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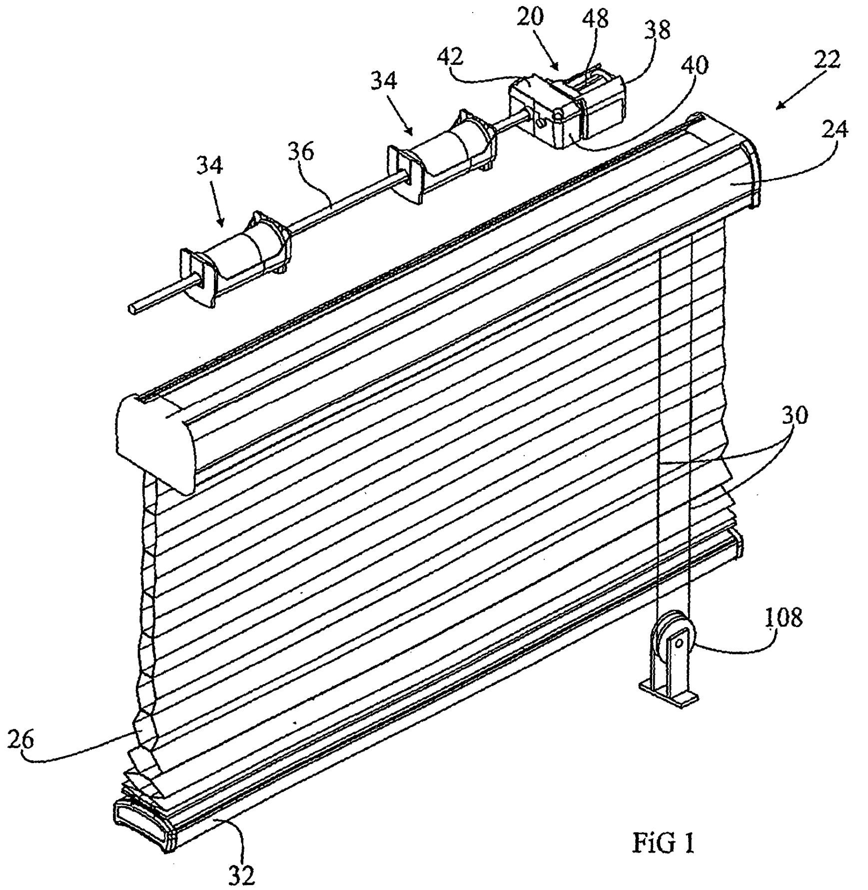
(54) Worm gear drive mechanism for a covering for architectural openings

(57) A drive module for a covering for architectural openings includes a driver worm and a driven worm with axes of rotation substantially parallel to each other.



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Description

BACKGROUND

[0001] This application claims priority from U. S. Provisional Application S/N 60/596,188 filed September 7, 2005, which is hereby incorporated by reference.

[0002] This application relates to a drive mechanism for use in coverings for architectural openings. Such coverings may include Venetian blinds, Roman shades, roller blinds, garage doors, and various other types of coverings.

[0003] Various types of drive mechanisms have been used in the past for coverings, including cord drives, gear drives, spring drives, and so forth. (In the case of garage doors, which are very heavy, the cord usually takes the form of a chain.) Most drives that are used for lifting the covering require the use of a brake or clutch in addition to the drive in order to prevent the covering from falling down after it has been raised.

SUMMARY

[0004] In one embodiment of the invention, a first, driver worm meshes with a second, driven worm to rotate a lift rod, which, in turn, raises the covering, which, in this embodiment, is a window blind. The axes of rotation of the driver and driven worms are almost parallel to each other and extend in the longitudinal direction of the head rail.

[0005] U. S. Patent No. 2,973,660, Popper et al, which is hereby incorporated herein by reference, explains many of the design considerations in designing a two-worm drive. In a two-worm drive with the worms nearly parallel, the mechanical efficiency of the drive approaches 90%, making it much more efficient than prior art drives for coverings.

[0006] Since the axis of rotation of the driver worm is substantially parallel to the axis of rotation of the driven worm, and since these axes may be oriented in the longitudinal direction of the head rail of the blind, there is plenty of room to provide any desired gear ratio within the space constraints of the head rail. In the lift mechanism depicted in this specification, the gear ratio is 2:1, resulting in a small amount of mechanical advantage. However, this can be changed to obtain any degree of mechanical advantage desired.

[0007] The driven worm has a larger lead angle than the driver worm. This means that the driver worm can drive the driven worm in both clockwise and counterclockwise directions, but the driven worm cannot back drive the driver worm. Any attempt to do so locks the mechanism against further rotation. Therefore, the user of the blind covering may pull the lift cord (which is connected to the driver worm via a lift cord pulley) to raise or lower the covering from the fully lowered position, through the fully raised position, and back to the fully lowered position, but, once the lift cord is released by the user, the blind is locked in place.

[0008] Similarly, in another embodiment described herein, in which the drive is used for tilting a blind, the tilt cord (which is connected to the driver worm via a tilter cord pulley) can tilt the slats of a window blind from the fully closed (room-side down) position, through the fully open, and on to the fully closed (room-side up) position, but, once the tilt cord is released by the user, the slats are locked in place.

[0009] If, in a Cartesian coordinate system (also referred to as a rectangular coordinate system), the axis of rotation of a gear (or worm) lies along the X-axis, and the Y-axis is perpendicular to the X-axis, then the lead angle is defined as the angle, measured off of the Y-axis, of the pitch or angle of the threads in the gear (or worm). In the embodiments described here, the lead angles typically are in the 4 to 6 degree range.

[0010] Assuming the lead angle of the driver worm is 5 degrees, then the lead angle of the driven worm should be slightly larger, so it might be 6 degrees, for instance. The difference between these lead angles, in that case, would be 1 degree. Since the gears must mesh in order for the device to operate, the axis of rotation of one of the two worms is offset from being truly parallel to the axis of rotation of the other of the two worms, and this offset is equal to the difference in the lead angles. This is why the figures show the axis of rotation of the driver worm sloped (or offset) slightly relative to the driven gear.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0011]

Figure 1 is a perspective view of a dual pleated fabric covering including a worm gear lift drive made in accordance with the present invention, with the components inside the head rail also shown in a partially exploded view;

Figure 2 is a perspective view of the worm gear lift drive of Figure 1;

Figure 3 is an exploded, perspective view of the worm gear lift drive of Figure 2, with the lift cords removed for clarity;

Figure 4 is a view along line 4-4 of Figure 2;

Figure 5 is a perspective view of a Venetian blind including a worm gear tilt drive made in accordance with the present invention, with the components inside the head rail also shown in a partially exploded view;

Figure 6 is a perspective view of the worm gear drive of Figure 5;

Figure 7 is an opposite end, perspective view of the worm gear drive of Figure 6;

Figure 8 is a lower angle, perspective view of the worm gear drive of Figure 7;

Figure 9 is an opposite end, perspective view of the worm gear drive of Figure 8;

Figure 10 is an exploded, front perspective view of the worm gear drive of Figure 6;

Figure 11 is a side view of the driver and driven worms of Figure 10, showing the very slight offset in their axes of rotation;

Figure 12 is a plan view of the driver worm of Figure 10;

Figure 13 is a view along line 13 - 13 of Figure 12;

Figure 14 is a plan view of the driven worm of Figure 10;

Figure 15 is a view along line 15 - 15 of Figure 14;

Figure 16 is an end view of the worm gear drive of Figure 9;

Figure 17 is a view along line 17 - 17 of Figure 16;

Figure 18 is a view along line 18 - 18 of Figure 16;

Figure 19 is an exploded, perspective view, similar to Figure 10, but showing another embodiment of a worm gear tilt drive made in accordance with the present invention;

Figure 20 is a section view, similar to that of Figure 18, but for the worm gear tilt drive of Figure 19;

Figure 21 is a section view, similar to that of Figure 18, but for yet another embodiment of worm gear tilt drive made in accordance with the present invention; and

Figure 22 is a plan view of the driver worm of Figure 21.

Description:

[0012] Figures 1 through 4 show a first embodiment of a worm gear lift drive 20 made in accordance with the present invention. Referring to Figure 1, the blind 22 includes a head rail 24, and a dual pleated fabric 26 is suspended from the head rail 24 via lift cables (not shown), which run downwardly inside the pleated fabric 26. As is explained in U.S. Patent 6,536,503, which is hereby incorporated herein by reference, a lift cable (not shown) is attached to each of the lift stations 34. The lift cables extend through the head rail 24 and through the dual pleated fabric 26 and are fastened at the bottom of the bottom slat (or bottom rail) 32.

[0013] Inside the head rail 24 are the worm gear drive lift mechanism 20, two lift modules 34, and a lift rod 36, which interconnects the worm gear lift drive 20 with the lift modules 34. This worm gear lift drive 20 is driven by two lift cord segments 30, which, in this case, are part of one continuous loop cord. Pulling on one of the lift cord segments 30 causes the lift rod 36 to rotate about its longitudinal axis in one direction, and pulling on the other lift cord segment 30 causes the lift rod 36 to rotate in the opposite direction, which, in turn, causes rotation of the lift modules 34. As the lift modules 34 rotate first in one direction and then in the other, they cause the lift cables to wind up onto and unwind from the lift stations 34, thereby raising and lowering the covering 26, depending upon the direction of rotation.

[0014] Referring now to Figures 2-4, the lift drive 20 includes a cord pulley housing 38, a main housing 40, a housing cover 42, a driver worm 44, a driven worm 46, and a lift cord pulley 48. The worm gear lift drive 20 also includes lift cord segments 30 (shown in Figure 2).

[0015] The driver worm 44 includes a first bearing support axle 50, a geared portion 52, a second bearing support 54, a non-circular cross-section portion 56, and a third bearing support 58. The geared portion 52 in this embodiment includes a worm gear 62 which has a small lead angle, preferably in the 3 to 7 degree range, and most preferably in the 4 to 6 degree range.

[0016] The driven worm 46 includes a first bearing support axle 64, a geared portion 66, and a second bearing support 68. The geared portion 66 in this embodiment includes a gear 70 which also has a small lead angle, preferably in the 3 to 7 degree range, and most preferably in the 4 to 6 degree range. The gear 70 of the driven worm 46 has a larger lead angle than the lead angle of the worm 62 of the driver worm 44. Preferably, this driven worm lead angle is only slightly larger than the driver worm lead angle, larger by 5 degrees or less, and preferably larger by 1 to 3 degrees.

[0017] In the embodiment shown here, the lead angle of the driven worm 46 is approximately one degree larger than the lead angle of the driver worm 44 (the difference between the two lead angles is approximately one degree). Since the threads on the driver 44 and driven 46 worms must mesh for the worm gear drive lifter 20 to operate, the axis of rotation of one of the worms is offset from the axis of rotation of the other worm by the difference between the two lead angles (which, as indicated above, is about one degree in this embodiment). This condition is depicted in more detail in the figures for the embodiment for a tilter mechanism below, such as in Figure 11, in which the axis of rotation 174 of the driven worm 146 is sloped down one degree from the axis of rotation 172 of the driver worm 144.

[0018] The driven worm 46 defines an inner shaft 75 with a non-circular hollow cross-section. This hollow shaft 75 engages the similarly-profiled lift rod 36 as described in more detail below. The two non-circular profiles mate, so the lift rod 36 and the driven worm 46 rotate together, with the axes of rotation of the driven worm 46 and of the lift rod 36 being the same.

[0019] The main housing 40 includes side walls 76, 78 and end walls 80, 82. Each of the end walls 80, 82 defines two "U"-shaped saddles. The end wall 80 defines the saddles 84a, 86a, and the end wall 82 defines the saddles 84b, 86b. The saddles 84a, 84b rotationally support the bearing supports 68, 64 of the driven worm 46 and properly align the driven worm 46 relative to the driver worm 44. The saddles 86a, 86b rotationally support the bearing supports 54, 50of the driver worm 44 and properly align the driver worm 44 relative to the driven worm 46.

[0020] When the driver and driven worms 44, 46 are assembled in the main housing 40, the location of the support saddle structures 84a, 84b and 86a, 86b for the worms 46, 44, respectively, automatically align the axes of rotation of the worms 44, 46 such that these axes are offset from being truly parallel to each other by the difference in the lead angles of the worms 44, 46, which, in this particular embodiment, is one degree.

[0021] The main housing 40 also includes a rectangular portion 88 appended to the end wall 80, and this rectangular portion 88 houses the lift cord pulley 48 and provides a slotted opening 90 through which the lift cords 30 exit the lift drive mechanism 20. The cord pulley housing 38 fits over this rectangular portion 88, which also includes a through opening 92 which provides rotational support for the bearing surface 58 of the driver worm 44. Finally, this rectangular portion 88 also includes a radiused surface 89 to gently guide one of the lift cords 30 under and around the lift cord pulley 48 as explained in more detail below.

