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(54) Door control having automatically adjustable damping capacity.

(57) A door control unit (100) provides real time continuously variable damping capacity to respond to changing conditions of weather, wear and use. By incorporating an electronic programmable controller (30), the door control unit always operates at optimum efficiency due to continuously variable fluidity of the control fluid within the control unit.

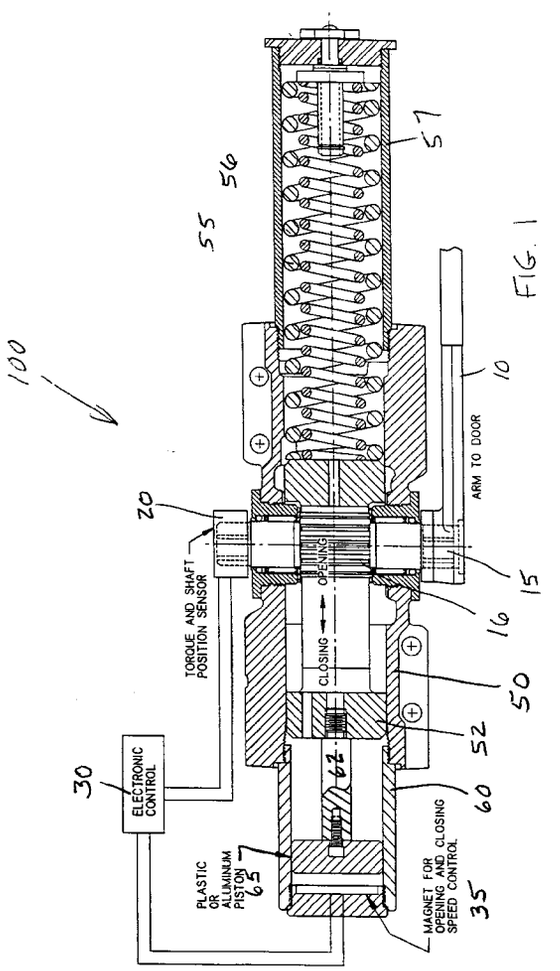

FIG. 1

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This invention relates generally to door control devices and, more particularly, to door control devices having self-regulating variable motion damping capability.

Door control devices are well-known and widely applied to provide a degree of damping to the opening or closing of the door. A typical door control device has a bridging function between a door and door frame. When the door is open, it moves a pivot arm on the door control thereby causing rotation of a pinion gear which drives a piston within the door control device against a heavy spring resistance. When the door is released the spring pushes the piston back and provides the closing force to the door through the pinion gear and arm. To prevent slamming, the cylinder in which the piston is housed is filled with fluid which moves from one side of the piston to the other during opening and closing of the door. This fluid transfer occurs either through a clearance between the piston and the cylinder wall, through orifices in the piston heads, or through passages which are exterior to the cylinder.

Most commonly, external fluid passages are used in door control devices because they permit external adjustment of the fluid transfer rate and, therefore, the rate of movement of the door. Usually such passages are in the walls of the door control housing and the fluid flow therethrough is adjusted by means of metering valves strategically placed in the passages. These valves are adjustable from the exterior of the control device, so they can periodically be adjusted throughout the life of the door control to account for wear, wind, and seasonal temperature changes. Typically, as many as four metering valves are provided to regulate back check speed when the door is opening, and general speed, latch speed, and delay speed when the door is closing.

Adjustment, however, requires a high level of skill and is time-consuming. Moreover, since many people do not know that door controls can be readjusted when required, a great number of doors with maladjusted controls operate improperly, thereby causing inconvenience to users of the door and an increased rate of wear and damage to the door. Furthermore, manufacture of the door control device is relatively expensive due to the precision required by the fluid passages and the regulating valves. In spite of the cost and complexity, the door control does not provide adaptive response to varying operating conditions. Once set, the door control responds to all operating conditions with the same degree of motion control.

