Oct. 4, 1966 J. M. STEVENSON 3,276,380

OIL WELL SHUT-DOWN DEVICE

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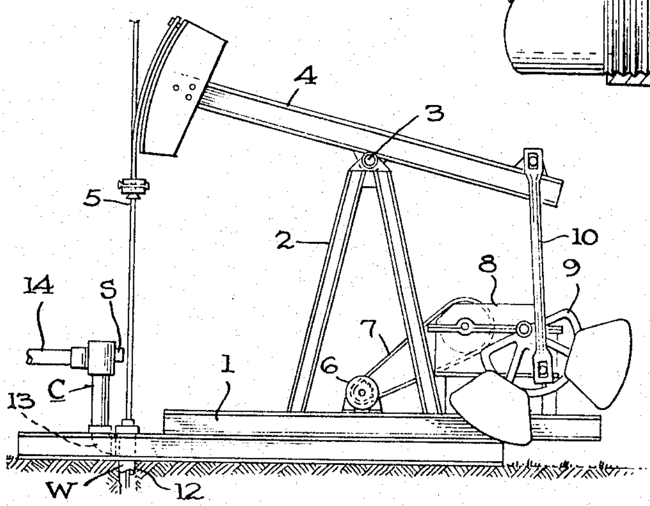
FIG. 1.



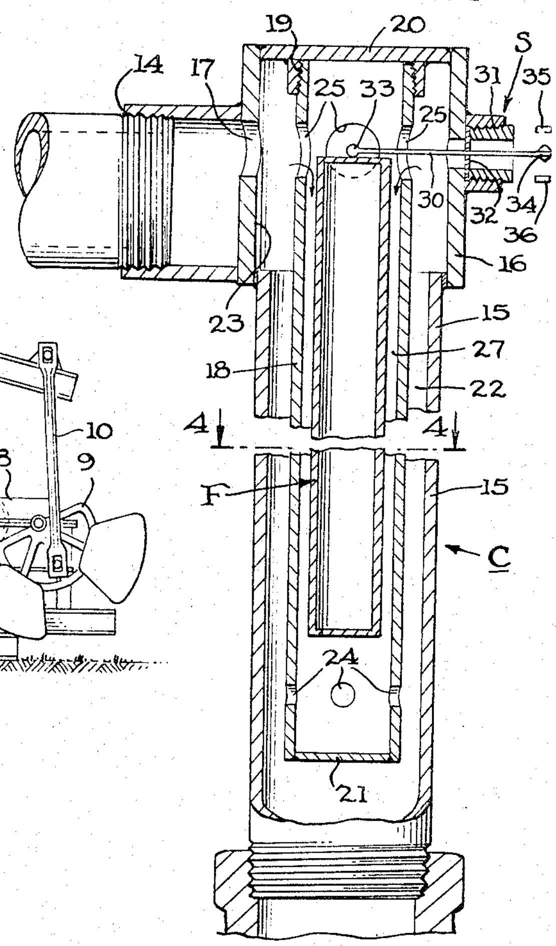
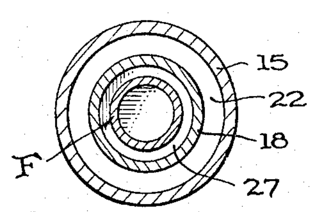


FIG. 2.

FIG. 4.



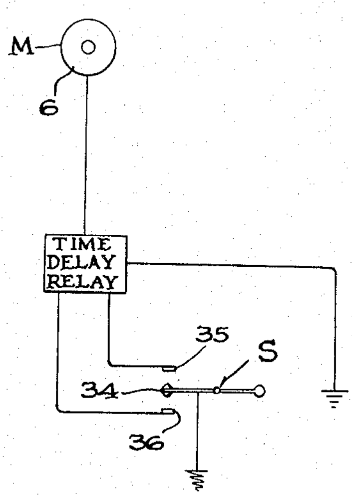


FIG. 3.

