The invention relates to a differential pressure unit which is particularly adapted for use in operation for a control valve in a system of flowing wells but may have many other applications where relatively high pressures are to be applied to diaphragms where the diaphragms must be reinforced or supported in order to transmit an indication of the applied pressure.

One of the objects of the invention is to provide a differential pressure unit wherein a pair of spaced diaphragms are reinforced to move in unison by a plurality of nested sleeves disposed between the diaphragms.

Another object of the invention is to operate a flow valve with a diaphragm unit.

It is also an object of the invention to provide in combination with a valve member a diaphragm unit which is operable by the differential pressure applied to the valve and the unit.

Another object of the invention is to provide a differential pressure unit for flow valves which is completely closed to prevent corrosion.

Another object of the invention is to provide a flow valve for wells wherein the differential pressure at which the valve will operate may be varied by changing the size of the valve member.

Another object of the invention is to provide a flow valve for wells which can be operated by a differential pressure applied to either side thereof.

Another object of the invention is to provide a flow valve which will operate regardless as to whether the flow is to be through the tubing or through the casing.

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 side elevation of a well casing equipped with a string of flow valves embodying the invention.

Fig. 2 is a side elevation of one of the valves, while Fig. 3 illustrates certain portions thereof in section.

The Fluid being produced will enter the well from the producing formation and is constrained to enter the string of tubing 3 which is disposed in the well inside of the casing 2. A packet or other suitable closure will form a seal between the inside of the casing 2 and the outside of the tubing 3 so that a chamber reservoir 4 is thus formed between the tubing and casing.

Disposed at suitable intervals along the tubing string 3 are the couplings 5, each of which carries a flow valve assembly 6.

These flow valves will be spaced at desired intervals depending upon the circumstances encountered in each particular well and it is their function to control the admission of pressure fluid to the tubing 3 if the well is being flowed through the tubing, or if the well is being flowed through the casing 2 then the valves control the discharge of the pressure fluid from the tubing 3 into the reservoir 4.

In either event the pressure fluid tends to aerate the column of liquid in the well and to discharge such liquid from the well.

It is intended that the valve and diaphragm unit to be described may be utilized to control the flow of pressure fluid either into or out of the tubing string 3. For purposes of illustration, however, it will be described as controlling the flow of pressure fluid from the reservoir 4 into the tubing 3 because this is the most generally practiced method.

In Fig. 2 the coupling 5 is made up with an enlargement 7 at one side which is internally recessed and threaded at 8 to provide a shoulder 9. A perforated plate 10 serves to close the inner end of the opening 8 and has a plurality of orifices 11 disposed therein and it has a central orifice 12.

Disposed in the opening 8 is a diaphragm unit 15 which carries a flange 16 which rests on the shoulder 9. This flange has a plurality of openings 17 therein so that there may be a flow of fluid past the diaphragm unit.

A closure plug 20 is threaded into the opening 8 and has the skirt 21 thereof arranged to bear against the flange 16 to clamp the diaphragm unit 15 firmly in position. The plug 20 has a recess 22 on its outer face which recess is closed on its inner end by a web 23. A plurality of openings 24 are provided in the web and a central opening 25 receives the shank 26 of a valve member 27.

This shank carries a non-metal stud 28 which bears against the diaphragm unit 15. A valve seat 29 is disposed in the recess 22 and is held in position by a closure cap 32 which is threaded into the recess 22. This cap has a plurality of ports 33 therein.

Particular attention is directed to the valve member 27 because the pressure in the reservoir 4 is exerted against the exposed area of this valve member. The total pressure thus applied to the valve member is transmitted by the stud 28 against the diaphragm unit 15.

As the parts are arranged in Fig. 2 the valve...
member 27 is closed. The diaphragm unit is in its normal position and the pressure on the outer exposed face of the valve 27 holds the valve in closed position. When a pressure is exerted on the inside of the diaphragm unit, which total pressure exceeds the total pressure on the valve 27, then the diaphragm unit tends to flex or move and in this manner move the stud 28 and the valve 21 so as to open the valve.

