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 Applicant : **ASCOLECTRIC LIMITED**
No. 10 Airport Road
Brantford, Ontario N3T 5M8 (CA)

Inventor : **Dry, Alan, George**
Cambridge RR 6
Ontario N1R 537 (CA)
 Inventor : **Davis, Jeffery, Alen**
22 Belhome Ave.
Brantford, Ontario N3T 1S1 (CA)
 Inventor : **Dunham, Michael, Stewart**
275 Darling Street
Brantford, Ontario N3S 3X7 (CA)
 Representative : **Weydert, Robert et al**
Dennemeyer & Associates Sarl P.O. Box 1502
L-1015 Luxembourg (LU)

Linear drive with cylinder without piston rod.

The linear drive has a one piece main body (3) with an elongate cylinder (5) therein, and a piston (9) moveable longitudinally within the cylinder (5). The main body (3) has an elongate cylinder slot (11) extending lengthwise thereof in communication with the cylinder (5) along its entire length. A carriage (13) is moveable along the cylinder (5) on the exterior of the main body (3) and a force transmitting member (17) is coupled to the piston (9) and extends radially outwardly of the cylinder (5) through the slot (11) for transmitting force from the piston (9) to the carriage (13) for effecting movement of the carriage (13). In elongate bearing cavity (19) is provided within the main body (3). A bearing body (29) is received within the bearing cavity (19) and is coupled to the force transmitting member (17) and to the carriage (13). The bearing body (29) has a plurality of bearings (33) for transmitting reaction forces to the main body (3) with minimal friction while holding the piston (9) against binding as it moves within the cylinder (5). For sealing the linear drive during movement, internal and external seals (41, 49) are provided.

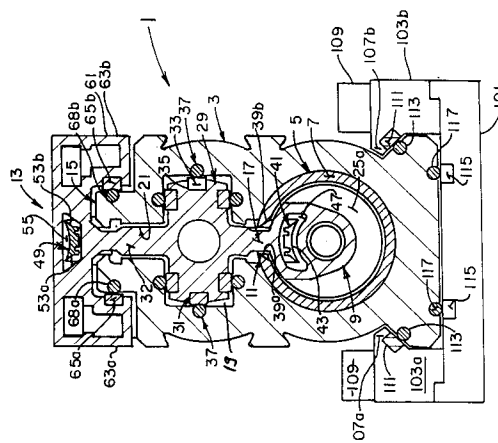


FIG. 7.

Background of The Invention:

This invention relates generally to a fluid operated linear drive for effecting reciprocable translation movement to an application, and is particularly adapted to effect the repeated application of force to a particular application, such as the repeated movement of a robotic arm or the like. Of course, it will be recognized that there are many other applications for such linear drives.

As shown in U.S. Patent 3,820,446, a linear drive or dual acting fluid pressure cylinder is disclosed having an elongate piston disposed within the cylinder and a mounting plate extending outwardly through a slot of the cylinder. A sealing strip is provided to seal the slot and yet to permit the mounting plate to pass through the slot and to move lengthwise thereof.

U.S. Patent 4,373,427 describes a fluid pressure cylinder which is generally similar to the fluid pressure cylinder disclosed in the above noted U.S. Patent 3,820,446 having an elongate piston moveable with the cylinder and a mounting plate or force transmitting bracket. In this patent, the seal for the cylinder slot is of a two piece laminated construction of a partially magnetized elastomeric material for magnetic attraction to the cylinder wall adjacent the slot.

U.S. Patent 4,545,290 discloses another pressure cylinder similar to the above described units in which the seal is an inverted T-shaped member lower seal member which closes the cylinder slot and which may be disengaged therefrom for passage of the force transmitting bracket along the path. An upper seal closes the cylinder slot from above.

Reference may also be made to U.S. Patents 4,555,980, and 4,829,881 which disclose alternative seal constructions for such pressure fluid cylinders.

In general, fluid pressure cylinders, as described in the above identified prior U.S. Patents, worked well for their intended purpose. However, reaction forces could be transmitted to the piston which resulted in binding action of the piston in the cylinder.

Attention is also drawn to U.S. Patents 4,724,744, 4,813,341 and 4,852,465 which disclose power cylinders or linear drives which have elongate bearing arms on the exterior of the cylinder main body journal the carriage on bearing rods as it moves longitudinally along the main body thereby to react out (i.e., transfer into the main body) forces applied to the carriage by its application or vice versa. While such the prior power cylinders or fluid power units having exteriorly mounted bearing rods did react out such forces, the external bearing rods were exposed to grit and contaminants which caused wear and inaccuracy of the linear drive. Also, with such externally mounted bearing rods on opposite sides of the unit, it was difficult to fully constrain the movable portions of the linear drive against lateral and vertical reaction forces which could result in binding of the piston.

Reference may also be made to U.S. Patent 4,601,234 and European Patent Specification 190,760 showing linear drives or fluid pressure units in the same general field as the present invention.

Summary of The Invention:

Among the several features and objects of the present invention may be noted the provision of a fluid powered linear drive in which a bearing body is located within the main body and is slidably journaled relative to the main body so as to effectively constrain the bearing body relative to the cylinder body and to transfer reaction forces to the cylinder body which would cause binding of the piston within the cylinder with minimum friction as the piston and carriage move lengthwise of the cylinder throughout its stroke;

The provision of such a linear drive in which the bearing body is sealed to minimize contamination and wear by dirt, grit, and the like;

The provision of such a linear drive in which the journal bearings and the bearing members journaling the bearing body are readily replaceable such that a worn linear drive may readily be refurbished;

The provision of such a linear drive including a pliable external and internal seal or a combined external/internal seal;

The provision of such a linear drive having a pliable cylinder slot seal which may be repeatedly removed from and resealed with the cylinder slot substantially without wear to the seal;

The provision of such a linear drive in which the bearing members (preferably of steel, stainless steel or the like) are substantially harder than the main body of the linear drive unit (typically extruded aluminum) such that the main body is subjected to little or no wear over a long service life of the linear drive; and.

The provision of such a linear drive unit which is economical to manufacture, which is reliable, and which has a long service life.

Briefly stated, a linear drive of the present invention comprises a one piece main body having an elongate cylinder therewithin. A piston is slidably, sealably disposed within the cylinder and is moveable longitudinally of the cylinder throughout its stroke by pressurized fluid introduced into the cylinder and acting against one face of the piston. The main body has an elongate cylinder slot extending lengthwise thereof in communication with the cylinder along substantially the entire length of the cylinder. A carriage is moveable along the main body on the exterior thereof. Means for transmitting force from the piston to the carriage for effecting movement of the carriage. The force transmitting means is coupled to the piston intermediate its ends extends radially outwardly from the cylinder through the cylinder slot. An elongate bearing cavity is provided within the main body intermediate the cylinder slot and the carriage. A bearing body is

received within the bearing cavity and is coupled to the piston and to the carriage by the force transmitting means for reacting forces into the main body as the piston and the carriage are moved longitudinally of the main body. The bearing body has a plurality of bearings for constraining the bearing body within the bearing cavity and for transferring reaction forces to the main body with minimum friction. An external and internal seal or a combined external/internal seal is used with the linear drive.

Other objects and features of this invention will be in part apparent and in part pointed hereinafter.

Brief Description of The Drawings:

FIG. 1 is a perspective view of a linear drive unit of the present invention illustrating a carriage moveable along a carriage track on the exterior of the main body of the linear drive;

FIG. 2 is a perspective view of the linear drive unit with the main body partially omitted illustrating certain internal components;

FIG. 3 is a longitudinal cross-sectional view of the linear drive;

FIG. 4 is a perspective view of a portion of the main body illustrating a cylinder, a bearing cavity, a cylinder slot, a carriage track, and a carriage track slot;

FIG. 5 is an end elevational view of FIG. 4;

FIGS. 6 and 7 are cross-sectional views on an enlarged scale taken along lines 6--6 and 7--7, respectively, of FIG. 3;

FIGS. 8 and 9 are similar to FIGS. 5 and 6, illustrating wire journals received in grooves around the bearing cavity, a cylinder sleeve received in the cylinder bore, and pliant seals received in the cylinder slot for sealing the cylinder and received in a slot in a carriage track for sealing the bearing cavity against debris and contaminants;

FIGS. 10A and 10B illustrate cylinder plugs at each end of the cylinder for cushioning the piston; FIG. 11 is an enlarged perspective view of the cylinder slot and an alternative seal of the present invention.

FIG. 12 is an enlarged cross-sectional view similar to FIG. 6 which shows a different construction for the elongate pliable external and internal slot seals;

FIG. 13 is a substantially enlarged cross-sectional view of the elongate pliable external slot seal used in the FIG. 12 linear drive assembly;

FIG. 14 is also a substantially enlarged cross-sectional view of the elongate pliable internal slot seal used in the FIG. 12 linear drive assembly;

FIG. 15 is a perspective view of a modified form of a main body in the linear drive assembly, together with an elongate pliable external slot seal;

FIG. 16 is a substantially enlarged cross-sectional view of the elongate pliable external slot seal releasably and sealably engaged within the external slot of the modified main body of the linear drive shown in FIG. 15;

FIG. 17 is a perspective view of a modified linear drive unit of the present invention illustrating a carriage movable along outer surfaces of a cylinder main body;

FIG. 18 is a cross-sectional view of the modified linear drive unit shown in FIG. 17 of the drawings; FIG. 19 is a cross-sectional view of the cylinder main body illustrated in the modified version of the linear drive unit shown in FIGS. 17-18 together with a single elongate pliable slot seal; FIG. 20 is a substantially enlarged cross-sectional view of the single elongate pliable slot seal used in the cylinder slot of the cylinder main body shown in FIG. 19;

FIG. 21 is a cross sectional view similar to FIG. 19 showing a modified form of single elongate pliable slot seal used with the cylinder slot modified version of the linear drive unit shown in FIGS. 17-18; and

FIG. 22 is a substantially enlarged cross sectional view of the modified form of a single elongate pliable slot seal shown in FIG. 21.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Description of Preferred Embodiment:

Referring now to the drawings, and more particularly to FIGS. 1-3, a linear drive of the present invention is indicated in its entirety by reference character 1. The linear drive comprises a one piece main body 3 preferably constituted by an integral extrusion of aluminum or other similar material. Drive body 3 preferably has an elongate cylinder 5 therewithin receiving a cylinder sleeve 7 preferably of a material harder than main body 3. For example, cylinder sleeve 7 may be of hard coated aluminum, steel or the like. It will be understood, however, that in certain linear drives of the present invention, the cylinder may be constituted by a bore in drive body 3 and a cylinder sleeve may not be necessary.

A piston assembly, as generally indicated at 9, is slidably, sealably moveable within the bore of cylinder sleeve 7 from one end thereof to the other constituting its stroke. When the cylinder sleeve is pressurized with a suitable pressurized fluid (e.g., pressurized air) introduced into the cylinder from one end thereof so as to act against an adjacent face of the piston assembly, the piston moves longitudinally within the cylinder sleeve. A cylinder slot, as generally indicated at 11, is provided within the main body and within the cylinder sleeve 7 and extends generally lengthwise of the main

body and cylinder sleeve and is in communication with the interior of the bore of the cylinder sleeve along substantially the entire length thereof. A carriage, as generally indicated at 13, on the exterior of the linear drive is moveable lengthwise thereof. Carriage 13 is reciprocally mounted on main body 3. As shown in FIGS. 1-9, the carriage is reciprocally mounted on a carriage track 15 integral with main body 3. However, within the broader aspects of this invention, carriage track 15 may not be required. Means, as generally indicated at 17, is coupled to piston assembly 9 and extends generally radially outwardly from the cylinder through cylinder slot 11 and is further coupled to carriage 13 for transmitting force from the piston to the carriage for effecting movement of the carriage along carriage track 15 on the exterior of main body 3 in response to movement of piston assembly 9. As perhaps best shown in FIGS. 4 and 5, a bearing cavity 19 is provided within main body 3 and extends longitudinally of the main body in an axial direction co-linear to cylinder 5 between cylinder 5 and carriage track 15 with cylinder slot 11 extending between cylinder 5 and bearing cavity 19. A carriage or track slot 21 extends from bearing cavity 19 through carriage track 15 to the outer most face of the carriage track.

