Feb. 24, 1953 R. M. CONKLIN ET AL 2,629,127

DOOR CLOSER WITH CONSTANT FLOW ORIFICE

Filed Feb. 1, 1950 4 Sheets-Sheet 1

FIG. 1.

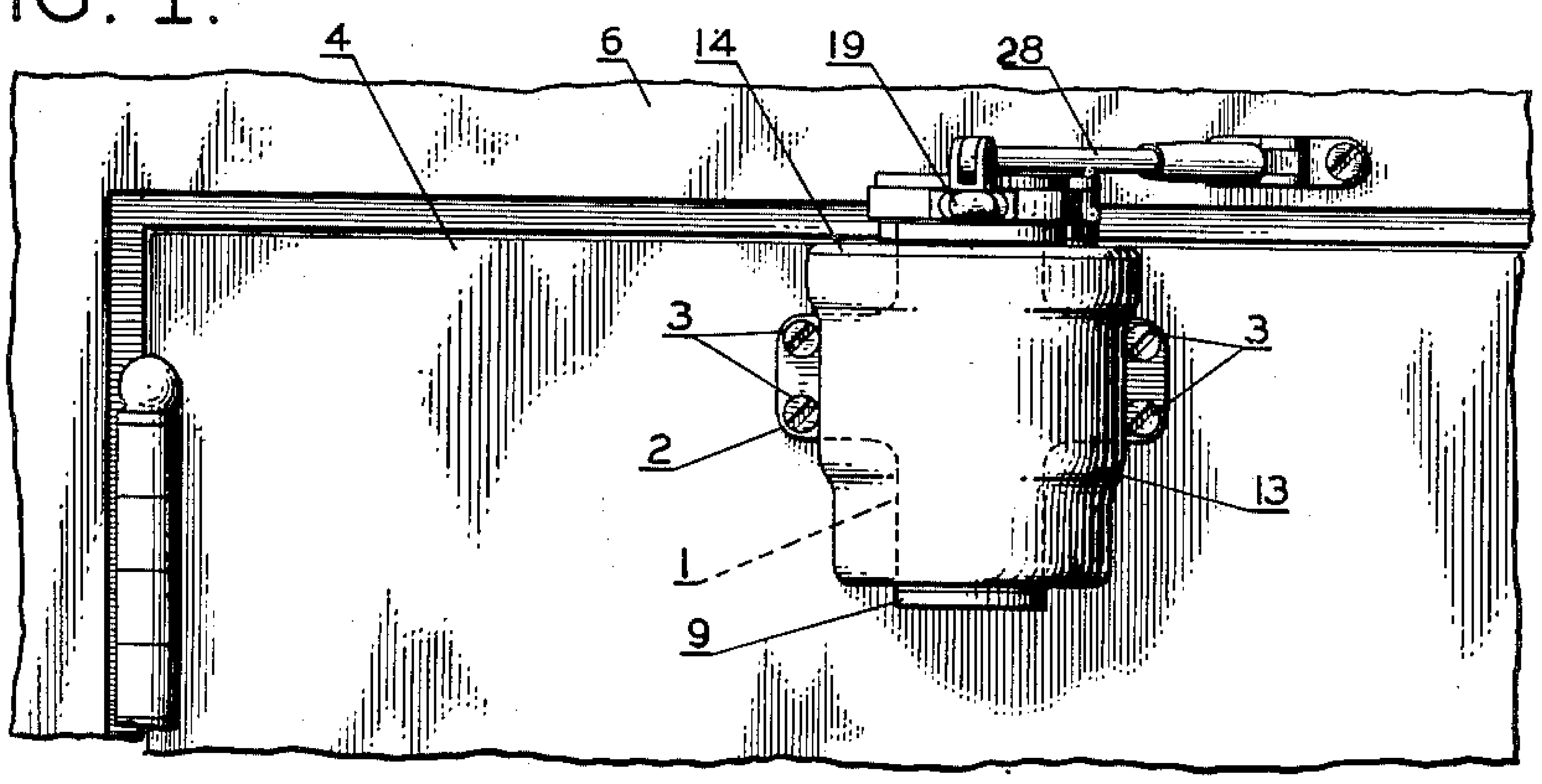
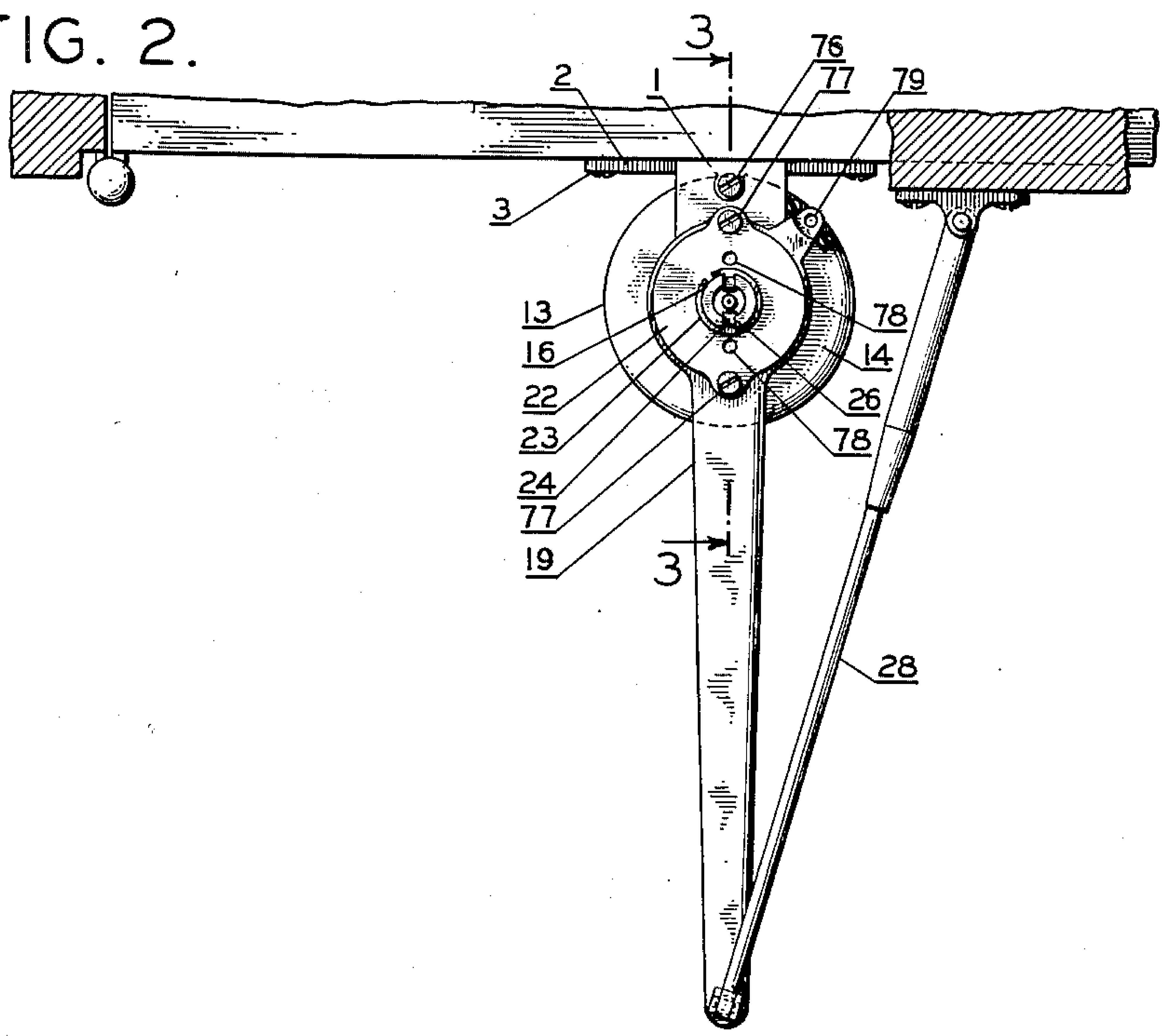


