HOLE-OPENER FOR ENLARGING PILOT HOLE

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The hole-opener is designed so that it can be disassembled in the field to replace worn cones or to enlarge the effective diameter of the tool. It comprises: a tubular drive sub, which connects at its front end with a rotating drill string which is being pulled along a pilot hole; a sleeve which slides over the rear portion of the drive sub; and a retainer sub which is connected with the rear end of the drive sub. The drive sub has external protruding bars which engage slots formed in the forward end of the sleeve, for limiting forward movement of the sleeve and locking the drive sub and sleeve together so that they rotate as a unit. The retainer sub has a radial shoulder which abuts the rear end of the sleeve to lock it in place. The retainer sub also transmits axial pull from the drive sub to the sleeve. The sleeve carries rotary cutting elements which are pulled and rotated to cut formation and enlarge the pilot hole.
HOLE-OPENER FOR ENLARGING PILOT HOLE

FIELD OF THE INVENTION

The present invention relates to a hole-opener for enlarging the diameter of an underground pilot hole. More particularly it relates to a hole-opener that can easily be disassembled to replace the rotary cutting elements.

BACKGROUND OF THE INVENTION

In connection with laying cables or installing a flowline it is periodically necessary to bore a generally horizontal, underground borehole extending between one surface location and another. This might be done, for example, to provide a borehole at a crossing beneath a river.

In such an operation, a relatively small diameter pilot hole is drilled by a rig. This is done using a string of drill pipe having, at the drilling end, a fluid-driven motor rotating a drill bit. Once the pilot hole is formed, the bit is replaced with a tool referred to as a hole-opener. The drill string is then rotated and pulled to draw the hole-opener back along the pilot hole to enlarge its diameter. This procedure may be repeated more than once with progressively larger hole-openers, to gradually increase the pilot tube diameter to achieve a borehole of the desired size.

A typical prior art hole-opener is shown in FIG. 1. It comprises:

- A one-piece tubular body forming a through bore and having threaded connections at the front and rear ends of the tool;
- ‘arms’ or bars are welded or bolted to the exterior surface of the body—they extend longitudinally thereof in parallel, circumferentially spaced apart relationship;
- Each arm has at its front end a rotary cutting element, such as a toothed cone mounted on a support pin extending between the arm and the body;
- Jet ports are provided, extending through the side wall of the body at the cones, for jetting drilling fluid into the annulus formed between the tool and drill string and the pilot hole wall to clean the cones and remove drill cuttings; and
- A threaded plug is provided for closing the through bore at the body’s rear end.

There are shortcomings associated with these commonly used tools. These shortcomings appear to have simply been tolerated for many years without a useful remedy, as far as I am aware.

More particularly, the cones wear out in use and need to be removed and replaced. However, it is not practical to make this change-out in the field with the prior art solid tools.

In addition, it is therefore necessary to maintain at the site an inventory of complete tools having progressively larger diameters, if the pilot hole is to be enlarged in stages.

It is the objective of the present invention to provide a tool or hole-opener which is improved with respect to these shortcomings.

SUMMARY OF THE INVENTION

In accordance with the invention, a hole-opener is provided which incorporates a removable sleeve mounted on a tubular body (referred to as a drive sub). Arms and cutting elements are affixed to the sleeve. Means are provided for locking the drive sub and sleeve together so that they rotate as a unit. Means are also provided for locking the sleeve axially in a predetermined position on the drive sub. And finally, means are provided for transmitting the pulling force of the drill string and attached drive sub to the sleeve and its cutting elements.

In one preferred embodiment, the hole-opener has front and rear ends and comprises:

- A tubular drive sub having a longitudinal bore and threaded connections at each end, more preferably a box at the front end and a pin at the second end;
- A tubular sleeve which slides onto the rear end of the drive sub. The sleeve has a plurality of radially protruding arms attached to its front end surface at spaced positions about its circumference. A cutting element, preferably a toothed cone, is rotatably mounted to the front end of each arm;
- Means for engaging the drive sub and sleeve so that they rotate together. More preferably such means comprise outwardly protruding, circumferentially spaced apart stabilizer bars affixed to the external surface of the drive sub and extending longitudinally thereof. These stabilizer bars engage corresponding slots formed in the front end of the sleeve. The bars and slot walls combine to transfer rotational force from the drive sub to the sleeve. The bars also function as a stop, to limit the axial travel of the sleeve along the drive sub and lock the latter’s front end at a predetermined position; and
- A retainer sub, which has a threaded connection at its front end for engaging the rear connection of the drive sub. The retainer sub also has a radial shoulder which abuts the rear end face of the sleeve and locks the sleeve at its rear in the predetermined position. The retainer sub also functions to transmit the axial pull force from the drill string and drive sub to the sleeve and its cutting elements;
- The drive sub forming ports extending through its side wall which, when the tool has been assembled, are positioned adjacent the cutting elements and serve to jet drilling fluid so as to clean the cones and remove cuttings through the annulus.

Broadly stated, the invention is concerned with a hole-opener for enlarging the diameter of a pilot hole, the hole-opener having front and rear ends and comprising: a tubular drive sub having an external surface, a longitudinal bore and threaded connections at its front and rear ends; a tubular sleeve for sliding axially over the rear end of the drive sub; means for locking the sleeve and drive sub together for rotation as a unit; means, carried by the drive sub, for engaging the front end of the sleeve to stop its axial movement along the drive sub at a predetermined position; a retainer sub for threadably engaging the rear end connection of the drive sub and bearing against the rear end of the
sleeve to lock the sleeve in the pre-determined position; the sleeve carrying at least one rotary cutting element assembly at its front end; the drive sub forming ports for jetting drilling fluid contiguous to the cutting elements when the sleeve is locked in the pre-determined position.

