Sept. 20, 1960

H. L. EDWARDS

2,953,659

SHUT-DOWN DEVICE

Filed May 16, 1955

3 Sheets-Sheet 1

FIG. 1

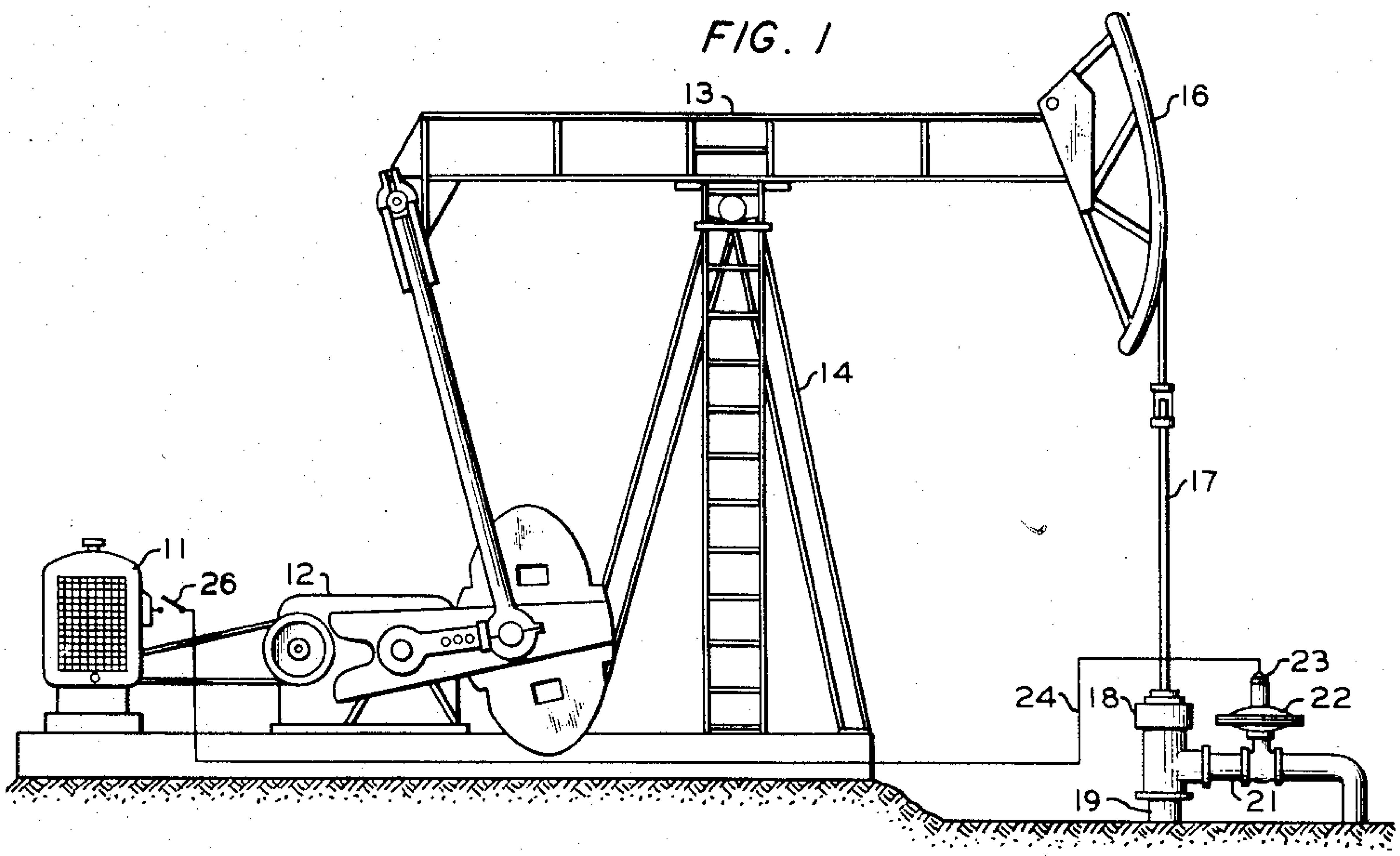


FIG. 2

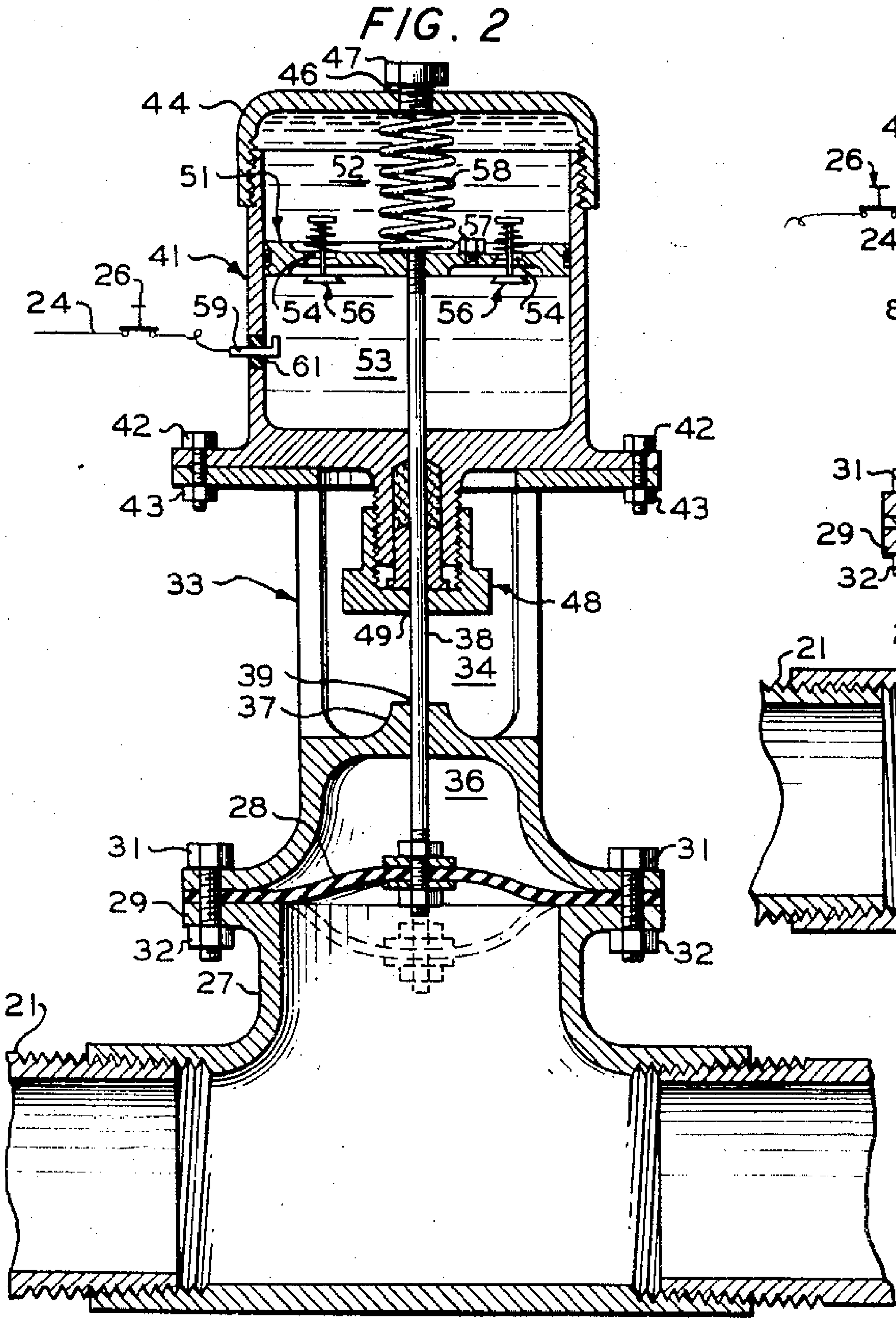
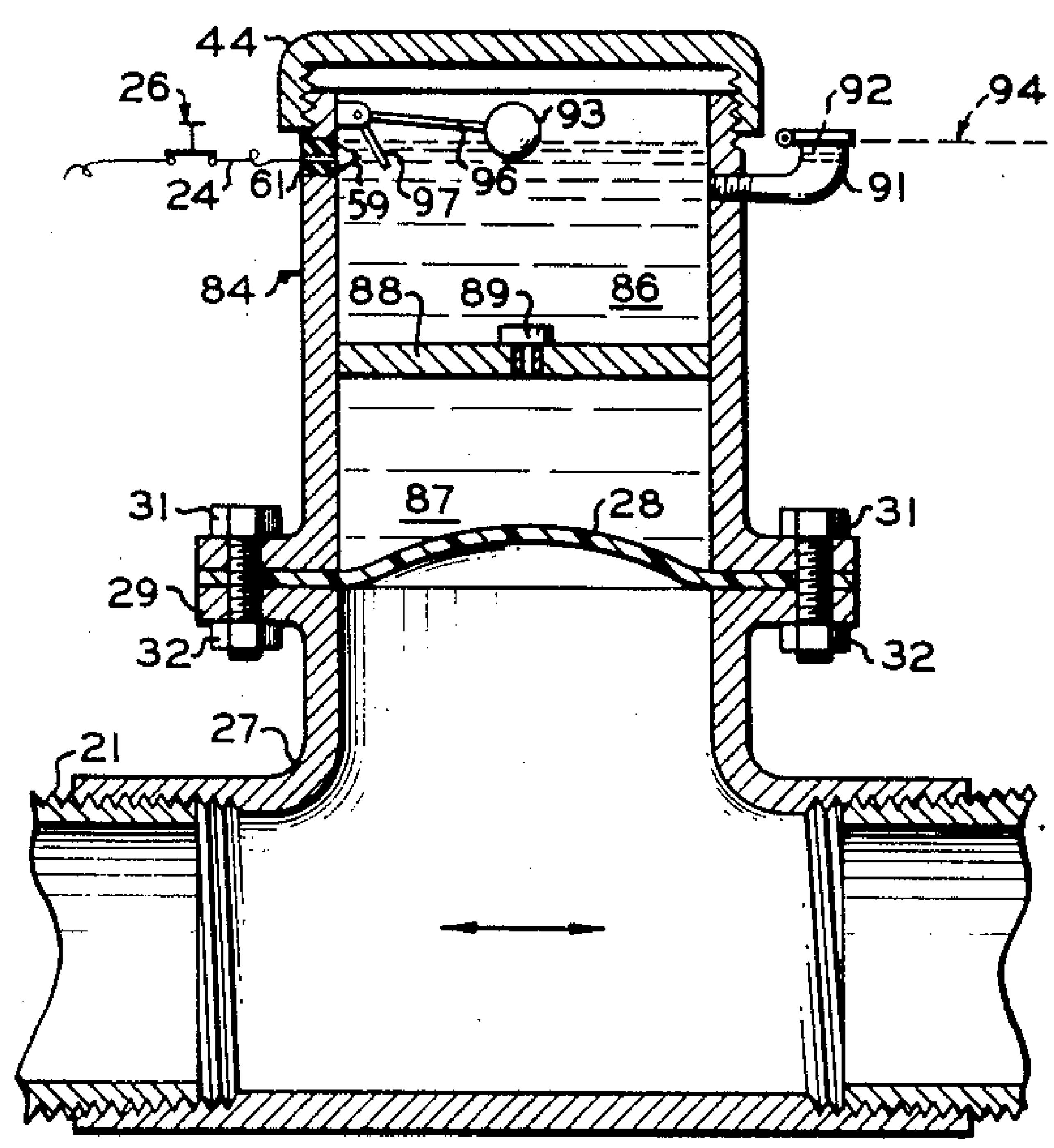


