

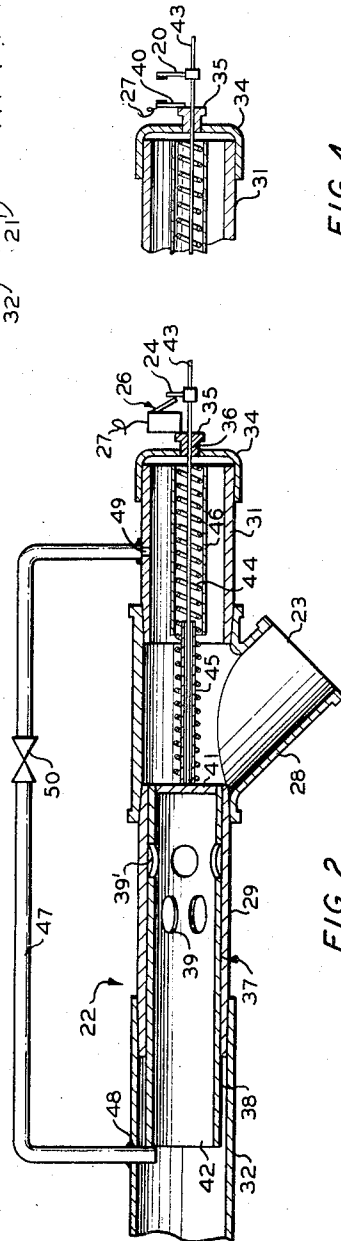
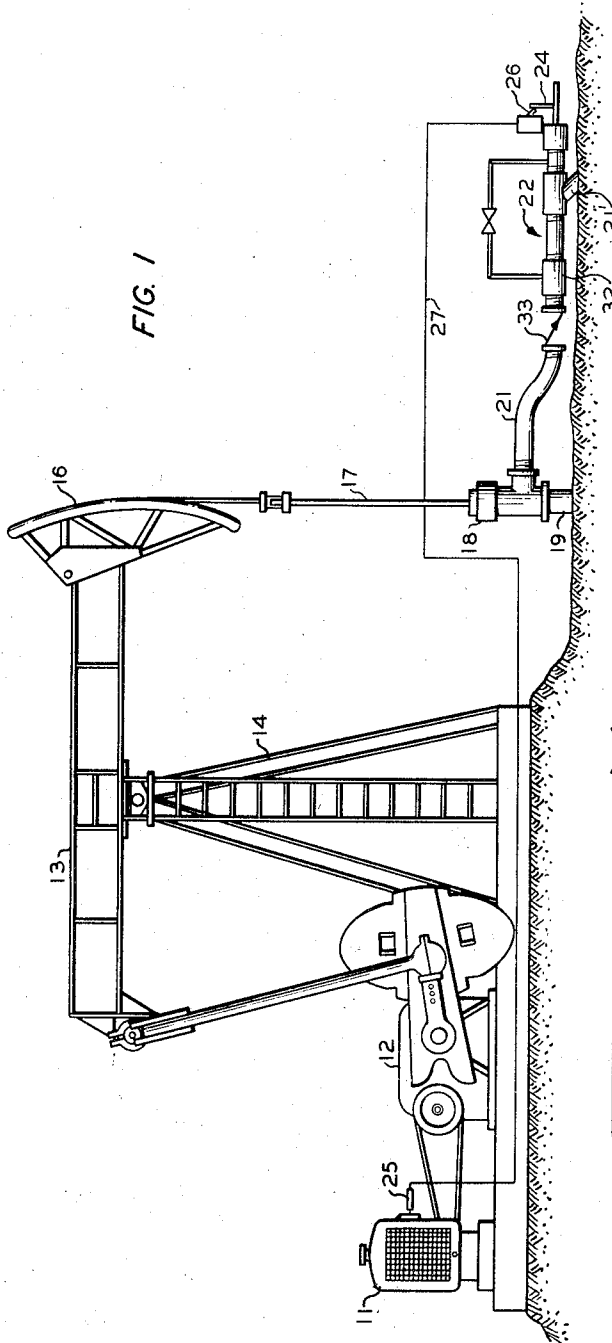
Sept. 23, 1958

