Feb. 28, 1939. J. W. TAYLOR **2,148,592**

SYSTEM FOR FLOWING WELLS

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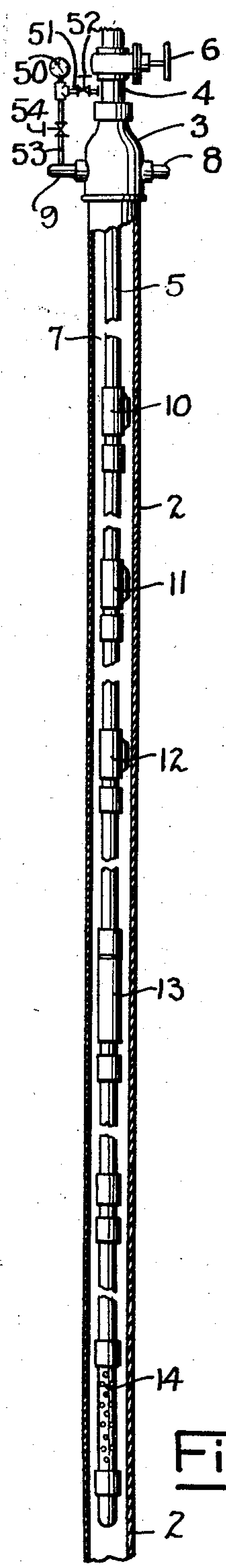

Fig. 1.

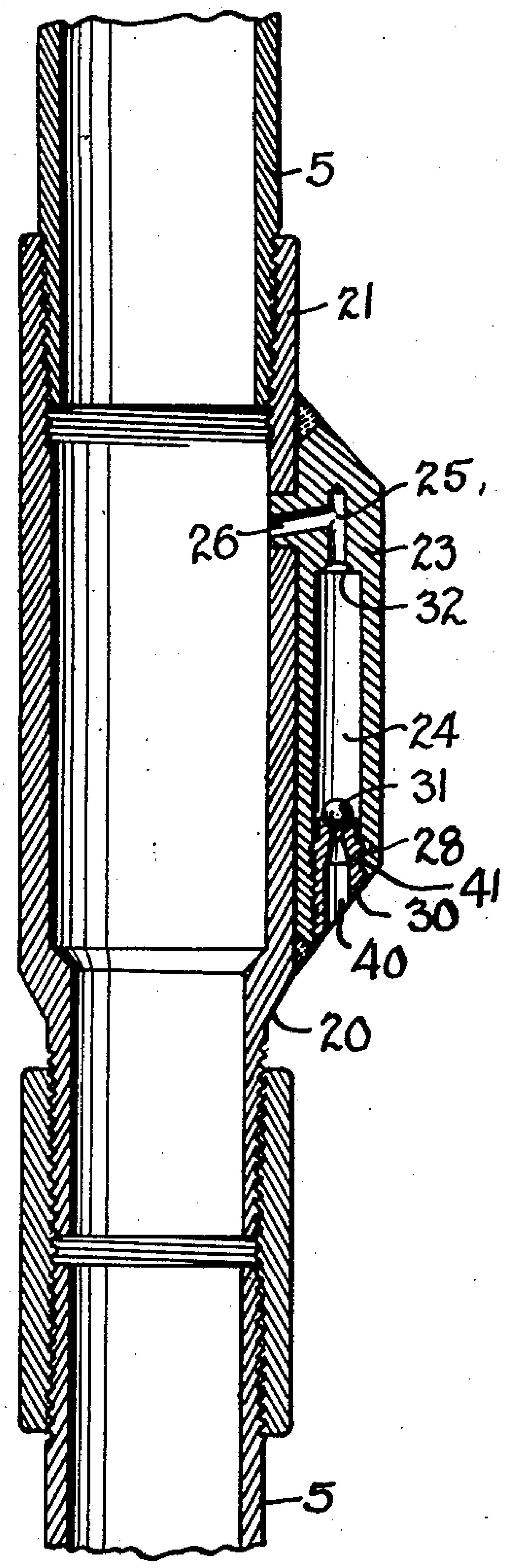

Fig. 2.

