Aug. 24, 1943. C. W. SAVITZ 2,327,610

CIRCULATING VALVE

Filed June 6, 1938

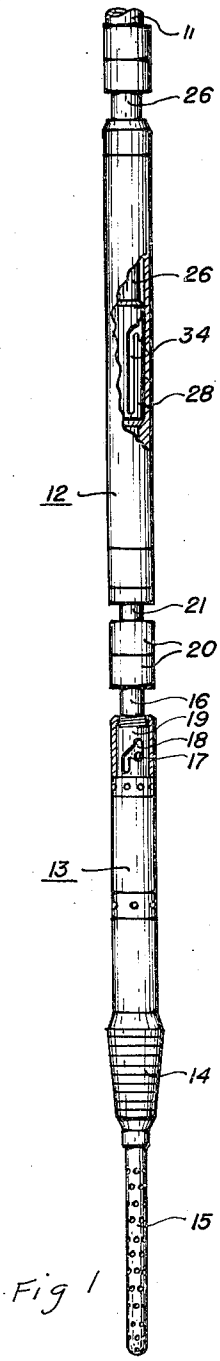


Fig 1

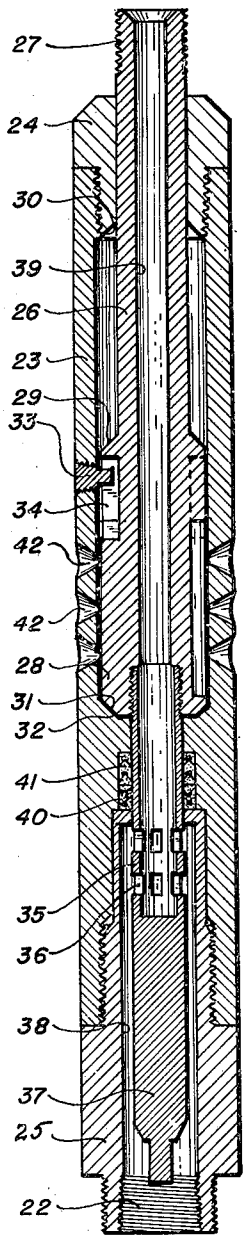


Fig 2

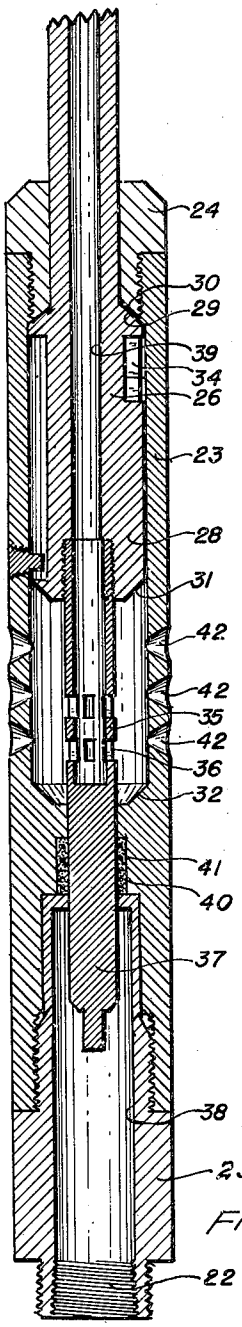


Fig 3

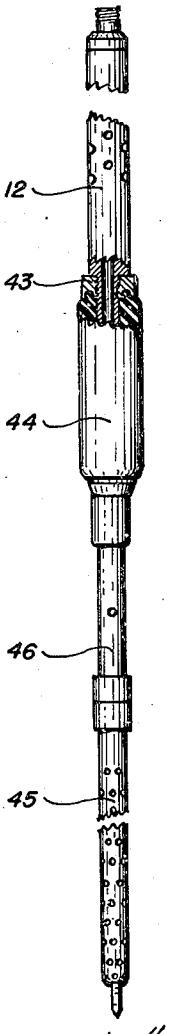


Fig 4.

