Feb. 21, 1956 A. B. HILDEBRANDT 2,735,654

EXPANDING TYPE MOMENTUM PELLET IMPACT DRILLING APPARATUS

Filed Oct. 28, 1952

FIG. — 1

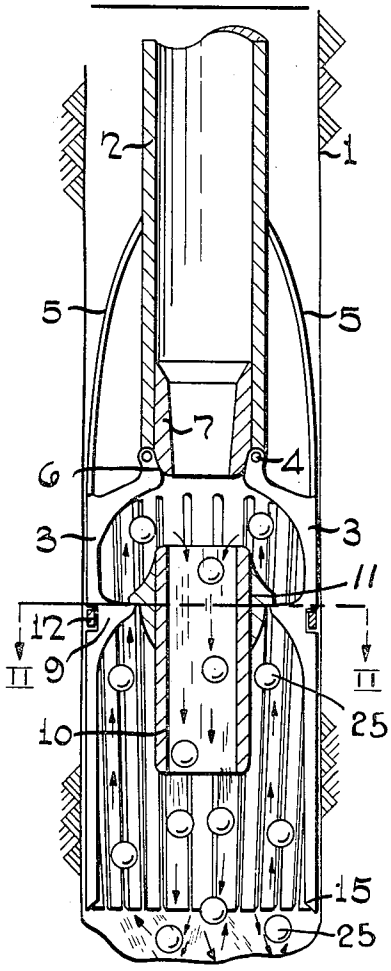
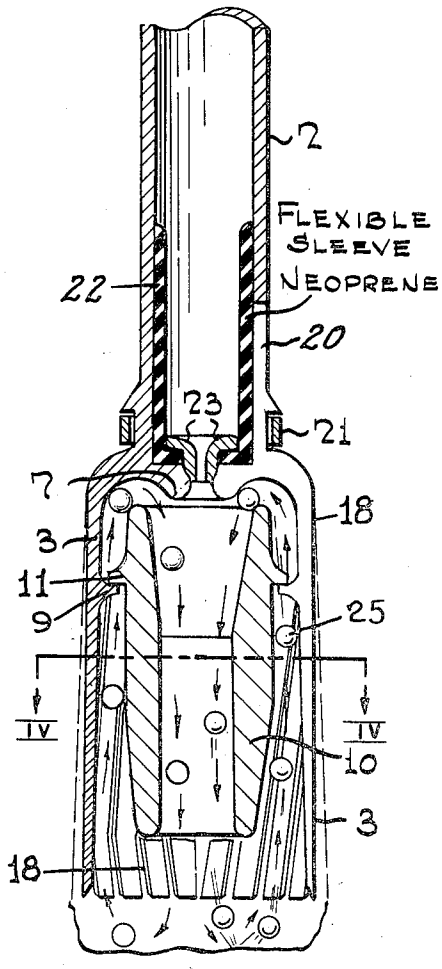



FIG. - 3



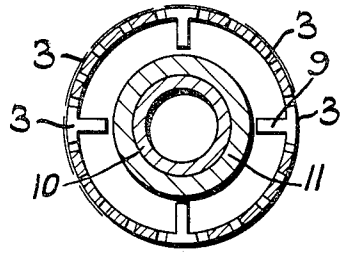




FIG. - 2

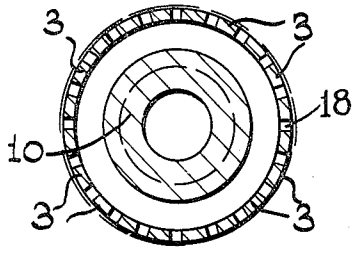



FIG. - 4

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# EXPANDING TYPE MOMENTUM PELLET IMPACT DRILLING APPARATUS

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4 Claims. (Cl. 255—61)

This invention concerns a novel form of a drill bit for the drilling of bore holes in the earth. The apparatus of this invention is of particular application in drilling for petroleum oil. The invention embodies the principles of pellet impact drilling in which a large number of hard dense spherical pellets are entrained in a high velocity fluid jet so as to be forcefully impinged against an earth formation to be drilled.

