

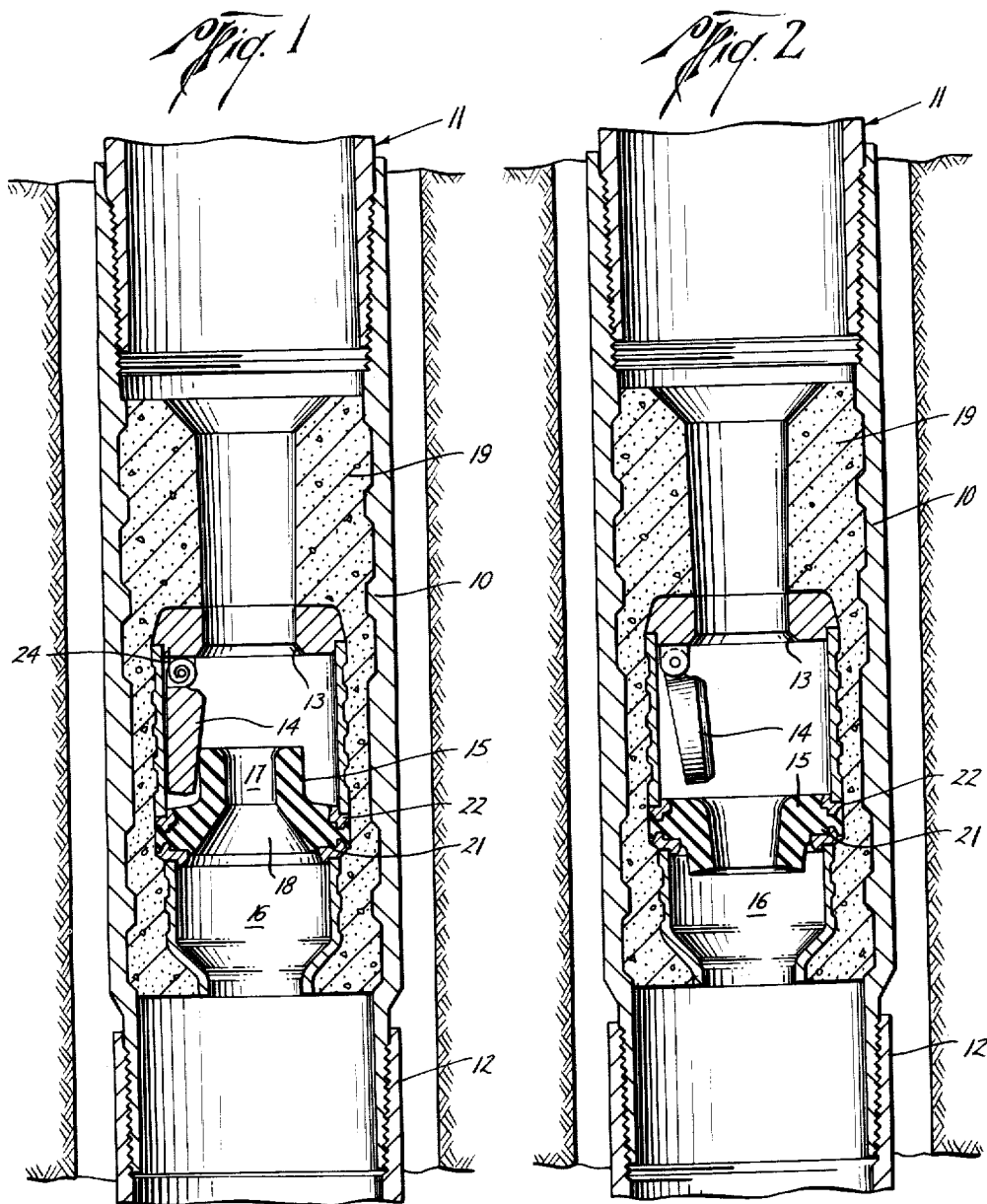
Feb. 28, 1961

W. F. NELSON
FLOW CONTROL DEVICE

2,973,006

Filed Sept. 30, 1957

4 Sheets-Sheet 1



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