United States Patent [19]

Dyer et al.

[11] **3,917,009**

[45] **Nov. 4, 1975**

[54] **REMOVABLE STEM FOR RAISE BITS**

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[22] Filed: **Sept. 16, 1974**

[21] Appl. No.: **506,667**

[52] **U.S. Cl.** **175/53;** 175/334; 285/323; 403/371

[51] **Int. Cl.²** **E21C 23/00;** E21B 9/24

[58] **Field of Search** 175/53, 325, 334, 344, 175/391; 403/370, 371; 285/421, 323

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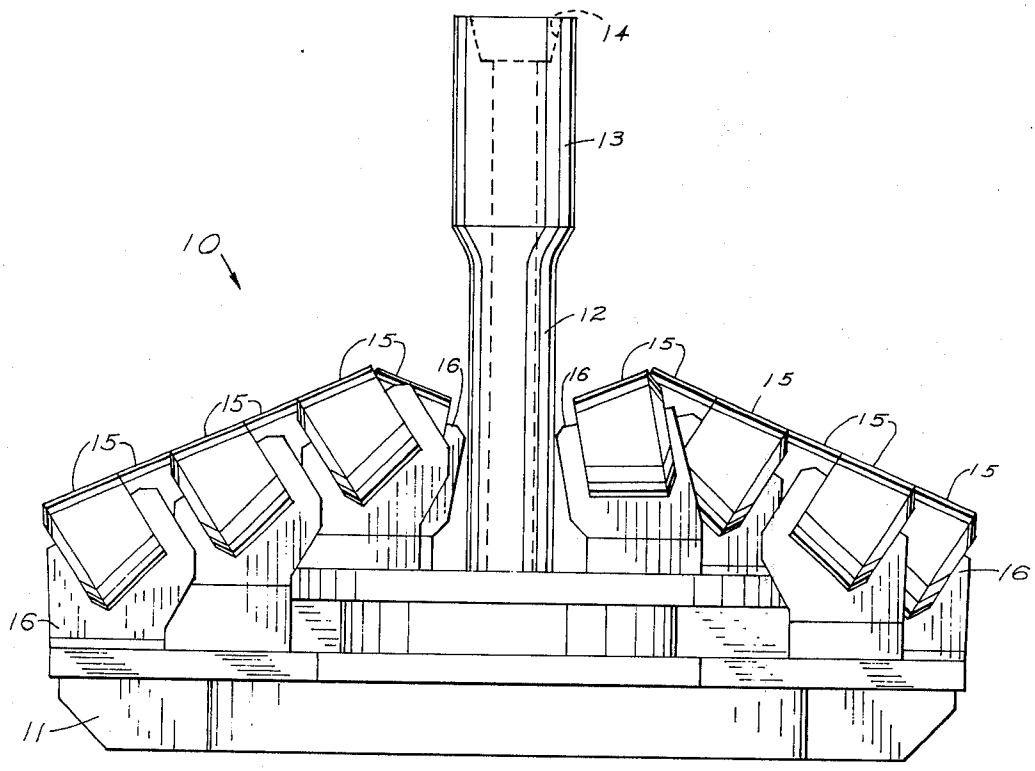
[57] **ABSTRACT**

A raise bit for enlarging a pilot hole into a larger diameter hole by disintegrating the earth formations surrounding the pilot hole includes a removable drive stem. The removable drive stem allows the raise bit to be transported through small drifts and helps extend the useful lifetime of the raise bit. The raise bit may be assembled without weakening the highly-stressed, heat-treated drive stem by welding. The raise bit body includes a multiplicity of rolling cutters for contacting and disintegrating the earth formations surrounding the pilot hole. The raise bit body includes a fixed collar with a truncated conical inside surface. A two-piece, split, removable collar with an inside surface that matches the outside surface of the drive stem and a conical outer surface that matches the inside surface of the fixed collar is positioned around the drive stem. A flange at the end of the drive stem allows the split collar to be drawn up into the fixed collar thereby developing frictional forces between the mating surfaces of the fixed collar, the split collar, and the drive stem. A preload is induced into the system to insure proper torque transmittal at low bit loads.

