

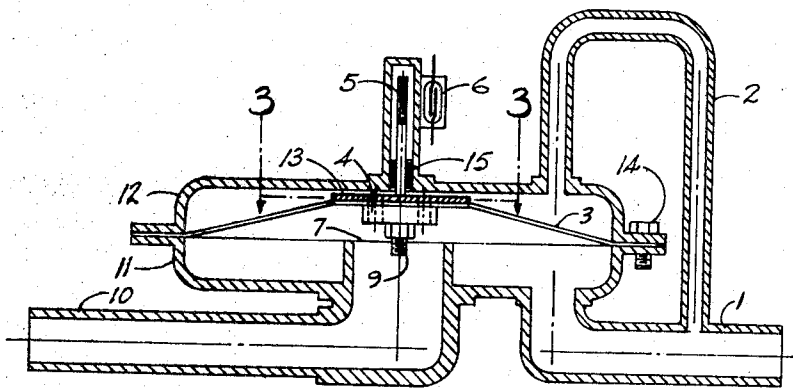
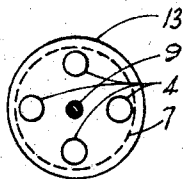
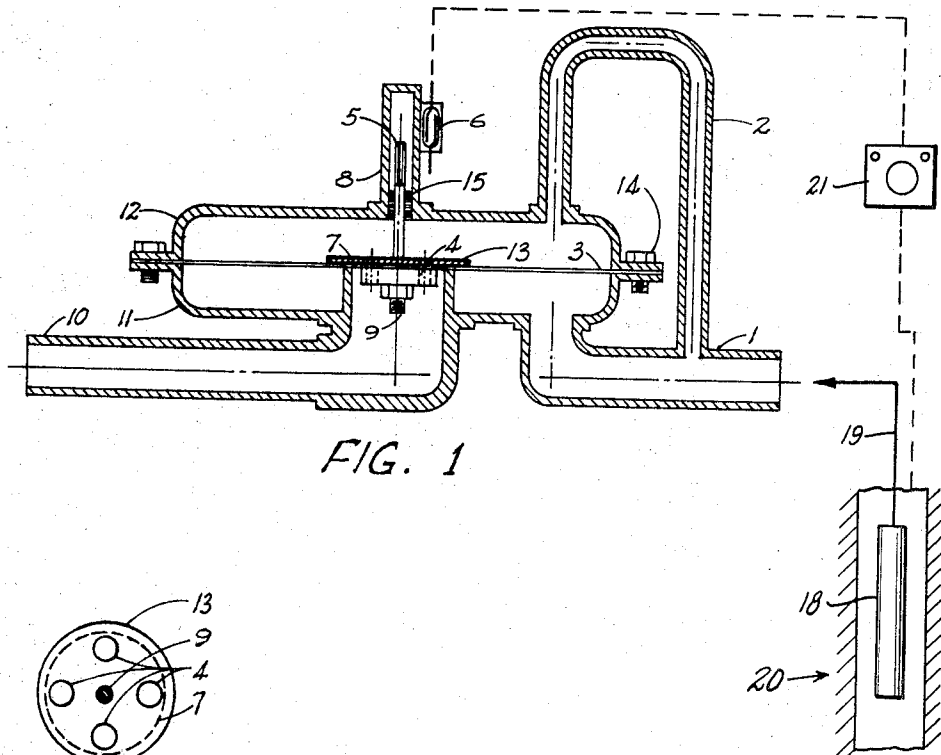
Dec. 29, 1970

J. N. HOOVER

3,551,071

FLOW NO-FLOW DEVICE

Filed May 14, 1968



INVENTOR.
J. N. HOOVER

1

3,551,071

FLOW NO-FLOW DEVICE

Jimmie N. Hoover, 2517 Cambridge St.,
Odessa, Tex. 79760

Filed May 14, 1968, Ser. No. 729,133

Int. Cl. F04b 49/00, 49/06

U.S. Cl. 417—43

10 Claims

ABSTRACT OF THE DISCLOSURE

A flow no-flow sensing device which differentiates between gas and liquid fluid flow therethrough. The device includes a movable element seated on an orifice similar to a valve element and seat. The movable element remains in the opened position when liquid or a mixture of gas and liquid flows therethrough, and assumes the closed or seated position upon the occurrence of gaseous fluid flowing therethrough. A switch associated with the movable element of the device is adapted to interrupt the current flow to a motor of a pump which provides the source of fluid flow.

