Nov. 19, 1963 L. B. WILDER 3,111,176

GAS OPERATED PERCUSSION DRILLING TOOL

Filed April 17, 1961 2 Sheets-Sheet 1

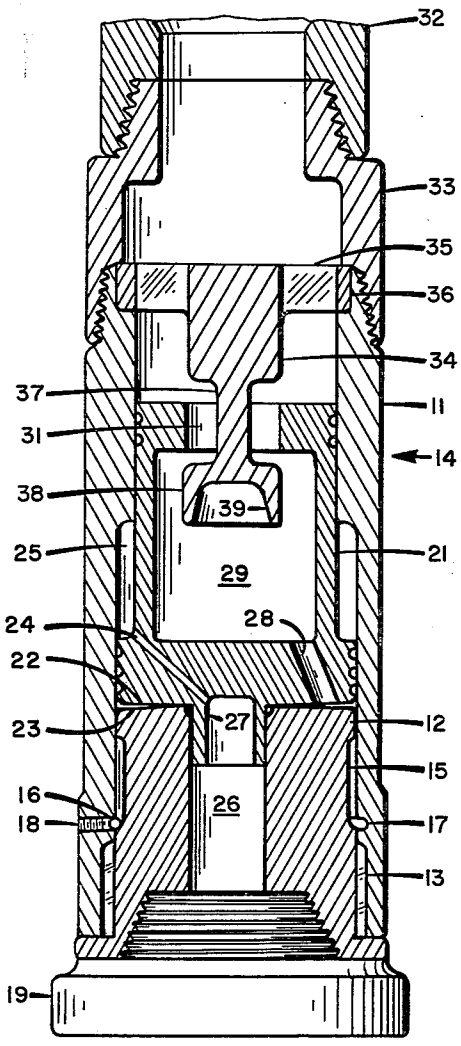


FIG. 1

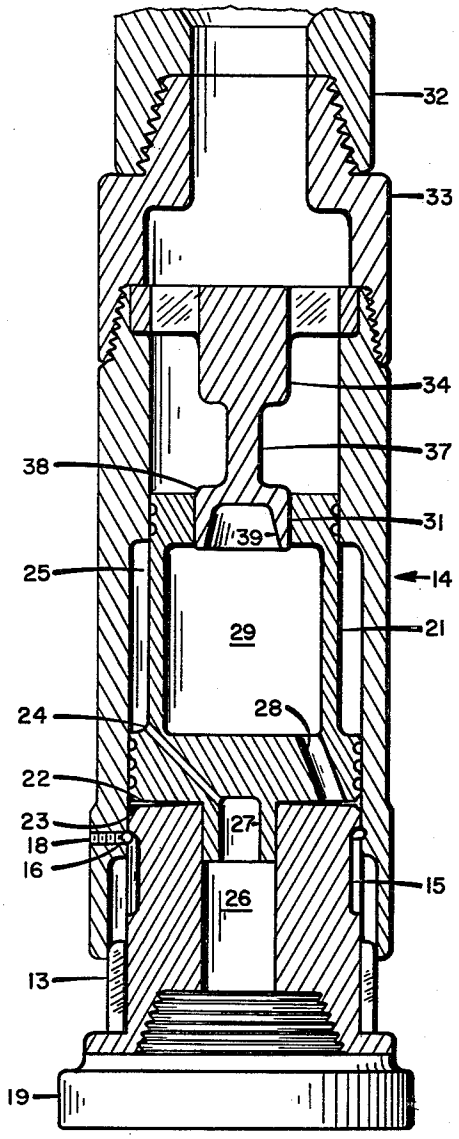


FIG. 2

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GAS OPERATED PERCUSSION DRILLING TOOL