The invention particularly concerns the manner in which these pellets are recirculated in the immediate vicinity of the drilling zone. In accordance with this invention a particular type of shroud or cage is provided to cause the captive deflection and re-circulation of the pellets adjacent the drilling zone so as to redirect the pellets into the fluid jet employed. A pellet deflecting cage is used incorporating means to expand the cage, during drilling, to the gauge size of the bore hole. When drilling is discontinued the pellet deflector cage is of a character permitting contraction to a diameter less than that of the drill hole to facilitate removal of the drilling apparatus from the bore hole.

It has recently been discovered that a remarkably effective drilling action can be achieved by a basic innovation in drilling techniques. The copending patent application, Serial No. 268,873 filed for Philip S. Williams, on January 29, 1952, entitled "Pellet Impact Drilling Method and Apparatus," sets forth the basic principles of this drilling technique. In accordance therewith a stream of fluid is pumped from the surface of the earth through a tubular member to a jet nozzle assembly suspended thereby in a bore hole. While a variety of jet nozzle assemblies may be employed, these assemblies are so arranged as to cause the forceful ejection of a directed high velocity jet of fluid. The nozzle assembly is of a nature to permit entrainment of a multitude of pellets in this fluid jet. Entrained in the fluid jet, the pellets attain a high kinetic energy so that on impingement against the bottom of the bore hole, percussion and fracturing forces cause a drilling action. The pellets to be employed are smooth, non-abrasive, spherical pellets having a diameter of about ⅛ of an inch to one inch. Hard, tough metallic alloys are preferably employed.

In considering this basic drilling technique it becomes important to provide a suitable and effective manner of securing continuous recirculation of the pellets in the fluid jet. Thus means are required to carry pellets upwardly after impact and to permit the pellets to be re-entrained in the fluid jet. In this connection it would appear impractical to consider circulating the pellets through any substantial length of the bore hole. It is clearly of the greatest practical importance to enable recirculation of the pellets in the immediate vicinity of the drilling zone. This serves to conserve the energy required and to increase the effective density of the pellets in the drilling zone while permitting use of a smaller number of pellets.

In the patent application referred to, setting forth the basic principles of pellet impact drilling, one manner of



securing the desired recirculation of the pellets is disclosed. This method requires configuration of the jet nozzle assembly so as to provide a gravity settling zone above the assembly, in which the pellets may separate from the drilling fluid so as to settle in a recirculation channel communicating with the fluid jet. This invention is in part directed to an improvement of this gravity separation technique, particularly in providing means to effectively employ momentum of the pellets for effective re-entrainment in the jet.

The basic principle employed in the method and apparatus of this invention is to provide a deflecting surface in the annular space above the jet assembly between the drill pipe and the bore hole. This deflecting device is so arranged as to effectively block passage of the pellets upwardly while permitting passage of drilling fluid and pulverized earth formation. Consequently the deflector serves to separate and, at least in part, to redirect the pellets towards the entraining fluid jet for recirculation.

To provide a deflector of the required character it has been found useful to employ a dependent shroud suspended below the nozzle assembly employed in propelling the pellets. This shroud can constitute a rigid metallic sleeve element having an outer diameter equal to the gauge of the bore hole drilled by the pellets. The sleeve is preferably joined to the jet assembly so as to provide a curved deflecting surface for pellets. In addition to these features the sleeve or shroud is perforated at least at the upper portion to permit the upward passage of the drilling fluid while blocking the passage of pellets upwardly. In this arrangement pellets ejected by the jet assembly are directed against the bottom of the bore hole to secure drilling action. The outer and upward circulation of the entraining drilling fluid causes the pellets to be directed upwardly along the inner surface of the sleeve. In the upward passage of the pellets along the sleeve, the pellets encounter the curved deflecting surface referred to so as to be redirected into the fluid jet for continuous cyclic drilling action.