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CIRCULATING VALVE

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Application June 6, 1938, Serial No. 212,054

3 Claims. (Cl. 166—1)

This invention relates to circulating valves, and more particularly to a valve arrangement suitable for use in drill pipe or the like in oil wells.

Where pipe is run into a well it is sometimes desirable to provide a valve therein at some point above the lower end so that fluid may be circulated therethrough above some apparatus connected to the lower end of the pipe. This is especially true if a packer is run on the drill pipe to seal it either to the wall of the well or to casing therein, and various valve arrangements have been proposed for this purpose these usually being referred to as "circulating valves" or "circulating subs."

The present invention is primarily concerned with a circulating valve which can be used in connection with a formation tester of the type disclosed in the United States patent to Simmons, No. 1,930,987, the Reissue patent to Halliburton, No. 20,688, or in other types of formation testers. The circulating valve may also be used in various other ways, as will be further explained hereinafter.

In circulating valves heretofore proposed, it has been common practice to employ cooperating telescoped members with ports which may be brought into alignment when desired to permit fluid to flow outwardly therethrough but such circulating valve or circulating subs have not prevented the passage of fluid longitudinally through the telescoping members when the circulating valve is open, with the result that the flow of fluid through the circulating valve cannot always be effected. This is especially true if an attempt is made to reverse the circulation—that is, pump fluid downwardly on the outside of the drill pipe or other conduit containing the circulating valve to force fluid upwardly on the interior thereof.

It is one object of the present invention to devise a circulating valve in which longitudinal flow of fluid through the portions thereof is prevented when the circulating ports therein are opened.

It is a further object of the invention to devise a circulating valve in which the normal circulation may be reversed and at the same time provide accurate control for the flow of fluid in drill pipe or other conduit connected to the circulating valve.

It is still another object of the invention to devise a novel combination of circulating valve and formation tester in which various advantages are attained.

It is still another object of the invention to devise a novel combination of circulating valve and packer adapted for use in connection with drill pipe or tubing and in which the parts especially cooperate to produce new and advantageous results.

Other objects and advantages reside in certain novel features of the arrangement and construction of parts as will be apparent from the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a view in side elevation of apparatus illustrating the principles of the invention, the arrangement showing a circulating valve in connection with a formation tester and showing some of the parts cut away to illustrate the internal construction;

Figure 2 is an enlarged vertical cross-sectional view of the circulating valve shown in Figure 1;

Figure 3 is a view similar to Figure 2 but showing the portion of the parts when the valve is opened; and

Figure 4 is a view in side elevation, with a portion cut away, of a circulating valve similar to that shown in Figures 1 and 2, the valve being assembled with a wall packer and an anchor pipe.

Referring to the drawing in detail, and first to the assembly shown in Figure 1, it will be seen that the apparatus there shown includes a portion of a drill pipe 11, a circulating valve assembly designated generally at 12, a formation tester designated generally at 13, a rat hole packer 14 and a perforated section of pipe 15, these parts being connected by suitable coupling members as illustrated and constituting apparatus which may be lowered into the well by means of the drill pipe.

The formation tester 13 may be of any known type, the arrangement illustrated being similar to that disclosed in the Halliburton Reissue Patent No. 20,688, reissued April 5, 1938, for "Apparatus for testing oil wells." This particular type of formation tester is generally referred to as a J-type tool, this being due to the fact that it is provided with a J-slot and pin connection for controlling its operation. Thus the formation tester may include a central mandrel only a portion of which is shown in Figure 1 and which is designated 16. The mandrel is provided with one or more pins 17 which cooperate with one or more slots 18 in a sleeve 19 which receives the mandrel 16 and which is integral with the main body of the formation tester and integral with the packer 14. It will be seen that with the construction as illustrated in Figure 1, the mandrel

16 may be moved downwardly with respect to the sleeve 19 only after it has been rotated to the right (as viewed from the top) from the position illustrated, and it will be understood that it is in response to relative movement between the mandrel 16 and the sleeve 19 that the valve in the formation tester is opened. The pin and slot arrangement could of course be so constructed that the tool would be rotated to the left to open the formation tester valve, but it is preferable to have it operate as illustrated unless the direction of rotation of the circulating valve described hereinafter is also reversed.

