Nov. 20, 1956 J. E. ECKEL ET AL 2,771,269

ENLARGING BORE HOLES BY PELLET DRILLING

Filed June 30, 1953 2 Sheets-Sheet 1

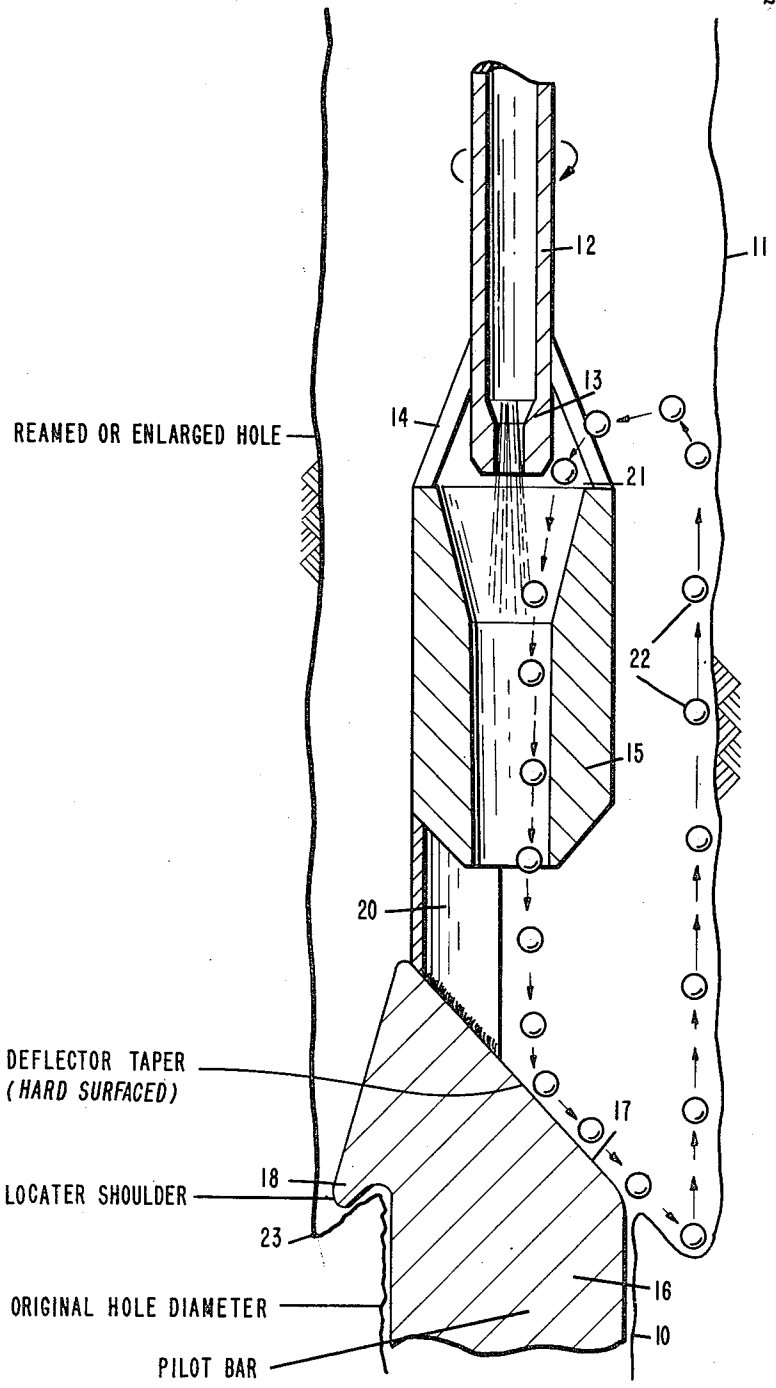


FIG. - 1

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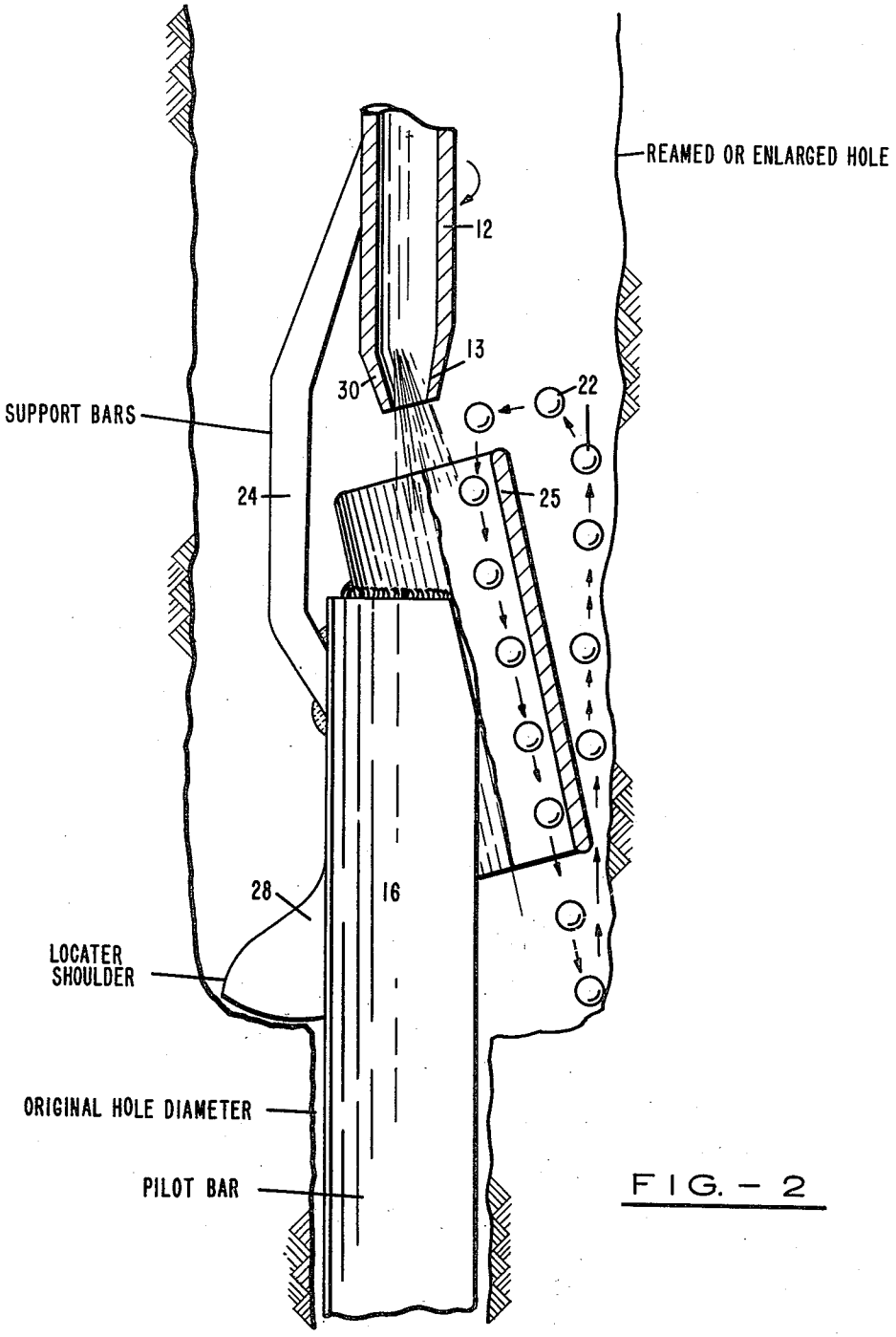


FIG. - 2

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ENLARGING BORE HOLES BY PELLET DRILLING

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3 Claims. (Cl. 255—1.8)

The present invention is concerned with a novel method and apparatus for enlarging the diameter of a previously drilled bore hole. The invention utilizes what is known as pellet impact drilling.

It is often desirable to increase the diameter of a bore hole that has already been drilled in the earth. For example, in the drilling of oil wells it is frequent practice to drill ahead of the normal sized hole to obtain cores for geological inspection and it is then later necessary to enlarge the hole to full gauge as drilling progresses. Also it is common practice to drill a rat hole ahead of a full gauge hole for the purpose of supporting a drill stem tester in the bore hole. After the test has been run, it is then necessary to drill the hole to full gauge. With conventional reaming bits that are used for the bore hole enlarging operation it often happens that the reaming bit teeth become dulled before the full length of the hole has been reamed, which necessitates removing the drill string and replacing the reaming bit. With a drill bit utilizing the pellet impact principle this would not be necessary since all that would be required would be to supply additional pellets as the original pellets are worn down or lost.

