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APPARATUS FOR STRAIGHTENING LARGE DIAMETER HOLES BY FLUID EROSION

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FIG. 2

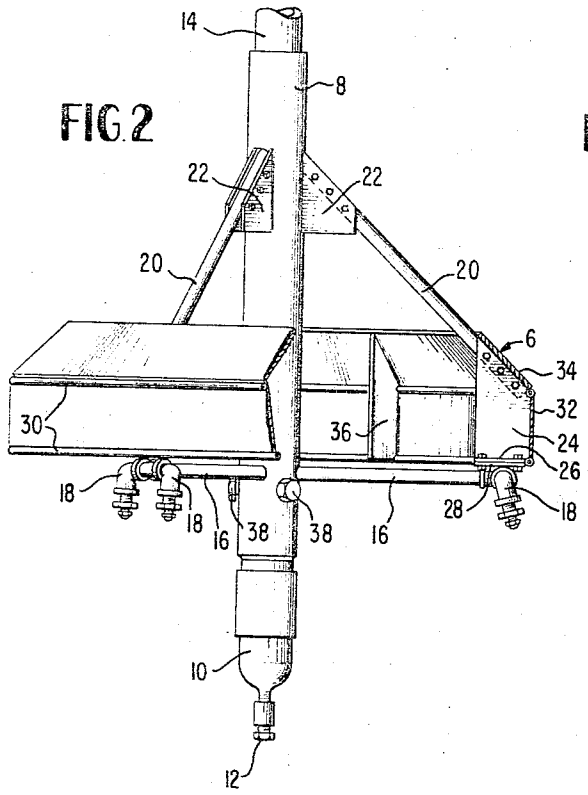
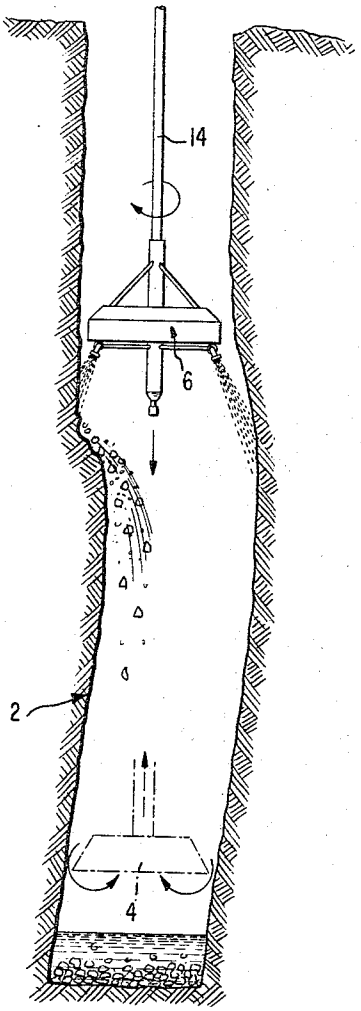


FIG. 1



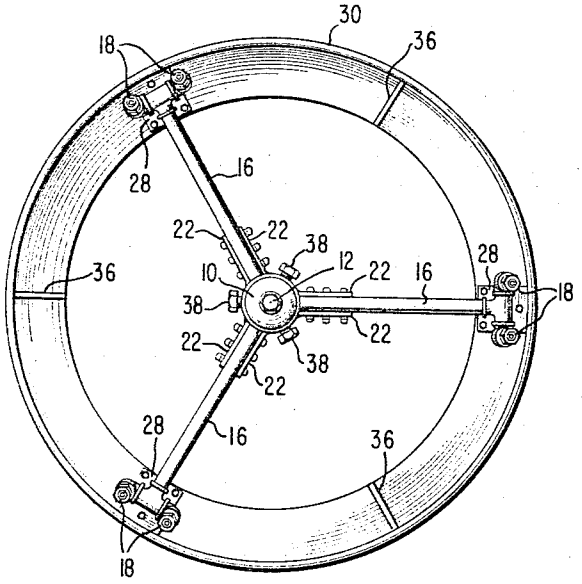


FIG. 3

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APPARATUS FOR STRAIGHTENING LARGE DIAMETER HOLES BY FLUID EROSION

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This invention relates to forming large diameter straight holes in earth formations, and more particularly, to an apparatus for straightening the sides of large diameter holes.

