Nov. 1, 1966 W. J. ARTIGUE 3,282,348

CIRCULATING DEVICE

Filed June 3, 1963 2 Sheets-Sheet 1

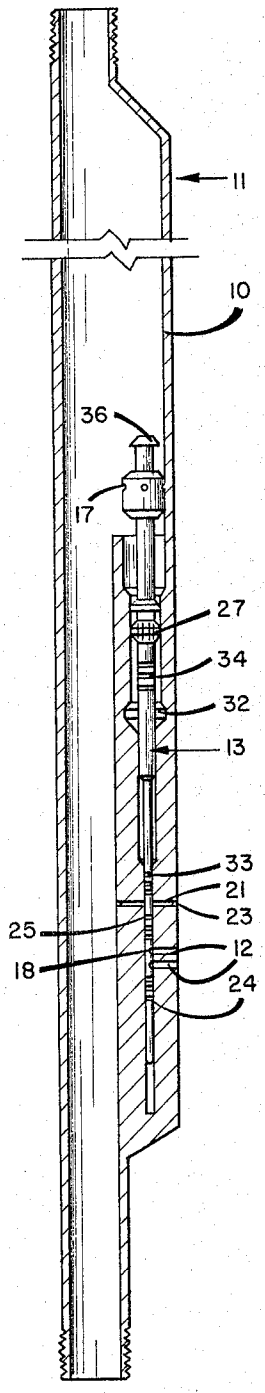


FIG.-1

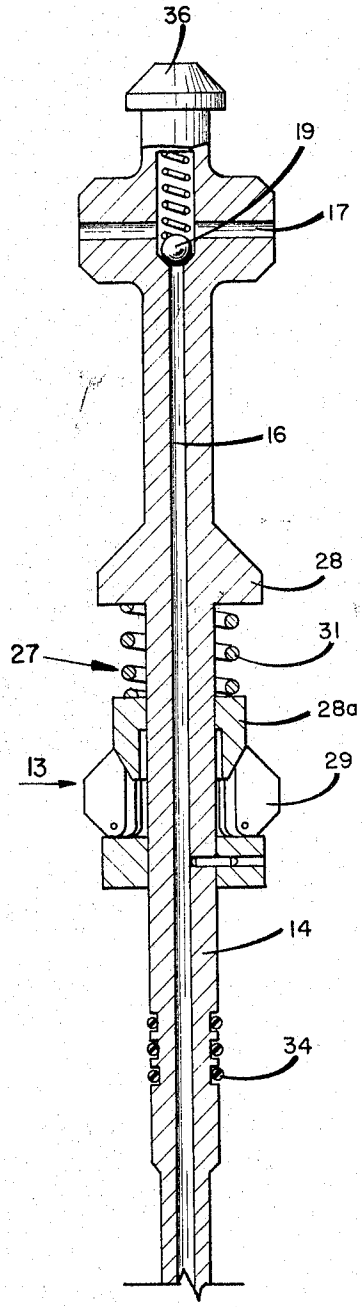


FIG.-2A

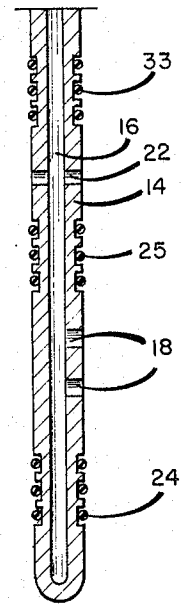


FIG.-2B

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CIRCULATING DEVICE

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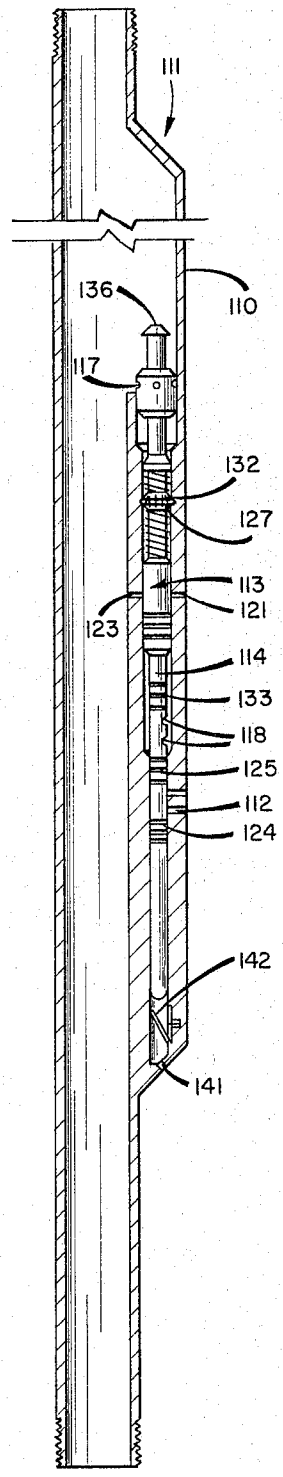


FIG.-3

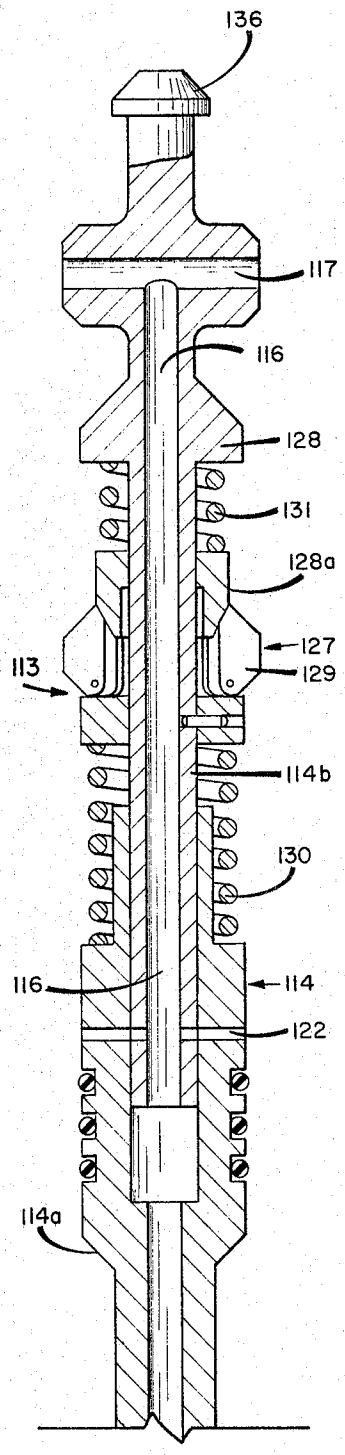


FIG.-4A