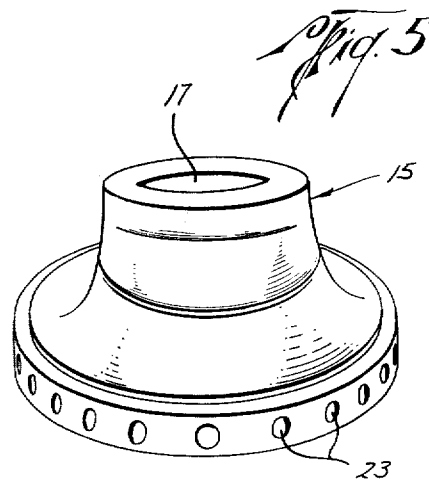
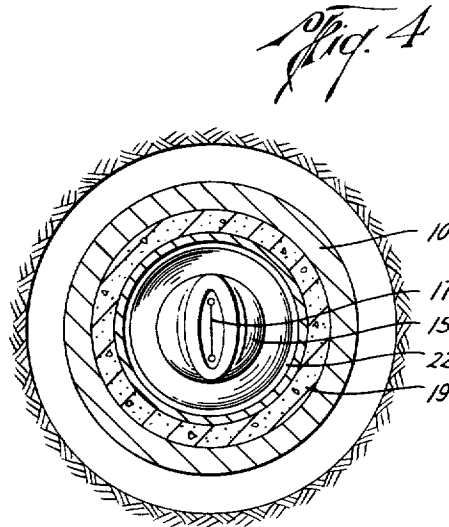
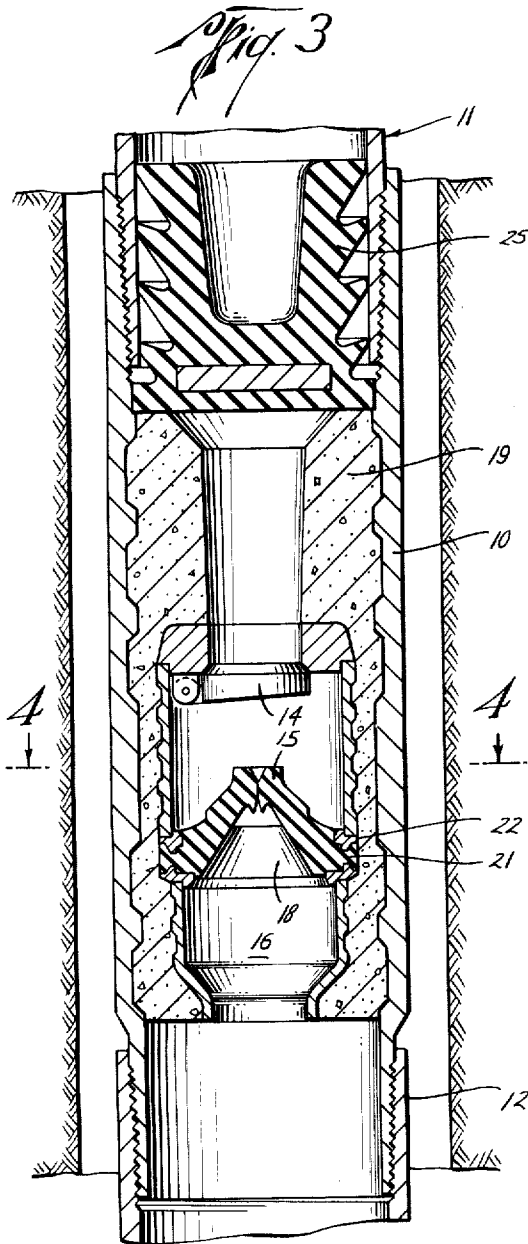
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4 Sheets-Sheet 2



