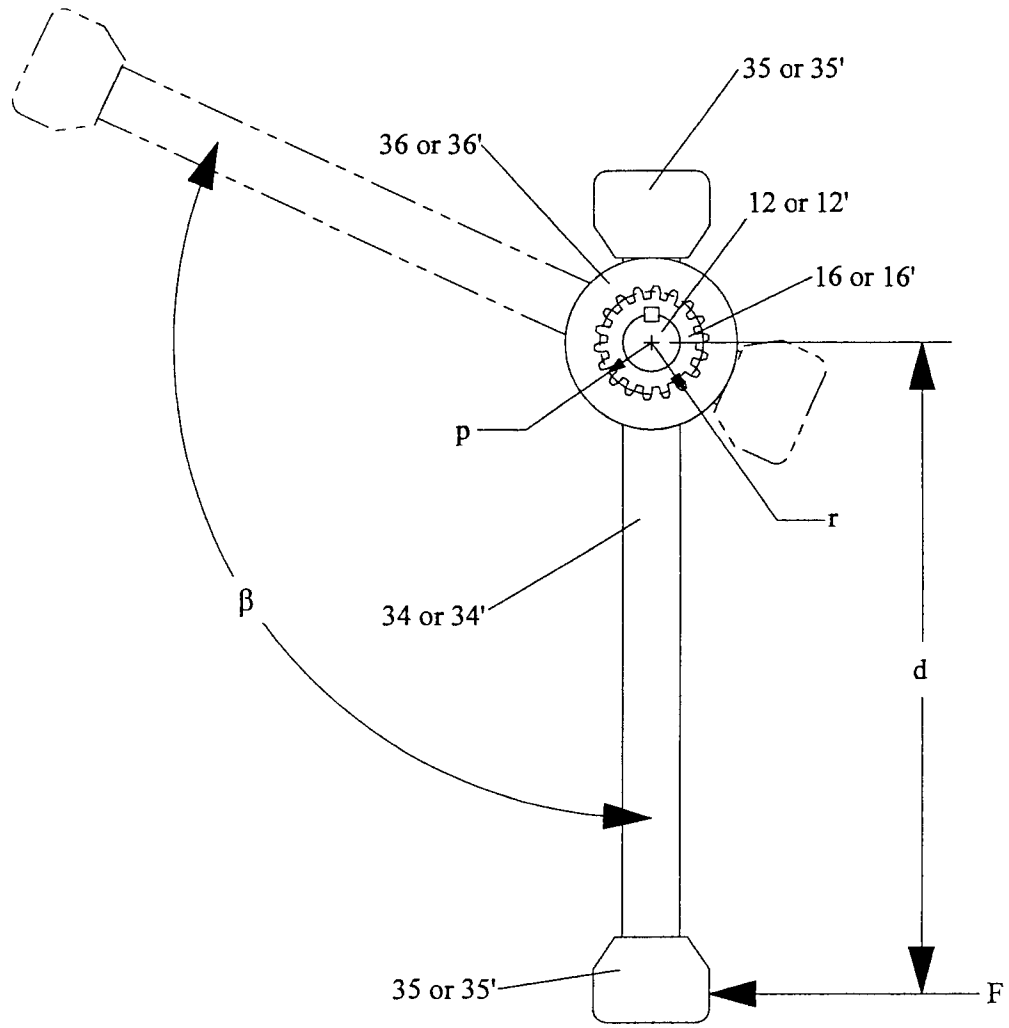


FIG. 9

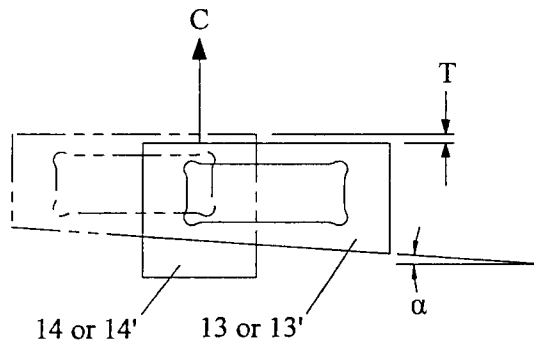


FIG. 10

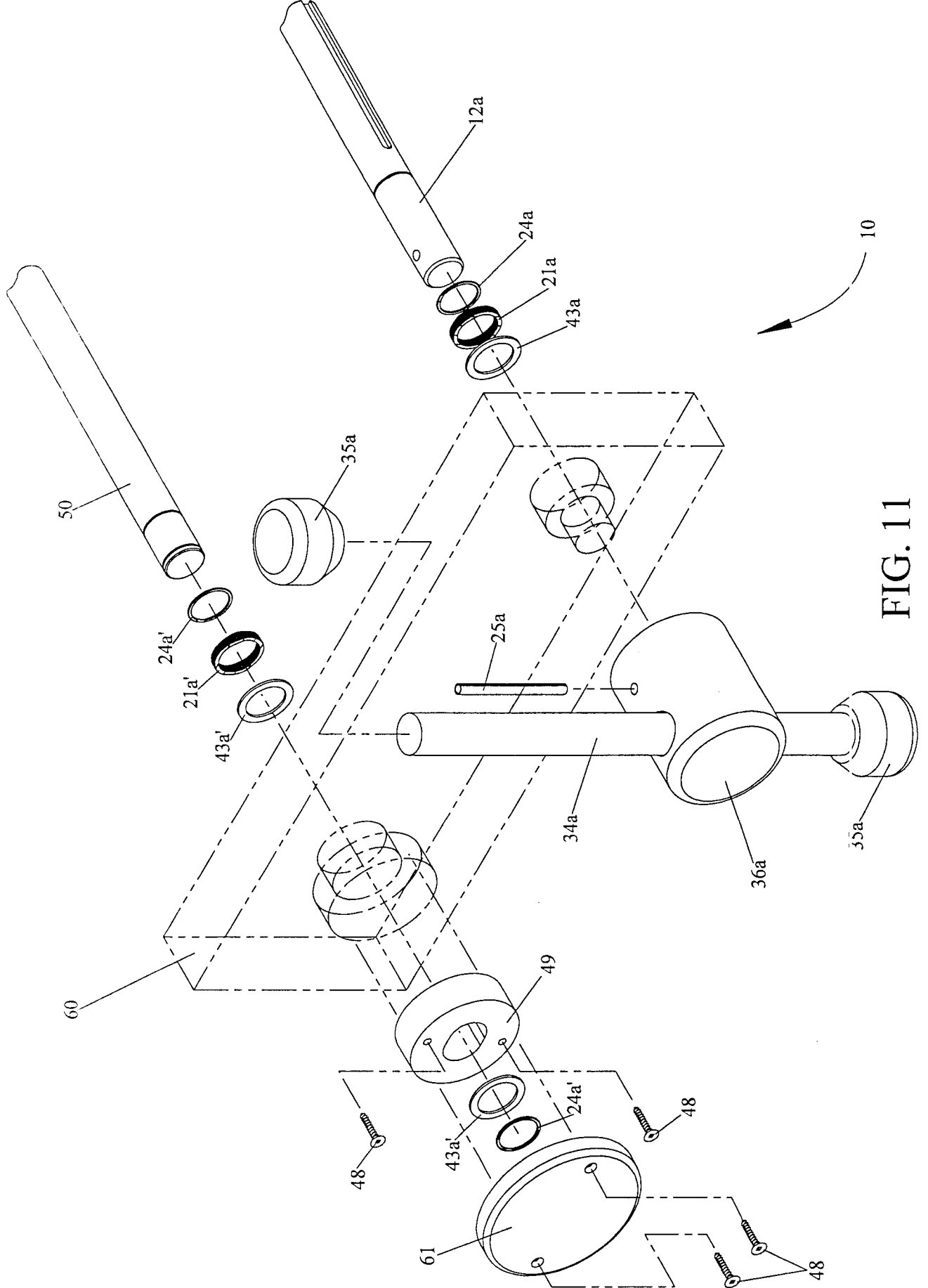


FIG. 11