8 Claims, 3 Drawing Figures



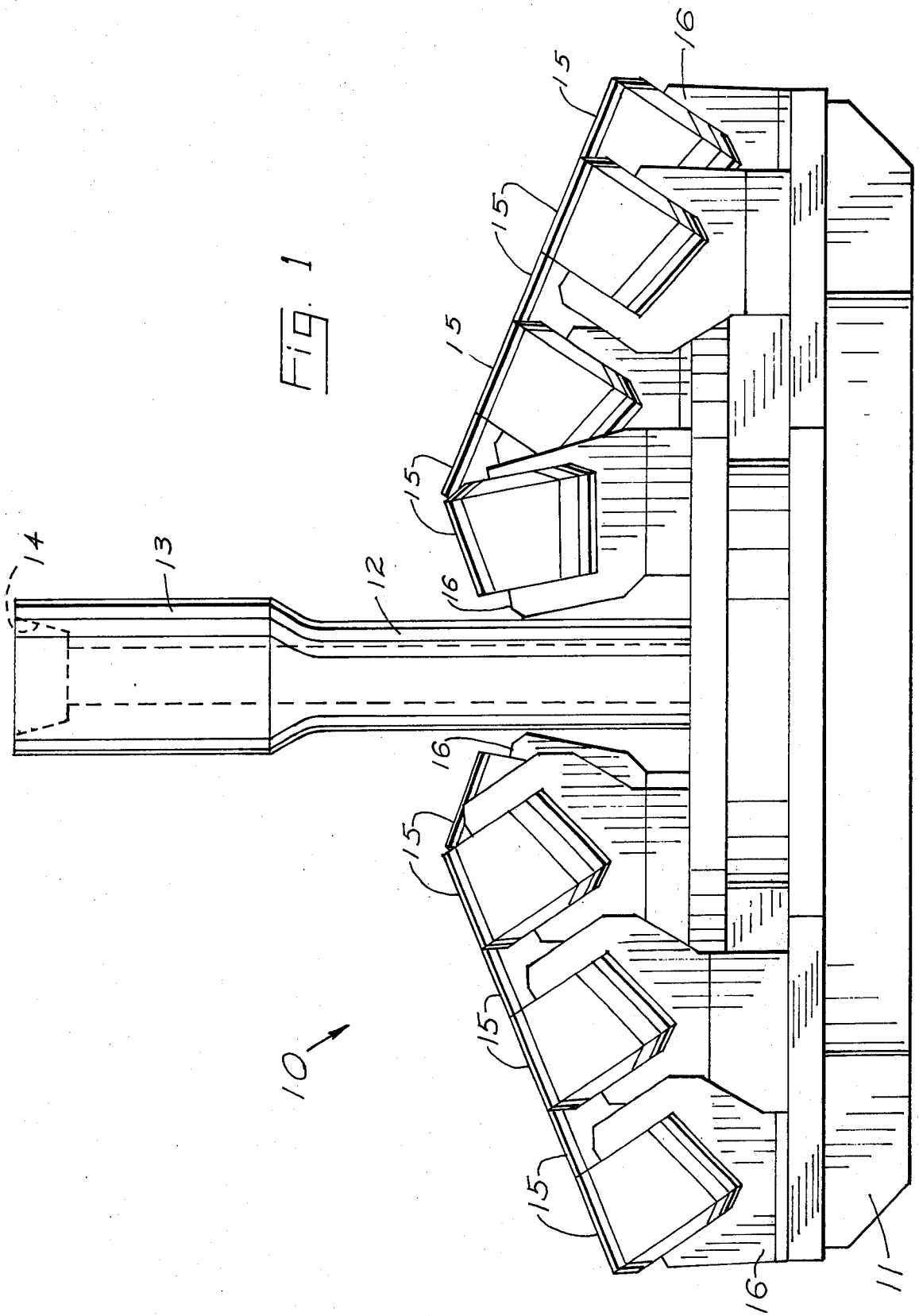
