July 23, 1968 E. A. MORI 3,393,756

RETRIEVABLE JET BIT WITH SWING JETS

Filed Nov. 16, 1966 2 Sheets-Sheet 1

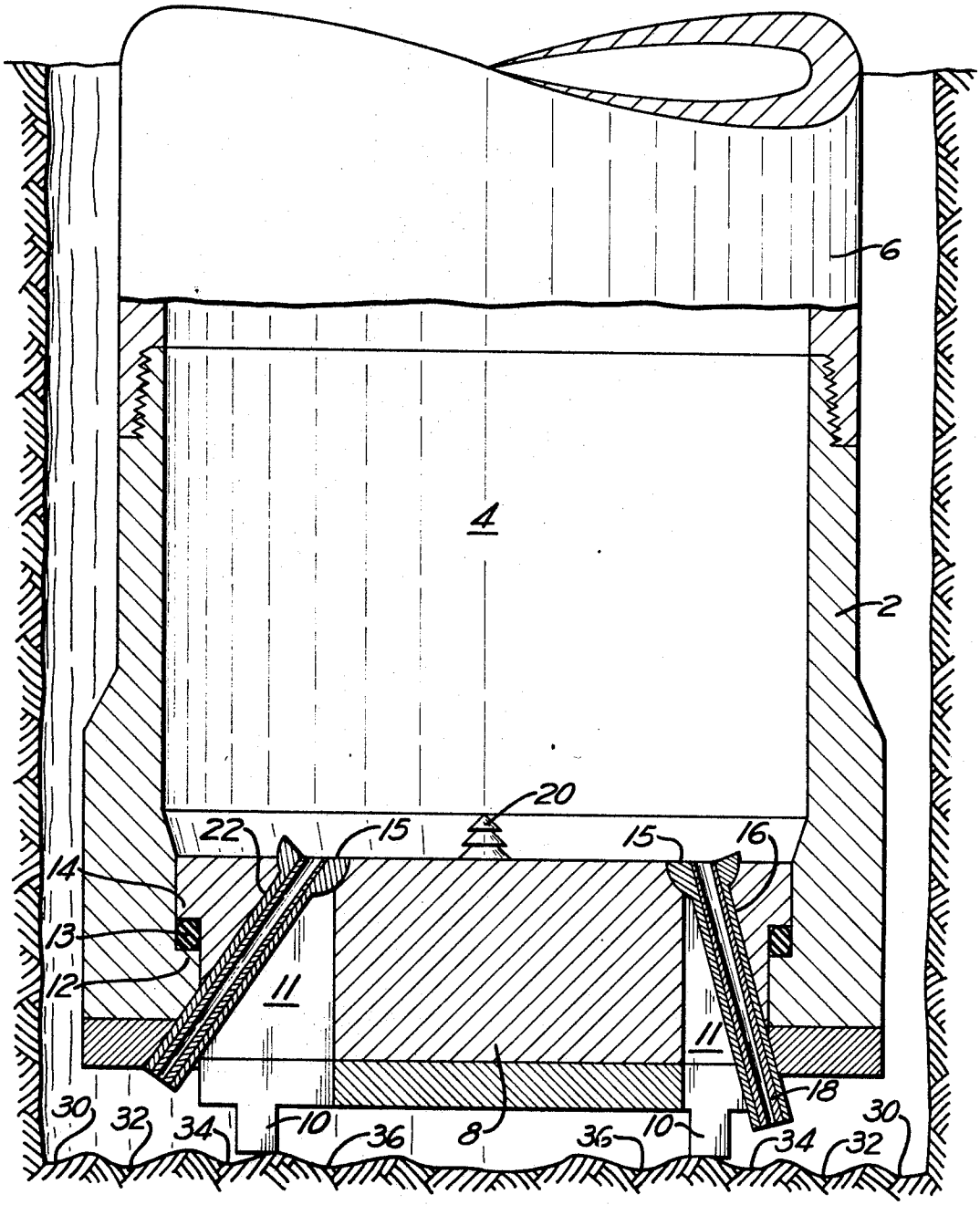

Fig. 1

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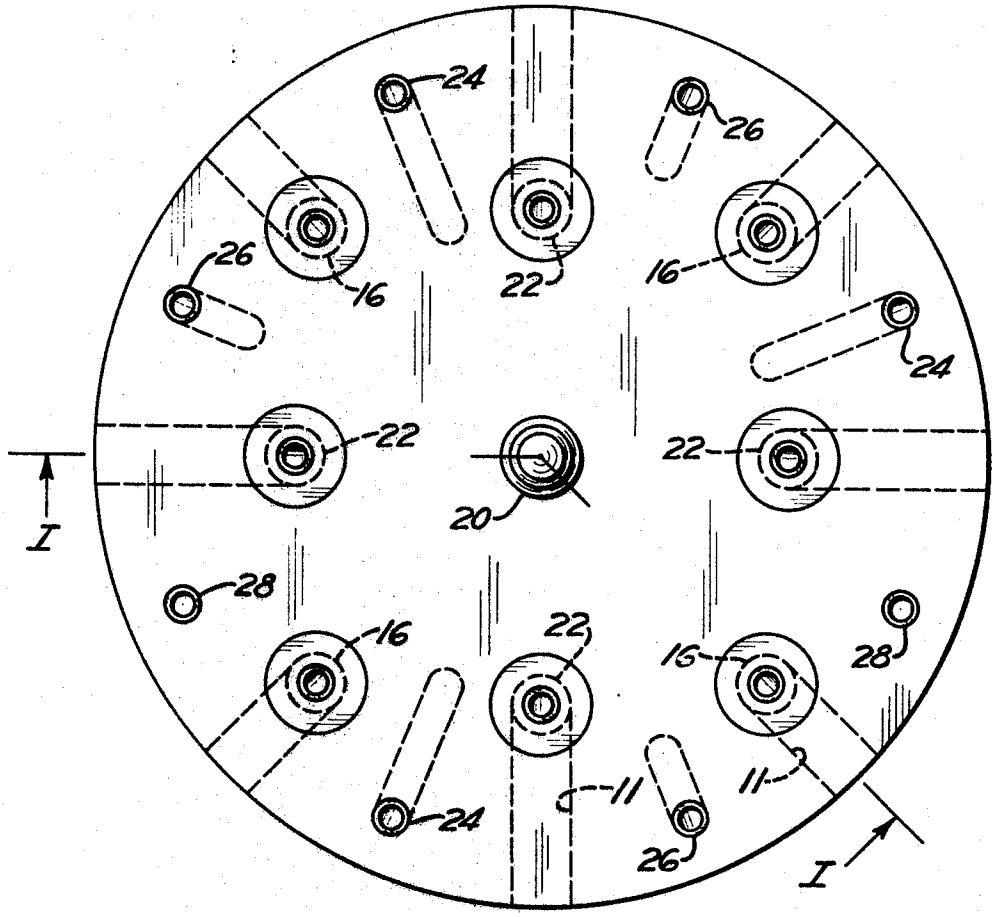

Fig. 2

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United States Patent Office

3,393,756

Patented July 23, 1968

3,393,756

RETRIEVABLE JET BIT WITH SWING JETS

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Filed Nov. 16, 1966, Ser. No. 594,900
7 Claims. (Cl. 175—258)

ABSTRACT OF THE DISCLOSURE

A drill bit for hydraulic jet drilling in which a nozzle holder is supported on a nozzle holder seat in the drill bit body to permit lifting of the nozzle holder from he seat for retrieving the nozzle holder. Nozzles are mounted pivotally in the nozzle holder whereby the application of pressure within the drill bit causes pivoting of the nozzle to a position at which a high-velocity stream discharged from the nozzle will cut a groove having a diameter larger than the drill bit body.

This invention relates to an apparatus for the hydraulic jet drilling of wells.