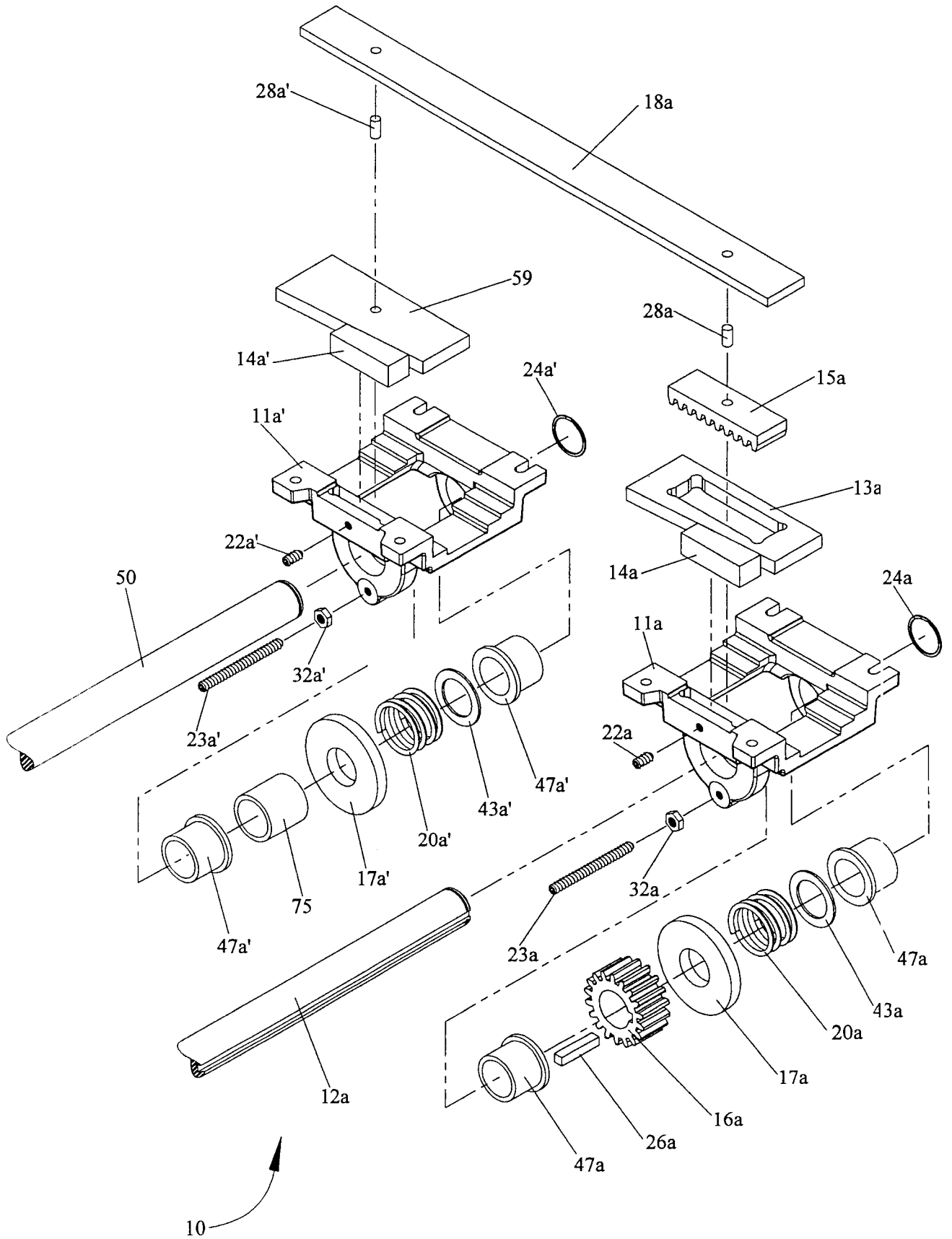


FIG. 12

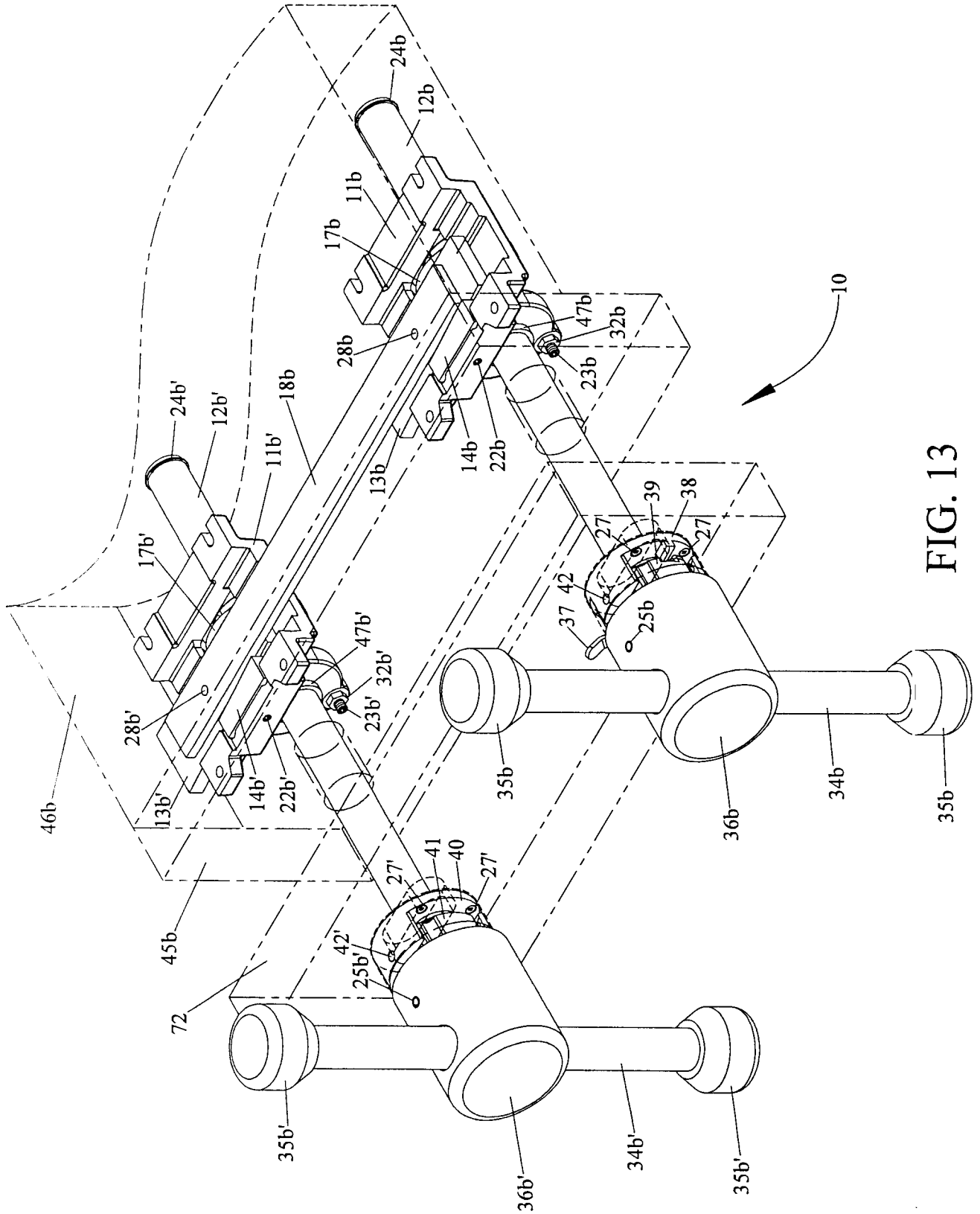


FIG. 13



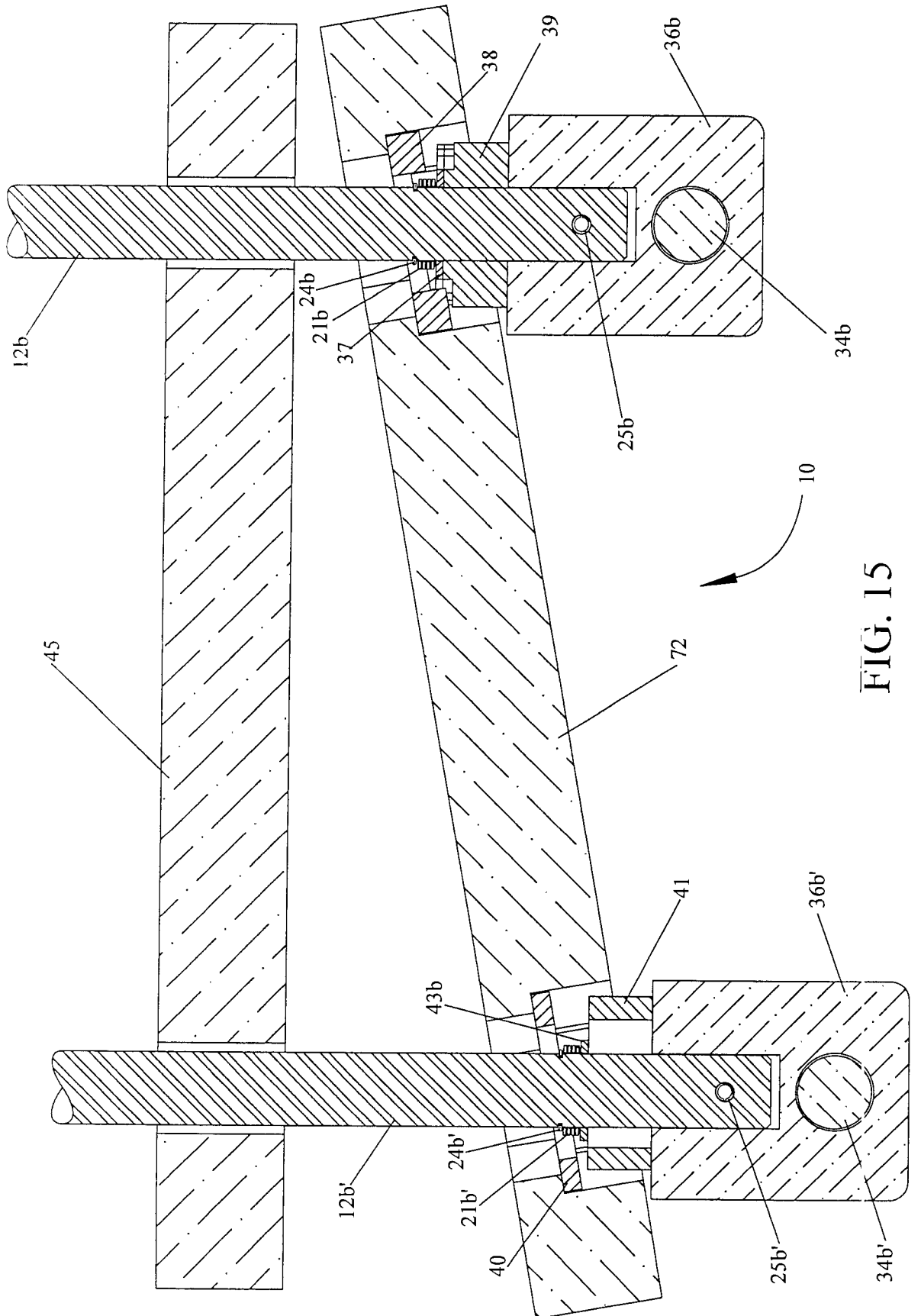