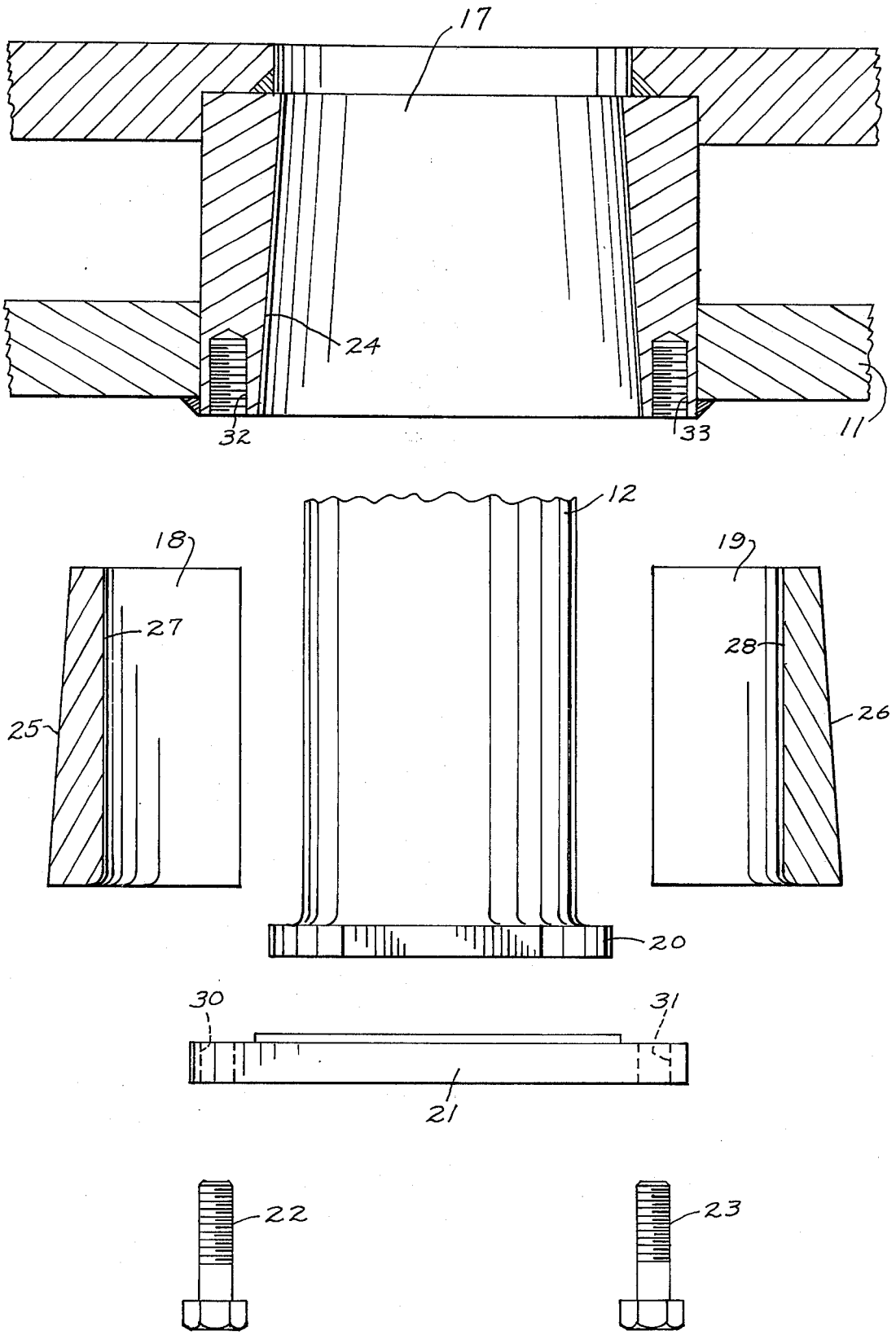