BACKGROUND OF THE INVENTION

In the production of oil wells by artificial lift, such as a bottom hole pump which is actuated by a pump jack located above the surface of the earth, a sucker rod is attached to the pump so as to deliver reciprocatory motion from the pump jack to the downhole pump. The sucker rod is attached to the pump jack by a polish rod, and a stuffing box seals the reciprocating polish rod to the fixed free end of the production tubing. The produced crude sufficiently lubricates the seal between the packing of the stuffing box and the polish rod. The pump cyclicly unloads the reservoir, causing gaseous fluid to be produced, and flow conducted past the seal provided by the stuffing box. This action causes rapid and excessive wear to occur between the polish rod and stuffing box because of the lack of lubrication and coolant normally provided by the produced crude. Accordingly, it is advantageous to be able to discontinue the operation of the pump jack motor upon a substantial amount of gaseous fluid being produced from the well. This discontinuance of operation is referred to as "pump-off control." Such an expedient not only minimizes wear upon the various components of the pump system, but also effects a savings in electric power.

Various mechanical and electro-mechanical devices have been suggested by the prior art in order to avoid continued operation of a pump jack upon the detection of a substantial flow of gaseous fluid flow. One such prior art device which has proven highly satisfactory is the apparatus described in Pat. No. 3,105,433 to Johnson.

Another form of the prior art devices which provides a pump-off control relates to measuring the tension on the sucker rod in order to ascertain the static head of produced fluid within the production tubing as described in Pat. No. 3,359,791 to Pantages. As evidenced by these and other known forms of the prior art devices directed to flow no-flow of fluid from an oil well, a substantial amount of circuitry and apparatus of a complicated nature is generally required.

SUMMARY OF THE INVENTION

The present invention provides a pump-off control means for effectively discriminating between gaseous and liquid fluid flow by providing a flow no-flow sensing device having a main housing within which there is operatively positioned a movable element which together with the housing forms an upper and lower chamber. An equalizer line connected between each of the chambers forms a

2

stand pipe. A passageway in the form of an orifice provided within the movable element equalizes the pressure between the two chambers when gas is flowing. A switch means adapted to be moved in response to movement of the movable element provides a means for interrupting current flow to a motor which actuates a downhole pump. Flow of produced liquid through the inlet and to the lower chamber provides a hydrostatic head in the equalizer line which is effected as an upwardly directed force on the movable element to thereby lift the element from an orifice which is in the form of a valve seat. This action maintains the switch in the closed or current flowing condition. When the production changes to gaseous flow, the absence of liquid eliminates the hydrostatic head in the equalizer line thereby equalizing the pressure between the two chambers. This action causes the movable element to be seated against the orifice, which in turn causes the switch to be returned to the opened position which interrupts current flow to the downhole pump motor, whereupon no flow of crude is possible until the pump motor is again energized.

A primary object of this invention, when properly installed in a pipeline, is to perform the novel function of differentiating between the flows of gases and fluids, and to actuate the contacts of a magnetically operated electric switch in the event of fluid flow.

Another object of this invention is to provide an improved and reliable means to determine when a fluid flow occurs in a crude oil production gathering system so as to provide a signal to a supervisory control computer.

An important object of this invention is to actuate, by means of a flexible diaphragm on which a rod and permanent magnet is centrally disposed, a switch capable of being actuated through a solid wall of the enclosing housing. This invention accomplishes the above by means of a diaphragm flexing under the influence of a fluid head, which lifts a magnet parallel to a switch whose contacts are attracted by the polarity of the magnet, causing the contacts to actuate. Because of close tolerance mechanical bearing surfaces and other mechanical parts, known forms used to perform the above mentioned objects are subject to sticking when subjected to foreign matter which is often encountered in the flow of crude oil. Another serious disadvantage to known forms is the fact that a flow of either gases or fluids may cause them to actuate. In practice, it is often desirable to determine when fluid only is flowing in a pipeline. My invention has this novel capability.

In this invention the problems often encountered in known forms are overcome. There are no precision mechanical parts in this invention, and the movement of a magnet used to actuate a switch is accomplished by the flexing of a diaphragm, which occurs when a fluid head of sufficient height is built up in a by-pass line. The fluid head results from a fluid flow through this invention.