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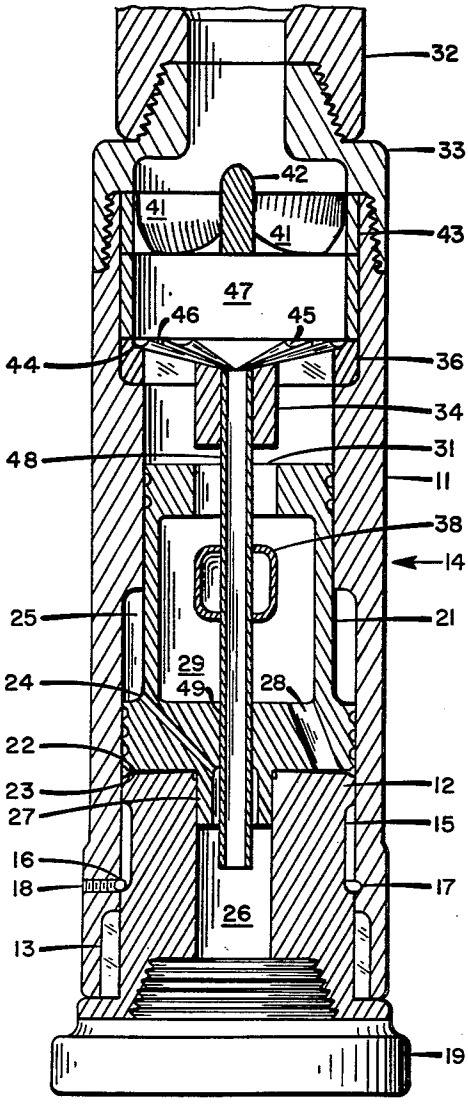


FIG. 3

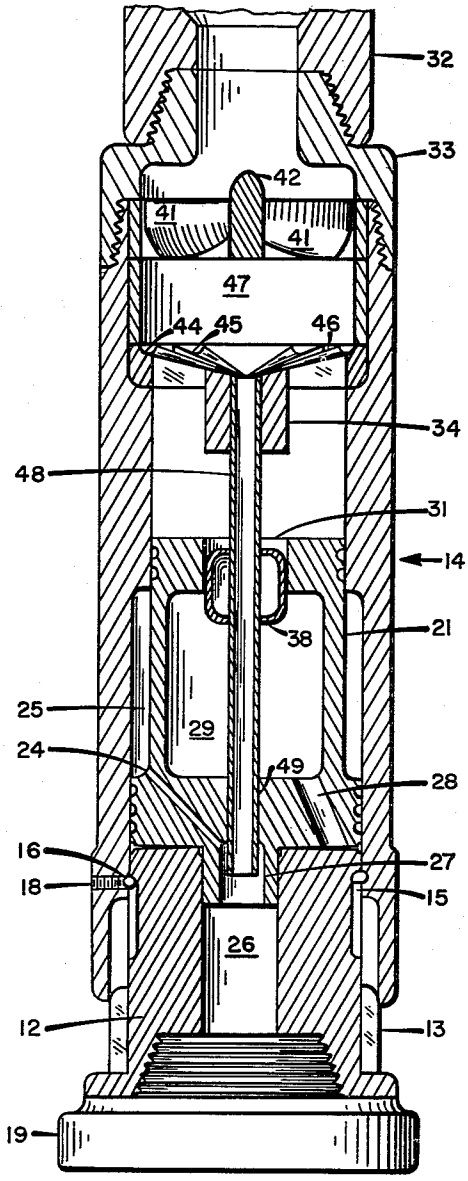


FIG. 4

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GAS OPERATED PERCUSSION DRILLING TOOL

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This invention relates to a percussion drilling tool of the type adapted for operation with a gaseous power fluid. More particularly, it concerns a motor which delivers percussive blows to a drill bit as a gas is circulated through the motor.

My invention comprises a valve mechanism in the gas-operated motor which can be closed by raising the tool off the bottom of the hole, whereby gas flow through the motor will be reduced during interruptions in drilling operations.

In the rotary drilling of wells for the production of oil and gas, it has been found that substantially greater drilling rates can be obtained if percussive blows are applied to the drill bit as it rotates in contact with the rock formation. Motors have been designed for operation in the drill string adjacent the bit whereby energy in the circulating gas stream can be used to power the motor and deliver percussive blows to the bit. The gas which exhausts from the motor is discharged through the bit to aid in removing bit cuttings from the bottom of the well and to carry them to the surface.