Fig. 1

Fig. 2



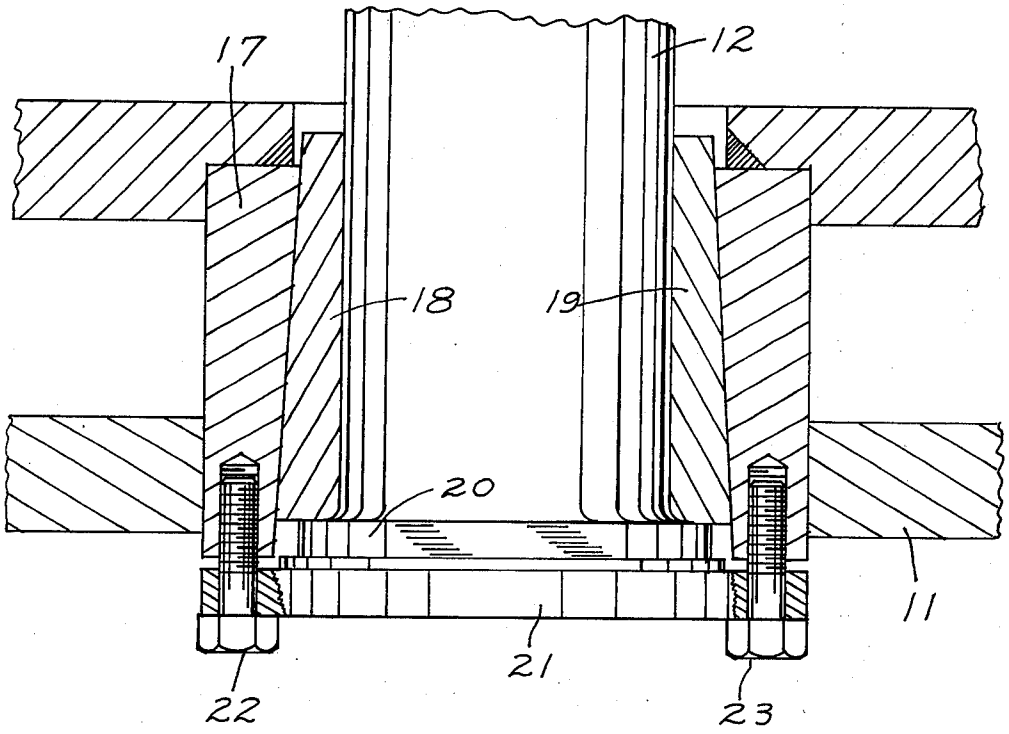


Fig. 3

REMOVABLE STEM FOR RAISE BITS

BACKGROUND OF THE INVENTION

The present invention relates to the art of earth boring and more particularly to a raise bit for enlarging a pilot hole into a larger diameter hole by disintegrating the earth formations surrounding the pilot hole.

A relatively large diameter hole may be provided between a first location and a second location in a mine by an operation commonly referred to as raise drilling. A raise drilling operation begins by drilling a small diameter pilot hole through the earth from the first location to an opening at the second location using a small diameter pilot bit. After the pilot hole is completed, the pilot bit is removed from the drill column and a large diameter raise bit attached. The raise bit is rotated and drawn along the pilot hole thereby enlarging the pilot hole to the desired size.

On many occasions, the small diameter pilot hole extends to an area accessible only through a small drift or passage. The removable drive stem of the present invention provides a raise bit with a low profile thereby allowing the raise bit to be transported through small drifts or passages. For example, a 72-inch diameter raise bit incorporating the present invention may be transported through a drift having a 30-inch height whereas a 72-inch diameter raise bit without the removable stem requires a drift with at least a 52-inch height.

During a raise drilling operation a tremendous amount of wear and stress is imposed upon the raise bit. Generally the pilot hole tends to wander thereby resulting in a series of curves over the length of the pilot hole. As the raise bit is drawn along the pilot hole the drilling geometry changes. This results in a tremendous amount of stress being transmitted to the raise bit when it is being drawn through the curves. The outside radius of the raise bit may be many times greater than the radius of the pilot hole, therefore, the moment developed is great. When resistance is encountered by cutters located on the outer radius of the raise bit as when drilling along the curve, it causes increased stress on the raise bit. It can be appreciated that any changes in formations encountered during the raise drilling operation complicates the above-mentioned conditions and adds to the drilling difficulties.

The tremendous stress and wear encountered during the raise drilling operation causes some elements of the raise bit to wear out much faster than others, notably, the cutters and the drive stem. The bit of the present invention allows the elements that have a relatively short lifetime to be replaced thereby extending the lifetime of the bit and reducing cost. The drive stem is removable, and therefore, replaceable as are the individual cutters. This allows the elements that receive the greatest stress and wear to be readily replaced. The relatively short lifetime of the individual cutters results from their nearly constant contact with the formations and their constant exposure to wear and abuse. The drive stem also contacts the formations and receives a great deal of wear and abuse. The drive stem absorbs a large amount of stress since it is the single link between the drill column and the body of the bit. All energy from the rotary equipment is transmitted to the raise bit through the drive stem.