Referring to FIG. 3, piston assembly 9 is shown to comprise a piston body 23 spacing apart pistons 25a, 25b at each end thereof, each piston carrying a respective circumferential piston seal 27a, 27b for sealing its piston to the bore of cylinder sleeve 7. Force transmitting member 17 is attached to piston body 23 intermediate pistons 25a, 25b. The force transmitting member extends radially outwardly of cylinder sleeve 7 through cylinder slot 11. An elongate, cruciform-shaped bearing body, as generally indicated at 29, is secured to (or is integral with) force transmitting member 17. Bearing body 29 is received in bearing cavity 19 and is constrained against lateral and vertical movement relative to the bearing cavity by bearing means, as generally indicated at 31, for reacting forces into main body 3 as piston 9 and carriage 13 are moved longitudinally of the main body and as force is transferred from piston 9 to the application (not shown) coupled to carriage 13 or vice versa. Bearing body bearing means 31 permit longitudinal movement of the bearing body within bearing cavity 19 with minimal friction while accurately constraining the bearing body within the bearing cavity and reacting out the above-noted forces. As further shown in FIG. 3, bearing body 29 has an upper reach 32 which is rigidly secured to carriage 13. Upper bearing body portion 32 extends radially outwardly of the main body through carriage track slot 21 and constitutes a portion of force transmitting means 17.

Referring to FIGS. 6 and 7, bearing body bearing means 31 is shown to comprise a plurality of elongate strips or bars 33 of suitable low friction plastic resin bearing material, such as a non-metallic high press-

ure bearing material commercially available under the trade designation Murlubric from Murtfeld Plastics of Germany. These bearing bars 33 are inserted in grooves 35 on the side, top, and bottom faces of bearing body 29. Bearing bars are held longitudinally in grooves 35 by means of removable bearing member end plates 36 held in place on bearing body 29 by screws 36a (see FIGS. 3 and 6) at each end thereof.

In accordance with this invention, main body 3 carries a plurality of bearing members, as generally indicated at 37, in generally circular grooves 39 formed in the portion of main body 3 defining bearing body cavity 19. Grooves 39 are perhaps best illustrated in FIGS. 4 and 5. Preferably, bearing body cavity bearings 37 comprise elongate steel wires inserted in grooves 39 with the diameter of the wires and the location of grooves 39 relative to bearing body cavity 19 being such that at least a portion of the bearing wires extend inwardly of the bearing cavity beyond the surfaces of main body 3 defining the bearing cavity. The bearing wires are in register with the elongate bearing body bearing members 33. In this manner, the low friction bearing members 33 positively engage bearing wires 37 so as to constrain the bearing body in both vertical and lateral direction, as viewed in FIGS. 6 and 7, with minimal backlash or "slop" while permitting axial movement of force transmitting member 17 and the carriage in lengthwise direction with piston assembly 9 with minimal friction. Accordingly, bearing body 29 effectively transfers force from piston assembly 9 to carriage 13, and, at the same time, is tightly constrained relative to main body 3 and reacts out reaction forces that may be applied to carriage 13 by its application (not shown). Thus, reaction forces are not transmitted to piston assembly 9 which may cause binding of the piston assembly within cylinder sleeve 7. If necessary, low friction bearing members 33 may be shimmed relative to bearing body 29 so that the outer faces of bearing members 33 snugly engage bearing wires 37 so as to take up dimensional tolerances and to properly constrain the bearing member within bearing cavity 19.

As perhaps best shown in FIGS. 6-9, cylinder sleeve 7 has an elongate beveled slot 39 extending lengthwise thereof which constitutes at least a portion of cylinder slot 11. A dove-tail shaped pliable cylinder slot seal, as generally indicated at 41, preferably, of a pliant elastomeric material, such as Nylon 6 commercially available from Bayer. Seal 41 has an inner part circular face 43, and beveled side faces 45a, 45b adapted to sealably mate with beveled side faces 39a, 39b of cylinder sleeve 7 defining cylinder slot 39. The ends of seal 41 are attached to end plates 73a, 73b (as hereinafter described) by attachment screws 42. As noted above, within the broad aspects of this invention, it may not be necessary or desirable to provide main body 3 with a cylinder sleeve 7. Instead, the cylinder 5 may be constituted by a bore in the main

body. In such constructions where no cylinder sleeve 7 is provided, it will be understood that the above-described beveled faces may be provided directly in the portions of main body 3 defining cylinder slot 11.

As shown in FIGS. 8 and 9, cylinder slot seal 41 is longitudinally undercut along its length adjacent the apexes of beveled sleeve side faces 39a, 39b in such manner as to positively engage (i.e., to snap fit on) the ends of the beveled sleeve side faces thereby to releasably hold seal 41 in place in cylinder sleeve slot 39. Of course, it will be appreciated that upon pressurizing the cylinder sleeve with suitable pressurized fluid, the pressure forces act against the part circular inner face 43 of seal 41 to force the beveled side faces 45a, 45b of the seal 41 into positive sealing engagement with the corresponding beveled side faces 39a, 39b of the cylinder slot in cylinder sleeve 7.

As shown in FIG. 11, an alternative cylinder slot seal is shown in its entirety by reference character 41'. Seal 41' has grooves 201a, 201b in its beveled side faces 45a', 45b' and grooves 203a, 203b in its upper face. The seal is preferably extruded of a suitable polyurethane or the like so as to resist wear and fatigue. However, such materials are often stiff and offer poor performance in resiliency and in affecting pressure sealing.

As indicated at 205a, 205b, elongate rod seals of a more resilient (soft) elastomeric material (e.g., Neoprene or the like) are inserted in respective grooves 201a, 201b on the beveled side faces 45a', 45b' of seal 41' so as to sealingly engage the beveled side faces 39a, 39b of cylinder sleeve 7. In this manner, the elongate rod seals reliably seal the slot along their entire length and thus form a line seal against beveled side faces 39a, 39b. Such line seals generally more reliably make a seal than face seals. Of course, during pressure sealing, the pressure forces acting on the inner face 43' of seal 41' cause the grooves 201a, 201b to sealingly grip their respective rods 205a, 205b.

As indicated at 207a, 207b, seal 41' is undercut at the upper end of side faces 45a', 45b' to snap fit over the outer ends of bevel faces 39a, 39b of cylinder sleeve 7. Soft elongate rods 209a, 209b are inserted in top grooves 203a, 203b to permit flexing of undercuts 207a, 207b during insertion and removal of seal 41' to and from cylinder slot 11.

As best shown in FIG. 3, cylinder slot seal 41 is adapted to be positively drawn out of cylinder sleeve slot 39 (i.e., to "tunnel" downwardly) into the bore of cylinder sleeve 7 to extend through a tunnel 47 in force transmitting member 17 intermediate piston ends 27a, 27b and then to "tunnel upwardly" between piston ends 25a, 25b of piston assembly 9 and to remake a seal with the beveled side faces 39a, 39b of cylinder sleeve slot 39. In this manner, it is possible for the force transmitting member 17 to extend radially outwardly from piston 9 through cylinder slot 39 to

bearing body 29 and for the seal to be in place sealing the cylinder slot beyond piston seals 27a, 27b of piston assembly 9.

Similar to cylinder slot seal 41, a carriage or track slot seal 49 is removably, sealably mated with portions of main body 3 defining the carriage track 15 defining carriage slot 25 therethrough for the purpose of preventing debris, particles, and other contaminants from entering the track slot and fouling bearings 33 and 37 within bearing cavity 19. More specifically, track slot dirt seal 49 is a pliant elongate seal made of suitable elastomeric material available from Bayer under the trade designation Durothane. Track seal 49 is attached at its ends to main body 3 by screws 50 and extends the entire length of the carriage slot 33. As perhaps best seen in FIGS. 4 and 5, carriage slot 25 has opposed beveled side faces 51a, 51b at the upper ends thereof. Carriage slot seal 49 has corresponding beveled side faces 53a, 53b (see FIGS. 6-9) which sealingly mate with beveled side faces 51a, 51b from above, thus permitting the carriage slot seal to be sealably pressed downwardly into carriage slot 25 from above thereby to seal the carriage slot, to be unsealed from beveled faces 51a, 51b and moved upwardly away from the carriage slot so as to permit the upper portion 33 of force transmitting 37 and carriage 13 to move longitudinally of carriage slot 25, and to be re-sealed on the opposite side of the force transmitting member thereby to re-close the carriage slot intermediate the ends of carriage 13 thereby to prevent the entrance of grit, dirt, and other contaminants. As shown in FIGS. 3 and 7, upper member 33 of force transmitting 17 has an upper tunnel 55 therethrough receiving seal 49 and permitting the seal to extend longitudinally through the tunnel. In this manner, as piston 9 moves in one direction, seal 49 tunnels upwardly through tunnel 55 and is lifted up from carriage slot 25 on the side of the carriage toward the direction of movement of the carriage. Upon movement of the carriage, seal 49 tunnels down to remake its seal with beveled side faces 51a, 51b. As best shown in FIGS. 1-3, 6 and 7, end caps or plates 57a, 57b are provided on the outer ends of carriage 13 and are generally U-shaped so as to accommodate carriage track 15. A shoe-seal or wiper 59, as perhaps best shown in FIGS. 2 and 3, is mounted on the bottom of end plates 57a, 57b. Preferably, shoe-seal 59 has a resilient foam scrapper 60 at the center thereof to press down on the upper face of carriage slot seal 49 thereby to resiliently force the track slot seal into sealing engagement with beveled faces 51a, 51b of the carriage slot and further to wipe on the upper and side surfaces of carriage track 15 thereby to seal the interior of carriage body 13 relative to the side and upper faces of carriage track 15 and relative to the upper face of seal 49. In this manner, even though seal 49 is lifted clear of the carriage slot intermediate the ends of carriage 13, the track slot is re-sealed

thereby preventing the entrance of debris and other contaminants into track slot 21 and to protect bearings 33 and 35.

Referring to FIG. 7, carriage 13 comprises a unitary carriage body extrusion 61 which is rigidly secured to the upper portion 33 of force transmitting means 17 so as to insure that the carriage moves with piston assembly 9. Generally, carriage extrusion body 61 is an inverted channel-shaped member having a central opening adapted to fit over and to receive carriage track 15. Seal tunnel or opening 55 extends through the upper center portion of the carriage extrusion and is adapted to receive seal 49. The channel-shaped carriage extrusion body 61 has downwardly extending track flanges 63a, 63b. These track flanges carry low friction sliding bearing blocks or strips 65a, 65b facing inwardly toward the sides of carriage track 15. As shown best in FIGS. 4 and 5, carriage track 15 has elongate grooves 67a, 67b on its outer faces thereof which receive respective wire bearing members 68a, 68b which are slidably engaged by carriage bearing blocks 65a, 65b so as to hold carriage centered with respect to carriage track 15 and to aid in constraining the carriage against lateral or rocking movement with minimal friction. In the event high lateral or rolling loads are applied to carriage 13, a bearing bar 65a or 65b will engage its respective bearing wire 68a or 68b and thus transfer a substantial portion of this lateral load to main body extrusion 3. This, in turn, prevents localized application of this lateral load to only a portion of carriage track 15 thus preventing distortion of slot 21. It will be appreciated that with carriage end caps 57a, 57b securely held in place on the ends of carriage extrusion body 61, low friction bearing members 65a, 65b are held longitudinally in place with respect to the carriage body.

Referring now to FIG. 3, it will be seen that at each end of cylinder sleeve 7, a one piece cylinder plug, as generally indicated at 69a, 69b, is inserted into each end of the cylinder sleeve and is sealed with respect to the bore of the cylinder sleeve by means of respective circumferential seals 71. The cylinder plug 69a, 69b are sealably held in place by end plates 73a, 73b which are in turn fixedly secured to the ends of main body 3 by means of suitable screws or bolts 74. End plates 73a, 73b also engage the ends of wire bearings 37 and 68a, 68b thus preventing longitudinal movement thereof.

Each of the cylinder plugs 69a, 69b includes an air valve 75 which may be connected to a supply of compressed air (not shown) permitting pressurized air (or other suitable pressurized gas or low pressure liquid) to be admitted into one end of the cylinder thereby to act against the adjacent face of piston assembly 9 to effect axial movement of the piston assembly within the cylinder away from the end of the piston into which the pressurized air is admitted.