FIG. 4



INVENTOR.
H.L. EDWARDS

BY

Hudson & Young

ATTORNEYS

Sept. 20, 1960 H. L. EDWARDS 2,953,659

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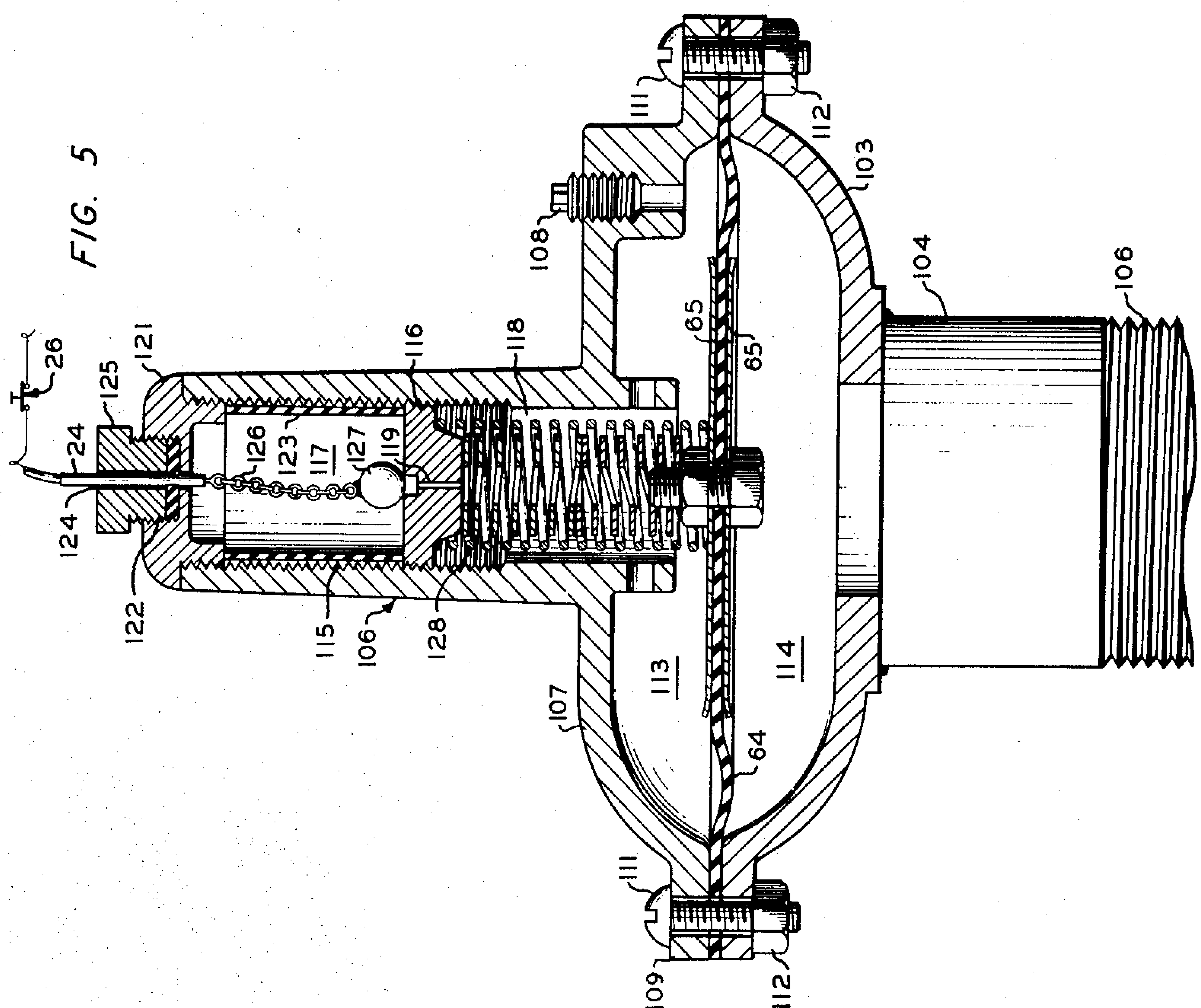