FIG. 15



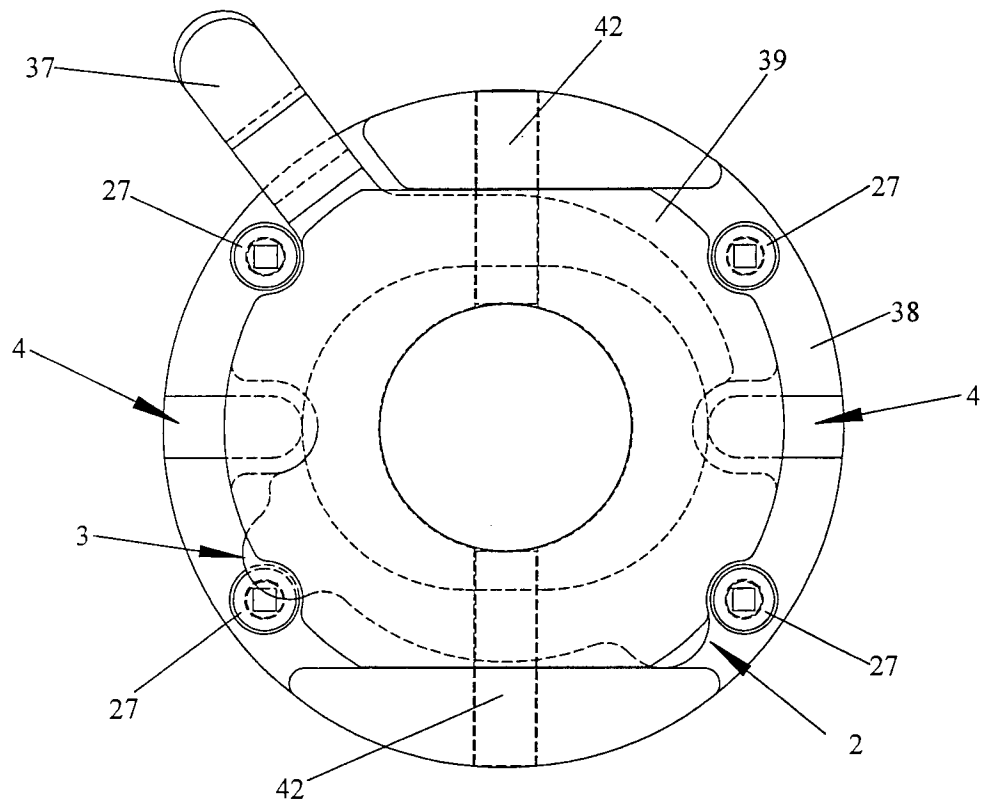


FIG. 16

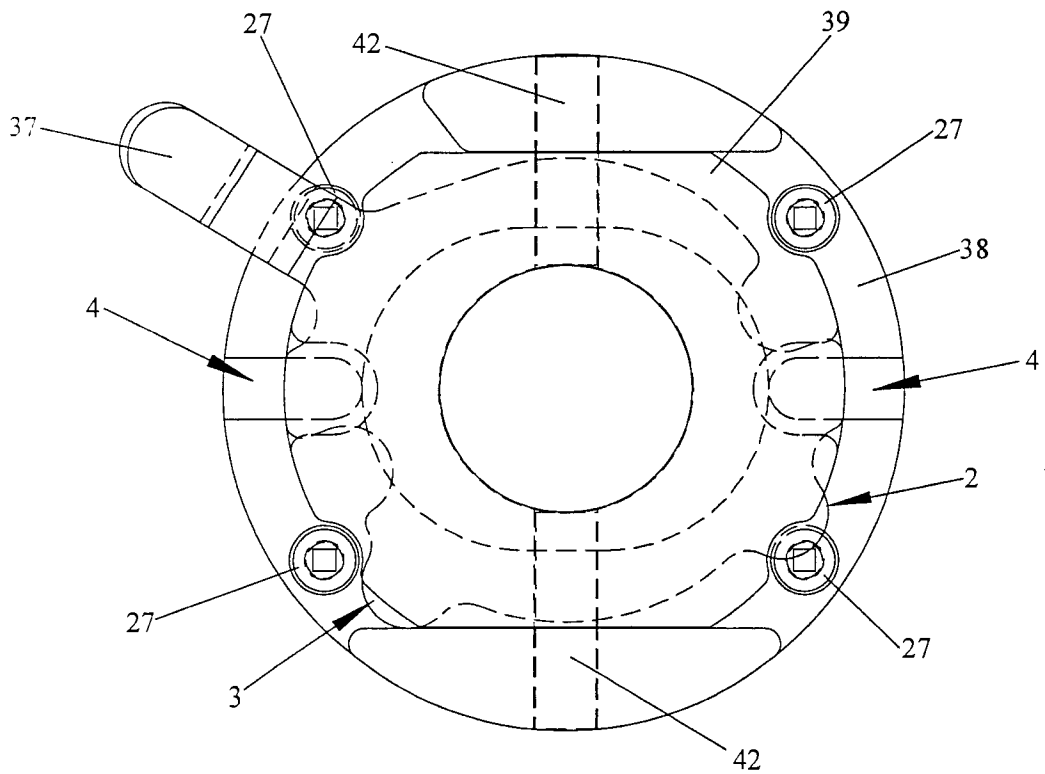


FIG. 17

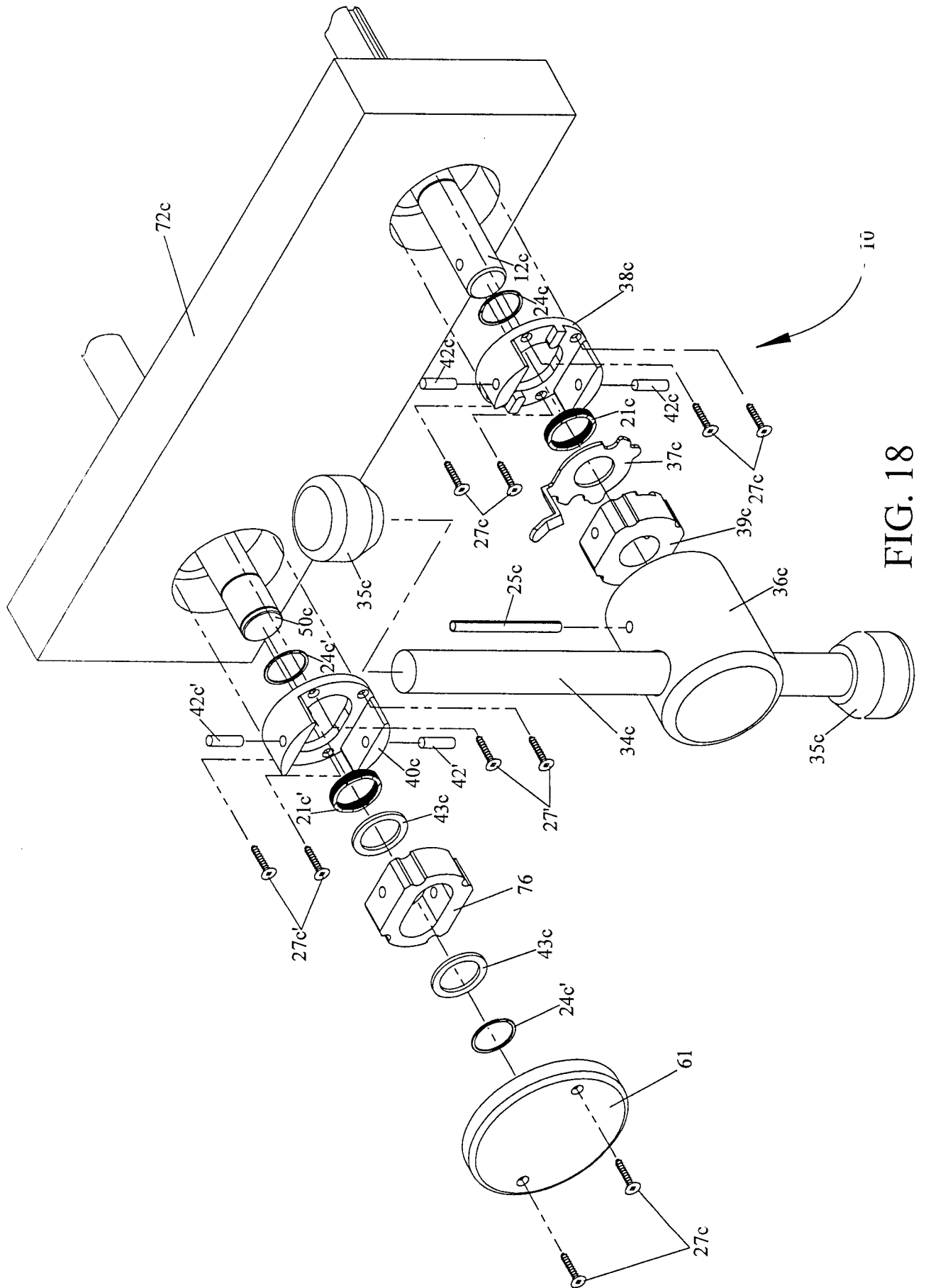