As shown at each end of cylinder 5, means, as

generally indicated at C, is provided for cushioning piston 9 at the end of its stroke. More specifically, cushioning means C comprises a tube 77 integral with its plug body 79 having an axial bore 81 extending therethrough with bore 81 being in communication with air inlet valve 75. A corresponding coaxial blind bore 83 is provided in the end face of piston each body 25a, 25b so as to receive tube 77 as the piston moves toward the end of its stroke (as shown in FIG. 10B). A relatively wide circumferential groove 85 is provided around bore 83 loosely receives an O ring assembly 87 in such manner that the O ring assembly is able to shift axially within groove 85 in a manner and for purposes as will appear. A port 89 is in communication with groove 85 and the end face of the piston body. It will further be noted that the outer end of tube 77 is tapered, as indicated at 90.

Referring to FIG. 10B, it will be seen as piston 25a moves toward cylinder plug 69a as the carriage moves toward the end of its stroke, bore 83 in the end face of piston body 25a coaxially receives the outer end of tube 77. Tube 77 has a diameter slightly larger than the inner diameter of O ring assembly 87 thereby allowing a sealing fit with the O ring assembly. Continued movement of piston body 9 in the direction of the arrow in FIG. 10B toward cylinder plug 69a causes O ring assembly 87 to shift within groove 85 and to be lodged against the innermost edge of groove 85 thus forming an expansible chamber constituted by the end portion of blind bore 83 and the bore 81 in tube body 77. A radial bore 91 and an intersecting longitudinal bore 93 within cylinder plug body 79 provide communication with the interior of cylinder 5. As shown best in FIG. 3, a metering screw 95 installed in bore 93 regulates the rate at which compressed air trapped within cylinder 5 is exhausted from air valve 75 via bores 91 and 93 thereby to trap air ahead of the advancing piston head on the non--pressurized end of the piston assembly and to release it at a controlled rate so as to pneumatically cushion the piston at the end of its stroke. More particularly, as piston 25a moving in the direction of the arrow in FIG. 10B approaches cylinder plug 69a, the tapered outer end 90 of tube 77 enters bore 83 in the end face of the piston 25a and engages O ring assembly 87 so as to slide the O ring assembly toward the right toward the inner edge of groove 85 thereby to effect a seal on the outer surface of tube 77. Upon continued movement of the piston toward plug 69a, air within cylinder 5 is compressed thus cushioning movement of the piston as it nears the end of its stroke. The compressed air within the cylinder is bled from the cylinder by metering screw 95 and exhausted port 75 in a controlled manner thus controlling the cushioning movement of the piston.

With the piston 25a received on tube 77 of plug body 69a, pressurized air may be admitted into bore 81 of tube 77 by air inlet valve 75 thereby to effect

movement of the piston assembly 9 in the opposite direction within cylinder 5. This causes pressurized air to initially pressurize bore 83 of the piston body to a relatively high pressure level which initially displaces O ring assembly 87 in gland or groove 85 from the position shown in FIG. 10B generally to the opposite side of groove 85, as shown in FIG. 10A. Then, pressurized air from bore 83 is then permitted to flow around tube 77 and into cylinder 5 via port 89. As air is admitted into the cylinder, it acts against the end face of piston body 25a and effects movement of the piston body within cylinder sleeve 7 in the direction of the arrow as shown in FIG. 10A. Of course, as the piston moves clear of tube 77, entering pressurized air then directly pressurizes the cylinder. It will be understood that the purpose of cushioning means C, as above-described, is to gently cushion or slow movement of the piston at the end of its stroke, but to allow startup of the piston in a rapid or breakaway manner at the start of its stroke.

Referring to FIGS. 1 and 4-7, it will be seen that the main body 3 is provided with an adjustable bracket mounting base at 99 at each end thereof for either adjustably securing drive unit 1 in place relative to its application and for permitting precise adjustment (positioning) of the drive unit relative to its application, or for permitted repeated reciprocal sliding movement of the cylinder on its base. More particularly, each bracket mounting base 99 comprises a base 101 extending transversely beneath the main body and having clamping or guide members 103a, 103b each side thereof extending upwardly therefrom. The drive body 3 has beveled shoulders 105a, 105b at the bottom thereof and clamping members 103a, 103b each have a cooperable angled flange 107a, 107b which overlies and faces its corresponding main extrusion body angled shoulders 105a or 105b, as best shown in FIGS. 4-6. A clamping or adjustment screw 109 draws its respective clamping members 103a, 103b forcibly downwardly relative to base 101 against its respective angled shoulder 105a, 105b. For a reciprocal sliding mount of the fluid cylinder on its application, a low friction bearing strip 111 is carried by the angled shoulders 105a, 105b of clamp members 103a, 103b. Likewise, a corresponding bearing wire 113 is received in a groove 114 (as best shown in FIGS. 8 and 9) of main body extrusion 3. Further, elongate low friction bearing strips 115 are provided in the upper face of clamp base 101 and are slidably engaged by bearing wires 117 carried in the bottom face of main body extrusion 3 in respective grooves 119, as best shown in FIGS. 8 and 9. Bearing wires 113 and 117 are of a relatively hard material (compared to main body extrusion 3), such as steel, stainless steel or brass. In this manner, by adjusting clamp bolts 109, main body 3 may be readily reciprocated in axial direction with respect to mounting bracket 99 on low friction bearing bars 111 and 115 and bearing

wires 113 and 117 while precisely held in a desired axis of movement without binding. If it is desired to fixedly clamp the fluid cylinder in a locked position with respect to its application, the low friction bearing bars 111 and 115 are replaced with suitable higher friction materials and then clamping bolts 109 are securely locked in place at any position along the length of main main body 3.

It will be understood that in certain applications for linear drive 1, carriage 13 may be securely mounted to a parent machine (not shown), such that actuation of the linear drive causes main body 3 to move longitudinally relative to clamp base 101 and clamps 103. Thus bearing bars 111 and 115 and respective bearing wires 113 and 117 serve to permit longitudinal movement of the main body with minimal friction and to accurately constrain the main body,

In operation of the linear drive unit 1 shown in FIGS. 1-11 of the drawings, the drive unit 1 is properly secured to its application (e.g., a robotic application) by mounting brackets 99 and with carriage 13 secured to its respective operating member of its application (also not shown). Pressurized fluid is admitted under pressure into one end of cylinder sleeve 7 by means of inlet valve 75 in a respective plug body 69a, 69b. As described above in regard to FIGS. 10A and 10B, the pressurized fluid initially acts upon bore 83 of piston body 25a so as to incipiently effect movement of piston 25a away from cylinder plug 69a. As the piston body 25a begins to move in the direction of the arrow in FIG. 10A, O ring 87 shifts within groove 85 thereby permitting pressurized fluid from bore 83 to flow through port 89 and to act against the entire end face area of piston of 25a.

Referring to FIG. 3, as the piston begins moving in one direction or the other, as piston head 25b moves axially within the cylinder sleeve 7, seal 41, behind piston head 25b is drawn from cylinder slot 11 and is drawn downwardly into cylinder sleeve 7 and passes through tunnel 47 in force transmitting member 17 so as to permit axial movement of force transmitting member 17 along cylinder slot 11. This in turn causes bearing body 29 to move axially within bearing cavity 19. Because piston 9 is rigidly interconnected with carriage 13 by force transmitting member 32, the carriage is caused to move as a unit with the piston. Of course, as carriage 13 moves along carriage track 15 on the exterior of main body extrusion 3, the upper track slot seal 49 is withdrawn upwardly from track slot 21 and is threaded through carriage tunnel 55 within the carriage extrusion body 61. This allows portion 32 of force transmitting member 17 to move axially through the track slot.

It will be appreciated that bearing members 33 carried by bearing body 29 and bearing wires or rods 37 carried by main body extrusion 3 around bearing cavity 19 and bearing blocks 65a, 65b carried by carriage extrusion 61 and corresponding bearing wires

68a, 68b carried on the outer faces of the carriage slot 15 constrain and accurately guide carriage 13 and piston 9 along their respective strokes with minimal friction and without binding. In this manner, fluid pressure force may be readily transmitted from piston assembly 9 to the carriage and reaction forces of the application of the carriage (not shown) to the piston are reacted against the main extrusion body 3.

Further referring to FIG. 3, as piston assembly 9 moves to the right, the portion of the track slot seal 41 exiting tunnel 55 is drawn downwardly toward the track slot seal by piston end 25a and the track slot is firmly pressed into place within the track slot such that the beveled faces 45a, 45b of seal 41 are sealingly mated with respective mating faces 39a, 39b of the portion of cylinder sleeve 7 defining track slot 11. The inner part circular face 43 of track slot seal 41 forms a portion of the circumference of the cylinder slot 7 and permits the pressurized fluid within the one end of the cylinder sleeve to fully pressurize the piston without leakage through the track slot.

After the track slot seal 49 has passed through tunnel 55 of carriage extrusion 61, the track slot seal is drawn downwardly toward the track slot by means of sliding seals or cushions 59 held in place by end caps 57a 57b on the carriage so as to positively press the track slot seal 49 into the track slot and to slidably seal against both the side and upper faces of the carriage track thereby to positively prevent dirt, debris, and other contaminants from migrating into the internal portions of the carriage 13 and to find their way into track slot 21. In this manner, the bearing members 33 and 37 are sealed against dirt and contaminants thus significantly increasing their service life.

In accordance with this invention, if, after a normal service life, it is desired to overhaul the drive unit, this may be readily accomplished by replacing seals 41 and 49, and by replacing the worn bearings and bearing wires 31 and 37 on the bearing block and the bearings and bearing wires 65a, 65b and 67a, 67b on the carriage. This may be readily accomplished by removing end plates 73a, 73b thus allowing the wire bearings 37 to be axially withdrawn from their respective wire slots 39 around bearing cavity 19 and for new bearing wires to be inserted therein. Likewise, end caps 36 on bearing member 29 may be removed to facilitate changing of bearing bars 33. It will be understood that since bearing wires 37 are preferably of steel or the like which is substantially harder than the aluminum main body extrusion, substantially all wear is born by the wire bearing members 37. Likewise, end caps 29 on the bearing body may be removed and the low friction bearing members 31 may be replaced. Similarly, end caps 57a, 57b on carriage 13 may be removed thus permitting replacement of the low friction strip 65a, 65b for the carriage.

Reference is now made to FIGS. 12-22 of the drawings which show a modified form of elongate pli-

able slot seal that may be used either the linear drive assembly shown in FIGS. 1-11 of the drawings or in a main body modification thereof illustrated in FIGS. 15-16 of the drawings or as a single elongate pliable slot seal in a single seal cylinder drive unit shown in FIGS. 17-22 of the drawings.

Referring first to FIGS. 12-13 of the drawings, the linear drive unit illustrated in FIGS. 1-11 of the drawings is shown in the cross-sectional illustration of FIG. 12, generally corresponding to FIG. 6, but with a modified form of elongate pliable slot seal for both the external seal and the internal seal, as shown in FIGS. 13-14 respectively. Unlike the FIGS. 1-11 embodiment where different constructions are used for the internal seal 41 and the external seal 49, the single elongate pliable slot seal 301 used in the FIG. 12 linear drive has substantially the same configuration whether used as an external seal as shown in FIG. 13 or as an internal seal as illustrated in FIG. 14.

The single elongate pliable slot seal 301, as shown in the external and internal slot seal applications of FIG. 13, FIG. 14, respectively, includes an extruded elastomeric body portion 303 having a shank section 305 and an enlarged head 307 at one outer end thereof. The enlarged head 307 preferably has the cross-sectional configuration illustrated where it first tapers away from the shank section 305, then extends in an axial direction for a short distance and finally assumes a curvilinear shape to meet the transversely extending outer face. The seal 301 further includes, at an opposite end of the shank section 305, a flexible sealing wiper 309, preferably a stainless steel sealing strip which is secured by an adhesive or other suitable method to the outer free end of the shank section 305. Opposite marginal edge portions 311, 311 of the flexible sealing wiper sealable engage spaced surfaces adjacent the external or internal slot, as will become apparent.