Large diameter holes are drilled in earth formations for various purposes, such as for subterranean installations. The diameter of such holes may be of the order of four feet or more. One conventional method of drilling large diameter dry holes is to use an oversized drill. The drill bit may have a plurality of cutting wheels arranged in a conical pattern, or the cutting wheels may be mounted on a relatively flat drill bit body. A pilot hole is usually drilled first to guide the large bit. Air is pumped down the hole at a low velocity to carry the cuttings and dust into an opening at the bottom of the drill pipe and upwardly through the drill pipe at a high velocity to the top of the hole. Large diameter holes can be formed in the earth using this technique, but due to the large size of the drill bit, it tends to drift from the vertical center line of the hole when it encounters sloping formation interfaces and formations of non-uniform hardness. Therefore it is often necessary to straighten the hole before a casing or lining can be installed.

Conventional equipment, such as wall scrapers, are unsatisfactory for straightening large diameter holes, because of the large amount of torque required to rotate the tool and because there is no effective way of maintaining the tool at the desired central axis of the hole. Physical engagement of the tool with the side wall of the hole would cause the tool to follow the contour of the side wall rather than cut away the eccentric side wall portions. There is no effective way to guide the tool against the side wall at substantial depths in the hole.

In view of these defects of the prior art methods and apparatus for forming large diameter holes, it is an object of this invention to provide an apparatus for forming large diameter holes which are straight.

It is another object of this invention to provide an apparatus for rapidly straightening bore holes.

It is a still further object of this invention to provide an apparatus for straightening a dry hole in an earth formation, without unnecessarily increasing the diameter of the hole.

Another object of the invention is to provide an apparatus for forming a hole in an earth formation which has a substantially vertical central axis.

These objects are accomplished in accordance with the preferred embodiment of the invention by a tool having a plurality of nozzles which are mounted on a support at substantially equal distances from the central axis of the support. A conduit communicates with each nozzle for supplying fluid to the nozzle. The support is attached to the lower end of a tubing string and lowered into a large diameter hole in the earth. Fluid is pumped out of the conduit through the nozzles at a high velocity and the nozzles are rotated about the central axis of the support as the tool is lowered in the hole. As the tool travels to the bottom of the hole, the side wall which projects too close to the desired center line is eroded at a greater rate by the fluid than the opposite side wall which is spaced a greater distance from the desired center line of the hole. In this manner the side wall of the hole is straightened.

This preferred embodiment of the invention is illustrated in the accompanying drawings, in which:

FIG. 1 is a schematic view of an earth formation showing a hole being straightened by the method and apparatus of this invention;

FIG. 2 is a side elevational view, partially in section, of the hole straightening apparatus; and

FIG. 3 is a bottom plan view of the straightening apparatus.

Referring to FIG. 1, a large diameter hole **2** is formed in an earth formation by a conventional but oversized drill bit **4**, which is shown schematically. Cone type or flat type rotary drill bits having a plurality of cutting wheels are commonly used. The drill bit **4** has an opening communicating between the cutting side of the bit and the drill pipe. At the top of the hole a seal is provided around the drill pipe and air is pumped down the hole **2** at a relatively low velocity. The air circulates around the cutting wheels where it picks up cuttings and dust and carries them through the opening in the drill bit and upwardly through the drill pipe at a high velocity to the top of the hole **2**. The use of air is preferred over liquids because large diameter holes are usually drilled in porous formations which can not be kept full of liquid, or are too weak to sustain the head pressure of a hole full of liquid. Furthermore, removing the cuttings with air permits the hole to remain dry, which is often desirable.

The drill pipe is suspended vertically in the hole and a pilot hole may be drilled to guide the large diameter bit **4** along the desired vertical center line of the hole. Due to its large diameter, however, the bit tends to drift off of the desired center line as it cuts into formations of varying hardness and sloping formations. Consequently, an irregular hole may be formed as shown in FIG. 1. It then becomes necessary to straighten the hole, which is the purpose of the apparatus of this invention.

The hole straightening tool **6** includes a pipe **8**. The lower end of the pipe **8** is closed by a plug assembly **10**, having a threaded cap **12** which may be removed for flushing out the interior of the pipe **8**. The upper end of the pipe **8** is secured to a tubing string **14** by conventional screw threads.

A plurality of conduits **16** extend outwardly from the pipe **8** and are arranged symmetrically around the pipe, as shown in FIG. 3. A pair of nozzles **18** are mounted on the outer end of each of the conduits **16**. The nozzles **18** slope outwardly from an axis parallel with the central axis of the pipe **8**, and preferably the central axis of each nozzle is inclined at an angle of about 15 degrees with respect to the central axis of the pipe **8**. The nozzles **18** and the pipes **16** are individually supported by arms **20** which extend outwardly from the pipe **8**. A pair of brackets **22** are secured to the pipe **8** at spaced intervals around the circumference of the pipe, and one end of the arms **20** is received between each of the pair of brackets **22**. The arms **20** are secured in the brackets by screws or other conventional means.