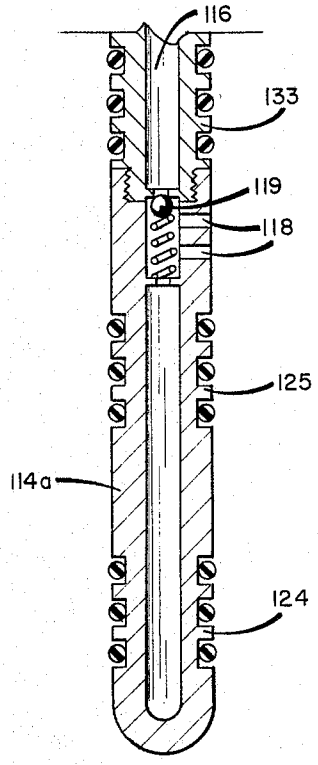


FIG.-4B

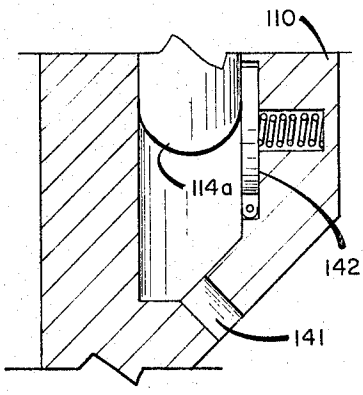


FIG.-5

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CIRCULATING DEVICE

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6 Claims. (Cl. 166—224)

This invention relates to a circulating device for use in passing fluid into, or from, well tubing. More particularly, the invention relates to a down-hole circulating valve device for use in the completion of, or the production from, oil wells or the like.