As shown in FIG. 13 of the drawings, the elongate pliable slot seal 301 sealably disengages and engages spaced surfaces adjacent the external or carriage slot 25 in the main body 3. In this connection, it will be noted that the enlarged head 307 engages the internal shoulders 313, 313 at the lower end of the beveled side faces 51A, 51B which taper downwardly and inwardly to the spaced internal shoulders 313, 313, on opposite sides of the external or carriage slot 25. Enlarged head 307 of the elastomeric body portion 303 of the seal 301 compressibly engages the internal shoulders 313, 313 so as to allow the enlarged head 307 to move below the internal shoulder 313, 313 for releasably holding the seal 301 in position relative to the external slot 25. As will be appreciated, the elastomeric enlarged head 307 has a width greater than the distance between the internal shoulders 313, 313, causing the enlarged head 307 to deform as it passes by the internal shoulders 313, 313 until it assumes a position generally illustrated in FIG.

13 of the drawings where the enlarged head 307 releasably holds the seal 301 in position relative to the external slot 25. In this position, the flexible sealing wiper 309, which extends laterally outwardly beyond the shank section 305 of the elastomeric body portion 303 and the enlarged head 307, is in position to sealably engage the downwardly and inwardly tapering bevel side faces 51A, 51B adjacent the external slot 25. For this purpose, the opposite marginal edge portions 311, 311 slidably and sealably engage the spaced downwardly and inwardly tapering bevel side faces 51A, 51B adjacent the external slot 25, throughout pressure differential changes in the linear drive assembly.

The seal 301 for use in sealing the internal slot 11, is illustrated in FIG. 14 as operating in generally the same way as in the FIG. 13 external slot application, with the following differences. In the first instance, note that the seal 301 is reversely positioned from the FIG. 13 external slot application. In this regard, the enlarged head 307 engages internal shoulders 315, 315 adjacent the internal slot 11, while the marginal edge portions 311, 311 of the flexible sealing wiper 309 are positioned to engage the spaced curvilinear or cylindrical surfaces 317, 317 on opposite sides of the internal or cylindrical slot 11. It will be further noted that opposite marginal edge portions 311, 311 in the seal 301 are illustrated in FIG. 14 as including tapered edges, as distinct from those shown in FIG. 13, in order to facilitate sealing of the spaced curvilinear or cylindrical surfaces 317, 317. The tapered edges are an optional variation which are useful in certain applications.

In both the external and internal slot applications shown in FIG. 13-14 of the drawings,, the shank section 305 of the seal 301 is laterally spaced from the spaced surfaces adjacent the slot in each case to enable the opposite marginal edge portions 311, 311 of the flexible sealing wiper 309 to firmly and sealably engage the spaced surfaces adjacent the slot, without pressure differential build up behind the flexible sealing wiper 309. Thus, no pressure can be trapped behind the stainless steel flexible sealing wiper 309 since no pressure can be accumulated between the flexible sealing wiper 309 and the shank section 305 of the elastomeric body portion 303. This will assure a firmer contact between the flexible sealing wiper 309 and the spaced surfaces adjacent the external or internal slot in the FIGS. 13-14 illustrations.

In addition to the FIGS. 1-11 linear drive assembly, the seal 301 may be used in a modified construction of the main body 3' illustrated in FIGS. 15-16 of the drawings. In this modification, the surfaces surrounding the external slot 25, have a different construction, as best illustrated in FIG. 16 of the drawings. The downwardly and inwardly tapering surfaces 319, 319 are substantially shorter in height than the side faces 51A, 51B shown in FIG. 13 of the drawings. At

the lower end of the shorter in height downwardly and inwardly tapering surfaces 319, 319, the internal shoulders 313, 313 are provided for engaging the enlarged head 307, in the same manner as described in connection with FIG. 13. However, at the upper end of the downwardly and inwardly tapering smaller in height surfaces 319, 319, a complementary configured recess 321, 321 may be provided (see FIG. 16) on opposite sides of the external slot 25 for receiving marginal edge portions 311, 311 of the flexible sealing wiper 309 therein. This provides a smooth and continuous upper surface and an enhanced dirt seal. Alternatively, as shown in FIG. 15 of the drawings, the flexible sealing wiper 309, with tapered or non-tapered edges, may simply rest upon the upper outer surface of the main body extrusion 3, as illustrated.

Reference is now made to FIGS. 17-22 of the drawings which illustrate a modified form of linear drive assembly 1' for use in single seal applications. In this regard, note that the one-piece main body 330 has an elongate outer body cylindrical configuration 331 and an elongate cylinder bore 333 formed therein. The one-piece main body 330 is preferably formed as an integral extrusion of aluminum or other similar material, with a supporting pedestal or foot 335, as best illustrated in FIGS. 17-18. A carriage 337 is movable along the cylinder body 330 exteriorly thereof. In this connection, note that the outer cylinder body 330 on opposite upper sides thereof at 339, 339 and the downwardly extending track flanges 341, 341 at 343, 343 have semi-circular openings for receiving solid or composite bearing members 345, 345 carried by the carriage 337 thus enables slidable movement of the carriage 337 relative to the cylinder body 330, along the outer corresponding semi-circular openings 339, 339 thereof.

As best seen in FIG. 18 of the drawings, means generally indicated at 347, is coupled to a piston assembly (not shown) and extends radially outwardly from the cylinder 333 through cylinder slot 349, for further coupling to the carriage 337, in order to transmit force from the piston (not shown) to the carriage 337 for effecting movement of the carriage 337 along the bearing members 345, 345 on the exterior of the body cylinder 330, in response to movement of the piston assembly (not shown). The general operation of the aforementioned components is the same as in the FIGS. 1-11 embodiment, differing principally in the modified shape and configuration of the various components, as illustrated.

Because of the aforementioned shape and configuration of the components constituting the modified linear drive assembly 1' together with the use of a single elongate pliable slot seal 301, as described in connection with FIGS. 19-22, the modified linear drive assembly 1' has a much smaller height and width, enabling the linear drive assembly 1 to be used in application environments where size and space are

limiting factors.

Reference is now made to FIGS. 19-22 of the drawings which shows the single elongate pliable slot seal 301 used in conjunction with the main cylinder body 330 of the modified linear drive assembly 1'. As described above, there is a single cylinder slot seal 349 which comprises both the internal and external slot seal in the modified linear drive assembly 1'.

In the enlarged cross-sectional view shown in FIG. 20 of the drawings, the single elongate pliable slot seal 301 operates much in the same manner as described in connection with the internal slot seal 301 in the FIG. 14 illustration. Note again the manner in which the enlarged head 307 of the elastomeric body portion 303 releasably engages the spaced internal shoulders 315, 315 in the cylindrical slot 349, while the opposite marginal edge portions 311, 311 of the flexible sealing wiper 309 slidably and sealably engage the spaced curvilinear or cylindrical surfaces 317, 317 on opposite sides of the cylindrical slot 349. Thus, the single elongate pliable slot seal 301 as shown in FIG. 20 may be used as both an external dirt seal and an internal pressure seal, as will be apparent.

FIGS. 21-22 shows a modified single elongate pliable slot seal construction in order to achieve the improved releasable holding of the seal 301, while achieving an enhanced internal dirt seal. In this connection, note in FIG. 22 that the enlarged head 307 has a modified shape for reception within complementary shaped outer recess surfaces 351, 351, as illustrated. Thus, the modified generally polygonally shaped enlarged head 307 fits within corresponding complementary shaped outer recess surfaces 351, 351, such that a smooth upper profile including the seal 301 and outer cylindrical body 330, offers an easy to clean outer surface area. Also, the complementary mating engagement between the generally polygonally shaped enlarged head 307 and the complementary shaped outer recess surfaces 351, 351 causes the seal 301 to be secure but releasably latched or held in place against inward pressure differential. The upper outer face of the elastomeric body portion 303 may have a flat surface 353 as shown in FIG. 20, or may be indented at 355 as shown in FIG. 22 to enhance the flexibility, and therefore the releasable locking action of the generally polygonally shaped enlarged head 307 for secure complementary mating engagement with the complementary shaped outer recess surfaces 351, 351.

In the modified drive assembly 1 described in connection with FIGS. 17-22 of the drawings, the single elongate pliable seal 301 enables the upper part of the carriage 337 to be much simpler, as well as lower in height, since it does not need to have a mechanism and channel to lift an upper seal out of and back into its corresponding slot at every passing, as would be the case of the drive assembly 1 shown

in FIGS. 1-11 of the drawings. The modified drive assembly 1', together with the single elongate pliable slot seal 301, provides a much simpler, smaller in dimension linear drive assembly where space and size in the desired application are limiting factors, as noted.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results are obtained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Claims

1. A linear drive comprising a main body having an elongate cylinder therein, a piston slidably, sealably disposed within said cylinder and being movable longitudinally throughout its stroke within said cylinder by pressurized fluid introduced into said cylinder and acting against one face of said piston, said main body having an elongate cylinder slot extending lengthwise thereof in communication with said cylinder along substantially the entire length of said cylinder, a carriage movable along said cylinder body exteriorly thereof, means coupled to said piston and extending generally radially out of said cylinder through said slot for transmitting force from said piston to said carriage for effecting movement of said carriage, means for sealing said cylinder slot permitting pressurization of said cylinder, an elongate bearing cavity within said main body intermediate said cylinder slot and said carriage, a bearing body received within said bearing cavity and coupled to said force transmitting means and to said carriage for reacting forces into said main body as said piston and said carriage are moved longitudinally of said main body, said bearing member having a plurality of bearings for transferring said reacting forces to said main body with minimal friction.
2. A linear drive as set forth in claim 1 wherein said bearing body bearings are of low friction synthetic resin bearing material for transmitting force between said bearing body and said main body.
3. A linear drive as set forth in claim 2 wherein portions of said main body defining said bearing cavity include bearing members carried by said main body engageable by said bearing body bearings.

4. A linear drive as set forth in claim 3 wherein said main body bearing members extend substantially continuously longitudinally of said bearing cavity for engagement by said bearing body bearings as said bearing body moves longitudinally of said main body with said piston. 5
5. A linear drive as set forth in claim 4 wherein said main body bearing members comprise elongate members of a material substantially harder than said main body. 10
6. A linear drive as set forth in claim 5 wherein said main body bearing members are lengths of wire extending longitudinally of said bearing cavity with portions of said wires extending at least partially into said bearing cavity and being slidably engaged by said bearing body bearings. 15
7. A linear drive as set forth in claim 6 wherein said wires are of hard bearing material and said main body is of aluminum. 20
8. A linear drive as set forth in claim 1 said sealing means comprises an elongate, pliable cylinder slot seal disengageable into said cylinder from portions of said main body defining said cylinder slot and drawn into said cylinder between the ends of said piston opposite from the end of said piston having said pressurized fluid acting thereagainst as said piston move longitudinally within said cylinder so as to permit said piston force transmitting means to pass through said cylinder slot, and sealingly engageable with said portions of said main body defining said cylinder slot from within said cylinder thereby to seal said cylinder slot so as to entrap pressurized fluid within one end portion of said cylinder and to permit said pressurized fluid to forcibly act against one adjacent face of said piston as the latter moves longitudinally within said cylinder. 25 30 35 40
9. A linear drive as set forth in claim 8 wherein said cylinder body comprises an exterior carriage track along which said carriage is movable, said carriage track comprising a portion of said main body having an outer face and opposed side faces, said carriage having opposed, inwardly facing carriage journal faces in close proximity with said track side faces. 45 50
10. A linear drive as set forth in claim 9 wherein said carriage journal faces are of suitable low friction synthetic resin material slidably engageable with elongate bearings on said track side faces. 55
11. A linear drive as set forth in claim 9 wherein said carriage track further comprises a track slot

extending between said track outer face and said bearing cavity, said force transmitting means extending from said bearing body through said track slot to said carriage.