By means of coupling members 20, the mandrel 16 of the formation tester is connected to a nipple 21 which is in turn screw threaded into the lower end of the circulating valve assembly 12, the lower end of this assembly being provided with screw threads 22 as shown in Figure 2 for this purpose.

As best shown in Figures 2 and 3, the circulating valve assembly includes an outer cylindrical member or sleeve 23 to which a guiding and lifting member 24 is screw threaded at the upper end and to which a coupling and packing member 25 is screw threaded at the lower end. Within the sleeve 23 a mandrel 26 is mounted, this mandrel being provided with screw threads at its upper end as shown at 27 to provide means for making connection to the drill pipe 11 as shown in Figure 1.

At its lower end the mandrel 26 is provided with an enlargement 28 which is tapered at its upper and lower surfaces and which provides means for transmitting force from the mandrel to the sleeve 23. The upper shoulder 29 of the enlargement 28 cooperates with a similar shoulder 30 on the bottom of the member 24 when the mandrel is lifted up, as when tension is taken in the drill pipe, and the bottom shoulder 31 cooperates with a similar shoulder 32 formed within the sleeve 23 to transmit downward force from the mandrel to the sleeve 23 and thence to any members mounted on the lower end of the circulating valve assembly when the drill pipe and mandrel are set down with respect to the sleeve 23.

Some means is also provided between the mandrel 26 and the sleeve 23 for controlling relative movement therebetween. In the arrangement illustrated, this consists of a number of pins and cooperating J-slots, but these are to be considered as illustrative only, it being within the purview of the invention to employ various types of threaded connections or to use mutilated threads for controlling relative longitudinal movement between the members until they have been rotated relative to one another a predetermined amount. In the control means illustrated, pins 33 are screwed into the sleeve 23 and extend inwardly therefrom. J-slots 34 are provided in the enlargement 28 of the mandrel 26 so as to receive the pins 33. As best shown in Figure 1, each J-slot 34 is of such shape that the pin 33 normally remains in the upper lateral portion thereof but when the mandrel is lifted and rotated to the left the slots move with respect to the pins until the pins are in the portion of the slots which have the greatest longitudinal dimension so that the pin and slot arrangement no longer confines or limits relative longitudinal movement between the members.

Beneath the enlargement 28 and the control means just described, the mandrel has a depending portion or sleeve 35 which is provided with openings 36 substantially midway of its length but which is closed at the bottom as illustrated at 37. With the parts in the position shown in Figure 2, it will be seen that the ports 36 in the sleeve 35 are within an enlarged opening 38 in the lower coupling member 25. Means is thus provided for the flow of fluid from whatever device is connected to the lower end of the coupling member 25 up through the enlarged passageway 38 and the ports 36 into the interior of the sleeve 35 and thence upwardly through the bore 39 of the mandrel 26 to the drill pipe or whatever is connected to the upper end of the circulating valve assembly by means of the threaded connection 27.

Above the openings 36 the sleeve 35 connected to the mandrel, passes through two sections of packing illustrated at 40 and 41. This packing is preferably of the "Chevron" type as illustrated and is mounted within the sleeve 23 and compressed and held in position by the coupling member 25 which is screw threaded to the sleeve 23 as illustrated. The packing elements 40 and 41 may be mounted either face to face or back to back and provide effective means for preventing any fluid from flowing between the sleeves 23 and 35, and since the ports 36 within the sleeve 35 are normally beneath the packing, the arrangement is such that the connections are the same as though no circulating valve were employed when the parts are in the position shown in Figure 2.