According to the present invention, there is provided a door control for regulating the speed of opening and closing of a door in its frame, comprising a housing having a bore in which a piston is reciprocably disposed, said piston having a rack engaged with a pinion such that the pinion rotates when the piston reciprocates; means for biasing the piston to a door-closed position; a connecting arm arrangement operably attached to a shaft which rotates with the pinion and provides connection between a door frame and a door to be operated by the door control; a fluid filling the bore of the housing on both sides of the piston; and means for allowing the fluid to flow from one side of the piston to the other side during reciprocation of the piston; characterised by means for regulating the fluidity of the fluid to control the flow rate of the fluid from one side of the piston to the other side.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which: -

Figure 1 is a cross-sectional elevation view of one embodiment of a door control for regulating the speed of opening and closing of a door in its frame,

Figure 2 is a view similar to Figure 1 of another embodiment,

Figure 3 is a fragmentary cross-sectional plan view of another embodiment applied as a variation of, or a retrofit of, a conventional door control device,

Figure 4 is a sectional side view of a door control incorporating a rotary drive mechanism for pushing against the piston to open the door, and

Figure 5 is another embodiment, as in Figure 4, this time showing a fluid powered piston for opening the door.

Figure 1 illustrates a door control unit 100 with a housing 50 which has a bore in which a piston 52 can reciprocate to the right or left depending on the rotation of a pinion 16 on a shaft 15 as driven by an arm 10 during motion of the door (not shown). When the piston 52 travels to the right, it must overcome biasing forces of springs 55 and 56 or of a pneumatic compression cylinder (not illustrated), either of which may provide the door closing force when the door is released. In this embodiment a piston 65 in a housing extension 60 is connected to the piston 52 by a connecting rod 62. The piston 65 is made of plastics, aluminium, or other non-magnetisable material for this embodiment and is provided with a clearance in the bore of the housing extension 60 through which control fluid can flow during reciprocation of the piston. The control fluid is a magneto-rheological fluid which, when exposed to a magnetic field, loses fluidity or becomes more viscous as the magnetic field strength increases. When the magnetic field is reduced or removed, the control fluid decreases in viscosity and becomes more fluid. It is this property of the magneto-rheological fluid which permits the automatic adjustment of damping capacity for the door control.

In the embodiment of Figure 1, adjustment of the door control damping capacity is achieved by means of a shaft position and torque sensor 20 mounted on

the shaft 15 of the pinion 16. The sensor 20 transmits a signal to an electronic control 30 which translates the signal to door direction, position and speed. The control 30, in turn, transmits a variable electric signal to an electromagnet 35, thereby varying the magnetic field strength of the electromagnet 35 and increasing the stiffness of the control fluid. The stiffness increase in the control fluid is proportional to the strength of the magnetic field imposed; therefore, any electromagnet is very effective in the application.

The electronic control 30 can be a standard programmable controller available from many sources. Door speed desired vs. position curves are established for opening and closing operations. These are translated to indications of torque magnitude and direction, shaft speed and direction, and shaft position as monitored by sensor 20 on the pinion shaft 15. The signals from the sensor 20 are transmitted to the electronic control 30 in which they are compared to the preprogrammed desired door opening and closing curves. The electronic programmable control 30 generates a signal proportional in magnitude and direction to the deviation between the sensed values from the sensor 20 and the desired values of the program. The signal from the control 30 is transmitted to the magnet 35 to either increase the magnetic field strength or decrease magnetic field strength in order to increase viscosity or stiffness of the control fluid or decrease it depending on whether the door is moving too rapidly or too slowly, respectively.

It should be noted that, although the control fluid is described as being a magneto-rheological fluid, the same performance could be accomplished using an electro-rheological fluid which responds to electrical field changes in much the same way as the magneto-rheological fluids respond to magnetic field changes.

Figure 2 illustrates another embodiment. In this case, virtually all parts have the same function as those described with respect to Figure 1; however, there is no housing extension in this embodiment. Also rather than a single electromagnet 35 as in Figure 1; an electromagnet 40 provides closing speed control while another magnet 42 provides opening speed control. Door position, speed, direction, and torque, as sensed by the sensor 20, generates signals to the electronic control 30 as in the embodiment of Figure 1. Depending on whether the door is opening or closing, the electronic control 30, in this embodiment, provides control signals to the electromagnet 42 or 40 as the case may be. These magnets, being smaller, provide the advantage of somewhat more localised effect on the control fluid. As a consequence, a somewhat finer degree of control may be possible.

