

April 3, 1945.

H. C. LAIRD ET AL

2,373,034

WELL CONTROL DEVICE

Filed Sept. 5, 1941

3 Sheets-Sheet 1

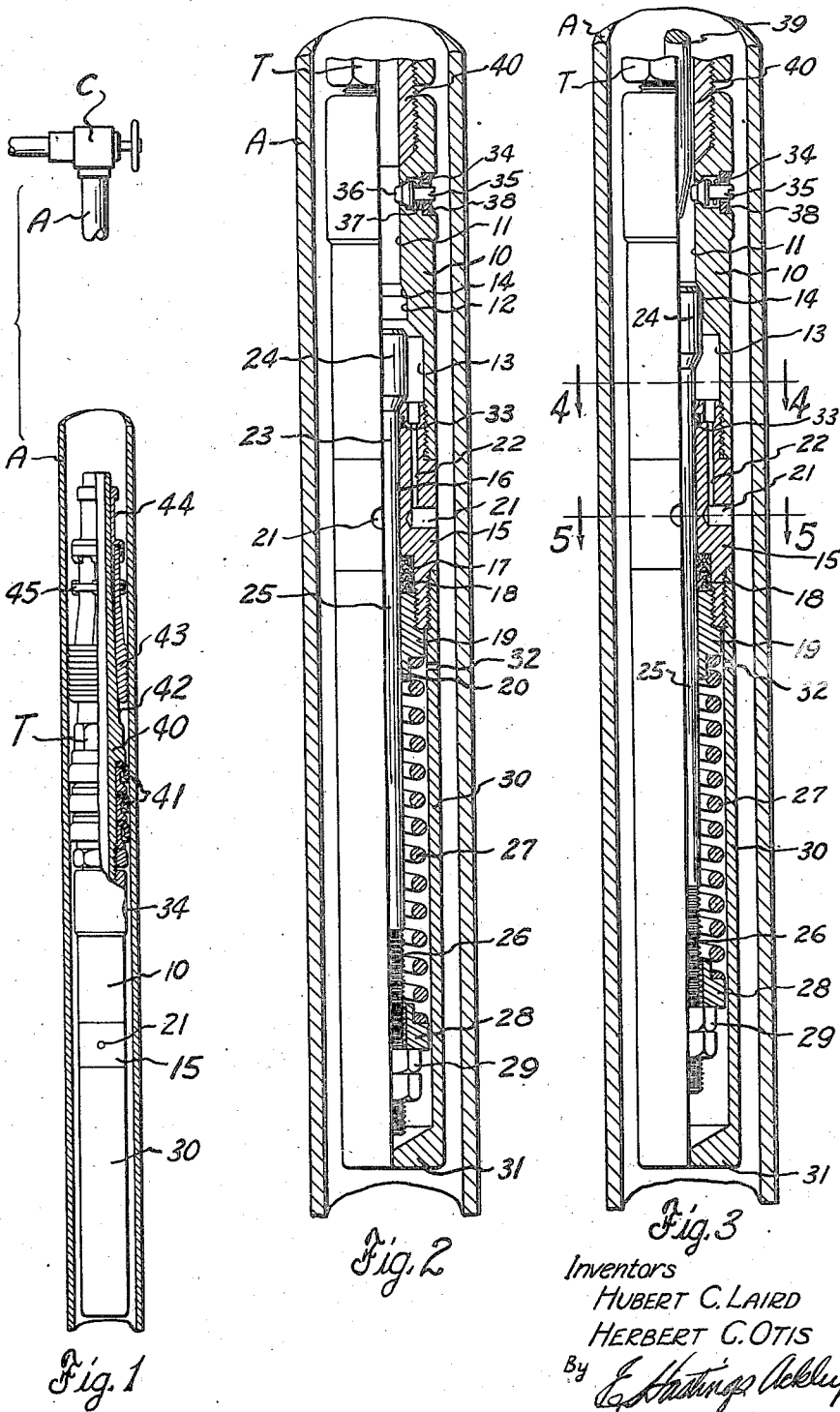


Fig. 3
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April 3, 1945.

