Jan. 5, 1943. F. S. TUTTON 2,307,171

SYSTEM AND APPARATUS FOR FLOWING WELLS

Filed Dec. 15, 1939 4 Sheets-Sheet 1

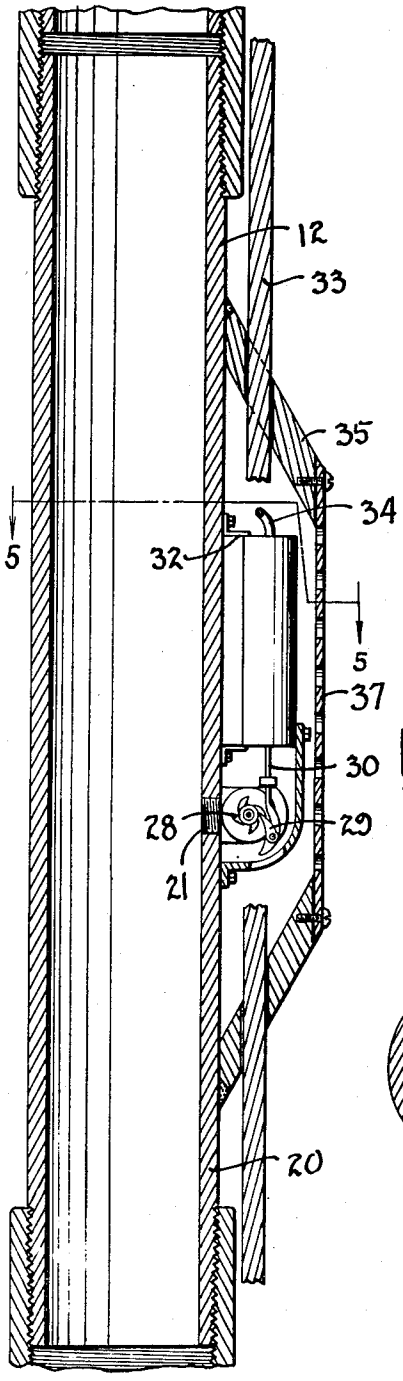


Fig. 1.

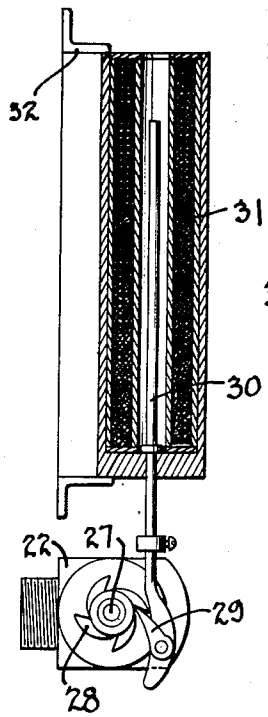


Fig. 2.

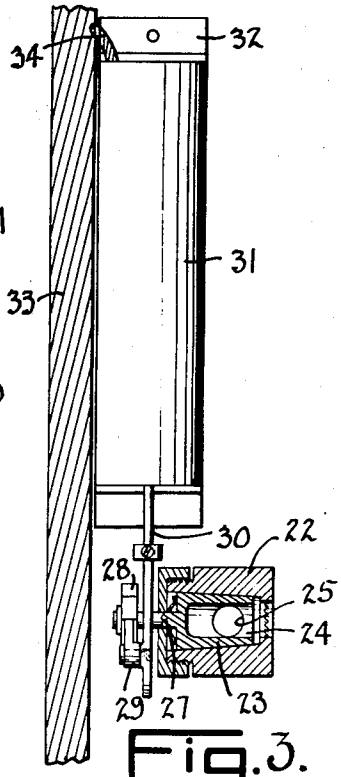


Fig. 3.

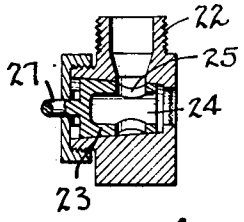


Fig. 4.