Figure 3 shows a fragmentary cross-sectional view of another embodiment, in which the door control is applied to a current design door control unit. Note that this could also be applied as a retrofit to an existing door control unit. Since this is a plan view, the rack 17 of the piston 52 is now visible, although pinion 16 and shaft 15 have been eliminated for clarity. In this case, three small electromagnets 82, 84 and 86 are provided in the sites where screw adjustable valves were formerly placed. Thus, the electromagnet 82 now controls opening speed, electromagnet 84 controls closing speed, and electromagnet 86 controls latch speed by controlling the stiffness of the control fluid flowing through passages 90 and 92. In addition, piston 52 has passages 98 and 96, each of which has a ball to function as a check valve permitting passage of control fluid in one direction only. Operation of this embodiment is no different from those of Figures 1 and 2. Sensor 20 and electronic control unit 30 (not shown) perform the same functions as in the other examples. Since passages 90 and 92 are small and are intersected at key points by electromagnets 82, 84 and 86, control is achievable with much less powerful magnetic field because only a small passage must be plugged by the stiffened control fluid. It could be expected that this situation will yield the finest degree of control of the three embodiments discussed so far.

In the embodiment shown in Figure 2, it is entirely possible, if so desired, to substitute a large electromagnet for either magnet 40 or 42 and thereby to generate a magnetic field powerful enough to affect all the fluid in the housing. However, the degree of control achieved with the embodiment of Figure 2 without modification is a strong argument against this approach.

In summary, the present construction consists of providing variable damping capability by employing a control fluid of variable viscosity rather than attempting to adjust, in real time, the size of a passage through which the control fluid must flow. This results in, for the first time, a continuously variable damping performance by a door control unit.

Figures 4 and 5 illustrate the present construction incorporated in power operated door operating units. Figure 4 shows a rotary actuated linear drive mechanism 220 which pushes the piston 52 by means of drive rods 225 to open the door. Rod 225 extends through a sealed bushing 230 in a head 240 to push the piston 52 rightward so as to open the door. Backcheck during opening is controlled by magnet 142 for door opening speed control as in previously discussed embodiments. The functions of the shaft position sensor 20 and electronic control 30 are as previously described. A rotary actuating mechanism 210 may be powered by air, hydraulic, or electric power or combinations thereof and, through coupler 215, will drive the piston 52 rightward to open the door. Linear drive mechanism 220 may be a screw drive or other rotary actuated linear drive which, once the door is completely open, is rapidly retracted so that closing of the door is controlled by the electronic control 30 through the magnet 140.

The embodiment of Figure 5 is identical in all respects to that of Figure 4 from the head 240 to the right of both Figures. In this case, however, the drive mechanism is directly powered by fluid pressure (hydraulic or pneumatic) and, therefore, requires a fluid tight cylinder 320 in which pistons 310 can reciprocate without losing pressure. Rods 315 and 225 penetrate heads 340 and 240, respectively, through sealing bushings 330 and 230 to operate the piston 52, pinion 16, shaft 15 and door arm 10. Once the door is fully opened, the fluid pressure is released, and control of the door closing is handed off to the electronic control 30. In both the embodiments shown in Figures 4 and 5, the electronic control 30 monitors door position, speed and torque during opening and transmits an appropriate signal to magnets 140 and 142 according to its preprogrammed instructions.

Claims

1. A door control (100) for regulating the speed of opening and closing of a door in its frame, comprising a housing (50) having a bore in which a piston (52) is reciprocably disposed, said piston having a rack (17) engaged with a pinion (16) such that the pinion rotates when the piston reciprocates; means (55, 56) for biasing the piston to a door-closed position; a connecting arm arrangement (10) operably attached to a shaft (15) which rotates with the pinion and provides.connection between a door frame and a door to be operated by the door control; a fluid filling the bore of the housing on both sides of the piston; and means for allowing the fluid to flow from one side of the piston to the other side during reciprocation of the piston; characterised by means (35) for regulating the fluidity of the fluid to control the flow rate of the fluid from one side of the piston to the other side.

2. A door control according to claim 1, further comprising means (20) for monitoring the position and speed of the door and for generating a signal to a programmable electronic control unit which processes said signal and generates a control signal to said means for regulating the fluidity of said fluid thereby to impose a continuously variable damping action on motion of the door.

