Nov. 7, 1961 W. F. NELSON 3,007,527

FLOW CONTROL DEVICE

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Fig. 1

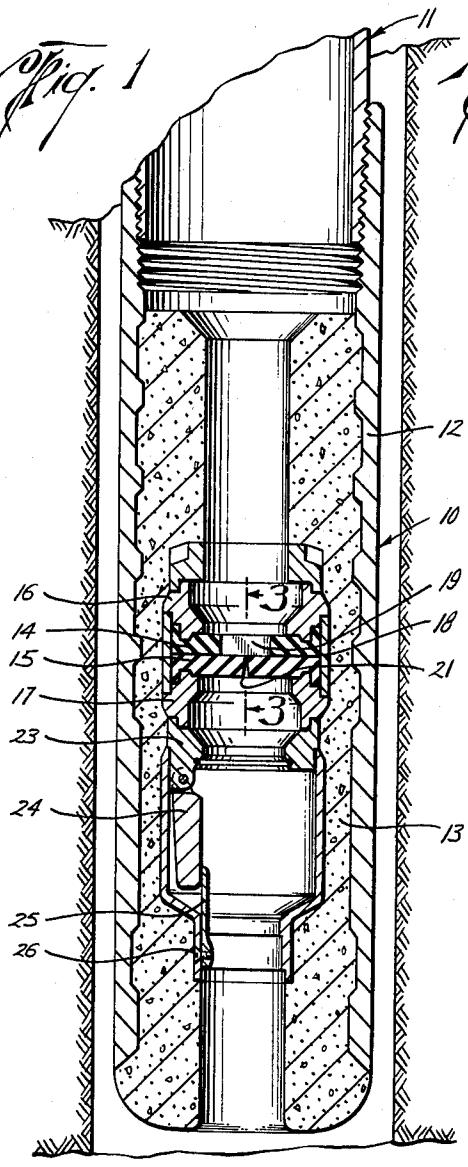


Fig. 2

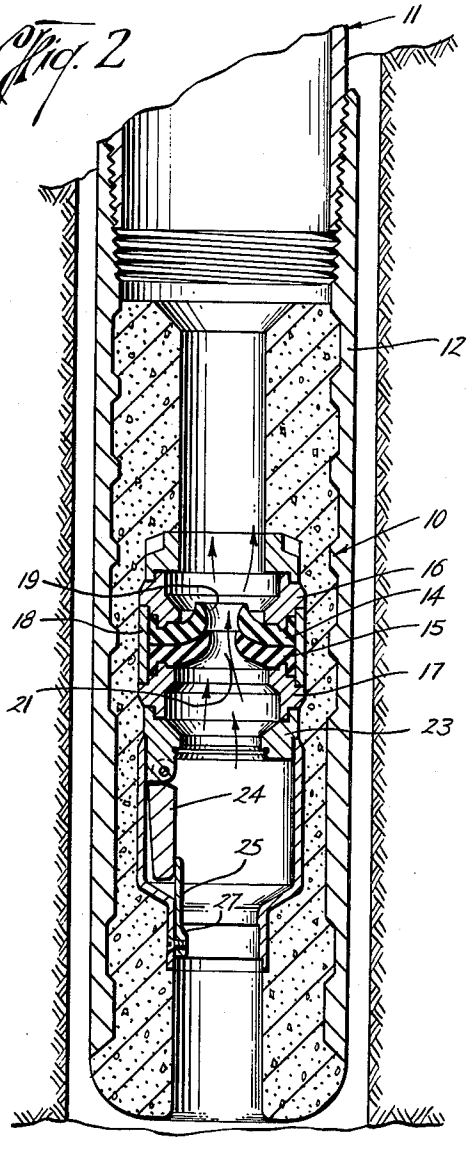
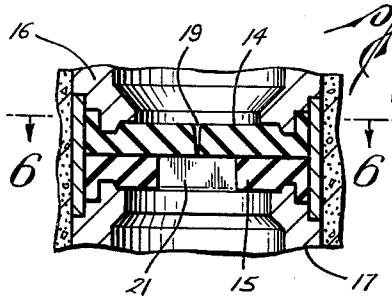