Various types of circulating valves are used in the petroleum industry in connection with the completion of, or the production from, oil wells. Typically, such valves are employed in displacing undesirable materials, such as water or excess cement, from the well by circulating a fluid between the tubing and the casing in the well to remove such materials. When the displacing operation is completed, the circulating valve is closed to permit normal operation of the well. Such devices generally comprise a valve, positioned in the tubing string to control the flow of fluid from the annulus between the casing and the tubing into the tubing, or from the tubing into the annulus. Generally, such devices are positioned at a mandrel in the tubing string and are actuated by the use of wire line tools, so that the valve may be closed, or opened, by wire line tools extending from the surface down into the well bore. Particularly in the instance where very deep wells are being drilled, the wire line expenses and loss in rig time, due to difficulties in obtaining the proper jarring action necessary to actuate the circulating valve, can run the costs to quite a high figure. Additionally, there is a hazard, when using such devices, of losing the wire line tools in the hole. Where internally, plastic-coated tubing is utilized there is the likelihood that the wire line tools will damage the plastic coating and such damage can lead to premature failure by corrosion of the tubing.

The present invention provides a down-hole circulating device which can be actuated from the surface by the application of a fluid, such as gas, water, drilling fluid, or the like, to the device to establish a predetermined pressure differential across the device and without the necessity of using wire line tools, or the like. Typically, the circulating device can be closed from the surface upon the completion of displacing operations by reversing the flow of fluid through the device and by supplying the reverse-flow fluid to the device at a pressure sufficient to actuate a positioning means on the device and cause the device to close.

In accordance with the present invention, there is provided a down-hole circulating device, which comprises a circulating valve, adapted to be positioned in the side pocket of a mandrel which can be positioned in a string of well tubing. The side pocket of the mandrel is provided with a port placing the side pocket in flow communication with the exterior of the mandrel. The circulating valve comprises a cylindrical, elongated member having a longitudinal cavity through its body, an upper circulating port and a lower circulating port in the elongated body, with the circulating ports being in flow communication with the longitudinal cavity. A check valve is positioned between the upper and lower circulating ports to permit the passage of fluid through the valve in one direction, while preventing the flow of fluid in the reverse direction. Initially, the circulating valve is positioned in the side pocket and the circulating ports are maintained in flow communication with the side-pocket port to permit the desired unidirectional fluid flow through the device.

Means are provided for reversing the flow of fluid to close the check valve and for the application of fluid pressure, sufficient to actuate a positioning device used to maintain the position of the circulating valve in the side pocket, so that the reversal of the fluid flow causes the circulating valve to slide longitudinally within the side pocket and break the flow communication between the circulating port and the side pocket port. Sealing rings are provided on the circulating valve, adjacent the side-pocket port, so that when the valve slides, the side pocket port is effectively sealed against the flow of fluid therethrough, and a latch on the circulating valve engages with the side pocket to maintain the seal so that the device is closed against the flow of fluid.

Thus, a general object of the invention is an improved well-circulating device which may be easily and economically actuated from the surface of the well by the application of fluid pressure to the device in a preselected direction without exposing the well to the danger of damage. Other objects will become apparent from the following description and the accompanying drawings of preferred embodiments of the invention, wherein:

FIGURE 1 schematically illustrates, in partial cross section, a circulating valve positioned in a side-pocket mandrel, with the circulating valve being open to the flow of fluid into the tubing; and

FIGURES 2A and 2B, taken together as FIGURE 2, constitute a partial cross-sectional view of the circulating valve employed in the device of FIGURE 1; and

FIGURE 3 schematically illustrates, in partial cross section, a circulating valve positioned in a side-pocket mandrel to permit the flow of fluid from the tubing to the exterior of the tubing; and

FIGURES 4A and 4B, taken together as FIGURE 4, constitute a partial cross-sectional view of the circulating valve employed in the device of FIGURE 3; and

FIGURE 5 is a partial cross-sectional view of the lower section of the mandrel of FIGURE 3.