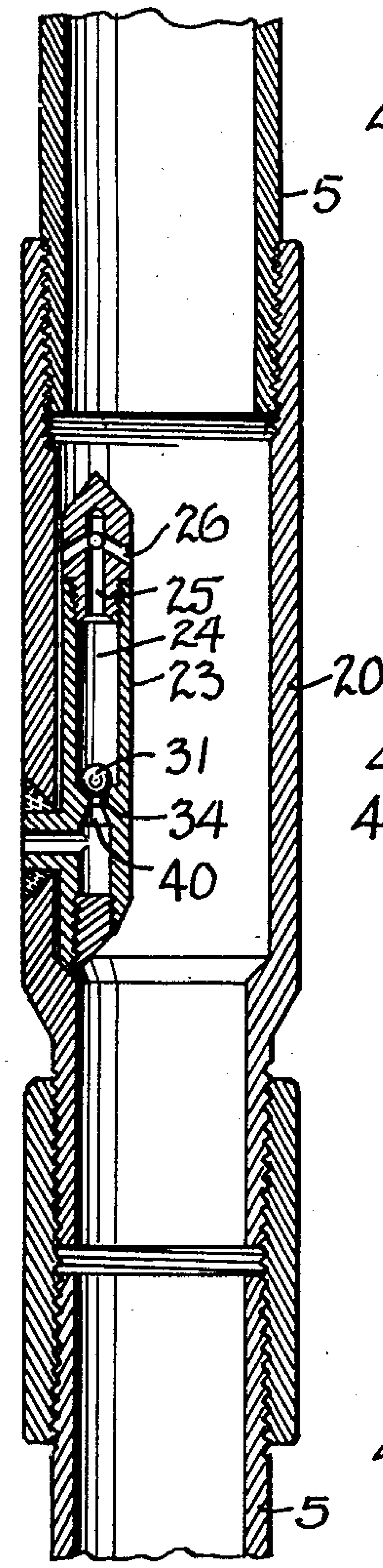

Fig. 3.

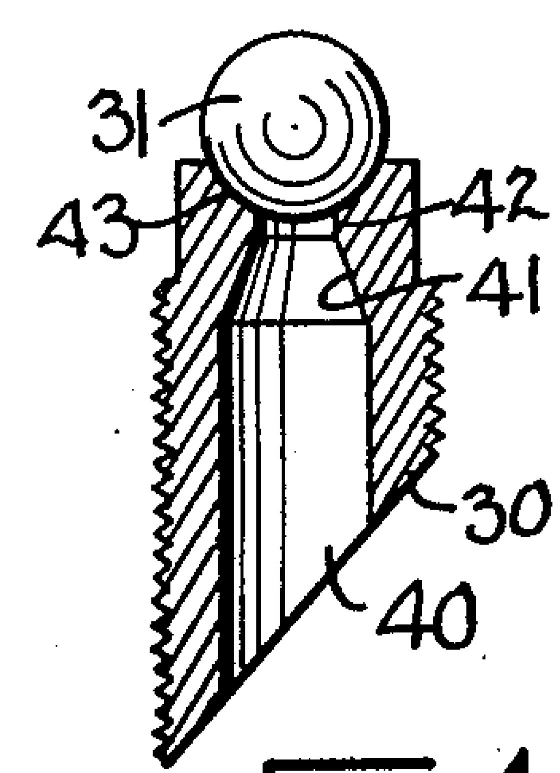

Fig. 4.

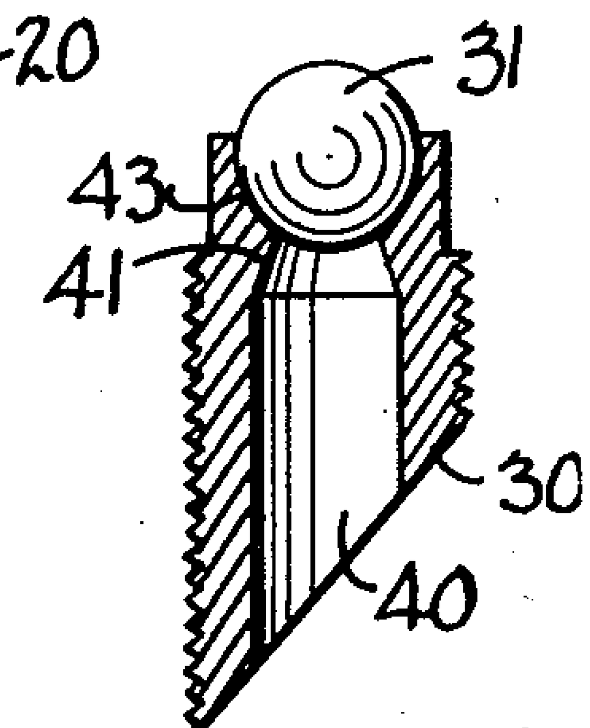

Fig. 5.