FIG. 18

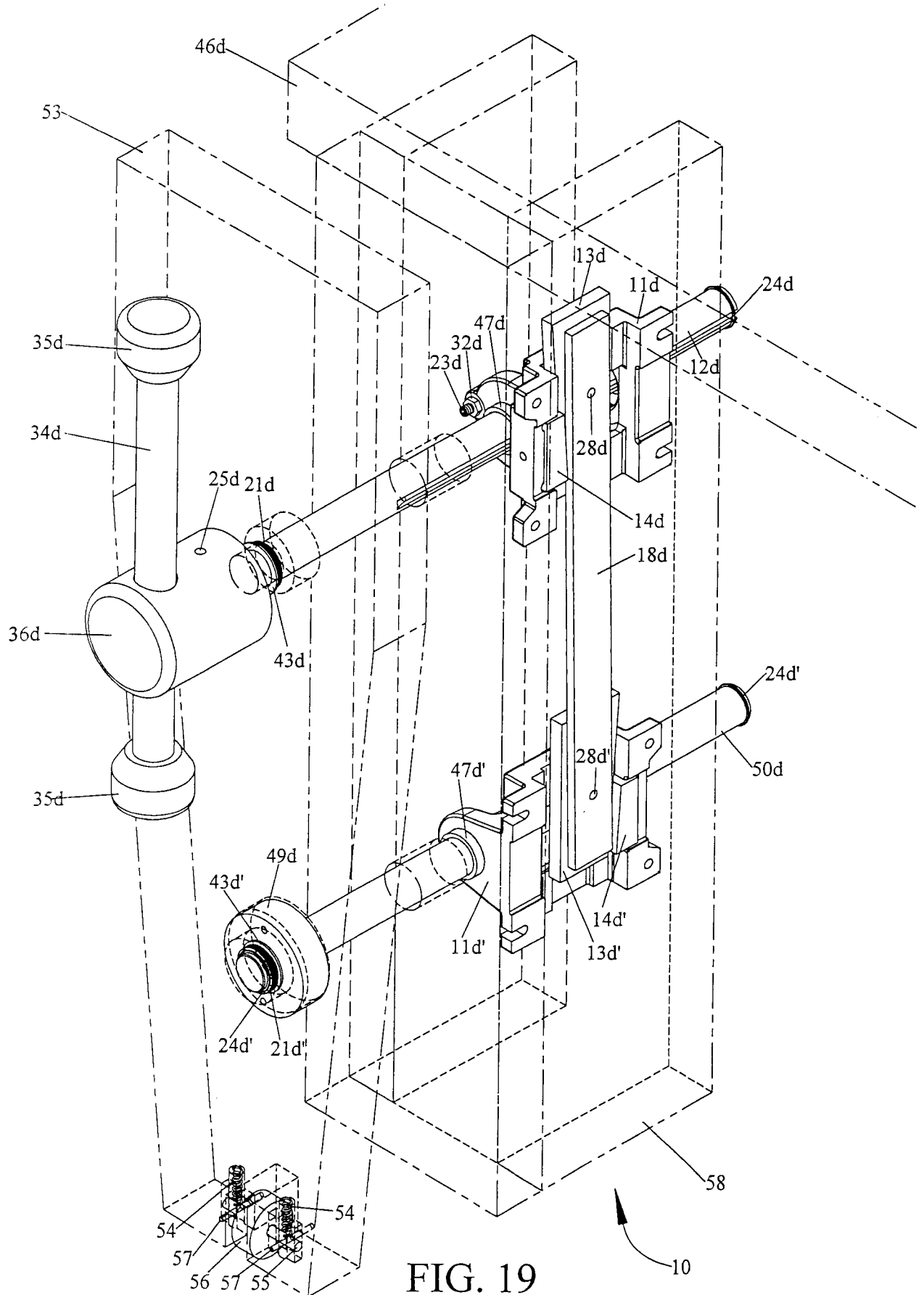


FIG. 19

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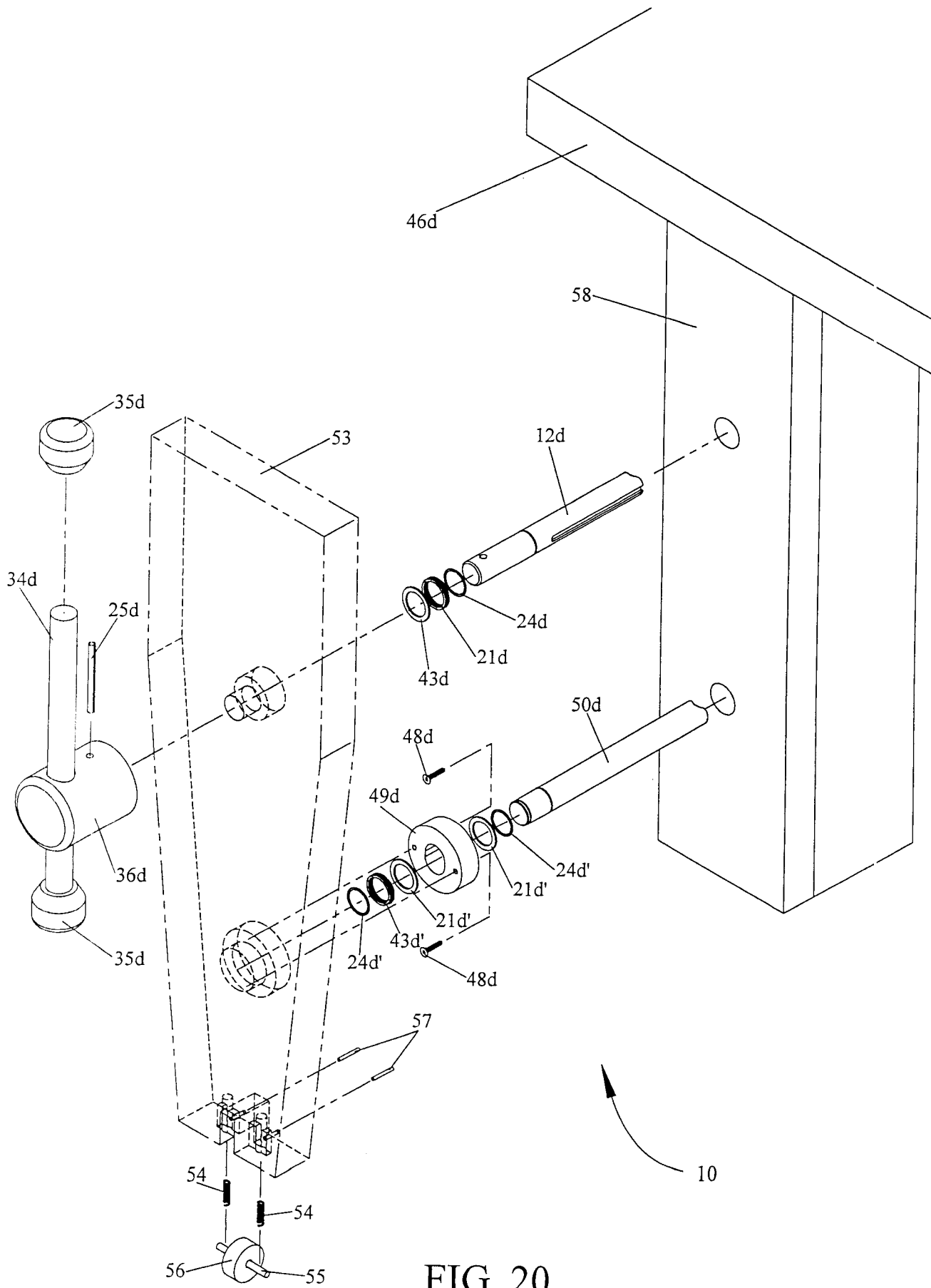