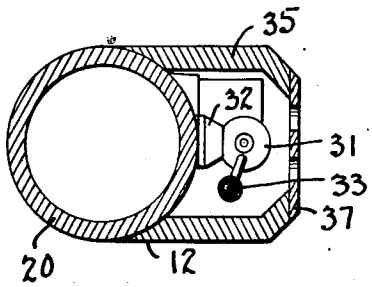


Fig. 5.

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SYSTEM AND APPARATUS FOR FLOWING WELLS

Filed Dec. 15, 1939 4 Sheets-Sheet 2

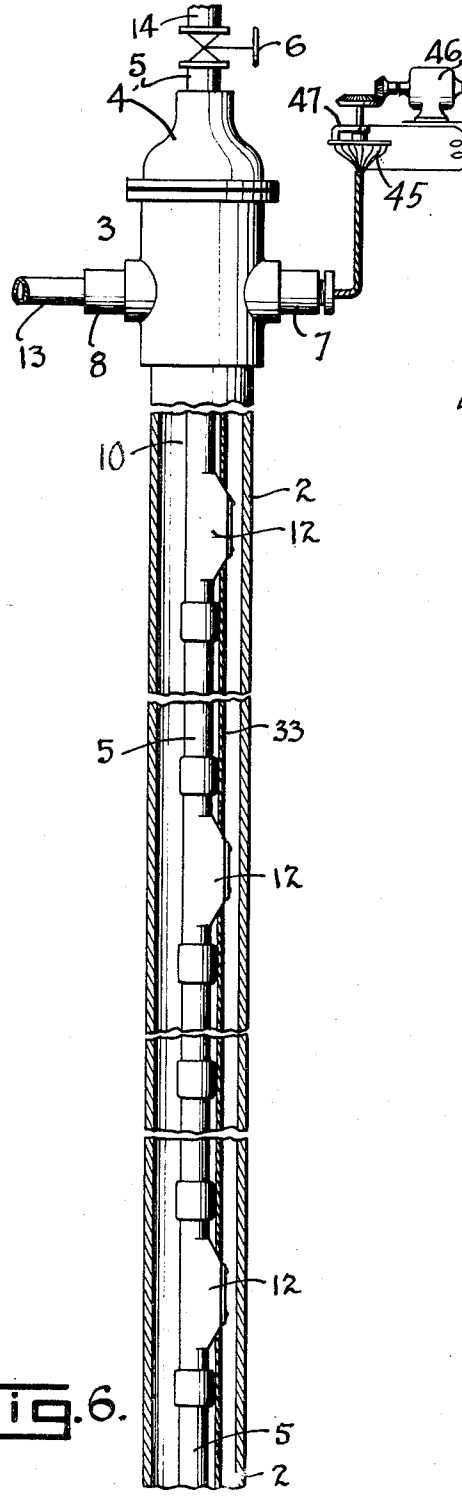


Fig. 6.