O. B. REYNOLDS
FLOW-RESPONSIVE DEVICE

2,853,575

Filed May 9, 1955

2 Sheets-Sheet 1



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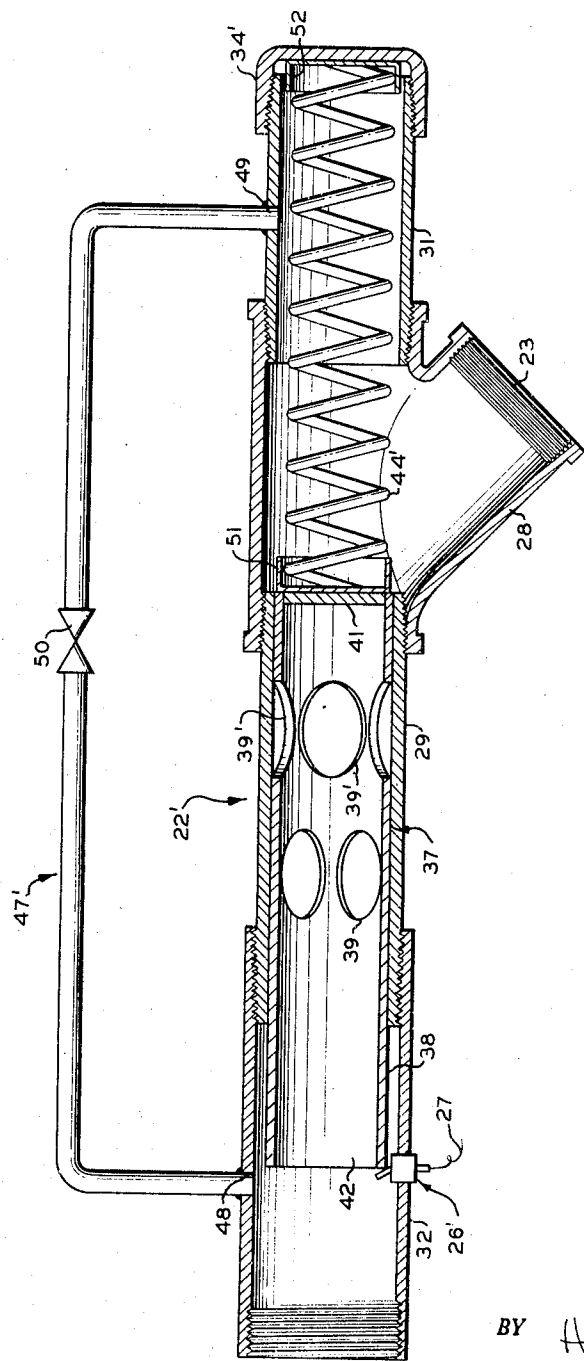
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FIG. 3



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FLOW-RESPONSIVE DEVICE

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Application May 9, 1955, Serial No. 506,863

9 Claims. (Cl. 200—81.9)

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 rate of flow of fluid exists in a conduit or vessel but allows the contacts to close when the rate of flow of fluid drops to a predetermined minimum.

In recent years a great deal of emphasis has been placed on the more efficient utilization of labor. A large number 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, shut-down 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 forming a part of said conduit and responsive to the rate of flow of fluid in said conduit and adapted to automatically shut down the pumping unit when the rate of

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flow of the fluid in said conduit upstream from said shut-down device falls below a predetermined minimum for a substantial period of time. There are several adverse conditions which causes the rate of flow 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 rate of flow which is usually encountered in well pumping systems and short surges will not cause the shut-down device to be actuated because a dashpot mechanism acting as a 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 rate of 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 rate of flow exists in a conduit or vessel but allows the contacts to close when the rate of flow 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 upstream from the shut-off device, 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 rate of flow of fluid and is actuated only after a hydraulic time delay has elapsed.

A further object is to provide a shut-down device which is responsive to a substantial rate of flow of fluid in a conduit or vessel and is not easily made inoperable by accumulation of solids therein.

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 shut-down device.

Figure 2 is a partial cross-sectional view of the shut-down device operatively responsive to the rate of flow of fluid under pressure by the pumping unit shown in Figure 1.