[0022] Referring to Figure 3, the housing cover 42 defines arcuate recesses 94a, 94b, which, when the cover 42 is assembled onto the housing 40, lie adjacent the end wall 80 of the housing 40 above the arcuate recesses 84a, 86a. The housing cover 42 also defines identical arcuate recesses on its other end wall, which, when the cover 42 is assembled onto the housing 40, lie adjacent the other end wall 82 of the housing 40 above the arcuate recesses 84b, 86b. These arcuate recesses in the housing cover 42 cover the respective shaft supports 50, 54, 64, 68 and act to hold the driver drum 44 and the driven drum 46 securely in place inside the main housing 40 when the housing cover 42 is assembled to the main housing 40.

[0023] The main housing 40 includes several projections 98 (See Figure 3) which cooperate with matching holes 100 in the housing cover 42 and in the cord pulley housing 38 to assemble all the parts 38, 40, 42 together using the snap-together design for component assembly disclosed in U. S. Patent application S/N 60-679956 filed on May 5, 2005, which is hereby incorporated herein by reference.

[0024] The cord pulley housing 38 also includes a ledge 99 which extends over the housing cover 42 when the worm gear lift drive 20 is fully assembled. This ledge 99, (together with the projection 98' in the housing cover 42 which engages the matching hole 100' in the cord pulley housing 38) helps ensure that the housing cover 42 remains firmly assembled to the main housing 40 and improves the assembled integrity of the worm gear lift drive 20.

[0025] Finally, the lift cord pulley 48 is a substantially cylindrical element with flanges 102 at its ends. The lift cord pulley 48 defines a non-circular cross-section hollow, inner shaft 104 sized to receive the non-circular cross-section portion 56 of the driver worm 44, as described in more detail below. It may be noted that the substantially cylindrical surface 106 of the lift cord pulley 48 may have a polygonal cross-sectional profile (instead of a circular cross-sectional profile). In Figure 3, the surface 106 is depicted as having an octagonal cross-sectional profile, but other polygonal cross-sectional profiles may be used as desired, as well as a circular or other cross-sectional profile. A polygonal cross-sectional profile may enhance the "grip" of the lift cord 30 on the pulley 48. Of course, other ways for improving the grip of the lift cords 30 (such as knurling, or placing a rubber sleeve on the surface 106) may be used as well.

Lift Drive Assembly

[0026] To assemble the lift drive 20, the lift cord pulley 48 is slid over the end of the driver worm 44 such that the non-cylindrically profiled portion 56 of the driver worm 44 engages the hollow shaft 104 of the pulley 48. This assembly is installed in the main housing 40 with the bearing support surfaces 50, 54 of the driver worm 44 resting on the saddles 86b, 86a of the main housing 40, and the pulley 48 lying within the rectangular portion 88 of the main housing 40. Similarly, the driven worm 46 is also installed in the main housing 40 with the bearing support surfaces 64, 68 of the driven worm 46 resting on the saddles 84b, 84a of the main housing 40.

[0027] As indicated earlier, the support saddles 84a, 84b and 86a, 86b on the main housing 40 are located to ensure that the axes of rotation of the driver and driven worms 44, 46 are offset from each other by the difference in the lead angles of the threads of the driver and driven worms 44, 46. In the embodiment depicted here, this offset is approximately one degree.

[0028] The lift cord segments 30 (which in this embodiment are part of a single lift cord wrapped in a continuous loop) are fed through the slotted opening 90 of the rectangular portion 88 of the main housing 40 and wrapped several times around the pulley 48 (in the embodiment depicted in Figure 2, the lift cord 30 is wrapped three times around the pulley 48). The lift cord segments 30 are then fed back out of the main housing 40 via the same slotted opening 90 and routed down and around a tension pulley 108. The tension on the lift cord 30 is adjusted so that putting on one side of the lift cord loop 30 results in rotation of the cord pulley 48 (and consequent raising or lowering of the blind 22 as discussed below) with little, if any slippage of the lift cord 30 on the pulley 48.

[0029] It may be noted that the particular embodiment of the worm gear lift drive 20 of Figure 2 is designed to operate with both lift cord segments 30 under tension, which may be accomplished by having the lift cord 30 be a continuous loop tied down around the tension pulley 108. If the tension on the lift cord 30 is not maintained, the lift cord 30 slips around the drive pulley 48 and the lift drive 20 fails to operate.

[0030] The housing cover 42 is then installed over the main housing 40, and the pulley housing 38 is installed over the pulley 48, with the bearing support surface 58 of the driver worm 44 resting in the opening 92 of the pulley housing 38. The projections 98, 98' engage with the holes 100, 100', respectively, to lock together the housings 38, 40 and the housing cover 42.

[0031] The lift rod 36 is then inserted through the hollow shaft 75 of the driven worm 46, and the entire assembly is then installed in the head rail 24, mating the lift rod 36 with the lift stations 34 and snapping the outer contour of the housing into the inner contour of the head rail so the housing is fixed relative to the head rail. (See Fig. 1)

Operation

[0032] Once the worm gear lift drive 20 is installed in the head rail 24 as described above and as shown in Figure 1, it is ready for operation. Pulling on one of the lift cord segments 30 causes the cord pulley 48 to rotate in one direction. As an example, we can assume that, as the operator pulls on a first lift cord segment 30, the cord pulley 48 rotates in a clockwise direction (as seen from the left end of the window covering) and the first lift cord segment 30 unwinds from one side of the cord pulley 48. At the same time, the second lift cord segment 30 winds up onto the cord pulley 48 (this second lift cord segment 30 is guided by the generously radiused surface 89 of the rectangular portion 88 of the main housing 40, to the far side of the pulley 48).

[0033] This clockwise rotation of the cord pulley 48 drives the driver worm 44 in a clockwise direction (as the non-cylindrically profiled shaft 56 of the driver worm 44 engages the similarly non-cylindrically profiled hollow shaft 104 of the cord pulley 48). The driver worm 44, in turn, drives the driven worm 46 in a counter-clockwise direction (as the threaded gear portion 52 of the driver worm 44 meshes with the threaded gear portion 66 of the driven worm 46). The counter-clockwise rotation of the driven worm 46 causes the counter-clockwise rotation of the lift rod 36 (as the non-cylindrically profiled shaft hollow shaft 75 of the driven worm 46 engages the similarly non-cylindrically profiled lift rod 36). The rotation of the lift rod 36 causes the rotation of the lift modules 34, pulling up on the lift cables which run inside the double pleated fabric 26 in order to lift the bottom rail 32 of the window covering 22.

[0034] When the blind is lifted to the desired position, the operator releases the lift cord segment 30, and the blind 22 remains in that position. Should something attempt to reposition the blind 22 (for instance, a person physically pulling down on the bottom rail 32, or the force of gravity acting on the blind 22), the worm gear lift drive 20 locks up, since the driven worm 46 is unable to back drive the driver worm 44 without locking up the lift mechanism 20.

[0035] If the operator pulls down on the second lift cord segment 30, the entire sequence described above repeats itself, but in the opposite direction. As this second lift cord segment 30 unwraps from the cord pulley 48 (and the first lift cord segment 30 wraps back onto the cord pulley 48), the cord pulley 48 rotates in a counter-clockwise direction, as does the driver worm 44. The driven worm 46 then rotates in a clockwise direction as does the lift rod 36, turning the lift modules 34 so as to lower the lift cables which run inside the double pleated fabric 26 in order to lower the bottom rail 32 of the window covering 22. Once again, releasing the lift cord segment 30 at any position freezes the blind 22 in that position.

[0036] While this embodiment uses a cord drive to drive the driver worm gear, it would also be possible to use other known types of drives, such as an electric motor, a hand crank, or other known drives which are commonly used for raising and lowering window shades. Also, while this worm gear lift drive 20 has been described above as used to drive a lift rod 36 which drives lift stations 34, it could alternatively be used to drive a tilt rod which drives tilt stations, as described below, or to open and close a vertical blind or a garage door, or to drive other aspects of coverings.

Tilt Drive Mechanism

[0037] Figures 5 through 18 show another embodiment of a worm gear tilt drive 120 made in accordance with the present invention. Referring to Figure 5, the blind 122 includes a head rail 124 and a plurality of slats 126 suspended from the head rail 124 by means of tilt cables 128 and the associated cross cords which together comprise ladder tapes. As is typical in a window blind, two lift cords 130 extend through the head rail 124 and through holes (not shown) in the slats 126 and are fastened at the bottom of the bottom slat (or bottom rail) 132, which typically is heavier than the other slats 126. Inside the head rail 124 are a conventional cord lock mechanism 119, a cord tilter module including the worm gear tilt drive 120, two tilt modules 134, and a tilt rod 136, which interconnects the worm gear drive 120 with the tilt modules 134. This worm gear tilt drive 120 is driven by tilt cord segments 138. Pulling on one of the tilt cord segments 138 causes the tilt rod 136 to rotate around its longitudinal axis which, in turn, causes the tilt modules 134 to rotate as well. This action lifts up on one side of the tilt cables 128 while lowering the other side, in order to rotate the slats 126 to the open or closed position.

[0038] Referring now to Figures 6 through 10, the worm gear tilt drive 120 includes a front housing 140, a rear housing 142, a driver worm 144, a driven worm 146, and a cord tilter pulley 148. The worm gear drive 120 also includes tilt cord segments 138 (not shown in these views but seen in Figure 5, together with the tilt rod 136).

[0039] Referring to Figures 12 and 13, the driver worm 144 includes a first bearing support axle 150, a geared portion 152, a second bearing support 154, and a non-cylindrically profiled, cantilevered portion 156, terminating with a short radial indentation 158 and a tapered end 160. The geared portion 152 in this embodiment includes a worm gear 162 with a single gear start (as shown in Figure 13), and this gear 162 has a small lead angle, preferably in the 3 to 7 degree range, and most preferably in the 4 to 6 degree range.

[0040] Referring to Figures 14 and 15, the driven worm 146 includes a first bearing support axle 164, a geared portion 166, and a second bearing support 168. The geared portion 166 in this embodiment includes a worm gear 170 with five gear starts (as shown in Figure 15), and this gear 170 has a small lead angle, also preferably in the 3 to 7 degree range, and most preferably in the 4 to 6 degree range. The gear 170 of the driven worm 146 has a larger lead angle than the lead angle of the gear 162 of the driver worm 144. Preferably this driven worm lead angle is only slightly larger than the driver worm lead angle, larger by 5 degrees or less, and preferably larger by 1 to 3 degrees.

[0041] In the embodiment shown here, the lead angle of the driven worm 146 is approximately one degree larger than the lead angle of the driver worm 144 (the difference between the two lead angles is approximately one degree). Since the threads on the driver 144 and driven 146 worms must mesh for the worm gear tilter drive 120 to operate, the axis of rotation of one of the two worms is offset from the axis of rotation of the other by the difference between the two lead angles (which, as indicated above, is about one degree in this embodiment). This condition is depicted in Figure 11, in which the axis of rotation 174 of the driven worm 146 is sloped down one degree from the axis of rotation 172 of the driver worm 144.

[0042] Referring back to Figure 15, the driven worm 146 defines an inner shaft 175 with a non-cylindrical, hollow profile. This shaft 175 engages the similarly-profiled tilt rod 136 as described in more detail below, so the driven worm 146 and the tilt rod 136 rotate together and have the same axis of rotation.

[0043] Referring to Figures 10 and 18, the rear housing 142 defines a large cylindrical cavity 176 to house the driven worm 146, and a smaller cylindrical cavity 178 to house the driver worm 144. Referring to Figure 18, the rear wall 180 of the rear housing 142 defines a cavity 182 for rotationally supporting the axle 150 of the driver worm 144, as well as a through opening 184 for rotationally supporting the axle 164 of the driven worm 146. The rear wall 185 of the front housing 140 defines a first through opening 186 for rotationally supporting the axle 168 of the driven worm 146, as well as a second through opening 188 for rotationally supporting the axle 154 of the driver worm 144.

[0044] The front wall 187 of the rear housing 142 includes two projections 190 (See Figure 10) which cooperate with matching holes 192 in the front housing 140 to assemble the front and rear housings 140, 142 using the snap-together design for component assembly disclosed in the U. S. Patent application S/N 60-679956 filed on May 5, 2005, which is hereby incorporated herein by reference. A hole 194 on a flange 196 of the front wall 187 of the rear housing 142 may also be used to further securely fasten the front and rear housings 140, 142 via a screw (not shown).

[0045] When the driver and driven worms 144, 146 are assembled in the front and rear housings 140, 142, the location of the bearing support structures (182 and 184 in the rear housing 142, and 186 and 188 in the front housing 140) for the worms 144, 146 automatically align the axes of rotation 172, 174 of the worms 144, 146, respectively, such that these axes are offset from being truly parallel to each other by the difference in the lead angles of the worms 144, 146, which, in this particular embodiment, is one degree.