FIG. 20

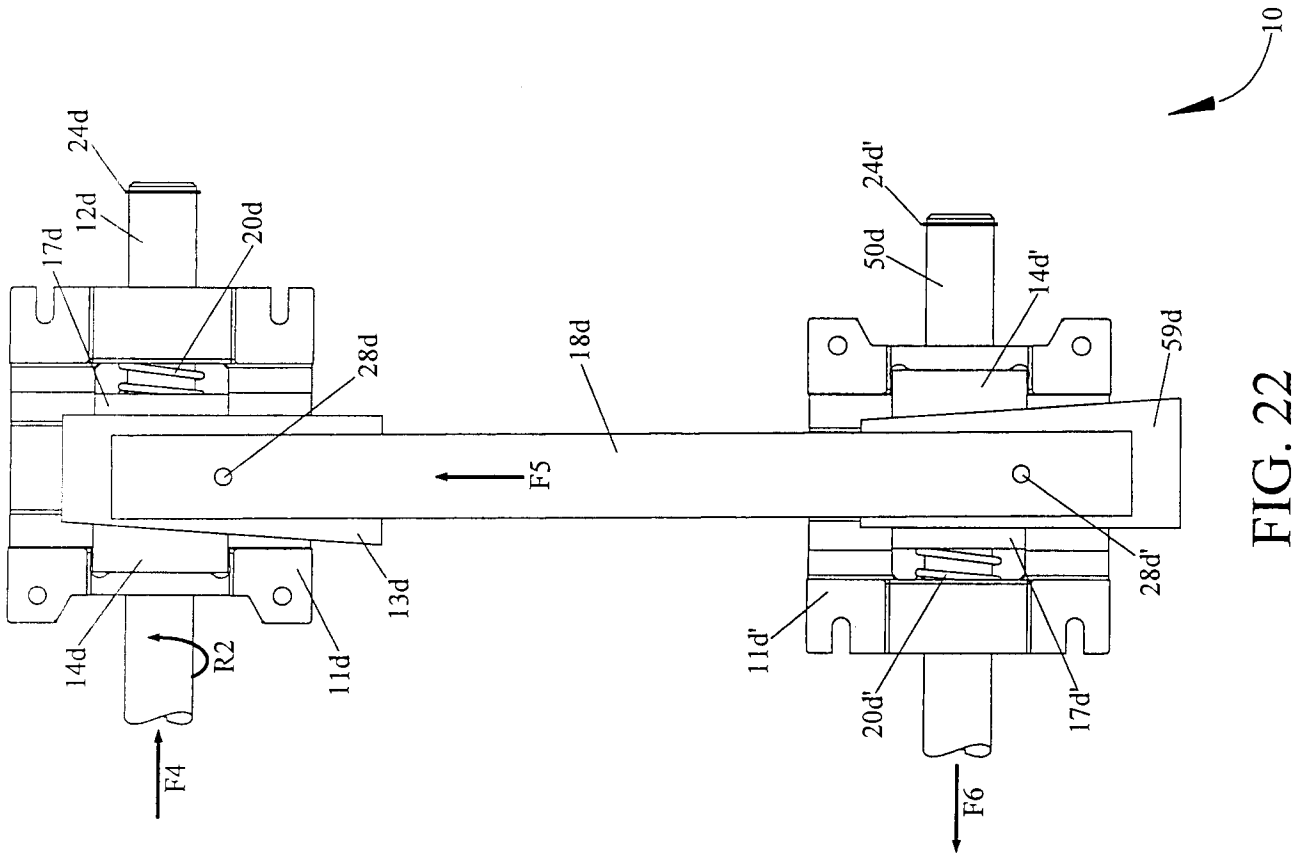


FIG. 21

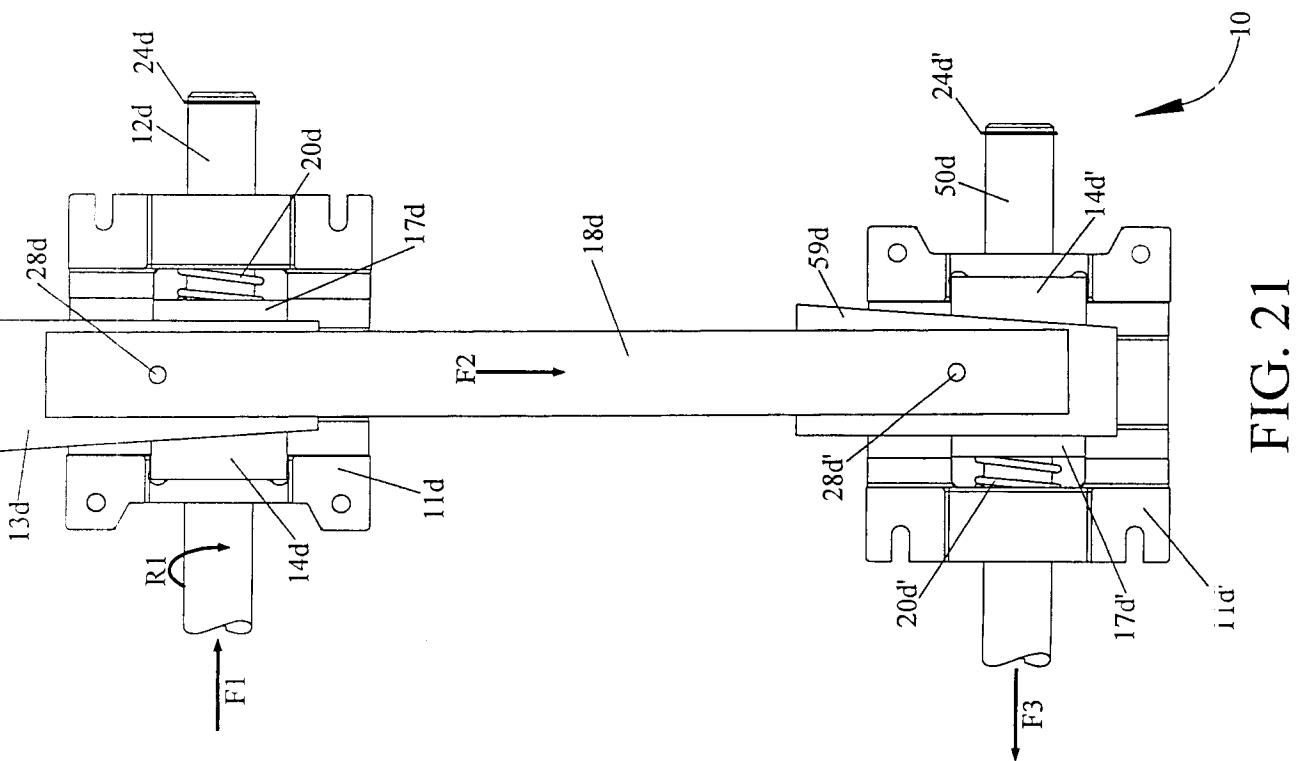


FIG. 22