DESCRIPTION OF THE DRAWINGS

[0022] FIG. 1 is a perspective sectional side view of a hole-opener in accordance with the prior art;

[0023] FIG. 2 is a partly sectional side view of an assembled hole-opener in accordance with the present invention;

[0024] FIG. 3 is a sectional side view of the drive sub;

[0025] FIG. 4 is a sectional side view of the retainer sub; and

[0026] FIG. 5 is a sectional side view of the sleeve showing a slot, the arms and rotary cones.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0027] The tool or hole-opener 1 comprises a drive sub 2, a sleeve 3 and a retainer sub 4.

[0028] ‘Subs’ are used because they are heavy steel tubulars equipped with threaded pins and boxes adapted to connect with the connections of drill pipe commonly used in this service. The subs are adapted to be ‘made up’ and ‘broken’ by the rig equipment. However the subs have been modified in certain respects, as described below, to prepare them for use in this tool.

[0029] More particularly, the drive sub 2 has a box connection 5 at its front end 6 and a pin connection 7 at its rear end 8. Stabilizer bars 9 are welded to the drive sub’s external surface 10. These stabilizer bars 9 extend longitudinally of the drive sub 2 at spaced positions around its circumference. The stabilizer bars 9 are designed to centralize the tool in the pilot hole (not shown). They also function to act as stops limiting axial advance of the sleeve 3 along the drive sub 2 and as part of the rotary drive connection between the drive sub 2 and sleeve 3. The drive sub side wall 11 also forms ports 12, between the stabilizer bars 9, for jetting drilling fluid into the annulus formed between the tool and the borehole wall.

[0030] The sleeve 3 is formed with slots 13 in its forward end 14, for receiving the stabilizer bars 9. The side walls 15 of the slots 13 and the bars 9 combine to lock the sleeve 3 and drive sub 2 together for rotation as a unit. The sleeve 3 also carries a plurality of outwardly protruding arms 16 affixed to the front end of the sleeve’s outer surface 17. The arms 16 extend longitudinally of the sleeve 3 in spaced apart arrangement. Each arm 16 carries a rotatably mounted, toothed cone 18 at its front end 19. The cones 18 are positioned adjacent the jet ports 12.

[0031] The retainer sub 4 has a box connection 20 at its front end, sized to be slidably received in the rear end of the bore 21 of the sleeve 3. The box connection 20 is connected with the pin connection 7 of the drive sub 2. The retainer sub 4 also has a radial shoulder 22 which abuts the rear end face 23 of the sleeve 2 when the tool is assembled. The retainer sub 4, being threadably engaged with the drive sub 2, therefore functions to transmit axial pull from the drill string 24 to the sleeve 3 and its rotary cones 18. In addition, the retainer sub shoulder 22 combines with the stabilizer bars 9 to lock the sleeve 3 in a pre-determined position with the cones 18 positioned opposite the jet ports 12.

[0032] A plug sub 25 is threaded onto the rear pin connection 26 of the retainer sub 4, to close off its bore 27.

[0033] The resultant tool can be disassembled by backing off and removing the retainer sub 4 and removing and replacing the sleeve 3. This is done when the cones 18 are worn or are to be replaced to cut a larger diameter borehole.

[0034] It is contemplated that variants of the described tool can be implemented by those skilled in the art without changing the substance of the tool. For example, splines can be used to lock the drive sub and sleeve for rotation together. In addition, the tubular retainer sub can be replaced with a plug—the term ‘retainer sub’ is intended to be interpreted to include a plug.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A hole-opener for enlarging the diameter of a pilot hole, the hole-opener having front and rear ends and comprising:
   a tubular drive sub having an external surface, a longitudinal bore and threaded connections at its front and rear ends;
   a tubular sleeve for sliding axially over the rear end of the drive sub;
   means for locking the sleeve and drive sub together for rotation as a unit;

2. The hole-opener as set forth in claim 1 wherein the drive sub has outwardly protruding, circumferentially spaced apart bars affixed to its external surface and extending longitudinally thereof and the front end of the sleeve is slotted to engage the bars to stop forward axial movement of the sleeve and to lock the sleeve and drive sub together for rotation as a unit.

3. A hole-opener for enlarging the diameter of a pilot hole, the hole-opener having front and rear ends and comprising:
   a tubular drive sub having an external surface, a longitudinal bore and threaded connections at its front and rear ends;
   a tubular sleeve mounted on the rear end of the drive sub;
   means for locking the sleeve and drive sub together for rotation as a unit;
means, carried by the drive sub and engaging the front end of the sleeve, for stopping the sleeve at a pre-determined position;

a retainer sub threadably engaging the rear end connection of the drive sub and having a shoulder bearing against the rear end of the sleeve to lock the sleeve in the pre-determined position;

the sleeve carrying a plurality of rotary cutting element assemblies at its front end;

the drive sub forming ports for jetting drilling fluid contiguous to the cutting elements.

4. The hole-opener as set forth in claim 3 wherein the drive sub has outwardly protruding, circumferentially spaced apart bars affixed to its external surface and extending longitudinally thereof and the front end of the sleeve forms slots engaging the bars so that the bars cooperate with the retainer sub to lock the sleeve axially in the pre-determined position, the bars and sleeve interlock so that the drive sub and sleeve will rotate as a unit and the drive sub will impart pulling force to the sleeve through the retainer sub.

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