[0046] Referring to Figures 10, 17, and 18, the front housing 140 defines a large, semicylindrical cavity 198 which houses the cord pulley 148. The bottom wall 200 of the front housing 140 defines two through openings 202, 204 through which the two tilt cord ends 138 are threaded to be attached to the cord pulley 148 as described in more detail below.

[0047] Referring to Figures 10 and 18, the cord pulley 148 is a substantially cylindrical element with a non-cylindrically profiled, hollow inner shaft 206 sized to receive the mating non-cylindrically profiled, cantilevered portion 156 of the driver worm 144. A detent projection 208 on the cord pulley 148 is deflected outwardly by the tapered end 160 of the driver worm 144 during assembly. The detent projection 208 then snaps back into position into the indentation 158 of the driver worm 144, locking the cord pulley 148 against axial motion relative to the driver worm 144. Thus, the cord pulley 148 is releasably mounted onto the cantilevered portion 156 of the driver worm 144, and, when the cord pulley 148 rotates, it rotates the driver worm 144 as well.

[0048] The cord pulley 148 defines annular flanges 210, 212 at its ends, as well as a third annular flange 214 approximately half-way between the end flanges 210, 212. Two through openings 216, 218 extend through the cylindrical wall of the cord pulley 148 and into the inner core 220 (See Figure 18) so that the tilt cord segments 138 may be secured to the cord pulley 148 as described below.

Tilter Assembly

[0049] To assemble the worm gear tilt drive 120, the driver worm 144 is matched against the driven worm 146 such that their corresponding geared portions 152, 166 are meshed. The rear housing 142 is installed such that the driven worm 146 is inside the larger cavity 176, and the driver worm 144 is inside the smaller cavity 178. The bearing support axle 150 of the driver worm 144 rests in the cavity 182, and the bearing support axle 164 of the driven worm 146 rests in the through opening 184.

[0050] The front housing 140 is brought up against the front wall 187 of the rear housing 142, such that the projections 190 line up with the holes 192, and the assembly snaps together. The bearing support (or axle) 168 of the driven worm 146 rests on the through opening 186 on the front housing 140, and the bearing support (or axle) 154 of the driver worm 144 rests on the through opening 188 on the front housing 140. As indicated earlier, the openings 186, 188 on the front housing 140 are located to ensure that the axes of rotation 172, 174 of the driver and driven worms 144, 146 are offset from each other by the difference in the lead angles of the threads of the driver and driven worms 144, 146. In the embodiment depicted, this offset is approximately one degree.

[0051] The tilt cord segments 138 are brought up through the head rail 124 (See Figure 5). One tilt cord segment 138 is fed through one of the openings 202 in the front housing 140, and is then fed through one of the openings 216 in the cord pulley 148 where it is secured to the cord pulley 148 (for instance, by tying a knot or other enlargement to the end of the tilt cord 138 so that the end can not be pulled back out through the opening 216). The other tilt cord segment 138 is likewise fed through the other opening 202 in the front housing 140, is fed through the other opening 218 in the cord pulley 148, and is secured with an enlargement such as a knot. One of the tilt cord segments 138 is then partially wrapped around the cord pulley 148, while the other tilt cord segment 138 may remain unwrapped or, if desired, may be counter-wrapped (wrapped in the opposite direction) onto the cord pulley 148. These two sections of wrapped, counter-wrapped tilt cord segments 138 are separated by the middle annular flange 214 to keep the cord segments 138 from wrapping over each other.

[0052] The cord pulley 148 is then inserted into the cavity 198 of the front housing 140 such that the cantilevered portion 156 of the driver worm 144 fits into the hollow shaft 206 of the cord pulley 148, and the detent 208 latches into the indentation 158 of the driver worm 144. The tilter 120 is now ready for installation into the head rail 124, with its outer contour snap fitting into the inner contour of the head rail to fix it relative to the head rail, and with the tilt rod 136 fitting into the hollow shaft 175 of the driven worm 146.

[0053] The tilt rod 136 also connects to the tilt modules 134 in order to drive the tilt modules 134, which are described in U. S. Patent No. 6,536,503, which is incorporated herein by reference.

Operation

[0054] Once the worm gear drive 120 is installed in the head rail 124 as described above and as shown in Figure 5, it is ready for operation. Pulling on one of the tilt cord segments 138 causes the cord pulley 148 to rotate in one direction. As an example, we can assume that, as the operator pulls on a first tilt cord segment138, the cord pulley 148 rotates in a clockwise direction (as seen from the left end of the window covering) as the first tilt cord segment 138 unwinds from one side of the annular flange 214 of the cord pulley 148. At the same time, the second tilt cord segment 138 winds up onto the cord pulley 148 on the other side of the annular flange 214.

[0055] This clockwise rotation of the cord pulley 148 drives the driver worm 144 in a clockwise direction (as the non-cylindrically profiled shaft 156 of the driver worm 144 engages the similarly non-cylindrically profiled hollow shaft 206 of the cord pulley 148). It also drives the driven worm 146 in a counter-clockwise direction (as the threaded portion 152 of the driver worm 144 meshes with the threaded portion 166 of the driven worm 146). The counter-clockwise rotation of the driven worm 146 causes the counter-clockwise rotation of the tilt rod 136 (as the non-cylindrically profiled, hollow shaft 175 of the driven worm 146 engages the similarly non-cylindrically profiled tilt rod 136). The rotation of the tilt rod 136 causes the rotation of the tilt modules 134, pulling up on one side of the tilt cables 128 while lowering the other side of the tilt cables 128 in order to tilt the slats 126 of the window covering 122.

[0056] When the slats 126 are tilted to the desired position, the operator releases his grip on the tilt cord segment 138, and the slats 126 remain in that position. Should something attempt to reposition the slats 126 (for instance, a person physically handling the slats 126, or the force of gravity acting on the slats 126), the worm gear drive 120 locks up, since the driven worm 146 is unable to back drive the driver worm 144 without locking up the tilter mechanism 120.

[0057] If the operator pulls down on the second tilt cord segment 138, the entire sequence described above repeats itself, but in the opposite direction. While this second tilt cord segment 138 unwraps from the cord pulley 148 (and the first tilt cord 138 wraps back onto the cord pulley 148), the cord pulley 148 rotates in a counter-clockwise direction, as does the driver worm 144. The driven worm 146 then rotates in a clockwise direction as does the tilt rod 136, turning the tilt modules 134 so as to tilt the slats 126 in the opposite direction. Once again, releasing the tilt cord segment 138 freezes the slats 126 in the desired position.

Additional Embodiment of a Worm Gear Tilt Drive Mechanism

[0058] Figures 19 and 20 depict another worm gear tilt drive mechanism 120' made in accordance with the present invention. A comparison of Figure 19 with Figure 10 shows that the main difference is in the shape of the tilt cord pulley 148', which in this embodiment has the shape of two frustroconical elements placed end-to-end, resulting in an hourglass-shaped pulley 148'. In addition, the surface 222' of the pulley 148' is now a threaded surface to help guide the placement of the tilt cord segments 138 onto the surface 222'.

[0059] As is known in the industry, the tilting of slats 126 in a blind 122 requires a relatively constant force throughout the entire range of motion of the slats 126 except at the end of the stroke, when tilting the slats 126 of the blind 122 to the fully closed position (either room-side up or room-side down). At that point, the force required to fully close the blind 122 increases substantially, as the entire set of slats 126 and the bottom rail 132 are lifted by the tilt mechanism in order to achieve total closure of the blind 122.

[0060] The worm gear tilt drive mechanism 120' addresses this issue by the hourglass shape of the tilt cord pulley 148'. When the slats 126 of the blind 122 are fully closed in one direction (say room-side up), a first tilt cord segment 138 begins unwinding from the tilt cord pulley 148' starting at the smallest diameter of the tilt cord pulley 148'. The second tilt cord segment 138 is fully (or substantially) unwound from the tilt cord pulley 148' and hanging down off of its largest diameter, as it starts winding onto the tilt cord pulley 148', moving toward the center of the tilt cord pulley 148' where it has the smallest diameter.

[0061] As the blind 122 continues to tilt open, and then goes on to tilt closed in the opposite direction (room-side down), the first tilt cord segment 138 advances on the threaded surface 222' of the tilt cord pulley 148', unwinding itself toward the largest diameter, which results in progressively larger torque, until the highest torque is obtained at the end of the travel of the first tilt cord segment, where it is most needed to counter the extra force required to raise the slats 126 and bottom rail 132 to ensure complete closure of the blind 122. At that same time, the second tilt cord segment 138 is fully (or substantially) wound up onto the threaded surface 222' of the tilt cord pulley 148'.

[0062] To put it another way, the largest torque is obtained when the tilt cord segment 138 is unwinding from the largest diameter of the tilt cord pulley 148' but does so at the expense of longer linear travel of the tilt cord segment 138 for a corresponding angular displacement of the slats 126. However, as the tilt cord segment 138 moves down along the frustroconical surface 222' toward the smaller diameter of the tilt cord pulley 148', the torque is reduced, but less of a linear travel of the tilt cord 138 is required for a corresponding angular displacement of the slats 126. Thus, the frustroconical tilt cord pulley 148' allows for the tilt cord pull in the center of the tilt range of the blind 122 (where the diameter of the tilt cord pulley 148' is smallest) to be minimized so that the total tilt cord travel is greatly reduced without increasing the maximum operational force of the tilter 120'.

[0063] The actual location of the tilt cord segments 138 on the tilt cord pulley 148' may be chosen either to minimize total distance traveled by the tilt cord segments 138 or to maximize the torque available to tilt the blind closed in one or the other directions (room-side up or room-side down) or both, or to achieve any desired combination thereof (of distance traveled versus torque available). Also, in order to minimize the length of the tilt cord pulley 148', the tilt cord segments 138 could be wrapped such that the first tilt cord segment 138 is fully wound onto the threaded surface 222' of the tilt cord pulley 148', while the second tilt cord segment 138 is fully unwound from the tilt cord pulley 148' and is on the same end of the tilt cord pulley 148' as the first tilt cord. Thus, as the first tilt cord unwinds from the tilt cord pulley 148', the second tilt cord winds up on the same thread just being vacated by the first tilt cord. As a result, the tilt cord pulley 148' only needs to have one half the total number of threads as may otherwise be required, resulting in a shorter tilt cord pulley 148'.

[0064] While this is not shown in the figures of this specification, it may well be possible to replace the lift cord pulley 48 (See Figure 3) of the worm gear lift drive mechanism 20 discussed earlier with a frustroconical, threaded pulley similar to the pulley 148' of the worm gear drive tilt mechanism 120' disclosed above. In this instance, a simple frustroconical threaded pulley, or perhaps a combined part-frustroconical, part-cylindrical pulley, instead of the double frustroconical threaded pulley 148' may be all that is needed as discussed below.

[0065] In a typical blind, a progressively larger force is required to lift (or raise) the blind. When the blind is in the fully lowered position, the ladder tapes (the tilt cables) are supporting all the slats and only the bottom rail needs to be raised at the onset. As the raising of the blind progresses, more of the slats stack up onto the bottom rail, and this additional weight must be countered with a larger force. In essence, the lift cords and the ladder tapes exchange loads as the blind is raised and lowered. As this load shifts from the ladder tapes to the lift cords when raising the blind, a larger force is required to raise the blind.

[0066] The use of a frustroconical pulley with a threaded surface instead of the cylindrical pulley 48 of the worm gear drive lift mechanism 20 in Figure 3 would reduce the amount of input force required by the operator pulling down on the lift cord segment 30 (at the expense of more distance traveled by the lift cord segment 30). If the pulley had a first portion which was cylindrical and a second portion which was frustroconical with an increasing diameter as you move away from the cylindrical portion, the lift cord segment 30 could begin unwinding from the cylindrical portion of the pulley as it begins raising the blind. The force required to continue raising the blind would continue to increase steadily until it reached a higher acceptable limit (say, for instance, 12 to 15 pounds of force by the operator). At that point, the lift cord segment would start to unwind from the frustroconical portion of the pulley (at an increasingly large diameter) which would act to reduce the amount of force required, countering the increasing amount of force to continue raising the blind. The force required by the operator could be kept at or below the threshold limit deemed acceptable by the operator.

[0067] Since the lift cord pulley is practically parallel to the longitudinal axis of the head rail (in the embodiments shown, the axis of rotation of the lift cord pulley is only offset one (1) degree from the axis of rotation of the driven worm 46, which is most likely aligned with the longitudinal axis of the head rail 24), it is possible to have a fairly long lift cord pulley within the confines of the head rail in order to accommodate a long stroke of the lift cord segment 30.