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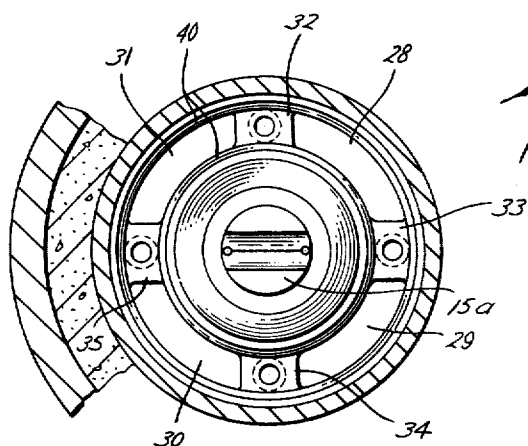
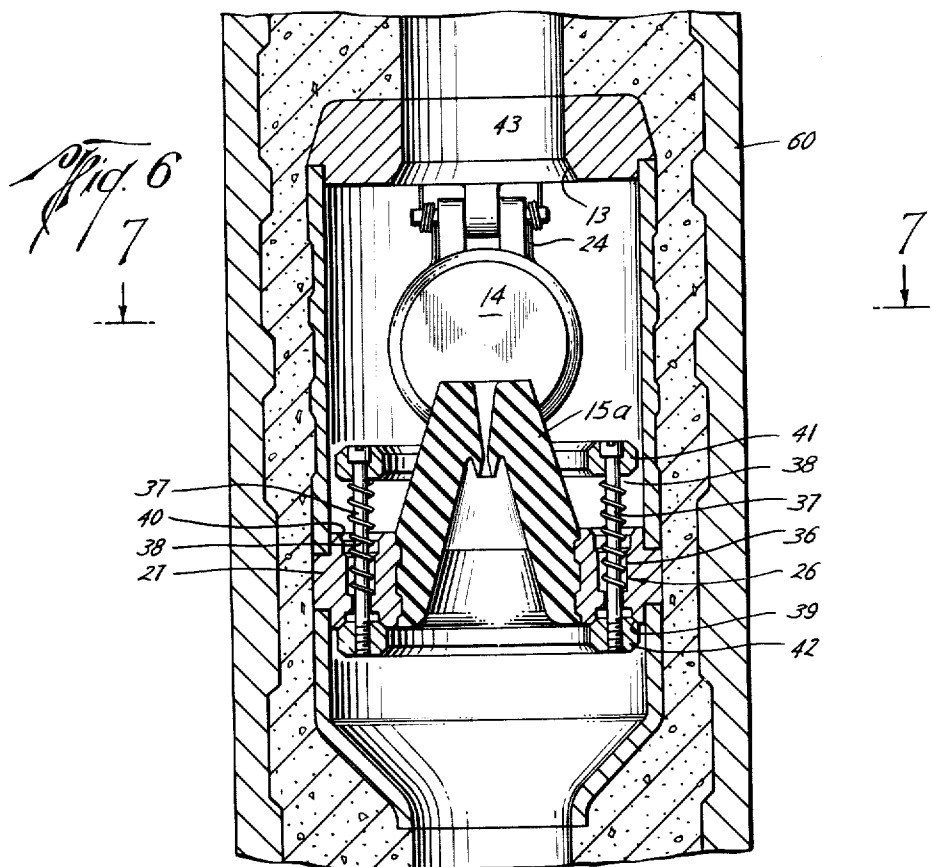
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4 Sheets-Sheet 4

Fig. 8

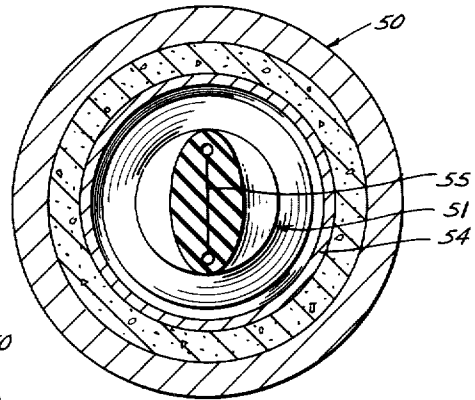
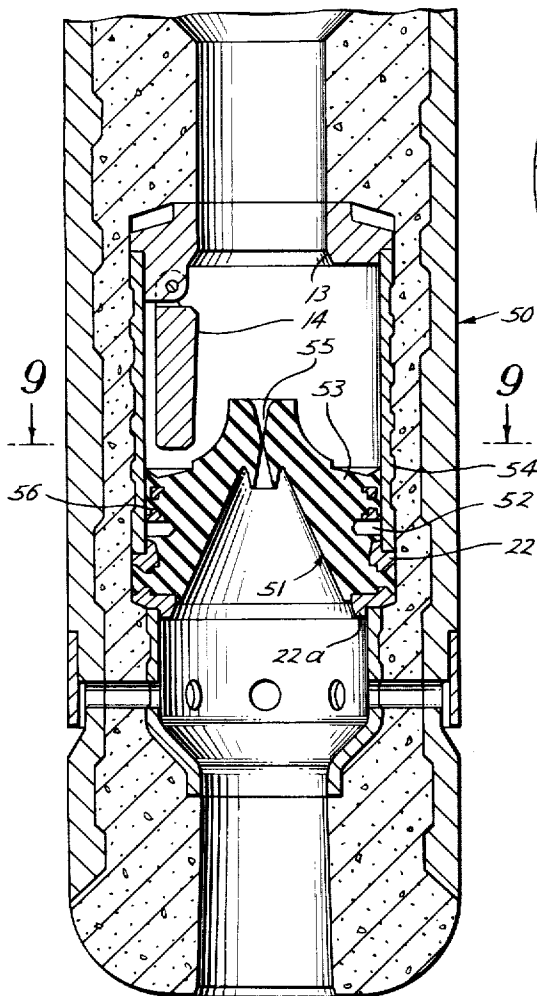