The opposite end of each arm **20** is secured between a pair of brackets **24** by conventional screws or other suitable means. The brackets **24** have outwardly projecting flanges **26** adjacent the nozzles **18** and a plate **28** extends between the flanges of each of the pair of brackets **24**. The nozzles **18** are preferably welded to the plate **28**, but they may be strapped or otherwise secured to the plate.

A pair of rings **30** are secured to the outer edge of the brackets **24** and extend around the pipe **8**. A band **32** is also secured to the outer edge of the bracket **24**, between the rings **30**. The band **32** is spaced outwardly from the pipe **8** a slightly greater distance than the nozzles **18** to prevent the nozzles from moving into direct engagement

with the wall of the hole. A guard **34** is secured along the upper edge of the brackets **24** to prevent the tool **6** from being hung up on the wall of the hole when it is withdrawn from the hole. A plurality of spacer elements **36** are secured to the rings **30**, the band **32** and the guard **34** to provide rigidity to the structure. If it is desired to have additional nozzles **18**, plugs **38** in the pipe **8** may be removed and substituted by additional conduits **16**.

In operation, the hole straightening tool **6** is secured to the end of the tubing string **14** and suspended in a previously formed hole **2** at the desired center line of the hole. The tubing string **14** is then rotated. A fluid is pumped down the tubing string **14** and into the pipe **8** where it is distributed through the conduits **16** to the nozzles **18**. The fluid is pumped out of the nozzles **18** with sufficient velocity to erode the side wall of the hole adjacent the nozzles, if the nozzles are sufficiently close to the side wall. Ordinarily, clear water is the fluid which is sprayed through the nozzles. In a porous formation, the water used in straightening the hole is dispersed through the formation and the hole does not fill up with water. Abrasives may be added to the fluid to accelerate the rate of erosion of the side wall of the hole, but the abrasives would accumulate in the bottom of the hole and may have to be removed. If abrasives are to be used, 20 to 40 mesh sand is preferred. The abrasives may be suspended in a fluid, such as air or gas, or drilling mud.

The fluid streams issuing from the nozzles **18** impinge on the side wall of the hole at an acute angle and the erosion effect of the stream on the side wall decreases exponentially as the distance between the nozzle and the side wall increases. The apparatus **6** is rotated by means of the tubing string **14** to cause continuous erosion of the portions of the side wall which are too close to the desired center line, but the portions of the side wall which are spaced a greater distance than desired from the center line are substantially free from erosion by the fluid stream. As the tubing string **14** is rotated, it is lowered from the top to the bottom of the hole. If the tool **6** should accidentally move against the side wall of the hole **2**, the band **32** protects the nozzles **18** from engagement with the side wall. When the desired depth is reached, the flow of fluid through the nozzles **18** is stopped and the tool **6** is raised from the hole. The guard **34** guides the apparatus around any obstructions in the hole which might hinder upward movement of the tool through the hole.

One advantage of the tool of this invention is that it does not ordinarily engage the side wall of the hole, and therefore very little torque is required in rotating the tool.

For this reason, the apparatus may be used in straightening very large holes, without requiring a great deal of rotary power. Since this invention relies primarily on gravity for assuring that it remains on the desired center line, it is necessary only to maintain the top of the tubing string at the desired center line. No down hole guidance mechanism is required. After straightening, the hole is concentric with the desired center line, except where the drilling tool wandered off center, and in those areas, the diameter of the hole is not increased by this invention substantially more than necessary to make the hole straight.

While this invention has been illustrated and described in one embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claim.

I claim:

Apparatus for straightening holes in earth formations comprising a tubular body, a plurality of rigid conduits fixed in relation to said body and extending radially outward from said body, an annular shield mounted in coaxial relation on said body, a plurality of nozzles being in fluid communication with the interior of said body through said conduits, said nozzles being directed in acute angular relation with the central axis of said body and away from said shield, said nozzles being substantially equally spaced from said body central axis, a plurality of rigid arms secured at one end to said body and at the opposite end to said shield, means for attaching said conduits to said shield, said shield being spaced radially from said body and having a radial thickness substantially less than the radial distance between the nozzles and the body, said shield having a peripheral surface and said surface being spaced radially from said central axis a greater distance than said nozzles.

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