A recent development for drilling formations is to utilize abrasive-laden liquid as a drilling fluid and bombard the bottom of the borehole with this liquid by passing it through nozzles at extremely high velocities of at least 500 feet per second. In the operation of heretofore employed jet bits the outlet of the nozzles is maintained within a close and carefully controlled distance from the bottom of the borehole to prevent dissipation of the impact energy in the high-velocity stream of abrasive-laden liquid discharged from the nozzles and to reduce erosion of the bit by back splash of the abrasive-laden liquid against the bottom of the bit. The drill string is rotated to rotate the bit and cause the exit points of the high-velocity streams to travel over the bottom of the borehole to cut a borehole of the desired diameter. Drilling liquid downwardly discharged from the nozzles cuts, substantially by impact, overlapping or continuous grooves. Virtually the entire removal of rock from the bottom of the hole is thereby accomplished by the initial bombardment of the streams of drilling liquid.

Other jet bits have been designed whose nozzles cut a plurality of concentric vertical grooves separated by intervening annular ridges. The proper interval of separation between the nozzle outlet and the formation is maintained by standoff bars mounted on the bottom of the jet bit. The leading edge of the standoff bars mechanically break the intervening ridges.

These heretofore employed bits must be removed from the bottom of the borehole when their nozzles become damaged or worn. To accomplish removal, the entire string of drill pipe must be pulled from the hole and rerun with a new or repaired bit installed on its lower end. This bit change operation requires a great deal of time and supervision. This necessary bit change operation also functions to seriously decrease the amount of borehole that can be drilled per day.

This invention resides in an improved hydraulic jet drilling apparatus in which the nozzles are contained within a nozzle body which may be removed from the well without pulling the drill pipe. To permit removal of the nozzle holder and maintain proper nozzle standoff during drilling operations, the nozzle holder of this invention contains a series of concentrically placed differential area swing nozzles. These swing nozzles, owing to their design, will swing outwardly with the initiation of fluid through the bit, but when pressure is released will swing to a vertical position to permit withdrawal of the nozzle holder through the drill pipe which has a larger

inside diameter than the outside diameter of the nozzle holder. It is necessary for the nozzles to swing to an outward position during drilling operations to assure the proper standoff distance between the discharge end of the nozzles and the formation. The swing nozzles of this bit cut overlapping grooves whose outer diameter is the same as the diameter of the borehole. A series of inclined stationary nozzles are directed and positioned to cut and abrade the rock between the center of the borehole and the groove cut by the series of swing nozzles. Standoff bars are mounted on the nozzle holder to maintain the proper standoff distance between the formation and the outlet of the nozzles. A fishing neck is mounted on top of the nozzle holder to permit the removal of the nozzle body by the use of an overshot run on a wire line.

In the drawings:

FIGURE 1 is a diagrammatic view, partially in cross section, taken along section line I—I of FIGURE 2, of the drill bit of this invention located in the borehole of the well.

FIGURE 2 is a plan view of the top of the nozzle holder used in the bit of this invention.

Referring to FIGURE 1, in which a bit of this invention is illustrated, the drill bit **2** has a central opening **4** extending upwardly through the bit **2** for communicating with the opening of the drill string **6**. The lower end of the opening **4** is closed by a nozzle holder **8**. Short concentrically shaped standoff bars **10** are positioned around the bottom of the nozzle holder **8**. These standoff bars **10** are protected from abrasion by mounting hard abrasive-resistant material **11**, such as tungsten carbide, on their outer surface. The bottom of the drill bit **2** and the nozzle holder **8** are likewise protected from abrasion.