Many other objects and advantages of this invention will become apparent from consideration of the following detailed description in conjunction with the drawings which form a part of this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view in elevation of a flow-no flow device constructed in accordance with this invention, showing the device in the position of operation it assumes when no flow occurs, or when gas only flows through it.

FIG. 2 is a sectional view in elevation of a flow-no flow device constructed in accordance with this invention, showing the device in the position of operation it assumes when a fluid flow occurs through it.

FIG. 3 is a top view taken in the plane 3—3 of FIG. 2, showing detailed disposition of gas orifices.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Looking to the details of FIG. 1, in conjunction with the remaining figures, there is seen an inlet 1 connected to an equalizer line 2 which in turn is connected to the upper portion of a main housing which forms the body of a flow no-flow device made in accordance with the present invention. The main housing is preferably formed of complimentary dished plate members 11 and 12, each of which include a bolt flange mated together in the usual manner. Each member cooperates together to form an enlarged chamber having an orifice in the form of the illustrated valve seat therein. A circular diaphragm 3 divides the enlarged chamber of the main housing into an upper and lower chamber with the lower chamber being connected to the before mentioned inlet and to the outlet 12, with the orifice being interposed therebetween. Centrally located and attached to the diaphragm there is seen a disk 13 having a multiplicity of apertures or gas orifices 4 drilled therethrough and with a rod 9 longitudinally disposed through the central axis thereof. The upper marginal end portion of the rod has a permanent magnet 5 attached thereto. The magnet and rod are slidably received within the tubular raceway 8. Attached to the raceway and spaced apart from the magnet is a dry reed switch 6. The lower terminal end of the rod is provided with the illustrated conventional attachment means for rigidly securing the disk and rod to the movable diaphragm. Guide bushing 15 maintains the rod centrally located and slidably received within the raceway.

The raceway is preferably fabricated from a plastic-like material which permits the magnetic field associated with the magnet 5 to be imposed upon the magnetically sensitive contacts of the encapsulated dry reed switch 6; the details of the switch being known to those skilled in the art.

As seen in FIG. 1, the diaphragm 3 is normally seated against the illustrated orifice which is in the form of a valve seat member. When the movable element assumes the illustrated "closed" position, the magnet 5 is vertically displaced a sufficient distance away from the reed switch to cause the switch to assume the "normal" or opened position. When the orifice or valve seat and movable element are displaced away from each other, that is, in the liquid flow permitting condition, the magnet is moved vertically upward into close proximity to the reed switch, thereby causing the contacts of the reed switch to assume the closed position while fluid flow occurs from the inlet into the lower chamber through the valve seat and through outlet 10.

As further seen in FIG. 1, a downhole pump means 18 is flow connected to inlet 1 of the pump-off control means by flow line 19. The pump means 15 located within a borehole 20 can take on several different forms, as for example, a downhole pump actuated by power fluid or a downhole pump of the reciprocatory type, as is well known to those skilled in the art. Controller 21 cyclicly energizes the pump on a time cycle based on the production history of the well. The switch 6, when actuated by the movable element, causes the pump to remain energized. When a pump-off condition is encountered, the movable element is again seated, thereby causing the pump to be deenergized by the action of the switch.

The following description of operation is deemed best illustrated in conjunction with the downhole pump of the reciprocatory type wherein an electric motor drives a pump jack which in turn reciprocates a polish rod which is connected to the downhole pump by sucker rods, all of which is well known to those skilled in the art. A timer (not shown) activates the electric motor in the usual manner, and the pump jack commences operation whereupon liquid commences to flow from the production tubing towards inlet 1. Since the flow no-flow device is in the configuration of FIG. 1, and since gas initially

fills the inlet, it follows that the pressure is kept equal on each side of diaphragm 3 in upper chamber 12 and lower chamber 11 by means of the passage formed by by-pass line 2, and diaphragm 3 remains seated on orifice 7. When gas and liquid enter inlet 1, gas being lighter than liquid rises through by-pass line 2 into upper chamber 12, down through orifices 4, into outlet 10. As liquid continues to enter inlet 1, it is forced by the combined weights of diaphragm 3 and its affixed appurtenances 5, 9, and 13, to rise in by-pass line 2 until a liquid head of sufficient height is attained so that the static head, working against the effective area of diaphragm 3 ultimately provides sufficient force to overcome the weight of diaphragm 3, magnet 5, rod 9, and weight 13. At this point diaphragm 3 will begin to rise, opening orifice 7, allowing liquid to move through orifice 7 into outlet 10. As diaphragm 3 rises, rod 9 being attached to it rises, moving magnet 5 in position to attract the contacts of switch 6, causing said contacts to actuate. Thus, under the influence of either a liquid flow or liquid and gas flowing through my invention, the position of operation shown in FIG. 2 is assumed, actuating switch 6.