The drive stem is very often subject to failure prior to failure of the body of the raise bit. It is, therefore, desirable to be able to easily and quickly remove the stem from the raise bit and replace it with a new drive stem. The stem is generally constructed of a high-strength, heat-treated material and would be weakened by welding. It is, therefore, desirable to be able to attach and remove the stem from the raise bit body without welding. From the foregoing, it will be appreciated that the stem must be constructed of material that will stand up under the harsh conditions encountered. Such material is expensive and any reduction in the amount of this material required is a cost savings. The bit of the present invention allows the stem to be manufactured from high-strength material, whereas the body may include lower strength and, therefore, less expensive materials.

The stem or a stabilizer section on the stem should be nearly the size of the pilot hole during the raise drilling operation to insure a smooth drilling operation. In order to use the same bit body in pilot holes of different sizes, it is desirable to be able to remove the stem from the raise bit body and replace it with an appropriately sized stem. The stem should be easy to remove and replace using simple hand tools. This allows the stem to be replaced in the field under adverse conditions.

DESCRIPTION OF PRIOR ART

A general description of a raise drilling operation is presented in U.S. Pat. No. 3,220,494 to R. E. Cannon et al, patented Nov. 30, 1965. In the system disclosed in this patent, a pilot hole is enlarged to the desired raise hole size by rotating and drawing a large diameter raise bit upward along the pilot hole.

In U.S. Pat. No. 3,659,659 to Carl L. Lichte, patented May 2, 1972, a large diameter raise bit with a replaceable stem is shown. The body of the bit includes a multiplicity of cutting stages around a central axis. The raise bit is attached to the drill column by a replaceable stem connected to the main body of the bit and the body of the bit includes a series of plates separated by a series of hollow support elements.

Raise bits manufactured by The Robbins Company, 650 South Orcas Street, Seattle, Washington 98108, include a stem that may be replaced by disconnecting taper collets on the top of the body that mate with the tapered section on the stem and disconnecting a bolt with a split tapered bushing that extends through the lower end of the stem.

SUMMARY OF THE INVENTION

The present invention provides a raise bit for enlarging a pilot hole into a large diameter hole by disintegrating the earth formations surrounding the pilot hole. The body of the raise bit includes a multiplicity of rolling cutters for contacting and disintegrating the earth formations surrounding the pilot hole. A collar with a truncated conical inside surface is affixed to the raise bit body. One end of the drive stem extends into the collar. A two-piece, split collar with an inside surface that matches the outer surface of the stem and a conical outer surface that matches the inside surface of the collar is positioned around the lower end of the drive stem. The drive stem and split collar are then drawn up into the collar. Frictional forces are developed between the mating surfaces of the collar, the split collar, and the drive stem thereby preventing rotational, radial, and axial movement of the drive stem with respect to the raise bit body.

The drive stem of the present invention may be removed and a new drive stem inserted in its place. The

raise bit of the present invention may be transported through small drifts or passages by removing the drive stem from the raise bit body. The drive stem may then be reattached and the raise bit is ready for operation. The high-strength, heat-treated stem is not weakened by welding. The raise bit body may be constructed of materials that are less expensive than the materials that make up the drive stem. Different sized drive stems may be attached to the raise bit body to allow the raise bit to be used in pilot holes of different sizes. The removal of the stem and replacement with a new stem may be accomplished in the field under adverse conditions with simple hand tools. Zero clearance is provided between the stem, the split collar, and the collar. This insures a rigid connection between the drive stem and the raise bit body. The drive stem of the present invention may be easily removed and a new stem put in place without removing the cutter saddles adjacent the stem. The above and other features and advantages of the present invention will become apparent from a consideration of the following detailed description of the invention when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a bit constructed in accordance with the present invention.

FIG. 2 is an exploded view of a portion of the raise bit shown in FIG. 1.

FIG. 3 shows the location of the elements shown in FIG. 2 when the elements are assembled.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, a side view of a raise bit constructed in accordance with the present invention and generally designated by the reference number 10 is shown. The raise bit 10 includes a raise bit body 11 or cutter stage body and a drive stem 12. The upper portion of the drive stem 12 is enlarged to form a stabilizer section 13. The raise bit 10 is adapted to be connected to a rotary drill column by a threaded connection 14. A multiplicity of rolling cutters 15 are mounted in a corresponding multiplicity of saddles 16. The saddles 16 extend from the raise bit body 11.