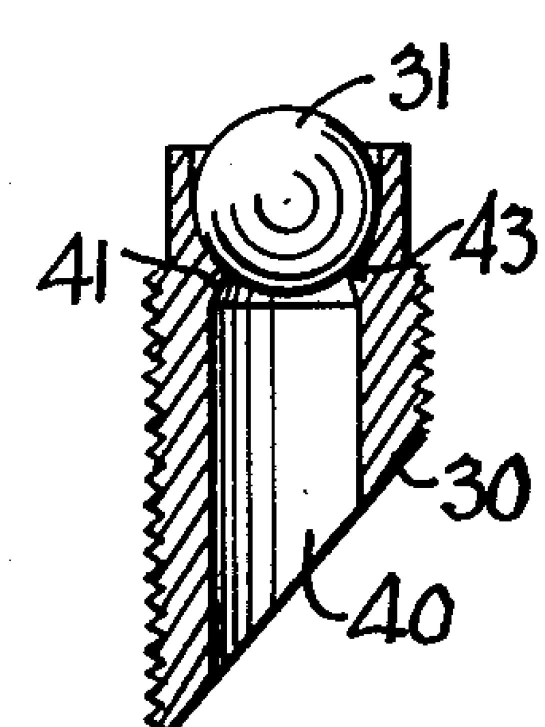

Fig. 6.

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SYSTEM FOR FLOWING WELLS

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2 Claims. (Cl. 103—233)

The invention relates to a system for arranging an assembly of valves in a well so as to produce flow from the well in a most efficient manner and particularly deals with an arrangement of the valves such that they will adapt themselves to the conditions and differential pressures occurring at the various elevations in the well at which they are located.

The invention is arranged to be incorporated in a well where the oil and gas are produced through a pipe or tubing by means of a lifting fluid which is injected into the eduction or production pipe at stages or intervals along its length so as to obtain a step by step of lifting action due to the aeration of the column of liquid in the production tubing or pipe.

It is of course desirable to control the operation of these valves so as to permit the injection of a minimum volume of lifting fluid so as to obtain the desired lifting effect and to have the valve remain closed when no lifting fluid is needed at that particular elevation.

The present valves are designed to operate at predetermined pressure differentials; that is, to operate, depending upon the difference in pressure on the inside and the outside of the production tubing, it being the practice to enclose the production tubing in the casing so as to form a reservoir for the pressure or lifting fluid and to incorporate the control or flow valves in the string of tubing so that they will be subjected to the pressure in the reservoir and also to the pressure inside of the production tubing.

It will be readily apparent that a well producing a heavy viscous oil will require operation of the valves at a greater pressure differential than would a well which produced a comparatively light oil in which there is a substantial amount of gas in solution. It is also, therefore, apparent that a valve having the same size inlet cannot be used for both of the foregoing conditions because in one instance an insufficient amount of lifting fluid would be admitted and in the other an excessive amount of lifting fluid would be admitted. It is therefore very difficult to design and arrange a series of valves for any one well which will operate at the proper pressure differential when they are inserted in a long flow line of production tubing. This is particularly true where the pressure on the inside of the tubing is reduced as it approaches the surface because much of the gas may come out of solution or move in the well so that there is a greater ratio of gas to oil nearer the surface than there is in the lower regions of the well.