Compressed gas in the drill pipe vented at the derrick floor when the swivel and kelly joint were removed in preparation for adding a joint of drill pipe. The gas blowing from the pipe produced considerable difficulties in adding joints of drill pipe. This problem was substantially overcome by placing a check valve in the drill string below the kelly joint. Subsequent additions of drill pipe are made above the check valve, thereby avoiding the venting of gas from the entire drill string. Each time the entire string of pipe is pulled to change drill bits, the check valve is relocated above the joints of drill pipe which were added following the previous round trip. In this manner the check valve is kept near the top of the drill string where it will be most effective.

As drilling progressed to greater depths, a further problem developed. The high-pressure gas in the drill pipe between the motor at the lower end and the check valve at the upper end continued to flow through the motor and up the well annulus while an additional joint of drill pipe was being added to the string. When the kelly joint and swivel were reconnected and gas flow resumed, considerable time was required for the compressors to build up the pressure in the drill pipe to the desired level for best operation of the percussion motor. On a well drilling at a depth of 8,000–10,000 feet, as long as 15 minutes might be required to restore the gas pressure. During the time the operating pressure is subnormal, the motor runs at low speed, delivering light blows to the drill bit, and less than normal quantities of gas are exhausted through the bit for removing bit cuttings.

I have invented a means for conserving the gas pressure in the drill string during brief interruptions in the supply of power fluid, as when a joint of drill pipe is being added to the string. Upon the resumption of drilling operations following such a stoppage, the pressure of the power fluid delivered to the percussion motor is soon restored to the peak operating level. The means by which I prevent the loss of gas pressure comprises a valve mechanism in the motor which closes or restricts the passageway through the motor when the bit is lifted off the bottom of the hole. The valve is arranged in such a way that it does not interfere with the motor during normal drilling operations.

It is therefore an object of my invention to reduce the loss of gas pressure from the drill pipe during interruptions in the supply of high-pressure gas to the pipe.

Another object of this invention is to reduce the length of time required to repressure the drill pipe to the desired operating pressure following a temporary stoppage of drilling operations.

These objects are accomplished using the apparatus in the manner described hereinafter in connection with the accompanying drawings.

FIGURE 1 is a view in cross-section of a percussion drilling motor having a valve adapted to close the fluid passageway through the motor when the bit is raised off bottom. In this view the valve is open and the motor is operative.

FIGURE 2 is another view of the apparatus shown in FIGURE 1 with the bit lifted off bottom and the fluid passageway closed.

FIGURE 3 shows a cross-sectional view of a percussion motor having a device for separating liquids carried in the air stream and bypassing them through the motor or for bypassing extra gas through the motor necessary for hole cleaning but not needed for operating the motor effectively. The valve member, inoperative in this figure, is located on the bypass tube.

FIGURE 4 shows the apparatus of FIGURE 3 with the valve closing the gas passageway through the percussion motor.

Referring now to FIGURE 1, the percussion motor 14 has a housing 11 with an anvil 12 in the lower end of the housing. A splined connection 13 transmits rotary motion from the housing to the anvil as the anvil moves longitudinally within the housing. The distance which the anvil can move within the housing is limited by the width of groove 15 in the anvil. Retainer balls 16 in the semicircular groove 17 in the housing 11 engage the upper and lower ends of the wide groove 15, thereby limiting the extent of movement of the anvil within the housing. The balls are retained in the semicircular groove by set screw 18. A drill bit 19 is connected to the lower end of the anvil 12. A hammer 21 is arranged for reciprocation inside housing 11 with the striking face 22 of the hammer delivering percussive blows to the upper face 23 of the anvil. Passageway 24 equalizes the gas pressure inside the annular chamber 25 with the motor exhaust in axial passageway 26 as the hammer reciprocates, varying the volume of chamber 25. Gas port 28 conducts the gas from the chamber 29 to a space within the housing between the striking face 22 of the hammer and the upper face 23 of the anvil. Inlet port 31 admits the gas to the chamber 29 from the drill pipe 32. An upper finger valve 34, supported by radial ribs 35 in ring 36, is adapted to close inlet port 31 at the upper position of the hammer. An adapter 33 holds the ring 36 in the upper end of the housing 11 and provides a connection for the drill pipe 32. Valve member 38, separated from the upper finger valve 34 by the reduced-diameter section 37, is positioned whereby it remains within the chamber 29 and does not interfere with the operation of the motor while the splined connection is retracted, as shown in FIGURE 1. On the other hand, valve member 38 closes inlet port 31 when the bit 19 is raised off bottom, permitting the extension of the splined connection as shown in FIGURE 2. In this position, the flow of gas through the motor is substantially terminated, thereby reducing the loss of gas pressure in the drill pipe. A cavity 39 in valve member 38 is provided to enable the frequency of the hammer to be adjusted. The volume of the cavity may be altered, e.g., either by filling the cavity with a solid material or by placing a cover over the cavity, to adjust the gas capacity of chamber 29.

