Fig. 3a

Fig. 3b

Fig. 3c

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ABSTRACT OF THE DISCLOSURE

A well reaming tool has a rotatable shaft with hubs thereon for the rollers. Adjacent hubs are connected by rings mounted on the shaft. A pair of eccentric socket elements at each end of each hub connects the hub to the adjacent rings.

The present invention relates to tools for reaming a well or bore bored in the ground which are particularly suitable for use with boring equipment using a flexible tube at the lower end of which is suspended a bottom motor driving the boring tool. Reaming of a well or bore in the ground may be carried out during boring between descents of the boring tool or at the end of the boring operation before insertion of the tubing.

Known reaming tools usually include a body having a shaft which is coupled to the lower end of a series of rigid drill pipes utilized in rotary drilling and including a number of rollers provided with cutting elements or abrasive elements, these rollers being disposed in recesses formed in the periphery of the body of the reaming tool and rotating around axes parallel to the axis of the body, or more frequently, inclined with respect to said axis.

The axes of these rollers are mounted on slide bearings and the diameter of the rollers is generally on the order of a third of that of the body of the reaming tool.

Coupling of a reaming tool of this type to the rotor of a bottom motor having a speed of rotation of the order of one thousand to fifteen thousand revolutions per minute provides a rotation of the rollers of between 3,000 and 4,500 revolutions per minute which is prohibitive when the rollers are mounted on slide bearings.

Further, in view of the small diameter of the recesses for the rollers in known reaming tools, it is very difficult to mount the axes of these rollers on suitable bearings and lubrication thereof would be a very difficult matter.

A solution of this problem is provided by a reaming tool having ribs on the body of the tool, but such a construction requires a greater force to rotate it than can be absorbed by the flexible tubing except in a very limited range of types of ground and under conditions such that the points of contact of the ribs with the wall of the bore are so spaced and so irrigated as to reduce to a minimum the force necessary for rotation.

A better solution to this problem is obtained when annular rollers are provided around the body of the reaming tool at different levels thereof and are mounted for rotation around hubs fixed to the body of the reaming tool, the association of each roller with the corresponding hub constituting a reaming element, an assembly being provided in which the hubs of the different rollers are slightly eccentric with respect to the axis of the body of the reaming tool, with the axes of at least two of the rollers being angularly displaced with respect to each other. The hubs are preferably distributed at equal angular intervals about the axis of the body of the reaming tool in such a way as to distribute regularly the points of contact of the rollers on the wall of the bore.

The rollers then roll on the wall of the bore at the speed of rotation of the reaming tool which then acts as a crankshaft.

The problem of obtaining a rigid assembly of the hubs having the characteristics above described is difficult to solve.

A suitable assembly can be obtained by connecting the hubs of the consecutive reaming elements by coupling rings in which the hubs are screwed but it is very difficult in this way to obtain a correct relative angular positioning of the axes of the hubs around the axis of the body of the reaming tool.

Another solution is the use of a shaft for the reaming tool on which eccentric hubs are mounted and the rollers turn on these hubs on axes parallel to the shaft with the hubs being fastened to the shaft for rotation either by keying on the shaft or by utilization of a shaft having a polygonal section.

Any of the solutions discussed above require a shaft having a cross-section sufficient to transmit large forces of rotation to the reaming elements.

An object of the present invention is to provide a rigid assembly of reaming elements in which the transmission of the torque to these reaming elements is provided by the assembly itself which is solidly and directly connected to the driving shaft of the bottom motor which drives the tool in rotation.

Summary of invention

In accordance with the present invention, the hubs of the reaming elements of the tool are each provided with an internal bore to receive the shaft of the tool and are connected by rings having an internal bore for the shaft. The rings and hubs provide a pair of couples of socket elements eccentric with respect to each other, each couple including a male socket element and a female socket element. The hubs and the rings when mated form an assembly having an internal bore for housing the said shaft with a slight play. The arrangement of these socket elements is such that when the assembly is mounted on the shaft the pairs of couples of socket elements are eccentric in at least two different angular positions with respect to the axis of the shaft and are inclined to the axis of the shaft thus preventing any separation of the elements of the couples by reason of the fit of the shaft in the bore of the assembly. This assembly is driven at one of its extremities in rotation by the head of the shaft which head transmits the torque directly to the assembly.