3. A door control according to claim 1 or 2, when said fluid is a magneto-rheological fluid.

4. A door control according to claim 1 or 2, wherein said fluid is an electro-rheological fluid.

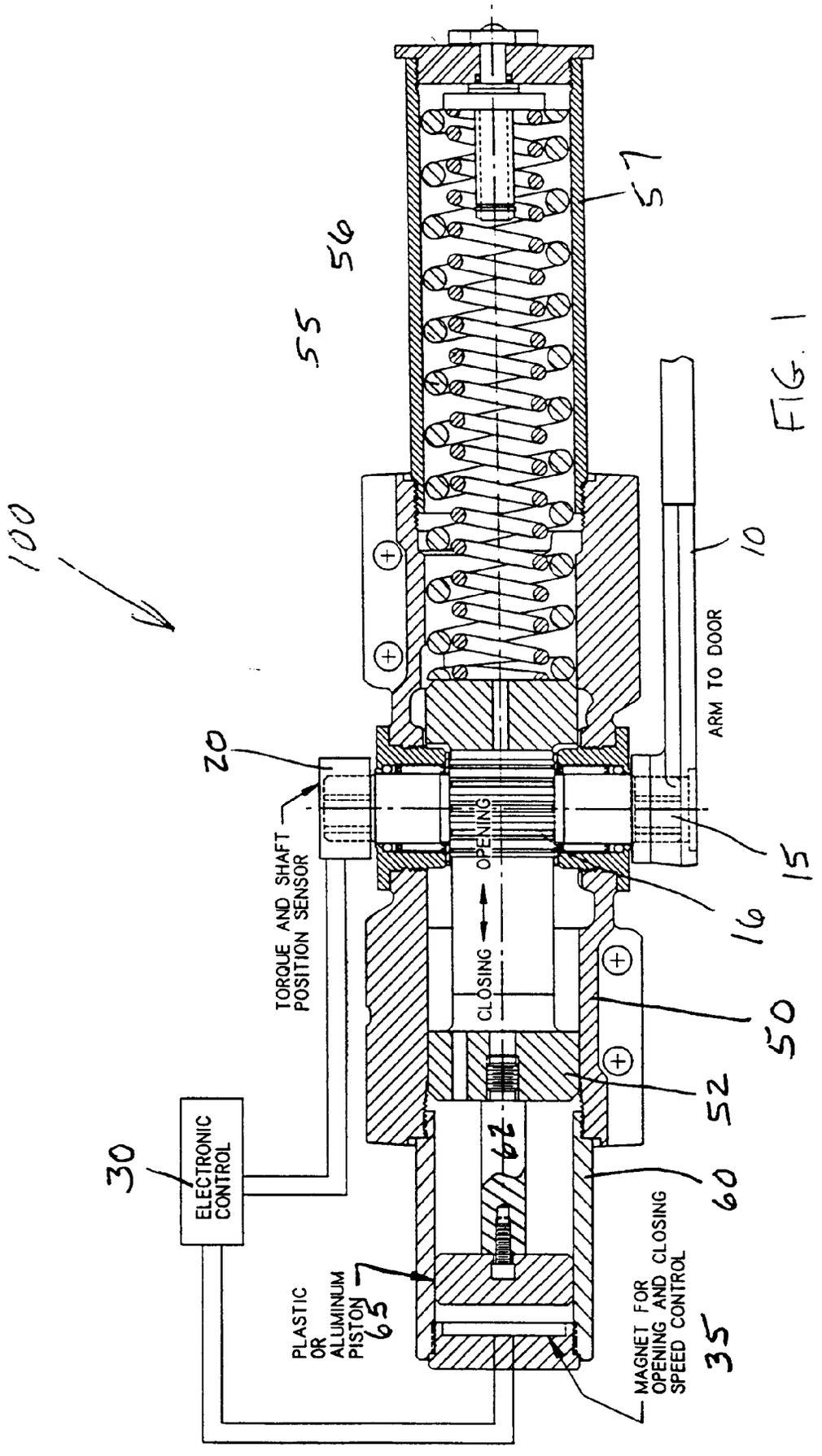
100
57
56
55
10
ARM TO DOOR
20
TORQUE AND SHAFT POSITION SENSOR
OPENING
CLOSING
16
15
50
52
62
60
30
ELECTRONIC CONTROL
PLASTIC OR ALUMINUM PISTON
65
MAGNET FOR OPENING AND CLOSING SPEED CONTROL
35