Figure 3 is a partial cross-sectional view of another embodiment of the shut-down device and like reference numbers have been used to designate like parts.

Figure 4 is a fragmentary detail view showing in cross section another embodiment of control means actuated by the shut-down device of Figure 2.

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 polished 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, liquid will be drawn up through well tubing 19 whereupon it is discharged through

conduit 21. As long as there is an ample supply of liquid in the well, a certain amount of liquid will be discharged through conduit 21 on each upward stroke of the walking beam 13. Whenever liquid is pumped it will be discharged in surges or pulsations through conduit 21. Shut-down device 22 is in communication with conduit 21 and forms a part thereof, discharging liquid through a lateral outlet 23, Figure 2, into a continuation 21' of conduit 21. Shut-down device 22 is adapted to actuate switch 26, which can be a snap-action switch, by means of lug 24 and complete the circuit of wire 27 to ground, thus grounding the magneto ignition system of engine 11, and shutting down the pumping unit. This actuation or grounding of the magneto ignition system is operatively adapted to occur when the rate of flow of fluid in conduit 21 falls below a predetermined minimum due to adverse conditions such as a failure in any part of the pumping unit, a break in the discharge conduit, or the "pumping-off" of the well.

Referring now to Figure 2, a T fitting 28 with threaded open ends is connected to a tube 29 and a tubular extension 31 and has a lateral outlet 23 in communication with continuation 21'. A collar 32 having a threaded open end to receive the other end of tube 29 is in communication at its other end through an inlet in the conduit 21 within which is check valve 33, Figure 1. A cap 34 closes the other end of tubular extension 31 and has an opening 36 therein. A piston indicated generally by reference numeral 37, removable through the end of tubular extension 31 when cap 34 is removed, is slidably movable within the shut-down device 22 and consists of a hollow sleeve 38, is fitted with perforations 39 generally adjacent to end piece 41 and removed from skirt portion 42. A rod 43 is attached to end-piece 41 and extends at one end through the opening 36 of cap 34 through stuffing box 35 and to this end is connected a lug 24. Switch 26 is fitted to the outside of cap 34 and insulated therefrom, and has a pair of normally open contacts (not shown), one of which is grounded, and the other connected to line 27. A compression spring 44 surrounds rod 43 and is interposed between the end piece 41 and the cap 34. Between spring 44 and rod 43 is interposed guide 45 and surrounding spring 44 is guide 46. A by-pass line generally indicated by reference numeral 47, extends at one end through opening 48 into collar 32 and at the other end to an opening 49 in tubular extension 31. A needle valve 50 is positioned in this by-pass line 47.

Referring now to Figure 3, a modification of the shut-down device as shown in Figure 2, switch 26' extends through collar 32 and is actuated by the end of piston 37 when the latter returns to its first position of no fluid flow. Spring positioning cups 51 and 52 are attached to end piece 41 and cap 34', respectively. If desired, means other than the switch 26' can be fitted inside collar 32 to stop piston 37, although it is not absolutely necessary for any supplementary stopping means to be employed other than those shown.

Figure 4 shows a modification of the control means actuated by the shut-down device. The control means in this modification comprises a stationary contact 40, attached to and insulated from the shut-down device, preferably attached as shown to stuffing box 35; and a contact 20 attached to that portion of rod 43 extending out from cap 34. Contact 20 is grounded by reason of its connection to the shut-down device.

Operation

In operation, on the up-stroke of walking beam 13 of Figure 1, fluid is drawn up through wall tubing 19, whereupon it is discharged through conduit 21, thence through the shut-down device 22 and on through a continuance 21' of conduit 21 to the fluid storage equipment (not shown). The fluid produced from the well flows through check valve 33 of Figure 1 into hollow sleeve

38 and forces the piston 37 against the compression spring 44 to move from its first position of no fluid flow toward its second position of fluid flow when one of the perforations 39' nearest end-piece 41 projects from the end of tube 29 to allow fluid to flow therethrough into lateral outlet 23 and discharge into continuation 21' of conduit 21. To allow any flow to be thus discharged, piston 37 must travel an appreciable distance to reach its second position of fluid flow before even a small amount of fluid is permitted to pass through the perforations 39'. However, the shut-down device 22 can accommodate a large volume of fluid since the other perforations 39 are also in fluid communication with the lateral outlet 23 as piston 37 moves beyond its second position towards cap 34.