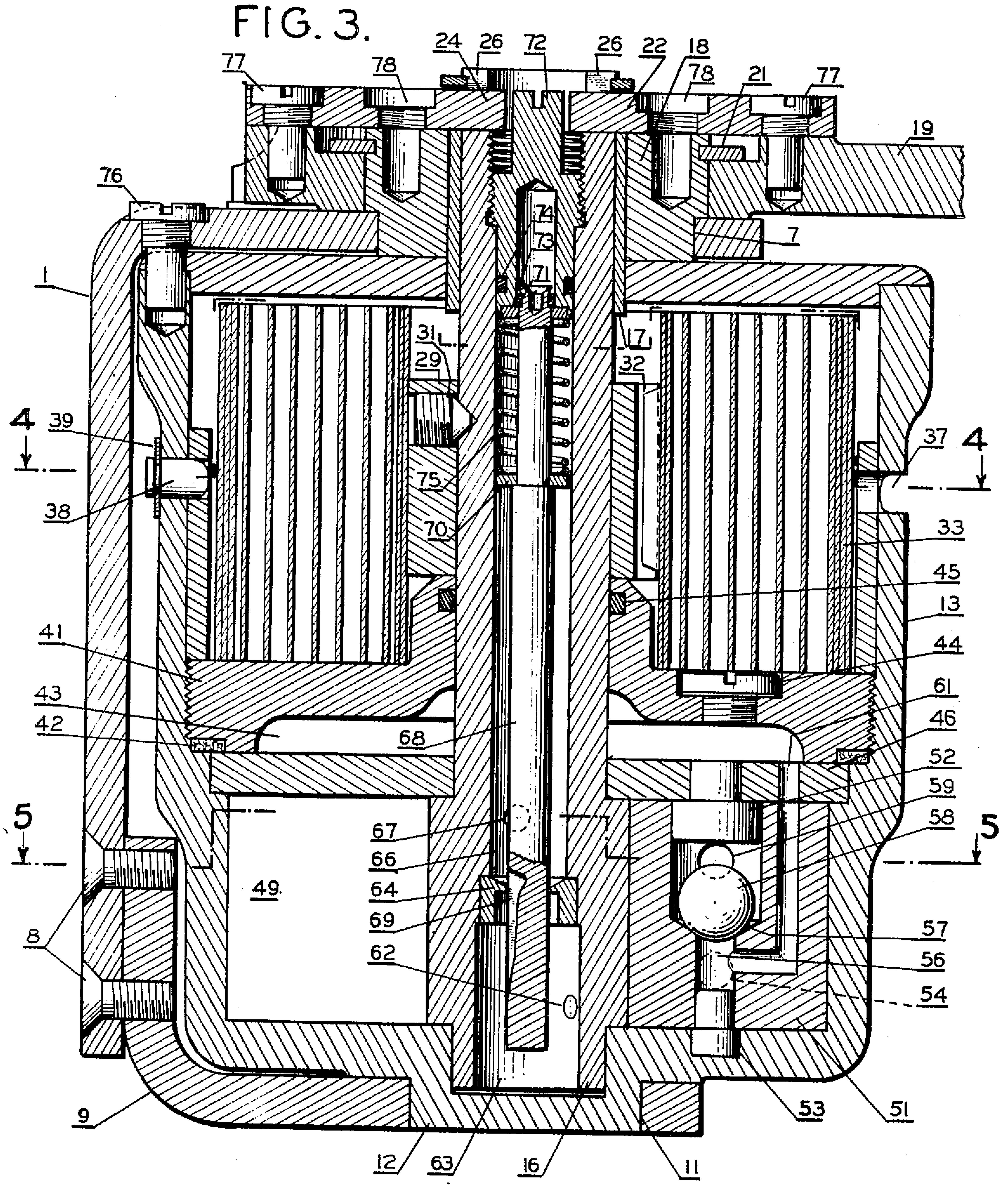
FIG. 2.



INVENTORS.
ROBERT M. CONKLIN
BY ARTHUR SCHARF

Marcus Lothrop
ATTORNEY.

FIG. 3.



INVENTORS.
ROBERT M. CONKLIN
ARTHUR SCHARF
BY Marcus Lothrop
ATTORNEY.

FIG. 4.