[0068] Of course, it may be desirable to keep the continuous loop feature of the lift cord segments 30 of Figure 1 for the lift drive instead of the two separate tilt cord segments 138 of Figure 5. This could still be accomplished despite the use of a frustroconical threaded pulley, or a combined part-frustroconical, part-cylindrical pulley as described above. Means for maintaining a proper tension on the continuous loop lift cord segments 30 (such as the use of biasing spring to pull on the tension pulley 108) may be used for the operation of such a lift drive.

[0069] Figure 21 depicts yet another embodiment of a worm gear tilt drive 120" made in accordance with the present invention. A comparison of Figure 21 with Figure 18 shows that the main difference is in the shape of the driver worm 144", which in this embodiment has an interrupted thread portion 230" (which can be readily appreciated in Figure 22). In addition, the housing 142" has a bearing support portion 232" which extends toward, and receives, the interrupted thread portion 230" of the driver worm 144" to provide additional rotational support to the driver worm 144". This support is provided approximately at the midpoint of the geared portion 152" of the driver worm 144", resulting in a geometrically increased shaft strength to obtain much greater torsional output. Other than this, there is no difference in the operation and performance of this worm gear tilt drive 120" relative to the worm gear tilt drive 120 described above.

[0070] While these embodiments use a cord drive to drive the driver worm gear, it would also be possible to use other known types of drives, such as an electric motor which is often used in lift drives, or a tilt wand, which is commonly used for tilting window shades. Also, although it is not shown in the drawings herein, it would be possible to use worm gear drives both for raising the blind and for tilting the slats in the same blind. While some specific lead angles and gear ratios have been taught here, it is understood that other embodiments may use different lead angles and/or gear ratios.

[0071] The embodiments of the invention described above are a few examples of products made in accordance with the present invention. It will be obvious to those skilled in the art that modifications may be made to the embodiments described above without departing from the scope of the present invention.

Claims

1. An arrangement for covering an architectural opening, comprising:

a movable covering for architectural openings defining a longitudinal direction;
an elongated rod extending in said longitudinal direction and operatively connected to said covering;
a first worm gear defining a first axis of rotation oriented in said longitudinal direction and defining a first lead angle;
a second worm gear meshing with and driven by said first worm gear; said second worm gear defining a second axis of rotation and a second lead angle, wherein said first and second axes of rotation are substantially parallel to each other, and said second lead angle is larger than said first lead angle, said second worm gear being coaxial with and operatively connected to said elongated rod; and
a housing supporting said first and second worm gears for rotation.

2. An arrangement as recited in claim 1, wherein said covering includes a plurality of lift cords, and wherein said elongated rod is operatively connected to said lift cords.

3. An arrangement as recited in claim 1 or 2, wherein said covering is a blind including a plurality of slats supported on a plurality of ladder tapes, and wherein said elongated rod is operatively connected to said ladder tapes for tilting said slats open and closed.

4. An arrangement as recited in claim 1, 2 or 3, and further comprising:

a pulley defining a cord-receiving surface, said pulley being operatively connected to said first worm gear; and
first and second counter-wrapped actuating cord segments secured to said pulley, wherein pulling on said first cord segment rotates said first worm gear in a first direction, and pulling on said second cord segment rotates said first worm gear in the opposite direction.

5. An arrangement as recited in claim 4, wherein said cord-receiving surface is substantially cylindrical and includes at least one annular flange separating said counter-wrapped cord segments.

6. An arrangement as recited in claim 4 or 5, wherein said cord-receiving surface includes at least one frustroconical portion.

7. An arrangement as recited in claim 6, wherein said cord-receiving surface is threaded.

8. An arrangement as recited in any preceding claim, wherein the lead angles of said first and second worm gears are in the 3 to 7 degree range, and the difference between the lead angle of the first worm gear and the lead angle of the second worm gear is less than 4 degrees.

9. An arrangement as recited in claim 8, wherein the difference in the lead angles between said first and second worm gears is in the 1 to 3 degree range, and said axes of rotation of said first and second worm gears are offset from being truly parallel to each other by said difference in the lead angles.

10. An arrangement as recited in claim 9, wherein said housing includes a first housing portion and a second housing portion, which, when assembled, substantially enclose and secure said first and second worm gears, preventing axial movement of said first and second worm gears and defining bearing support surfaces which rotationally support said first and second worm gears and maintain said offset between said first and second worm gears.

11. An arrangement as recited in any preceding claim, wherein said first worm gear further defines an interrupted thread portion, and said housing further defines a bearing support portion which is received by said interrupted thread portion and supports said first worm gear.

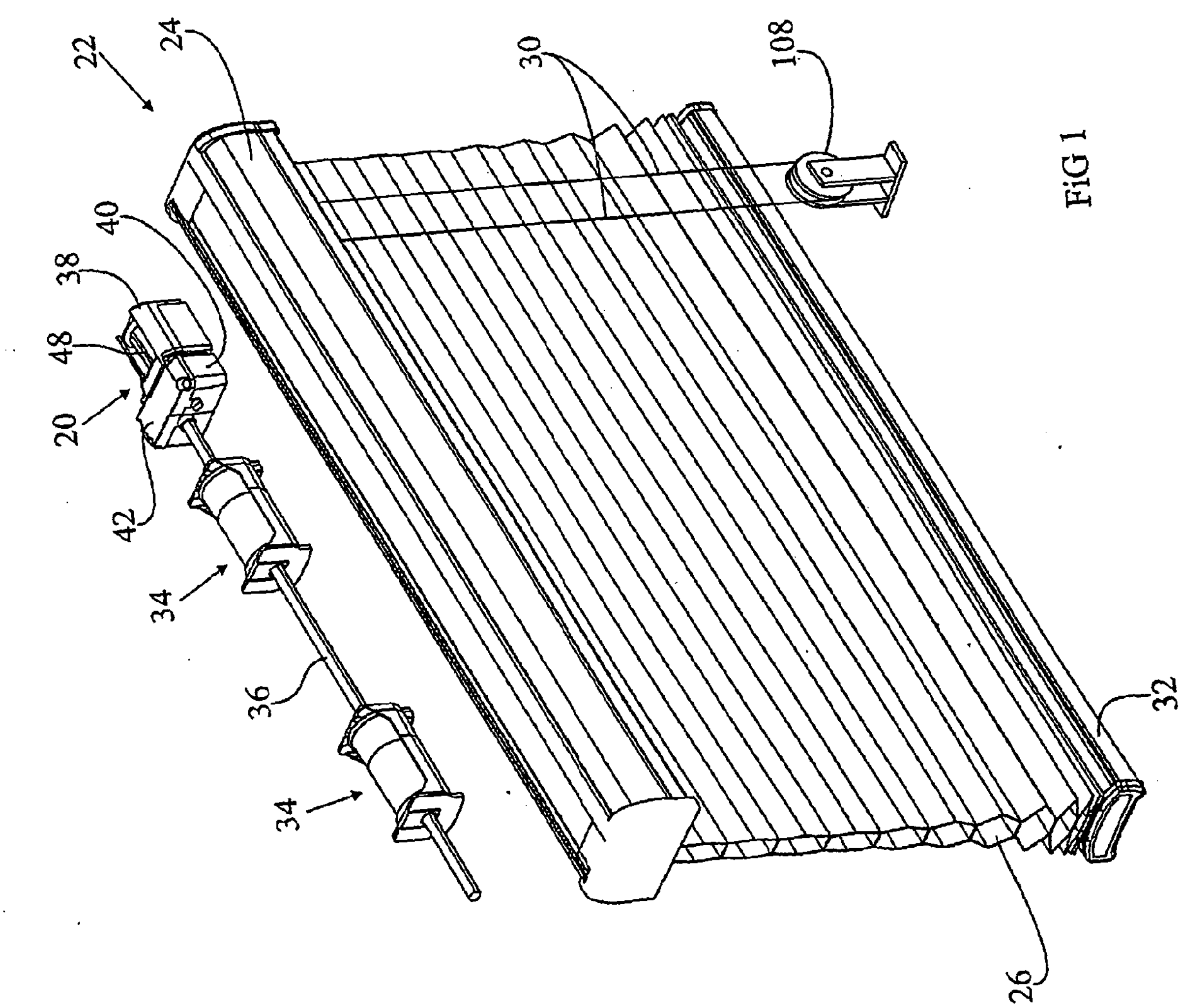
12. An arrangement for a covering for an architectural opening, comprising:

> a movable covering having an extended position and a retracted position;
> at least one cord operatively connected to said movable covering for extending and retracting said movable covering;
> a driver operatively connected to said cord, said driver including
>
> > a first worm gear defining a first axis of rotation and a first lead angle;
> > a second worm gear meshing with and driven by said first worm gear; said second worm gear defining a second axis of rotation and a second lead angle, wherein said first and second axes of rotation are substantially parallel to each other, and said second lead angle is larger than said first lead angle; and
> > a housing supporting said first and second worm gears for rotation.

13. An arrangement as recited in claim 12, wherein said covering is a horizontal blind and said cord is a lift cord.

14. An arrangement as recited in claim 13, and further comprising a lift rod driven by said second worm gear and a plurality of lift spools mounted on said lift rod, said cord being wrapped onto one of said lift spools.

15. An arrangement as recited in claim 14, and further comprising a drive spool drivingly connected to said first worm gear.



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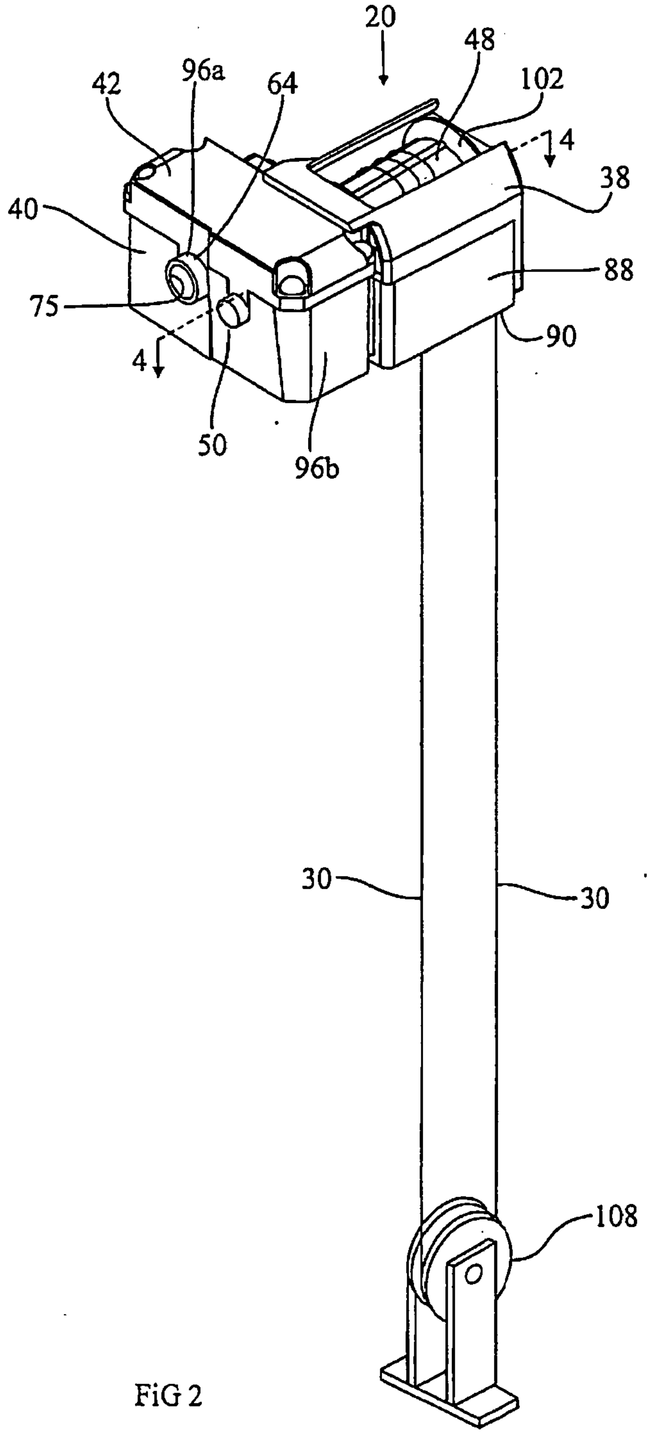