FIG. 1

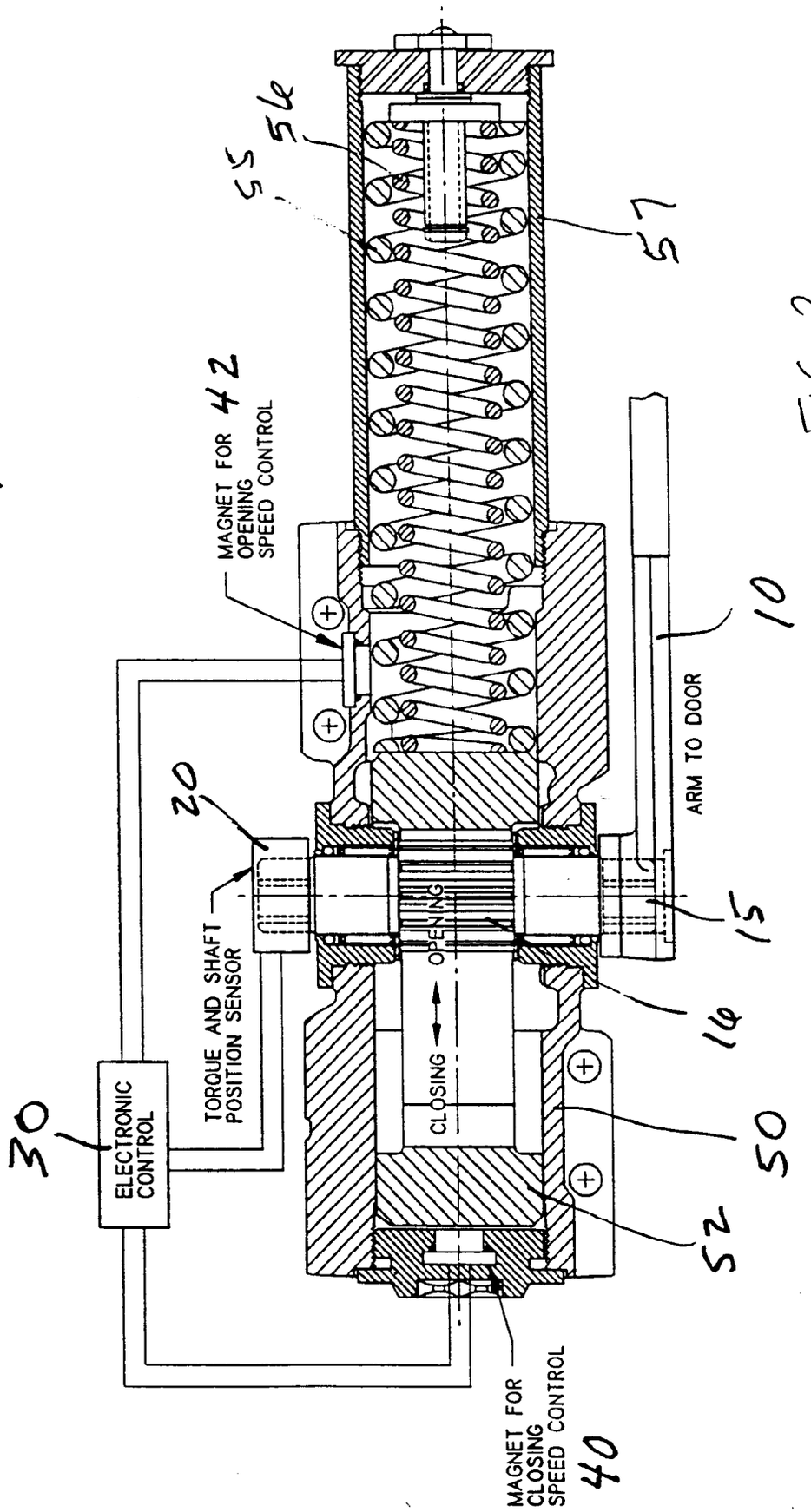
100
55
54
57
MAGNET FOR OPENING SPEED CONTROL
42
ARM TO DOOR
10
20
TORQUE AND SHAFT POSITION SENSOR
OPENING
CLOSING
15
16
30
ELECTRONIC CONTROL
50
52
MAGNET FOR CLOSING SPEED CONTROL
40