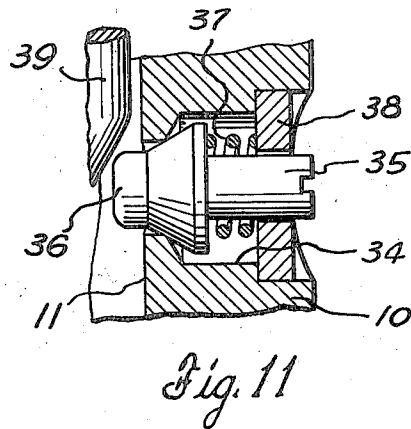
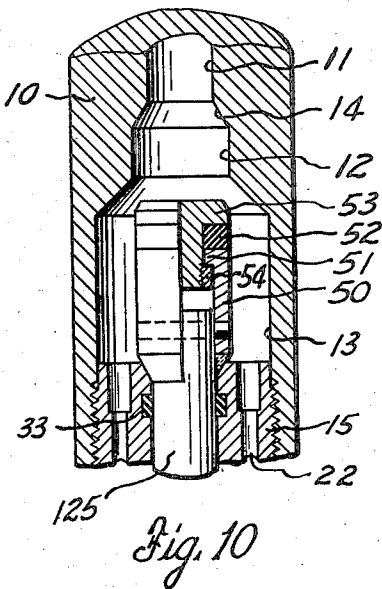
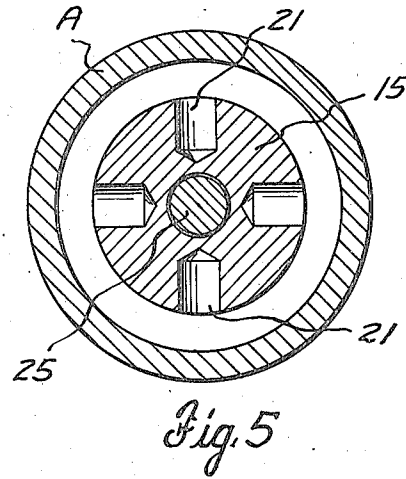
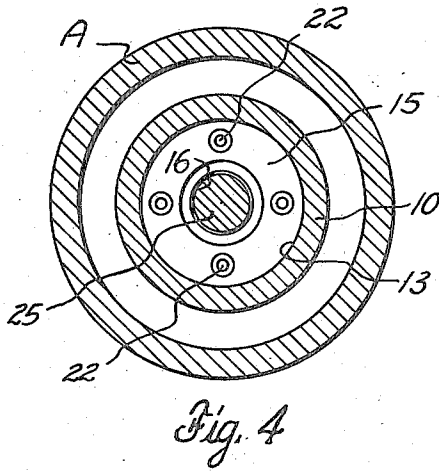
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3 Sheets-Sheet. 2



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3 Sheets-Sheet 3

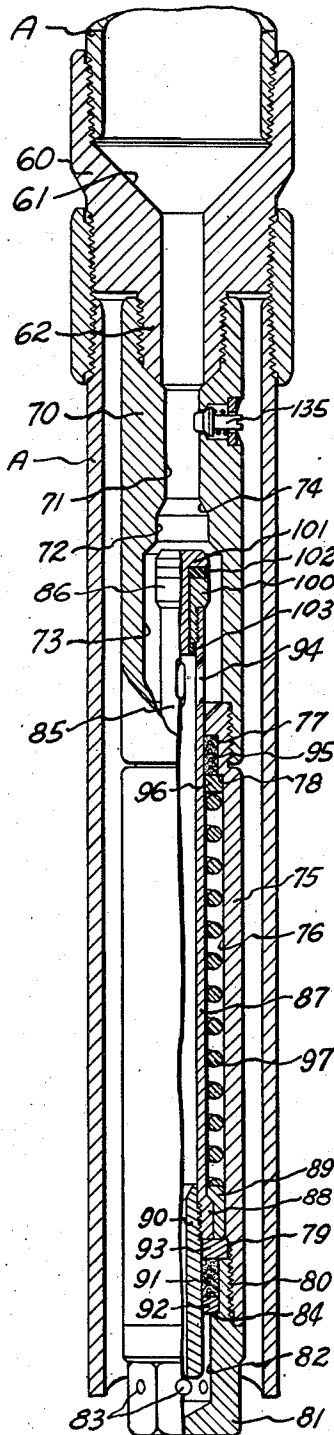


Fig. 6

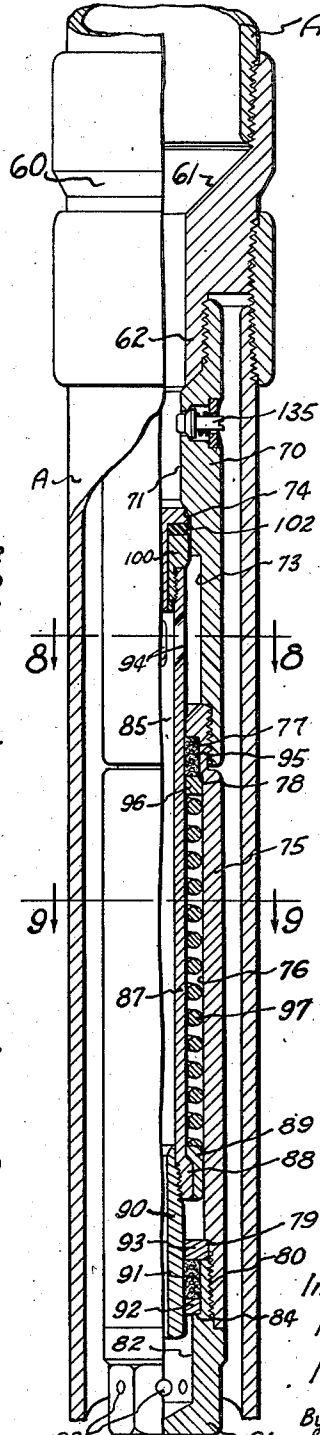


Fig. 7

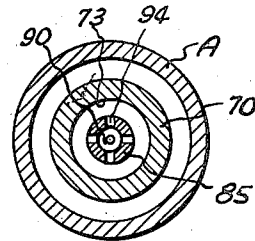


Fig. 8

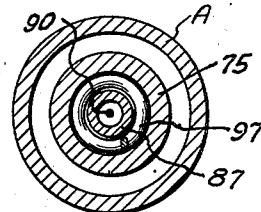


Fig. 9

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UNITED STATES PATENT OFFICE

2,373,034

WELL CONTROL DEVICE

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Application September 5, 1941, Serial No. 409,668

10 Claims. (Cl. 166—2)

This invention relates to new and useful improvements in well control devices.