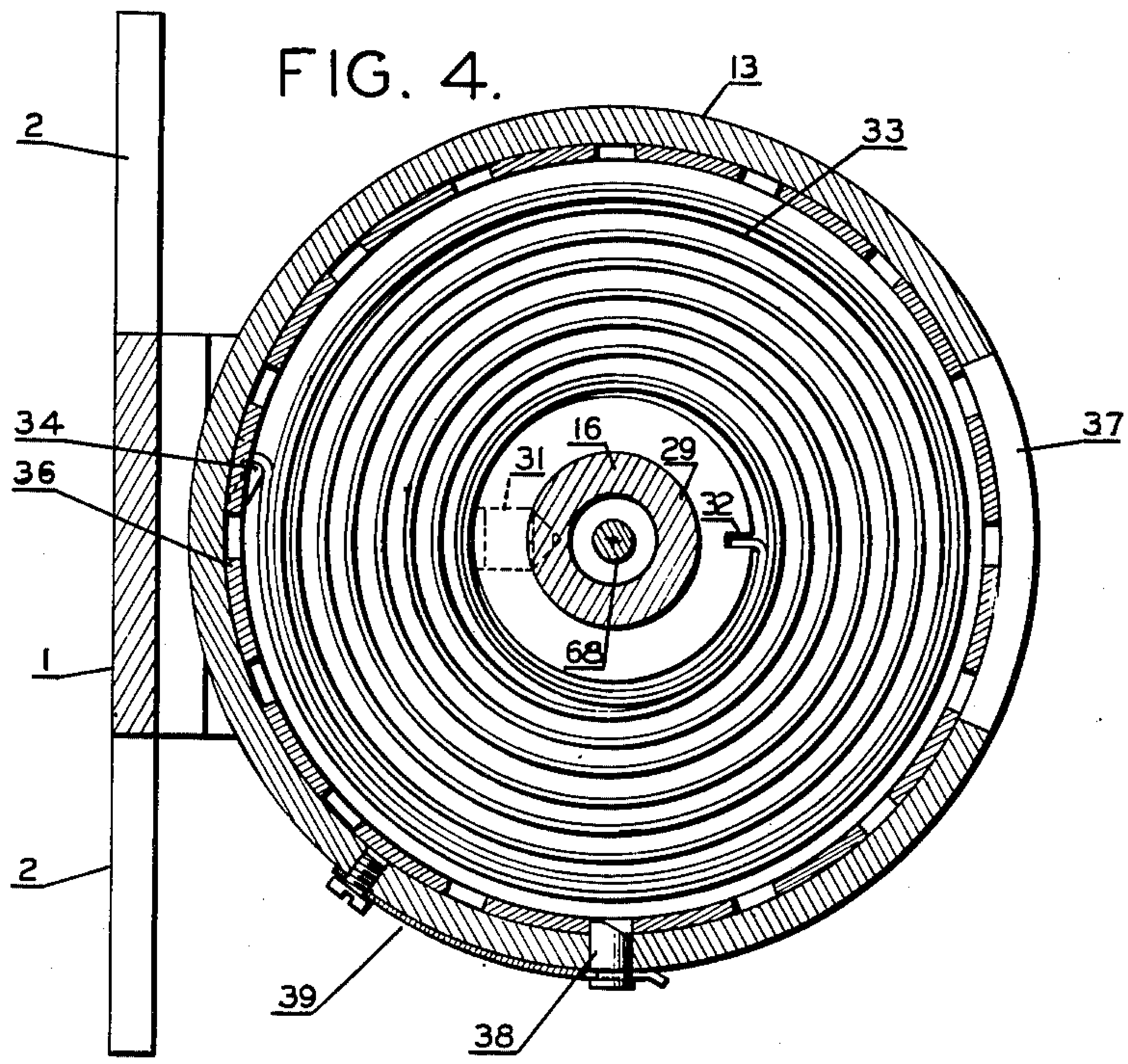
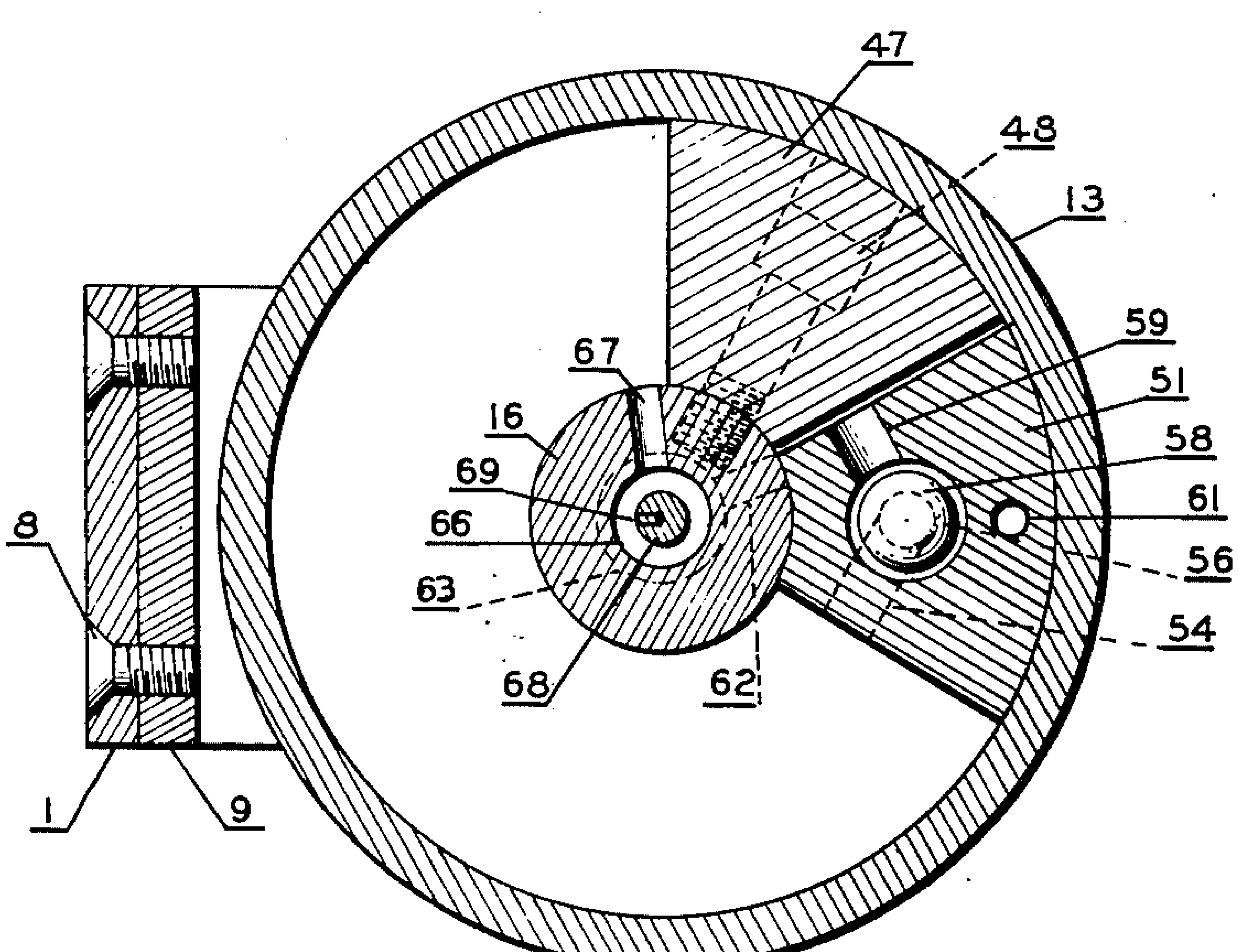


FIG. 5.



INVENTORS.
ROBERT M. CONKLIN
ARTHUR SCHARF
BY
Marcus Lothrop
ATTORNEY.

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FIG. 7.

