Dec. 27, 1955 E. M. McNATT 2,728,557

CONTROLLING OFF-BOTTOM POSITION OF PELLET IMPACT DRILL

Filed July 15, 1953 2 Sheets-Sheet 1

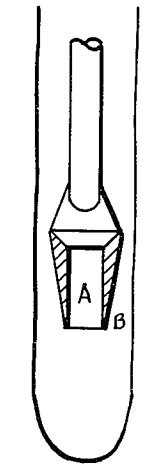


FIG.- 1

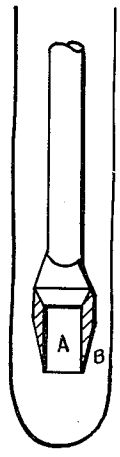


FIG.-2

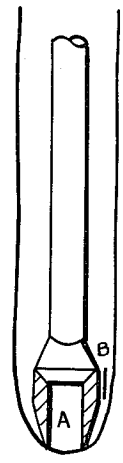


FIG.-3

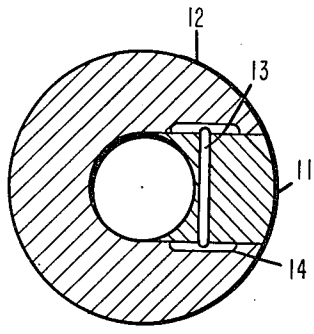


FIG.- 5

FIG. - 4

EUGENE M. McNATT INVENTOR

BY W. O. Heilman ATTORNEY

Dec. 27, 1955 E. M. McNATT 2,728,557

CONTROLLING OFF-BOTTOM POSITION OF PELLET IMPACT DRILL

Filed July 15, 1953 2 Sheets-Sheet 2

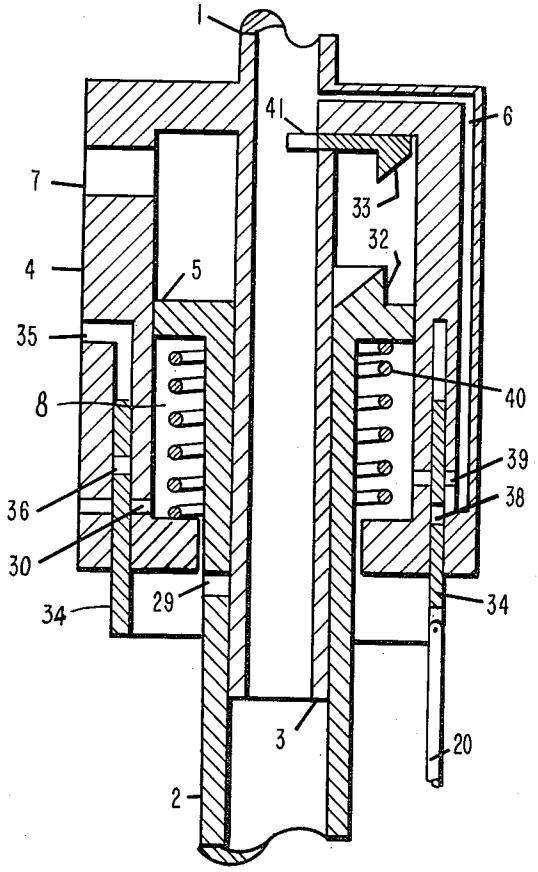


FIG. - 6

EUGENE M. McNATT INVENTOR

BY W. O. Tolman ATTORNEY

United States Patent Office 2,728,557 Patented Dec. 27, 1955

2,728,557

CONTROLLING OFF-BOTTOM POSITION OF PELLET IMPACT DRILL

Eugene M. McNatt, Tulsa, Okla., assignor to Esso Research and Engineering Company, a corporation of Delaware

Application July 15, 1953, Serial No. 368,141

7 Claims. (Cl. 255—61)

The present invention is concerned with a novel method and apparatus for the drilling of bore holes into the earth's substrata. It is particularly concerned with an improved method and apparatus for the production of, or the recovery of oil from the earth's substrata. The drilling method of the present invention employs novel principles to secure the recirculation and replenishment of solid pellets utilized in a bore hole for effectively drilling the hole. The force of the pellets impinging on the bottom of the hole pulverizes the formation and materially aids in the drilling of the hole. Circulation of the pellets is maintained by a bit arrangement involving the propulsion and recirculation of pellets in a fluid stream. The particular function of the present invention is to provide a novel and effective means for controlling the off-bottom position of the pellet impact drill.