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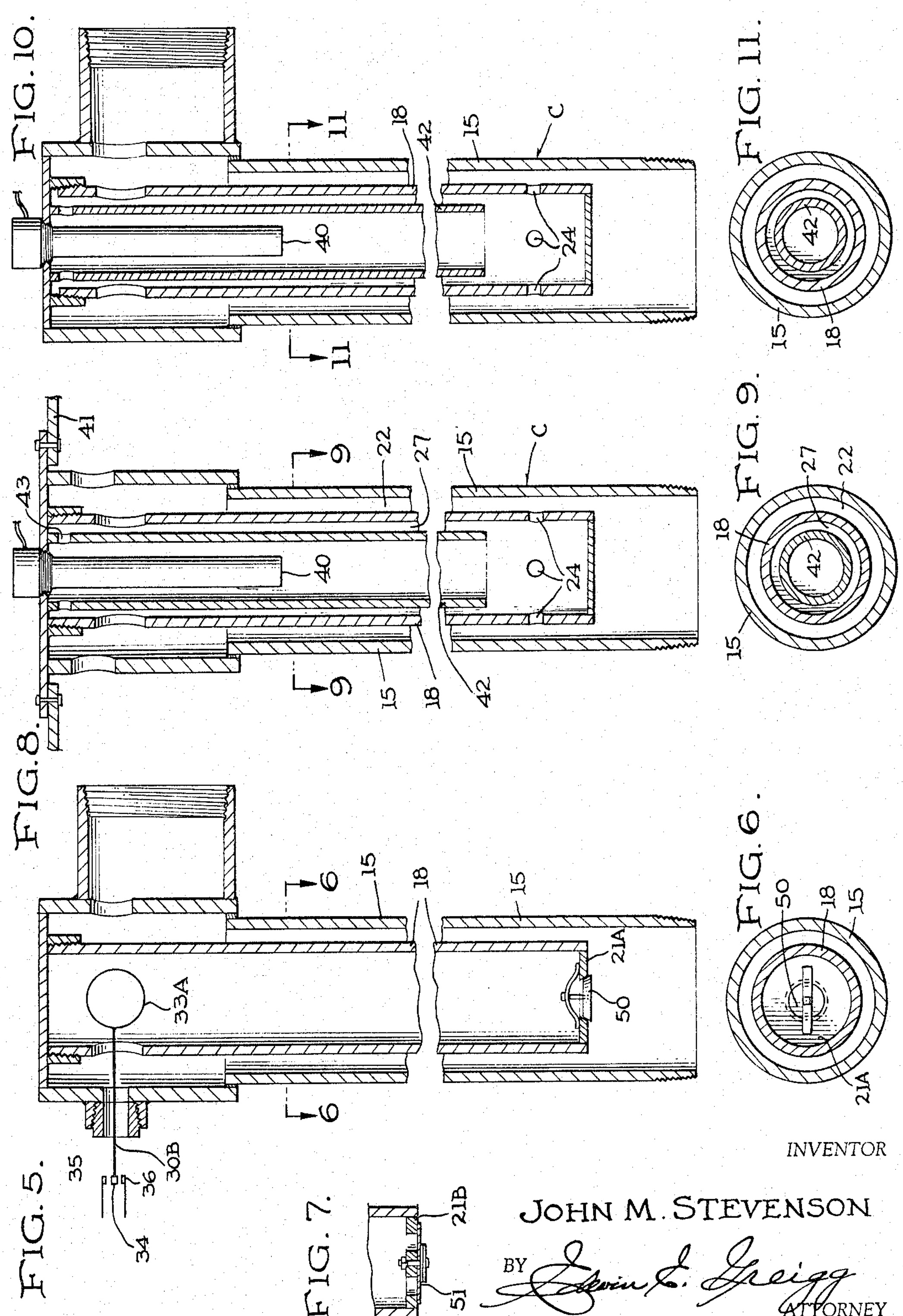

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OIL WELL SHUT-DOWN DEVICE

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The present invention relates to the control of wells and more particularly to the control of pumping means for producing well fluid.