Fig. 9

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2,973,006

FLOW CONTROL DEVICE

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8 Claims. (Cl. 137—493.9)

This invention relates to flow control devices and more particularly to flow control devices which are employed in running and cementing casings in well bores.

During successive stages of drilling it is customary to run in and cement in place strings of casing. It is desirable to fill the casing with drilling mud fluid through the bottom end of the casing while it is being run. Filling should be done in a manner which will prevent the fluid level within the casing from reaching the top of the well to avoid spilling of mud on the derrick floor. Mud on the derrick floor makes for slippery, dangerous working conditions and this is particularly true when an oil-based mud is being used.

After the casing is run to the desired depth cement is pumped down through the casing and out around its bottom end. The cement flows upwardly for a considerable distance between the casing and bore hole to cement the casing in place.

After cement has been pumped in through the casing it is desirable to hold a back pressure on the cement in the hole until it sets. It is expedient to provide a back pressure valve in the lower end of the casing for this purpose.

It may be desirable to establish normal circulation at any time during running of the casing. Thus provision should be made for a fluid flow in both directions through the casing in a manner to permit pumping of fluid downward through the casing, but limiting upward movement of fluid through the casing to the desired degree.

It is an object of this invention to provide a flow control device which may be made up in a casing and which will provide all of the above enumerated desirable features.

Another object is to provide a flow control device which is simple and rugged in construction.

Another object is to provide a flow control device to be made up at or adjacent the lower end of a string of casing which device has a flow valve to permit filling of the casing to a level within the casing below the level within the open hole and additionally functioning to hold a check valve in inoperative position until fluid is pumped down the casing at which time the check valve is released and will hold the back pressure of the fluid in the open hole.

Another object is to provide a flow control device as in the preceding object in which a bypass valve is provided for conducting fluid from the casing past the flow valve and to the open hole and in which the flow valve releases the check valve when the pressure differential across the flow valve reaches a predetermined value.

Another object is to provide for automatic filling of a casing from the bottom as it is being run in the well bore without overflowing to eliminate the necessity of filling from the surface and precluding time loss and danger of stationary casing becoming stuck in the well bore and the hazards of drilling mud on the derrick floor.

Another object is to provide a device to minimize the hydraulic ram effect attendant with conventional cement-

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ing equipment; thus reducing the tendency to break down the mud cake on the wall of the well bore at potential thief formations and to force mud into producible formations.

5 Another object is to provide a valve for use in running casing which is normally closed but which by pressure is expansively operable sufficient to permit passage of foreign matter such as chunks of non-fluid mud which would otherwise tend to clog the valve.

10 Another object is to provide a flow control device for use in running casing which has a resilient flow valve for maintaining the liquid level within the casing below the level in the open hole in which the flow valve has a larger area exposed to fluid within the casing than the open hole; which differential area tends to close the resilient flow valve with a lesser hydrostatic head of fluid in the casing than in the open bore.

15 Other objects, features and advantages of this invention will be apparent from the specification, the drawings and the claims.