The percussion motor shown in FIGURES 3 and 4

combines the valve means for retaining pressure in the drill pipe with a separator for dense materials carried in the gas stream. Curved vanes 41 between hub 42 and ring 43 impart a circular motion to the gas stream flowing to the motor. Liquids separated from the gas in chamber 47 collect in the circumferential trough 44 and the gas passes through openings 46 between the radial troughs 45 connecting the circumferential trough with the bypass tube 48. The valve member 38 is attached to the bypass tube 48. If desired, the valve member may be hollow, as shown, to reduce its mass. The length of valve member 38 may be chosen to produce the desired gas volume in chamber 29.

It is preferable that the bypass tube be long enough so that it will not be withdrawn from the lower opening 49 in the hammer, even when the splined connection is extended, as shown in FIGURE 4.

With the splined connection 13 retracted as in FIGURE 1, the percussion motor 14 operates by the flow of gas through inlet port 31, chamber 29 and gas port 28. The hammer is lifted until upper finger valve 34 closes inlet port 31. Momentum and expansion of the gas in chamber 29 continues to lift the hammer until the lower finger valve 27 is withdrawn from axial passageway 26, permitting the gas in chamber 29, and that between the hammer and anvil, to exhaust through passageway 26 and drill bit 19. Upon the decay of hammer momentum and the reduction of pressure below the hammer, the pressure above the hammer is able to reverse the direction of travel and start the hammer downward. First, the lower finger valve closes, then the gas trapped between the hammer and anvil flows through port 28, causing a slight increase in the pressure in chamber 29. Upper finger valve 34 subsequently clears inlet port 31, allowing high-pressure gas to flow into chamber 29. Sufficient momentum has been developed in the hammer that it continues to move until it strikes the anvil, producing a percussive blow which is transmitted to the bit 19.

It will be noted that valve member 38 remained wholly within chamber 29 during the above-described cycle of operation and in no way affected valve action. The volume of chamber 29 affects the frequency of the hammer, in that the pressure between the hammer and anvil must be equalized with that in the chamber via port 28. Therefore, the length of time required to change the pressure below the hammer is increased in relation to the volume of chamber 29. The volume may also be decreased by using a hammer having thicker walls or by using a shorter hammer. The thick-walled hammer is not desirable because the increased weight of the hammer decreases the blow frequency and usually requires redesign of other motor components. The shorter hammer is also undesirable for the reason that it is less stable and tends to wobble within the housing, and may be less efficient in transferring kinetic energy to the bit. A preferred method of reducing the volume of chamber 29 is to fill or otherwise close cavity 39 in valve member 38.

When it becomes necessary to add a joint of drill pipe to the drill string, the string is raised until the kelly joint is above the rotary table. This raises the bit off bottom and enables the weight of the bit and anvil to extend the splined connection 13 as shown in FIGURE 2. Retainer balls 16 engage the upper end of wide groove 15. This lowers the hammer to a position where valve member 38 closes inlet port 31 with striking face 22 of the hammer resting on upper face 23 of the anvil. In this position, there is not sufficient gas flow into chamber 29 to develop the momentum necessary to lift the hammer and open the lower finger valve. Therefore, the flow of gas through the motor is substantially stopped while the joint of drill pipe is being added to the drill string. There may be a small flow of gas through the motor owing to leakage at the valves. In gas-operated motors of this type it is usually desirable to position the finger valves whereby both are closed through about half of the hammer upstroke and downstroke. In order that the hammer will not reciprocate when the splined connection is extended, the wide groove 15 should enable longitudinal displacement through a distance at least as great as the length of the lower finger valve. This arrangement will not permit the hammer to be lifted high enough to close the top finger valve.