It is desired in the operation of pumping apparatus for oil wells that such apparatus be shut down when the capacity of the pump at a selected operating rate exceeds the productive capacity of the sub-surface earth formation from which fluids are being removed. Such shut down of the pumping apparatus may be intermittent to allow the filling of the sub-surface zone from which the pump takes its fluid, or if preferred, resumption of pump operation may require the attention of an attendant.

Devices for automatically shutting off such pumps have, heretofore, not been wholly satisfactory and have been subject to transient conditions which cause untimely shutting off of the pumping apparatus with consequent inefficiencies in production of the well fluid and requirements for personal attention.

The present invention has as an object the provision of pumping apparatus controlled in such a manner that the pump will be shut off if the well does not produce a sufficient volume of fluid.

Another object is to provide a control apparatus wherein a float in a float chamber is subjected to a downward flow of fluid to prevent the float from rising and actuating a control switch so long as the well produces an adequate volume of fluid through the apparatus.

Other objects and advantages of the invention will be hereinafter described or will become apparent to those skilled in the art and the novel features of the invention will be defined in the appended claims.

In the accompanying drawing:

FIG. 1 is a diagrammatic view illustrating the invention applied to a well pumping system;

FIG. 2 is a view in vertical section through the flow conduit and float assembly of the invention;

FIG. 3 is a diagrammatic view illustrating an exemplary control circuit for the system;

FIG. 4 is a cross-sectional view on line 4—4 of FIG. 2;

FIG. 5 is a view in vertical section through a flow conduit and float assembly of another embodiment of the invention;

FIG. 6 is a cross-sectional view on line 6—6 of FIG. 5;

FIG. 7 is a fragmentary view of a further modified form of valve construction such as that illustrated in FIG. 5;

FIG. 8 is a view in vertical section through another modified type of liquid control for use in tanks;

FIG. 9 is a cross-sectional view on line 9—9 of FIG. 8;

FIG. 10 is a view in vertical section through still another modified form of liquid control; and

FIG. 11 is a cross-sectional view on line 11—11 of FIG. 10.

Referring first to FIG. 1, there is illustrated a typical rod pump operating mechanism comprising a base support **1** having an upstanding support **2** on which is pivotally mounted at **3** a walking beam **4**. This walking beam is adapted to be actuated to effect reciprocation of a polish rod **5** which, in the usual manner, will be connected to a string of pump rods extending into the well designated at W. Operating means for the walking beam comprises a source of power, or in the present illustration, an electric motor **6**, which through a belt **7** drives a power transmission device **8** which, in turn, causes revolution of a flywheel assembly **9**, the latter being eccentrically connected by a rod **10** to the end of the walking beam **4** so as to effect oscillation of the latter.

In the operation of typical sucker rod pumps, when the subterranean earth formation from which well fluids are being produced are flowing into the well reservoir at an adequate rate, the flow conduit at the earth's surface at all times remains full of fluid. The pump discharging a volume equivalent to that of the working barrel of the pump upon the upstroke of the traveling valve of the pump and the standing valve maintaining the fluid column in the flow conduit upon the downstroke of the pump as the pump barrel is recharged through the traveling valve. However, in the event that the reservoir in the well from which the pump barrel is replenished cannot supply an adequate volume of fluid to the barrel, then the pump will produce a lesser volume of fluid per stroke and undesirable working stresses are set up in the rod string and the pump operating mechanism at the surface. Efficient pump operation requires that the rate of pump rod reciprocation be related to the ability of the productive formation to supply a volume of fluid at least equal to, if not in excess of, that moved to the earth's surface by the pump.

The present invention contemplates the combination with the above-described pump operating means of means which is responsive to a reduction of the volume of fluid passing through the flow conduit at the earth's surface to shut off the operating means to the pump. In FIG. 1 the control means is generally denoted at C and it will be observed that it is connected to the flow conduit or well pipe **12** at the top of the well by means of an elbow **13**. In addition, the control means C has an outlet pipe **14** for the discharge of produced fluid. Carried by the control means C and constituting a part thereof in the operation of the invention is a switch mechanism generally denoted at S which switch mechanism is actuated in a manner which will be more readily apparent upon reference to FIG. 2.