Assuming now that it is desired to open the circulating valve, the mandrel 26 is rotated to the left (as viewed from the top) and picked up so that it moves upwardly within the sleeve 23 until the shoulder 29 strikes the shoulder 30, the parts then taking the position shown in Figure 3. As shown in Figures 2 and 3, the sleeve 23 is provided with a number of openings 42 at any convenient point beneath the pins 33 and as the mandrel is raised upwardly fluid may flow through these ports and the ports 36 within the sleeve 35 either to or from the bore 39 within the mandrel 26. At the same time, the portion 37 of the sleeve 35 is brought up within the packing 40—41 so that the longitudinal or normal flow through the mandrel is sealed off.

From the above description it will be clear that the circulating valve assembly performs two functions. It provides means for connecting the interior of the drill pipe to the exterior thereof and it provides means for positively preventing the flow of fluid through the drill pipe to some point beneath the circulating valve when the circulating valve is open. As noted above, these functions are of particular importance when the circulating valve is used in connection with a formation tester.

Assuming that the assembly is as shown in Figure 1, it will be seen that the circulating valve is mounted above the formation tester and may be controlled independently thereof. This is due primarily to the fact that the circulating valve opens by rotation to the left, whereas the formation tester valve opens by rotation to the right, but it is also due in part, and may be due wholly, to the fact that the valve of the formation tester may be of such type as to be biased by the mud pressure or otherwise constructed as to require more pressure to open than is required to open the circulating valve.

The advantages of the combination of the particular circulating valve shown and the formation tester will be apparent from a consideration

of the manner in which this combination may be operated.

Let us assume that the assembly has been run into the well, and the packer seated, both the circulating valve and the tester valve remaining closed during the seating operation. The apparatus is now ready to take a sample of the formation. This is done by opening the tester valve, the drill pipe being rotated to the right and set down. The circulating valve does not open because rotation to the left is required to open it, and the parts of the circulating valve remain in the position shown in Figure 2. As the fluid from the formation flows upwardly through the formation tester, therefore, it flows through the ports 36 in the sleeve 35 and upwardly through the bore 39 of the mandrel 26 into the drill pipe 11. After a suitable interval of time the valve in the formation tester is closed by lifting or picking up the drill pipe.

The present invention provides means for removing the oil or other fluid from the formation which is then in the drill pipe and replacing it with mud or other heavy fluid before the drill pipe is removed from the well. This is often desirable, especially where the sample of fluid from the formation contains considerable gas which is apt to "head up" and cause the oil to be blown from the drill pipe while removing the same from the well after the test has been made.

To carry on these operations the drill pipe is rotated to the left and picked up while the packer 14 is still seated, the circulating valve being opened by this operation. At the same time mud is circulated in a reverse direction, that is, it is circulated downwardly on the outside of the drill pipe and flows inwardly through the ports 42 in the sleeve 23 and thence through the ports 36 in the sleeve 35 and upwardly through the bore 39 of the mandrel 26, thus forcing the sample from the formation upwardly through the drill pipe. The sample of formation fluid may be thus caused to flow out through the drill pipe through the flow lines and into the pit. In this way an accurate gauge of the amount of oil in the drill pipe can be obtained, the drill pipe is filled with mud and the mud on the outside of the drill pipe is prevented from becoming contaminated with oil.

As the circulating valve is opened, or immediately after it is opened, the packer is lifted off of its seat and the mud in the well enters the rat hole or portion of the well beneath the packer so as to hold the formation pressure so that there is no chance of the well blowing out even though the formation pressure is high.

It will be seen further that when the circulating valve is opened the portion 37 of the sleeve 35 connected to the mandrel seals off the chamber provided by the connections between the circulating valve and the formation tester. Both the formation tester valve and the valve 37 being closed, a sample of the formation fluid is entrapped therebetween. It will be seen that this entrapped sample is from the extreme bottom of the amount of fluid which entered the assembly from the formation during the taking of the sample and there is this portion which is usually of most interest to the oil operator. If it is desired to entrap a greater amount of the sample, the circulating valve may be separated from the formation tester by an additional amount of pipe than that illustrated in the drawing.