The basic principles of the pellet impact technique for the drilling of bore holes involve 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" to about 1" in diameter. It is preferred that hard, 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, filed by Philip S. Williams, on January 29, 1952 and entitled "Pellet Impact Drilling Method and Apparatus."

The present invention is directed to the use of the pellet impact technique for enlarging the diameter of a bore hole. A fluid jet issuing from a primary nozzle is directed into a tubular mixing chamber, also referred to as a secondary nozzle, wherein pellets are entrained in the fluid jet and the jetted fluid and pellets are discharged from the lower end of the chamber or nozzle. The stream of pellets and fluid leaving the secondary nozzle is directed so that the pellets will impinge on the side of the bore hole and thereby enlarge the same. This is done either by directing the stream against a sloping deflector guide or by positioning the secondary nozzle at a desired angle from the vertical. An elongated pilot guide bar or plug member of essentially the same

diameter as the original hole is supported below the tubular chamber or secondary nozzle and serves to center the device in the bore hole as well as to prevent the loss of pellets down through the original bore hole. A locator shoulder on the guide bar or pilot member rests on the ledge created at the bottom of the enlarged hole and thus controls the position of the drill with respect to the portion of the formation that is being drilled.

A fuller understanding of the nature of this invention may be obtained by reference to the accompanying drawing in which:

Figure 1 is an elevational view in section showing one embodiment of the invention in position in a bore hole; and

Figure 2 is a similar elevational view, partly in section, showing a second embodiment of the invention in position in a bore hole.

Referring now to Figure 1 in particular, a bore hole **10** is shown which it is desired to enlarge so as to obtain a bore hole **11** having a greater diameter than the original bore hole. A drilling apparatus of a character to accomplish this objective in accordance with the present invention is shown in reaming position. The apparatus is supported in the bore hole on a tubular support **12** which is adapted for attachment to the lower end of a conventional drill pipe. The lower end of member **12** terminates in a nozzle element **13**. Supported below the tubular member **12** and attached thereto by suitable means such as the web supporting members **14** shown is a second tubular element **15** which is positioned in substantial alignment with the primary nozzle. Fluid access to the top of the second tubular element from the bore hole annulus is provided through the throat or opening **21**.

Positioned below element **15** and fastened thereto by suitable means such as support member **20** is a pilot bar or closed plug element **16** which is constructed to have a diameter substantially that of the bore hole **10** that is to be reamed. The pilot bar serves the dual purpose of preventing the loss of pellets down the original bore hole as well as centering the device in the bore hole. The top of the pilot bar **16** presents an inclined deflector surface **17** so that the fluid and pellets leaving the bottom of the second tubular element will be deflected laterally to impinge against the wall of the bore hole to enlarge the same, as shown. Pilot bar **16** is provided with an outwardly extending shoulder **18** which rests at the bottom **23** of the enlarged bore hole so as to position the apparatus properly with respect to the portions of the formation that are being drilled.

To conduct the desired bore hole enlarging operation the apparatus illustrated is inserted in the bore hole until the pilot bar or plug element **16** enters the smaller diameter portion of the bore hole **10** and the shoulder **18** comes to rest at the bottom of the larger bore hole **11**. Then a plurality of pellets are placed in the bore hole. These will come to rest at the bottom of the larger bore hole and will be prevented from falling into the smaller portion of the bore hole by the pilot bar or plug element. Fluid is then pumped down the drill pipe through nozzle **13**. As it leaves this nozzle the fluid is converted into a high velocity jet stream which then enters tubular element or secondary nozzle **15** and passes through the same to impinge on the deflector surface **17** which directs the stream laterally against the side of the bore hole. The circulating fluid returns up the bore hole annulus and carries with it some of the pellets lying at the bottom of the enlarged portion of the bore hole. Essentially no fluid will be lost past the plug element **16** since the smaller bore hole **10** will be filled with fluid from previous operations. As the upward flowing stream of pellets and fluid reaches the enlarged annulus that