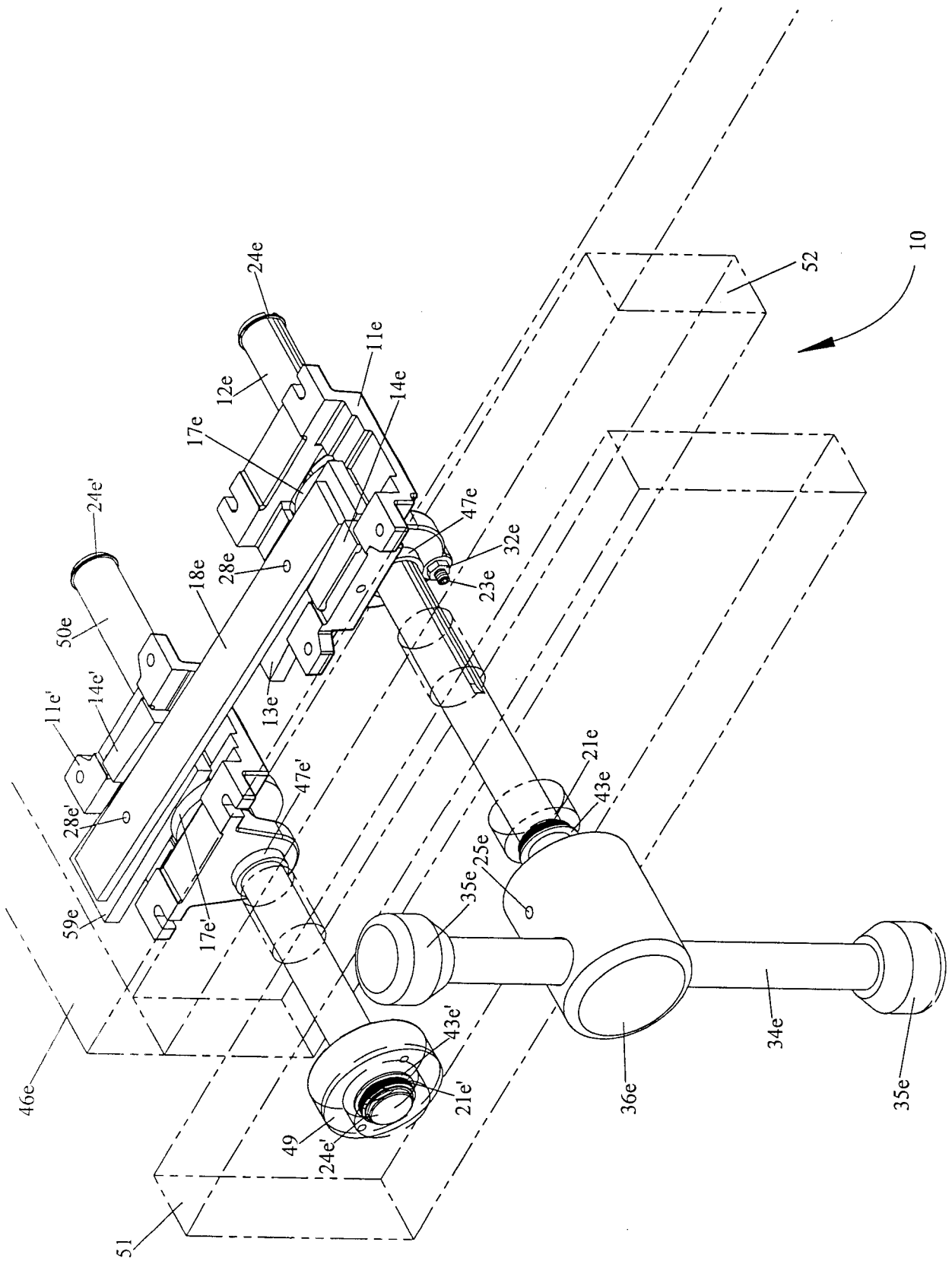


FIG. 23

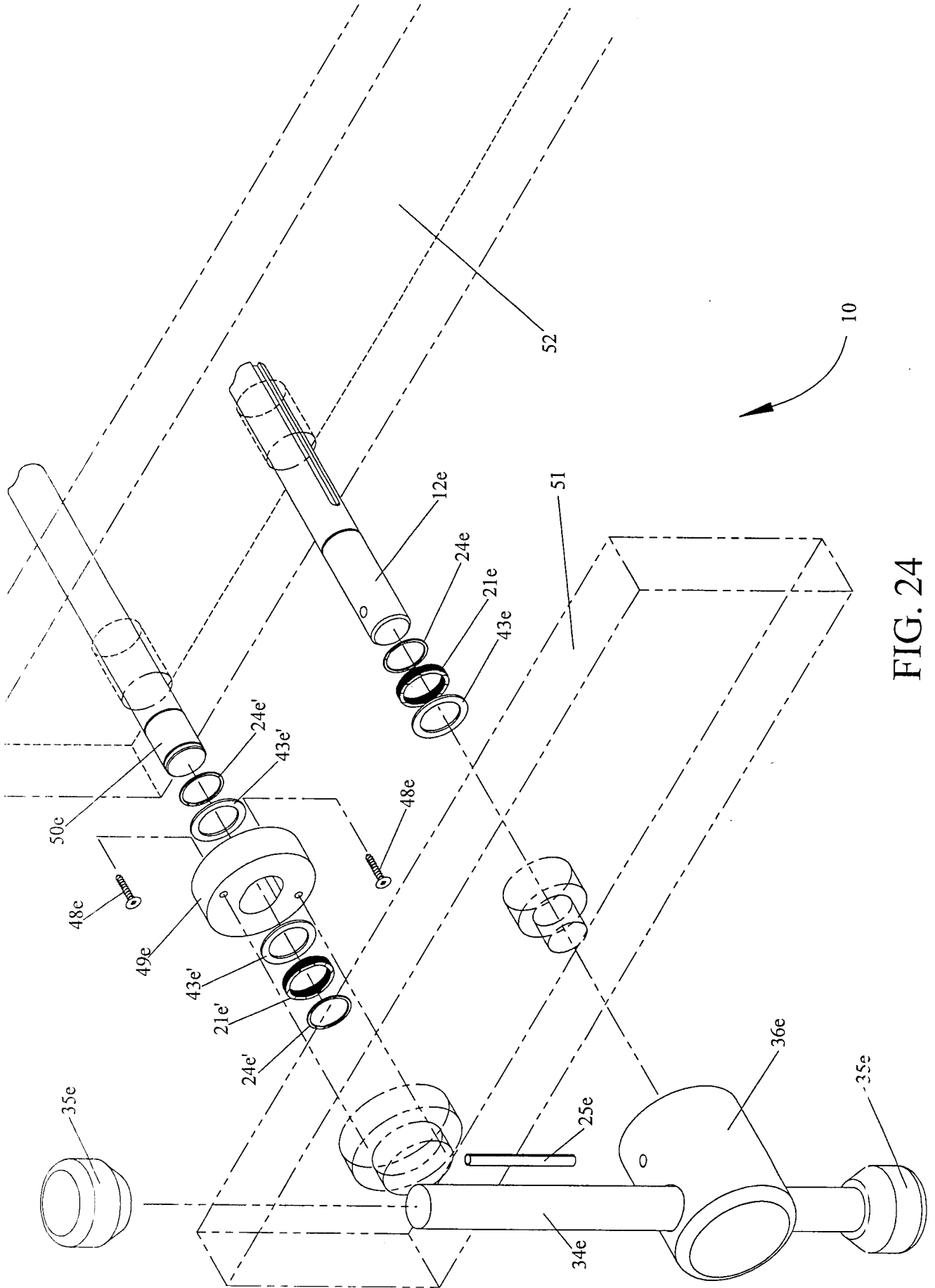


FIG. 24

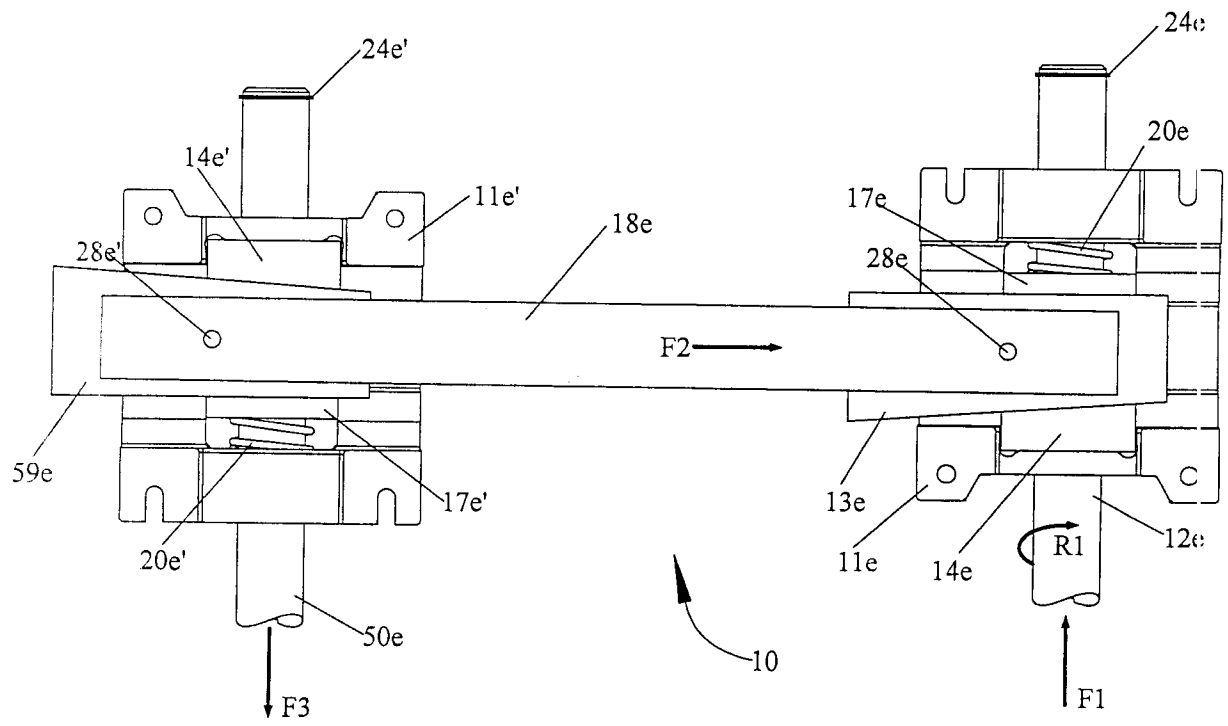