Basically the pellet impact technique for drilling bore holes in the earth involves the use of a stream of fluid pumped from the surface of the earth through a tubular member to a jet nozzle assembly adjacent the bottom of the bore hole. The jet nozzle assembly is adapted to direct a high velocity jet of fluid against the formation being drilled and is provided with means for entraining in the jetted fluid a multitude of pellets which are accelerated to high velocity in the jet stream and thereby acquire considerable kinetic energy so that when the pellets impinge against the formation the resulting percussive and fracturing forces exert a drilling action. Preferably the pellets that are employed are smooth, non-abrasive and essentially spherical and are of substantial size, preferably in the size range of about ⅛ inch to about 1 inch or more in diameter. It is preferred that hard, dense, tough metallic alloys be employed as the pellet material. The basic principles of the technique of drilling by pellet impact are set forth in co-pending application, Ser. No. 268,873 of Philip S. Williams, entitled "Pellet Impact Drilling Method and Apparatus," filed January 29, 1952.

The effectiveness of pellet impact drilling is to a great extent dependent upon the distance the device is held off the bottom of the hole. If the drilling device is too close to the bottom or too far away from the bottom, the efficiency of drilling drops off rapidly. It has now been discovered that the correct and most efficient position off-bottom for the device can be controlled by utilizing changes in the pressure differential across the wall of the secondary nozzle of the pellet impact bit.

The process and apparatus of the present invention may be fully understood by reference to the various figures of the drawing illustrating embodiments of the same.

Figures 1–3 schematically represent the device attached to the lower end of a drill string in a bore hole at various positions with respect to the bottom of the hole.

Figure 4 is a sectional elevation showing the details of one embodiment of the invention

Figure 5 is a section taken across line V—V of Figure 4.

Figure 6 illustrates a modification of the device, this figure constituting a sectional elevation of a structure

substituted for the upper half of the structure of Figure 4.

Referring specifically to Figures 1, 2 and 3, the principle of the variation in the pressure differential across the walls of the secondary nozzle of a gravity-aspirator type pellet impact bit is illustrated as the bit is raised off the hole bottom. With the bit resting on the bottom, as shown in Figure 3, the fluid pressure at A is greater than at B. On the other hand, because of the aspirator action of the jet as the bit is raised off bottom, as shown in Figure 1, the pressure at A will be less than at B. It therefore follows that at some intermediate position, as shown in Figure 2, the pressures must be equalized, at which point pressure A equals pressure B.

The use of this principle for securing the correct off-bottom position is illustrated by Figure 4, showing one mechanism suitable for use. The device shown in Figure 4 is depicted in its desired off-bottom position in a bore hole **50** being drilled by action of circulating pellets **55**. Drill string **1** supports the entire assembly in the bore hole. Primary nozzle barrel **2** is slidably fitted on tubular support member **3**. Cylinder **4** is integrally attached to the support member at its upper end and at its lower end is slidably fitted to primary nozzle barrel **2**. The upper end of primary nozzle barrel **2** terminates in piston **5**, which fits slidably within cylinder **4**. Cylinder **4** has a channel **6** cut in it to provide a fluid connection between the interior of support member **3** and annular chamber **8**. Ports **7** provide a fluid passageway to equalize the pressure on the top side of piston **5** with that in bore hole annulus **9**. The diameter of piston **5** is adjusted so that the upper thrust on piston **5**, when bleed port **30** is open is equal to the downward force on the primary nozzle **10**. This arrangement provides a neutrally stable, primary nozzle barrel **2** which will remain in a given position until the balance of upward and downward thrusts is destroyed.