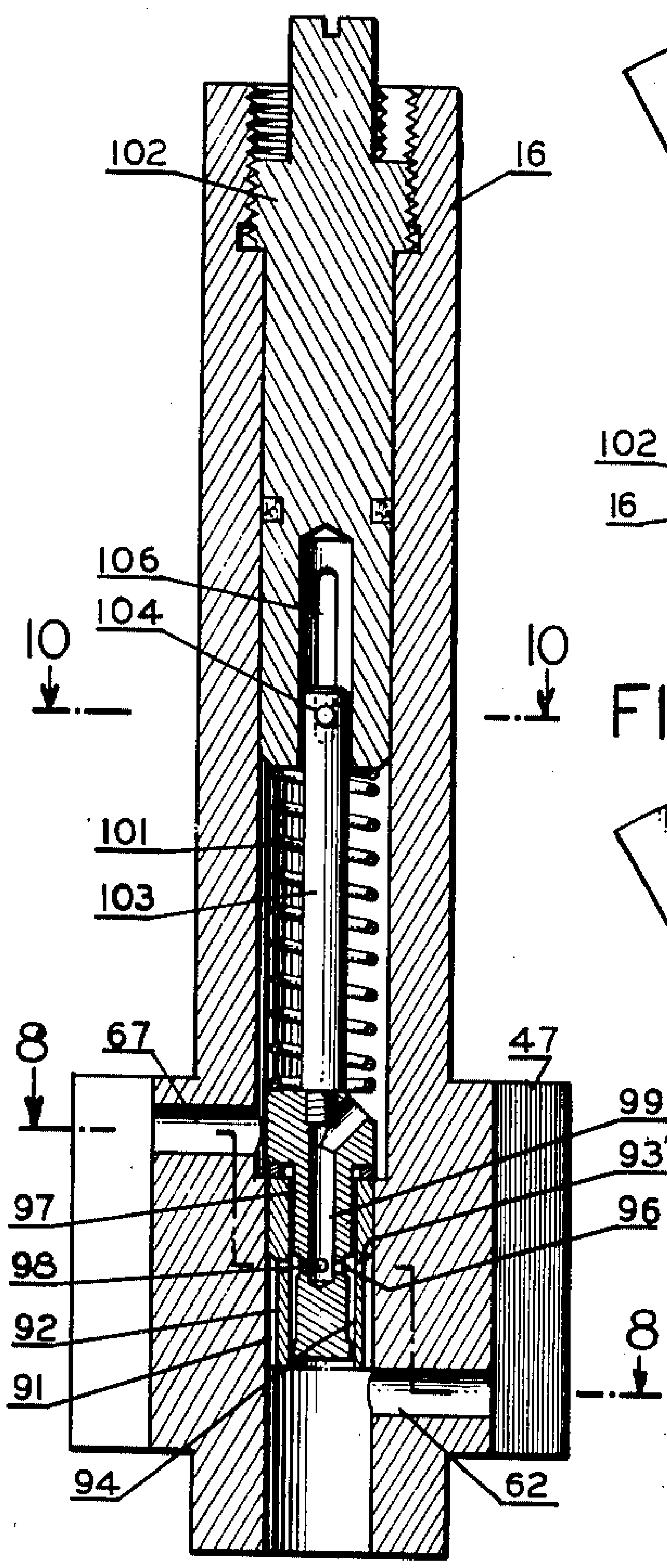


FIG. 9.

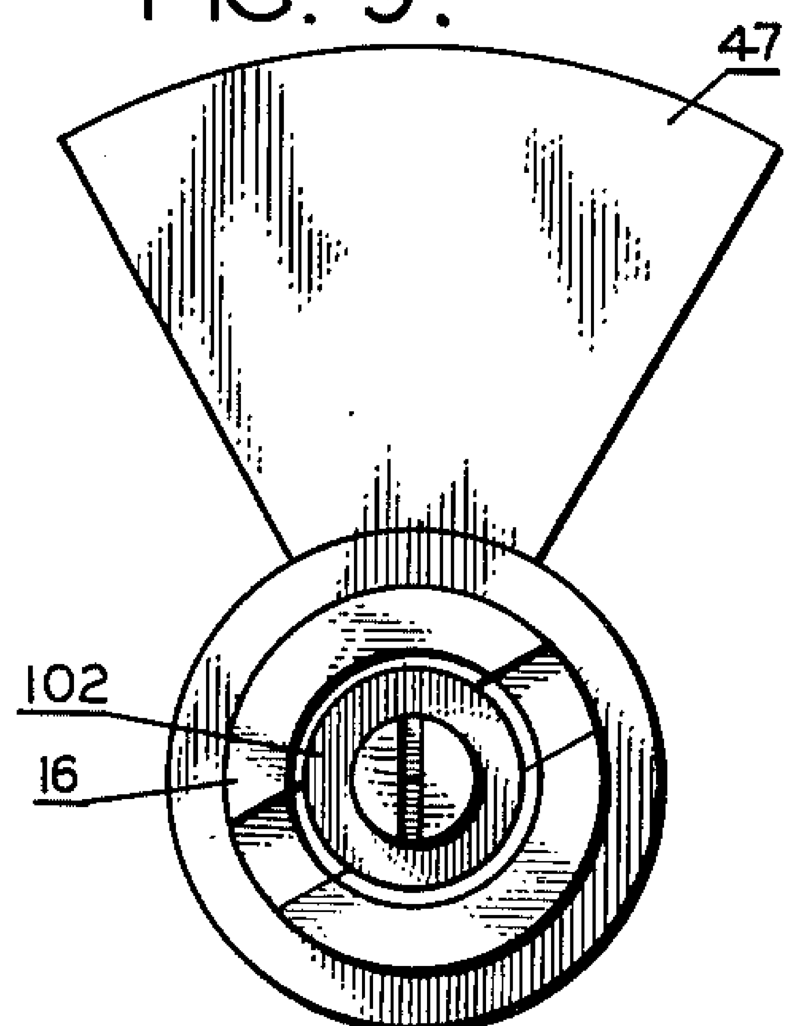


FIG. 6.

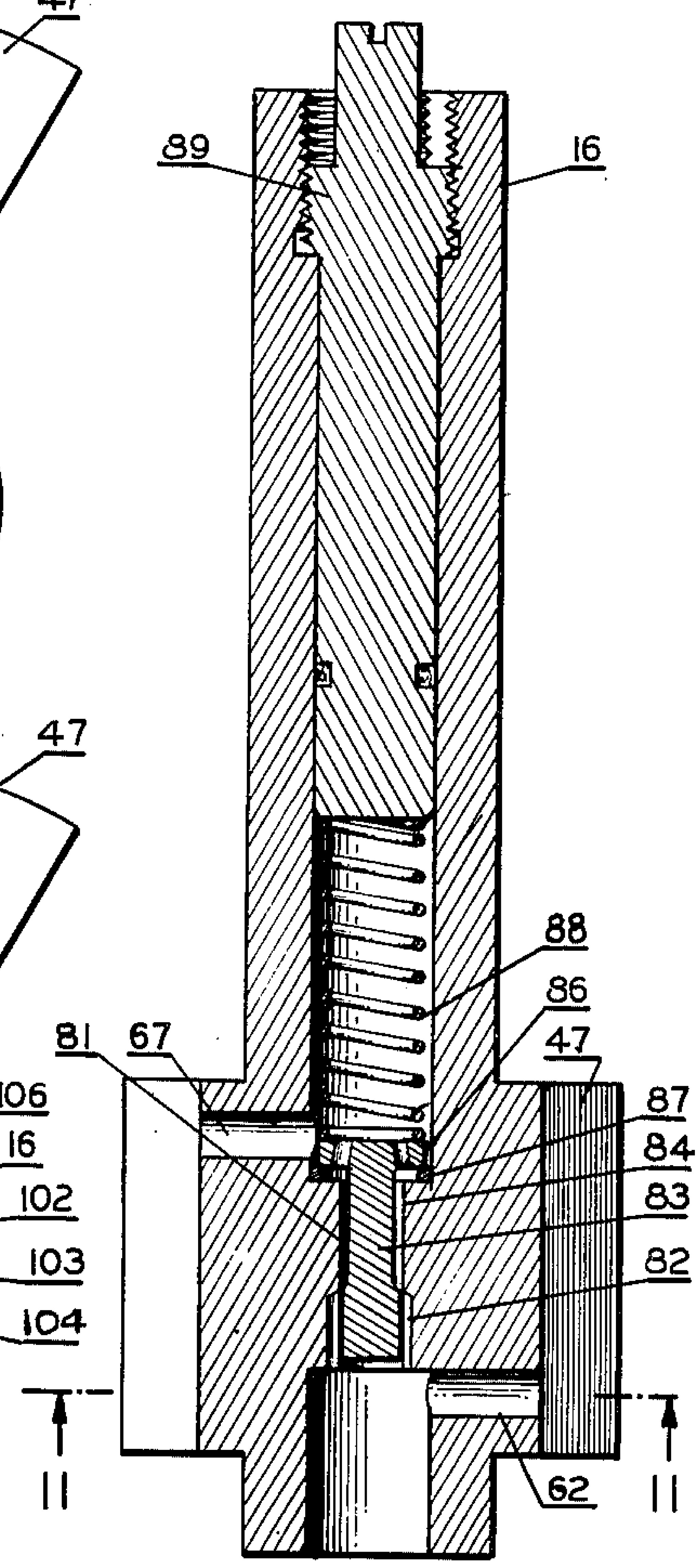


FIG. 10.