After the surface connections have been completed and the pipe is lowered in the well, the bit may engage cuttings which have settled in the well while gas circulation was stopped, or at least the circulation was at a reduced rate. The splined connection will retract, permitting inlet port 31 to clear valve member 38. Hammer reciprocation can then start, providing gas circulation to carry the settled cuttings from the bottom of the hole. Also, there will be substantially no delay in reaching stabilized drilling operations because the gas pressure in the drill pipe could not bleed down while the surface connections were being made.

In some instances it is desirable to inject small quantities of a liquid along with the gas used to operate the drill. This is frequently necessary when the well has penetrated water-producing zones. An oil, a foaming agent, or other material must be used to promote the removal of wet bit cuttings from the well. Substantial quantities of these materials do not pass through the percussion motor easily because they are substantially noncompressible. A separator and bypass arrangement, such as that shown in FIGURES 3 and 4, can be used to transport the noncompressible fluids through the motor. The percussion motor is substantially equivalent to that shown in FIGURES 1 and 2. The high-pressure gas containing entrained droplets flows down the drill pipe and through adapter 33. Curved vanes 41 between hub 42 and ring 43 impart a spiral motion to the gas and droplets. The centrifugal force throws the droplets against the wall of separation chamber 47 where they collect and run down the wall into circumferential trough 44. The liquid drains through radial troughs 45 into bypass tube 48 which conducts it through the motor to axial passage 26. Gas in separation chamber 47 flows through openings 46 between radial troughs 45, thence to the motor. Valve member 38 is attached to the bypass tube at a distance below upper finger valve 34, whereby it will close inlet port 31 when the splined connection 13 is extended as shown in FIGURE 4. The outside diameter of member 38 is substantially equal to the inside diameter of port 31. The volume of the chamber 29 may be adjusted by changing the volume occupied by valve member 38. The diameter of that portion which enters port 31 cannot be altered, therefore changes in the length or diameter must be restricted to the lower end of valve member 38 where it does not engage the hammer or the inlet port.

The bypass tube should be long enough so that it is not withdrawn from lower opening 49 in the hammer. Vibrations in the tube could move the tube out of axial alignment, causing it to strike the lower wall of chamber 29 and damage the tool. The lower portion of opening 49 through the finger valve is bell-shaped to avoid interference of the gas flow through passageway 24 by the lower end of the bypass. It will be apparent that the bypass tube will continue to pass gas through the motor, even though valve member 38 has closed inlet port 31. The flow capacity of the bypass tube is ordinarily quite small in relation to that of the motor; therefore, the loss of pressure in the drill pipe will be considerably less than it is when the flow through the motor is not stopped. In some instances it may be desirable to have a small flow of gas through the bit during short interruptions in drilling to hinder the settling of cuttings in the annulus. The bypass tube would serve this purpose. A continuous flow of gas through the motor shown in FIGURE 1 could be provided by an axial passageway, not shown, through upper finger valve 34 and valve member 38, and a passage-

way from chamber 29 through lower finger valve 27 to axial passageway 26.

From the above, it can be seen that I have provided a means for preventing a substantial loss of gas pressure from the drill string when there has been an interruption in the injection of high-pressure gas at the surface. This improvement is of particular value in that it reduces the time required for the compressors to restore the desired operating pressure level. It will be apparent that the valve member 38 should be positioned in hammer chamber 29, whereby it does not interfere with the flow of gas through port 31 during the operation of the motor and at a position whereby it closes port 31 when the splined connection is extended its maximum distance.

I claim:

1. A gas-operated percussion drilling tool comprising a hammer and an anvil, means for connecting a drill bit to said anvil, a housing for said hammer and anvil, an extensible splined connection between said housing and said anvil, an operating gas passageway through said hammer and anvil, a first inlet valve means and an outlet valve means in said operating gas passageway adapted to open and close said passageway alternately as said hammer reciprocates when said splined connection is contracted, and a second inlet valve means adapted to close said gas passageway when said splined connection is longitudinally extended and said outlet valve means is closed.