As illustrated by Figure 5, the secondary nozzle assembly comprises two pieces, **11** and **12**, which are slidably fitted to each other. Element **12** is rigidly fixed to nozzle barrel **2** by means of struts or web members **28** The relative movements of parts **11** and **12** is limited to horizontal translation (as viewed in Figure 4) by a plurality of pins **13**, sliding in slots **14**. Part **11** is fitted with slot **15** which slidably receives bell crank **16**. Pin **17** is attached rigidly to part **11** and passes through slot **18** in the bell crank **16**. Bell crank **16** pivots about pin **19** which is rigidly attached to web **21**, which in turn is an integral part of nozzle barrel **2**. Pin **22** is a pivot pin connecting link **20** with bell crank **16**. A housing **26** is provided which is attached to nozzle barrel **22** and surrounds a portion of the lever mechanism comprising bell crank **16** and link **20** to prevent damage by pellets or other solid material that may be present in the bore hole annulus. Spring **27** attached at one end to the nozzle barrel **2** and at its other end to lever **16** may be used in the event that a preloading is desired on the bell crank lever **16**. The upper end of link **20** is pivotally connected to slide valve **31** which serves to open or close port **30**. In operation, when the drill bit is too close to the hole bottom, the pressure inside the secondary nozzle assembly **11—12** increases. This causes outward motion of element **11** relative to element **12**, which in turn causes the linkage made up of lever **16** and link **20** to move valve **31** upwardly and close port **30**. This in turn causes the pressure in annular chamber **8** to increase, thus upsetting the balance of upward and downward forces acting on nozzle barrel **2**. This unbalanced upward force causes the nozzle barrel **2** to slide upwardly on support member **3** until the pressure inside secondary nozzle assembly **11—12** decreases to the initial value. When this occurs, the desired off-bottom spacing will have been attained and the pressure differential across

the secondary nozzle wall will cause element 11 to move radially inward. This will open port 30. In the manner described, the bit will have automatically corrected for too short an off-bottom spacing.

To correct for too great an off-bottom spacing bell crank 16 has a slot 23 cut in it through which pin 24 passes. Pin 24 in turn is attached to the end of member 25. The other end of member 25 slidably fits in a slot in the primary nozzle 10. In operation, as the off-bottom distance increases the pressure inside secondary nozzle assembly 11—12 decreases and the pressure differential across the nozzle wall causes element 11 to slide toward element 12. Pin 17 causes bell crank 16 to move pin 24 inwardly which moves the left end of member 25 into the primary jet stream. This increases the downward force on nozzle barrel 2 and destroys the previous balance of force. Therefore, the nozzle barrel and entire bit will move downwardly until the desired off-bottom position is attained. At this point the pressure differential across the wall of the secondary nozzle will have moved element 11 back to its original position, which will pull member 25 out of the primary jet stream and restore the balance of up and down forces. Since these forces are in equilibrium the bit will come to rest at this position.

Referring specifically to Figure 6, illustrating an alternate arrangement which may be used to achieve the desired automatic correction for incorrect off-bottom positions, this alternate device is similar in many respects to that of Figure 4. The major differences between the structures are that valve 31 is replaced by the cylindrical slide valve 34 that is capable of controlling port 39 in channel 6 as well as controlling port 30, and that the spring 40 is placed under piston 5. The device illustrated in Figure 6 will provide an upward force on nozzle barrel 2 which is independent of variations in fluid pressure. This is the function of spring 40. Spring 40 should be at least ten times as long (in its unstressed position) as the length of deflection desired so as to require a relatively constant force for its deflection.

In the arrangement illustrated in Figure 6, the net area of piston 5 is constructed so as to give a greater upward force than the downward force exerted by fluid of equal pressure on primary nozzle 10. In operation, at the desired off-bottom position, the total down load on nozzle barrel 2 is balanced by a combination of upward forces due to spring 40 and the fluid pressure in annular chamber 8 and the cylindrical slide valve 34 is positioned so as to prevent fluid from entering or leaving annular chamber 8. Port 35 equalizes pressures on the top and bottom of cylindrical slide valve 34. If the off-bottom spacing becomes too small, the pressure in secondary nozzle assembly 11—12 increases with the resulting outward relative movement of member 11. This causes the bell crank 16 (Figure 4) to move link 20 upward. This in turn causes port 38 in slide valve 34 to come in line with port 39 which opens a fluid passage into annular chamber 8. The result is that the fluid pressure in annular chamber 8 increases, forcing piston 5 upwardly. When the bit has moved the necessary amount upwardly, the pressure differential across the wall of the secondary nozzle causes the component 11 to return to its normal position which causes slide valve 34 to close off port 39. Therefore the upward motion of the bit stops and automatic adjustment of off-bottom position is secured.