It is an important object of the invention to provide an improved control device adapted for use in a well flow conductor and which has means arranged to be actuated by the flowing well fluids to automatically shut off flow through the conductor when such flowing well fluid has created a pressure differential across the device in excess of a predetermined value.

Another object of the invention is to provide an improved device for controlling the flow of well fluids through a flow conductor wherein the well fluids are directed through a flow passage provided in said device, the device having a movable valve element exposed to the well fluids and means for restricting the flow of fluids through the device so that a fluid pressure differential is set up across the valve element to actuate the same, said element being arranged to be actuated by a predetermined fluid pressure differential to close off flow through the conductor.

A further object of the invention is to provide, in a device of the character described, resilient means for resisting movement of the valve element to a closed position shutting off flow through the conductor.

Still another object of the invention is to provide, in a device of the character just described, means for varying the force exerted by the resilient means, or a changeable means for restricting flow of fluids through the device, or both, whereby the value of the predetermined fluid pressure differential required to close the valve may be readily altered.

It is a particular object of the invention to provide a well flow control device for use in conjunction with the well surface controls, such as chokes, valves, regulators and the like, of a flowing well and which is arranged to provide a positive and automatic sub-surface shut-off of flow of well fluids through the well flow conductor when the said surface controls are damaged, regardless of whether the damage be caused by "flow-cutting" or by an outside impact or otherwise, whereby the well will not be permitted to flow in excess of predetermined flow conditions.

Still another object of the invention is to provide an improved well control device, of the character described, which is arranged to be actuated by the fluid pressure differentials created thereacross by the flowing well fluids, and wherein fluctuating velocities of flow, such as occur in wells which flow by heads or surges, will not effect premature closure of the valve, thereby providing for uninterrupted normal flowing of the well.

It is a further object of the invention to provide, in a control device of the character de-

scribed, means for transferring the point of application of the fluid pressure differential from one area of the movable valve element to another and larger area thereof, so as to create a greater force acting upon the valve element and, thus, to assure its closure.

A still further object of the invention is to provide, in combination with a well fluid flow control device of the character described, improved means for causing reopening of the device to resume flowing of the well, which means is actuated by a suitable tool introduced into the flow conductor and operable to cause such resumption of flow without disturbing the position of the control device in the conductor or removing it from the conductor.

Another object of the invention is to provide a well control device, of the character described, which is automatically actuated by the fluid pressure differential thereacross and which is readily adjustable so as to be actuated by a desired fluid pressure differential, said device being so constructed that, if desired, it may be lowered into, locked in, and removed from the well flow conductor by means of tools operated by a flexible cable or line, or, which may be directly coupled in the flow conductor.

Additional objects and advantages of the invention will be apparent from a reading of the following description of a device constructed in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

Figure 1 is a view, partly in elevation and partly in section, of a device constructed in accordance with the invention and located in a well conductor,

Figure 2 is an enlarged view, partly in elevation and partly in section, of the control device, showing the valve in its open position,

Figure 3 is a view similar to Figure 2, showing the valve in a closed position,

Figure 4 is an enlarged horizontal cross-sectional view taken on the line 4—4 of Figure 3,

Figure 5 is a similar view taken on the line 5—5 of Figure 3,

Figure 6 is a view, partly in elevation and partly in section, of a modified form of the invention, and showing the same in an open position in a well conductor,

Figure 7 is a view similar to Figure 6, showing the valve in a closed position,

Figures 8 and 9 are horizontal cross-sectional views taken on the lines 8—8 and 9—9 respectively of Figure 7,

Figure 10 is an enlarged transverse vertical sectional view of a modified form of the valve head for use with the valve of Figure 2, and

Figure 11 is an enlarged sectional view of the by-pass valve.

In the drawings, the numeral 10 designates a

tubular body or cage which is formed with an axial bore 11 extending entirely therethrough. The central portion of the bore is enlarged as shown at 12, while the lower portion is still further enlarged to provide a chamber 13. The annular shoulder which is formed between the bore 11 and the enlarged central portion 12 is inclined or bevelled to form an annular valve seat 14.

An orifice or guide block 15 has its upper end portion secured by screw threads to the lower portion of the chamber 13 so as to close the lower end of the chamber. The guide block has an axial opening or bore 16 which is enlarged at its lower portion to provide a packing recess 17. A plurality of composition chevron or pressure seal type packing rings 18 are mounted in the recess 17 and are held therein by means of a packing gland 19 which is threaded into the lower end of the recess. The gland 19 is provided with an axial bore 20 corresponding to and forming an extension of the bore 16 of the guide block below the packing rings.