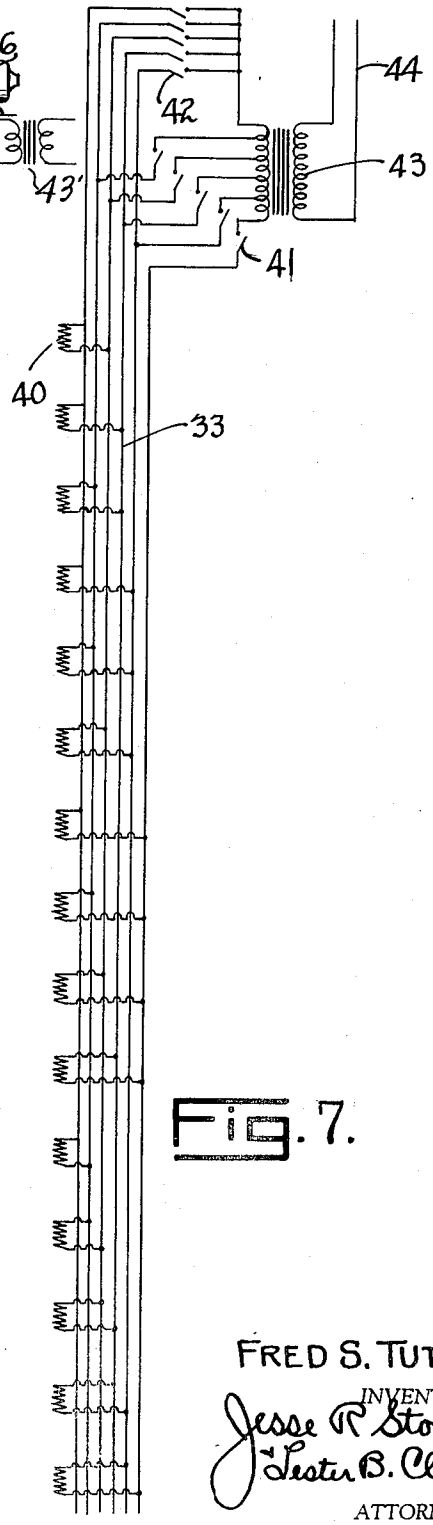


Fig. 7.

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SYSTEM AND APPARATUS FOR FLOWING WELLS

Filed Dec. 15, 1939 4 Sheets-Sheet 3

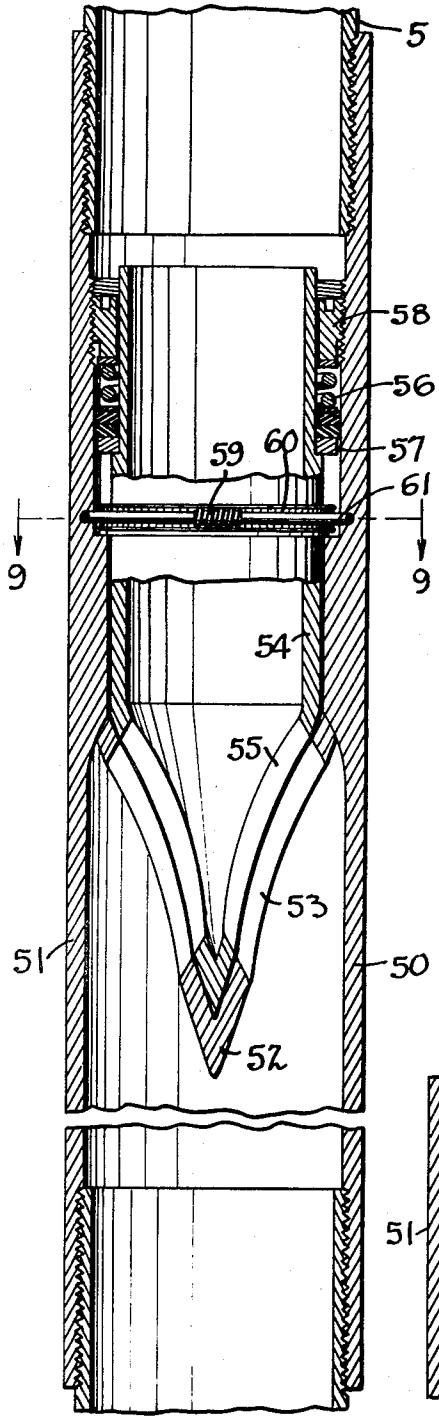


Fig. 8.

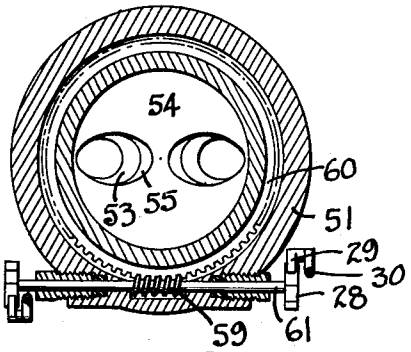


Fig. 9.