Fig. 3



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Fig. 4

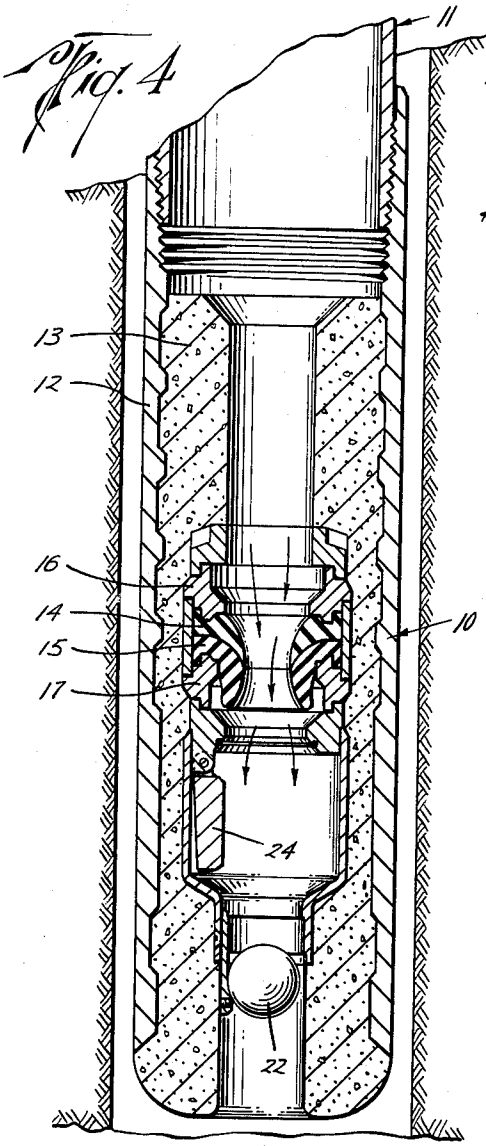
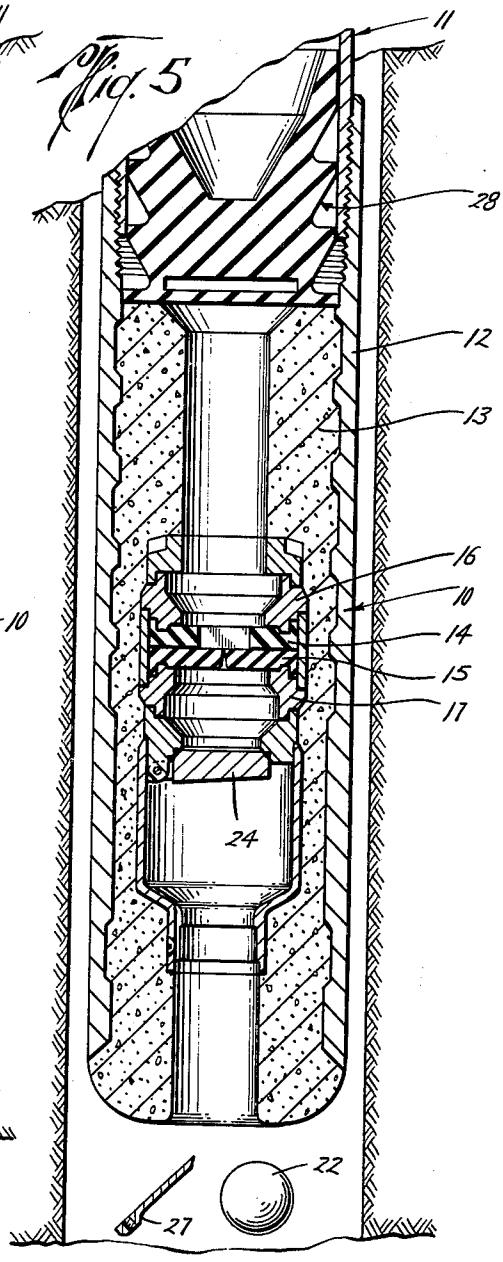