FIG. 25

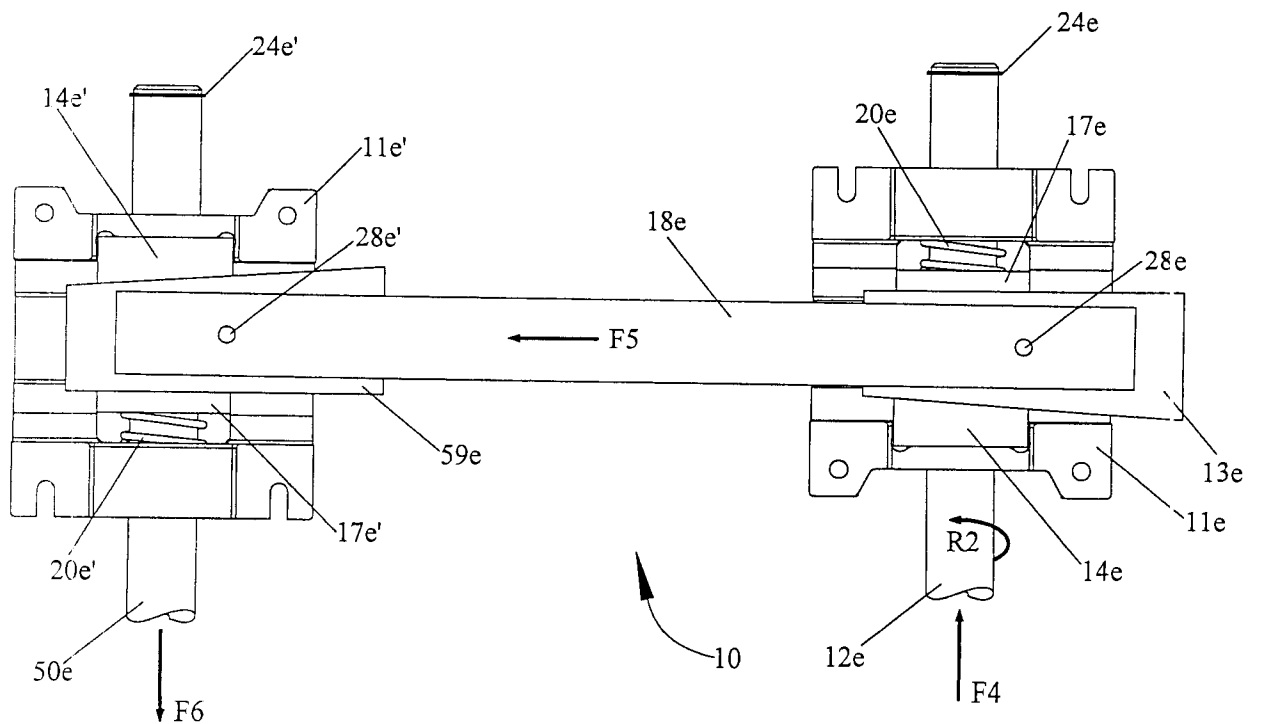


FIG. 26



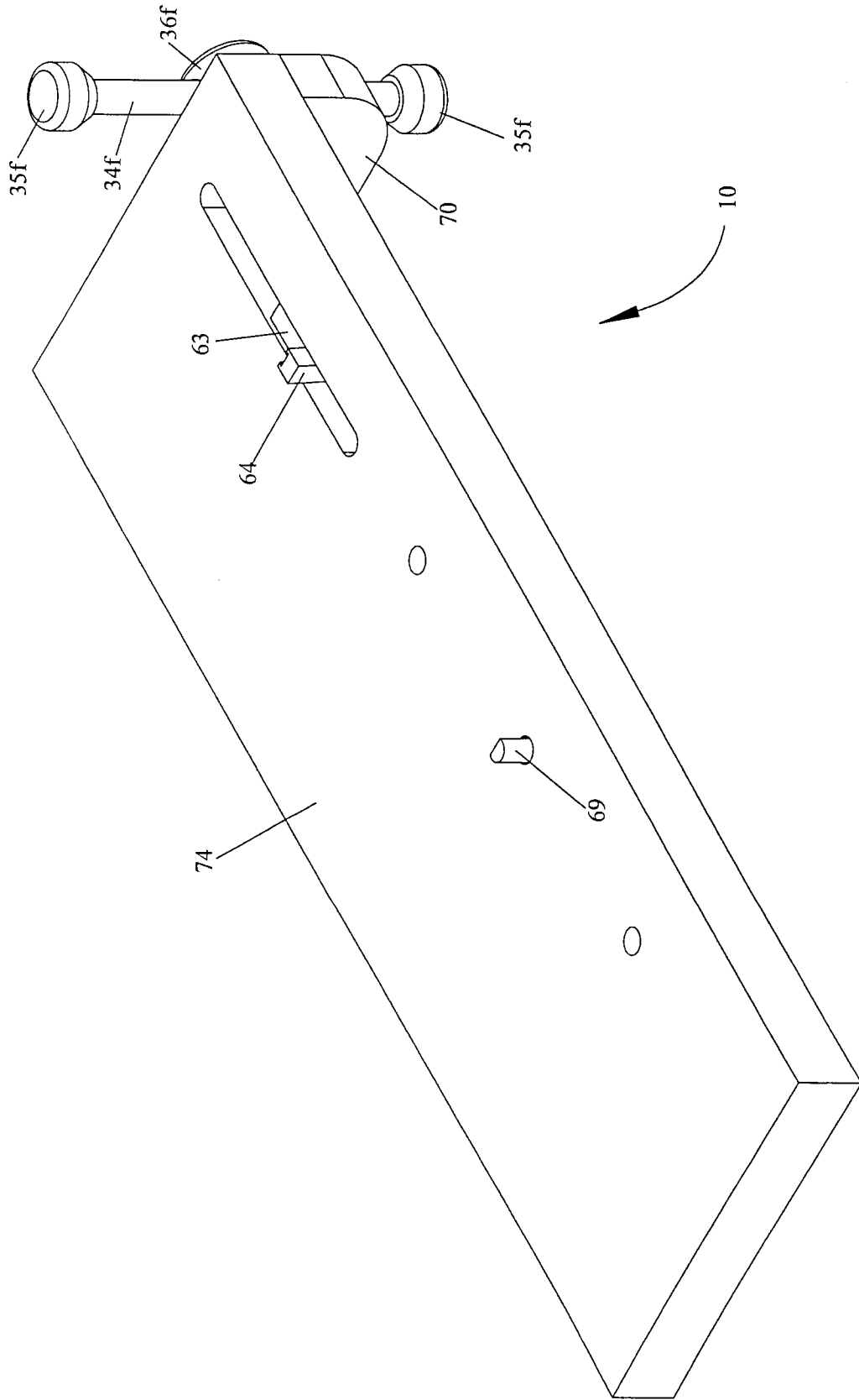