20 In the drawings wherein there is shown by way of illustration three embodiments of this invention and wherein like reference numerals indicate like parts:

25 Fig. 1 is a view in vertical cross section through a flow control device embodying this invention and being run in a well;

30 Fig. 2 is a view similar to Fig. 1 in which normal flow through the casing has been established to build up a differential across the resilient valve to release the check valve;

35 Fig. 3 is a view similar to Figs. 1 and 2 after cement has been pumped into the well and showing the check valve in closed position and maintaining back pressure of the cement; the resilient valve is shown 90° from its position in Fig. 1;

40 Fig. 4 is a view along the lines 4—4 of Fig. 3;

45 Fig. 5 is a perspective view of the resilient valve of the flow control device;

50 Fig. 6 is a fragmentary sectional view through a modified form of this invention on an enlarged scale;

55 Fig. 7 is a view along the lines 7—7 of Fig. 6 with the bypass valve member omitted;

60 Fig. 8 is a view in vertical cross section through a modified form of this invention with the resilient valve shown rotated 90° from its true position; and

65 Fig. 9 is a view along the lines 9—9 of Fig. 8.

Referring first to Fig. 1, the tool is shown with its parts in the posture they occupy while being run in a hole. The hole and casing will have drilling fluid therein. This drilling fluid as well as the cement for cementing the casing in place which will be present in the hole during the use of the tool as shown in Figs. 2 and 3 have been omitted for sake of clarity.

70 The flow control device as illustrated in Fig. 1 may be carried in a collar 10 adapted to be made up in a string of casing illustrated generally at 11. Below the collar may be a shoe, a fragment of which is shown at 12. The flow control device may also be made in a shoe to be run on the end of the casing string.

75 For purposes of preventing back flow through the casing while the cement is setting between the casing and well bore, a back pressure or check valve provided by a seat 13 and a flapper valve member 14 is provided. As it is preferred to permit the casing to fill partially with well bore fluid during the running in of the casing, the flapper valve is held in an out-of-the-way position by the flexible valve 15.

80 The resilient valve 15 provides a means for regulating the flow of fluid from the well bore into the casing while it is being run in. The valve 15 is characterized by maintaining a lower liquid level within the casing than is present within the open hole to avoid spilling of mud

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on the derrick platform. The valve 15 is also characterized by the ability to move into an out-of-the-way position at the desire of the operator to release the check valve 14. All of the above desired functions may be accomplished by using a generally conically shaped resilient valve 15 which has its base secured across the passageway 16 through the collar and its apex in a position to interfere with the movement of the check valve 14 from opened to closed position. As best shown in Fig. 4 the flexible resilient valve 15 is slotted at 17. As shown in Fig. 1 the slot 17 communicates with a conical bore 18 within the valve 15.

With the valve 15 in unstressed condition the slot 17 is substantially closed and the valve prevents flow of fluid other than perhaps a slight seepage from the open hole into the casing. Slight seepage is not objectionable as the casing is run-in in a substantially continuous operation. Furthermore, as a stand of pipe is added and the string lowered, additional fluid is desirably admitted to the interior of the casing. The valve 15 may be provided from any desired material, such as, for example, natural or synthetic rubber.

The two valves of the flow control device are preferably made of drillable material and anchored in place within the collar 10 by a body of concrete 19. This permits drilling up of the two valves after the string has been run to permit additional work through the casing.

The resilient valve 15 is molded in an anchoring ring 22. Ring 22 has a plurality of circumferentially spaced radial holes 23 into which the material of the resilient valve extends to assist in securing the resilient material to the ring.

In operation the flow control device is made up at the lower end of a casing and run into the hole. When assembled the check valve 14 is held in the open position by the apex of the resilient valve as illustrated in Fig. 1. Drilling mud passes through valve 15 as the casing is run in the hole. Controlled filling is provided by valve 15 and it is pointed out that large chunks of non-fluid mud may be passed by the valve. The valve functions to maintain the level within the casing below the level within the open hole. As mud flows into the casing during running operations the hydraulic ram effect in the hole is reduced and damage to the mud cake on the wall of the hole is less likely to occur.

After the casing is fully run, normal circulation is commenced through the casing and when the pressure in the casing builds up to a predetermined value the valve 15 is inverted by the pressure thus exerted. This condition is shown in Fig. 2 and permits normal circulation to be established in the hole. As the valve 15 is moved into an out-of-the-way position the flapper check valve 14 is free to move to closed position and is so urged by a spring 24.