Fig. 5



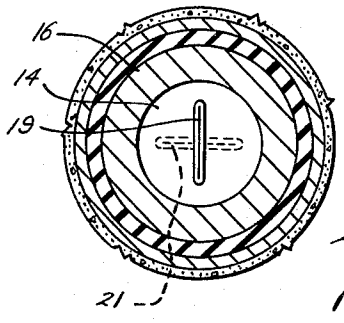


Fig. 6

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FLOW CONTROL DEVICE

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9 Claims. (Cl. 166—225)

This invention relates to flow control devices and more particularly to flow control devices which are employed in running and cementing casing 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 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 muds on the derrick floor. Mud on the derrick floor makes for slippery, dangerous working conditions, and this is particularly true when 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 circulation in either direction during running of the casing. For instance, it may be desirable or necessary to circulate drilling mud under pressure to wash out an obstruction blocking lowering of the casing. Thus, it is apparent that during running of the string, provision should be made for circulation in both directions. After the string is run, it is desirable to have a back pressure valve in the lower end of the casing for holding a back pressure on cement in the hole.

It is an object of this invention to provide a device for controlling flow of fluid through a casing while it is being run and set in a bore hole in which normal circulation may be established at any time during running of the string.

Another object is to provide a simple structure which permits automatic filling of a well casing as it is run without overflowing and permits normal circulation at any time.

Another object is to provide in a device for running a string of casing a resilient valve which will resist flow sufficient to maintain the casing level substantially below the open hole level and prevent overflow of the casing and yet will open to a substantial sized hole when circulation is established through the casing.

Another object is to provide a flow control valve for a casing collar or a casing shoe which is extremely simple and inexpensive to manufacture and assemble.

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

In the drawings wherein there is shown an illustrative embodiment of this invention and wherein like numerals indicate like parts:

FIGURE 1 is a view in vertical cross section through a flow control device embodying this invention with the device stationary in the well and the flow control valve maintaining the liquid level within the casing below the liquid level within the open hole (the fluid with which the casing and open hole are filled has been omitted in all of the figures for clarity in the drawings);

FIGURE 2 is a view similar to FIGURE 1 showing the tool being run in the hole and mud from the open hole passing into the casing through the valve;

FIGURE 3 is a view along the lines 3—3 of FIGURE 1;

FIGURE 4 is a view similar to FIGURE 1 illustrating the device after the casing has been fully run, normal circulation established and a ball pumped through the casing to release the back pressure valve preparatory to cementing;

FIGURE 5 is a view similar to FIGURE 1 showing the device after cement has been run into the hole; and

FIGURE 6 is a view along the lines 6—6 of FIGURE 3.

Referring first to FIGURES 1, 3 and 6, the flow control device indicated generally at **10** is illustrated as being made up in a running shoe to be attached to the lower end of casing string **11**. Of course the device could be made up as a part of a casing collar as illustrated in the flow control device shown in my co-pending application, Serial No. 686,947, now Patent 2,973,006.

The running shoe **12** provides a body for the device and the two valves for controlling flow during running and setting of the tool are shown to be contained with a cement annulus **13** in the conventional manner. Of course the valves and cement annulus are designed to be drilled up after the casing has set. The two valves and their associated retainer rings are molded in place in the cement annulus **13**.

The valve for controlling flow through the shoe in either direction while the casing is being run is provided by a diaphragm or disc shaped resilient valve. While the valve may be provided by a single disc, it is preferred that the valve be provided by a pair of diaphragms **14** and **15**. Also more than two diaphragms may be used if desired. The two diaphragms are positioned between retainer rings **16** and **17**. The retainer rings are held in spaced relation by an annular retainer **18** interposed therebetween to avoid movement of the retainer rings when a differential is developed across the valve.