The raise bit 10 is used in a raise drilling operation to provide a relatively large diameter hole from a first mine level to a second mine level. The raise drilling operation begins by drilling a small diameter pilot hole through the earth from a first location to an opening at a second location using a small diameter pilot bit. After the pilot hole is completed, the pilot bit is removed from the drill column and the raise bit 10 is attached to the drill column. The raise bit 10 is rotated and drawn along the pilot hole thereby enlarging the pilot hole to the desired size.

Referring now to FIG. 2, an exploded view of a portion of the stem 12 and raise bit body 11 is shown. A cylindrical collar 17 is affixed to the raise bit body 11. The collar 17 has a truncated conical inside surface 24. The apex of the conical surface 24 intersects the center of rotation of the raise bit. The lower end of the drive stem 12 extends through the collar 17. A two-piece, split, removable collar consisting of sections 18 and 19 is positioned around the drive stem 12. The section 18 includes a surface 25 that forms a portion of a conical outer surface that matches the conical inner surface 24 of collar 17. The section 19 includes a surface 26 that forms a portion of the aforementioned conical outer surface that matches the conical inner surface 24 of collar 17. The section 18 includes a surface 27 that forms a portion of a cylindrical inner surface that matches the cylindrical outer surface 29 of drive stem 12. The section 19 includes a surface 28 that forms a portion of the aforementioned cylindrical outer surface 29 of drive stem 12. A flange 20 extends from the lower end of the drive stem 12. A cap 21 is positioned below the flange 20 and a pair of bolts 22 and 23 are positioned to extend through holes 30 and 31 respectively in the cap 21 and engage threaded recesses 32 and 33 respectively in the collar 17.

Referring now to FIG. 3, the elements of FIG. 2 are shown in their assembled position. The sections 18 and 19 of the split collar are positioned around the lower end of the drive stem 12. The stem 12 and the sections 18 and 19 are then drawn up into the collar 17. The stem 12 is initially prevented from pulling through the collar 17 by the flange 20 extending from the lower end of stem 12. The flange 20 also exerts force on the sections 18 and 19 of the split collar forcing it even tighter against the collar 17. The matching conical surfaces on the collar 17 and the sections 18 and 19 of the split collar force the sections 18 and 19 against the outer surface of the stem 12. A load applied to the raise bit increases the aforementioned forces. Frictional forces developed between the mating surfaces of the collar 17 and the sections 18 and 19, and the drive stem 12 prevent rotational, radial, and axial movement of the drive stem 12 with respect to the raise bit body 11. A preload is induced into the system to insure proper torque transmittal at low bit loads by the cap 21 and bolts 22 and 23. When bolts 22 and 23 are tightened, they urge the cap 21 against the flange 20 and the sections 18 and 19 upward in the collar 17.

The structural details of a raise bit constructed in accordance with the present invention having been described, a raise drilling operation will now be considered using the bit shown in FIGS. 1, 2, and 3. The raise drilling operation begins by drilling a small diameter pilot hole through the earth from a first location to an opening at a second location using a small diameter pilot bit. After the pilot hole is completed, the pilot bit is removed from the drill column and the raise bit 10 is attached to the drill column. The raise bit is rotated and drawn along the pilot hole, thereby enlarging the pilot hole to the desired size. The collar 17 and sections 18 and 19 of the split collar provide a rigid connection between the drive stem 12 and the raise bit body 11.

The raise bit may be transported through small drifts or passages by removing the drive stem 12 and transporting the drive stem 12 and the raise bit body 11 through the small drifts or passages separately. The bolts 22 and 23 are removed, thereby disconnecting the cap 21 from the collar 17. The drive stem 12 and the sections 18 and 19 of the split collar are moved downward thereby disengaging the sections 18 and 19 of the split collar from the collar 17. With the split collar removed, the drive stem 12 may be removed from the raise bit body 11. The separate elements of the raise bit 10 may then be transported separately through the small drift or passage. When the raise bit 10 is to be connected to the drill column, the drive stem 12 is inserted through the collar 17. The sections 18 and 19 of the split collar are positioned around the lower end of the drive stem 12 and the drive stem 12 and the split collar are moved upward into the collar 17. The cap 21 is positioned in contact with the flange 20 and bolts 22 and 23 are engaged with the threaded recesses 32 and

33 respectively. Tightening of the bolts 22 and 23 imposes a preload on the system. The raise bit 10 is again ready for operation.