The magnitude of a liquid head required to raise diaphragm 3 and its affixed appurtenances 5, 9, and 13, can be varied by changing the effective area of diaphragm 3, or by changing the weight of diaphragm appurtenances 5, 9, or 13. With switch 6 designed to be adjustable with respect to the travel of magnet 5, switch 6 can be made to open or close its contacts at different points of travel of magnet 5.

The present invention can be used to provide a pump-off control means wherever it is necessary to discriminate between the flow of liquid and gas, that is, to provide a signal indicating that liquid is flowing through a flow conduit. The invention finds its maximum utility in controlling the action of a downhole pump which artificially lifts fluid through a production tubing to the surface of the ground whereupon the fluid is then connected to a suitable gathering system, such as a tank battery. The term "artificially lifting fluid" is intended to indicate a mechanical device or apparatus which pumps or forces fluid to flow from a fluid producing formation to the surface of the ground as contrasted to a "free flowing" well. An example of artificially lifting fluid is the well known downhole pump which may be actuated by sucker rods; a submersible pump which may be powered by an electric motor; and a hydraulically actuated downhole pump as seen in Roeder, Pat. No. 3,453,963; all of which are known to those skilled in the art of oil well production techniques.

I have described my invention in its preferred form, however the same is subject to modification and refinement without departing from the basic principles outlined above, and accordingly I desire not to be limited in my protection to the specific details illustrated and described except as may be necessitated by the appended claims.

What I claim is:

1. In a downhole motor driven pump assembly for artificially producing fluid from a borehole wherein the motor is cyclicly actuated for predetermined intervals of time, the method of sensing a pump-off condition comprising the steps of:

- (1) dividing an enclosure into an upper and lower chamber by a movable element;
- (2) flow connecting the produced fluid for flow through an orifice located in the lower chamber;
- (3) actuating the movable element from a position adjacent the orifice to a position away from the orifice in response to flow of liquid into the lower chamber;
- (4) flow-connecting the upper and lower chambers together by a standpipe and in a manner to enable liquid to develop a hydrostatic head in said standpipe when liquid is present in the lower chamber;
- (5) flow connecting the upper chamber to the down-

stream side of the orifice by providing a passageway which forms a flow path from the upper chamber and through the movable element;

- (6) adjusting the area of the movable element which is exposed to upstream fluid pressure to a valve which will provide a sufficient force to move the movable element to a position clear of the orifice when a liquid head is present in the standpipe, and which will move the movable element to a position adjacent the orifice when gas displaces liquid from the standpipe;

- (7) controlling the operation of the pump motor in response to the movement of the movable element.

2. The method of claim 1 wherein step (7) is carried out by:

- (8) moving a magnet in response to movement of the flow restricting device;

- (9) moving said magnet into and out of close proximity of a magnetically actuated switch means in order to control the flow of current to the motor in response to actuation of the switch means.

3. In an oil well having a downhole pump for artificially lifting fluid through a production tubing to the surface of the ground, and a flow conduit connected to the production tubing of the well, the improvement comprising:

- a pump-off control means for discriminating between the flow of liquid and gas; said pump-off control means including means forming a main housing; means forming an orifice within said housing; means forming a movable element; said movable element dividing said main housing into upper and lower chambers, said movable element adapted to be moved from a position in contact with said orifice to a position which is spaced apart from said orifice; said lower chamber having means forming an inlet and an outlet to enable the lower chamber to be connected in series with the flow conduit; means connecting said orifice to said means forming an outlet;

means forming an equalizer line which is flow connected between said upper and lower chamber;

means forming a flow passageway through said movable element for communicating said upper chamber to the means forming an outlet;

control means responsive to movement of said movable element;

said control means adapted to maintain the downhole pump energized when said movable element is free of the orifice, and to de-energize the downhole pump when said movable element is in contact with the orifice.

4. The improvement of claim 3 wherein said equalizer line is a standpipe having an upper and lower end portion with the lower extremity thereof being flow connected to the lower chamber inlet, and with the upper extremity thereof being flow connected to the upper chamber of the main housing to thereby enable a hydrostatic head to be developed in the standpipe when liquid is present in the flow conduit.