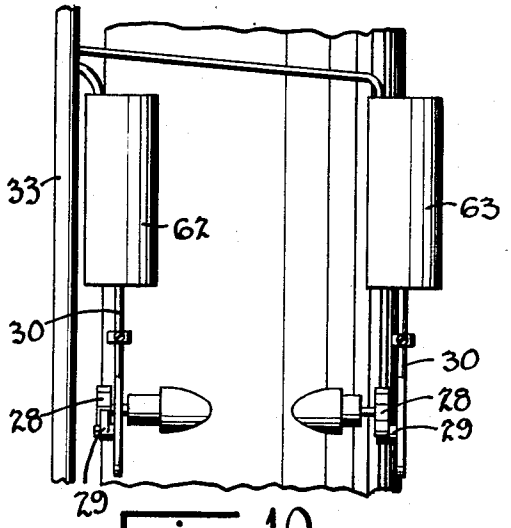


Fig. 10.

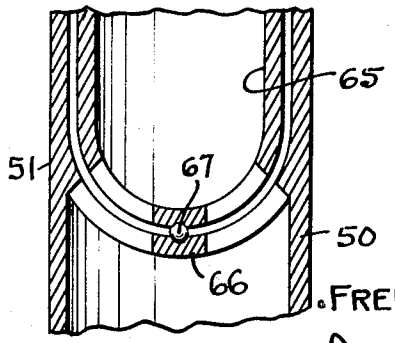


Fig. 11.

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SYSTEM AND APPARATUS FOR FLOWING WELLS