FIG. 2

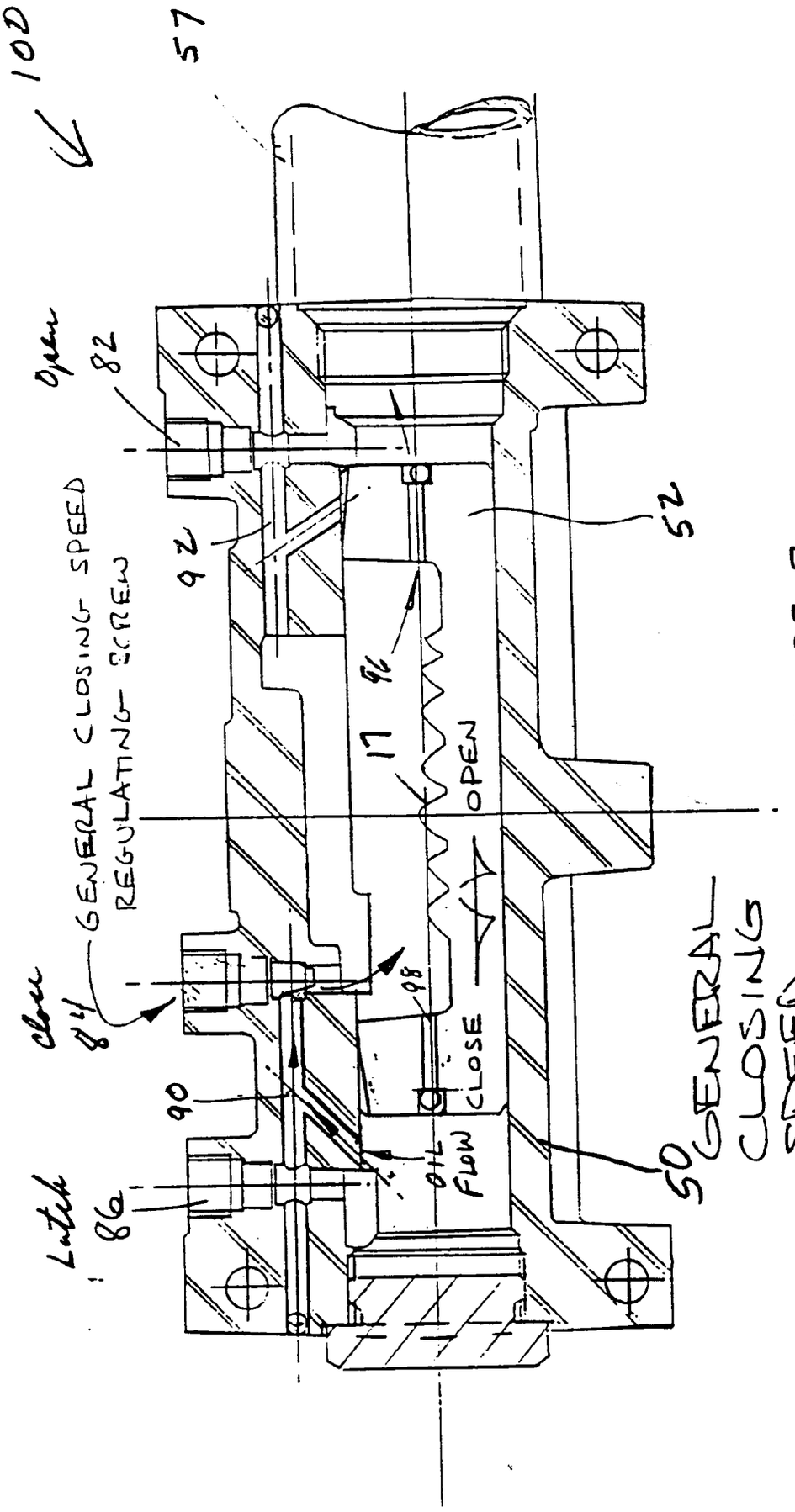
100
57
Open
82
92
52
96
17
OPEN
GENERAL CLOSING SPEED
REGULATING SCREW
Close
84
98
CLOSE
90
OIL FLOW
Latch
86
50 GENERAL CLOSING SPEED EXAMPLE