The flow of fluid through conduit 21 normally is pulsating due to the reciprocating walking beam 13. To prevent a reversal of flow which could cause piston 37 to move back to its first position of no fluid flow, a check valve 33 is provided in conduit 21 upstream from shut-down device 22. If the shut-down device is in close proximity to the well head, a check valve is not always necessary, because the check valve within the pump itself would act to prevent a reversal of flow.

During normal operation of the pumping unit of Figure 1 and when a normal or pulsating flow of fluid exists in conduit 21, piston 37 will substantially be in its second position of fluid flow with each surge or pulsation. However, if the rate of flow of fluid is produced in short surges or if the rate of flow falls below a predetermined minimum due to a failure in the pumping unit, etc., piston 37 will tend to move towards its first position of no fluid flow. To control this movement, by-pass line 47 provided with needle valve 50 is adapted to act as a time-delay and needle valve 50 is adjusted to allow a flow of fluid therethrough at a predetermined rate from collar 32 to tubular extension 31 allowing piston 37 to return at a predetermined retarded rate to its first position. The end of that part of by-pass line 47 which passes through opening 48 and extends into collar 32 also serves as a stop for piston 37.

When piston 37 returns to its first position of no fluid flow, lug 24 comes into junction with switch 26 completing the circuit of wire 27 of Figure 1 to ground thus grounding the magneto ignition system of engine 11 stopping the pumping unit from causing any further damage or loss of fluid. However, in order to prevent the actuation of the shut-down device before a predetermined rate of flow is initially reached, switch 25 of Figure 1 is manually opened when the pumping unit is put into operation and then closed when said predetermined rate of flow is maintained, thereby completing the circuit of wire 27 from the contact 24 to the magneto ignition switch of engine 11.

It is noted that piston 37 is of such length that, in normal operation, it passes out of both ends of tube 29, thus preventing an accumulation of solid material from depositing from the fluid within tube 19 which might make the shut-down device 22 inoperable. Preferably, piston 37 is of such length that either end passes through the corresponding end of tube 29 at each stroke of walking beam 13 but, if desired, piston 37 can be made of a greater length than tube 29 so that the ends of piston 37 are always outside of tube 29.

The operation of the embodiment shown in Figure 3 is obviously similar to that set forth above in regard to Figure 2, switch 26' being actuated by the end of piston 37 instead of the rod 43 of Figure 2.

In Figure 4, stationary contact 40 comes into junction with movable contact 20 when the latter moves in response to the return of piston 37 to its first position, whereby contacts 40 and 20 are closed and the source of power is made inoperative to actuate the fluid moving means in order to prevent further undesirable functioning of the latter.

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 is possible within the scope of the foregoing disclosure.

I claim:

1. A flow switch for use in combination with a conduit conducting fluid, comprising a cylinder with an inlet opening at one end to receive fluid from said conduit and with an outlet opening to conduct said fluid to a continuation of said conduit; a piston slidably movable within and fitting said cylinder, said piston being adapted to move between a first position of no fluid flow and a second position of fluid flow; means to bias said piston towards said first position; a normally open restricted by-pass line in communication with said cylinder and adapted to conduct fluid around said piston; said by-pass line, cylinder, and piston acting as a dashpot adapted to retard at a predetermined rate the movement of said piston from its said second position to its said first position; and an electrical switch adjacent one end of said cylinder and adapted to be actuated by said piston when said piston is in its first position, said flow switch being independent of and unaffected by the electrical conductivity of said fluid being conducted therethrough.

2. A flow switch according to claim 1 in which said electrical switch comprises a pair of electrical contacts, one of which is stationary and the other movable in response to said piston, said pair of contacts adapted to come into junction when said piston is in its first position.