Filed Dec. 15, 1939 4 Sheets-Sheet 4

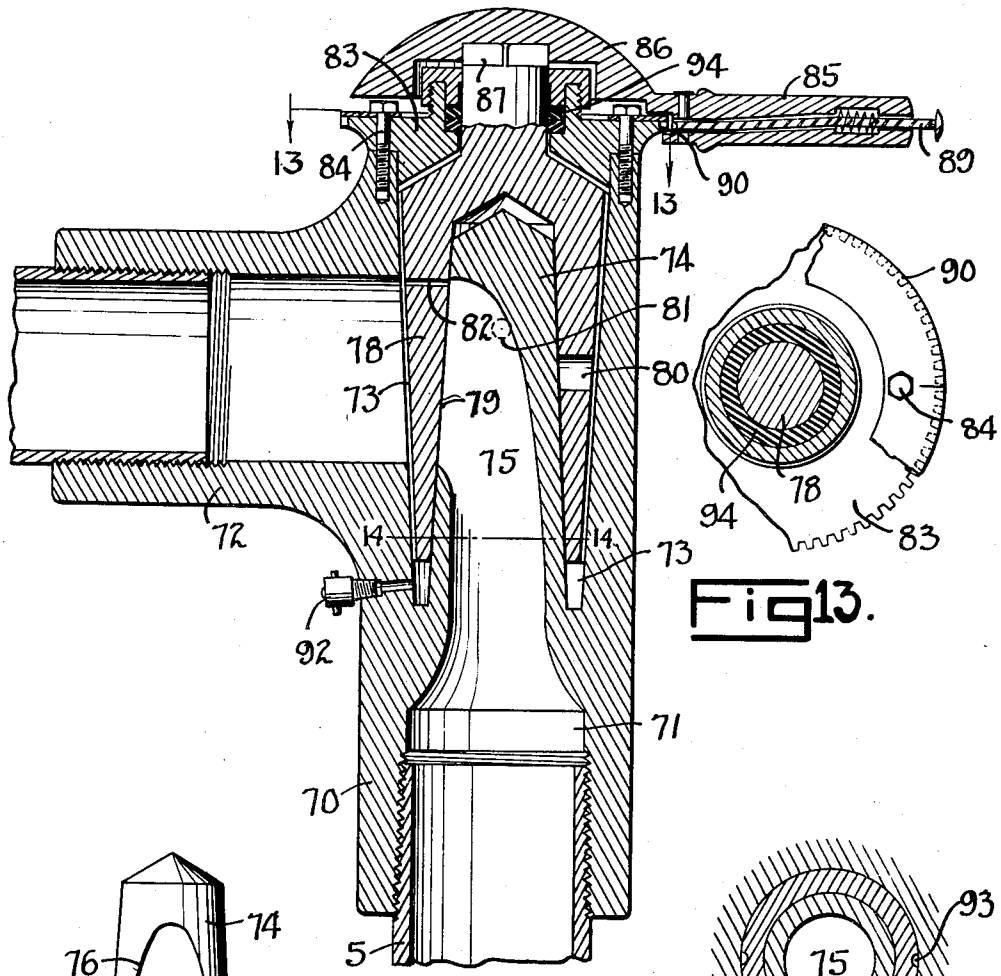


Fig. 12

Fig 13.

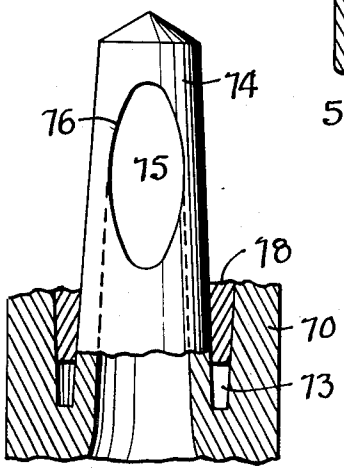


Fig. 15.

Fig 14.

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UNITED STATES PATENT OFFICE

2,307,171

SYSTEM AND APPARATUS FOR FLOWING WELLS

Fred S. Tutton, Fort Worth, Tex.

Application December 15, 1939, Serial No. 309,313

5 Claims. (Cl. 103—233)

The invention relates to a system and apparatus for flowing wells and particularly a system wherein accurate regulation may be had of the inlet to the well of the liquid to be produced, the rate of introduction of the pressure fluid to flow the well and lastly accurate regulation of the discharge from the well so as to control the gas, oil and water ratios.

In the flowing of wells by pressure fluid it has been found that each well is subject to peculiarities which it is difficult to determine prior to actual experimentation therewith, that these peculiarities vary with different wells and even in the same well over a period of time, that some of the circumstances that effect a well are variations in the bottom hole pressure, the nature of the formation from which the flow occurs, the relationship of the gas, oil and water to each other, the specific gravity and viscosity of the oil and other fluids as well as the various physical properties of the oil.

With the foregoing conditions in mind the present invention has been devised so that the system is adjustable to adapt itself to varying conditions on each well so as to control the inlet of fluid to the well, to control the rate of pressure fluid introduced to discharge the liquid from the well, and to also control the rate of discharge so as to maintain sufficient pressure upon the discharging liquid to control the gas, oil and water ratios of the well.

It is one of the objects of the invention to provide a system for flowing wells wherein the control valves are operated either independently or simultaneously by an automatic regulator from the surface.

Another object of the invention is to provide a particular type of bottom hole valve which may be regulated from the surface.

Another object of the invention is to provide a series of flow valves for a well tubing which can be adjusted and regulated either independently of each other or the entire series simultaneously.

Another object of the invention is to provide a solenoid operated flow valve which has a plug valve member which can be rotated continuously in one direction to open, close or regulate the valve.

Another object of the invention is to provide a form of well head which will control the discharge rate of the liquid therefrom.

Other and further objects of the invention will be readily apparent when the following description is considered in connection with the accompanying drawings wherein:

Fig. 1 is a broken vertical sectional view of the tubing equipped with one of the flow valves of the present invention.

Fig. 2 is a sectional view of the solenoid and the ratchet escapement used to operate the valve.

Fig. 3 is a view of one of the valves showing the valve in vertical section.

Fig. 4 is a section of the valve in horizontal section.

Fig. 5 is a section across the tubing on the line 5—5 of Fig. 1.

Fig. 6 is a diagrammatic view of a well casing, tubing and well head to which the invention has been applied.