While the type of a rigid shroud element described has been found effective in controlling recirculation of pellets during drilling, difficulties have been encountered in removal of this apparatus from a bore hole. By the nature of the shrouded pellet impact drilling apparatus, the shroud will and must fit closely in the bore hole during drilling. Consequently when it becomes necessary to remove this drill from the bore hole the possibility of jamming exists and it may become difficult to extract the drill from certain formations.

It is therefore the principal object of this invention to provide a shrouded pellet impact drill in which the shroud can assume one of two positions. In a first contracted position, assumed by the apparatus when drilling has been discontinued, the shroud of the apparatus is maintained at a smaller diameter than the bore hole drilled by the apparatus. In a second drilling position of the apparatus, the shroud is maintainable in an expanded position equal to the gauge size of the bore hole drilled. This expansible feature of the shroud greatly improves the practical utility of the drilling apparatus and eliminates problems otherwise encountered in withdrawing the apparatus from the bore hole.

The apparatus by which these objectives are accomplished is characterized by use of a shroud or pellet deflecting cage which is segmented. Thus the sleeve or shroud employed may be cut along vertical planes so that the shroud includes some 10 to 20 individual segments. Each of these segments is dependent from a supporting member which may constitute the nozzle assembly used for propelling the pellets. The individual segments are hinged to the supporting member or may be flexibly fixed thereto, so as to permit limited expansion

and contraction of the lowermost portion of the shroud. In order to secure the positive expansion of the shroud segments, hydraulic means are employed to forcefully expand the shroud members to the extended drilling position when drilling fluid is pumped through the nozzle assembly for drilling operations.

The nature of this invention may be fully understood by reference to the accompanying drawings in which:

Fig. 1 diagrammatically illustrates in a cross-sectional elevational view one form of the apparatus of this invention employing articulated shroud segments adapted to be expanded to drilling position by the hydraulic force exerted on the primary nozzle of the jet assembly.

Fig. 2 is a sectional view of Fig. 1 along line II—II of Fig. 1 particularly showing the manner in which the secondary nozzle is supported by the segmented shroud.

Fig. 3 shows an alternative form of the present invention in cross-sectional elevational detail particularly adapted for use of flexible shroud members.

Finally Fig. 4 shows a cross-sectional view of Fig. 3 along line IV—IV to particularly show the segmented shroud members.

The apparatus of Fig. 1 is illustrated in drilling position within a bore hole **1** drilled in the earth. The drilling apparatus is held in the bore hole on a drill string or tubular member **2**. A plurality of shroud segments **3** are hinged to the lower termination of the tubular support **2**. Thus, for example, each of the shroud segments may be held in pivotal relation to support **2** by means of pivot pins **4** passing through lugs of each shroud segment and fixed to tubular support **2**. The shroud segments are maintained in closely spaced relation with each other.

Each of the shroud segments **3** carries an upwardly extending spring extension **5** which bears against tubular support **2**. The spring extensions **5** bear against support **2** so as to urge the lower edges of each shroud segment inwardly towards the center of the bore hole. Each of the shroud segments **3** is provided with an inner extension adjacent the pivot **4** which tapers inwardly and downwardly. These extensions are identified by numeral **6** in Fig. 1. A nozzle element **7** fitting within the lower extension of tubular member **2** is shaped to mate with the tapered extensions **6**. Thus the lower end of nozzle **7** tapers inwardly at its lower termination so as to bear against the inclined surfaces presented by the extensions **6**. From this configuration it is apparent that a downward force exerted on the nozzle **7** applies a cam or lever action against the extensions **6** forcing each of the segments outwardly in the bore hole.

In addition to the elements described a number of inwardly extending lugs **9** may be positioned on some of the shroud segments. As shown in Fig. 2 four such inwardly extending lugs may be employed. These lugs are used to hold a secondary nozzle element **10** within the shroud concentric with the primary nozzle **7**. Thus the secondary nozzle **10** is equipped with an enlarged collar element **11** adapted to rest on the inwardly extended lugs **9** of the shroud. The collar **11** of the secondary nozzle **10** has a sufficient diameter to permit the shroud segments to expand or contract within the range desired without permitting the secondary nozzle to drop downwardly.