If the bit is too far off bottom the pressure differential across the wall of the secondary nozzle causes component 11 to move inwardly. This causes link 20 to be pulled downwardly, which in turn moves slide valve 34 down until port 36 mates port 37 and provides a fluid passage out of annular chamber 8. At the same time, member 25 (Figure 4) closes off the primary jet with the result that the downward forces overbalance the upward forces on nozzle barrel 2 and it moves downwardly until the desired off-bottom position is attained. At this point, the secondary nozzle member 11 will return to its normal relative position relative to member 12 (because of a change in the pressure differential across the nozzle wall) and hence the mechanical linkage will simultaneously close port 37 and remove member 25 from the primary jet. Thus, the bit will come to rest at the new position which is the desired off-bottom position.

The device of the present invention also provides for sending an indication to the surface when nozzle barrel 2 has reached the lower and upper limits of its travel. When the lower limit of travel is reached port 29 drops below the lower end of support member 3 and provides a fluid passage from the interior of the support member to the annulus. This port 29 is of sufficiently large area to cause a noticeable pressure drop at the surface which indicates to the driller that the automatic adjustment has reached the end of its travel and more pipe must be let down into the bore hole.

On the other hand, the upper limit of the travel of the bit is indicated by a pressure rise. This is achieved as piston 5 approaches the upper limit of its travel. Cam 32 on piston 5 engages cam 33 and causes cam 33 to slide to the left and force plate 41 into the path of the fluid in the drill string. The subsequent reduction of flow area in the drill string causes the pressure to rise at the surface and thus warns the driller, who can take the necessary action.

As pointed out before, the present invention comprises a method of utilizing changes in the pressure differential across the wall of a secondary nozzle of a gravity-aspirator type bit in order to control automatically its off-bottom position and thus insure efficient operation at all times.

What is claimed is:

1. An apparatus for drilling a bore hole in the earth by pellet impact which comprises a tubular support member, a cylinder fixed to and surrounding said support member, a nozzle barrel slidably surrounding said support member, said nozzle barrel terminating below said support member in a primary nozzle in fluid communication with the bore of said support member and terminating at its upper end in a piston fitting slidably within said cylinder in a manner defining a first annular chamber below said piston between said cylinder and said nozzle barrel and a second annular chamber above said piston between said cylinder and said support member, said cylinder having a lower exterior port into said first annular chamber, an upper exterior port into said second annular chamber and a passageway establishing fluid communication between said first annular chamber and the bore of said support member, a secondary nozzle fixed to said nozzle barrel and spaced below said primary nozzle, said secondary nozzle including a segment movable in response to changes in the pressure differential across said secondary nozzle, and means controlling the opening of said lower port in response to the motion of said movable segment.

2. Apparatus as defined by claim 1 including means controlling flow through said passageway in response to the motion of said movable segment.

3. Apparatus as defined by claim 1 including means controlling fluid flow through said primary nozzle in response to the motion of said movable segment.

4. Apparatus as defined by claim 1 wherein said nozzle barrel is provided with a port in the wall thereof so located that said port is closed off by said tubular member except when said piston has moved to a position adjacent its lowermost point of travel, whereby exposure of said port will cause a drop in pressure within said support member indicative of said lowermost positioning of said piston.

5. Apparatus as defined by claim 1 including means for restricting flow through the bore of said tubular support member and means for activating said flow restricting means when said piston has reached a position adjacent its uppermost point of travel, whereby said flow restriction will cause a pressure buildup within the bore of said tubu-

lar support indicative of said uppermost positioning of said piston.

6. Apparatus as defined by claim 1 wherein said means for controlling the opening of said lower port comprises a slide valve and a lever linking said slide valve to said movable nozzle segment in a manner causing said slide valve to close said port on outward movement of said segment.

7. Apparatus as defined by claim 1 wherein said means for controlling the opening of said lower port comprises a slide valve movable to a first position closing said lower port and also said passageway, to a second position opening said lower port while maintaining said

passageway closed, and to a third position opening said passageway while maintaining said lower port closed, and a lever linking said slide valve to said movable nozzle segment in a manner moving said slide valve toward said second position on outward movement of said segment, moving said slide valve toward said third position on inward movement of said segment and placing said valve in said first position when said segment is intermediate its inwardmost and outwardmost positions of travel.

References Cited in the file of this patent

UNITED STATES PATENTS

1,659,826 Malloy et al. ---------- Feb. 21, 1928