A plurality of radial recesses 21 are formed in the central portion of the outer periphery of the guide block, and a vertical restricted flow passage 22 extends upwardly through the guide block from each of these radial recesses, as is clearly shown in Fig. 2, whereby communication is established between the outside of the guide block and the chamber 13 by means of the radial recesses and the vertical flow passages. Thus, well fluids may enter the radial recesses, flow upwardly through the restricted flow passages 22 into the chamber 13, from which they may flow upwardly past the valve seat 14 and through the bore 11 of the cage 10. The number and size of the flow passages 22 may, of course, be varied as desired.

For controlling the flow of fluids through the device, a valve element 23 is provided. This valve element includes an enlarged valve head 24 which has its upper edge bevelled and adapted to engage the inclined or bevelled seat 14 within the cage 10. An elongate valve stem 25 extends downwardly from the valve head 24 through the axial bore 16 of the guide block and the bore 20 of the packing gland 19 and is slidable longitudinally therein. The lower end of the stem extends a considerable distance below the gland 19 and is provided with screw threads 26. For constantly urging the valve element downwardly, so as to urge the valve head 24 away from the seat 14, a coiled spring 27 surrounds the stem below the gland. This spring has its upper end engaging the under side of the gland 19, while its lower end rests upon a flanged washer 28 which is slidable on the stem 25. The washer 28 is adjustably retained in position on the stem 25 by means of lock nuts 29 which are threaded onto the lower end of said stem. Manifestly, the compressed spring exerts its force to constantly urge the valve element 23 toward its lowermost position, as shown in Fig. 2, and the spring pressure may be readily varied by adjusting the lock nuts 29.

The lower projecting end of the stem 25, together with the coiled spring 27 and its associated parts, are completely enclosed by an elongate tubular housing or cover 30 which is connected by screw threads to the lower end of the guide block 15 and which has its lower end 31 completely closed. A port 32 is formed in the wall of the housing below the gland 19 for the purpose of admitting well fluids into the housing to act upon the valve stem, as will be explained.

A wiping ring 33 is mounted in an annular recess formed near the upper end of the bore 16

of the orifice or guide block 15. This ring lightly engages the upper portion of the valve stem 25 as it moves longitudinally therethrough and prevents sand and other foreign matter from entering the space between the stem and guide block and causing the valve element to stick in an open or closed position.

Above the valve seat 14, a radial opening or port 34 extends through the wall of the cage 10 and provides communication between the exterior of said cage and the bore 11 thereof, whereby fluid may flow through said port to the bore of the cage when the port is open. The port is provided at its inner end with a valve seat and a valve member 35, having a head with an inwardly extending nose 36, is mounted in the opening or port and is arranged to engage said seat to close said port. A coiled spring 37 surrounds the valve stem and resiliently holds the valve head against the seat. The spring is held in compression within the port by an orifice plate 38 which is secured in the outer portion of the port and has a central opening, slightly larger than the stem of the valve, through which well fluids enter the port. As clearly shown in Fig. 11, the nose of the valve head extends or protrudes into the bore of the cage, and it will readily be seen that a suitable tool (not shown) having a rod or prong 39 may be lowered through the well conductor until said prong engages the protruding nose of the valve member 35 and moves the head of said valve member from its seated or closed position to permit flow of fluid through the port into the bore of the cage.

The assembly as above described is adapted to be positioned or mounted within a well tubing or flow conductor A. The assembly may be positioned by any suitable means or in any suitable manner but, as illustrated in Figs. 1, 2 and 3, said device is connected to the lower end of a running and locking tool T. The running tool includes an elongate tubular mandrel 40 which is provided with pressure seal type packing elements or cups 41 on its lower portion. Above the packing cups, the mandrel has a slip expanding portion 42 which is arranged to coact with gripping slips 43 which are slidably mounted on the mandrel. The slips are carried by a suitable carrier or sleeve 44 and upward displacement of the carrier and slips from the mandrel is prevented by an external flange 45 which is formed on said mandrel. This tool is substantially identical with the tools shown and described in patents, Nos. Re. 20,546 and 1,972,791, issued to Herbert C. Otis, and, obviously, may be locked at any desired elevation within the tubing by means of lowering and removing devices operated on a wire line or cable as set forth therein.

In use, for lowering the device into the well flow conductor or tubing A, a suitable lowering device (not shown) is connected to the running or locking tool T in the manner described in the aforementioned patents and, suspended from a flexible line or cable, the assembly is lowered into the well. While lowering the assembly, the well surface controls, which will ordinarily include a variable choke or needle valve C, as well as other suitable and customary well surface control devices, are closed to prevent any flow through the tubing.

When the device has been lowered to the desired position, the wire line and lowering device are manipulated to lock the running tool T in the tubing at that point. The wire line and lowering device are then removed from the well and the surface controls, including the choke C, are

opened to permit the well fluids to flow upwardly through the tubing. Since the cups 41 prevent fluid from flowing upwardly outside the running tool T, all flowing fluids pass through the radial openings 21 and restricted orifices 22 to the bore 11 of the cage, from whence they flow upwardly through the mandrel 40 to the well surface and outwardly through the surface controls.