An embodiment of the reaming tool of the present invention will be described hereinafter.

Reference will be made to the accompanying drawings, in which like reference characters indicate like parts. This embodiment is shown by way of example but it is in no way to be construed as limiting the invention.

In the accompanying drawings, FIG. 1 is a schematic view of an embodiment of the present invention having three reaming elements inclined to and eccentric with respect to the shaft of the reaming tool, with the elements being distributed over regular angular intervals around the shaft;

FIGS. 1a, 1b and 1c show, respectively, cross-sectional views of the tool of FIG. 1 perpendicular to the axis xy of the shaft on the lines a—a, b—b and c—c showing the location of the contacts of the rollers with the wall of the well or bore;

FIG. 2 shows a hub of a reaming element on a more reduced scale than the scale of the parts illustrated in the following figures;

FIGS. 3a, 3b, 3c and 3d show the upper terminal ring connecting the hub of the upper reaming element with
the head of the shaft, respectively, in elevation; in partial cross-section on the lines a—c; in section on line b—b as seen from above; and as seen from below;

FIGS. 4a, 4b, 4c and 4d are corresponding views for intermediate rings connecting consecutive reaming elements; and

FIGS. 5a, 5b and 5c show the lower terminal ring of the reaming assembly.

In the embodiment of FIG. 1, the upper part or head 1 of the reaming tool is fastened by conical threads 2 to a piece 3 fixed to the driving shaft of a bottom motor which is located at the lower end of a flexible tube, not shown, descending from the surface in the bore 41.

The lower part of the stator of the driving bottom motor is shown at 4.

The cylindrical shaft 5 of the reaming tool is of monoblock construction and is formed as an extension of the head 1.

On shaft 5 is mounted an assembly formed by the following elements beginning at head 1:

(1) An upper mounting ring 6 having the same axis xy as shaft 5 and including an internal bore 50 (FIGS. 5a to 5d) in the same axis xy.

(2) A first reaming element 7—8 the axis of which st is different from the axis xy of the shaft, this axis being offset and inclined with respect to axis xy. This reaming element comprises an annular roller 8 provided with teeth and mounted on hub 7 through bearings 9, the hub having a bore for shaft 5.

(3) An intermediate mounting ring 10 having an axis coincident with axis xy of shaft 5 and having an internal bore 51 with the same axis xy as shaft 5.

(4) A second reaming element 11—12, similar to the first one and having an axis ub, offset by 120° to the right with respect to the first reaming element, as seen from the top toward the bottom of the axis xy of shaft 5.

(5) An intermediate mounting ring 13 with the same axis xy as shaft 5, ring 13 being identical to ring 10.

(6) A third reaming element 14—15 having an axis wz, similar to the two preceding reaming elements and offset by 120° to the right with respect to reaming element 11—12.

(7) A lower mounting ring 16 with the same axis xy as shaft 5 having an internal bore 52 centered on the same axis xy so as to receive shaft 5.

The assembly is formed by the successive mounting of the preceding elements on each other.

To this end, the hubs of the reaming elements, all three of which are identical, have an internal bore 63 for shaft 5 as seen in FIG. 2 and include at each of their extremities two cylindrical shoulders with one shoulder being eccentric with respect to the other, as seen at 17 and 18 and at 19 and 20 for the hub 10 of the first reaming element, received, respectively, in two female sockets in the mounting ring (FIG. 2), the cooperation of the male shoulders of the hub and of the female shoulders of the rings providing pairs of couples of socket elements.

The cylindrical male shoulders 18 and 20 have the same axis as the hub (i.e., st for the first smoothing element) and the cylindrical shoulders 17 and 19 located at the extremity of the hub have a smaller diameter than shoulders 18 and 20 and have axes parallel to the common axis of shoulders 18 and 20 but are eccentric with respect thereto.

The female shoulders 48 and 49 which are formed in the upper support ring 6 for receiving male shoulders 17 and 18 of hub 7 have their axes inclined and eccentric with respect to the axis xy of the ring as seen in FIGS. 3a, 3b, 3c and 3d, the angle α of inclination being, for example, on the order from 3° to 4°.