A seating shoulder **12** is formed on the inside lower portion of the drill bit **2** to contact a nozzle holder seat **14** formed on the outer periphery of the nozzle holder **8**. A sealing ring of rubber **13**, or other deformable material, is placed between the seating shoulder **12** and the nozzle holder seat **14** thereby effecting a fluid seal and causing fluid to pass through the plurality of nozzles. Outwardly extending differential area swing nozzles, generally indicated by numerals **16** and **22** with nozzle inserts **18**, as preferred in this invention, are installed through the nozzle holder **8**. The fluid passageways of the swing nozzles **16** and **22** are positioned eccentrically through the nozzle holder **8** thereby causing the swing nozzles **16**, **18** to pivot outwardly as pressure is applied to the top of the nozzle holder. As the pressure is released from the drill string **6** the discharge end of the swing nozzles **16**, **18** will swing downwardly to a position which will allow recovery of the nozzle holder **8** through the drill string **6**. A fishing neck **20** is mounted on the top of the nozzle holder to be used to remove the nozzle holder **8** from the well.

Numeral **30** represents the overlapping groove cut by the abrasive-laden fluid stream discharged from swing nozzle series **22**. Swing nozzle series **16** will cut the overlapping grooves **32**. The inwardly directed stationary nozzle series **28** will cut and abrade an overlapping groove, indicated by numeral **34**. The center of the borehole will be removed by abrasive-laden fluid discharged from nozzle series **24**. Nozzle series **26** will cut an overlapping groove **36** and remove the rock between the grooves cut by nozzle series **28** and **24**.

The abrasive-laden drilling liquid is passed through the drill string, the drill bit **14** and discharged from the nozzles at a rate of at least 500 feet per second resulting in a pressure drop through the nozzles of the drill bit of the order of at least 2000 pounds per square inch to impart the desired high velocity to the drilling liquid discharged from the nozzles. The drill string and the drill bit are rotated during the drilling operations whereby the high-

velocity streams of drilling liquid discharged from the nozzles cut a series of overlapping concentric grooves whose outer diameter is substantially the diameter of the borehole.

FIGURE 2 shows the concentric placement of the nozzle inlets and the nozzle holder **8**. A series of outwardly extending differential area swing nozzles, indicated by numeral **22**, are positioned to cut a groove in the formation whose outer diameter is substantially the same as the diameter of the borehole. A second series of outwardly extending differential area swing nozzles, indicated by numeral **16**, are positioned to cut a groove in a formation whose outer diameter overlaps the groove cut by nozzle series **22**. Other series of nozzles **24**, **26**, **28**, with circumferentially positioned inlets, are directed and positioned to cut and abrade the rock between the center of rotation of the bit and the groove cut by the series of swing nozzles **16**.

The swing nozzles are pivotally mounted through the nozzle holder **8** with their fluid passageways eccentrically positioned in nozzle supports **15**. A slot **11** is formed through the nozzle holder **8** extending outwardly to the lateral surface of the nozzle holder **8** thereby permitting the swing nozzle to pivot outwardly as pressure is applied to the top of the nozzle holder **8**.

As preferred in this bit, stationary downwardly and inwardly directed nozzles **24** are directed to cut and abrade the center of the borehole. Stationary downwardly and inwardly directed nozzles **28** are positioned to cut and abrade a groove whose outer diameter will overlap the inner diameter of the groove cut by swing nozzles **16**. Stationary downwardly and inwardly directed nozzles **26** are positioned to cut and abrade an overlapping groove and remove the rock between the grooves cut by stationary nozzles **28** and **24**.

During drilling operations the pressure on top of the nozzle holder will cause the swing nozzles to swing outwardly through slots formed through the nozzle holder and thereby be in a proper position and at a proper standoff distance to cut and abrade the outer extremes of the borehole. The proper standoff distance of the series of swing nozzles which cut the outermost groove in the borehole will be a position whose distance from the center of rotation is greater than inside radius of the bit body. As pressure is released from the drill string the discharge end of the swing nozzles will swing downwardly to a position which will permit recovery of the nozzle holder upward through the drill string.