The flow control diaphragms **14** and **15** are substantially disc shaped with anchoring parts adjacent the outer periphery for engagement with the retainer rings **16** and **17**. Other than the anchoring parts, the diaphragms are preferably provided with parallel flat faces.

Flow through the valve is provided by a slit **19** in diaphragm **14** and a slit **21** in diaphragm **15**. These slits are preferably at the center of the diaphragms. The two diaphragms should be arranged with these slits crossing each other, preferably at approximately a right angle, as best illustrated in FIGURE 6. By employing a pair of diaphragms and having their slits crossing each other, the unslit portion of one diaphragm tends to seal the slit of the other diaphragm and vice versa. Therefore under static or substantially static conditions, there will only be a small central area through which the flow will tend to occur. As each stand of casing is added at the wellhead and lowered into the well, additional fluid is desirably admitted to the interior of the casing. Therefore, a slight leakage through this small central area is permissible as the casing is run in in a substantially continuous operation.

By arranging the two diaphragms in abutment with each other and with their slits at right angles to each other, the maximum effect of one diaphragm on the other will be obtained. It will be appreciated that while this arrangement is desirable, the slits need not be arranged at a 90 degree angle to each other. This type of arrangement results in a double diaphragm valve member which may be opened to a circumference substantially twice the length of the slits to permit passage of lumps

in the drilling fluid and the ball 22 (FIGURES 4 and 5) to release the back pressure valve.

The diaphragms may be constructed of any desired resilient material such as synthetic rubber. The flexibility of the diaphragms should be such as to maintain the fluids level within the casing sufficiently below the fluid level within the open hole that fluid will not overflow onto the derrick platform as casing is being run.

After cement is run, it is desirable to be able to maintain a back pressure on the hole with a check valve in the lower end of the casing. Such a check valve is provided by seat 23 and flapper 24. The flapper is urged toward seated position by a conventional spring (not shown). Of course the flapper must be maintained in inoperative position during running of the tool and for this purpose a restricting means 25 is secured in the body by a shear pin 26. The restricting means 25 holds the flapper in open position. Of course the flapper could be arranged either above or below the diaphragm valve. The restricting means is removable by the ball 22 in the conventional manner to permit the flapper valve to seat and maintain a back pressure on the open hole.

In operation, the shoe or collar containing the flow control device is made up as a part of casing string 11 and the casing run in the hole. While a stand of casing is being added, the double diaphragm valve will assume substantially the condition illustrated in FIGURE 1. After a stand has been added, the lengthened string is lowered. During lowering, the double diaphragm will open in the manner illustrated in FIGURE 2 to permit drilling mud in the well to flow into the casing. The resistance to opening of the valve will be such that the fluid level within the casing will always be below the fluid level in the open hole.

In the event it becomes necessary to circulate drilling fluid in the hole for any reason, the operator may connect his pumps to the casing at the wellhead and pump down through the tubing as illustrated in FIGURE 4.

After the casing has been run and is ready for cementing in place in the hole, normal circulation is established and the bridging ball 22 is permitted to gravitate or is pumped down to the diaphragm. If desired, the ball may be permitted to gravitate to the diaphragm before normal circulation is established. In either event, the bridging ball can be pumped through the double diaphragm valve to seat on the shoulder 27 of the retaining member 25. At a predetermined pressure, for instance 400 to 600 p.s.i., the pin 26 will shear and the ball and restricting means fall into the bottom of the hole.

After the flapper valve has been released, cement may be introduced into the hole in the usual manner followed by the cement plug indicated generally at 28. This plug provides a clear line of demarcation between the cement and following fluid and signals, by a build-up in pressure at the wellhead, that the column of cement has been introduced into the open hope. After the plug comes to rest on cement annulus 13, pump pressure at the wellhead will be reduced. This will permit the flapper 24 to seat and hold a pack pressure on the cement in the hole.