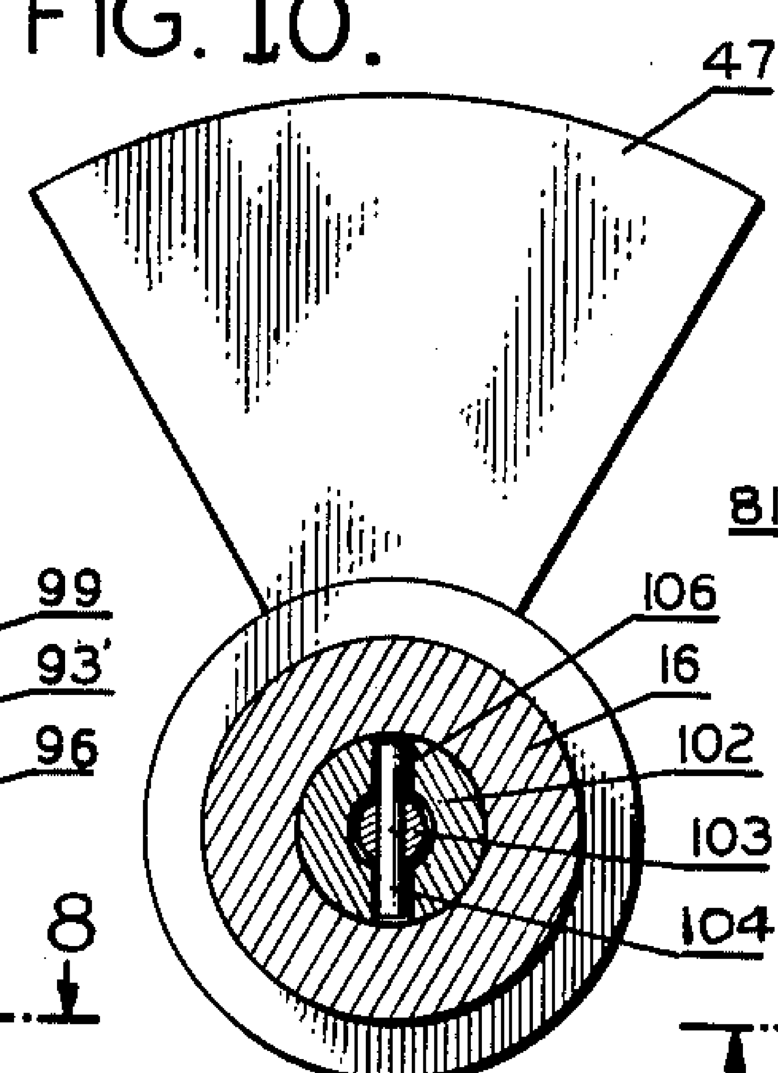


FIG. 8.

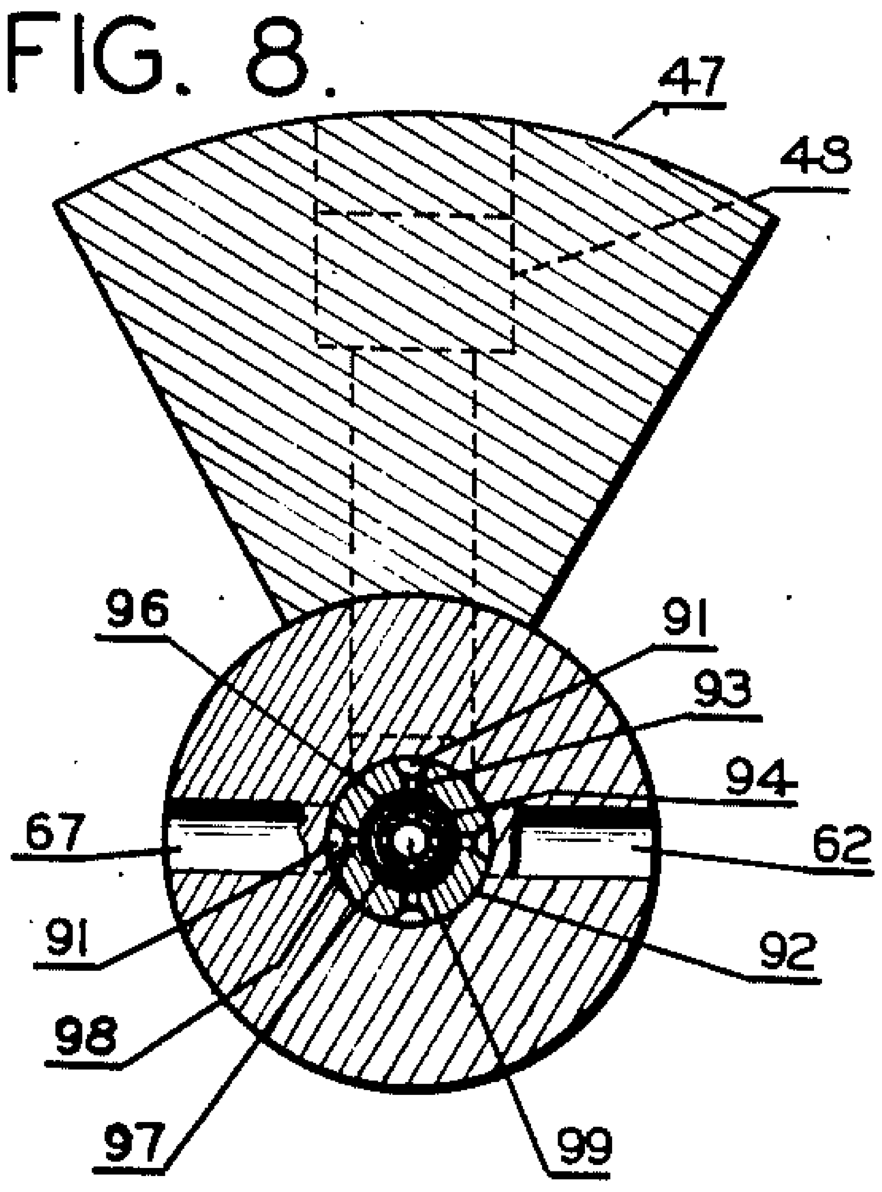
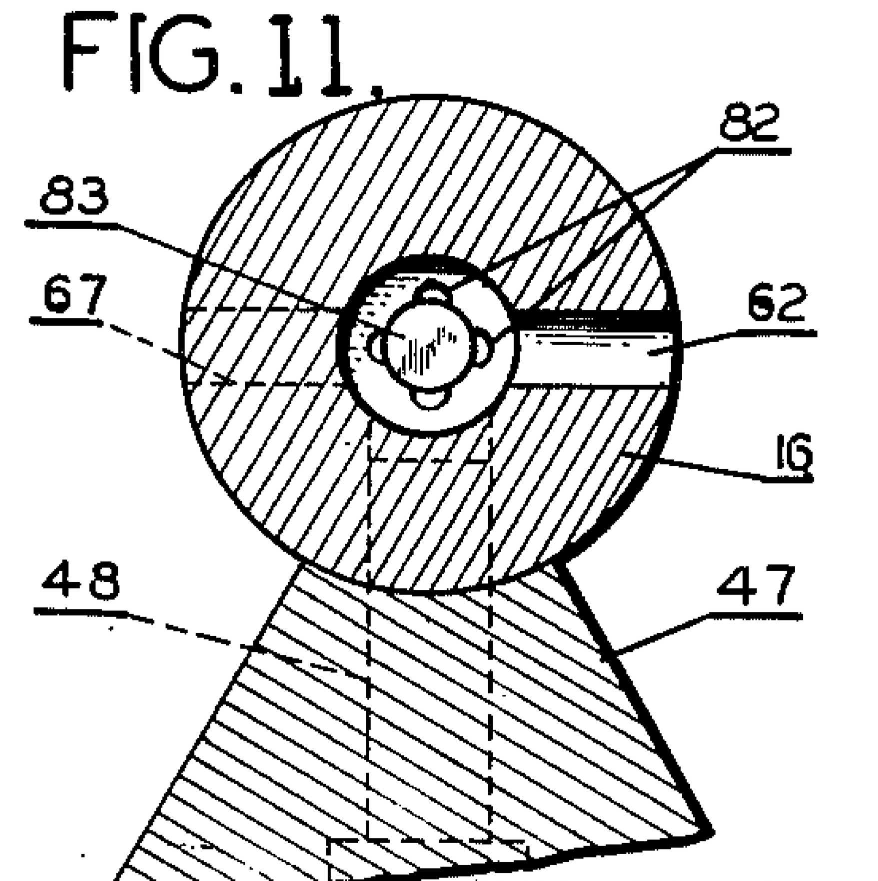