12. A linear drive as set forth in claim 11 further comprising a pliable track slot seal sealably engageable with portions of said carriage track defining said track slot from said outer track face for sealing said track slot against dirt and contaminants from entering said track slot beyond the ends of said carriage said track slot seal being disengageable from said portions of said carriage defining said track slot, said track seal being disengaged from said track as said piston and carriage are moved longitudinally of said main body so as to permit passage of said force transmitting means along said track slot and being re-sealable with said portions of said carriage track.
13. A linear drive as set forth in claim 8 wherein said portions of said main body defining said cylinder slot are beveled faces angled radially outwardly of said cylinder and converging toward the center of said slot, said cylinder slot seal having an inner part circular face having a radius of curvature substantially equal to the radius of said cylinder and beveled side faces extending radially outwardly of said inner part circular face sealably engageable with said beveled faces of said cylinder slot such that said seal may be disengaged from said cylinder slot beveled faces and drawn into said cylinder so as to permit movement of said force transmitting means along said cylinder slot, and, after passage of said force transmitting means, said cylinder seal being moved toward said cylinder slot and re-sealed with respect to said cylinder slot beveled faces after passage of said force transmitting means, said inner part circular face of said cylinder seal constituting a portion of said cylinder permitting said pressurized fluid to act against an adjacent piston face.
14. A linear drive as set forth in claim 13 wherein the outer portion of said cylinder seal has means for the removable snap fit securement of said seal to portions of said main body defining said cylinder slot thereby to hold said cylinder slot seal in place in said cylinder slot, but to permit said cylinder slot seal to be readily disengaged from said cylinder slot beveled faces.
15. A linear drive as set forth in claim 11 further comprising an elongate pliable track slot seal sealably disengageable and engageable with portions of said track defining said track slot thereby to open said track slot so as to permit said force transmitting means to pass through and along said track

slot and so as to forcibly move said carriage along said track, and, after passage of said force transmitting means past a point, to re-seal said track slot behind said force transmitting means, said track seal being drawn outwardly of said track so as to open said track slot and moved toward said track slot to re-close the latter as said carriage moves along said track.

16. A linear drive as set forth in claim 15 wherein portions of said main body defining said track slot are beveled faces angling outwardly of said track slot and diverging away from said track slot, said track slot seal having an outer face and beveled side faces extending radially inwardly toward the center of the seal for sealingly mating with said beveled faces of said track slot such that said track slot seal may be disengaged from said track slot beveled faces and drawn away from said track so as to permit passage of said force transmitting means along said track slot and moved toward said track and re-sealed with respect to said track slot beveled faces upon passage of said force transmitting means.

17. A linear drive as set forth in claim 16 wherein said carriage has a wiper member at each end thereof for insuring sealing of said track slot seal in said track slot as said carriage moves therealong in one direction or the other.

18. A linear drive as set forth in claim 17 wherein said carriage wipers substantially seal the ends of said carriage with respect to said carriage track as said carriage moves along said track.

19. A linear drive as set forth in claim 1 further comprising an elongate pliable cylinder slot seal sealably engageable and disengageable with portions of said main body defining said cylinder slot from within said cylinder thereby to seal said cylinder slot so as to entrap pressurized fluid within one end portion of said cylinder and to permit said pressurized fluid to forcibly act against one adjacent face of said piston, said cylinder slot seal being disengaged from said portions of said main body defining said cylinder slot and drawn into said cylinder between the ends of said piston opposite from the end of said piston having said pressurized fluid acting thereagainst as said piston moves longitudinally within said cylinder so as to permit said force transmitting means to pass through said cylinder slot, and said cylinder slot seal being drawn toward said slot and re-sealed relative to said portions of said main body prior to being engaged by said piston face having said pressurized fluid acting thereagainst moves longitudinally within said cylinder, said linear drive

further comprising a pliable track slot seal-sealably engageable with portions of said carriage track adjacent said outer track face for sealing said track slot against dirt and contaminants from entering said track slot beyond the ends of said carriage and disengageable from said portions of said carriage track as said piston and carriage are moved longitudinally of said main body thereby to permit passage of said force transmitting means along said track slot and re-sealable with said portions of said carriage track after passage of said force transmitting means.

20. A linear drive as set forth in claim 13 wherein said cylinder slot seal has elongate grooves in its beveled side faces, said seal grooves receiving elongate seal rods of relatively soft elastomer or the like for sealing engagement along a line of sealing on the beveled side faces of said main body.

21. A linear drive as set forth in claim 20 wherein said seal has means for the snap fit removable securement of said seal to the upper ends of the beveled side faces of said main body defining a part of said cylinder slot.

22. A linear drive as set forth in claim 21 wherein said seal has longitudinal grooves therein adjacent said snap-fit securement means, said grooves receiving elongate rods of relatively soft material so as to facilitate the snap fit securement of said securement means onto said upper ends of the beveled side faces of said main body defining a part of said cylinder slot.

23. In a linear drive assembly, an elongate pliable slot seal sealably disengageable and engageable with spaced surfaces adjacent said slot, said seal including an elastomeric body portion having a shank section and an enlarged head at one outer end thereof, said enlarged head being compressively engageable by internal shoulder means in said slot and being capable of passing by said internal shoulder means for releasably holding said seal in position relative to said slot through said enlarged head, said seal at an opposite end of said shank section having a flexible sealing wiper which extends laterally outwardly beyond said shank section on opposite sides thereof, said flexible sealing wiper being capable of engaging spaced surfaces adjacent said slot which are axially spaced from said internal shoulder means, opposite marginal edge portions of said flexible sealing wiper slidably and sealably engaging said spaced surfaces throughout pressure differential changes in said linear drive assembly.

24. The elongate pliable slot seal as defined in claim 23 including two elongate pliable slot seals where one seal is used as an external slot seal and an identically constructed second seal is used as an internal slot seal, in order to engage spaced surfaces on opposite sides of said external slot and internal slot in said linear drive assembly.

25. The elongate pliable slot seal as defined in claim 24 wherein said external slot seal and said internal slot seal are reversely positioned in said linear drive assembly with the enlarged head of said external slot seal positioned inwardly, of said external slot while the flexible sealing wiper thereof engages spaced outer surfaces adjacent said external slot, and the enlarged head of said internal slot seal positioned outwardly of said internal slot while the flexible sealing wiper thereof engages spaced inner surfaces adjacent said inner slot.

26. The elongate pliable slot seal as defined in claim 23 wherein said seal comprises an internal slot seal in said linear drive assembly and the opposite marginal edge portions of said flexible sealing wiper engage spaced internal curvilinear surfaces of an elongate cylinder on opposite sides of an external slot in said linear drive assembly.

27. The elongate pliable slot seal as defined in claim 23 wherein said seal comprises an external slot seal in said linear drive assembly and the opposite marginal edge portions of said flexible sealing wiper engage spaced outer downwardly and inwardly tapering surfaces on opposite sides of an external slot in said linear drive assembly.

28. The elongate pliable slot seal as defined in claim 23 wherein said seal comprises an external slot seal in said linear drive assembly and said opposite marginal edge portions of said flexible sealing wiper on opposite sides of said shank section being received within a complementary configured recess on opposite sides of said external slot.

29. The elongate pliable slot seal as defined in claim 23 wherein the shank section of said seal is laterally spaced from the spaced surfaces adjacent said slot to enable the opposite marginal edge portions of said flexible sealing wiper to firmly and sealably engage the spaced surfaces adjacent said slot without pressure differential build-up behind said flexible sealing wiper.

30. The elongate pliable slot seal as defined in claim 23 wherein the enlarged head of said shank section is received within complementary shaped

outer recessed surfaces on opposite sides of said external slot.

31. The elongate pliable slot seal as defined in claim 23 wherein an outer face of said enlarged head is generally flat.

32. The elongate pliable slot seal as defined in claim 23 wherein an outer face of said enlarged head is indented.

33. The elongate pliable slot seal as defined in claim 23 wherein said flexible sealing wiper comprises a stainless steel strip secured to one end of the shank section of the elastomeric body portion.

34. The elongate pliable slot seal as defined in claim 33 wherein the opposite marginal edge portions of said stainless steel strip include tapered edges.

35. A linear drive comprising a main body having an elongate cylinder therein, a piston slidably, sealably disposed within said cylinder and being movable longitudinally throughout its stroke within said cylinder by pressurized fluid introduced into said cylinder and acting against one face of said piston, said main body having an elongate cylinder slot extending lengthwise thereof in communication with said cylinder along substantially the entire length of said cylinder, a carriage movable along said cylinder body exteriorly thereof, means coupled to said piston and extending generally radially out of said cylinder through said slot for transmitting force from said piston to said carriage for effecting movement of said carriage, means for sealing said cylinder slot permitting pressurization of said cylinder, including an elongate pliable slot seal sealably disengageable and engageable with spaced surfaces adjacent said cylinder slot, said seal including an elastomeric body portion having a shank section and an enlarged head at one outer end thereof, said enlarged head being compressively engageable by internal shoulder means in said cylinder slot and being capable of passing by said internal shoulder means for releasably holding said seal in position relative to said cylinder slot through said enlarged head, said seal at an opposite end of said shank section having a flexible sealing wiper which extends laterally outwardly beyond said shank section on opposite sides thereof, said flexible sealing wiper being capable of engaging spaced surfaces adjacent said cylinder slot which are axially spaced from said internal shoulder means, opposite marginal edge portions of said flexible sealing wiper slidably and sealably engaging said spaced surfaces throughout pressure differential changes in said linear drive

assembly.

- 36.** The linear drive as defined in claim 35 wherein said elongate pliable slot seal comprises both an external and internal slot seal for the cylinder slot in said linear drive. 5
- 37.** The linear drive as defined in claim 36 wherein the opposite marginal edge portions of said flexible sealing wiper engage spaced internal cylindrical surfaces of said elongate cylinder on opposite sides of said cylinder slot. 10
- 38.** The linear drive as defined in claim 37 wherein the enlarged head of said seal releasably engages internal shoulder means in said cylinder slot, and the shank section of said seal is laterally spaced from surfaces surrounding said cylinder slot in order to enable opposite marginal edge portions of said flexible sealing wiper to firmly and sealably engage the spaced internal cylindrical surfaces of said elongate cylinder without pressure differential build-up behind said flexible sealing wiper. 15 20

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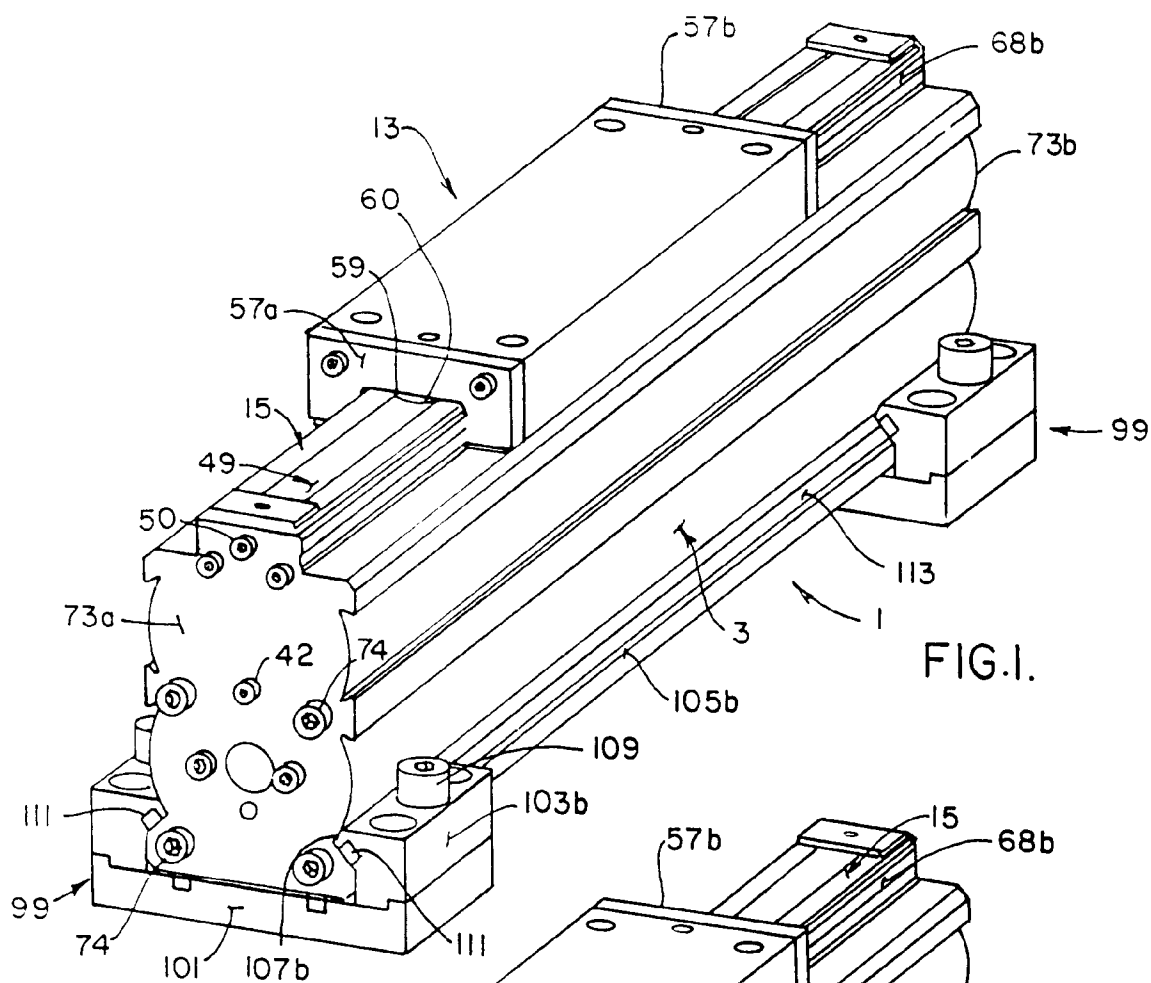


FIG.1.