Referring to FIGURES 1 and 2, wherein there is illustrated one embodiment of the circulating device adapted for circulating fluid from the well into the tubing, there is provided a side-pocket mandrel **11** of the conventional type, adapted for insertion in a string of well tubing. The mandrel is provided with a cylindrical side pocket **10** having a wall portion integral with the mandrel wall, the outer portion of the wall being provided with ports **12**, placing the side pocket in flow communication with the exterior of the mandrel. A circulating valve member **13** is positioned in the side pocket **10** and comprises an elongated cylindrical body member **14** having a longitudinal cavity **16** therethrough, upper circulating ports **17** and lower circulating ports **18** communicating with the longitudinal cavity to provide fluid flow through the circulating valve. A check valve **19**, preferably of the spring-loaded type, is positioned in the upper end of the circulating valve adjacent the upper circulating ports to provide a means for controlling the direction of fluid flow through the circulating valve. In this embodiment, the check valve permits the flow of fluid through the lower circulating ports, upwardly through the longitudinal cavity and out of the valve into the tubing through the upper circulating ports, while preventing the flow of fluid through the upper circulating ports downwardly through the circulating valve.

FIGURE 1 shows the circulating valve positioned in the side pocket in the open position to permit fluid to flow through the lower ports upwardly through the valve and out of the upper circulating ports. The circulating valve is positioned in place by means of a positioning member, such as one or more shear pins **21** of preselected characteristics, placed through shear-pin holes **22** in the

elongated member and held in place by holes 23 in the walls of the side pocket. Advantageously, the shear pins are screwed into the outside wall of the mandrel so that leakage through the shear-pin holes is prevented. A first set of sealing rings 24, preferably O-rings, and a second set of sealing rings 25 are positioned on the exterior of the elongated member on each of the upper and lower sides of the lower circulating ports 18 provided therein. When the device is in the open position, these sealing rings are in fluid-tight contact with the inner walls of the side pocket so that fluid passing from the exterior of the mandrel through the lower mandrel port cannot escape, except through the lower circulating ports.

When it is desired to close the above circulating device, the fluid flow is reversed so that fluid passes down the tubing, into the upper circulating ports and closes the check valve positioned therein. For this purpose, a pump (not shown), or other such means for passing a fluid down the tubing, is employed to establish the desired pressure differential across the circulating valve, and at a preselected differential pressure the shear pins holding the circulating valve in the open position shear, allowing the elongated member to slide downwardly within the side pocket and latch into the closed position. The latch assembly 27 may be of the conventional type and may be spring actuated as shown. In the drawing, the latch assembly 27 comprises a fixed upper shoulder 28, a sliding collar 28*a* and a dog 29 mounted on the elongated member with a compression spring 31 held in place between the upper shoulder and the collar, so that when released the spring and collar force the dog outwardly. When the circulating valve drops into the closed position, the latch engages with a radial groove 32 in the wall of the side pocket and secures the circulating valve in position. The mandrel port 12 is then sealed against fluid flow by a third set of sealing rings 33 mounted on the elongated member and the aforementioned second set of sealing rings to prevent the entry of fluid into the side pocket. A fourth set of sealing rings 34 serves also to seal against the passage of fluid between the elongated member and the inner wall of the side pocket. If it is desired to remove the circulating valve from the side pocket at a later time, wire line tools may be used to engage the fishing neck 36 on the upper end of the circulating valve so that the valve may be pulled from the side pocket.

The circulating device shown in FIGURES 3 and 4 is adapted for use when it is desired to circulate fluid from the tubing to the annular space outside the tubing as, for example, in the instance of tubing-to-casing displacement. This type device may be utilized in displacing the fluid in the tubing string by pumping another fluid down the tubing and up the annulus between the casing and tubing. In FIGURE 3 there is illustrated a circulating valve member 113 positioned in the side pocket 110 of a side-pocket mandrel 111. As shown, the device is in the closed position so as to prevent the flow of fluid between the tubing and the annulus. FIGURE 4 illustrates the circulating valve of FIGURE 3, except that the valve is shown as it would be in the open position so as to permit fluid flow from the tubing to the annulus.