FIG. 5

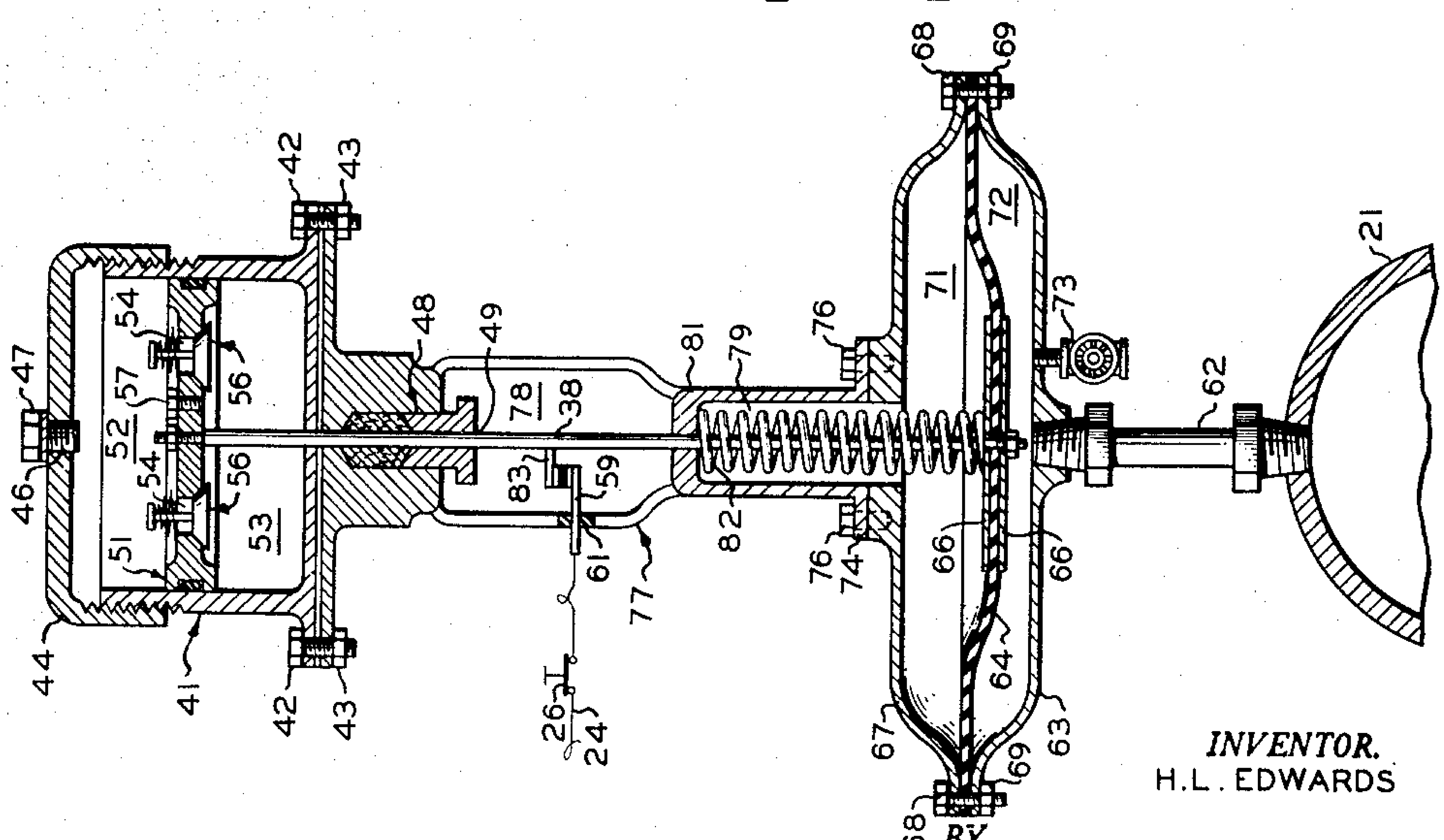

FIG. 3

INVENTOR.
H.L. EDWARDS

BY Hudson & Young

ATTORNEYS

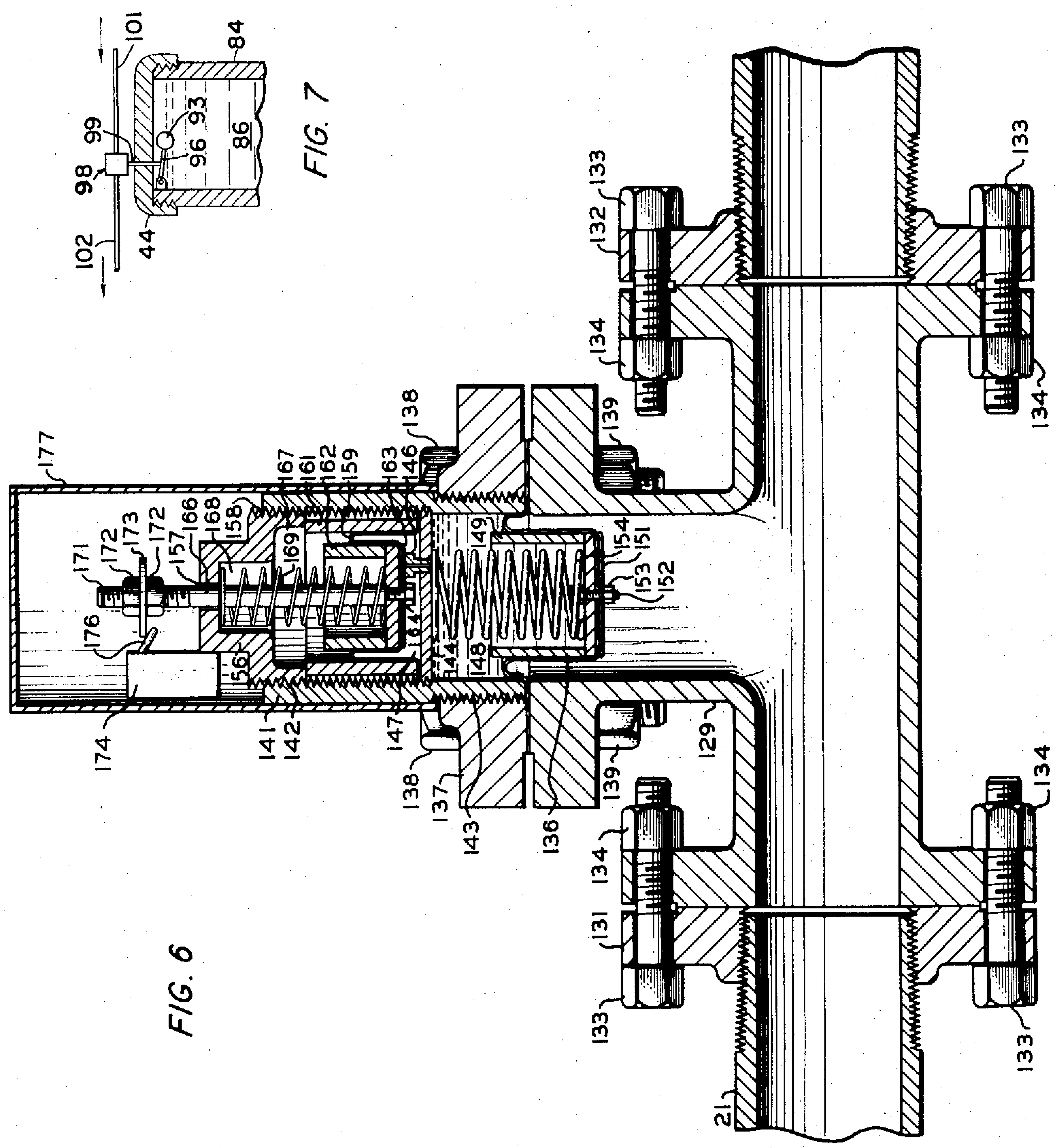

FIG. 6

INVENTOR.
H.L. EDWARDS

BY Hudson & Young

ATTORNEYS

United States Patent Office 2,953,659
Patented Sept. 20, 1960

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2,953,659
SHUT-DOWN DEVICE

Harold L. Edwards, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

Filed May 16, 1955, Ser. No. 508,716
2 Claims. (Cl. 200—83)

This invention relates to a shut-down device. In one of its aspects the invention relates to a shut-down device for a fluid pumping system. In another aspect it relates to a shut-down device for an oil-well pumping system. In a further aspect the invention relates to a device which maintains a pair of contacts open as long as a steady or pulsating pressure exists in a conduit or vessel but allows the contacts to close when the pressure drops to a predetermined minimum.

In oil production in recent years a great deal of emphasis has been placed on the more efficient utilization of labor. A large amount of labor-saving automatic devices have been proposed and the prior art provides many types of control devices which can be adapted to cause the shut-down of a pumping unit and some of these devices have been operated successfully. Inertia-type switches have been adapted to cause immediate shut-down whenever the walking beam of an oil well pump unit has departed from a predetermined pattern or standard, for example, upon the breaking of a sucker rod or change of the driving speed of the driving engine. Shut-down devices responsive to fluid pound are also known and have been adapted to shut down a pumping unit when the pump has lost suction. Time switches have also been adapted to shut down pumping units after a certain predetermined time interval. The time interval may be determined by either a time piece or a stroke counter. Furthermore, shutdown devices sensitive to the sag of a rod line have also been used to shut down a pumping unit. A sagging line denotes a high fluid level in the well whereas a taut line denotes a "pumped off" condition in the well. Shut-down devices responsive to a check valve have also been adapted to shut down a pumping unit. The prior art shut-down devices, although clearly operable and satisfactory from a number of points of view do not function for many conditions which are encountered in pumping a well. Furthermore, those devices can only protect the unit against a particular well condition. Therefore several different devices should be installed to sufficiently protect the unit. Moreover, the prior art devices cannot detect, and hence operate for, undesirable well conditions such as leaky tubing, leaky pump, gradual "sanding up" of the pump, etc.