The intermediate mounting ring 10 of FIGS. 4a to 4d provides at its upper portion a female socket element having two internal shoulders 53 and 54 having axes eccentric with respect to axis xy of the ring and inclined by the same angle α to this axis as seen in FIG. 4c.

Hub 11 of the second reaming element has similar cylindrical male shoulders 45 and 46 at one of its extremities forming a socket assembly with female shoulders 55 and 56 formed in support ring 10.

Female shoulders 55 and 56 are angularly displaced with respect to the analogous female shoulders 53 and 54 formed in the other extremity of ring 10 by an angle of 120° with respect to axis xy of the ring.

Intermediate mounting ring 13 is identical to intermediate ring 10 which is described above.

The internal bores formed in the mounting rings have a diameter which is only slightly larger than that of shaft 5.

Intermediate rings 10 and 13 are provided with guide shoes 64 (FIG. 4c) for the shaft.

Lower mounting ring 16 has two internal shoulders 57 and 58, as seen in FIGS. 5a, 5c, adapted to receive male socket elements located at the base of hub 14 of the third reaming element.

Internal shoulders 57 and 58 axe which are eccentric to and are inclined at angle α, as described above, with respect to axis xy of ring 16.

Mating the male shoulders of the hubs of the reaming elements in the corresponding female shoulders of the support rings provides an assembly in which the elements cannot turn with respect to each other because of the double socket construction. This assembly provides an internal longitudinal passage in which shaft 5 is mounted with slight play.

The mounting of this assembly on shaft 5 provides for the centering of the mounting rings.

Because of the combination of the small clearance between the shaft 5 and the internal passage of the assembly and the inclination given to the pairs of double socket elements, the elements of the assembly cannot separate when the shaft is inserted in the assembly.

The assembly is solidly fixed to head 1 of the shaft which is also the head of the reaming tool, in such a way that there is no substantial transmission of the torque of the bottom motor to the hubs through the shaft 5 itself, the required mechanical resistance of the shaft being therefore lower, so that the latter can be of a diameter smaller than that of head 1.

In the embodiment as shown, the head of the shaft comprises two male shoulders 59 and 60 having axes parallel to the axis of the shaft and one of which is eccentric with respect to the other. These male shoulders cooperate with female shoulders 61 and 62 formed in the upper part of the terminal ring 6 as seen in FIGS. 3b, 3c in such a way as to drive the assembly in rotation with the head of the shaft. Further, in order to avoid any separation by longitudinal displacement between the head of the shaft and the assembly, the lower part of the assembly is fastened to the lower part of the shaft by suitable securing means.

The assembly can be fixed to the head of the shaft by any suitable means as by set screws or by keys.

A pair of socket male elements can be used for the lower part of the head of the shaft disposed eccentric and inclined with respect to the axis of the shaft, cooperating with an upper mounting ring 6 formed of two half rings obtained by cutting the ring along a diametrical plane passing through the axis of the shaft. These half rings would then be put in place laterally to make the complementary double socket elements of the head of the shaft and of the ring register with each other. The two half rings could then be secured to each other by conventional means such as by bolting or by covering with an exterior sleeve.

Whatever the means of mounting the assembly on the head of the shaft, an axial compression is then applied to the assembly. This compression is sufficient to transmit the torque from the motor to the elements comprising the assembly by friction between these elements.

Transmission of the torque by the off-set socket elements
then occurring only in case of loosening of the assembly.

To obtain this axial compression, shaft 5 terminates at its lower end in a threaded part 21 on which is mounted an intermediate axial compression member 22 and a nut 23. A lock nut 24 is also provided to prevent rotation of the entire assembly. The assembly described above is thus interlocked by compression between head 1 of the shaft on one hand, provided with male shoulders on which the upper ring 6 is mounted, and nut 23 on the other hand. A high compression can be obtained by heating the shaft 5 to the temperature of the neighborhood of 150° prior to the tightening of nut 23 and lock nut 24. This high temperature can be obtained by introducing a heating rod in the bore of shaft 5.

It is also possible to obtain high compression of the assembly prior to the tightening of nut 23 by other means as for example, by the use of a jack or by cooling of the assembly to a very low temperature prior to the mounting on shaft 5.