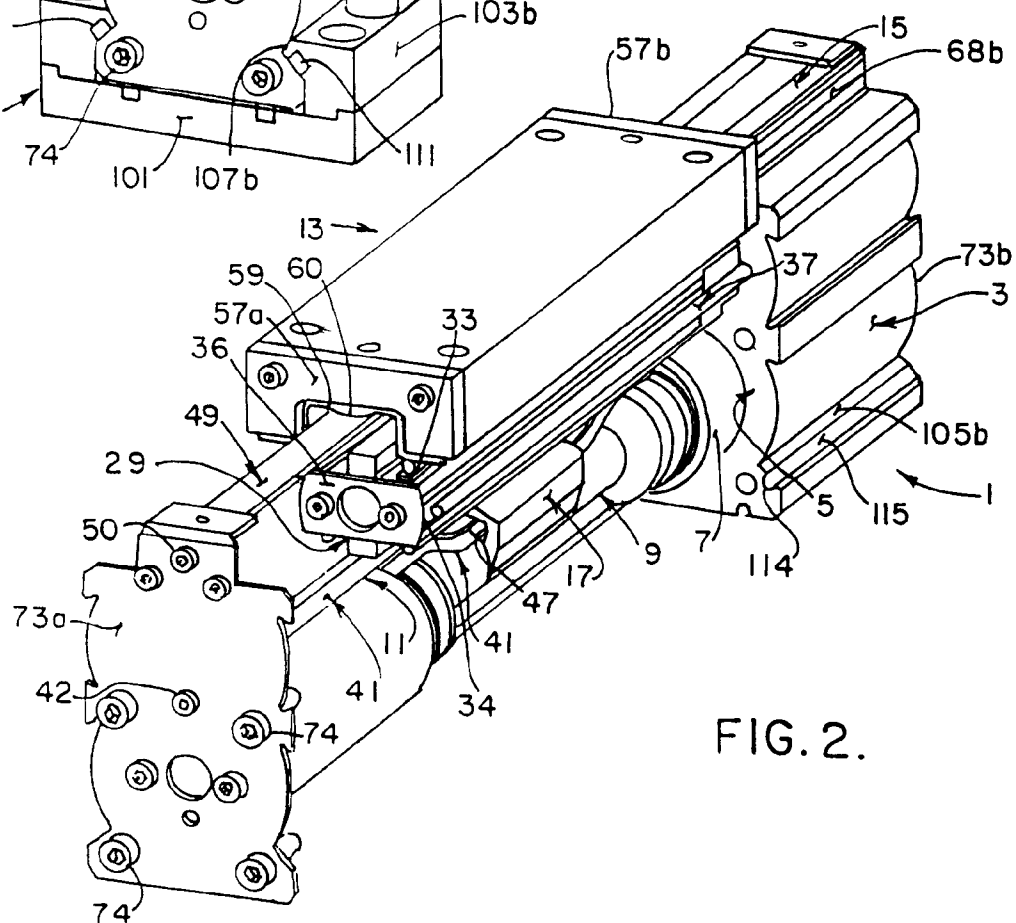


FIG. 2.

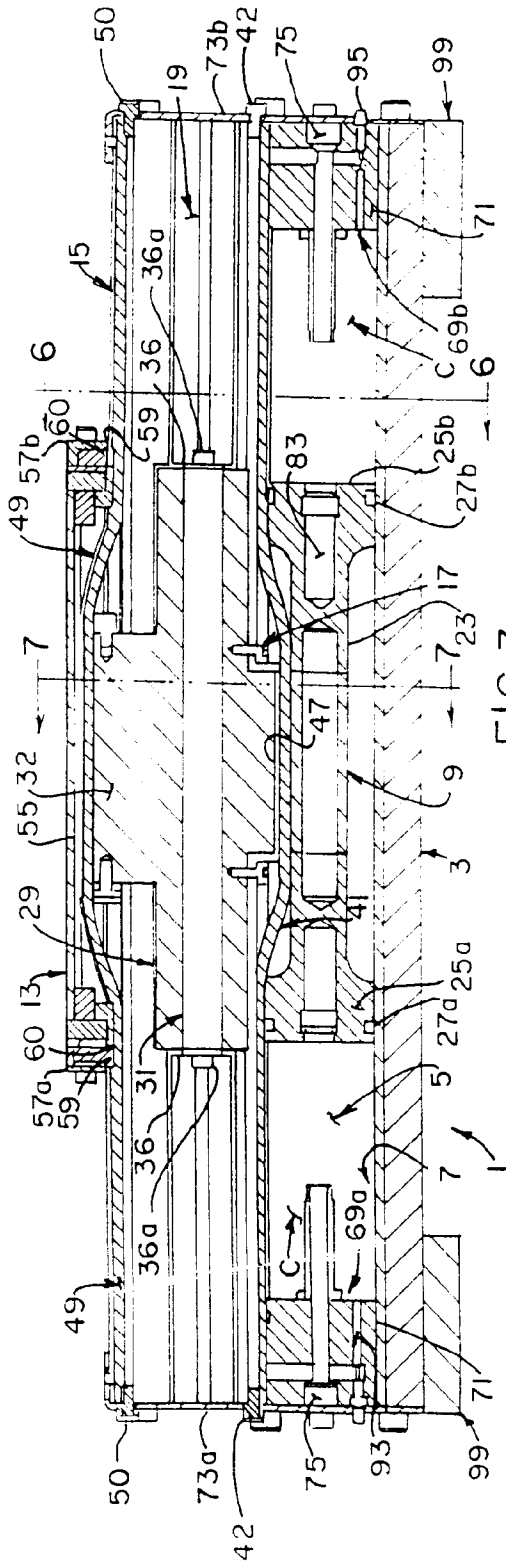


FIG. 3.

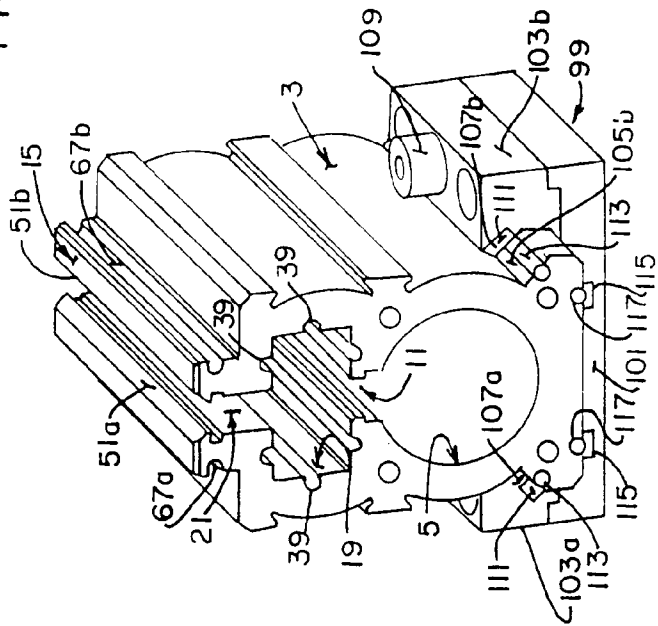


FIG. 4.

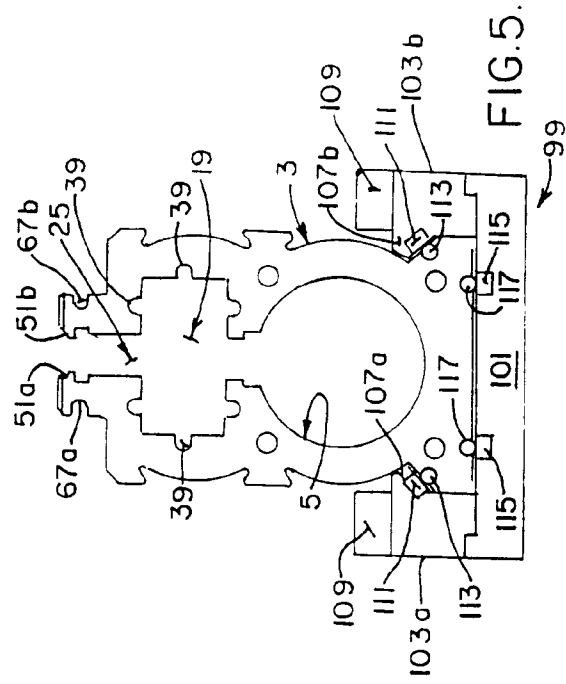


FIG. 5.

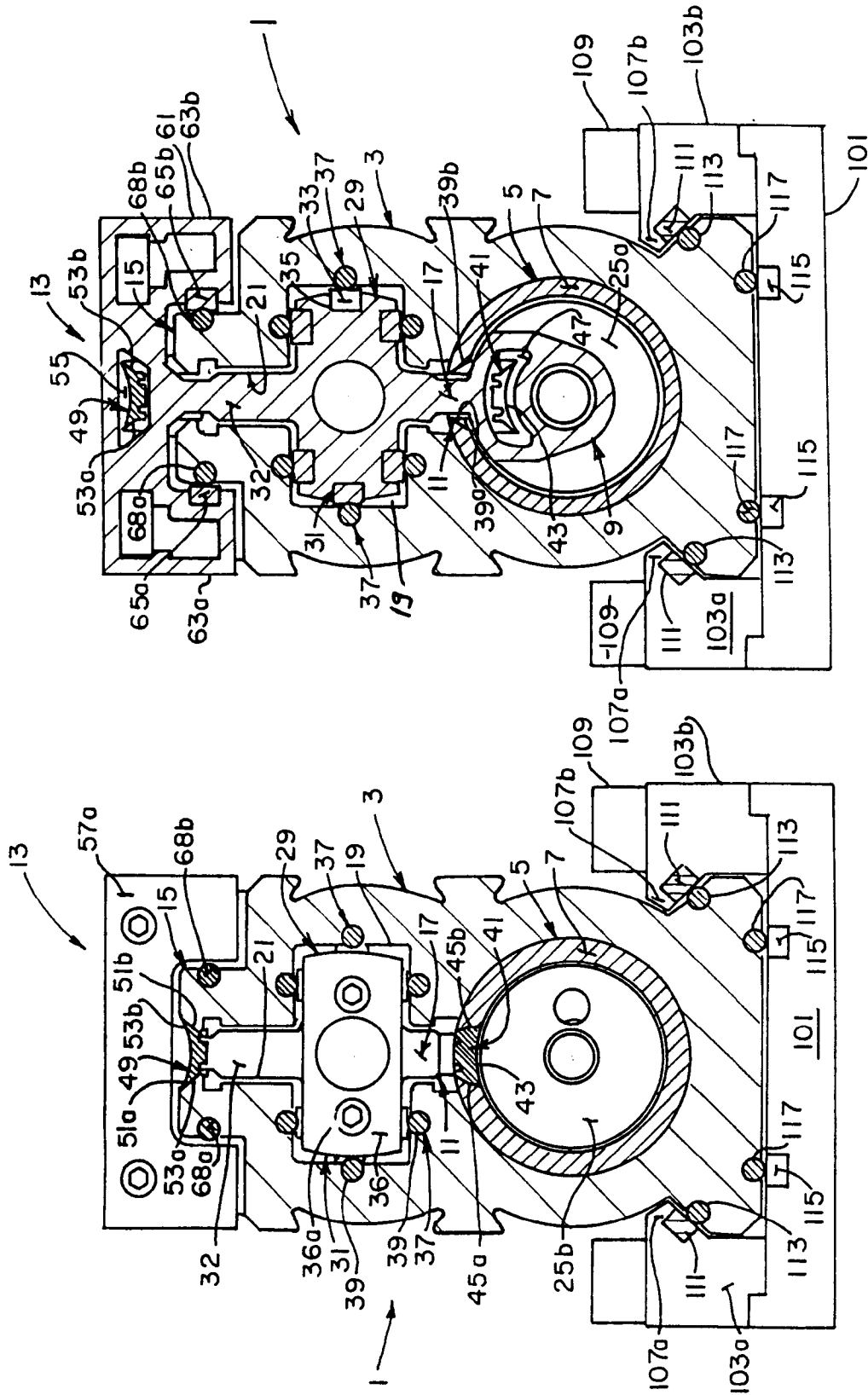


FIG. 7.