The circulating valve may be used for various purposes other than in connection with a formation tester, and Figure 4 shows one such adaptation. In this figure a circulating valve identical in construction to that shown in Figures 2 and 3 is connected to the upper shoe 43 of a wall packer 44 which is in turn connected to an anchor pipe 45 by a suitable connecting pipe 46. With this arrangement it will be apparent that drill pipe or tubing can be packed off in a well being supported by the anchor pipe 45, the packer being set while the parts of the circulating valve are in the position shown in Figure 2.

Should it be desired to open the circulating valve this can be done by rotating the drill pipe or tubing to the left. When the valve is opened no fluid can flow through the packer but circulation above the packer can be effected either in the ordinary or in the reverse direction.

The arrangement shown and described herein may be used to advantage in connection with the acidizing of oil wells, as disclosed in United States Patent No. 2,143,251, granted January 10, 1939, to Christian W. Savitz. The circulating valve may also be used in various other ways, as will be apparent to those skilled in the art.

From the above description, it will be clear that the invention resides primarily in the structure of the circulating valve assembly and in the combination of this device with a packer and with a formation tester. The circulating valve arrangement illustrated is of the type in which a mandrel is telescoped within a sleeve and the valve arrangement is of the sleeve type, but it is obvious that other constructions than that illustrated could be employed and that in its broader aspects any arrangement for providing a conduit for the flow of fluid from end to end of the assembly would be the equivalent provided the construction is such that the conduit can be closed and communication established between the exterior and interior of the assembly at the desired time.

While only one embodiment of the circulating valve has been shown and described herein, therefore, it is obvious that various changes may be made in the construction and arrangement of parts without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. A circulating valve assembly adapted for use with pipe in an oil well or the like, said assembly including a central hollow mandrel and an outer sleeve telescoped together, coupling means on said mandrel and sleeve for limiting relative longitudinal and rotative movement therebetween, and packing means between the mandrel and sleeve, said sleeve having ports therein and said mandrel having ports therein which may be brought into juxtaposition with the ports in the sleeve to establish communication for flow of fluid between the interior and the exterior of said assembly when the mandrel is moved into one longitudinal position with respect to said sleeve and which may be passed through said packing means to close and prevent communication, as aforesaid, when the mandrel is moved to another longitudinal position with respect to said sleeve, said mandrel also having means cooperating with said packing means for preventing longitudinal flow of fluid through the assembly when communication is established between the interior and exterior thereof, as aforesaid.

2. A method of testing the productivity of a formation encountered in a well containing drill-

ing fluid, which includes lowering an empty string of pipe, sealed at its lower end, into the well through the drilling fluid to a point adjacent the formation, packing off the drilling fluid from the formation at a point above the formation, breaking the seal at the lower end of the pipe after packing off the drilling fluid to permit cognate fluid from the formation to enter the pipe, again sealing the pipe against the entrance of fluid from the well by movement of the pipe, opening the pipe at a point above the point where the drilling mud is packed off to thereby cause the drilling fluid to enter the pipe and force the cognate fluid to the surface of the well.

3. The method of testing the productivity of a formation encountered in a well containing drilling fluid, which includes lowering an empty string of pipe, sealed at its lower end, into the well through the drilling fluid to a point adjacent the formation, packing off the drilling fluid from the formation at a point above the formation, breaking the seal at the lower end of the pipe to permit cognate fluid from the formation to enter said pipe, again sealing the pipe to prevent further entrance of fluid into the pipe, sealing the pipe at a point spaced from the bottom to entrap a sample of the cognate fluid between the bottom and the point spaced from the bottom of the pipe, opening the pipe at a point above both seals and above the point where the drilling mud is packed off and circulating drilling fluid downwardly on the outside of said pipe, into the pipe through said opening and upwardly on the inside of said pipe to force the cognate fluid in said pipe to the surface of the well.

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