Should the drive stem 12 experience failure prior to failure of the raise bit body 11, the drive stem may be removed from the raise bit body 11 and a new drive stem inserted in its place. The bolts 22 and 23 are removed thereby disconnecting the cap 21 from the collar 17. The drive stem 12 and sections 18 and 19 of the split collar are moved downward thereby disconnecting the drive stem 12 from the raise bit body 11. The drive stem 12 is removed and the new drive stem inserted through the collar 17. The sections 18 and 19 of the split collar are positioned around the new drive stem and the new drive stem and the sections 18 and 19 of the split collar are moved upward into the collar 17. The cap 21 is positioned in contact with the flange on the end of the new drive stem and bolts 22 and 23 are engaged in the threaded recesses 32 and 33. Tightening of the bolts 22 and 23 imposes a preload on the system and the raise bit is ready for operation.

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

1. A bit for enlarging a pilot hole into a larger diameter hole by disintegrating earth formations surrounding the pilot hole, comprising:
- a drive stem having an upper end for projecting into said pilot hole;
- a main bit body including a multiplicity of cutters for contacting and disintegrating earth formations surrounding the pilot hole;
- a central opening in said main bit body substantially surrounding said drive stem, said central opening having a conical inner surface that tapers inward toward said drive stem in the direction of said upper end of said drive stem;
- and means around said drive stem having a tapered outer surface that tapers inward toward said drive stem in the direction of said upper end of said drive stem and engages said conical inner surface for retaining said drive stem in said central opening and connecting said drive stem to said main bit body.

2. The bit of claim 1 including a flange projecting from said drive stem for contacting said means around said drive stem.

3. The bit of claim 2 wherein said drive stem has a lower end, said bit including a cap that fits over said lower end of said drive stem and bolt means for forcing said cap against said lower end of said drive stem.

4. A raise bit for enlarging a pilot hole into a larger diameter hole by disintegrating earth formations surrounding the pilot hole, comprising:
- a cutter stage body, said cutter stage body having an upper portion and a lower portion;
- a multiplicity of saddles mounted on said upper portion of said cutter stage body;
- a multiplicity of rolling cutters positioned in said saddles;
- a central opening in said cutter stage body, said central opening having a conical inner surface tapering toward said upper portion of said cutter stage body;
- a drive stem positioned in said central opening;
- retaining element means around said drive stem for retaining said drive stem in said central opening, said retaining element means having an outer surface adapted to mate with said conical inner surface; and
- means for urging said retaining element means into said central opening.

5. The raise bit of claim 4 wherein said retaining element means is a two-piece collar with a conical outer surface tapering toward said upper portion of said cutter stage body.

6. A bit for enlarging a pilot hole into a larger diameter hole by disintegrating earth formations surrounding the pilot hole, comprising:
- a drive stem having an upper end for projecting into said pilot hole;
- a main bit body including a multiplicity of cutters for contacting and disintegrating earth formations surrounding the pilot hole;
- a collar positioned around said drive stem connected to said main bit body, said collar having a conical inner surface that tapers inward toward said drive stem in the direction of said upper end;
- a retaining element having a conical outer surface that matches said conical inner surface adapted to be positioned around said drive stem;
- a flange on the end of said drive stem for urging said retaining element into said collar; and
- cap means for contacting said flange and urging said retaining element into said collar.

7. A raise bit for enlarging a pilot hole into a larger diameter hole by disintegrating earth formations surrounding the pilot hole, comprising:
- a drive stem having an upper end for projecting into said pilot hole and a lower end;
- a cutter stage body;
- a multiplicity of saddles mounted on said cutter stage body;
- a multiplicity of rolling cutters positioned in said saddles;
- a collar positioned around the lower end of said drive stem and connected to said cutter stage body, said collar having an inner conical surface that tapers inward toward said drive stem in the direction of said upper end; and
- a retaining element means positioned between said collar and said drive stem, said retaining element means having a tapered outer surface adapted to mate with said conical inner surface.

8. The raise bit of claim 7 including a flange projecting from said drive stem and a cap means positioned over said flange for urging said tapered surface into contact with said conical inner surface.

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