Ordinarily, the well production is controlled by adjustment of the choke C to increase or decrease the amount of flow. Therefore, when the well surface controls are opened to permit the well to be flowed, the surface choke C is adjusted to secure the desired predetermined normal rate of production. During such normal predetermined flow the valve of the control device remains open.

The well fluids will flow through the restricted passages 22 of the guide block without creating any appreciable pressure differential until the size of the flow controlling opening of the surface choke C, or other surface control, is effectively equal to or greater than the combined areas of the restricted passages. When this condition is reached, a fluid pressure differential is created across the guide block, and, since the well fluids enter the cover 30 through the port 32 below the guide block, it will be seen that the higher upstream pressure below the assembly acts upon the cross-sectional area of the valve stem 25 which extends below the packing 18. Due to the fact that the upper end of the valve element is exposed to the lower downstream pressure above the guide block, it is apparent that the differential between upstream and downstream pressures acting upon the cross-sectional area of the valve stem will tend to urge the valve stem upwardly against the force exerted thereon by the spring 27. When the pressure differential has reached a sufficient value to move the stem upwardly against the compression of the spring, the valve head will engage the seat 14 and close off all flow through the device. As the valve head enters the central portion 12 of the bore of the cage, the point of restriction of flow is changed from the passages 22 in the guide block to the space between the valve head and the central portion 12 of the bore of the cage. When this occurs, the area of application of the fluid pressure differential is transferred from the valve stem 25 to the larger cross-sectional area of the valve head, thus causing the valve to snap closed and supplying sufficient energy to overcome the additional compression introduced into the spring 27 by the upward movement of the valve element.

It is to be noted that, since there is usually very little pressure differential created across the valve by a surging flow action, the valve will remain open during such surging or heading flow, and will close only when sufficient fluid pressure differential has been created to move the valve element against the force of the spring. The valve element 23 is not exposed to the direct impact of the flowing well fluids. This is a distinct advantage over flow velocity or impact operated valves, since such valves react more readily to surging or heading flow, due to their being exposed to the direct impact of the flowing well fluids.

It is well known that damage of many types may occur to the well surface controls. Damage may be caused by the cutting action of sand or other matter in the well fluid stream, by unforeseen failure or accidental breakage of some of the surface connections, such as may be caused by storms or, where wells are located in bodies

of water, by driftwood or ships striking the surface connections, as well as by many other agencies.

It will readily be seen, however, that in the event of the occurrence of such damage to a well wherein a control device of the type just described has been installed, any flow of well fluid at a rate sufficient to create a pressure differential across the device in excess of the predetermined differential for which the device is set, will immediately cause the valve to close to shut off flow of fluids through the conductor in which it is located. Thus, the well is prevented from flowing wild and waste of the well fluids is substantially eliminated. Since the valve shuts off flow through the conductor, the damage to the surface controls or connections may be repaired in safety before the valve is reopened.

To open the valve after it has closed, a suitable tool (not shown) having a rod or prong 39 depending therefrom is lowered into the conductor by means of a flexible line until it engages the protruding nose 36 of the by-pass valve 35 and forces said valve member outwardly away from the seat in the port 34, thereby opening the port to establish communication between the well fluid below the assembly and the bore of the well conductor above the device. Manifestly, once the valve is opened, the well fluid may flow through the port 34 until the forces acting downwardly upon the valve element 23, that is, the fluid pressure above the valve plus the force exerted by the spring 27, are great enough to move said valve element downwardly against the pressure acting upon the valve stem below the guide block. The same result may be obtained by introducing liquid, or fluid pressure, into the well conductor at the well surface in sufficient amount to cause the valve element 23 to reopen. When the valve has been reopened the well may, of course, again be flowed at the desired predetermined rate.

As is clearly shown in Fig. 11, the flow space between the stem of the valve 35 and the central opening of the orifice plate 38 is made smaller in cross-sectional area than any other annular space between the valve and the walls of the port. This is particularly true of the space between the nose 36 of the valve and the seat in the port, since this reduces the pressure differential across the valve seat and minimizes the cutting action of the flowing well fluids on these parts. Likewise, the flow space between the stem and the orifice plate is preferably made sufficiently small that the velocity of flow through the port will not displace the rod or prong 39 from its position holding the valve open. Removal of the prong from within the bore 11 will permit the valve to close.

The entire assembly may be removed at any time by lowering a suitable removing device (not shown) and engaging the sleeve 44 of the running or locking tool T and jarring downwardly upon the mandrel 40 to release the slips 43, whereupon the assembly may be lifted from the well conductor.

If desired, the fluid pressure differential required to move the valve element 23 to its closed position may be varied by adjusting the lock nuts 29 to increase or decrease the force exerted by the spring 27 in holding the valve element open. Or, the orifice or guide block 15 may be replaced with another having a different size or number of orifices. The tool may then be repositioned within the well conductor for further use. Thus, the many well flow conditions found in the various oil or gas fields may be compensated and the

desired predetermined closing conditions accurately provided for.