The circulating valve 113 comprises an elongated, cylindrical body member 114 having a longitudinal cavity 116 provided therein, with upper circulating ports 117 and lower circulating ports 118 communicating with the longitudinal cavity to provide fluid flow through the circulating valve. The body member 114 is comprised of an upper section 114*b* and a lower section 114*a* slidably connected thereto. A check valve 119, preferably of the spring-loaded type, is positioned near the lower end of the circulating valve adjacent the lower circulating ports to provide a means for controlling the direction of fluid flow through the circulating valve. In this embodiment, the check valve permits the flow of fluid through the upper circulating ports 117, downwardly through the longitudinal cavity, out of the lower circulating ports 118 and through the mandrel ports 112 when the valve is in the open position in the side pocket. Of course, the check valve 119 provides unidirectional flow and prevents fluid from flowing through lower circulating ports 118 and upwardly through the circulating valve.

When in the open position, the circulating valve is positioned in the side pocket by one or more shear pins 121 placed through the shear-pin holes 122 in the elongated member and held in place by holes 123 in the walls of the side pocket. As mentioned above, the shear pins preferably are screwed into the outside wall of the mandrel in order to minimize leakage through the shear-pin holes in the mandrel wall. When in the open position, the lower circulating ports 118 are aligned with the mandrel ports 112, with the ports being sealed on either side by the second set of sealing rings 125 and the third set of sealing rings 133, preferably O-rings, mounted on the elongated member to contact the inside wall of the side pocket to provide a fluid-tight seal. As before, the shear pins are such as to be shearable by the application of a preselected fluid pressure to the circulating valve in the direction causing the check valve to close, so that a pressure differential is established across the circulating valve sufficient to cause the pins to shear and thereby permit the elongated member to slide within the side pocket into the closed position shown in FIGURE 3. As shown, the elongated member has moved up in the side pocket so that fluid communication between the lower circulating ports 118 and the mandrel ports 112 is broken and the mandrel ports are sealed on either side by the second set of sealing rings 125 and a first set of sealing rings 124.

As mentioned above, this embodiment of the circulating device is closed by circulating fluid down the annulus through the mandrel ports 112 and the lower circulating ports 118 to close the check valve and establish the desired pressure differential to shear the pins which hold the valve in the open position. When the preselected pressure differential is reached the pins shear, allowing the lower section 114*a* to slide upwardly on the upper section 114*b* and break the flow communication between ports 112 and 118 so as to close the circulating valve. The closing of the valve is aided by the spring 130 mounted on the valve body between its upper and lower sections and installed in tension when the valve is in the open position. The latch assembly 127 engages with the radial groove 132 in the wall of the side pocket to maintain the circulating valve in position in the side pocket at all times. This latch is similar to the latch described above, however, any of the well-known latching devices may be used for this purpose. The fishing neck 136 on the circulating valve enables the valve to be removed from the side pocket with wire line tools when desired.

In this latter embodiment, the side pocket is preferably provided with a port 141 in the lower end which permits fluid from the annulus to enter the lower portion of the mandrel so that the fluid pressure exerted on the bottom of the elongated member aids in closing the circulating valve. When the circulating valve moves into the closed position, the spring-loaded stop 142 positioned in the bottom of the mandrel beneath the lower end of the valve, moves into the mandrel pocket to prevent any downward motion of the valve due to differential pressure.

From the foregoing description of the two embodiments of the circulating device of my invention, it is seen that apparatus described can readily be employed to close a down-hole circulating device from the surface by the application of differential pressure to the device without the need for using wire line tools or other auxiliary apparatus to actuate the device.

From a reading of the foregoing description, various modifications and alterations in the details of construction and operation of the device of the invention will become apparent to the skilled artisan, and, as such, it is understood that these fall within the spirit and scope of the invention.

What I claim is:

1. A down-hole circulating device which comprises:

a side-pocket mandrel adapted to be positioned in a string of well tubing,

first port means in said mandrel, communicating the side pocket of said mandrel with the exterior of said mandrel,

valve means adapted to be positioned in said side pocket, said valve means comprising an elongated member having a longitudinal cavity therein, lower circulating port means and upper circulating port means in communication with said cavity, check valve means positioned between said upper and lower circulating port means to unidirectionally control the fluid flow through said valve means,

positioning means for maintaining said valve means in said side pocket so as to maintain said lower circulating port means in flow communication with said first port means when said circulating device is open, but permitting said elongated member to slide longitudinally within said side pocket when a preselected pressure differential is established across said device to break said flow communication,

sealing means cooperating with said elongated member adjacent said first port means to effectively seal said side pocket from the exterior of said mandrel upon breaking of said flow communication, and

latch means for latching said valve means in place in said side pocket to maintain said seal.