Referring now to FIG. 2 the control means C comprises a vertically disposed elongate tubular housing **15** which, for all practical purposes, is an upward extension of the flow conduit through which produced fluid flows to the outlet **14** referred to above. Adjacent its upper end the housing or flow conduit **15** has an enlarged cross-sectional area head **16** having an outlet port **17** leading into the conduit **14** referred to above. Coaxially disposed within the housing **15** is a float tube **18** which is threaded as at **19** or otherwise suitably connected to the upper closure **20** of the enlarged head section **16** of the conduit **15**. This float tube is closed at its bottom **21** and provides with the flow conduit **15** an annular flow passage **22** through which fluid produced by the pump mechanism must flow in order to reach the outlet port **17**. The cross-sectional flow area of the annular passage **22** is less than the flow area of the conduit **15** below the flow tube and hence the velocity of fluid passing through the annular passage **22** is increased. On the other hand when such fluid reaches the enlarged head **16** of the control means, there is in this head an annular region **23** of larger flow area than the passage **22** so that there is a resultant decrease in velocity of the fluid as it passes from the annular passage **22** into the annular region **23**.

According to Bernoulli's theorem, in a system such as this where the energy balance remains constant, changes in velocity or kinetic energy are balanced by corresponding and equal changes in pressure or static energy. Thus the velocity of the produced fluid is increased in the reduced flow passage between the float tube **21** and the flow conduit **15** with a resultant decrease in pressure. As the velocity of the fluid is reduced in the increased annular space of the head **16** at the top of the float tube **21**, the pressure returns to normal.

This change in velocity of the produced fluid is employed to induce a flow of fluid within the float tube **18**, and in this connection it will be noted that the latter is provided with sets of lower ports **24** and upper ports **25**. Thus, the ports **24**, being located in the region in which the fluid velocity is increased, will have a lower pressure applicable to the fluid with the result that there will be an induced downward flow of fluid as indicated by the arrows through the float tube from between the upper ports **25** and the lower ports **24**.

Freely disposed within the float tube **18** is a float F which may be only slightly buoyant in the fluid which is being produced through the fluid conduit. The float in the illustrative embodiment is a tubular member defining with the inner wall of the float tube **18**, a restricted flow passage **27** through which the downward flowing fluid within the flow tube as previously described must pass, with the result that fluid friction acting on the float as a result of downward flow will tend to hold the float downwardly to prevent its rising in the body of fluid within the float tube **18**, so long as the pump is producing a volume of fluid such that there is sufficient flow through the annular passage **22** and into the zone **23** and thence through the outlet port **17**.

In a further application of this principle, the float F is so designed that it will float freely within the float tube **18**, and not be held down by the downward flowing fluid in the float tube with the upstroke of the pump. The upper ports **25** and the lower ports **24** are so sized that the volume of fluid entering the upper ports shall be equal to or less than the volume of fluid flowing from the lower ports **24**. With the float thus free, its maximum upward position will be determined by the static fluid level held in the housing **15** by the standing valve while the well pump is refilling on the down stroke. The balanced flow of fluid in at ports **25** and out at ports **24** will prevent the float from bobbing above the static fluid level in the housing **15** on the upstroke of the pump. As the static fluid level in the housing falls, either due to pump failure or failure of the formation to produce fluid, then the maximum upward position of the float will be lowered.