By actual experience it has been ascertained that where a ball valve member is provided in a flow valve of the type herein disclosed even if the differential pressure at which the valve is to close is not correct that the ball valve will not as a matter of fact move to its upper seat and shut off the flow of fluid but will be buoyed upwardly by the incoming flow of gas in such a manner that a chattering action is set up by the ball valve member engaging its lower seat and then being quickly moved off its seat by the incoming gas. This chattering action results in a constant hammering effect upon the valve seat, and the present invention concerns itself with providing a particular type of seat in which the valve opening will vary due to the tapered construction of the seat so that as the hammering effect of the valve continues the size of the opening for admitting the pressure fluid will gradually change due to the hammering action of the valve member and that eventually the size of the opening will in this manner be adjusted by the hammering on the seat until such a time that the size of the opening admits the proper amount of pressure so as to maintain the proper differential pressure at that particular location, so that the chattering action will cease and the valve will operate in its intended manner.

One of the objects of the present invention is therefore to provide a seat for a ball valve which has a tapered portion such that as the seat wears away the orifice being closed by the valve will gradually increase in size, depending upon the differential pressure which is proper to maintain the valve in a definite open or closed position depending upon the differential which is present at the valve location.

Another object of the invention is to arrange a series of valves upon a string of production tubing at different elevations thereof so that the valves will automatically seat themselves by hammering their seats until the seat takes a configuration such that it will admit the proper amount of fluid therethrough to maintain a differential such that the valve will be balanced and will move to either direct open or closed position.

Another object of the invention is to provide a system for controlling the flow of fluid from wells by automatically providing a pressure differential at each stage of the elevation of the liquid from the well which will most efficiently elevate the fluid at that elevation.

Another object of the invention is to provide a series of unloading valves on a string of production tubing which will operate to unload the column of liquid above each particular valve in a successive operation.

Another object of the invention is to provide an unloading valve which will open when a predetermined differential pressure occurs therein so as to unload the column of liquid above that valve and to thereafter remain closed until another load of liquid occurs above that valve to create the predetermined pressure that will cause opening of the valve.

Another object of the invention is to provide a method of automatically seating an unloading valve by causing a hammering action of the valve on a seat which will vary in size as a result of the hammering until an orifice is in this manner created which will provide a flow to effect the desired predetermined pressure differential at that particular location of a valve.

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

Fig. 1 is a side elevation of a well which is equipped with the present system of flowing the well and illustrates the arrangement of the valves on the production tubing.

Fig. 2 is a vertical section of a piece of tubing showing one of the valves attached to the exterior of the tubing.

Fig. 3 shows another form of the production tubing wherein the valve has been attached to the interior of the tubing.

Figs. 4, 5 and 6 are vertical sectional views of the ball and seat construction which has automatically adjusted itself to provide different size orifices for admitting the pressure fluid.

In Fig. 1 the well casing is illustrated generally at 2 and extends into the well bore, being closed by the casing head 3. This casing also serves to support a string of tubing 4 which extends into the well in the form of an eduction pipe of tubing 5. The flow from this tubing is controlled by a valve 6 above the casing head 3.

The area 7 between the casing 2 and the tubing 5 is in the form of a reservoir for pressure fluid which may be delivered to the well through the inlet pipe either 8 or 9.

Attached on the tubing 5 are a series of unloading valves indicated generally at 10, 11 and 12, whereas the kick-off or flow valve is shown generally at 13. All of these valves are carried by the tubing 5 as is the strainer 14 attached to the lower end thereof. If desired, a suitable packer or other restriction may be provided around the tubing 5 in order to form a seal with the casing 2 to limit the size of the reservoir 7. On the other hand, in some wells no such packer is provided and none is illustrated in the present instance.

Fig. 1 is merely diagrammatic and it is intended that any number of unloading valves can be provided at spaced intervals along the tubing, depending upon the circumstances encountered, which, of course, vary with the depth of the well, the viscosity of the oil, the size of the tubing, the volume of flow, the gas pressure encountered, as well as many other factors which enter into the equipping of a well with valves of the present type.

In Fig. 2 one of the valves is illustrated generally at 20 and is shown as having been attached to a coupling or sub 21. This coupling is threaded at its ends in order to be connected to the upper and lower sections of the tubing 5.

The valve itself is contained within a housing 23 which includes a valve chamber 24 with the passages 25 and 26 leading therefrom into the inside of the flow pipe.

The lower end of the chamber 24 is threaded at 28 in order to receive the nipple 30; such nipple is threaded in position and serves as a seat for the valve member which is here shown in the form of a ball. The top of the chamber 24 is also provided with a valve seat 32 which receives the ball member when the pressure differential is such that the valve member will move to its upper seat to cut off the inflow of pressure fluid. In the positions shown in Fig. 2 the pressure is greater inside of the tubing and there is no inflow of pressure fluid.