If for any reason it may be desirable to release the check valve at any time during the casing run, this may be done. Such action will permit the casing to float in, relieving the supporting equipment of a substantial part of the weight of the casing.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A device for controlling flow of fluid through a casing while it is being run in a well bore and set comprising, a body having a flow-way therethrough adapted to be made up as a part of a string of casing, a check valve mounted in the flowway for preventing back flow from the well bore into the string of casing, means mounted in the flowway for preventing operation of the check valve until said check valve is removed by means pumped down the casing, and flow valve means mounted in the flowway and controlling flow through the flowway in both directions including a diaphragm valve of resilient material having a slit therethrough.

2. A device for controlling flow of fluid through a casing while it is being run in a well bore and set comprising, a body having a flow-way therethrough adapted to be made up as a part of a string of casing, a check valve mounted in the flowway for preventing back flow from the well bore into the string of casing, means mounted in the flowway for preventing operation of the check valve until said check valve is removed by means pumped down the casing, and flow valve means mounted in the flowway and controlling flow through the flowway in both directions including a pair of diaphragms of resilient material each having a slit therethrough, said diaphragms arranged side by side with the slits crossing each other.

3. A device for controlling flow of fluid through a casing while it is being run in a well bore and set comprising, a body having flow-way therethrough adapted to be made up as a part of a string of casing, a check valve mounted in the flowway for preventing back flow from the well bore into the string of casing, means mounted in the flowway for preventing operation of the check valve until said check valve is removed by means pumped down the casing, and flow valve means controlling flow through the body in both directions including a pair of diaphragms of resilient material each having a slit therethrough, said diaphragms extending across and mounted in said flowway, said diaphragms arranged side by side with the slits crossing each other at approximately a right angle.

4. A device for controlling flow of fluid through a casing while it is being run in a well bore and set comprising, a body having a flow-way therethrough adapted to be made up as a part of a string of casing, and flow valve means mounted in the flowway and controlling flow through the flowway in both directions including a diaphragm valve of resilient material having a slit therethrough, the portions of the diaphragm forming the sides of the slit normally remaining in contact and separating under pressure differential to permit flow therethrough.

5. A device for controlling flow of fluid through a casing while it is being run in a well bore and set comprising, a body having a flow-way therethrough adapted to be made up as a part of a string of casing, and flow valve means mounted in the flowway and controlling flow through the flowway in both directions including a pair of diaphragms of resilient material each having a slit therethrough, said diaphragms arranged side by side with the slits crossing each other.

6. A device for controlling flow of fluid through a casing while it is being run in a well bore and set comprising, a body having a flow-way therethrough adapted to be made up as a part of a string of casing, and flow valve means controlling flow through the flowway in both directions including a pair of diaphragms of resilient material each having a slit therethrough, said diaphragms extending across and mounted in said flowway, said diaphragms arranged side by side with the slits crossing each other at approximately a right angle.

7. In a device for controlling flow of fluid through a casing while it is being run in a well bore and set including a body having a flow-way therethrough and a check valve mounted in the flow-way which is released by a member pumped through the flow-way after the casing has been run to hold a back pressure on cement in the well bore, the improvement which comprises the

combination therewith of a diaphragm flow valve mounted in the flowway for controlling flow through the flowway in both directions before the check valve is released, said diaphragm having a slit therethrough.

8. In a device for controlling flow of fluid through a casing while it is being run in a well bore and set including a body having a flow-way therethrough and a check valve mounted in the flowway which is released by a member pumped through the flowway after the casing has been run to hold a back pressure on cement in the well bore, the improvement which comprises the combination therewith of a pair of diaphragms each having a slit therethrough, said diaphragm mounted in and extending across the flowway, said diaphragms arranged in side by side abutment with the slits crossing each other.

9. In a device for controlling flow of fluid through a casing while it is being run in a well bore and set including a body having a flow-way therethrough and a check

valve mounted in the flowway which is released by a member pumped through the flowway, after the casing has been run to hold a back pressure on cement in the well bore, the improvement which comprises the combination therewith of a pair of diaphragms each having a slit therethrough, said diaphragms mounted in and extending across the flowway, said diaphragms arranged in side by side abutment with the slits crossing each other at approximately a right angle.

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