Means are provided that will respond to either of the just mentioned situations, i.e. the float rising or the float falling below a predetermined level due to a lowering of the static fluid level in the housing **15**. Such means in the illustrative embodiment is in the form of the above-referred to switch S which, as seen in FIG. 2, includes a switch arm **30** extending through a gland **31**, which sealingly supports a diaphragm **32** through which the switch arm **30** extends and in which the switch is free to pivot. At the inner extremity of the switch arm is a weight **33** which will cause the inner extremity of the switch arm to drop if the float drops, and which may be engaged by the float upon upward movement or rising of the float within the float tube to cause upward movement of the inner extremity of the switch arm **30**. Such movement of the switch arm **30** in either direction will cause engagement of an electrical contact **34** on the outer extremity of the switch arm **30** with either a contact **35** or a contact **36** of the switch mechanism, and such switch mechanism is in a suitable circuit with the electric motor which drives the pumping mechanism so that closure of the contacts **34** and **35** or **34** and **36**, as the case may be, will cause the energization of the motor to shut off operation of the pump.

Further, it is contemplated to be within the scope of this teaching also that should the pump fail to function and completely fill, the level in the float tube will drop on the downstroke. Thus, when this occurs, the electric contacts will close and consequently initiate shutdown of the pump.

In still another embodiment of the invention shown in FIG. 5, it is proposed to attach a unitary float **33A** to the switch arm **30B** with the free end of the arm being provided with the same type of electrical contact means shown and described in detail in connection with the embodiment of the invention illustrated in FIG. 2. However, it is contemplated that in this more simplified arrangement of elements, the venturi principle referred to hereinbefore will prevent the float arm from erratic fluctuations, such as when a slug of fluid moves thereby and which would otherwise tend to inadvertently initiate the shutdown process.

Referring to FIG. 3, there is diagrammatically illustrated a simple electrical circuit including the switch S and the motor **6** and it will be noted that if desired a time delay relay may be interposed in the circuit whereby actuation of the switch S as may be caused by some transient condition will not immediately cause de-energization of the motor **6**, but such de-energization may come after a suitable time lag during which the transient condition may pass.

In addition, it will be appreciated that various timing devices may be installed in the electrical circuit between switch S and motor **6** which may be variable in nature such that if desired pump operation may be cycled and timed in relation to the production capacity of the subsurface formation. Furthermore, it will be understood that if desired various other sensing devices may be employed to sense pump failure, pump overload, or the like, so as to interrupt the source of electrical power thereby shutting off the pump.

Finally, in this connection it will be apparent that if desired the time relay referred to above may include also a time controlled mechanism for re-energizing the circuit to the motor after a lapse of a suitable period of time and in the event that the pump is capable of resuming the production of fluid in sufficient volume to cause the float F to assume its normal position allowing disengagement of the switch contact **34**, **35** or **36** within the time delay allowed by the time delay relay, then the well will resume production.

In still another embodiment of the invention as typified in FIG. 8, there is disclosed a surge-proof liquid level control for tanks which incorporates the basic principles involved in the oil well shutdown device described in the preferred embodiment of this invention. In this form of the invention the control unit **40** provided with suitable control leads is mounted in a tank **41** by and suitable means and with simple modifications, which will be obvious to those skilled in the art; this unit may be mounted on the side of the tank, either inside or on the outside thereof. In this form of the invention, as with the oil well shutdown device previously described, the purpose is to eliminate the effect of surging and turbulence on the liquid level control mechanism.

Any of the various modifications of actuating the device or of controlling surging within the device shown in the various drawings could be used with this tank level control. The primary application of this control unit would be to effectively control or indicate the average level of fluid within a tank where fluid level surges would make other commonly used methods of liquid lever control undesirable or subject to continual on-off operation due to turbulence rather than an actual change in the average liquid level.

It is to be noted that the elements comprising this embodiment of the invention are all substantially identical to that shown in the preferred embodiment of the invention in FIG. 2 and, accordingly, have been given the same reference numerals except for the innermost concentric tubular means denoted as **42**. This tubular means tends to lessen turbulence about the control unit **40** and is provided with means defining openings at **43** which function to by-pass liquid about the control.

In the form of the invention shown in FIG. 10, there is shown another alternative form of the invention of the type shown in FIG. 2 and in which a level or sensing probe **40A** also provided with suitable control leads is arranged to be threaded into the end wall of a tank.