5. The improvement of claim 3 wherein said control means includes:

a magnet attached to and adapted to be moved by said movable element;

means forming a magnetically actuated switch which is adapted to be actuated by movement of said magnet; whereby:

when said magnet is brought into close proximity of said switch, the switch is actuated to thereby provide the recited function of energizing the pump.

6. In a flow control system for a downhole pump which is powered by an electric motor, a source of current adapted to be connected to the electric motor, with the pump outlet being flow connected to a fluid conduit, the improvement comprising:

- a pump-off control means for discriminating between gaseous and liquid fluid flow, said pump-off control

means including a main housing having means forming an inlet, an outlet, and an orifice in the form of a valve seat interposed between said inlet and said outlet, and further including a movable element;

said movable element dividing the main housing into a lower chamber and an upper chamber;

said orifice adapted to cooperate with said movable element in a manner wherein the element can move from a position adjacent the orifice to a position which is spaced apart from the orifice;

means including an equalizer conduit forming a flow passageway from said lower chamber to said upper chamber, and means forming a flow passageway from said upper chamber through said movable element, and into communication with the interior of said orifice;

switch means adapted to be actuated by movement of said movable element for causing current to flow to the motor when said movable element is spaced apart from the seat and for interrupting current flow to the motor when said movable element is adjacent the seat; whereby:

said switch, when connected to interrupt current flow to the electric motor, provides a pump-off control for the downhole pump.

7. The improvement of claim 6 wherein said switch means includes:

a magnet adapted to be moved by said movable element;

a magnetically actuated switch adapted to be actuated by said magnet; whereby:

when said magnet is brought into close proximity of said switch, the switch is actuated to thereby provide a means of controlling current flow to the pump motor.

8. In a flow control system for apparatus which artificially lifts fluid from a borehole, wherein the borehole has located therein an electric motor driven downhole production pump of the reciprocating type, a source of current adapted to be connected to the electric motor, with the pump being flow connected to a fluid conduit, the improvement comprising:

a pump-off control means for discriminating between the flow of gaseous and liquid fluid through the fluid conduit, said pump-off control means including a main housing having an inlet, an outlet, an orifice, and a movable element;

said inlet and outlet being series connected to the fluid conduit;

said movable element dividing the main housing into a lower chamber and an upper chamber;

said orifice being located in said lower chamber and series connected between said inlet and outlet, said orifice having means forming a seat which is adapted to cooperate with said movable element in a manner whereby the element can move from a position adjacent the seat to a position clear of the seat;

means including an equalizer line forming a flow passageway from said inlet to said upper chamber; means forming a flow passageway from said upper chamber, through said movable element into said orifice;

switch means connected to and actuated by said movable element for causing current to flow to the motor when said movable element is in the position which is clear of the seat, and for interrupting current flow when said movable element is moved to a position which is adjacent the seat; whereby:

said switch means, when connected to control current flow to the electric motor, provides a pump-off control for the downhole pump.

9. The improvement of claim 8 wherein said switch means includes:

a magnet including means by which it is moved in conjunction with said movable element;

7

a magnetically actuated switch means adapted to be actuated by said magnet; whereby:
when said magnet is brought into close proximity of said switch means, the switch means is actuated to thereby provide the recited function of controlling the operation of the pump motor.

10. A flow, no-flow device for discriminating between liquid and gas fluid flow comprising:
a main housing, a movable element, and an orifice therein with the movable element adapted to be received on said orifice when the flow, no-flow device is in the no-flow position;
means forming an equalizer line, said equalizer line being in fluid communication with said upper and lower chamber;
means forming a flow passageway through said movable element for communicating said upper chamber to the interior of said orifice;
control means responsive to movement of said movable element;

5

10

15

20

8

said control means adapted to produce a signal to indicate the position of said movable element with respect to the orifice.

References Cited

UNITED STATES PATENTS

2,051,732	8/1936	McKee	137—183
2,281,283	4/1942	Haast	137—199
2,550,093	4/1951	Smith	103—25
2,953,659	9/1960	Edwards	103—25
3,327,079	6/1967	Widl	200—82
3,285,183	11/1966	Hambree et al.	103—25
3,325,613	6/1967	Dunn et al.	200—82

WILLIAM L. FREEH, Primary Examiner

U.S. Cl. X.R.

137—183; 417—44