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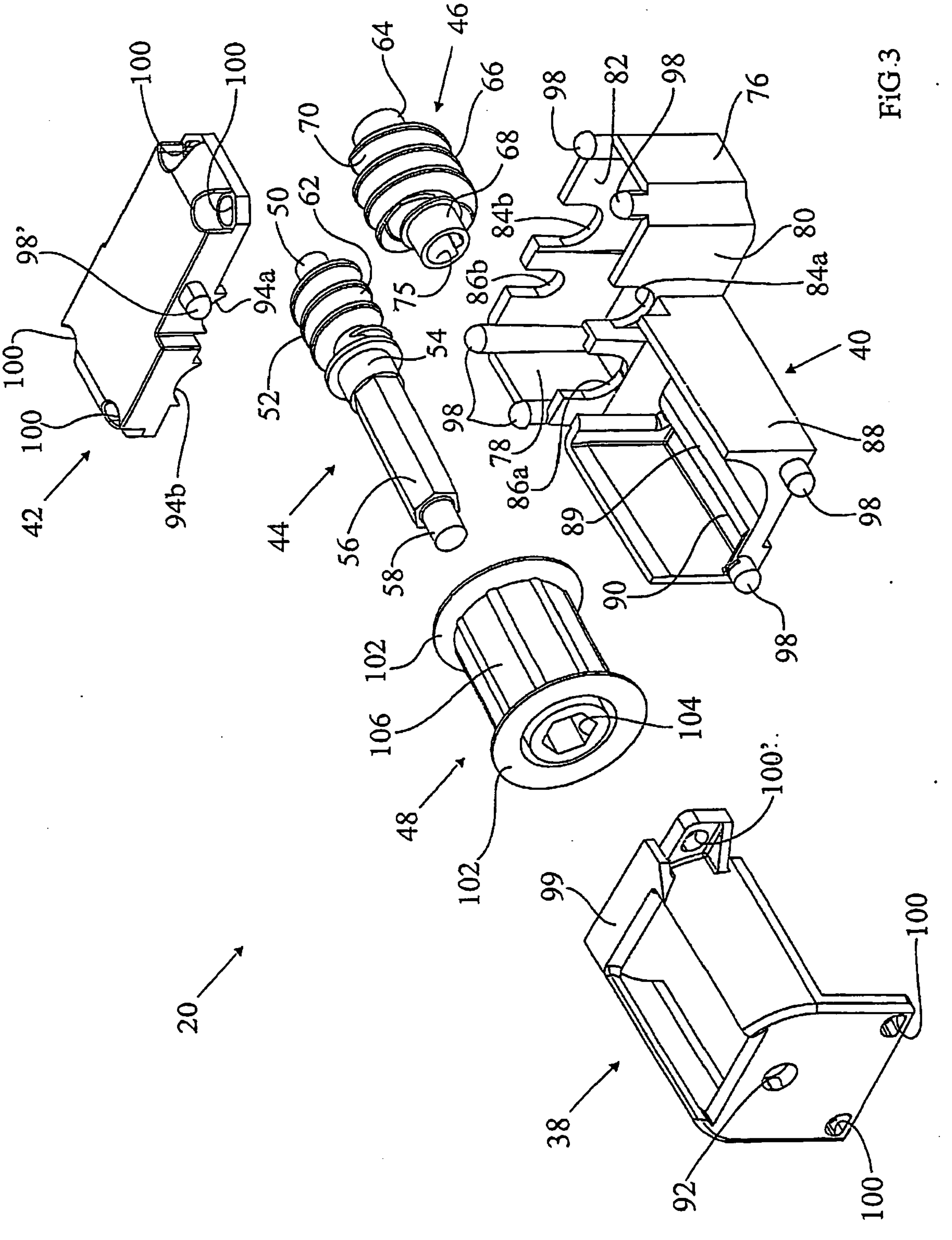
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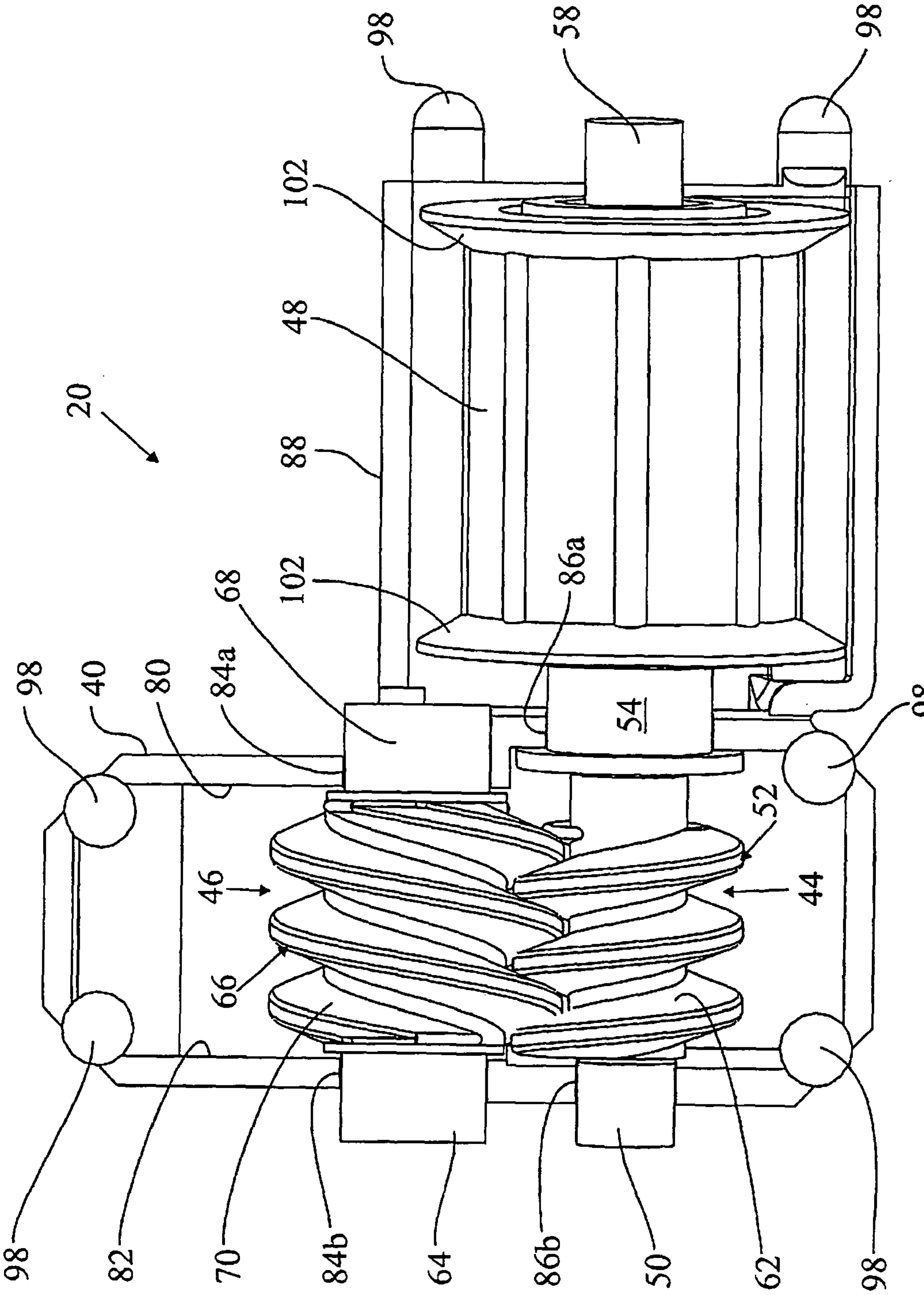
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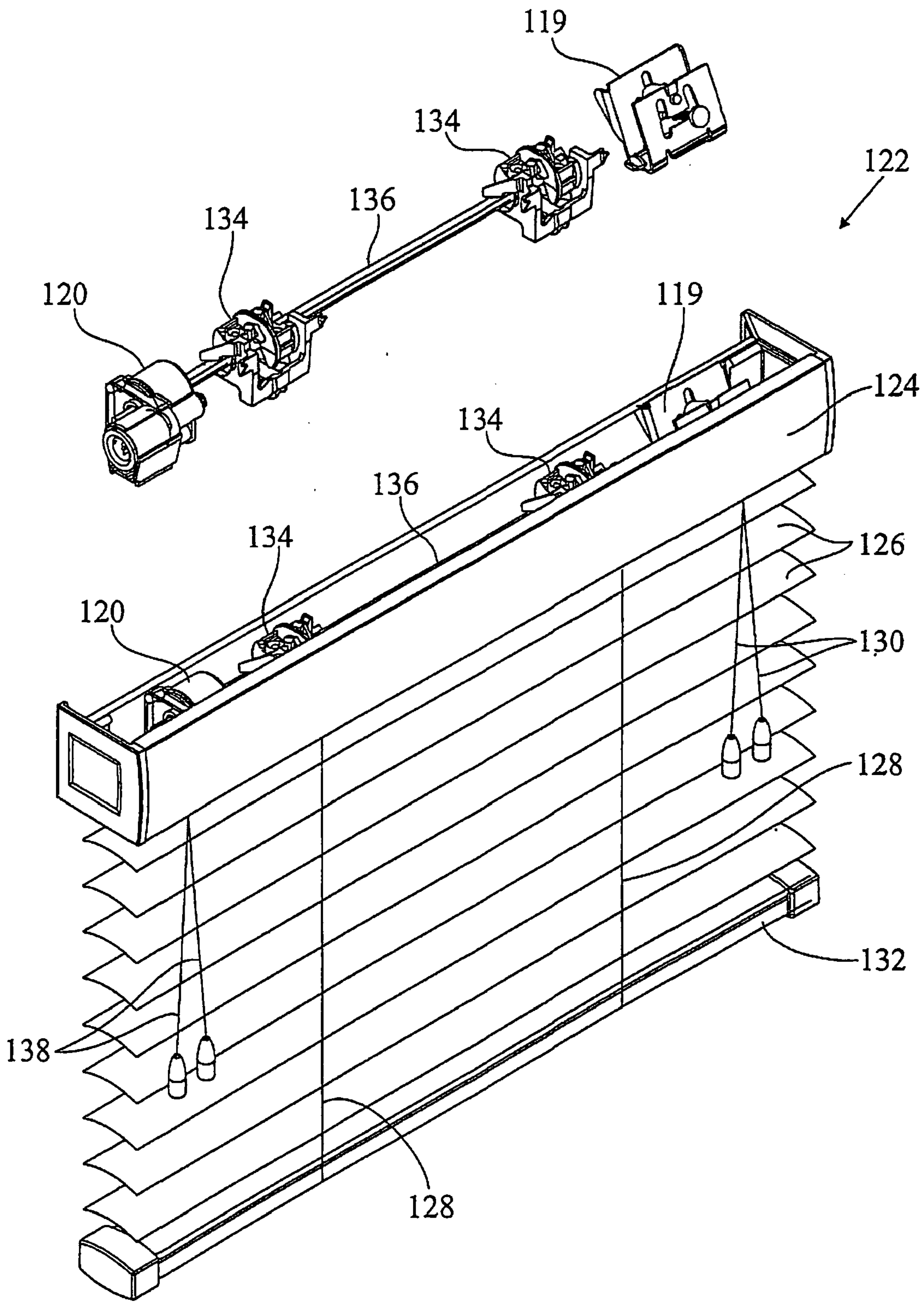
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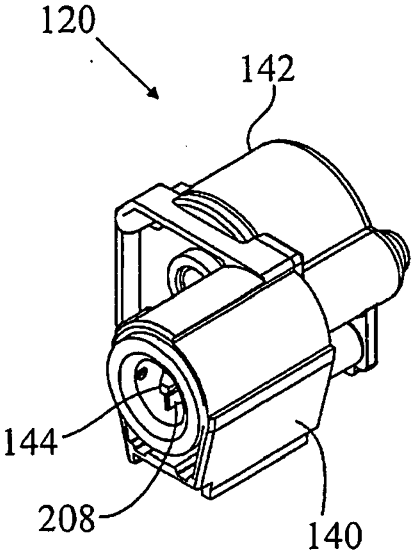

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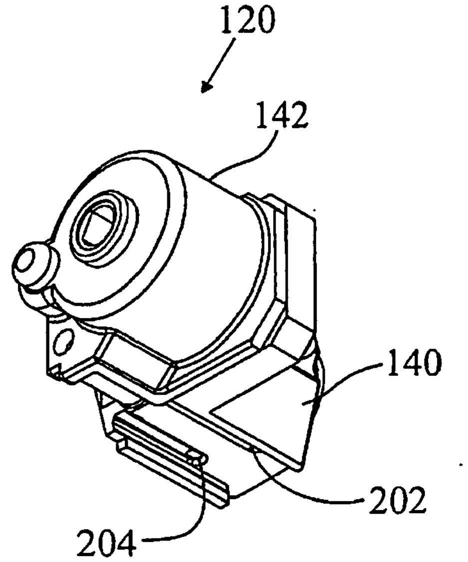