The ratio of the pressure on the inside 35 of the tubing and in the reservoir 4 at which the valve will operate can be readily controlled by changing the size of the seat 30 and the valve 27. As an instance, if the exposed area on the inside of the diaphragm unit is 4” and the exposed area on the valve 27 were 2”, then the valve would open when the pressure inside of the tubing was one-half that of the pressure in the reservoir. Any desired ratio can be obtained by substituting different size valves 21.

The particular construction of the diaphragm unit 15 is of importance since it is constructed to operate with a minimum of friction loss and suitably support the diaphragm for flexing or movement under high pressure at which the diaphragms would not operate unless they were suitably reinforced. The unit is self contained so that the internal working parts thereof cannot be corroded or subjected to sand or abrasion.

As seen in Fig. 2 the unit is made up of an outer housing or cylinder 40 which has the flange 46 formed thereon. This cylinder has an inwardly extending web 41 which terminates in a cylindrical bore 42. Nested inside of this cylinder 40 is a sleeve or piston 44 which has a shoulder 45 spaced from the shoulder 46 which is the inner face of the web 41. The sleeve 44 has a cylindrical portion 47 which fits in the bore 42. Particular attention is directed to the space 56 between the shoulders 45 and 46 as the parts are positioned in Fig. 3. Another somewhat smaller sleeve 49 is nested inside of the sleeve 44 and has complementary parts to cooperate with the sleeve 44 in the same manner that the sleeve 44 fits into the cylinder 40. A third sleeve 50 in turn fits within the sleeve 48. While the central portion of the diaphragm unit is filled by the plunger 51 which has a head 52 thereon to rest with the sleeve 50.

The outer ends of these sleeves are somewhat beveled as at 53 so as to fit snugly against a diaphragm 55. This diaphragm has its rim affixed at 56 to the periphery of the cylinder 40 but it has a normally depressed central portion 57 which tends to hold the nested sleeves or pistons in the position shown in Fig. 2 with the shoulders such as 45 and 46 spaced apart so that each sleeve may have some relative movement outwardly or to the right as viewed in Fig. 3 with respect to the next adjacent larger sleeve.

The inside of the diaphragm unit is closed by a diaphragm 58 which is affixed to the periphery of the cylinder 40 as at 59. These diaphragms are preferably welded or soldered in place to completely seal the nested sleeves and plunger inside of the unit. These sleeves may be suitably lubricated at the time the unit is assembled or a thin lubricant of some sort of a suitable type may be used to fill all of the spaces as at 48.

It seems obvious that the differential unit will flex under a differential pressure applied thereto when the unit is held firmly in place by the flange 46.

Flexing of the unit will occur because the inner diaphragm 58 is subjected to a pressure which can move the diaphragm over a circular area which is defined by a circle along the periphery 60 of the sleeve 44 so that the applied pressure multiplied by the area inside of the circle 60 will give the necessary applied pressure.

This total applied pressure will be transmitted through the diaphragm unit and cause relative movement of the nested sleeves and the plunger 51. This total applied pressure is available on a smaller exposed area on the outer diaphragm 55, however, because of the reduced size of the nested sleeves, so that this total pressure is applied over an area which is inside of the circle 61 defined by the periphery of the cylindrical portion 47 of the sleeve 44 inside of the cylinder 42. In the present instance this transmitted pressure is used to move the valve 24 and the stud 28 because the stud 28 abuts against the diaphragm 55 and holds the diaphragm and the nested sleeves against movement. Thus, the total pressure applied to the valve 27 is transmitted to the stud 28 and retards flexing of the diaphragm unit until such time as the total applied pressure on the inside of the unit exceeds the total applied pressure on the valve 27.

The arrangement of the sleeves tends to reinforce the diaphragms 55 and 56 so that they will not rupture under higher pressures and at the same time to transmit the movement from one diaphragm to the other.

Fig. 3 shows a somewhat larger sectional view of the parts and the dotted lines 63 and 64 illustrate the position of the diaphragms 55 and 56 when there is a predetermined pressure on the diaphragm 58. In this position the shoulders 45 and 46 will abut together and in this manner limit the movement or flexing of the diaphragms.

Attention is directed to the fact that the total area of all of the openings 17 is somewhat less than the total area of all of the openings 24 so that in this manner the openings 17 serve as a choke to prevent the same pressure being applied to the diaphragms 55 and 56. The total area of the openings 41 plus that of the opening 12 is also greater than the area of the opening 17 so that if the flow is reversed the same choking effect will be obtained.