After normal circulation is resumed a column of cement of the desired character and volume is introduced into the casing and pumped down into the hole. A cement plug such as illustrated at 25, Fig. 3, may follow the cement to provide a clear line of demarcation between the cement and the following fluid and to signal, by a build-up in pressure when the plug strikes the concrete annulus 19, that the column of cement has been substantially all introduced into the open hole. After the plug 25 comes to rest the pump pressure will be reduced by the operator. This will permit the check valve 14 to engage seat 13 and hold the back pressure of the cement in the open hole. As the pressure differential across the resilient valve 15 reduces it may or may not resume its normal undistorted position as shown in Fig. 3. Inasmuch as the valve has served its purpose, this is of no consideration.

After the cement has been allowed to set for the customary time the two valves carried within collar 10 may be drilled up in the usual manner and subsequent operations continued through the casing in the customary way.

Referring now to Fig. 6 there is shown a form of this

invention in which provision is made for normal circulation without release of the check valve. This feature is provided by a bypass valve permitting normal flow past the resilient valve 15a so long as the pressure differential across the resilient valve is within a range less than that predetermined pressure at which the valve 15a inverts itself to permit normal flow.

Such a bypass valve can be provided by the double-acting valve indicated generally at 26. In this form of the invention a sleeve 27 is provided in collar 60 and the valve 15a has its base secured across the opening in the sleeve 27. The sleeve 27, as best seen in Fig. 7, is spider-like in form providing flow ways 28 through 31. These flow ways preferably have a total flow area approximating that of passageway 43.

Each of the bridging arms 32 through 35 is identical in form and has a bore 36 in which the valve stems 37 are slidably mounted. The stems are urged upwardly toward the check valve seat by a plurality of resilient means such as springs 38.

The bottom and top of the sleeve 27 are provided with lower seat 39 and upper seat 40 respectively. Upper and lower valve members 41 and 42 are carried by the valve stems 37 and cooperate with the upper and lower seats to control the flow through the bypass.

In the operation of the form of valve shown in Figs. 6 and 7 the parts are in the posture as shown in Fig. 6 while the tool is being run in to the hole in the same manner as explained with reference to the Fig. 1 embodiment. If at any time it is desired to establish normal circulation during the running of the casing without making the check valve operative, this may be accomplished by increasing the pressure within the casing to a range great enough to unseat valve member 42 but not sufficient to seat valve member 41 or to invert the resilient valve 15a.

After the casing is fully run the pressure within the casing is increased until the differential across the bypass valve is greater than the aforementioned predetermined range and the upper valve 41 seats to stop flow through the bypass. Thereafter the pressure within the casing is raised to a sufficient value to invert the resilient valve 15a in the manner heretofore explained and permit release of the check valve 14 to seating position.

The device shown in Figs. 8 and 9 is generally similar to the device of Fig. 1 with the exception of the valve. In this case the device is incorporated in a shoe 50, but could be in a collar just as well.

Check valve 14 is provided in the same manner as in the Fig. 1 embodiment and is held in open position by resilient valve 51 during running of the casing.

The resilient valve 51 is constructed to have a larger effective pressure area exposed to casing fluid than to open hole fluid. As the apex of the resilient valve is exposed to casing fluid the force of casing fluid on this larger area tends to close the resilient valve. The valve, 51 has an annular groove 52 positioned just above anchor ring 22. The valve 51 has portion 53 above the groove which sealingly engages the wall of spacer 54. The valve member below groove 52 is in sealing engagement with spacer 54 and therefore groove 52 is isolated from both open hole and casing fluid. It results that casing pressure is effective over an area equal to the bore of spacer 54 and open hole pressure is effective over approximately the area defined by the inner diameter of anchor portion 22a. Casing pressure acting on portion 53 of valve 51 urges valve portion 53 downward and in so doing tends to close slot 55 in the valve member.

If desired portion 53 of the valve member may be reinforced as by member 56 or in any other desired manner.

Other than closing with a greater differential in fluid level in the casing and open hole, valve 51 functions in the same manner as valve 15 of Fig. 1 and the device is utilized in the same manner.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes may be made within the scope of the appended claims without departing from the spirit of this invention.

What is claimed is:

1. A flow control device comprising, a body having a flow way therethrough, flapper check valve means controlling flow through the device, expansible cone-like resilient valve means positioned across the flow way and controlling flow in response to a predetermined differential in one direction across the resilient valve means, said resilient valve means rendering the check valve inoperative and movable into an out-of-the-way position in response to a predetermined differential in the other direction to render the check valve means operative.