FIG. 11.



INVENTORS.
ROBERT M. CONKLIN
ARTHUR SCHARF

BY

Marcus Lothrop
ATTORNEY.

Patented Feb. 24, 1953

2,629,127

UNITED STATES PATENT OFFICE

2,629,127

DOOR CLOSER WITH CONSTANT FLOW ORIFICE

Robert M. Conklin and Arthur Scharf, Columbus, Ohio, assignors, by mesne assignments, to Schlage Lock Company, San Francisco, Calif., a corporation of California

Application February 1, 1950, Serial No. 141,821

5 Claims. (Cl. 16—58)

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Our invention relates to devices for providing substantially constant fluid flow regardless of external conditions and has particular reference to a door closer, although it has many other applications as well. Door closers incorporating this invention hydraulically control the operation of doors at a predetermined or substantially constant closing speed regardless of external conditions, such as changes in force applied and temperature.

The functioning of a door closer can be considered in two phases, first, the action taking place during door opening and second, the action taking place during door closing. Excluding the action of the damping or regulating mechanism, one action is the reverse of the other. The closing action may be considered in five stages of operation. These are 1, when the door is at rest just prior to the start of its closing, 2, when the door is accelerating from rest position, 3, when the door is moving at constant velocity, 4, when the door latches, and 5, when the door is at rest just after closing. A satisfactory closer must control a door during each stage under conditions which are not constant during the life of the closer. Although there are cases where it is not necessary to check the closing until the door is about to latch, it is preferable to control the door at all closing angles as a safety feature and to prevent slam. The closing action should, furthermore, be normal whether the door has been opened widely or whether it has been opened only a small fraction of its travel. The closer should be effective despite slight irregularities in mounting and accumulations of dust, grit and paint. Maintenance should be minimized in frequency and seriousness. It should be possible to adjust the closing time over a considerable range but no variation in operation of the closer should result from temperature changes.

The closing force for the door closer is obtained during door opening, is stored most commonly in a mechanical spring, and is discharged during the closing of the door. The amount of energy necessarily stored in the spring system to close the door against a maximum adverse wind is, in most cases, in excess of the amount required to close the door normally. The energy released by the spring and the energy released by deceleration of the door as it nears closure must be dissipated or transformed if the movement of the door is to be properly controlled. Changing friction and temperature, and the varying angle of the door opening make it necessary to provide a checking mechanism or regulator to absorb

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varying amounts of the total energy necessarily supplied for maximum operating conditions.

The requirement of uniform operation with variations in closing torque is not met by present fluid-damped closers. If the damping control is adjusted for normal closing speed in still air, the door will close at from about two to about four times this speed under the influence of a 15 M. P. H. wind. If the closer is set to provide a reasonable closing speed when the wind acts on the door, then the closing rate in still air is too slow. The possibilities are either a rapid closing (possibly a slam) or an excessively slow closing. Changes in wind and in temperature require frequent adjustment of the spring tension, closing speed mechanism, and latching speed mechanism.

It is therefore an object of this invention to provide a substantially constant closing mechanism, independent of external conditions.

It is another object of this invention to provide self-compensating closing speed control means for a door closer.

It is still another object of this invention to provide a fluid flow controlling mechanism for governing the speed of door closing regardless of external conditions.

It is a further object of this invention to provide a hydraulically damped door closer with a constant flow orifice for controlling the speed of the door closer in the closing direction, the flow being constant despite variations in external forces and temperatures operating on the door closer.

Other objects and advantages of this invention are attained by the forms of the present invention described in the accompanying description and shown in the accompanying drawings in which:

Figure 1 is a front elevational view of our assembled door closer mounted for operation, and

Figure 2 is a top plan view of the door closer, and

Figure 3 is a vertical sectional view of the door closer along the line **3—3** of Figure 2, and

Figure 4 is a horizontal sectional view of the door closer along line **4—4** of Figure 3, and

Figure 5 is a horizontal sectional view of the door closer along the line **5—5** of Figure 3, and

Figure 6 is a vertical sectional view of a modified plunger and shaft assembly, and

Figure 7 is a vertical sectional view of a further modified plunger and shaft assembly, and

Figure 8 is a horizontal sectional view along the line **8—8** of Figure 7, and

Figure 9 is a plan of the plunger and shaft assemblies of Figures 6 and 7, and

Figure 10 is a sectional view along the line 10—10 of Figure 7, and

Figure 11 is a horizontal sectional view along the line 11—11 of Figure 6.

The door closer shown in Figures 1 to 5, includes a top bracket plate 1 provided with lateral arms 2 having screws 3 therein to enable the door closer to be readily attached to either a door 4 or to a door frame 6 and is pierced to form a bearing mounting 7. Machine screws 8 at its lower end secure the top bracket plate to a bottom clamp plate 9 also having a bearing 11 in which a hub 12 depending from the door closer case 13 can rotate. The case 13 includes a cover plate 14 removably mounted thereon. A vertically disposed central hollow shaft 16 is journalled at its lower end within the hub 12 of the case 13 and at its upper end passes through a bushing 17 disposed in the cover plate 14 and in a hub 18 welded to the top bracket plate 1. An arm 19 surrounds the top hub 18 above the plate 1 and is held in axial position by a snap ring 21. A bridge 22 rides on the hub 18 and is retained by a snap ring 23. The bridge has central lugs 24 entering a slot 26 in the end of the shaft 16 and has fasteners 77 securing it to the arm 19 so that the arm and the shaft 16 turn together. A toggle arm 28 is fastened to the arm 19 and the door casing 6 in the usual way.