FIG. 27

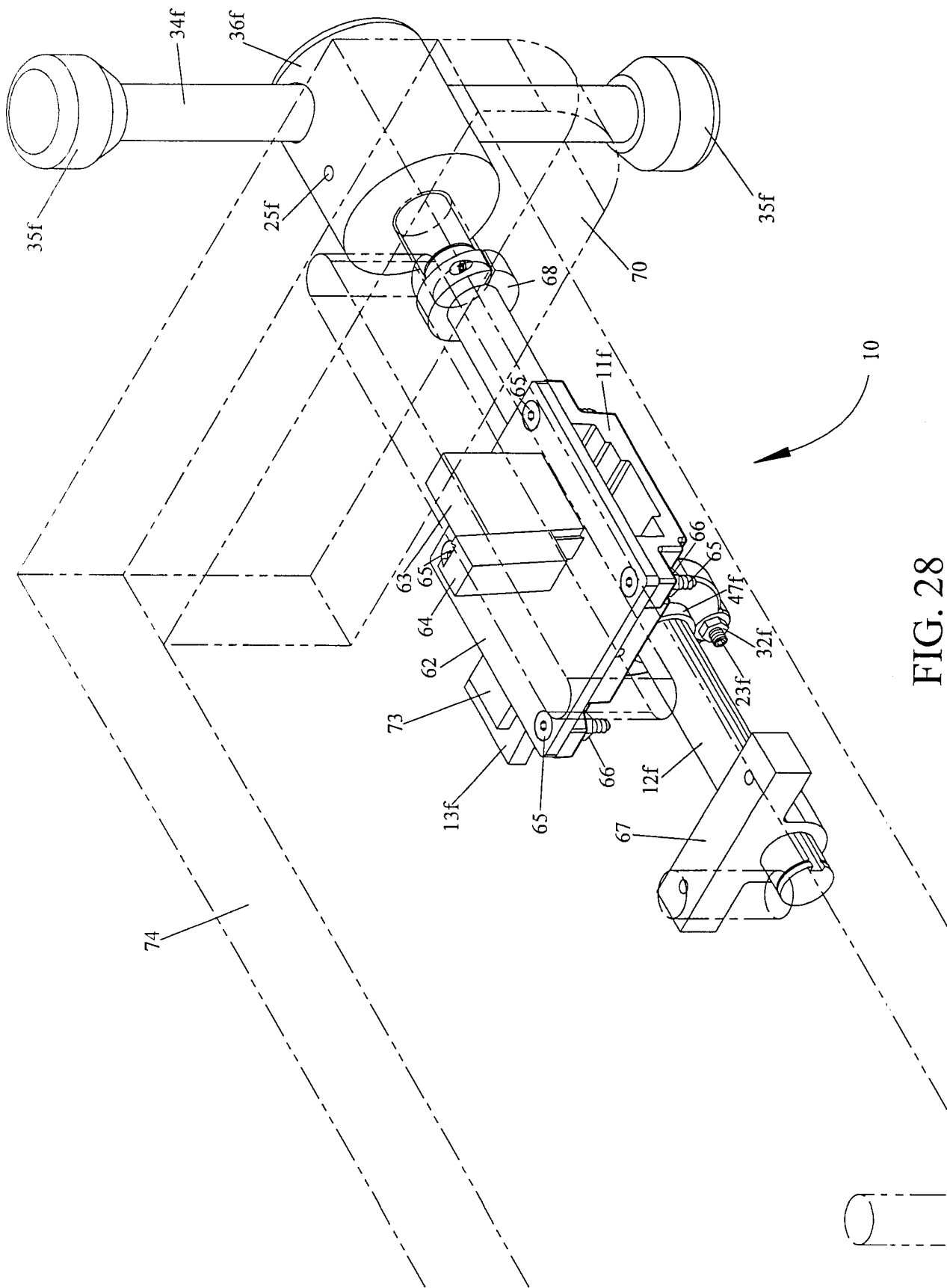


FIG. 28

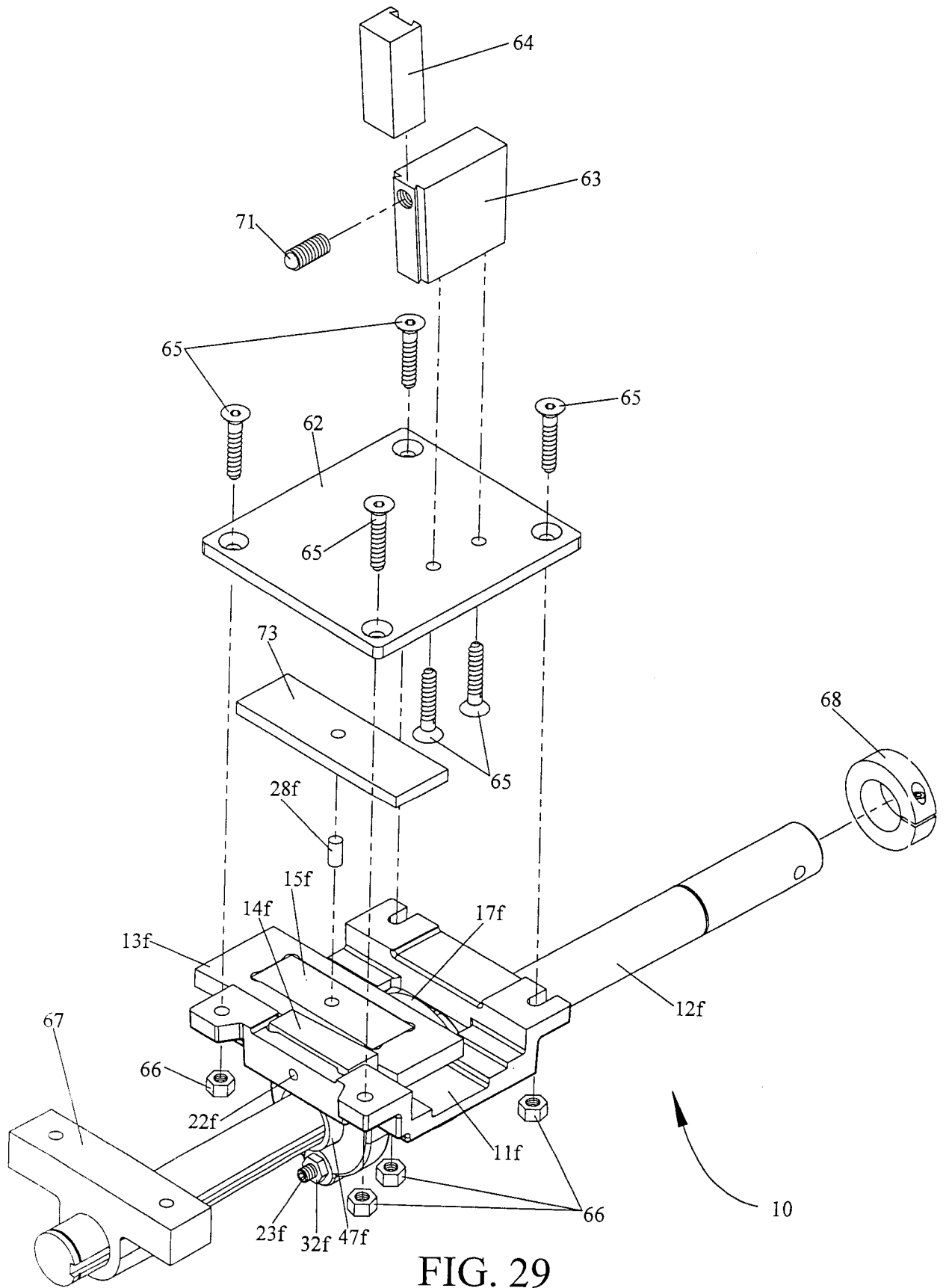


FIG. 29