3. A flow switch for use in combination with a conduit conducting fluid, comprising a cylinder with an inlet opening at one end to receive fluid from said conduit and with an outlet opening to conduct said fluid to a continuation of said conduit; a piston slidably movable within and fitting said cylinder, said piston having a hollow sleeve provided with perforations, said piston being adapted to move between a first position of no fluid flow and a second position of fluid flow, said perforations adapted to permit fluid communication between said inlet and outlet openings when said piston is in said second position; means to bias said piston towards said first position; a normally open restricted by-pass line in communication with said cylinder and adapted to conduct fluid around said piston, said by-pass line, cylinder, and piston acting as a dashpot adapted to retard at a predetermined rate the movement of said piston from its said second position to its said first position; and an electrical switch adjacent one end of said cylinder and adapted to be actuated by said piston when said piston is in its first position, said flow switch being independent of and unaffected by the electrical conductivity of said fluid being conducted therethrough.

4. A flow switch for use in combination with a conduit conducting fluid, comprising a check valve in said conduit to prevent reversal of flow therethrough; a cylinder including a middle part, a collar part, a tube, a tubular extension, and a cap, said middle part having openings at both ends to receive said tube and said tubular extension and an outlet opening in communication with a continuation of said conduit, said collar part having an opening at one end to receive said tube and an inlet opening to receive fluid from said conduit, said cap adapted to close one end of said tubular extension and having an opening therein; a piston and rod mechanism carried laterally by said cylinder, said piston including a hollow sleeve with a skirt portion and an end piece, said sleeve provided with lateral perforations spaced generally adjacent said end piece and removed from said skirt portion through which communication can be had with the said inlet and outlet openings when said piston moves a predetermined distance from a first position of no fluid flow to a second position of fluid flow, said piston of such length that each end passes in turn through the corre-

sponding end of said tube at each stroke and a second position of fluid flow, said rod connected to said end-piece and extending longitudinally through the opening in said cap and adapted to move in response to the movement of said piston; a spring interposed between said end-piece and said cap to bias the movement of said piston towards its first position; a restricted by-pass line in communication with said collar and extending therein to serve as a stop for said piston, said by-pass line adapted to conduct fluid around said piston, and to discharge said fluid into said tubular extension, said by-pass line, cylinder, and piston acting as a dashpot adapted to retard at a predetermined rate the movement of said piston from its said second position to its said first position; a needle valve in said by-pass line by which the flow of fluid therethrough may be regulated; and a pair of electrical contacts adapted to be closed when said piston is in its first position.

5. A flow switch for use in combination with a conduit conducting fluid, comprising a check valve in said conduit to prevent reversal of flow therethrough; a cylinder including a middle part, a collar part, a tube, a tubular extension, and a cap, said middle part having openings at both ends to receive said tube and said tubular extension and an outlet opening in communication with a continuation of said conduit, said collar part having an opening at one end to receive said tube and an inlet opening to receive fluid from said conduit, said cap adapted to close one end of said tubular extension and having an opening therein; a piston and rod mechanism carried laterally by said cylinder, said piston including a hollow sleeve with a skirt portion and an end piece, said sleeve provided with lateral perforations spaced generally adjacent said end piece and removed from said skirt portion through which communication can be had with the said inlet and outlet openings when said piston moves a predetermined distance from a first position of no fluid flow to a second position of fluid flow, said piston of such length that both ends are always outside the ends of said tube and a second position of fluid flow, said rod connected to said end-piece and extending longitudinally through the opening in said cap and adapted to move in response to the movement of said piston; a spring interposed between said end-piece and said cap to bias the movement of said piston towards its first position; a restricted by-pass line in communication with said collar and adapted to conduct fluid around said piston; said by-pass line, cylinder, and piston acting as a dashpot adapted to retard at a predetermined rate the movement of said piston from its said second position to its said first position, a needle valve in said by-pass line by which the flow of fluid therethrough may be regulated; and a pair of electrical contacts adapted to be closed when said piston is in its first position.