In Figure 10, a modified form of valve head is shown wherein an enlarged sleeve 50 having an internal annular flange 51 at its upper end is welded or otherwise secured to the upper end of the valve stem 125. A relatively soft packing ring 52 is confined between the upper end of the sleeve 50 and a valve tip 53 having a reduced lower portion extending downwardly through said packing ring into the upper portion of the bore of the sleeve. A retaining nut 54 is threaded or otherwise secured to the lower end of the reduced portion of the tip and engages under the internal flange 51 of the sleeve to retain the tip in position. The upper peripheral edge of the tip is bevelled to engage the seat 14 and, when this engagement occurs, it will be seen that the fluid pressure acting upon the valve sleeve and stem will deform the packing ring 52 into sealing engagement with the wall of the enlarged central bore 12 of the cage 10. Thus, a seal will be assured even though the engagement of the valve tip with the seat 14 fails to close off flow.

A modified form of the invention is shown in Figures 6 to 9 inclusive. In this form, the control device is secured within the well tubing or flow conductor A by means of a connecting or supporting member 60 which is connected in the tubing string by means of screw threads. The supporting member has an axial bore 61 which is flared outwardly at its upper end to substantially the diameter of the bore of the tubing, and through which all fluid flowing through the tubing must pass.

The supporting member is provided with an axial depending shank 62 which is externally screw threaded and which is adapted to receive the upper end of the tubular body or cage 70 of the control device.

The cage 70 has an axial bore 71, the central portion of which is enlarged as shown at 72, and which is still further enlarged at its lower portion to form a chamber 73. The annular shoulder between the bore 71 and the enlarged central portion 72 is inclined or bevelled to form an annular valve seat 74.

An elongate cylindrical housing 75, having an axial bore 76 extending therethrough, is secured by screw threads to the lower end of the cage 70. The upper end of the bore 76 is reduced and immediately below the reduced portion an offset is provided, whereby an internal annular shoulder 77 is formed within the bore of the housing. Below the offset portion a second and smaller shoulder 78 is provided.

The lower end of the bore 76 is enlarged slightly to form a small shoulder 79 and below the shoulder the bore is provided with internal screw threads 80. A thimble or cap 81 is threaded into the lower end of the bore of the housing. The thimble has a bore 82 which is completely closed at its lower end, and a plurality of lateral openings 83 are provided in the wall of the thimble to admit fluid into its bore. The upper end of the bore 82 is enlarged to form an upwardly facing internal annular shoulder 84.

A valve element 85, having an enlarged replaceable head 86 and an elongate tubular shank or stem 87, is slidable longitudinally in the bores of the cage and housing. The upper end of the valve stem is slidable in the upper reduced portion of the bore 76 of the housing so as to be

guided in its vertical movement, and the valve head is movable within the chamber 73. The lower end of the stem 87 is formed with an annular boss 88 and a guide ring 89 surrounds the boss. The upper portion of the bore of the guide ring is reduced in diameter so as to engage over the boss and the ring has a tight fit on said boss. The periphery of the ring has a diameter slightly smaller than the bore 76 of the housing whereby it has a free sliding fit therein.

A replaceable orificed choke member or bean 90 is secured by means of screw threads to the lower end of the valve stem 87 and extends therebelow into the cap or thimble 81, as is clearly shown in Fig. 6. A plurality of packing rings 91, which are preferably of the chevron or pressure seal type, surround the bean and are confined in sealing position between a packing ring 92 supported upon the upwardly facing shoulder 84 in the thimble and a stop ring 93 which is held securely between the upper end of the thimble and the shoulder 79 at the lower end of the housing. The lower end of the bean is spaced from the closed end of the thimble at all times, whereby fluid entering the lateral openings 83 may enter the orifice of the bean and flow upwardly through the tubular stem 87.

The upper end of the stem 87 is provided with lateral flow openings or slots 94 spaced therearound in the wall below the head 86. It is noted that the slots 94 are always located above the upper end of the housing 75, even when the valve element is in its lowermost position, as shown in Fig. 6. Thus, fluids flowing through the stem, may flow outwardly through the slots into the chamber 73.

A plurality of secondary packing rings 95, also preferably of the chevron or pressure seal type, surround the upper portion of the tubular valve stem 87, the uppermost ring abutting the shoulder 77. The lowermost packing ring rests upon a follower or adjusting ring 96 which has its outer edge abutting the shoulder 78. Manifestly, the space between the ring 96 and the shoulder 77 forms a packing chamber for the packing rings. A coiled spring 97 surrounds the stem 87 and has its upper end engaging the under side of the adjusting ring 96, while its lower end engages the top of the guide collar 89. The spring is under compression and exerts its force to constantly urge the valve element 85 downwardly within the housing and cage, and away from the seat 74.

Downward movement of the valve element within the housing is limited by the engagement of the lower end of the stem 87 and the guide collar 89 with the stop ring 93 supported on the upper end of the thimble 81. Upward movement of the element is limited by the engagement of the valve head 86 with the seat 74 in the bore of the cage 70.