2. A gas-operated percussion drilling tool comprising a housing, an anvil in said housing, a splined connection between said housing and said anvil, said connection being adapted for longitudinal movement between contracted and extended positions, a hammer in said housing, said hammer arranged for reciprocation in said housing above said anvil thereby producing a variable-volume chamber between said hammer and anvil, a metering chamber in said hammer, a gas passageway between said metering chamber and said variable-volume chamber, an axial gas passageway through said anvil, a lower finger valve between said hammer and said axial gas passageway, a gas inlet in said metering chamber, a first upper finger valve arranged to open and close said gas inlet as said hammer reciprocates with said splined connection in its contracted position, a second upper finger valve arranged to close said gas inlet when said lower finger valve is closed at the extended position of said splined connection, thereby rendering said hammer inoperative.

3. A rotary-percussion drilling tool comprising a tubular housing, a hammer adapted for reciprocation in said housing, an anvil below said hammer in said housing, a splined connection between said housing and anvil, means for limited longitudinal movement of said anvil in said housing, a metering chamber in said hammer, a gas inlet in said metering chamber, an upper finger valve in said housing adapted to open and close said gas inlet as said hammer reciprocates in said housing, a volume reducer in said metering chamber depending from said upper finger valve, said volume reducer adapted to close said gas inlet when said splined connection is longitudinally extended.

4. In a gas-operated percussion drilling tool wherein a hammer reciprocates in a housing as gas flows therethrough under control of an upper and a lower gas valve and delivers percussive blows to an anvil rigidly affixed to a drill bit, said reciprocation being produced by the flow of gas through said tool with alternate opening and closing of said upper and lower gas valves, said anvil being adapted for limited longitudinal movement in said housing, the improvement comprising valve means adapted to block the flow of gas through said hammer when said anvil is extended longitudinally and said lower gas valve is closed.

5. A gas-operated percussion drilling tool comprising a housing, an anvil in the lower end of said housing, a gas inlet at the upper end of said housing, means for connecting a drill pipe to the upper end of said housing, a hammer arranged for reciprocation in said housing above said anvil, a liquid extractor including collector means in said gas inlet, a bypass tube axially disposed in said housing and extending, through said hammer, means for conducting liquid from said collector to said bypass tube, a gas passageway through said hammer, said gas passageway including inlet and outlet ports with a metering chamber between said ports, upper and lower finger valves adapted to open and close said inlet and outlet ports in alternate sequence, a splined connection between said housing and said anvil, an annular groove between said anvil and said housing, a retainer means in said groove adapted to limit the longitudinal movement of said anvil in said housing to a distance equal to the width of said groove, the minimum width of said annular groove being equal to the length of said lower finger valve, a valve member on said bypass tube, said valve member being positioned whereby it closes said inlet port when said lower finger valve is closed with said splined connection extended.

6. A gas-operated percussion drilling tool comprising a housing, an anvil in said housing, said anvil being arranged for longitudinal movement between upper and lower positions in said housing, a hammer adapted for reciprocation in said housing above said anvil, a gas passage through said hammer and anvil, said passage having a gas inlet at the top of said hammer and a gas outlet in said anvil, a first inlet valve member and an outlet valve member arranged for alternate opening and closing of said gas inlet and gas outlet when said hammer reciprocates with said anvil in said upper position, a second inlet valve member positioned to close said gas inlet when said anvil is in said lower position and said outlet valve member closes said gas outlet, and means to attach a bit to said anvil.

7. A gas-operated percussion drilling tool including a housing, an anvil in said housing, a splined connection between said anvil and said housing adapted for longitudinal movement of said anvil between upper and lower positions in said housing, a hammer in said housing adapted for reciprocation above said anvil, a gas passage through said hammer and anvil, said gas passage including an inlet at the top of said hammer and an outlet in said anvil, a first upper valve member attached to said housing and arranged to open and close said gas passage inlet, a lower valve member on the bottom of said hammer adapted to close said gas passage outlet, the opening and closing of said gas passage inlet alternating with that of said outlet as said hammer reciprocates with said anvil in said upper position, a second upper valve member attached to said housing and arranged to close said gas passage inlet when said anvil is at its lower position in said housing and said outlet is closed.

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