exists above the top of the secondary nozzle **15** the velocity of the stream is reduced so that the pellets tend to accumulate in this area and will be drawn into the throat of the secondary nozzle **15** by gravity action as well as by the aspiration effect created by passage of the fluid jet from the primary nozzle into the secondary nozzle. The pellets that enter tubular element or nozzle **15** will be admixed with the high velocity jet of fluid and will attain substantially the same velocity as the fluid stream so that as they leave the bottom opening of element **15** they will be directed by the deflector surface against the bore hole wall to drill an enlarged bore hole in the manner depicted. By rotating the drill pipe the stream of pellets and fluid will be directed in every direction about the bore hole so as to drill the same uniformly.

A second embodiment of the invention is shown in elevation in Figure 2. In this embodiment the pilot bar or plug member **16** is supported by the tubular member **12** by means of one or more support bars **24**. The second tubular element or secondary nozzle **25**, which is shown partially sectioned along its length, is welded to the top of the guide bar **16** and is positioned at an angle from the vertical so as to direct the stream of pellets and fluid in a lateral direction to drill, as shown, an enlarged hole by direct impingement of the pellets carried by the jet stream. The lower termination **30** of the primary nozzle **13** is directed at substantially the same angle as the secondary nozzle **25** so as to be essentially coaxial therewith. As in the embodiment of Figure 1 the rotating shoulder **28** fastened to pilot bar **16** positions the drill at the proper level in the bore hole so as to effect the desired drilling operation.

Each of the embodiments shown has some advantages over the other. For example that of Fig. 1 is simpler to construct and provides for more effiecient recycling of pellets. The embodiment shown in Fig. 2 has the advantage of more efficient use of the kinetic energy supplied to the pellets in view of the fact that the pellets impinge directly against the formation without first losing some energy to a deflector surface. It is to be understood that the embodiments shown and described have been presented by way of example and that the invention is not to be limited thereto. The true scope of the invention is defined in the appended claims.

What is claimed is:

1. A drilling apparatus for enlarging the diameter of a bore hole in the earth comprising a tubular support member terminating at its lower end in a jet nozzle adapted to provide a downwardly directed high velocity jet of fluid, a second tubular member positioned below said jet nozzle and supported by said first tubular member with the inner bore of said second tubular member substantially aligned with said jet nozzle, a plug element supported below said second tubular member in a manner providing access to the inner bore of said tubular member from the bore hole annulus, said plug member having an inclined upper surface whereby to deflect laterally fluids and solids impinging thereon from said second tubular member, said plug element having a diameter substantially that of the bore hole to be enlarged, and a lateral projection adjacent the upper end of said plug element whereby to position the same at the bottom of the enlarged portion of the bore hole.

2. A drilling apparatus for enlarging the diameter of a bore hole in the earth comprising a tubular support member terminating at its lower end in a jet nozzle adapted to provide a downwardly directed high velocity jet of fluid, a second tubular member positioned below said jet nozzle and supported by said first tubular member with the inner bore of said second tubular member substantially aligned with said jet nozzle, said second tubular member having its lower end directed in a downward direction away from the bore hole axis whereby to direct fluids and solids emerging from said tubular member against the bore hole wall, a plug element fastened to and extending below said second tubular member, said plug element having a diameter substantially that of the bore hole to be enlarged, and a lateral projection adjacent the upper end of said plug element whereby to position the same adjacent the bottom of the enlarged portion of the bore hole.

3. The method of enlarging the diameter of a bore hole in the earth comprising the steps of directing a high velocity jet of fluid downwardly in the bore hole, introducing into and admixing with said jet a plurality of essentially spherical pellets of substantial size, directing said mixture against the walls of the bore hole in a generally downward direction whereby said pellets are impinged against said wall to drill an enlarged annulus, conducting said fluid and pellets upwardly in said enlarged annulus, removing said pellets from said upflowing fluid, reintroducing said pellets into said fluid jet, continuously blocking entry of pellets into the original bore hole below said enlarged annulus by positioning blocking means in said original bore hole in the vicinity of the bottom of said enlarged annulus and gauging the proper positioning of said blocking means by continually resting an upper lateral projection thereof on said bottom of said enlarged annulus.

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