A shut-down system has now been devised to provide positive protection for the pumping unit against a plurality of undesirable well conditions. While the shut-down device of the instant invention may be advantageously employed in various types of pumping systems, it is especially useful in oil well pump systems and it will be applied to such a system for purposes of illustrating its operation and it is obviously not necessarily limited thereto.

The shut-down device of this invention is adapted to a pumping system which combines a pump having an outlet conduit for conducting a fluid under pressure, a conduit for receiving the discharge from said pump, a motor or engine to actuate said pump, and a shut-down device responsive to the flow of fluid under pressure in said

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conduit and adapted to automatically shut down the pumping unit when the pressure of the fluid in said conduit, either upstream or downstream from said shut-down device, falls below a predetermined minimum for a substantial period of time. There are several adverse conditions which causes the pressure to fall below this predetermined minimum, such as in the case of failure of any part of the pump, if a break occurs in the line, or if the well "pumps off." However the normal or pulsating pressure which is usually encountered in well pumping systems, and momentary interruptions of flow, will not cause the shut-down device to be actuated because a hydraulic time delay in the shut-down device is operatively adapted to make allowance for these conditions.

The shut-down device of this invention does not require an external source of energy, such as compressed air or electricity, to effect its important function and the particular form of pump and motor or engine has no bearing on the present invention. The device is operable for a wide range of pumping rates and its installation in a pumping system means that an operator need not make as frequent surveillance trips to the well site as heretofore had been necessary.

An object of this invention is to provide a shut-down device for a fluid pumping system.

Another object of this invention is to provide a shut-down device which is responsive to the flow of fluid in a conduit or vessel.

Another object of this invention is to provide a shut-down device which maintains a pair of contacts open as long as a steady or pulsating pressure exists in a conduit or vessel but allows the contacts to close when the pressure drops below a predetermined minimum.

A further object is to provide a shut-down device for an oil well pumping system which is activated when any part of the pump fails or a substantial break occurs in the discharge line from the pump, or when the well "pumps off."