Broadly the invention contemplates a differential pressure unit which will operate at high pressures.

What is claimed is:
1. A device for flowing wells having a casing comprising a string of pipe in said casing, a control valve thereon to control the admission of a fluid pressure contained in said casing in the well to said pipe, a valve member in said valve, and a pressure unit responsive to pressure in the pipe to move said member, said unit including a set of relatively movable nested pistons, a diaphragm bearing on said pistons at each end thereof so that the pistons support and reinforce the diaphragms in movement, and means on said valve member to engage one of said diaphragms and to move therewith.
2. A device for flowing wells comprising a casing having a string of pipe therein, a control valve thereon to control the flow of fluid pressure from said casing in the well to said pipe, a valve member for a fluid passage through said valve, and a pressure responsive unit to move said member, said unit including a set of relatively movable nested pistons, a diaphragm bearing on said pistons at each end thereof so that the pistons support and reinforce the diaphragms in movement, means on said valve member to en-
gage one of said diaphragms and to move there- with, and additional means to admit the pressure in said pipe against one diaphragm and the pressure in the casing against said valve member whereby the flow of pressure fluid into said pipe is controlled by as a function of the differential pressure between said pipe and said reservoir.

3. A flow valve for wells including a hollow pipe coupling, a passage therethru from the exterior to the interior, a valve member to close said passage, and a pressure responsive unit to move said valve including a plurality of nested sleeves having limited movement in one direction, and diaphragms sealed over the ends of said sleeves.

4. A flow valve for wells including a hollow pipe coupling, a passage transversely through the side thereof, a valve member to close said passage, and a pressure responsive unit to move said valve including a plurality of nested sleeves having limited movement in one direction, and diaphragms sealed over the ends of said sleeves.

5. A flow valve for wells including a hollow pipe coupling, a passage therethru from the exterior to the interior, a valve member to close said passage, and a pressure responsive unit to move said valve including a plurality of nested sleeves having limited movement in one direction, and diaphragms sealed over the ends of said sleeves to be reinforced to withstand the pressures applied thereto.

6. A differential pressure diaphragm unit to withstand relatively high pressures, said unit including a central plunger having an enlarged head, a set of stepped sleeve members nested to be moved in succession by the head of said plunger, a diaphragm to bear on said head and said sleeve members, and a second diaphragm bearing against the other end of said plunger and said sleeves, both of said diaphragms being flexible.

7. A differential pressure diaphragm unit including a pair of spaced diaphragms, a plurality of relatively slideable supporting members disposed to bear against and separate said diaphragms, one diaphragm being normally flexed to hold said members in position to be moved upon a pressure flexing the other diaphragm, each of said members including a shoulder area having a cylindrical portion extending in one direction from the outer edge and from the other direction on the inner edge so that the sliding movement of adjacent members in one direction is limited by abutment of the shoulder area, the differential of said unit being the area of the shoulder of the largest supporting member.

8. A valve housing, a diaphragm unit having two spaced diaphragms therein capable of flexing due to application of pressure from within said housing, a valve member exposed to pressure outside of said housing and bearing against said unit and movable to open position thereby when the total pressure on said unit from within the housing exceeds the total pressure on said valve unit, the area of one diaphragm on said unit which is exposed to pressure within the housing being greater than the other diaphragm upon which the differential pressure is in contact with the valve whereby the differential pressure on the inside of the unit and upon the valve is utilized to actuate the valve.

9. A differential pressure transmitting unit including a plurality of stepped nested sleeve-like members, a diaphragm sealed about the largest member and overlying the ends of all the members at each side of the unit, the smaller ends of the inner members being progressively shorter so as to form a dished or concave surface at one side with the diaphragm on that side being normally concaved to fit such surface, said diaphragms being flexible so that the maximum movement of the members substantially flattens the concave surface and the diaphragm.

10. A differential pressure transmitting unit including a plurality of stepped nested sleeve-like members, a diaphragm overlying the ends of the members at each side of the unit, said diaphragms being sealed to the outer one of the members, and a liquid filling the interstices between the members and confined by the diaphragms so that a differential pressure across the unit is set up due to the difference in size of the movable area of the opposite diaphragms contacted by the stepped portions of the members.

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