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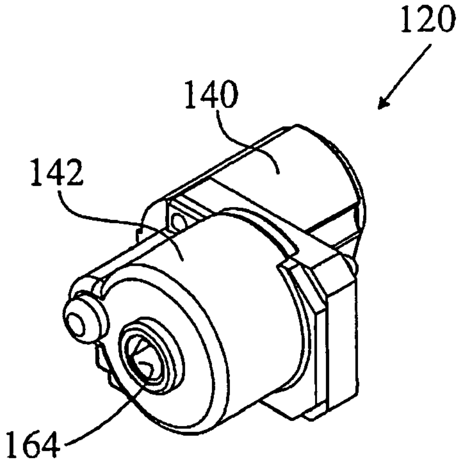

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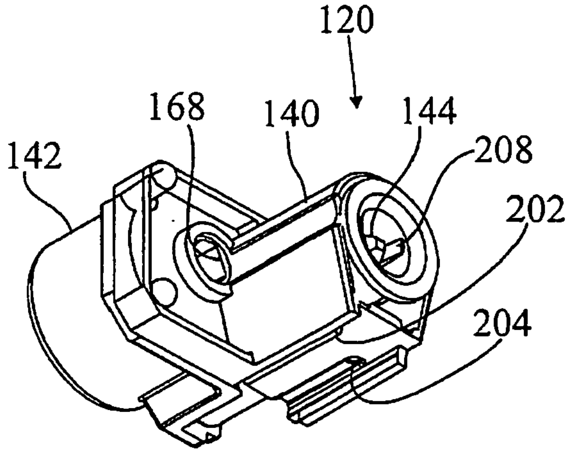

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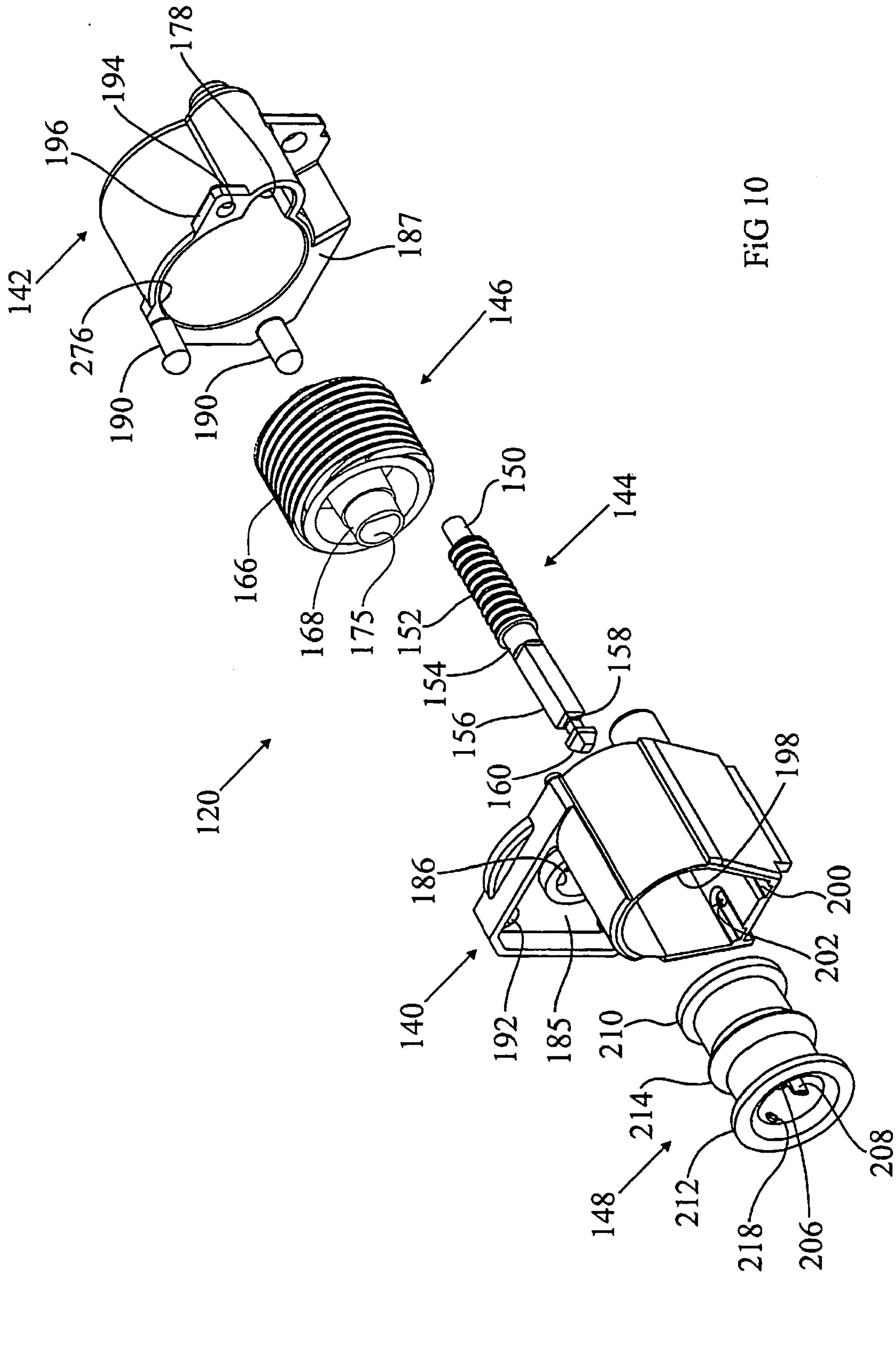

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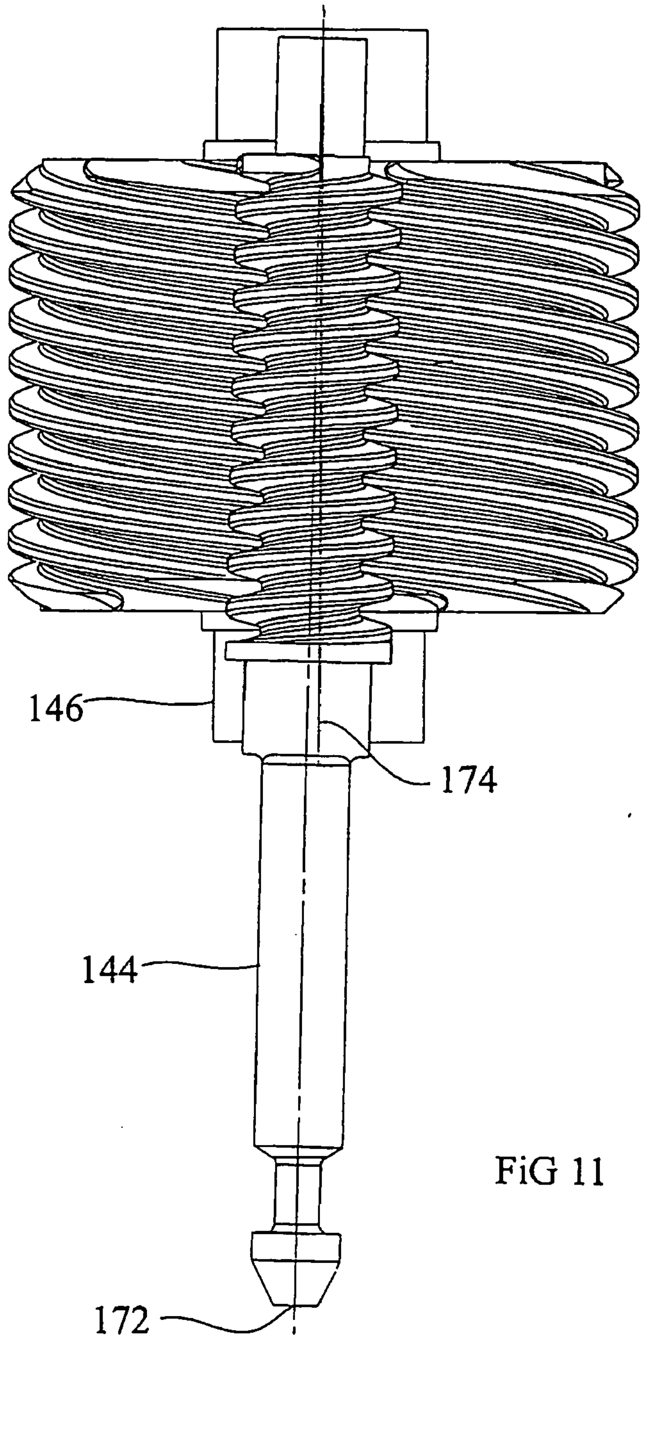

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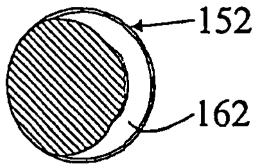

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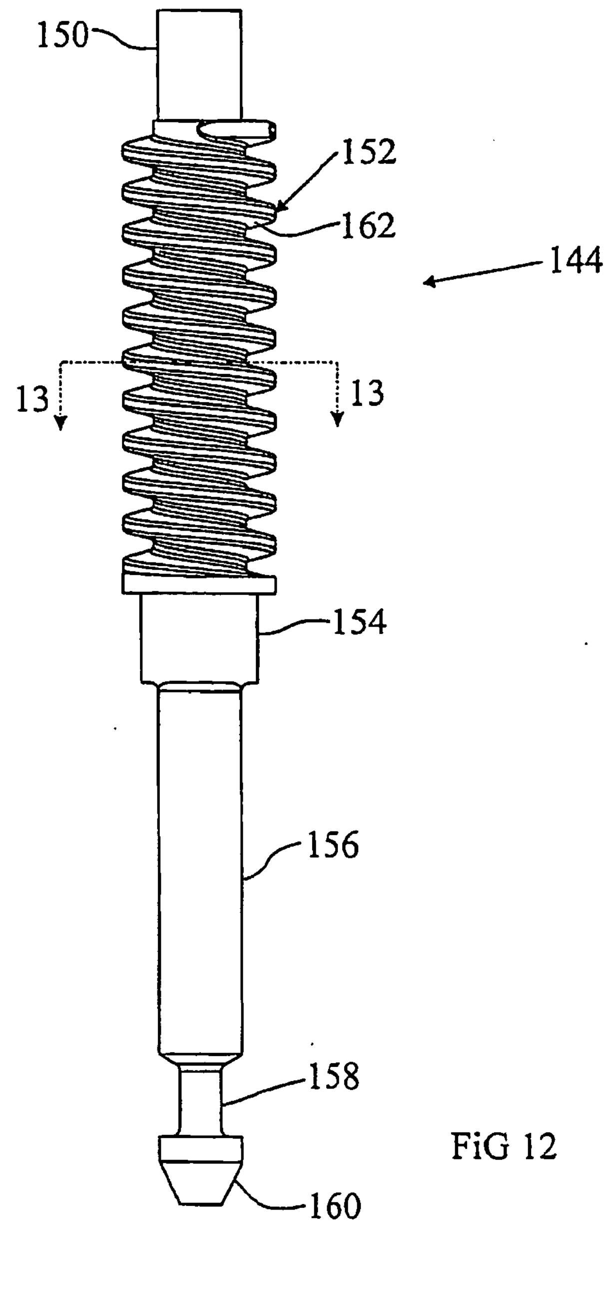

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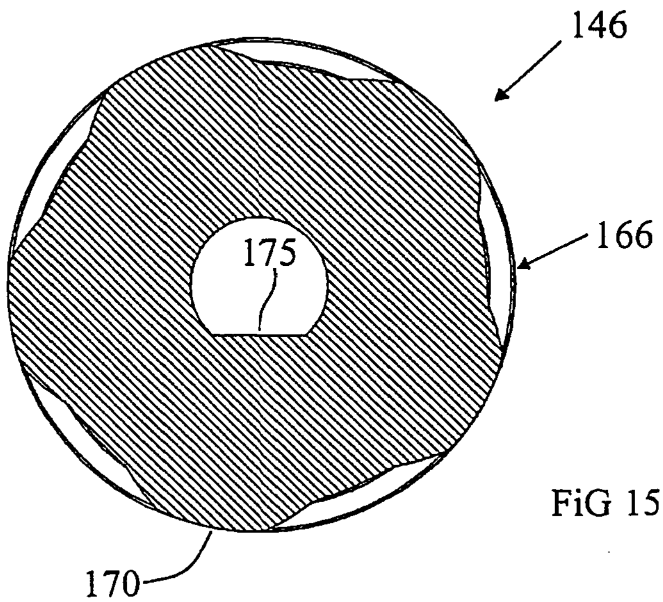