The valve head 86 is shown as including a sleeve 100, which is threaded into the upper end of the valve stem 87, and within which the elongated shank of a valve tip 101 is slidable. A relatively soft packing ring 102 is confined between the upper end of the sleeve 100 and the enlarged upper end of the tip 101. A retaining nut 103 is threaded or otherwise secured to the lower end of the shank of the tip 101 and engages the lower end of the sleeve to retain the tip in position. The upper peripheral edge of the tip is bevelled to engage the seat 74 and when this occurs, the fluid pressure acting upon the valve stem will deform the

packing ring into sealing engagement with the wall of the enlarged central portion 72 of the bore of the cage in the event the tip 101 fails to close off flow. The valve head may, of course, be made of solid metal similar to the head of the valve illustrated in the previous form.

A by-pass or equalizing valve 135 is provided in the wall of the cage above the seat 74, in the same manner and of the same construction as the valve 35 of the first described form of the invention, and this valve functions and is operated in the same manner as the valve 35.

In use, the control device is positioned in the well conductor A, either by means of a supporting member such as is shown in Figures 6 and 7, or secured therein by means of a suitable removable running and locking tool such as was used in the form first described. It is pointed out either control device may be positioned in any suitable manner and that the means illustrated are merely two of the many for accomplishing the purpose.

When the control device has been positioned in the well conductor and the surface controls adjusted to permit flow of the well fluids, it will readily be seen that flow of such fluids upwardly outside the cage and housing is prevented by the supporting member 60, and that flow upwardly outside the valve element is prevented by the packing rings 91 and 95. Therefore, the flowing well fluids will enter the lateral openings 83 in the thimble, flow through the orifice in the bean 90 and through the bore of the stem 87 and outwardly through the slots 94 into the chamber 73 in the cage. The fluids will then flow upwardly from the chamber past the seat 74 and through the bore 11 of the cage and the bore 61 of the supporting member to the bore of the well conductor or tubing and through the surface flow control devices.

The bean 90 is provided with an orifice of a size which will permit flow of the well fluids at the desired predetermined rate, and the well fluids will flow through the restricted orifice of said bean without creating any appreciable fluid pressure differential until the size of the flow controlling opening of the surface choke C, or other surface control, is equal to or greater than the orifice through the bean. When this condition occurs, a pressure differential is created across the bean 90, since the point of restriction of flow is then at the orifice through said bean, and, when this differential is increased in amount until it is sufficient, when acting upon the cross-sectional area of the bean, to move the valve element upwardly against the downward force exerted by the spring 97, the valve element will be lifted until the valve head 86 engages the seat 74 to close off all upward flow through the well conductor.

As the valve head enters the central portion 72 of the bore of the cage, the area of application of the fluid pressure differential is transferred from the bean 90 to the larger cross-sectional area of the valve head, thus causing the valve to snap closed and also supplying sufficient energy to overcome the additional compression introduced into the spring 97 by the upward movement of the valve element.

Once flow has been shut off by closure of the valve element 85, flow may be resumed by opening the by-pass or equalizing valve 135 by means of a prong 39 lowered in the same manner as was described for operation of the valve 35 of the previous form.

Operation and adjustment of the control device is substantially identical with that of the previous form. The orificed bean may be changed for a bean having an orifice of a different size, or the force exerted by the spring may be varied by varying the thickness of the follower or adjusting ring 96 used to change the amount of compression put into the spring.

Should the lower packing rings 91 fail to seal off upward flow of well fluids outside the bean, the secondary or upper packing rings 95 will seal against the valve stem 87 to permit functioning of the device. These upper packing rings also serve as a wiper to prevent sand and other matter from entering from the chamber 73 into the space between the valve stem and the housing 75, where it might prevent operation of the device.

It is to be noted that means other than the spring might be used in either form of the invention for resisting movement of the valve member to a closed position, one of which, for example, is a shear pin extending through the valve stem and guide block and adapted to be ruptured when the pressure differential across the valve member exceeds a predetermined value.

It will be seen that both forms of the invention are actuated by fluid pressure differential, and therefore are less subject to be moved to a closed position by a surging or heading well flow, whereby normal uninterrupted predetermined flow of the well fluids is permitted, but, upon failure of, or damage to the well surface connections or controls which permits a larger flow than said predetermined rate, both forms of the invention are adapted to immediately close and shut off further flow through the well conductor.

The above description of the invention is explanatory only, and changes in details of the constructions illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What we claim and desire to secure by Letters Patent is:

1. A well flow control device including, a support having a flow passage therethrough, flow restrictive means for creating a fluid pressure differential across the support, a valve member exposed to and actuated by such fluid pressure differential for closing off flow through the conductor, means closing off the lower end of the valve member from direct impact of the fluid flowing through the conductor, and means for normally holding said valve member open and set to yield to permit the valve to close when the fluid pressure differential acting upon said valve member exceeds a predetermined value.

2. A well flow control device for flowing wells including, a tubular body having an axial bore and a valve seat provided therein, a tubular valve element having a restricted flow passage therethrough mounted within the bore of the body and movable with relation to the valve seat, said element being adapted to engage said seat to shut off flow through the body, the upper end of said valve element being exposed to the pressure of the well fluid above the body with its lower end exposed to the well pressure below the body whereby said element is actuated by the differential in said fluid pressures, means for protecting the lower end of the valve element from direct impact of the well fluid, and means normally holding said element in unseated open position to permit flow of fluids through the body, said means

being set to permit the valve element to engage the valve seat to shut off flow through the body upon the application of a predetermined fluid pressure differential across said valve element.