Transmission of the torque from the driving motor driving shaft 5 to the reaming elements is thus provided by the non-rotary mounting of the elements and by a compression force sufficient for securing the transmis-

sion of normal values of this torque. Transmission of this torque to the reaming elements occurs through the assembly connected to the head 1 of shaft 5 and not through shaft 5 itself which only provides for the alignment of the reaming elements and their mounting rings and places the assembly in compression.

Lubrication is provided by ducts formed in the head of shaft 5 as at 25 and 26 and by radial ducts at 27 and 28 in the hubs of the reaming elements and by ducts 29, 30 and 31 through the mounting rings.

Circulation of the lubricating fluid is achieved by injecting the fluid from the surface into the flexible tubular supporting the reaming tool.

Fluid is introduced through an axial duct in the stator 4 of the motor and provides lubrication of the bearings by flowing in the direction of the arrows through the ducts described above.

A safety shaft 32 provides axial cohesion of the assembly in shaft 5 breaks or in case of loosening of the lock nuts. This safety shaft is mounted in an axial bore in shaft 5 and supports a lock nut 24 at its lower end. A cap 33 is screwed to the lower end of the safety shaft and bears on lock nut 24. At its upper extremity safety shaft 32 is put under slight tension by spring 34 located in a cavity of head 1 and resting on a portion of centering ring 35 in which the safety shaft can slide. Ring 35 is mounted on a seat 36 at the lower part of said cavity. A mushroom element 37 bears on a nut 38 threaded on the upper extremity of the safety shaft with a coter pin provided to prevent nut 38 from unscrewing, and stops the other end of spring 34. When shaft 5 breaks or its lock nuts become unscrewed, the safety shaft descends and the base of the mushroom 37 then rests on the seat in head 1 and partially blocks the fluid duct, thus provi-

ding a pressure rise in the circulation apparatus of the fluid at the surface installation, which pressure rise gives an alarm.

Further, the safety shaft maintains the cohesion of the elements of the assembly when shaft 5 breaks, as the mushroom 37 abuts against its seat 36 before the elements of the assembly have undergone relative axial displacement sufficient to separate from each other.

A guiding or piloting structure is provided at the lower end of the reaming tool such as a known tricone having a smaller diameter than that of the bore to be reamed or a cutter head may be used to center the axis xy in the bore.

This structure may comprise a body 40 secured to the lower mounting ring 16 by structure 39 in which it is screwed, structure 39 being screwed in ring 16 as by conical thread 47.

Three conical cutters 42, 43 and 44 turn around axes which are inclined with respect to the axis of body 40 and these conical cutters do not engage the wall of the bore.

When head 1 is rotated by the driving motor, rollers 8, 12 and 15 roll on the wall of the bore or well with the speed of rotation of the driving motor in the same manner as the teeth of a tricone. Two adjacent rollers have their lines of contact with the walls of the bore or well offset by 120° around the axis xy as seen in FIGS. 1a, 1b and 1c.

The rollers can advantageously be given a curved profile in the axial plane as seen in the drawings.

The rollers include on their peripheral surfaces cutting or abrasive elements to attack the earth.

These surfaces may include teeth, tungsten carbide elements or a diamond coating.

The alignment of the teeth, cutting or abraded ele-

ments can be parallel to the axis of the roller or inclined thereto.

In certain types of terrain the rollers can be smooth. Various modifications of the above-described embodiment will appear to those skilled in the art without departing from the present inventive concept.

It is possible, for example, to use, in place of three rollers offset at 120°, two groups of two rollers offset at 180°, these two groups being angularly shifted with respect to each other, or four rollers offset at 90°, a plurality of these combinations; or an arrangement in spiral.

Reference should therefore be had to the appended claims to determine the scope of this invention.