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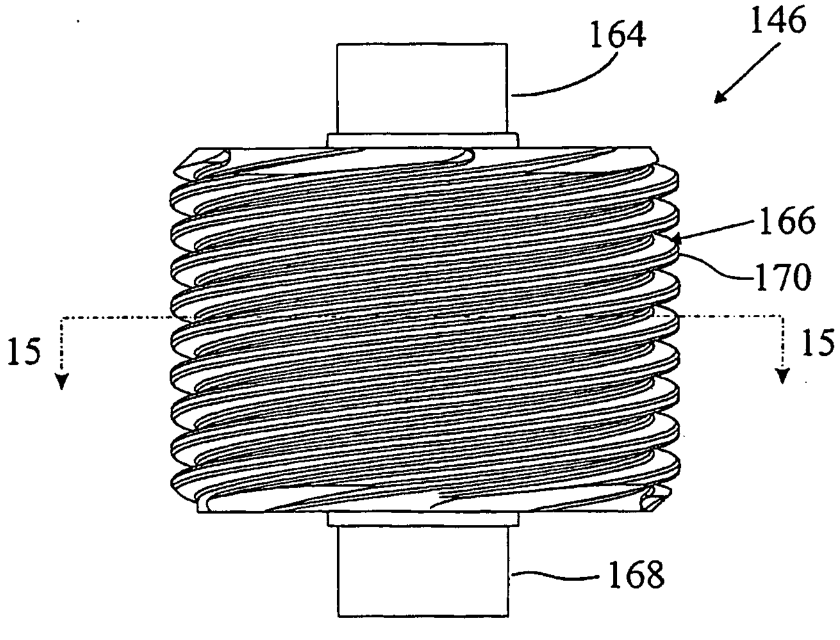

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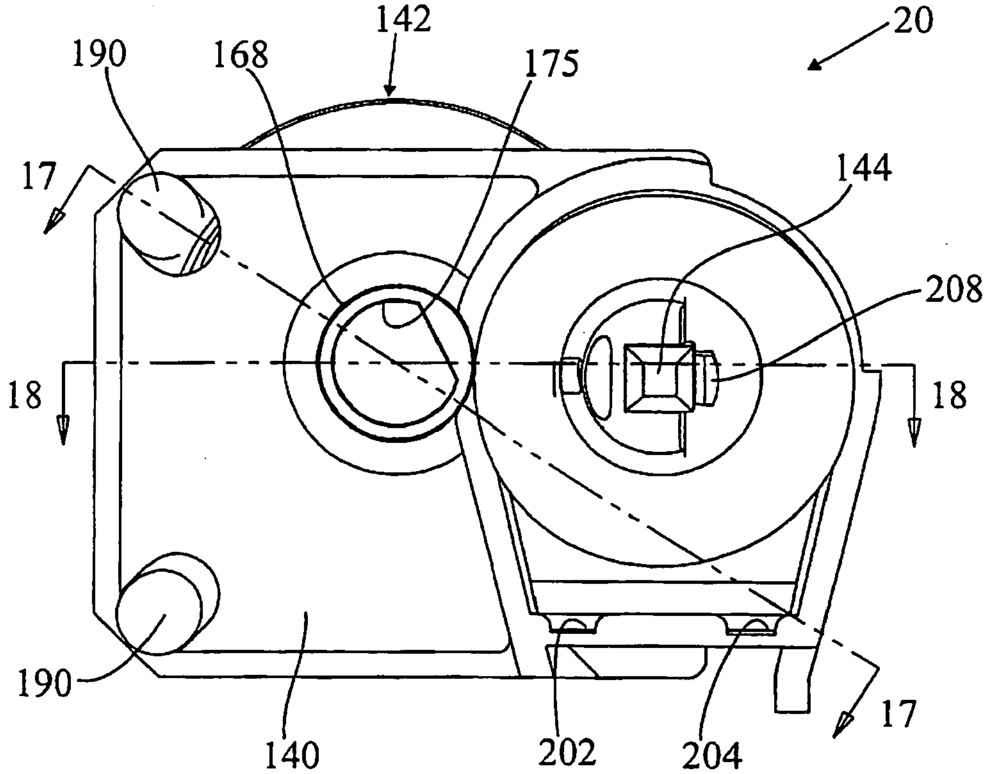

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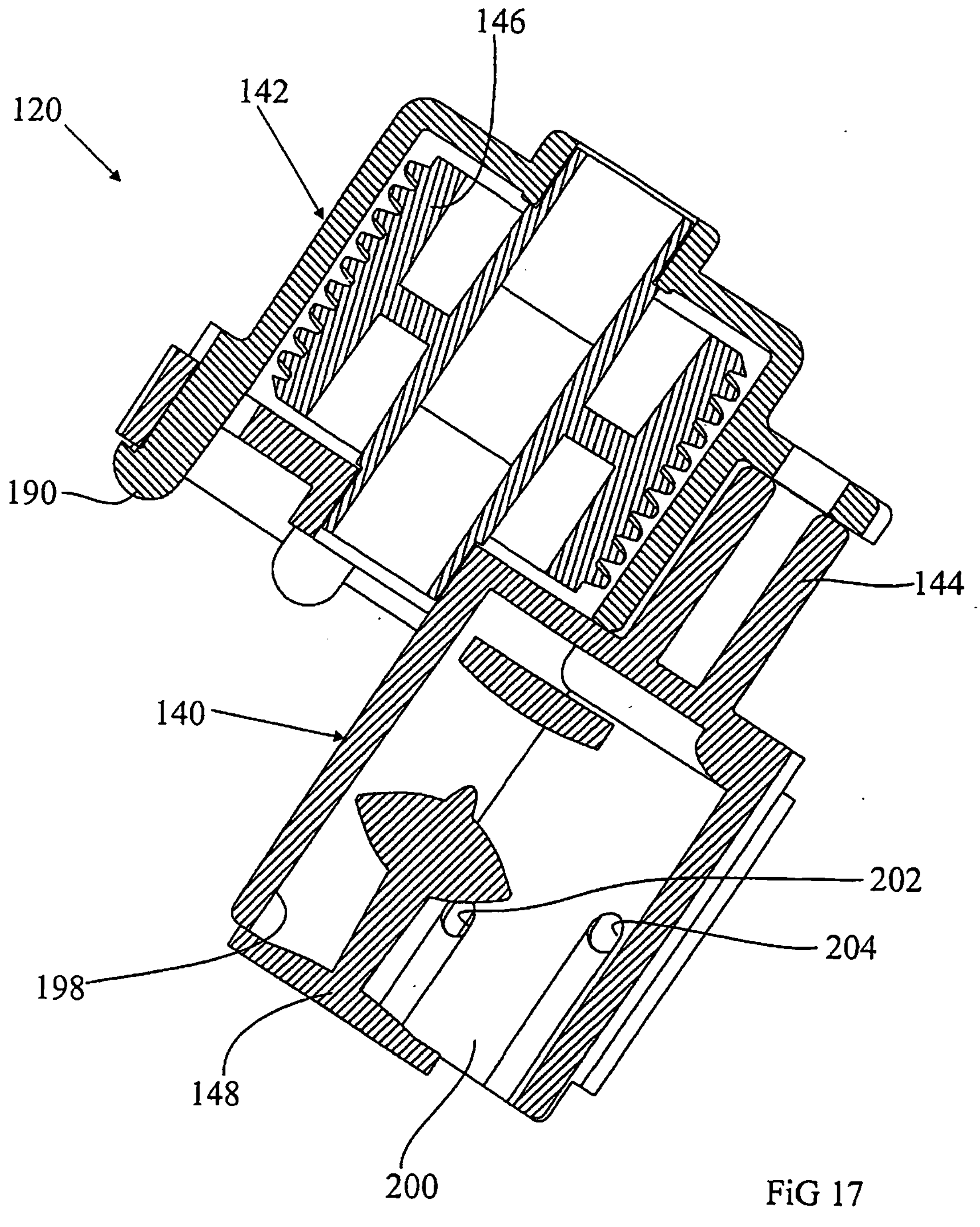

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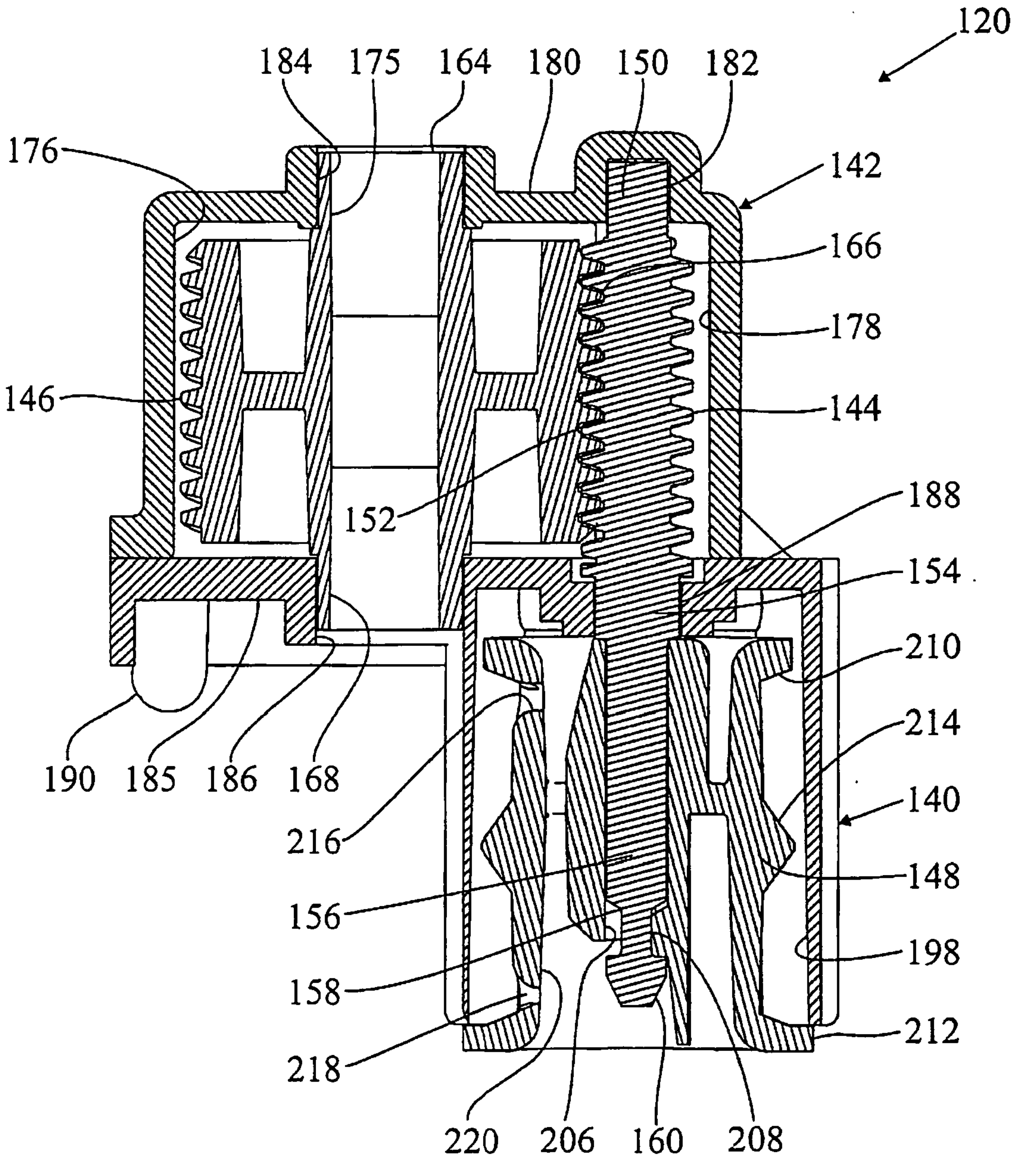
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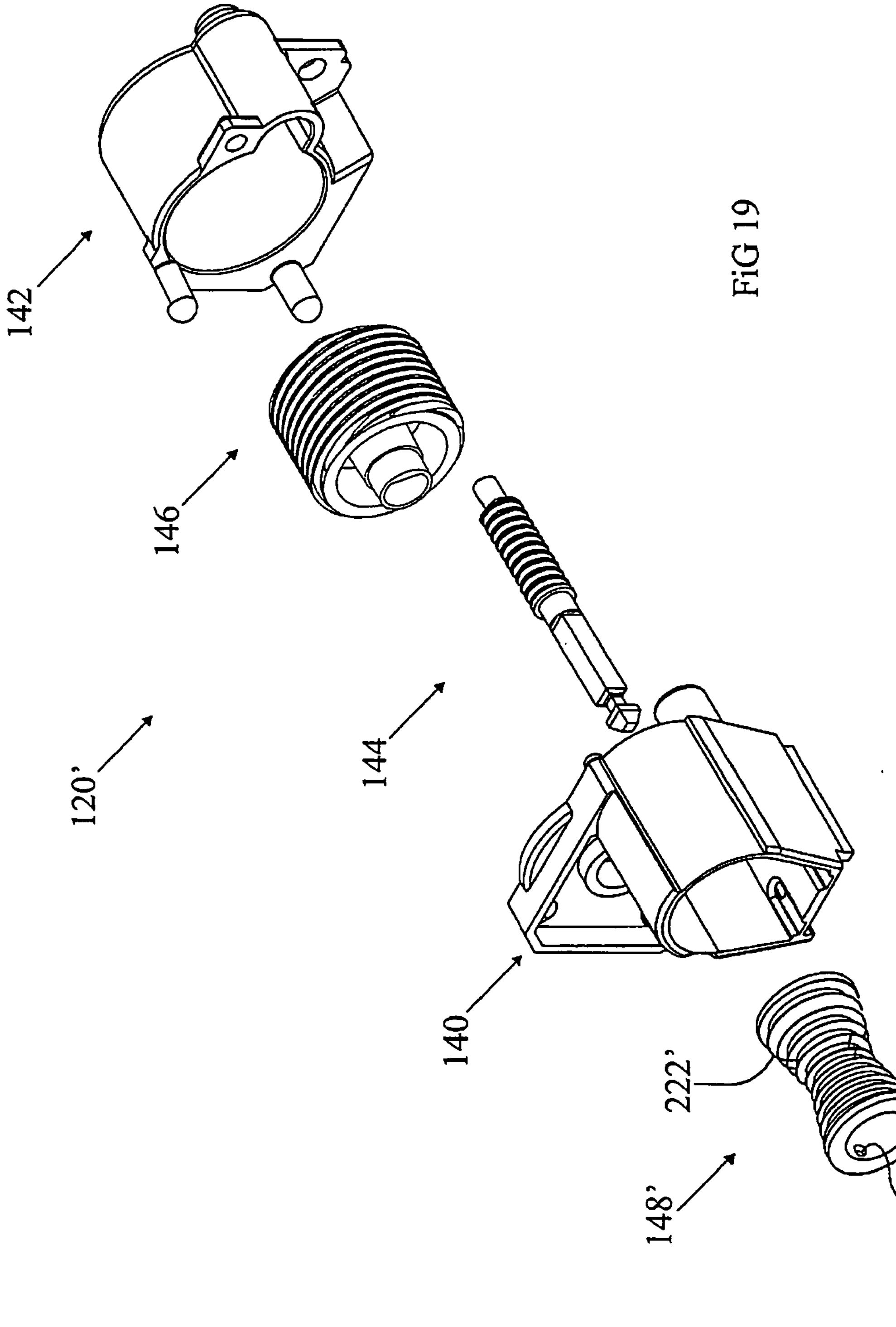