Another object of this invention is to provide a shut-down device for a fluid pumping system which is responsive to a steady or pulsating flow of fluid and is activated only after a hydraulic time delay has elapsed.

Other objects, features, and advantages of this invention should become apparent from the following detailed description taken in conjunction with the drawings and the appended claims.

To more fully enable the reader to understand the invention, reference is now made to the drawings in which:

Figure 1 shows diagrammatically a pumping unit on which is shown an embodiment of the invention.

Figures 2, 3, 4, 5, 6, and 7 show cross-sectional views of several embodiments of the shut-down device which is operatively responsive to the flow of fluid under pressure by the pumping unit shown in Figure 1 and where like reference numerals have been used to designate like parts.

Referring now to Figure 1, an internal combustion engine **11** and gear box **12** are used to move up and down the walking beam **13** supported on posts **14**. At the front end of the walking beam **13** is attached the horse head **16** from which is suspended pulsating rod **17** which extends through stuffing box **18** and actuates the pumping means in the well tubing **19**. It is apparent from the structure disclosed that in response to the reciprocation of the walking beam **13**, fluid will be drawn up through well tubing **19** whereupon it is discharged through a conduit **21**. As long as there is an ample supply of liquid in the well, a certain amount of fluid will be discharged through conduit **21** on each stroke of the walking beam **13**. Whenever fluid is being pumped it will be discharged in surges or pulsations through conduit **21**. Shut-down device **22** is in communication with conduit **21** and operatively adapted to actuate contact 23 which is connected by wire 24 in which there is a switch 26, to the magneto ignition system of engine 11 and thereby shut down the pumping unit by grounding the magneto ignition system when the pressure of fluid flowing in conduit 21 drops below a predetermined minimum. Wire 24 may also be operatively connected to other means for actuating the pumping unit, such as a motor.

Referring now to the modification of the shut-down device shown in Figure 2, conduit 21 is connected to T 27 on which the flexible diaphragm 28 is supported. This diaphragm may be made of rubber of any flexible substance preferably resistant to the attack of fluid flowing in conduit 21.

Secured to flange 29 to bolts 31 and nuts 32 and holding down diaphragm 28 is a yoke 33 which comprises open space 34 and chamber 36 defined from each other by a rod guide plate 37 which can be in the form of a spider. Attached to diaphragm 28 is a rod 38 which passes through opening 39 in rod guide plate 37.

Closing the top of yoke 33 is a liquid filled cylinder 41 which is secured thereto by bolts 42 and nuts 43. The top of cylinder 41 is closed with a threaded cap 44 having an opening 46 in its top in which a fill plug 47 is inserted. A packing gland 48 is positioned below the cylinder 41 and extends into chamber 34 and is provided with an opening 49 through which rod 38 is allowed to move reciprocally. To that end of rod 38 opposite the end connected to diaphragm 28 is threaded a piston 51 which is of such diameter that it moves axially within the cylinder 41 in response to the reciprocal movement of rod 38 and divides the cylinder 41 into an upper chamber 52 and a lower chamber 53. Within piston 51 are ports 54 and spring loaded valves 56 and a threaded orifice plug 57. Spring 58 is interposed between piston 51 and cap 44. A contact 59 extends through the wall of cylinder 41 and is insulated therefrom by any suitable insulation material 61 and is positioned below piston 51 to which it comes into junction when the piston 51 moves down. A wire 24 is attached to the contact 59 and completes the circuit from the magneto ignition system of engine 11 to ground when switch 26 is closed.

In the embodiment shown in Figure 3, which is a modification of that shown in Figure 2, a small tube 62 communicates with conduit 21 at one end and with a lower diaphragm housing 63 at the other end. A flexible diaphragm 64 supported by plates 66 is positioned between lower diaphragm housing 63 and an upper diaphragm housing 67, said housings 63 and 67 and diaphragm 64 are secured by bolts 68 and nuts 69 so that there is formed within said housings 63 and 67 an upper diaphragm chamber 71 and a lower diaphragm chamber 72. Lower diaphragm housing 63 is provided with a drain plug 73.

Secured to upper diaphragm housing 67 by flange 74 and bolts 76 is yoke 77 which is provided with an open space 78 and a chamber 79 defined from each other by rod guide plate 81. A spring 82 is positioned between diaphragm 64 and rod guide plate 81. Contact 59 extends through the yoke 77 into space 78 so that it will come into junction with contact 83 which is attached to rod 38 within space 78 when the rod 38 moves down.

In Figure 4 cylinder 84 comprises two liquid filled chambers 86 and 87 defined from each other by an orifice plate 88 and in communication with each other through orifice plug 89. A capped fill vent 91 fitted with a filter 92 extends through the wall of cylinder 84 into chamber 86. A float 93 floating on top of the liquid level 94 in chamber 86 and connected to the wall of the cylinder 84 by float arm 96 forms part of a float switch in which contact 97 is attached to the float arm 96. Contact 59 extends through the cylinder 84 into chamber 86 and is positioned so as to come into junction with contact 97 when the liquid level 94 moves down sufficiently.

The embodiment shown in Figure 4 can be used to control a motor valve, as shown in Figure 7, where an air control valve 98 is connected to float arm 96 by rod 99 so that the air in an air supply line 101 is restricted in passage through the air control valve 98 to a continuance of air supply line 102 leading to a motor valve in response to the movement of liquid level 94. In this embodiment, the contacts 59 and 97 of Figure 4 would not be used; in other respects, Figure 7 is the same as Figure 4. The embodiments shown in Figures 2, 3, 5 and 6 can be similarly adapted to control a motor valve.