Also in this view there is shown a poppet valve **50** which is positioned in an aperture in the end wall **21A** of the tube **18**. In this form of the invention this type of valve is substituted for the use of the lower ports **24** shown in FIG. 2.

In still another form of the invention, which is still a further modification of that structure in FIG. 2, there is illustrated in FIG. 7 an apertured end wall **21B** in which a diaphragm-type valve **51** is substituted for the lower ports **24**. Thus, it is to be understood that either of these valves will allow fluid to flow downwardly, out of the float tube, but would be forced closed on the upward stroke to keep the tube from filling and bobbing the float. In other words, considering that the basic purpose of the float tube **18** (FIG. 2) is to eliminate bobbing of the float during less than full volume pumping with each upward stroke of the pump, those skilled in the art will also appreciate that other concepts may be availed of in lieu of the venturi principle which has been referred to herein as being the preferred form of the invention. As described above, the installation of the one-way poppet valve **50**, as well as the flexible rubber-type impervious flapper valve **51**, may be positioned in the bottom of the float tube as described.

While the specific details of an illustrative embodiment of the invention have been shown, it will be further appreciated that various types of switch mechanisms may be employed in lieu of the specifically illustrated switch S and the float tube and float configuration may vary from that specifically herein shown. In any event the present invention contemplates essentially the provision in combination with a means for causing the flow of fluid through the flow conduit of a control means which will respond to reduction in such flow to shut off the operating means for the means causing the flow of fluid. Therefore, while a typical cyclically oscillatory walking beam type of pump actuator has been shown, it will be appreciated that the invention has applicability as well to other types of pump operating means, and indeed to other types of pumps which are operated by a power source which is under the control of the switch mechanism which is, in turn, responsive to the position of either of the float means discussed herein.

What I claim is:

1. In an assembly for containing a fluid flow the combination comprising, a plurality of concentric tubular means, means for positioning said concentric tubular means in contact with said fluid flow, electrical control means positioned within one of said concentric tubular means and means defining upper and lower openings in said one of said concentric tubular means, and means for creating a differential pressure between said upper and lower openings to direct substantially all of said fluid flow in a counter-direction through said one of said concentric tubular means.

2. In a device as defined in claim **1**, wherein another of said concentric tubular means includes a cap portion including means defining openings therein, a diaphragm in one of said means, said diaphragm providing means to pivotally support said electrical control means.

3. In a device as defined in claim **1**, wherein said electrical control means in disposed longitudinally of said concentric tubular means.

4. In a device as defined in claim **1**, wherein said one of said concentric tubular means is provided with an end closure said end closure being provided with means defining an opening and a valve means in said last named means.

5. Control means for shutting off the operating means for a well pump comprising: a flow conduit, a float chamber disposed in said conduit and forming with said conduit a flow passage therebetween, a float in said chamber, openings in said float chamber communicating with said passage below and above said float, the passage below said float being smaller than the passage above said float, whereby the flow of fluid through said passage will cause a differential pressure across said chamber between said openings below and above said float, a portion of said fluid flowing through said chamber from said larger openings to said smaller openings impinging on said float to prevent it from rising, and switch means operable by said float upon rising of said float in said chamber.

6. Control means for shutting off the operating means for a well pump comprising: a vertical flow conduit, an elongated hollow member supported in said conduit in coaxial spaced relation therewith, said member having lower and upper openings in its side walls, said lower openings having a flow area less than the flow area of said upper openings, an elongate float in said member, switch means adjacent the upper end of said member, and means for operating said switch upon movement of said float in said member.

7. Control mechanism for a producing well comprising in combination: a well production conduit, pump means for causing the flow of fluid from said well through said conduit, operating means for said pump means, control means for shutting off said operating means responsive to a reduction of the volume of fluid passing through said conduit, means forming a float chamber in said conduit, a float in said chamber, means responsive to said float rising in said chamber to shut off said operating means, and said means forming said chamber having means for causing the downward flow of fluid in said chamber to prevent said float from rising upon the flow of fluid through said conduit.

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