Fig. 7 is a wiring diagram of the electric circuits.

Fig. 8 is a vertical sectional view of the bottom hole valve which controls the inlet of fluid to the well.

Fig. 9 is a section taken on line 9—9 of Fig. 8.

Fig. 10 is a side elevation of the solenoid controls for the bottom hole valve.

Fig. 11 shows a modified form of the contour of the valve, which modification is particularly adapted to take the thrust of the column of liquid in the well.

Fig. 12 is a vertical sectional view of the control head which may be used in the system.

Fig. 13 is a section taken on the line 13—13 of Fig. 12.

Fig. 14 is a section taken on the line 14—14 of Fig. 12.

Fig. 15 is a side elevation of the spindle in the control head.

In Fig. 1 the well bore is illustrated as containing a casing 2 which extends down into the well to a point adjacent the production formation and may carry a suitable strainer or screen in some locations to exclude sand and other extraneous material while in other locations the flow is directly from the formation into the well bore.

This casing 2 carries a well head 3 which has a swedged nipple 4 thereon which forms a seal about a string of tubing 5. This tubing may be controlled by a valve 6. The head 3 also has the flow line connections 7 and 8 at either side thereof which in this instance may communicate with the annular space 10 inside of the casing and outside of the tubing string 5.

The tubing string may in some instances carry a packer intermediate its ends which packer

may be set to define the lower limit of the reservoir 10 inside of the casing and to form a seal between the tubing and the casing.

A series of flow valves 12 have been incorporated in the tubing 5 and these may be spaced in the tubing at various intervals depending upon the peculiarities of the particular well to which the system is to be applied. These flow valves are for the purpose of admitting pressure fluid to the string of tubing if the flow is to be upwardly thru the tubing or to discharge pressure fluid from the tubing if a flow is to be reversed upwardly thru the casing. The present installation will be described as utilizing pressure fluid introduced thru the pipe 13 and the flow line 8 into the reservoir 10. This pressure fluid will be introduced into the tubing 5 thru the flow valves 12 so as to elevate the fluid in the tubing 5 and to discharge it from the upper end 14 of the tubing.

Each of the flow valves 12 is of peculiar construction in that it is made up of a coupling 20 which has an opening 21 therein to admit or discharge pressure liquid. This opening has the valve housing 22 of Fig. 4 screwed thereinto and the valve member 23 in the housing 22 is utilized to control the flow of this pressure fluid regardless of whether the flow is into or out of the tubing. Attention is directed to the configuration of the plug valve member 23 in that it has a hollow portion 24 which opens into the ports 25 so as to establish communication thru the valve. The fact that a rotatable valve member is provided permits opening, closing and adjustment of the valve by rotating the valve constantly in the same direction, eliminating any reversal of the parts and providing a valve which is unaffected by variations in pressure.

To actuate the valve member 23 a stem 27 is provided which projects from the housing and carries an escapement wheel 28. This wheel is in the form of a ratchet arrangement which is adapted to be engaged by the pawl 29 on the rod or core 30 of a solenoid 31. The pawl 29 is so pivoted that on upward movement it will cause the escapement wheel 28 and the valve member 23 to rotate a portion of a turn but on downward movement of the core 30 the pawl 29 will pass over the next adjacent tooth of the escapement or ratchet wheel so that by energizing the solenoid 31 the core 30 may be drawn upwardly to actuate the valve. The escapement wheel 28 may have any desired number of teeth so that one or more than one stroke of the solenoid is necessary to open or close the valve or to obtain the adjustment desired. As shown in the illustrative embodiment of Figs. 1 to 4, inclusive, a single stroke by the solenoid moves the valve 23 from open to closed position or vice versa. The solenoid 31 is suitably mounted by brackets 32 on the coupling 20 and the electric circuit or cable 33 passes downwardly along the side of the tubing and has the connections 34 leading to the solenoid. Fig. 3 shows this construction in section whereas Fig. 5 shows it in plan view along with a section of the tubing and the protective housing 35 which encloses the flow valve. A perforate plate 37 protects the valve against injury.