Within the case 13 is a spring collar 29 secured to the shaft 16 by a set screw 31 engaging a notch in the side of the shaft. The spring collar has a groove 32 to receive the inturned end of a coil spring 33. The other end of the spring 33 hooks against a lug 34 on an adjusting ring 36, mounted to rotate within the case 13 and providing means for winding up the spring. The spring is wound up by inserting a tool through a slot 37 in the side of the case and engaging one of the circumferential series of holes in the adjusting ring and then advancing the ring in a clockwise direction, as seen in Figure 4. A pin 38 with a beveled end projects through the case into one of the holes in the adjusting ring. An external spring leaf 39 presses the pin into position to lock the spring 33 but yields in the winding direction of rotation of the ring to provide a ratchet. Once the pin is engaged in the desired hole in the adjusting ring, the tool can be removed from the slot 37 leaving the spring under the desired initial tension. The spring tension can be released by lifting the leaf 39.

Below the spring collar and surrounding the shaft is a screw plate 41 engaging threads on the inside of the casing and seating on a gasket 42 to close a hydraulic reservoir 43. A filler plug 44 is provided on plate 41 for the purpose of filling the chamber below it and all the spaces and passages communicating with the chamber with hydraulic fluid. An O ring 45 is disposed in a circumferential groove in the hub of the screw plate and bears against the shaft 16 to prevent leakage of fluid out of the reservoir 43. Below and abutted by the screw plate and seated in the casing is a seal plate 46. The reservoir between the screw plate and the seal plate provides a refuge for gases given off by decomposition of the hydraulic fluid and provides a space for thermal expansion of the fluid to prevent stress on the case 13.

Below the seal plate 46 a vane 47 is attached by screws 48 to the lower portion of the main shaft 16. The vane rotates in a chamber 49 de-

fined by the seal plate and the lower portion of the case 13 and also defined by an abutment 51 hydraulically tight and secured to the seal plate and bottom portion of the case by means of pins 52 and 53.

A horizontal passage 54 leads from the side of the abutment generally designated the low-pressure side to a vertical passage 56 opening on to a seat 57 on which a ball 58 normally rests by gravity. Above the seat a horizontal passage 59 leads to the high-pressure side of the abutment. A passage 61 also leads from the reservoir through the seal plate to the passage 56 in order to provide a sufficient operating level of fluid.

There is a passage 62 extending from the high pressure side of the abutment through the wall of the shaft 16 into the central compartment 63. Flow of hydraulic fluid from the compartment is through an orifice plate 64 into a chamber 66 in the shaft 16 from which a passage 67 leads to the low pressure side of the abutment in the chamber 49. The orifice plate 64 provides a knife edge opening or orifice of a fixed and established diameter and can readily be replaced with an orifice of different size or, when worn with a new one of the original size, but having no substantial length does not variably restrict flow of liquid due to viscosity changes therein.

Co-operating with the orifice plate to provide a smaller resulting opening is a plunger 68 movable through the orifice and itself having an especially contoured groove 69 formed in its active portion. The cross sectional shape of the groove, when considered with the adjacent part of the knife edge orifice, provides a net or resultant opening of predetermined size or area to regulate the precise amount of flow therethrough for a certain pressure drop. (The plunger moves according to pressure drop across the orifice between it and the orifice plate 64.) The flow area between the exposed part of the knife edge and the adjacent cross section of the groove in any position of the plunger corresponds to the pressure that moves the plunger to that position so that the flow, which depends upon pressure drop and area, is held virtually constant or to any desired value.

The plunger 68 has a reduced portion passing through a spring abutment washer 70 and is flared at its upper end to hold a plunger ring 71 slidable within an adjustment screw plug 72 threaded into the upper portion of the main shaft 16. The adjustment screw provides a closing speed adjustment for the door closer. The adjustment screw plug 72 is crimped to hold a plunger guide and retaining washer 73. An O ring 74 provides a seal between the adjustment screw and the shaft to prevent entry of dirt and loss of fluid. A spring 75 is interposed between the washers 70 and 73 to oppose the lifting of the plunger 68 under pressure. Adjustment is made by rotating the screw plug 72 in order to establish the desired position of the plunger with respect to the orifice plate 64 at any given pressure.

Since the position of the plunger relative to the orifice changes in accordance with pressure drop across the orifice and since the area of the groove 69 corresponds to the plunger position, the net orifice area depends upon the pressure drop and is usually made an inverse function thereof. It is possible to obtain constant speed closing and even to over-compensate for wind pressure. The adjustment screw plug 72 provides a means to adjust the pressure response of the plunger to compensate for extreme changes in temperature, for personal choice of closing speed, for wear and subsequent leakage past the damping piston or plunger, and for dimensional variation within manufacturing tolerances.

To operate the closer, either the case 13 is anchored to the top bracket plate 1 and the shaft 16 is fastened to the arm 19, or the case 13 is fastened to the arm 19 and the shaft 16 is secured to the top bracket plate 1. As shown, the case 13 and bracket plate 1 are joined by a screw 76, while the bridge 22, secured to the shaft 16, is connected by screws 77 to the arm for right-hand operation. This mechanism is the subject matter of our co-pending application entitled "Reversible Door Closer," filed January 30, 1950, Serial No. 141,222. When screws 77 are removed and are inserted in holes 78 in the bridge and in the hub 18 and when the screw 76 is removed and is put into a hole 79 in the arm and case for left hand door operation, the arm is held to the case and both rotate clockwise (as seen in Figure 2) relative to the shaft which is held to the bracket or lower frame 9. When, as shown, the screws are inserted in the holes 77 in the bridge and arm, and the screw 76 holds the case fixed to the top bracket plate 1, the case is fastened to the door and the shaft 16 rotates counter-clockwise, as seen in Figure 2.

Upon opening of the door, the spring is wound either by the turning of the casing or by the turning of the shaft, depending on whether the closer is mounted and connected for left- or right-hand door operation. This arrangement permits an external change-over without disturbing the spring or damping system to provide unidirectional operation of the spring and damper combination.

Upon opening of the door for either right- or left-hand mounting, the vane and the casing rotate relatively in a direction to cause the fluid to leave the diminishing low pressure side by way of the passage 54 in the abutment and to force the ball 58 from its seat. The liquid then passes freely around the ball and out into the expanding high pressure side by means of the passage 59 in the abutment. At the end of the opening action much of the liquid is on the high pressure side.

On the closing action, the vane 47 moves due to pressure of the spring 33, relative to and toward the abutment 51. The fluid reverses its direction of flow and seats the ball 58. The only remaining flow path is then through the passage 62 into the interior of the shaft 16. The fluid is forced up around the plunger 68 and through the area defined by the groove 69 in the plunger and the sharp edge of the orifice insert 64. As the pressure in the lower portion of the shaft chamber below the insert increases, the plunger moves vertically upward decreasing the area between the groove and the insert and thereby maintaining the quantity of flow constant, despite the increasing upstream pressure of the fluid. Thus a constant or regulated flow is maintained into the upper chamber 66 from which the fluid leaves through the passage 67 and enters the low-pressure space.