FIG. 6.

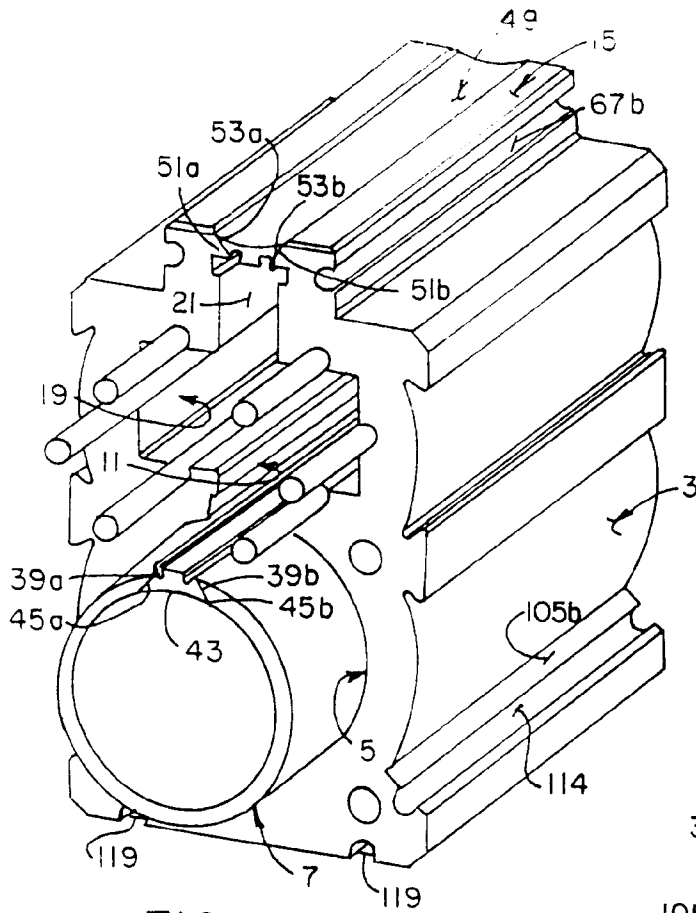


FIG. 8.

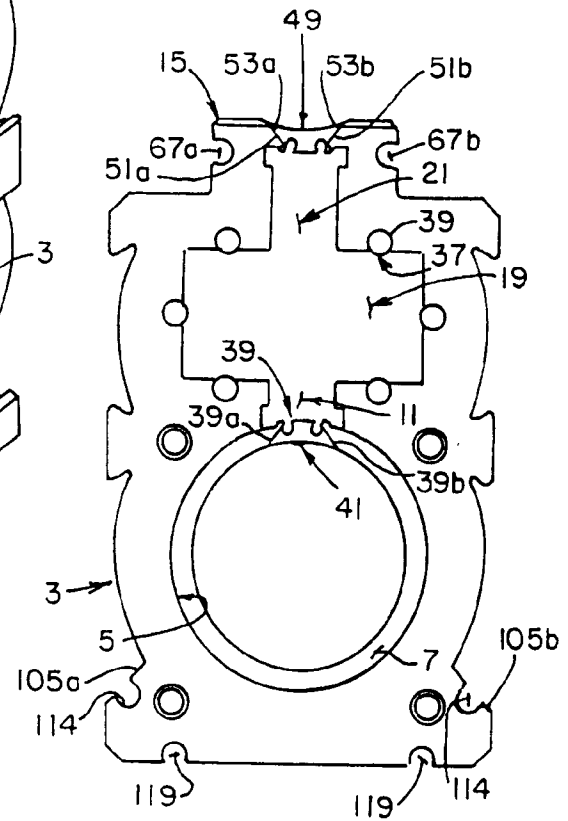


FIG. 9.

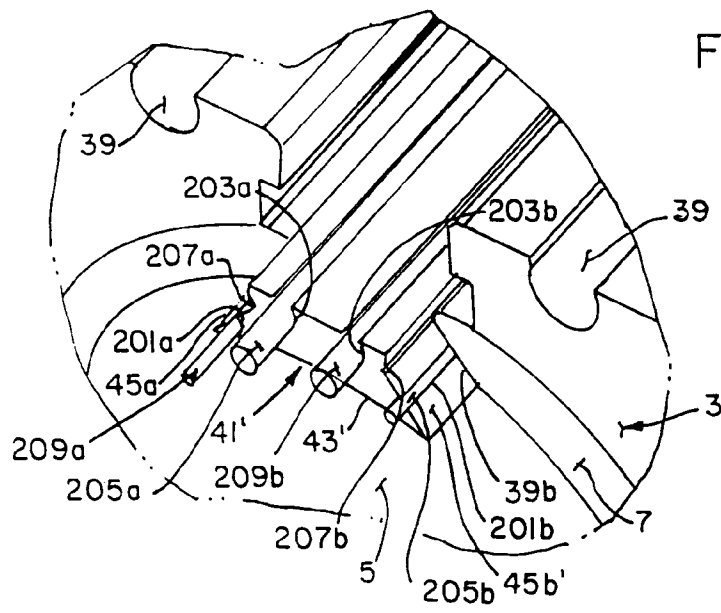


FIG. 11.

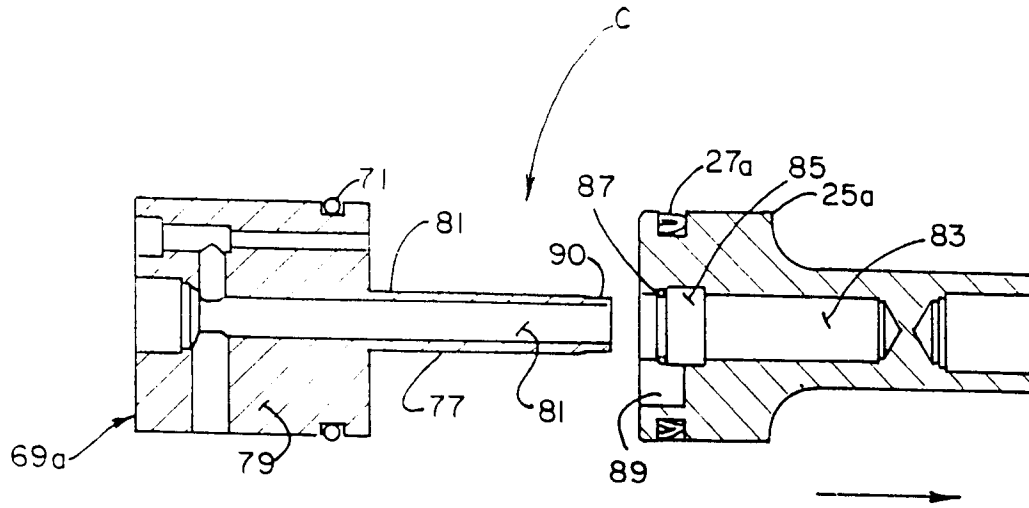


FIG. 10 A.

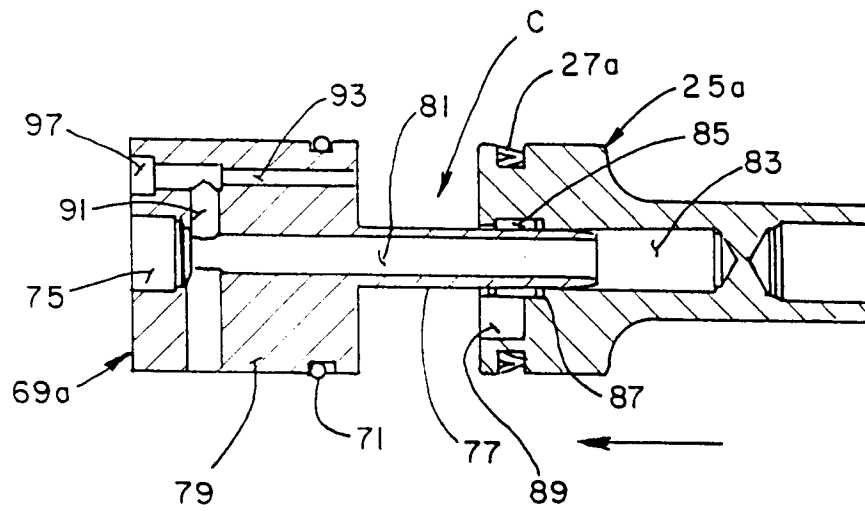


FIG. 10 B.

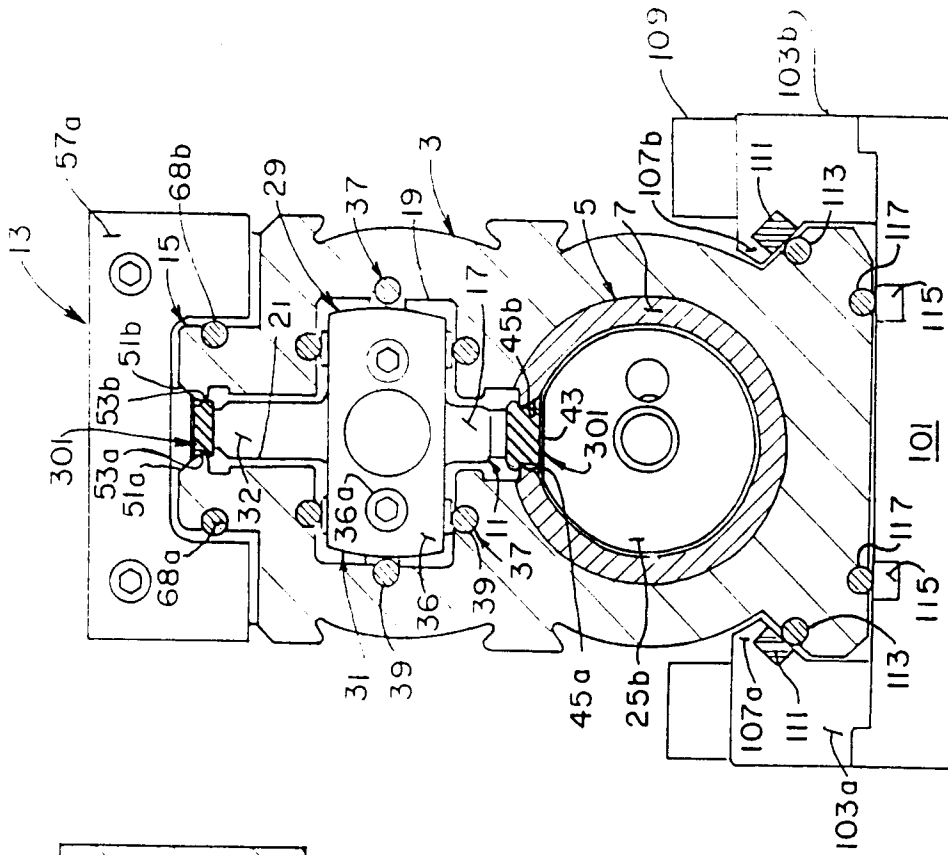


FIG. 12.