A worn or damaged nozzle holder may be recovered at the surface by utilizing a wire line operated catch tool. An overshot, attached to a wire line, is run into the well and attached to the fishing neck mounted on top of the nozzle holder. The drill bit is then forced downwardly against the bottom of the borehole to unseat the nozzle holder from the bit body. The inside diameter of the drill pipe is larger than the inside diameter of the bit area in which the nozzle holder is seated. As the bit is bumped down the nozzle holder will be forced upward into the portion of the bit having a larger diameter, thereby making recovery of the nozzle holder less difficult. The nozzle holder may then be pulled up the drill pipe and recovered at the surface. To insert a nozzle holder into the bit body the nozzle holder may be either run on a wire line and released or bumped down the drill string and seated into the bit body. During insertion of the nozzle holder the swing nozzles will be resting in a substantially vertical position.

In the drilling of a well with the hydraulic jet bit of this invention, penetration is accomplished by the high-velocity streams of abrasive-laden liquid. The swing jets of this bit operate to permit the recovery of the nozzle holder through the drill pipe and allow proper nozzle standoff to be maintained during drilling operations.

Therefore I claim:

1. In apparatus for the hydraulic jet drilling of a borehole of a well by discharging high-velocity jet streams from a drill bit against the bottom of the borehole, an improved drill bit comprising a tubular drill bit body adapted to be connected to the lower end of drill pipe, an inwardly extending seating surface at the lower end of the drill bit body, a nozzle holder on the seating surface, a pivotally mounted nozzle support in the nozzle holder, a slot in the nozzle holder below the nozzle support extending outwardly to the lateral surface of the nozzle holder, and a nozzle eccentrically mounted in the nozzle support and extending downwardly through the slot whereby hydraulic pressure in the drill bit rotates the nozzle to an outer position to cut a groove having a larger diameter than the drill bit.

2. An apparatus for the hydraulic jet drilling of wells by discharging suspensions of abrasive particles in liquids from nozzles at a velocity of at least 500 feet per second against the bottom of the borehole comprising a hollow drill bit body, a nozzle holder seat formed on the inner surface of the drill bit body, a retrievable nozzle holder seated in the nozzle holder seat, a swing nozzle pivotally mounted on the nozzle holder and extending therethrough to cut a groove whose outer diameter is larger than the outside diameter of the bit body on rotation of the bit, and a plurality of stationary nozzles set through the nozzle holder positioned to cut the bottom of the borehole between the center thereof and the groove.

3. An apparatus for the hydraulic jet drilling of wells by discharging suspensions of abrasive particles in liquids from retrievable nozzles at a high velocity against the bottom of the borehole comprising a hollow drill bit body, a nozzle holder seat formed on the inner surface of the bit body, a nozzle holder in contact with the nozzle holder seat, a first swing nozzle pivotally mounted on the nozzle holder and extending therethrough to cut a groove whose outer diameter is substantially the same as the diameter of the borehole, a second swing nozzle pivotally mounted on the nozzle holder and extending therethrough to cut a groove whose outer diameter overlaps the groove cut by the first swing nozzle and whose inner diameter is less radially remote than the groove cut by the first swing nozzle, and a plurality of stationary nozzles set through the nozzle holder and directed to remove the rock between the center of rotation of the borehole and the groove cut by the second swing nozzle.

4. An apparatus as set forth in claim **3** in which the nozzles have a discharge diameter of $\frac{3}{32}$ to $\frac{1}{4}$ inch.

5. An apparatus as set forth in claim **3** in which the nozzle holder is of smaller outside diameter than the inside diameter of the drill string whereby the nozzle holder may be removed from the well without pulling the drill string.

6. An apparatus as set forth in claim **3** in which the nozzle holder has nozzle inserts installed therethrough.

7. An apparatus as set forth in claim **3** in which standoff bars are mounted on the bottom of said nozzle holder to maintain the proper standoff distance between the discharge end of the nozzles and the formation.

References Cited

UNITED STATES PATENTS

1,852,903	4/1932	Salmon	175—422
2,685,431	8/1954	James	175—393
2,720,390	10/1955	Brooks	175—422

JAMES A. LEPPINK, *Primary Examiner.*