6. A flow switch for use in combination with a conduit conducting fluid, comprising a cylinder including a middle part, a collar part, a tube, a tubular extension, and a cap, said middle part having openings at both ends to receive said tube and said tubular extension and an outlet opening in communication with a continuation of said conduit, said collar part having an opening at one end to receive fluid from said conduit, said cap adapted to close one end of said tubular extension and having an opening therein; a piston and rod mechanism carried laterally by said cylinder, said piston including a hollow sleeve with a skirt portion and an end piece, said sleeve provided in the lateral perforations spaced generally adjacent said end piece and removed from said skirt portion through which communication can be had with the said inlet and outlet openings when said piston moves a predetermined distance from a first position of no fluid flow to a second position of fluid flow, said piston of such length that each end passes in turn through the corresponding end of said tube at each stroke, said rod connected to said end-piece and extending longitudinally

through the opening in said cap and adapted to move in response to the movement of said piston; a spring interposed between said end-piece and said cap to bias the movement of said piston towards its first position; a restricted by-pass line connected to said collar adjacent said inlet opening and adapted to conduit fluid around said piston and to discharge said fluid into said tubular extension, said by-pass line, cylinder, and piston acting as a dashpot adapted to retard at a predetermined rate the movement of said piston from its said second position to its said first position; a needle valve in said by-pass line by which the flow of fluid therethrough may be regulated; and a switch comprising a pair of electrical contacts adapted to close when said piston is in its first position.

7. A flow switch for use in combination with a conduit conducting fluid, comprising a check valve in said conduit to prevent reversal of flow therethrough; a cylinder including a middle part, a collar part, a tube, a tubular extension, and a cap, said middle part having openings at both ends to receive said tube and said tubular extension and an outlet opening in communication with a continuation of said conduit, said collar having an opening at one end to receive fluid from said conduit, said cap adapted to close one end of said tubular extension; a piston carried laterally by said cylinder and having a hollow sleeve with a skirt portion and an end piece, said sleeve provided with lateral perforations, said piston adapted to move between a first position of no fluid flow and a second position of fluid flow; a spring interposed between said end-piece and said cap; a restricted by-pass line in communication with said collar and adapted to conduct fluid around said piston; a needle valve in said by-pass line; and a switch comprising a pair of electrical contacts and extending through the wall of said collar, said pair of contacts adapted to come in junction when said piston moves to its said first position.

8. A flow switch for use in combination with a conduit conducting fluid, comprising a cylinder including a middle part, a collar part, a tube, a tubular extension, and a cap, said middle part having openings at both ends to receive said tube and said tubular extension and an outlet opening in communication with a continuation of said conduit, said collar having an opening at one end to receive said tube and an inlet opening to receive fluid from said conduit, said cap adapted to close one end of said tubular extension; a piston carried laterally by said cylinder and having a hollow sleeve with a skirt portion and an end piece, said sleeve provided with lateral perforations, said piston adapted to move between a first position of no fluid flow and a second position of fluid flow; a spring interposed between said end-piece and said cap; a restricted

by-pass line connected to said collar adjacent said inlet opening and adapted to conduct fluid around said piston and to discharge same into said tubular extension; a needle valve in said by-pass line; a pair of contacts extending through the wall of said collar, and adapted to come in junction when said piston moves to its said first position.

9. A flow switch for use in combination with a conduit conducting fluid, comprising a check valve in said conduit to prevent reversal of flow therethrough, a cylinder having an inlet opening in communication with said conduit and adapted to receive fluid therefrom and having an outlet opening in communication with a continuation of said conduit, a piston carried laterally by said cylinder and having an end piece and a hollow sleeve with a skirt portion having an open end opposite said inlet opening, said sleeve provided with lateral perforations, said piston adapted to move between a first position of no fluid flow and a second position of fluid flow, said perforations adapted to permit fluid communication between said inlet and outlet openings when said piston is in said second position, a spring interposed between said end piece of said piston and the adjacent end of said cylinder, said spring adapted to bias said piston toward said first position, a normally open restricted by-pass line in communication with said cylinder and adapted to conduct fluid around said piston, a valve in said by-pass line, said by-pass line, cylinder, and piston acting as a dashpot adapted to retard at a predetermined rate the movement of said piston from its second position to its first position, and an electrical switch adjacent one end of said cylinder and adapted to be actuated by said piston when the latter is in its first position, said flow switch being independent of and unaffected by the electrical conductivity of said fluid being conducted therethrough.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,853,575

September 23, 1958

Orvel B. Reynolds

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, lines 39 and 40, strike out "and a second position of fluid flow"; column 7, line 6, for "conduit" read -- conduct --; column 8, line 10, for "therethorough" read -- therethrough --.

Signed and sealed this 16th day of June 1959.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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