What we claim is:

1. A reaming tool for bores formed in the earth, hav-

ing a shaft with an upper end and a lower end, a head at the upper end of the shaft coupled to the driving shaft of a motor, a plurality of reaming elements surrounding the shaft of said tool at different levels thereon, each reaming element consisting of a hub provided with an internal bore, and a roller surrounding the hub and rotatably mounted thereon, said tool further comprising mounting rings connecting the reaming elements and having an internal bore, pairs of sleeve couplings, said couplings being eccentric with respect to each other and connecting each hub to the adjacent one of said rings, each sleeve coupling including a male and a female element, the hubs and said mounting rings forming by inter-engagement a tool assembly having an internal bore adapted to receive the tool with a slight clearance, said pairs of couples of socket elements being so disposed that when said assembly is mounted on the shaft said pairs of couples of socket elements are eccentric in at least two different angular positions with respect to the axis of said shaft and are inclined to the axis thereof so as to prevent separation of said rings and said reaming elements as a result of the fitting of the shaft in said internal bore of said assembly, and said assembly being connected at one of its ends to the head of the shaft for rotation thereby, the torque of the driving motor thus being directly transmitted from said head to said assembly.

2. Apparatus as described in claim 1, including internal ducts in said assembly for lubrication fluid for the rollers and internal conduit means in the head of the shaft com-

municating with said internal ducts.

3. Apparatus as described in claim 1, including guide shoes in said rings fitting the shaft with a slight clearance.

4. Apparatus as described in claim 1, including shoulder means on the head of the shaft and stop means at the lower end of the shaft, for said assembly being locked therebetween.

5. Apparatus as described in claim 4, including a lower terminal mounting ring, the hub of the reaming element at the lower end of said assembly being connected to said lower terminal mounting ring, a pair of couples of socket element, said couples being eccentric with respect to each other and being provided for connection of said terminal mounting ring to said lower reaming element, each couple
of socket elements being constituted by the cooperation of a male element and a female element having axes inclined with respect to the axis of the shaft, said stop means being screwed on the lower end of the shaft.

6. Apparatus as described in claim 5, including an upper terminal mounting ring, the hub of the reaming element located at the upper end of said assembly being engaged with said upper terminal mounting ring, a pair of couples of eccentric socket elements connecting said upper terminal ring and the upper reaming element, each couple comprising a male element and a female element having axes inclined and eccentric with respect to the axis of the shaft said upper terminal mounting ring being fitted to said shoulder means of the shaft, a pair of couples of socket elements being provided for fitting said shoulder and said upper terminal ring, said couples being eccentric with respect to each other and each couple comprising a male and a female element having axes eccentric with respect to the axis of the shaft.

7. Apparatus as described in claim 6, including an internal axial conduit for the shaft, a cavity in said head communicating with the upper end of said axial conduit, a safety device, a shaft for said safety device mounted in said axial conduit, a mushroom shaped element provided at the upper end of said shaft and located in said cavity, an annular seal for said mushroom shaped element at the bottom of said cavity, spring means associated with said mushroom shaped element, and maintaining said shaft in an upper position above said seat, said mushroom shaped element, by engaging said seat in a lower position, partially blocking said internal conduit means, in the head of the shaft, a thread on the lower end of said safety shaft and a cap screwed on said thread, said cap bearing against said stop means at the lower end of the shaft.

8. Apparatus as described in claim 4, compression of said assembly between said shoulder means on the head and said stop means being increased by a permanent compression applied to said assembly.

9. Apparatus for reaming bores formed in the ground comprising a shaft, a head at the upper end of said shaft, a driving motor, a shaft for said driving motor coupled to said head, a plurality of reaming elements surrounding said shaft spaced along the length thereof, each of said reaming elements comprising a hub, a roller surrounding said hub for rotation thereon, each of said hubs comprising at each end a pair of socket elements, said elements being eccentric with respect to each other, mounting rings connecting said hubs, internal bores in said rings receiving said shaft, each of said rings at each end thereof having a pair of socket elements complementary to said pair of socket elements of the adjacent one of said hubs, at least one of said last named socket elements having its axis eccentric with respect to the axis of said internal bores of said rings, the pairs of said socket elements at the two extremities of a given one of said rings being angularly offset with respect to the axis of said internal bores of said rings, said reaming elements and said rings comprising an assembly having an internal passage for said shaft, an upper terminal mounting ring between an extremity of said assembly and said head of said shaft, a lower terminal mounting ring at the other extremity of said assembly, and a stop on said shaft bearing against said lower terminal mounting ring, relative rotation of said reaming elements about said shaft being prevented by said pairs of complementary socket elements and axial separation of said assembly being prevented by the combination of the inclination on the axis of said shaft of the axes of said socket elements and of the fit of said shaft in said internal bore of said assembly.

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