3. A well flow control device for flowing wells including, a tubular body having an axial bore and a valve seat provided therein, a valve element mounted in the bore of the body and movable with relation to the valve seat, said element having a closure head and a tubular valve stem with a flow restricting member therein, said valve element head being adapted to engage said valve seat to shut off flow through the body, the upper end of said valve element being exposed to the pressure of the well fluid above the body with its lower end exposed to the well pressure below the body whereby said element is actuated by the differential in said pressures, means for protecting the lower end of the valve element from direct impact of the well fluid, and resilient means normally holding said element in unseated open position to permit flow of fluids through the body, said means being set to permit the valve element head to engage the valve seat to shut off flow through the body upon the application of a predetermined fluid pressure differential across said valve element, by the restriction of flow of well fluid through the restricting member of the valve element.

4. A well flow control device including, a support having a flow passage therethrough, means for creating a fluid pressure differential across the support, means normally open while the fluids are flowing through the support and actuated by fluid pressure differential for closing off flow through the conductor when the fluid pressure differential acting thereon exceeds a predetermined value, means for protecting said normally open means against direct impact of the flowing fluids, and means for changing the point of application of fluid pressure differential to said normally open means to increase the energy applied by said fluid pressure differential to said normally open means to assure closing off flow through the conductor.

5. A well flow control device including, a support having a flow passage therethrough, flow restricting means for creating a fluid pressure differential across the support, closure means normally open while the well fluids are flowing through the support to permit predetermined flow therethrough, said closure means being actuated by the fluid pressure differential for closing off flow through the conductor when such fluid pressure differential exceeds a predetermined value, and means shutting off said normally open closure means from exposure to direct impact of the flowing well fluid.

6. A well flow control device including, a housing having a flow passage extending therethrough, flow restrictive means carried by the housing for creating a fluid pressure differential across said housing, a valve mounted in the housing and exposed to said fluid pressure differential, means for holding said valve normally open during predetermined flow and set to yield when the fluid pressure differential across said valve is unequalized to a predetermined degree whereby the flowing well fluid will close said valve, and means shutting off said valve from exposure to direct impact of fluid flowing through the well conductor.

7. A well flow control device including, a sup-

port having a flow passage therethrough and a valve seat in said passage movable valve closure means carried by said support and normally held open to permit flow through said passage and adapted to be moved to engage the valve seat in the passage to shut off flow through said passage, means protecting said closure means from exposure to direct impact of fluid flow through the conductor, and fluid flow restricting means ineffective during predetermined normal flow of the fluid and adapted to restrict flow through the passage of the support in the event the flow of the fluid exceeds said predetermined normal flow, whereby a fluid pressure difference is set up across the movable valve closure means to cause said means to move into engagement with the valve seat to shut off flow through the passage of the support.

8. A well flow control device for flowing wells including, a tubular support, a stationary valve seat within the passage, a valve member movable relative to said seat and having an upper portion exposed to the flowing fluid pressure in the tubing above the support and a lower portion exposed to the well pressure below the support so as to be operated by the differential in said pressures, flow restrictive means carried by the support for creating a fluid pressure differential thereacross, means for normally restraining the valve member away from the valve seat in open position, whereby a predetermined pressure differential is required to move said member from such open position to closed position to shut off flow of fluids through the support, and means for protecting said movable valve member from exposure to direct impact of fluid flowing through the well.

9. A well flow control device including, a valve body having a bore therethrough, a guide block carried by the body and having restricted flow passages therein for restricting flow through the body to create a fluid pressure differential across said block, a valve element slidable in the guide block and exposed to the fluid pressures on opposite sides of said block whereby said element is actuated by the differential in such fluid pressures, means closing off the valve element from exposure to direct impact of fluid flowing through the well, and resilient means normally holding said valve element in its open position and set to yield to permit the element to be moved to a closed position when the fluid pressure differential across the guide block exceeds a predetermined value.

10. A well flow control device including, a support having a flow passage therethrough, flow restricting means carried by the support for creating a fluid pressure differential across the support, a valve member actuated by such fluid pressure differential for closing off flow through the support, means for normally holding said valve member open and set to yield to permit the valve member to close when the fluid pressure differential acting upon said member exceeds a predetermined value, means for protecting said valve member from exposure to direct impact of fluid flowing through the conductor, and means carried by the support above the valve member and operable from the well surface to equalize pressure across the valve and for causing the latter to open after it has closed.

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CERTIFICATE OF CORRECTION.

Patent No. 2,373,034.

April 3, 1945.

HUBERT C. LAIRD, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, first column, line 65, for "laterial" read --lateral--; page 6, first column, line 49, claim 5, for "cross" read --across--; and second column, line 2, claim 7, after the word "passage" insert a comma; line 20, claim 8, after "support" insert --having a flow passage therethrough--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of June, A. D. 1945.

Leslie Frazer

(Seal)

Acting Commissioner of Patents.