In order to limit the extended position of the shroud segments a limiting ring **12** may be positioned in an external circumferential recess formed by notches in each of the shroud segments. This limiting ring will lie loosely in the circumferential recess when the segments are in the contracted position. However, when the shroud segments are extended by operation of the drill each of the segments will bear against the limiting ring so as to maintain the lower termination of the shroud at the desired gauge size.

In drilling with the apparatus described, during lowering of the drill to drilling position, drilling fluid is not circulated to the drill. As a result the upwardly extending spring **5** associated with the segments of the shroud will act to maintain the shroud segments in contracted position. This contracted position will be limited by contact of the lugs **9** against the secondary nozzle element **10**. When the apparatus has been lowered to drilling position and pellets **25** placed within the shroud element, drilling fluid is pumped downwardly through support **2**. This drilling fluid is converted to a high velocity fluid jet on passage through the primary nozzle **7**. Passage of the drilling fluid through the primary nozzle applies a downward force on the primary nozzle forcing the extension of the segmented shroud elements. The lever action of the nozzle on the shroud segments is controlled by design so that the normal drilling fluid action on the nozzle will cause full extension of the segments to the limiting position fixed by operation of the limiting ring **12**. The fluid ejected from the primary nozzle **7** is directed downwardly to the enlarged secondary nozzle **10**. In part due to the enlargement of the secondary nozzle, an aspirating action is exerted tending to entrain pellets in the fluid jet. These pellets are carried with the fluid jet through the secondary nozzle and are accelerated therein so as to be expelled forcefully against the bottom of the bore hole. The drilling fluid in its normal circulatory path carries the pellets outwardly and upwardly along the bottom of the bore hole. The pellets are aided in the upward circulation by the taper **15** provided at the lower termination of each of the shroud segments. The pellets are then carried upwardly along the inner surfaces of the shroud elements. The inward curvature of the uppermost portion of the shroud elements provided by extensions **6** directs the pellets inwardly toward the secondary nozzle. Here, as described, the pellets are again entrained in the fluid jet for continuous drilling action. Drilling fluid is adapted to pass upwardly in the bore hole however through the separation provided between adjacent shroud segments. If desired additional perforations may be cut in the shroud to ensure the free upward circulation of the drilling fluid while blocking passage of the pellets. The drilling fluid is thus enabled to pass upwardly to the surface of the earth in the bore hole annulus and may be recirculated downwardly through the tubular support **2**.

It is apparent that when drilling is discontinued, by stopping circulation of the drilling fluid, the spring members **5** will again force the segmented shroud to its contracted position to enable ready removal of the apparatus from the bore hole. To secure the desired advantages of this provision, only limited extension of the shroud elements is required. Thus it is not ordinarily required for the shroud to expand more than about ½" in diameter in order to fulfill the objectives of the invention.

The apparatus illustrated in Figures 3 and 4 is similar in nature to the apparatus described. For this reason corresponding elements are identified by similar numerals. Again in the apparatus of these figures the shroud constitutes a number of segmented elements **3**. These segments are not hinged as in the embodiment of Figure 1, but instead are rigidly fastened to or constitute a continuation of the tubular support member. Thus the tubular support member and the shroud member may be an integral unit and the shroud segments may be constructed by cutting a plurality of vertical slots **18** in the shroud body, and extending each of the slots to the region designated by reference numeral **19** in the lower end of the tubular support portion of the apparatus. In Figure 3 the vertical section has been taken through one of the slots on the right-hand side of the figure and through one of the segments on the left-hand side of the figure. The lower slotted section of the tubular member which comprises the upper portions **20** of each of the shroud segments may be sufficiently reduced in thickness so that each of the portions **20** will constitute a spring element which will be flexible in nature. Consequently each of the shroud segments is adapted to

move outwardly against the wall of the bore hole when force is applied against the flexible elements **20** which normally bias the shroud segments inwardly with respect to the vertical axis of the apparatus.