Referring now to Figure 5, lower diaphragm housing 103 is connected to conduit 21 by means of extension 104 which is threaded at its lower portion. A housing 106 forms in part the upper diaphragm housing 107, in which a fill plug 108 is fitted, and is connected to the lower diaphragm housing 103 by flange 109, bolts 111 and nuts 112. A flexible diaphragm 64 supported by plates 65 divides the space enclosed by diaphragm housings 103 and 107 into chambers 113 and 114. The housing 106 has a threaded inner portion 115 in which a threaded orifice plate 116 is fitted which divides housing 106 into two liquid filled chambers 117 and 118 through which communication can be had by means of orifice 119. Closing the top of housing 106 is a cap 121 which is provided with threads 122. A liner 123 of neoprene or other suitable insulating material is fitted into chamber 117. An insulated wire 24 extends through a passage 124 in a threaded plug 125 fitted in cap 121 and insulated wire 24 extends into chamber 117 and is attached therein to a flexible conductor 126 to which a float 127 made of conductive material is attached. The flexible conductor 126 is of such length that it is just long enough to allow float 127 to come into junction with the orifice plate 116 when chamber 117 is liquid empty. Interposed between diaphragm 64 and orifice plate 116 is a spring 128.

Referring now to Figure 6, a preferred embodiment of the shut-down device, flanged T 129 is secured to conduit 21 by threaded flanges 131 and 132, bolts 133 and nuts 134. A first flexible diaphragm 136 seals the end of flanged T 129 and is secured thereto by threaded flange 137, bolts 138 and nuts 139. A cylindrical housing 141 has an inner threaded portion 142 and is secured to threaded flange 137 by outer threaded portion 143. An orifice plate 144 having a threaded orifice plug 146 is fitted within inner threaded portion 142 of cylindrical housing 141 and divides the latter into an upper liquid filled chamber 147 and a lower liquid filled chamber 148. A first diaphragm retaining member 149 is attached to diaphragm 136 and diaphragm plate 151 by bolt 152 and nut 153. Interposed between retaining member 149 and orifice plate 144 is spring 154. A plug 156 having an opening 157 is secured to inner threaded portion 142 of cylindrical housing 141 by outer threaded portion 158. A second flexible diaphragm 159 provides a seal for upper chamber 147 and is secured to orifice plate 144 at its periphery by a sleeve 161, the top end of which abuts plug 156. A second retaining member 162 is attached to second diaphragm 159 and diaphragm plate 163 by bolt 164 which is screwed into a rod 166 which extends through opening 157. Plug 156 is provided with a plug chamber 167 and a recess 168, both of which are liquid-free, and spring 169 is interposed between second retaining member 162 and plug 156. Rod 166 is threaded at its end 171 on which is screwed nuts 172 between which is a washer 173 which serves to actuate lever 176. Fitted over the outside of cylindrical housing 141 and plug 156 is a removable cap 177.

All of the other features in Figures 3, 4, 5 and 6 are clearly the same as those described in Figure 2 and it is believed unnecessary to describe them further.

Operation

In Figure 2, the switch 26 is manually opened when the pumping unit of Figure 1 is initially put into operation and then is closed when a steady or pulsating flow of fluid in conduit 21 is maintained. When a peak pressure in conduit 21 is reached on the up-stroke of the walking beam 13, diaphragm 28 is forced upward from its first position of low pressure to its second position of high pressure. This diaphragm movement causes rod 38 to move upward through rod guide plate 37 and packing gland 48, thus forcing piston 51 to move correspondingly upward. Since the upper chamber 52 is liquid filled, the upward movement of piston 51 forces liquid down through ports 54 into lower chamber 53 when spring loaded valves 56 are opened by the differential liquid pressure across the piston 51. The shutdown device of Figure 2 is shown moving upward towards its upper limit. At the top of the upward movement of piston 51 the spring loaded valves 56 close as the fluid pressure in conduit 21 drops on the down-stroke of the walking beam 13 and the spring 58 forces piston 51 to move downward in response to the downward movement of diaphragm 28 and rod 38. Since valves 56 are closed as fluid pressure is released, liquid in the lower chamber 53 is forced through orifice plug 57 into chamber 52. Orifice plug 57 is of such size that a predetermined time delay is effected before piston 51 reaches its lowest limit. This orifice plug 57, as well as spring 58, can be substituted in size to change the time delay feature. As long as a steady or pulsating pressure is maintained in conduit 21, diaphragm 28 and piston 51 will substantially remain in the upward position. In case of failure in any part of the pumping unit or a break in the conduit 21 or if the well "pumps off," pressure will fall below a predetermined minimum in conduit 21 causing diaphragm 28, rod 38, and piston 51 to move downward at a predetermined rate due to the restricted flow of liquid from chamber 53 through orifice plug 57 into chamber 52. When diaphragm 28 returns to its first position of low pressure, piston 51 reaches its lowest point of travel and comes into junction with contact 59, thus grounding the magneto ignition system of engine 11 and causing the pumping unit to shut down whereby further damage to the pumping unit or loss of fluid is avoided. (However, the engine can also be rendered merely inoperative to actuate the pump.) After trouble has been located and repaired, the operator opens switch 26 (normally closed), holding it open until the engine is operating and the pump has built up sufficient pressure in conduit 21 to raise diaphragm 28 from its first position and piston 51 is in its uppermost point of travel, thereby breaking the junction of contact 59 and piston 51. Switch 26 is then returned to its closed position and the shutdown device is again in operation.