2. A flow control device comprising, a body having a flow way therethrough, flapper check valve means controlling flow through the device, and resilient valve means in the flow way holding the check valve off its seat to permit flow through the device which would be prevented by the check valve when seated, said resilient valve means movable into an out-of-the-way position in response to fluid pressure exerted through the check valve to release the check valve member and permit it to cooperate with its seat and control flow through the device.

3. A valve comprising, a body having a flow way therethrough, a valve seat surrounding the flow way, a valve member cooperable with the seat to control flow through the valve, means urging the valve member toward closed position, generally conically shaped resilient valve means having its base secured across the flow way and its apex obstructing movement of the valve member from open to closed position, said resilient valve means having a flow way therethrough which is normally closed and opens when the pressure on the base side of the resilient valve means is greater than on the apex side thereof, said resilient valve means turning inside out when pressure on the apex side exceeds pressure on the base side by a predetermined amount to release the valve member and permit it to cooperate with the seat.

4. A valve comprising, a body having a flow way therethrough, a valve seat surrounding the flow way, a flapper valve member cooperable with the seat to control flow through the valve, means urging the valve member toward closed position, generally conically shaped resilient valve means having its base secured across the flow way and its apex obstructing movement of the valve member from open to closed position, said resilient valve means having a greater pressure responsive area on the apex side of the resilient valve means than on the base side thereof and having a flow way therethrough which is normally closed and opens when the pressure on the base side of the resilient valve means is greater than on the apex side thereof by a predetermined amount, said resilient valve means turning inside out when pressure on the apex side exceeds pressure on the base side by a predetermined amount to release the flapper valve member and permit it to cooperate with the seat.

5. A flow control device comprising, a body having a flow way therethrough, check valve means controlling flow through the device, second valve means rendering the check valve means inoperative, said second valve means controlling flow in response to a predetermined differential in one direction across the second valve means, said second valve means movable into an out-of-the-way position in response to a predetermined differential in the other direction to render the check valve means operative, and double-acting valve means bypassing the second valve means and permitting flow only in response to a

pressure differential in said other direction less than the differential at which the second valve means is moved into an out-of-the-way position.

6. A flow control device comprising, a body having a flow way therethrough, a valve seat surrounding the flow way, a valve member cooperable with the seat to control flow through the valve, means urging the valve member toward closed position, an annular sleeve having a central opening therein positioned in the flow way adjacent said valve seat, a bypass through the sleeve, double-acting valve means resiliently urged upwardly toward said valve seat and preventing flow through the bypass, said double-acting valve means permitting flow through the by-pass in a direction away from said valve seat in response to a differential in pressure across the double-acting valve within a predetermined range and closing the bypass when the differential exceeds the range, generally conically shaped resilient valve means having its base secured across the opening in the sleeve and its apex obstructing movement of said valve member from open to closed position, said resilient valve means having a flow way therethrough which is normally closed and opens when the pressure on the base side is greater than on the apex side of the resilient valve means, said resilient valve means turning inside out when pressure on the apex side exceeds pressure on the base side by a predetermined amount greater than said range to release the valve member and permit it to cooperate with the seat.

7. A flow control device comprising, a body having a flow way therethrough, check valve means controlling flow through the device, second valve means rendering the check valve means inoperative, said second valve means controlling flow in response to a predetermined differential in one direction across the second valve means, said second valve means movable into an out-of-the-way position in response to a predetermined differential in the other direction to render the check valve means operative, and third valve means bypassing the second valve means and permitting flow through the device in response to a pressure differential in said other direction.

8. A valve device comprising, a body having a flow way therethrough, check valve means controlling flow through the device, generally conically shaped resilient valve means rendering the check valve means inoperative, said resilient valve means having a flow way therethrough which is normally closed and opens when the pressure on the base side of the resilient valve means is greater than pressure on the apex side of the resilient valve means by a predetermined amount, said resilient valve means movable into an out-of-the-way position in response to pressure on the apex side exceeding pressure on the base side of the resilient valve means by a predetermined amount, said resilient valve means having an annular portion of its base sealing secured across the flow way and an annular portion separated therefrom by an annular peripheral groove, said last mentioned portion having a sliding seal with the wall of the flow way to permit its movement along the flow way in response to changes in pressure on the apex side of the resilient valve means and vary with pressure on the apex side of the resilient valve means the forces tending to hold the resilient valve means flow way closed.

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