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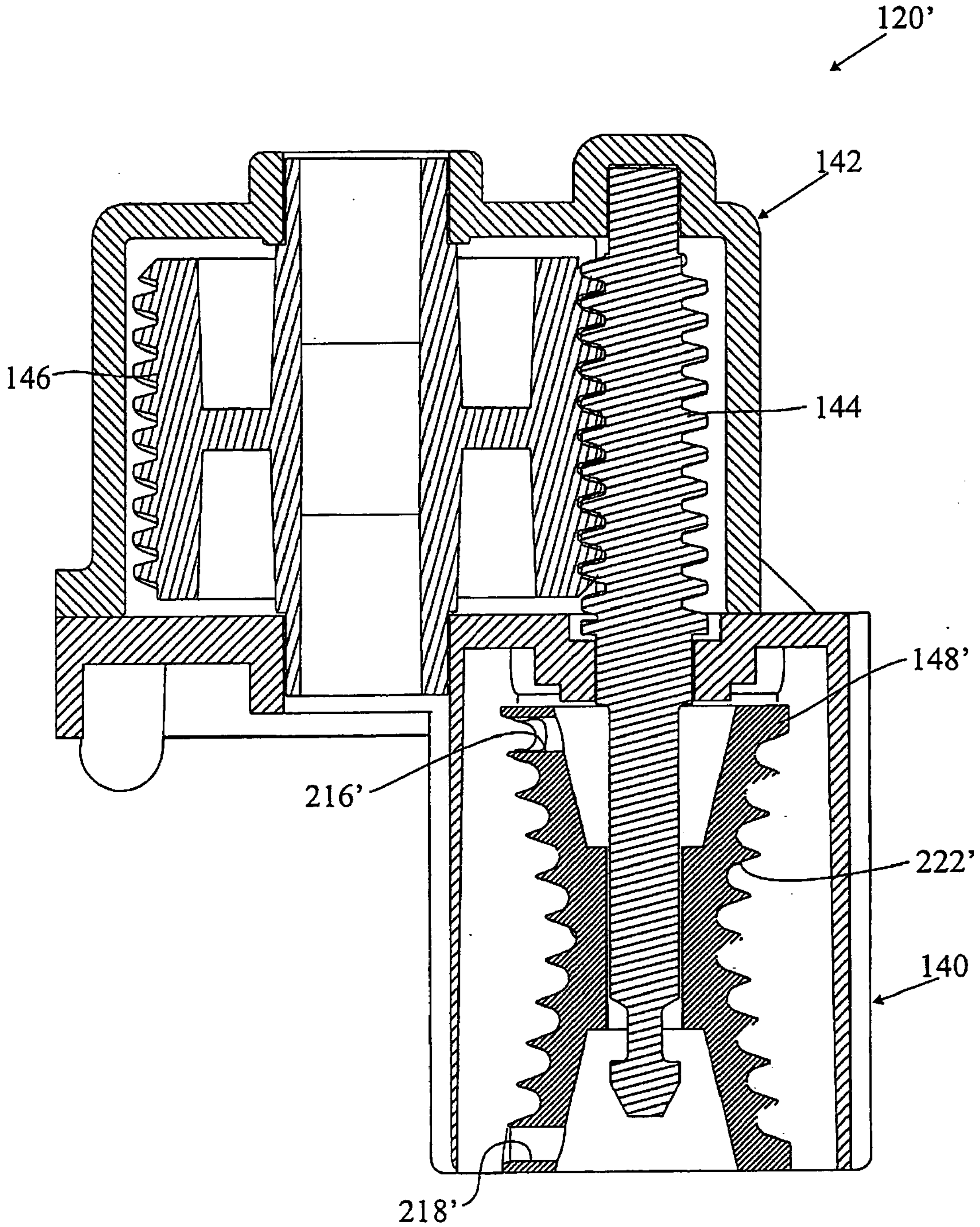

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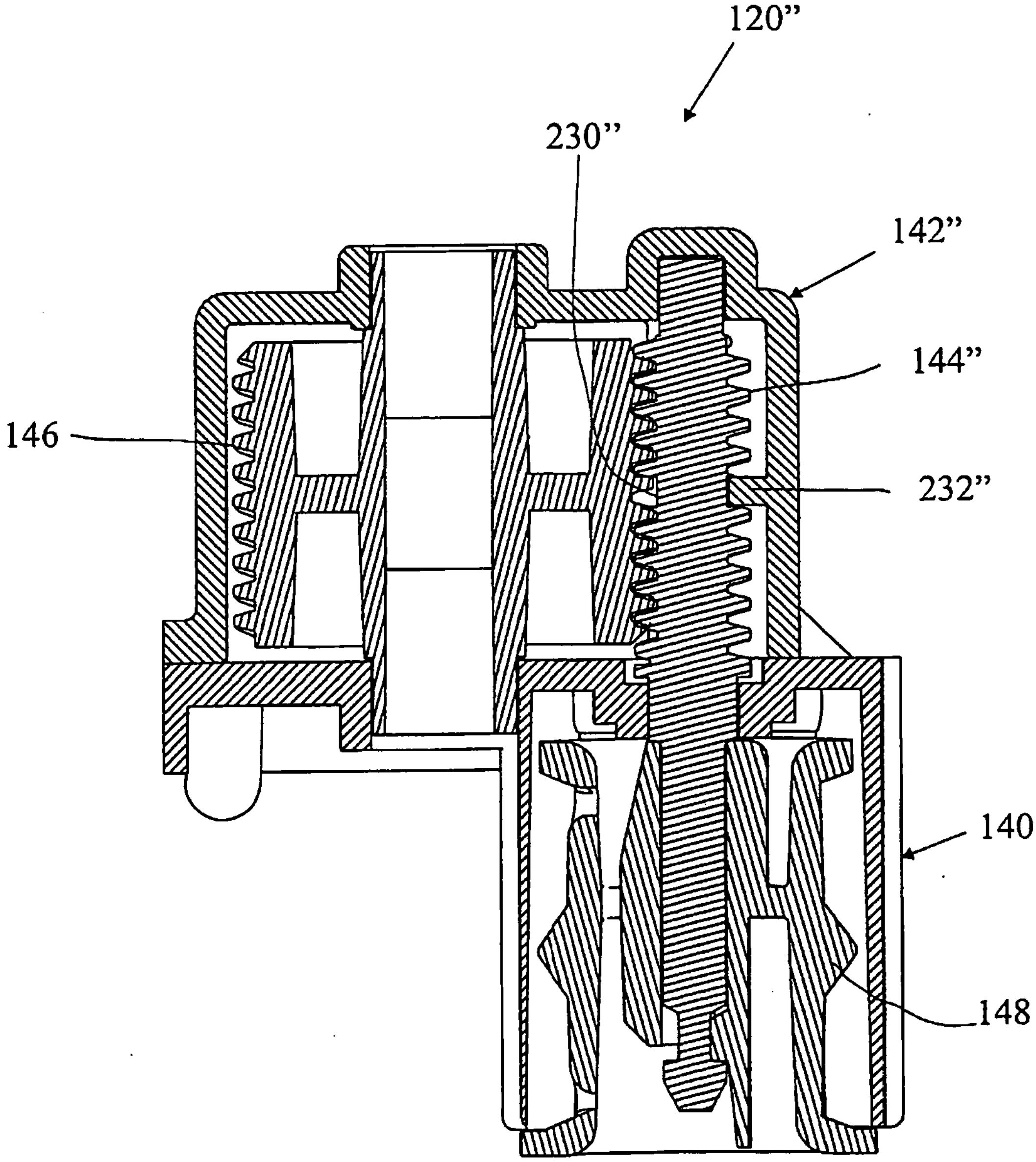

FIG 21

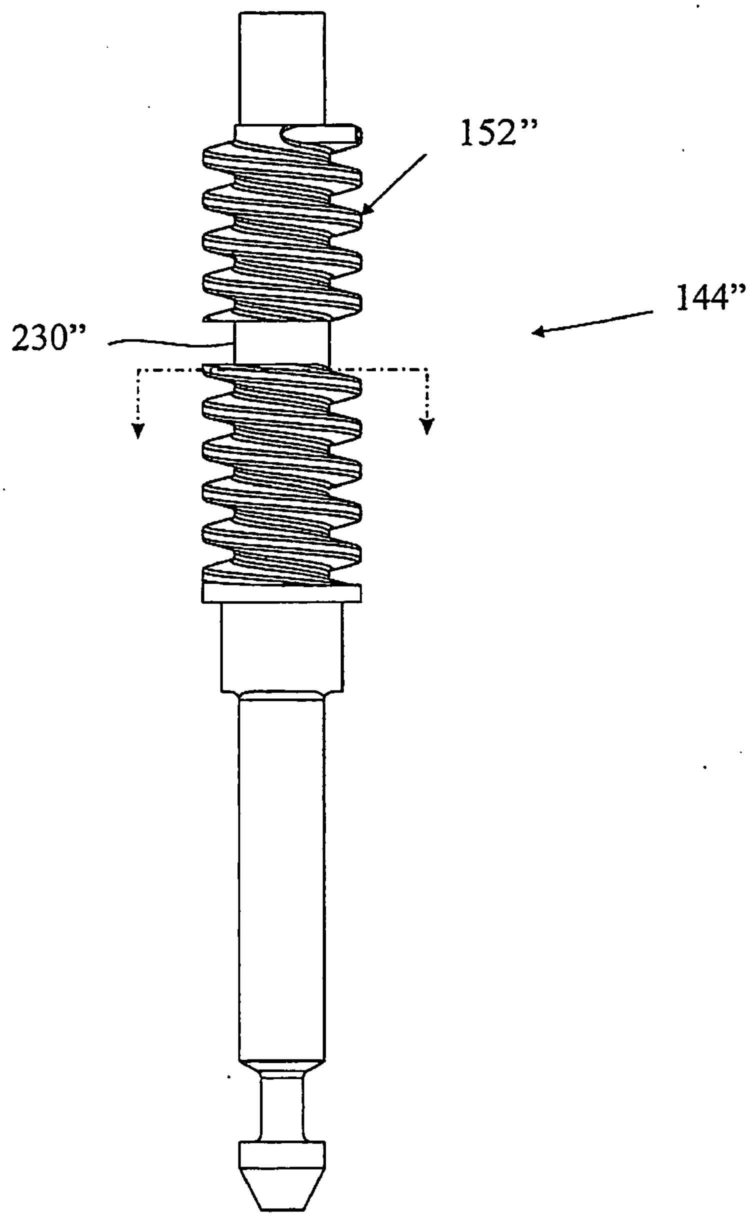

FiG 22

REFERENCES CITED IN THE DESCRIPTION

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