The operation of the modification shown in Figure 3 is essentially the same as that described above in relation to Figure 2. The diaphragm 64 is shown in its first position of low pressure and contacts 59 and 83 are in junction. Orifice plug 57 restricts the flow of fluid therethrough whereby the time delay feature described above in relation with the operation of the embodiment shown in Figure 2 is effected.

In the operation of the embodiment shown in Figure 4, as long as a steady or pulsating pressure is maintained in conduit 21, sufficient liquid will be maintained in the upper chamber 86 to maintain the contacts 97 and 59 of the float switch open. However, if the fluid pressure in conduit 21 drops for a predetermined period of time, enough liquid will drain through orifice plug 89 to allow the contacts 97 and 59 to come into junction, thus shutting down the pumping unit.

In the operation of the embodiment shown in Figure 5, the steady or pulsating pressure in conduit 21 maintains a supply of liquid in chamber 117 when the diaphragm 64 is in its second position, thus maintaining the float 127 above orifice plate 116. However, when the pressure drops to a predetermined minimum in conduit 21 and the diaphragm 64 returns to its first position, the liquid in chamber 117 drains through orifice 119 allowing the float 127 to come into junction with orifice plate 116 thus completing the circuit from wire 24 to the magneto ignition system of Figure 1 and effecting the shut-down of the pumping unit. Orifice plate 116 can be moved up and down in the threaded portion 115 of yoke 106 to adjust the tension on spring 128 and change the time delay necessary to operate the shut-down device.

In the initial operation of the preferred embodiment shown in Figure 6, cap 177 is removed and the operator closes switch 26 when the top of rod 166 reaches a predetermined height representative of normal flow in conduit 21. If desired, orifice plate 144 can be further modified by providing it with valve assemblies similar to that of Figures 2 and 3. It is obvious that the time delay feature of the embodiment shown in Figure 6 can be modified by changing the position of orifice plate 144 within cylindrical housing 141 and by changing sleeve 161, orifice plug 146, and springs 154, 169 as well as the position of contact 173 on rod 171.

While specific embodiments of the preferred form of the invention have been shown for illustrative purposes, it should be understood that reasonable variation and modification, such as the use of a mercury float switch in place of a float switch illustrated, is possible within the scope of the foregoing disclosure.

Having described my invention, I claim:

1. A pressure switch comprising a rigid fluid tight diaphragm housing having an open side in communication with a source of fluid under pressure; a first flexible diaphragm across the open side of said diaphragm housing and adapted to move between a first position of low pressure and a second position of high pressure; a cylinder connected to said housing and divided transversely by an orifice plate into liquid filled upper and lower chambers; an orifice in said orifice plate; a first diaphragm retaining member in said lower chamber and connected to said first diaphragm; a first spring interposed between said first retaining member and said orifice plate; a plug connected to said cylinder having a plug chamber therein and an upper opening; a second flexible diaphragm providing a sealing means between said upper chamber and said plug chamber; a second diaphragm retaining member in said plug chamber and connected to said second diaphragm; a second spring in said plug chamber interposed between said second diaphragm retaining member and said plug; a rod within said second spring and connected at one end to said second retaining member and extending through said plug opening at its other end; a removable cap enclosing the outside of said cylinder and said plug; and a pair of contacts outside of said plug and within said cap, one contact connected to said other end of said rod, and the other contact attached to said plug and insulated therefrom, said pair of contacts coming into junction when said first diaphragm is in its first position.

2. A pressure switch, comprising a rigid fluid diaphragm housing having an open side in communication with a source of fluid under pressure; a first flexible diaphragm across the open side of said diaphragm housing and impervious to said fluid, said first diaphragm adapted to move between a first position of low pressure and a second position of high pressure; a cylinder connected to and surmounting said diaphragm housing; an adjustable orifice plate dividing said cylinder into liquid filled upper and lower chambers, the lower end of the latter chamber defined by said first diaphragm; a first cup-shaped diaphragm retaining member in said lower chamber secured at its lower end to said first diaphragm and movable therewith; a first spring interposed between the lower end of said first diaphragm retaining member and said orifice plate, said first spring biasing the movement of said first diaphragm and urging the latter toward its first position; a replaceable orifice plug in said orifice plate; an adjustable plug connected to and closing the upper end of said cylinder, said adjustable plug having

an opening therein at its upper end; a second flexible diaphragm in said cylinder defining the upper end of said upper chamber, the upper side of said second diaphragm and the upper end of said adjustable lug defining the lower and upper ends respectively of a plug chamber; a second cup-shaped diaphragm retaining member in said plug chamber secured at its lower end to said second diaphragm and movable therewith; a second spring interposed between the lower end of said second diaphragm retaining member and the upper end of said adjustable plug, said second spring biasing the upward movement of said second diaphragm; a rod within said second spring, the upper end of said rod passing through said opening in said adjustable plug and the lower end of said rod connected to said second diaphragm retaining member and movable therewith; a replaceable cylindrical sleeve within said plug chamber defining the sides thereof, the upper end of said sleeve abutting said adjustable plug and the lower end of said sleeve abutting said orifice plate with the periphery of said second diaphragm therebetween; a removable cap enclosing the outside of said cylinder and said adjustable plug; and a pair of contacts outside of said plug and within said cap, one contact connected to the upper end of said rod and movable therewith, and the other contact attached to the outside of said adjustable plug and insulated therefrom, said

pair of contacts adapted to come into junction when said first diaphragm is in its first position.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,953,659 September 20, 1960

Harold L. Edwards

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 56, after "fluid" insert -- tight --; column 7, line 4, for "lug" read -- plug --.

Signed and sealed this 11th day of April 1961.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

ARTHUR W. CROCKER
Acting Commissioner of Patents