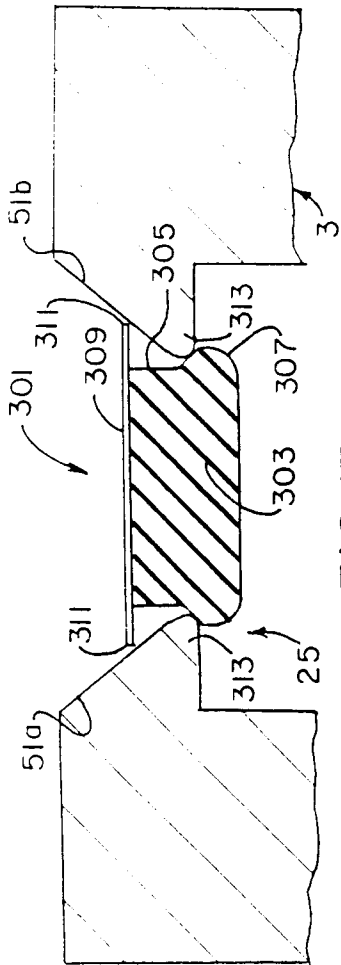


FIG. 13.

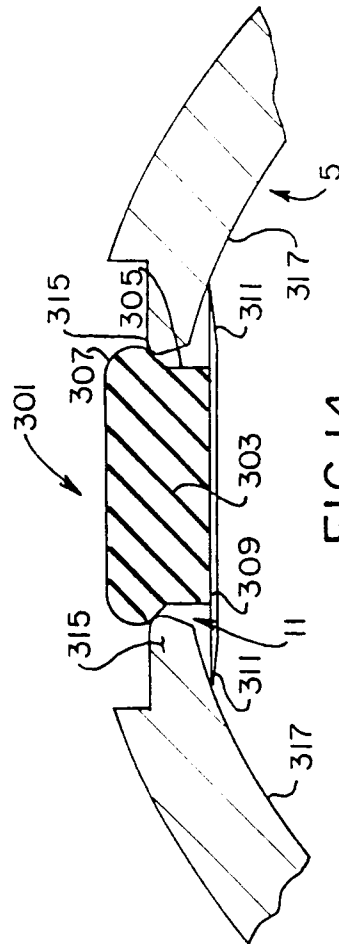


FIG. 14.

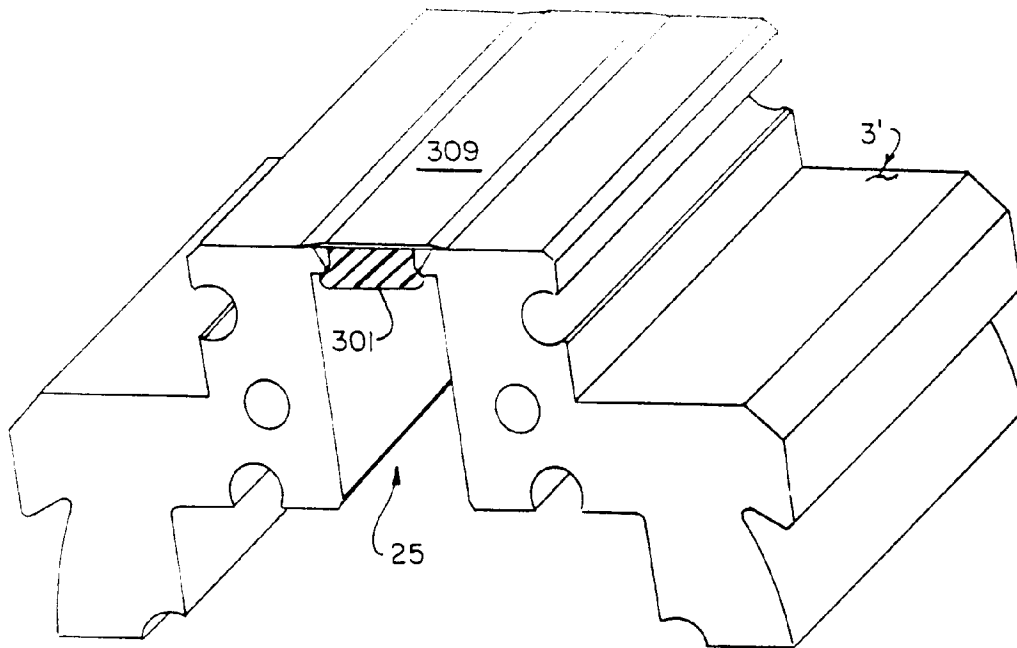


FIG. 15.

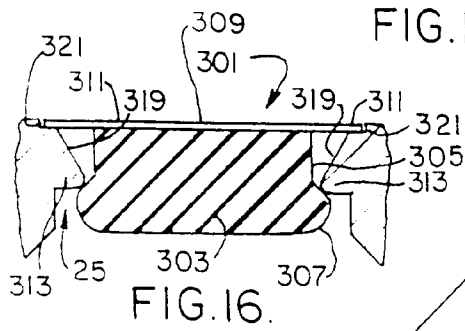


FIG. 16.

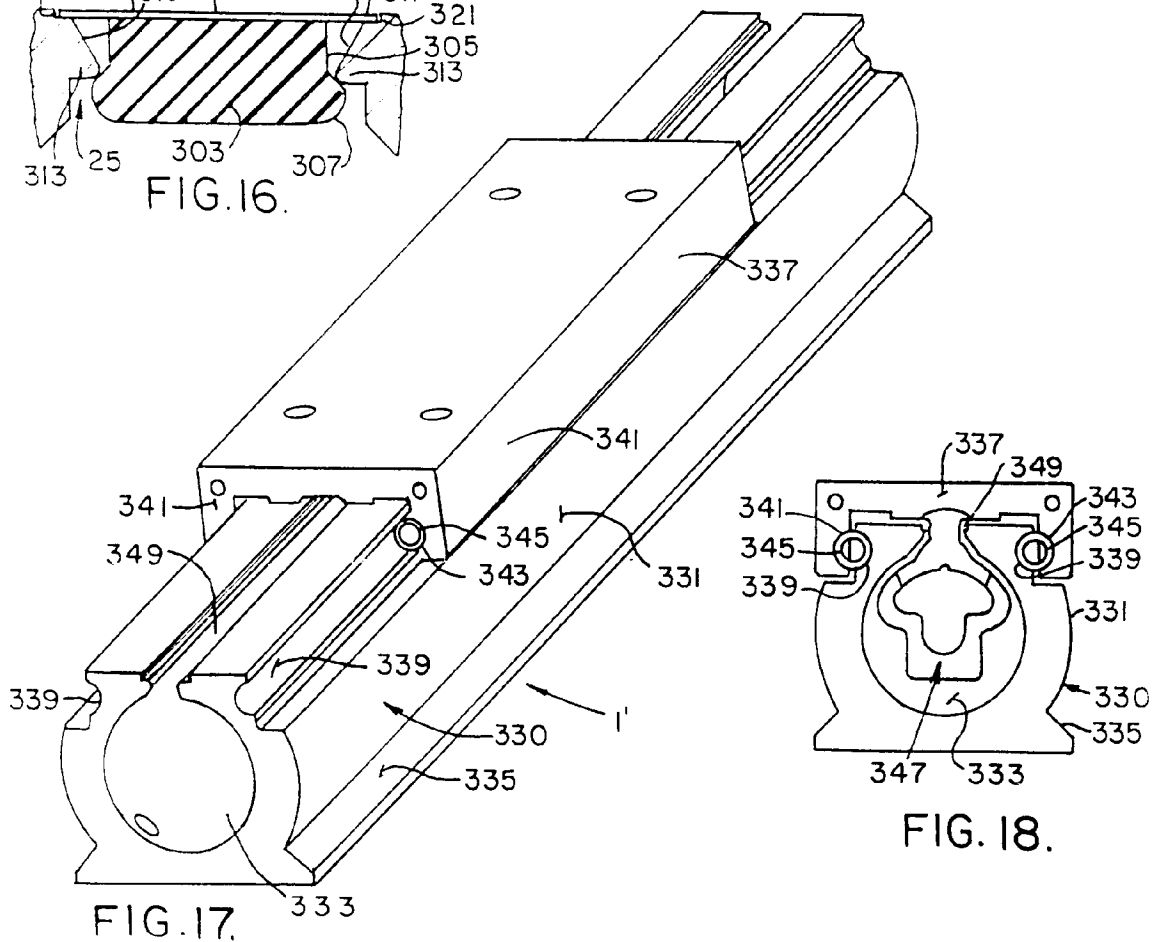


FIG. 17.

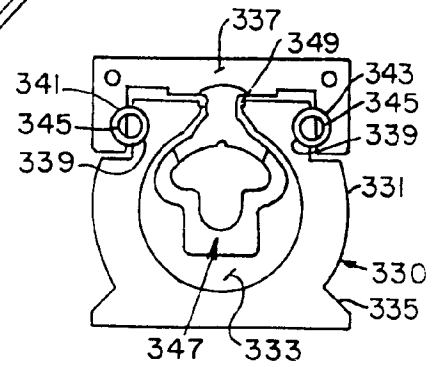


FIG. 18.

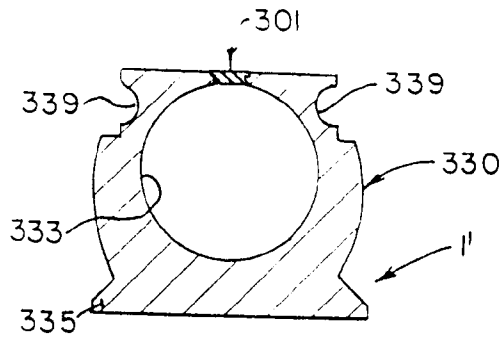


FIG. 19.

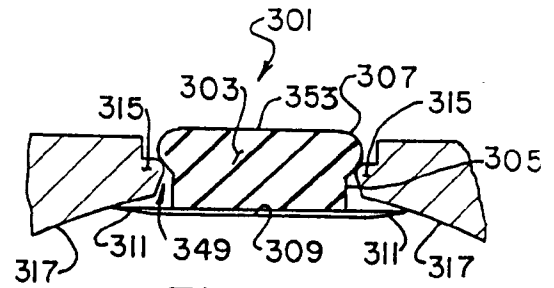


FIG. 20.

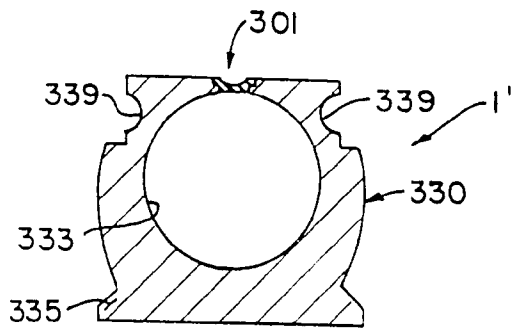


FIG. 21.

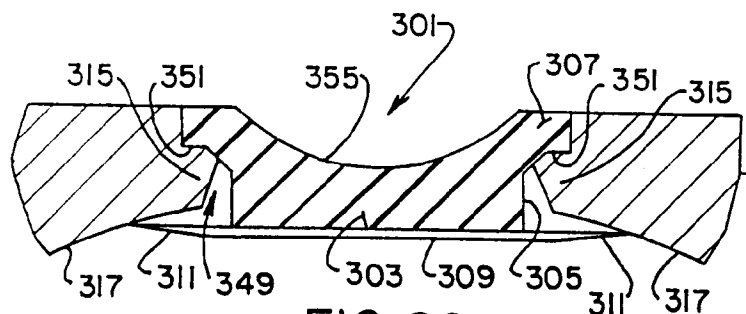


FIG. 22.



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 63 0023

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X A	EP-A-0 104 364 (KNORR-BREMSE) * page 11, line 29 - page 12, line 34 * * page 14, line 15 - line 19; claims 1-10; figures 5-7 *	1 8,35	F15B15/08
A	DE-A-3 802 703 (HOWA MACHINERY) * the whole document *	9-11	
A	EP-A-0 033 541 (TOL-O-MATIC) * claims 1,2; figures 1-6 *	8,12,13, 15,16,19	
A	EP-A-0 082 829 (AB MECMAN) * claims 1,3,4,9-11; figures 1-5 *	23-37	
A	DE-C-3 124 878 (KAISER) * the whole document *	23,35	
D,A	US-A-4 545 290 (LIEBERMAN)		
A	GB-A-2 202 587 (CKD CORPORATION)		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F15B
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 24 JUNE 1992	Examiner THOMAS C.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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