Again a limiting ring **21** may be positioned in a circumferential recess cut in the shroud segments so as to limit the extended position of the flexible shroud segments. A secondary nozzle **10** is supported within the shroud in the manner illustrated in Fig. 2, the enlarged collar element **11** of the nozzle resting on the inwardly extended lugs **9** of the shroud. In view of the fact that the segmented shroud members extend upwardly above the region of the primary nozzle into the flexible extensions **20**, it is necessary to employ an inner sealing sleeve **22** to prevent passage of drilling fluid through the slots between the segments. Sleeve **22** may constitute a cup-like member of flexible material such as rubber having a central opening in the bottom of the cup for passage of fluid to the primary nozzle. The upper portion of the cup **22** must extend within tubular support **2** above the juncture with the segmented shroud elements. In this arrangement the primary nozzle consists of a streamlined insert member **23** inserted at the bottom of the sleeve **22** for the direction of drilling fluid into the secondary nozzle **10**.

In this embodiment of the invention the cup-like sleeve member **22** plays an important part in the expansion of the shroud segments. During drilling when drilling fluid is pumped through tubular support **2** a high hydraulic pressure will be exerted within the cup member **22**. This force will cause the ballooning of the flexible cup member so as to forcefully expand the flexible portions **20** of the shroud segments. By this means the shroud is extended to the drilling position upon circulation of drilling fluid.

In other respects the apparatus and operation are of the nature formerly described with respect to the apparatus of Fig. 1.

As described therefore this invention concerns a pellet impact drill bit employing a segmented shroud for captive recirculation of the drilling pellets. The shroud segments are maintained in flexible relation with respect to the support member of the apparatus so as to permit outward extension of the shroud segments at the lower termination of the shroud. For this purpose, as described, the shroud segments may be hinged to the support member or may be constructed so as to be flexible in nature. In order to secure the positive expansion of these shroud segments the hydraulic force of drilling mud at the primary nozzle is employed to force extension of the shroud segments. In one form of the invention this hydraulic force is used to apply a cam action to the segmented shroud while in another form of the invention the expansive force of a sleeve member is employed to force extension of the shroud. It is apparent that the principles of this invention may be modified in many respects in providing desirable forms of expansible shrouds for pellet impact drills.

What is claimed is:

1. A drilling apparatus comprising in combination: a tubular support member, a plurality of circumferentially arranged shroud segments held by said support member in flexible relation thereto and extending below said support member in a manner defining an open-bottom shroud adapted to maintain a plurality of pellets in captive circulation therewithin, a first nozzle element supported by said tubular member adjacent the lower termination thereof and adapted to eject therefrom a high velocity stream of fluid, a second nozzle element supported below said first nozzle element in spaced concentric relation therewith, said second nozzle element being spaced from said shroud elements and from said first nozzle element to provide for upward passage of pellets between said second nozzle element and said shroud and for entry of pellets into the top of said second nozzle, means biasing said shroud segments inwardly with respect to the vertical axis of the apparatus and means adapted to force said shroud segments outwardly in opposition to said bias when fluid pressure is built up within said tubular support as a result of forcing fluid out of said support through said first nozzle.

2. Drilling apparatus as defined by claim 5 including inward extensions fixed to said shroud segments, said first nozzle element being slidably held within said tubular member and supported on said extensions, said extensions being characterized by a downward and inward taper whereby pressure applied downwardly to said first nozzle causes extension of said shroud segments.

3. Apparatus as defined by claim 1 including a flexible sleeve element positioned within said tubular support above said first nozzle element with a portion of said sleeve engaging the upper ends of said shroud segments in a manner forcing said segments outwardly upon said build-up of fluid pressure within said tubular support.

4. Apparatus as defined by claim 1 including notches in each of said shroud segments collectively defining an external circumferential recess and a ring fitting loosely in said recess when said segments are in their inward position, and tightly when said segments are extended, whereby to limit the outward extension of said segments.

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