During door opening action the orifice plunger, being substantially out of the close clearance portion of the orifice bore, permits a substantially free flow of the fluid. The direction of fluid tends to hold the plunger in free flow position or to move it into that position.

The speed of the door closer in the closing direction can thus be controlled and made substantially constant by the use of a hydraulic constant flow orifice. The constant flow orifice enables the maintenance of constant speed closing of the closer regardless of the wind forces acting against the door and regardless of temperature changes. A sharp-edged orifice with a close fitting notched plunger operating in it, provides a variable orifice effect to maintain a constant flow of liquid through the orifice regardless of fluid pressure drop and regardless of viscosity changes due to temperature variation. Nearly all of the flow of the fluid passes between the notch and the knife edge, and the effect of increased fluid pressure on the upstream side is to move the plunger vertically against the spring operatively connected to the upper portion of the plunger. The phrase "nearly all" is used since there is a minor amount of leakage due to tolerances in manufacturing. The spring on one end of the plunger applies force in one direction while the fluid applies force on the opposite end of the plunger in the other direction. Thus, in the low pressure or no-load ranges the fluid flow through the deep end of the notch is so small as to afford substantially low pressure drop and the position of the plunger is not changed so that the unit then operates as a fixed orifice. But when the pressure of the fluid on the upstream side is sufficient to overcome the spring pressure, the plunger moves vertically and the shallow portion of the notch moves to operating position. Thus the unit operates as a changeable orifice having a constant fluid flow. The notch is shaped so as to balance increased pressure with reduced notch cross-section thereby giving a resultant substantially constant flow. The action is free from temperature effects due to the short leakage path and the sharp edged orifice. The fact that the entire periphery of the sharp edged orifice is not used is not essential since using about a quarter of the sharp edged orifice as is done herein gives considerably more than the expected benefit from that much of the device.

A modification of the constant flow orifice is shown in Figure 6. While this arrangement is not as nearly independent of viscosity variations as the sharp edge orifice is, it is suitable where the fluid used is normally of substantially constant viscosity. The hollow shaft 16 has a bore 81 between ports 62 and 67. Part of the bore is relieved by grooves 82. A plunger 83 fits the bore 81 and is reduced in diameter for a part 84 of its length. A perforated head 86 is pressed toward a cushion 87 by a spring 88 retained by an adjusting screw 89. The plunger 83 fits in the shaft with a predetermined clearance. The fluid under pressure flows upwardly during closing causing the plunger head 86 to compress the spring and the plunger to enter farther into the bore 81. For a given fluid viscosity and plunger clearance, the resistance to flow through the annular clearance section between the plunger 83 and the shaft is directly proportional to the length of that path of fluid flow.

The hydraulic pressure on the plunger as it increases acts to increase also the length of the leakage path against the opposition of the spring which tends to decrease the length of the leakage path. A balance in the opposing forces therefore establishes a length of leakage path which is generally inversely proportional to the pressure drop across the restricted orifice. The net result is a substantially constant amount of flow independent of pressure. A low pressure causes the piston to assume a position providing a short leakage path with correspondingly large flow. A high pressure which in a fixed orifice would result in a greater amount of flow, forces the piston up to produce a longer leakage path and a relatively small flow. Actually, the spring and path characteristics are constructed so that in most cases the flow is held to as nearly constant a value as desired.

Figure 7 illustrates another modified plunger and spring assembly. The fluid from the high pressure side is introduced through a passage **62** into the hollow shaft **16** below the control mechanism and flows into vertical grooves **91** on the outside of a tubular insert **92** and thence through radial holes **93** to a central bore **94**. An external circumferential groove **96** is provided on the plunger **97** near but spaced from one end thereof and radial holes **98** in the plunger lead to a drilled escape passageway **99** in the plunger. The fluid leaves the passageway through the discharge port **67**. A spring **101** rests upon the plunger **97**, and against an adjusting screw **102**. A stem **103** on the plunger has a cross bar **104** riding in a slot **106** in the screw so that the plunger can be withdrawn as the screw itself is withdrawn although sliding motion of the plunger with respect to the adjusting screw is permitted. Variations in pressure are balanced by corresponding variations in the length of the annular restricted leakage path between the plunger **97** and the insert **92**. As the plunger is raised by fluid pressure, the external groove **96** serves more and more as a flow path from the apertures **93** to the apertures **98** and so provides a correspondingly increasing resistance to flow.

In tests of a device embodying one design of constant flow structure, a 30 M. P. H. wind increased the closing speed of the door about 20 percent and there was a variation in closing time of about 10 percent when a force equivalent to a 15 M. P. H. wind was applied to the door. The closing speed of a standard door closer is increased about 400 percent when the door is acted upon by a 15 M. P. H. wind. A door closer embodying a constant flow orifice of this invention provides a range of adjustment of the closing time from 4 to about 8 seconds. It is impossible to slam a door provided with this closer by the application of any practical force to it. Varying the ambient temperature of the closer from 60 degrees to 120 degrees F. caused only a 20 percent change in closing time. These test results indicate that the closer is relatively insensitive to viscosity variations and to temperature variations so that the orifice is practically a constant flow device.

We claim:

1. A constant-flow device, comprising a hollow shaft, a ring insert within said shaft having a knife-edged inner edge, and a plunger for reciprocating movement within said shaft and having a longitudinal groove of varying depth disposed to confront said inner edge, said plunger being adapted to move relative to said ring insert in response to a change in fluid pressure on said plunger.

2. In a constant-flow device, the combination of a hollow shaft, an insert in said shaft having a knife-edge orifice, and a reciprocating plunger passing through said orifice and yieldingly secured in said shaft, said plunger having a notch of increasing depth formed therein in a location so that said groove is in operative position with said knife edge of said orifice.

3. In a door closer, a case, an abutment within said case, a shaft having a bore and journalled in said case, means providing a restriction in said bore, a vane mounted on said shaft and movable with said shaft to provide a pair of variable chambers in said case between said abutment and said vane, means establishing communication between one of said chambers and said bore on one side of said restriction, means establishing communication between the other of said chambers and said bore on the other side of said restriction, a notched plunger movably disposed in said bore and extending through said restriction, and a spring in said bore for urging said plunger toward said one side of said restriction.

4. In a door closer having a case, an abutment within said case, a shaft having a bore and journalled in said case, a vane mounted on said shaft and movable with said shaft to provide a pair of variable chambers in said case between said abutment and said vane, means establishing communication between one of said chambers and one point in said bore, means establishing communication between the other of said chambers and another point in said bore, the combination of a knife-edge restriction in said bore between said points, a plunger having an irregular groove therein, and means for disposing said plunger in said bore and through said restriction for movement of said groove into different positions with respect to said knife-edge restriction.

5. In a door closer having means for impelling fluid flow through a bore, the combination of a knife-edge restriction in said bore, and a plunger having an irregular groove therein and movably disposed in said bore and through said restriction into different positions with respect to said knife-edge restriction.

ROBERT M. CONKLIN.
ARTHUR SCHARF.

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