Fig. 3 shows the housing 23 as having been positioned inside of the sub 20 instead of on the outside as shown in Fig. 2. Otherwise the construction is substantially the same except that the seat portion 34 for the valve member 31 is formed in the housing 23. It is to be understood, however, that it may be formed in a separate nipple in the same manner as it is formed in Fig. 2, so long as the pressure fluid can enter the nipple in order to be controlled by the valve member. The other parts in Fig. 3 are the same as in Fig. 2.

Particular attention is directed to the peculiar construction of the nipple of the valve seat member 30, and it will be observed that the inlet passage 40 is of uniform diameter, for a substantial length, and it is then reduced in diameter by the tapered section 41. Beyond the tapered section 41 is a second cylindrical section 42 of reduced size and then the upper portion of the nipple is cupped at 43 to form the original valve seat, reference being had to Fig. 4. The valve member 31 is shown as seated in Fig. 4 in the cupped portion in the manner which it will seat when the parts are new and ready for installation in the well.

With the parts assembled as shown in Fig. 4 the valves will be attached to the tubing and lowered into the well bore and the pressure will be applied thereto. If there is a load of oil in the tubing 5 above the valve 10 and if the head of the liquid in the chamber 7 is above the valve 10 then of course the pressure which is introduced into the reservoir 7 will cause depression of this column of liquid until it moves down to the level of the valve 10. When this occurs the pressure in the reservoir 7 will undoubtedly be greater than the back pressure exerted through the passages 25 and 26 in the chamber 24 and upon the valve member 31 due to the load of liquid in the tubing 5, so that a differential pressure will be exerted on the valve member 31 in the valve 10 and it will move upwardly to permit an inflow of pressure fluid. This pressure fluid aerates the column of liquid in the tubing 5 above the valve 10 and assists in discharging it from the well. The removal of this load of oil in turn reduces the pressure applied on the column of liquid which remains in the tubing 5 below the valve 10 and above the valve 11, and as the pressure on the inside and outside of the tubing will naturally tend to equalize itself the head of the liquid in the reservoir will again move downwardly until it reaches the next unloading valve 11.

The pressure fluid will then enter the valve 11, aerate the column of liquid above that valve, and discharge that body of liquid from the body of the well. This operation will of course be repeated as the head of liquid moves downwardly into the reservoir 7.

It is intended that after the liquid in the tubing above any particular unloading valve has been discharged that the differential pressure which predominates on the outside of the valve will keep the valve member 31 against the upper seat 32 in closed position to prevent entrance of pressure fluid. This is the theory of operation which is presumed to hold true in actual practice and a majority of the wells are equipped with valve constructions in accordance with this theory.

The present invention, however, substantiates the discovery by this applicant of the fact that the ball valves 31 do not move upwardly against the seat 32 and remain in this closed position due to differential pressure. Various circumstances cause a phenomenon of operation of ball member 31 and it has been found that this ball member merely floats on top of the incoming pressure fluid and is buoyed up in the chamber 24 so that there is a flow of fluid around the ball member and through the valve continuously; that in actual operation this ball member 31 merely bounces up and down on its seat 43 at a very rapid rate and that as a matter of fact a very substantial hammering action occurs on the valve seat 43 and in the past where the entire passage 40 was of uniform diameter it has been found that the ball member would hammer its way completely through the passage pounding a seat as it went so that in a very short period of time the seat was destroyed and a new nipple 30 had to be provided. The nipple 30 may be made of any desired material, brass having been found satisfactory.

As the result of such action an extensive study was made of the conditions encountered in a well and the taper 41 was provided in the seat 30 so that as the actual seating surface 43 was moved downwardly through the hammering action the size of the orifice 42 would vary and then become enlarged as the seat portion was moved downwardly along the taper 41, and that as a matter of fact when the seat 43 reached a certain position along the taper 41 thereafter the hammering action would discontinue and that the point where the hammering action ceased varied in different valves which were positioned along the tubing 5. Further, that there was a substantially uniform difference between the size of the orifice 42 between adjacent valves and that the change in the size of the orifice was uniform along the tubing, where the spacing of the valves was uniform.