A series of these valves 12 will be arranged on the tubing as seen in Fig. 6 and for purposes of illustration a wiring diagram is illustrated in Fig. 7 wherein the coils 40 represent the coil of the solenoid 31 and the wiring represents the circuits to these valves. The switches 41 are arranged to control the various circuits and by the manipulation of these switches 41 and the switches 42 it seems obvious that any desired combination of one or more solenoids may be operated as desired, each solenoid can be operated independently or they may all be operated simultaneously as the circumstances require.

A suitable transformer 43 is placed in the power line 44 in order to provide a suitable source for the circuit.

If it is desired that the well be operated automatically switching mechanism such as that shown in Fig. 6 may be used. In this construction a motor 46 can be arranged to turn the contact 47 so that it will sequentially engage contacts on the switch. Such contacts will be electrically interconnected in a manner that rotation of the contactor 47 will close electric circuits, either simultaneously or independently, from the transformer 43' to the solenoids 12 through the cable 33. It seems obvious that any desired type of automatic or manual switching can be provided in the system.

In order to admit the fluid from the formation into the tubing string 5 a bottom hole valve 50 may be provided on the lower end of the tubing preferably below any packer on the tubing and in a position to control the inlet flow to the tubing. This valve is made up of a housing or coupling 51 which has an axial bore therethru which bore carries the valve seat 52. This seat is in the form of a tapered member which has the ports 53 therein. These ports may be of any desired configuration such as elliptical, circular, spherical and any other configuration which might be found to be desirable. Arranged inside of the seat 52 is the bottom hole valve member 54 which is tapered to fit the inside of the seat and has the openings 55 therein which are arranged to be oriented relative to the ports 53 to open, close or adjust the valve as desired. In order to resiliently hold this valve member in its seat a coil spring construction 56 is provided which bears against a ring 57 on the valve member and against an anchor ring 58 which is threaded into the coupling 51. In order to rotate this valve member a worm 59 and ring gear 60 have been provided. The worm is rotated by the shaft 61 which extends across the coupling 51 as best seen in Fig. 9.

The solenoids 62 and 63 may be carried by the coupling and the escapements to be operated by these solenoids are the same as the escapements 28 previously described, as are the cores 30 and the pawl 29. These solenoids are energized from the cable 33 which extends into the well along side of the tubing.

It seems obvious that by proper manipulation of the solenoid 62 and 63 the valve member may be turned to any desired adjusted position so as to permit the full opening of the tubing to choke down the rate of entry or to completely close the tubing as circumstances require.

Fig. 11 shows a slightly modified form of this bottom hole valve wherein the valve member 65 has a hemispherical configuration to fit into the hemispherical configuration 66 of the valve seat. An anti-friction thrust bearing 67 is provided so that the load of the column of fluid in the tubing will not interfere with the turning of the valve. The ports in this valve and seat can be aligned

by turning of the valve member as explained in connection with Fig. 8.

Fig. 12 shows a sectional view of a control head which can be applied to the upper end of the tubing 5 in lieu of the valve 6 shown in Fig. 6. This head comprises a body 70 which has a passage 71 extending upwardly therein and has a lateral flow line connection 72. The chamber 73 is provided inside of the body and this chamber has an outstanding spindle 74 which projects into the chamber 73. This spindle is hollow to provide a continuation 75 of the passage 71 and eliptical opening 76 defines this passage 75 where it terminates in the periphery of the spindle 74.

In order to control the rate of flow from the tubing 5 and the opening 76 a head or valve member 78 is deposited in the chamber 73. This valve member is in the nature of a hollow cap which has an inside face 79 which is adapted to form a seal with the periphery of the spindle 74, both of these surfaces being tapered so that a seal can be obtained without applying a great deal of axial pressure. This head or cap extends downwardly over the spindle and has an opening 80 therein which is in the nature of a choke so that when this opening is rotated to overlie the opening 76 then there may be a discharge from the tubing 5 which is regulated by the size of this orifice 80. The valve member 78 may have a plurality of different size orifices such as 81 and 82 therein or a separate valve member may be applied for each different size orifice.