FIGURE 3

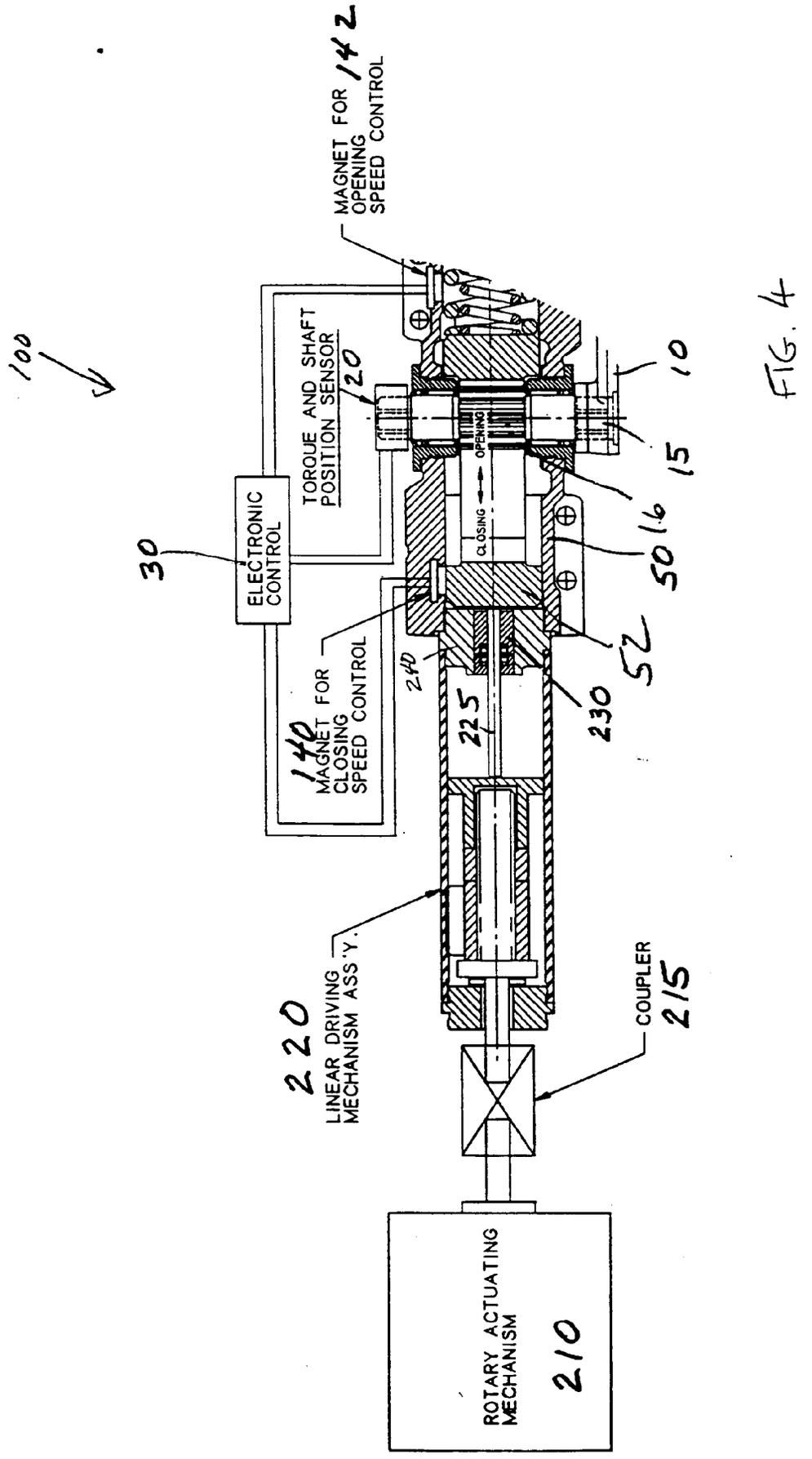
100
MAGNET FOR OPENING SPEED CONTROL
142
TORQUE AND SHAFT POSITION SENSOR
20
ELECTRONIC CONTROL
30
MAGNET FOR CLOSING SPEED CONTROL
140
OPENING
CLOSING
10
15
16
50
52
240
225
230
LINEAR DRIVING MECHANISM ASS'Y.
220
COUPLER
215
ROTARY ACTUATING MECHANISM
210