It was therefore determined that there was a predetermined and definite differential pressure at which each valve would operate properly, and that in order to maintain this proper differential pressure it was necessary to adjust the size of the orifice 42 through which the pressure fluid was admitted in order to maintain that proper differential pressure and that the size of the orifice varied with the position of the valve in the well because of the difference in the conditions encountered by each valve and the difference in the head of liquid on the inside or the outside of the production tubing.

With the foregoing in mind, therefore, the taper 41 has been provided on the passage 40 so that while all of the valves when positioned in the well are of uniform construction they, in a very short time due to the automatic seating conditions which are encountered in the well, will seat by an automatic operation which will depend upon its location in the well.

As an instance of this, in Fig. 4 the valve might maintain its seat 43 as illustrated with the orifice 42 of small diameter, whereas the next valve on the string of tubing would be represented by Fig. 5 where the ball member 31 has worn away the original seat and the uniform portion of the inlet orifice and has arrived at a position such that part of the taper 41 has been worn away and the seat 43 has moved to the position shown. Naturally the orifice 42 is somewhat larger in Fig. 5 than it is in Fig. 4 and a greater amount of pressure fluid will naturally be admitted through this larger orifice.

Fig. 6 shows another valve positioned at a different location on the tubing wherein the entrance orifice 42 has been substantially enlarged and the taper 41 has almost been worn away.

The applicant has therefore worked out a system by which valves of uniform size and capacity are applied to a well tubing but they are of such construction that each valve will automatically work out its own problem at that particular elevation so that within a very short time the seat for the valve has so adjusted itself due to the differential pressure encountered that it will admit the proper amount of pressure fluid in order to unload the column of liquid in the well above that valve and will then move to closed position without further chattering and until such proper size entrance orifices have been created that the valve performs a chattering operation which has been outlined in connection with the present invention, to create a seat of the proper size so as to eliminate the chattering action. The pressure gauge 50 is shown in Fig. 1 and its connection 51 with the tubing 5 carries a valve 52 while the connection 53 to the flow line 9 and casing 2 carries a valve 54. By manipulating these valves the pressure of either the casing or tubing may be determined or the pressure can be equalized by opening both valves.

In actual practice a set of seven valves were applied (all of uniform construction), to a well and the well placed in operation. Within a period of forty-eight hours an inspection was made of the valves and it was found that each valve had automatically seated itself by creating a seat of the proper size such that the desired flow of pressure fluid was permitted and further inspection of these seven valve seats showed that the size of the opening became larger in each succeeding valve as the depth of the well increased, the bottom valving creating the larger entrance opening so that the pressure differential between the inside and outside of the tubing was shown to be smaller as the operation progressed down the well. In other words, the upper valve wore but very little and each succeeding valve down the tubing received more wear before it arrived at a balanced position.

Further inspection of a system of valves of this sort showed that after they had once arrived at a proper size inlet orifice that there was then no further hammering effect and the valves operated for a long period of time without any further change in the size of the entrance orifice or the position of the seat. That because of the tapered area 41 each valve was permitted to wear to such an extent that it would automatically create the proper pressure differential for its particular elevation in the well. The foregoing is merely given as an illustration of the actual operation of the system.

Broadly, the invention contemplates a system of valves which will automatically seat themselves to control the pressure differential for the various elevations in the well so that valves will open to permit the entrance of the pressure fluid to unload the column of liquid above the valve and to thereafter close and remain in closed position without wear.

What is claimed is:

1. In a flowing valve for wells a housing, a valve chamber therein, inlet and outlet passages for said chamber, a valve member in said chamber, seats at opposite ends of said chamber at said inlet and said outlet, one of said seats being of a material to be deformed by said valve member to change the size of the entry of the housing.

2. A system of equipment for a well, including a series of flowing valves, a tubing in the well, flow valves spaced along the tubing, each of said flow valves having an inlet orifice and an oppositely tapered valve seat, a ball valve on said seat, said seat being of a material which will be deformed by the chattering of said ball valve so that the valve will chatter on its seat to deform the seat and thus change the size of the inlet orifice as said seat is deformed along the taper until the pressure fluid being admitted creates the differential pressure at that elevation which causes the valve to operate without chattering.

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