The valve member 78 is held in position by a gland 83 which is affixed to the body by the cap screws 84. This valve is arranged to be turned by a handle 85 which carries a plate 86 which fits upon the non-circular portion 87 of the valve member 78. A latch means 89 is arranged to engage with the teeth 90 on the periphery of the gland 83 as best seen in Fig. 13 so that the valve may be set in any desired adjusted position.

In order to facilitate operation of this valve member a plug 92 has been affixed to the body so as to introduce a lubricant into the base of the chamber 73. In this manner the inside and the outside of the valve member will be lubricated and if desired the grooves 93 may be arranged in the periphery of the valve member to allow distribution of the lubricant. The packing 94 about the stem of the valve member will confine this lubricant against escape at the top of the member.

In operation the parts will be assembled as seen in Fig. 6 and lowered into the well bore with or without a packer about the lower end of the tubing as circumstances warrant. Preferably the flow valves 12 are in closed position and the system will be manipulated to open the bottom hole choke 50 so as to allow the entrance of fluid from the formation. The elevation to which fluid will flow varies in different wells and may be controlled by manipulation of the bottom hole valve. When the desired body of liquid has entered the well the bottom hole valve may be closed if desired and the flow valves opened either simultaneously or sequentially as desired. The usual practice is to open the upper valves and flow off the head of liquid in the tubing by stages. The liquid may be partially or all discharged from the tubing as desired. In some instances the ratio of oil to water or oil and water to gas or gas to oil may have considerable bearing upon the operation of the well and it is intended that the present apparatus will be varied to control these ratios. In some instances it is very desirable to maintain the gas in solution in the oil and to control the water ratio by exerting a back pressure or control upon the discharge from the tubing. In some instances the valve 6 as seen in Fig. 6 may be utilized for this purpose but it has been found that a more accurate control can be obtained by a regulator head of Fig. 12. This head may be adjusted by having the proper choke or orifice in position to regulate the flow and in this manner the ratios of the various components being produced may be controlled.

It is to be understood that the control head of Fig. 12 may or may not be used and that in view of the large variation in the peculiarities of the wells that it is intended that the present invention insofar as the apparatus and its manipulation is concerned may be varied greatly to cope with existing conditions.

What is claimed is:

1. A well flowing system including a well casing and tubing, a series of flow valves on said tubing spaced along the tubing to control the flow into or out of said tubing, an electrically operable means to actuate each flow valve to both opened and closed position, said means being operable to actuate said valves either simultaneously or independently.

2. A well flowing system including a well casing and tubing, a series of flow valves on said tubing spaced along the tubing to control the flow into or out of said tubing, an electrically operable means to actuate each flow valve to both opened and closed position, said means being operable to actuate said valves either simultaneously or independently, and a bottom hole valve also operable either independently or simultaneously with the other said valves.

3. A well flowing system including a well casing and tubing, a series of flow valves on said tubing spaced along the tubing to control the flow into or out of said tubing, an electrically operable means to actuate each flow valve to both opened and closed position, said means being operable to actuate said valves either simultaneously or independently, including electric circuits into the well.

4. A well flowing system including a well casing and tubing, a series of flow valves on said tubing spaced along the tubing to control the flow into or out of said tubing, an electrically operable means to actuate each flow valve to both opened and closed position, said means being operable to actuate said valves either simultaneously or independently, including electric circuits into the well, and a solenoid on each valve.

5. A well flowing system including a well casing and tubing, a series of flow valves on said tubing spaced along the tubing to control the flow into or out of said tubing, an electrically operable means to actuate each flow valve to a desired position, said means being operable to actuate said valves either simultaneously or independently, including electric circuits into the well, and solenoid on each valve, with a ratchet escapement device connecting each solenoid to each valve.

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