2. Circulating valve means adapted to be positioned in the side pocket of a mandrel which is adapted to be positioned in a string of well tubing, said side pocket being provided with port means communicating said side pocket with the exterior of said mandrel, which circulating valve means comprises an elongated member having a longitudinal cavity therein; lower circulating port means and upper circulating port means in communication with said cavity; check valve means positioned between said upper and said lower circulating port means to provide unidirectional fluid flow in a preselected direction through said valve means; positioning means in contact with said valve means for maintaining said lower circulating port means in flow communication with said side-pocket port means when fluid is passed therethrough at less than a preselected pressure, but permitting said elongated member to slide longitudinally within said side pocket upon the application of fluid pressure in excess of said preselected pressure in the direction causing said check valve means to close and to break said flow communication between said circulating port means and said side-pocket port means; sealing means on said elongated member adjacent said side-pocket port means to effectively seal said side-pocket port means against the flow of fluid therethrough when said positioning means is actuated by fluid pressure in excess of said preselected pressure; and latch means on said elongated member cooperating with said side pocket for latching said valve means in place in said side pocket to maintain said seal.

3. A down-hole circulating device which comprises a side-pocket mandrel adapted to be positioned in a string of well tubing, the side pocket of said mandrel being provided with first port means in flow communication with the exterior of said mandrel, circulating valve means adapted to be positioned in said side pocket, said circulating valve means comprising an elongated member having a longitudinal cavity therein; said elongated member being provided with lower circulating port means and upper circulating port means in communication with said

cavity; check valve means positioned in said cavity between said upper and lower circulating port means to provide unidirectional fluid flow through said valve means in a preselected direction; shearable positioning means in contact with said elongated member and the wall of said side pocket for maintaining said lower circulating port means in flow communication with said side-pocket port means when said circulating device is open, but permitting said elongated member to slide longitudinally within said side pocket upon the application of a preselected fluid pressure to said valve means in the direction opposite said preselected direction and thereby break said flow communication; sealing means positioned on said elongated member to contact the side wall of said side pocket when said positioning means is sheared by said preselected fluid pressure; and latch means on said elongated member for latching said valve means in place in said side pocket to maintain said seal.

4. The device of claim 3 wherein said positioning means is a shear-pin member placed through said elongated member and mounted in the side wall of said side pocket.

5. The device of claim 3 wherein said sealing means is a plurality of resilient-ring members mounted on said elongated member to effect sealing contact with the wall of said side pocket, and positioned to contact said wall, both above and below the said first port means therein.

6. A down-hole circulating device which comprises a side-pocket mandrel adapted to be positioned in a string of well tubing; first port means in the outer wall of said side pocket communicating said side pocket with the exterior of said mandrel; circulating valve means adapted to be positioned in said side pocket, said circulating valve means comprising an elongated member having a longitudinal cavity therein; said elongated member being provided with lower circulating port means and upper circulating port means in communication with said cavity, check valve means positioned in said elongated member between said upper and lower said circulating port means to provide unidirectional fluid flow through said circulating valve means in a preselected direction; said elongated member and the wall of the said side pocket being adapted to receive a shear-pin member; a shear-pin member positioned in said elongated member to maintain said lower circulating port means in flow communication with said side-pocket port means when said shear-pin member is in place; said elongated member being slidable longitudinally within said side pocket and said shear-pin member being shearable upon the application of a preselected fluid pressure to said circulating valve means in the direction opposite said preselected direction to thereby break said flow communication; a resilient-ring member mounted on said elongated member to engage in sealing contact with said side-pocket port means to effectively seal said side-pocket port means when said elongated member slides within said side pocket upon the application of said preselected pressure to shear said shear-pin member; and latch means on said elongated member for latching said valve means in place in said side pocket to maintain said seal.

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