FIG. 4

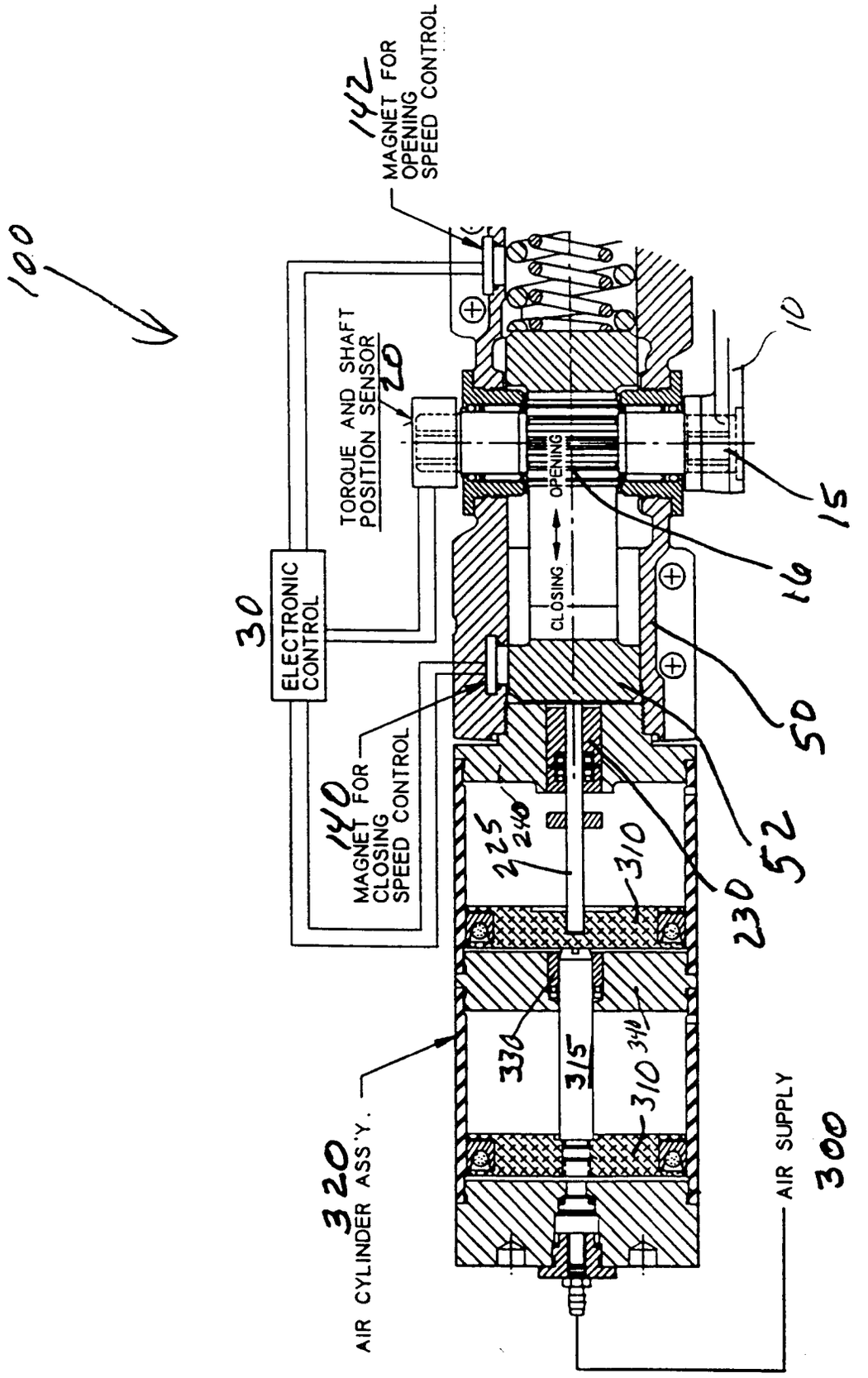
100
142
MAGNET FOR OPENING SPEED CONTROL
TORQUE AND SHAFT POSITION SENSOR
20
10
OPENING
CLOSING
15
16
30
ELECTRONIC CONTROL
50
140
MAGNET FOR CLOSING SPEED CONTROL
225
240
310
52
230
330
315
310
340
320
AIR CYLINDER ASS'Y.
AIR SUPPLY
300

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number EP 95300113.8

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.6)
A	US - A - 5 259 090 (FAYNGERSH) * Claims 1,5,6; abstract * --	1	E 05 F 3/00 E 05 F 3/04
A	US - A - 4 040 144 (LASIER et al.) * Abstract; fig. * --	1	
A	US - A - 4 339 843 (BURNETT, Jr.) * Abstract; fig. * ----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.6)

E 05 F 3/00
E 05 F 5/00
E 05 F 15/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	27-03-1995	RIEMANN

CATEGORY OF CITED DOCUMENTS

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