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(54) **Drilling equipment for percussive drilling.**

(57) The invention relates to a drilling equipment (25) composed of a combination comprising an annular drill bit (10), a tubular drill rod (12) attached to the drill bit by a thread coupling, a conversion connector (14) fastened to said tubular drill rod (12), and a drill rod (13), essentially smaller in outer diameter than the tubular drill rod (12). A design in accordance with the invention provides adequate support and guiding of the drill bit and subsequently high quality of the drillhole. A smaller-diameter rod system (13) is also easy to handle by means of for instance drill rod maganizes. The tubular drill rod (12) and the drill rod (13) are fastened to each other with the conversion connector (14). The invention also relates to the conversion connector for connecting the drill rod systems to each other.

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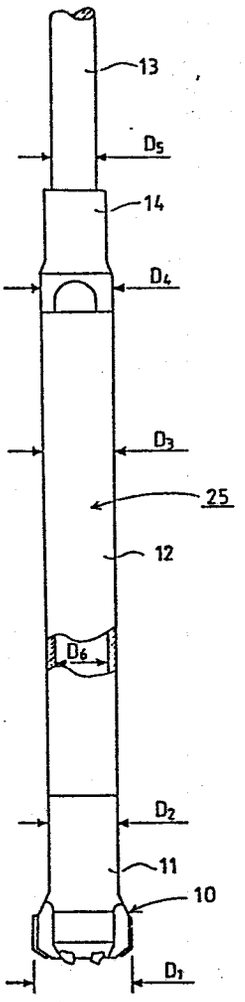

FIG. 2

Drilling equipment for percussive drilling

The present invention relates to drilling equipment for percussive drilling, said equipment comprising an annular drill bit and a drill rod system attached to the drill bit; the percussive and rotative drive are brought to the drill rod system by equipment located above the ground level.

A great problem of currently used drilling equipment systems has been the quality of the drillhole being drilled. The most widely used equipment consists of such a drilling stem system in which drilling stems of a diameter considerably smaller than the diameter of the bit and its stem is attached to the drill bit. This means that the drill bit with its short stem is not adequately supported by the walls of the drillhole. The controllability of the drill is bad and the danger of bending is great; the probability of the collapse of the drillhole is very obvious. The flushing characteristics of this well-known and conventional drill bit/drill rod combination are also very poor, which further worsens the support provided for the drill by the walls of the drillhole. With insufficient flushing, drilling dust and cuttings will pile up in the outer flushing channel, which also prevents the rod section from evening up the drillhole and being supported by its wall. Therefore the support will be very uneven.

In the Prior Art we know various types of down-the-hole drilling machines, in which connecting parts providing support have been attached to the annular drill bit. It should however be noted that these solutions specifically represent down-the-hole drilling machine applications; therefore they are not connected with rock drill applications, in which the rod system is only for transmitting impacts and rotation delivered on the surface and in which the drill is specifically driven

only from the surface. An example of the known down-the-hole drill drives is the United States publication No. 2,708,566.

On the other hand, the Applicants published Finnish application No. 824126 depicts such a drill rod system, in which the steel cross-section of the tubular drill rod is so dimensioned as to provide good flushing of the drillhole. The rod systems must also be easy to handle; therefore the outer cross-section of each rod unit should be as small as possible in order to properly fit into the drill rod magazine.

Yet no such combination has been designed in the Prior Art applications in which the rods could be handled quickly and the bulk of the rods could be stored in small space, for instance in drill rod magazines, and by which drill rod system the quality of the drillhole would be high, the drillhole would be straight, and which drill rod system would be economically more feasible than other systems.

With a drilling equipment combination in accordance with the invention is is possible to avoid the drawbacks of the combinations known in the Prior Art; a solution in accordance with the invention provides an entirely new unit comprising the annular drill bit, the rod system and a connector piece (conversion connector); this unit gives good support to the annular drill bit, creates good-quality drillholes and makes the handling of the whole rod system good and optimized.

A drilling equipment combination in accordance with the invention comprises, except for the conversion connector, only existing components known as such. It provides a new possibility to make use of existing drilling equipment in a new feasible way. The invention combines the advantages of tubular drilling equipment and rod-type drilling equipment at the same time eliminating their drawbacks. Old drilling equipment, maganizines included, may be used with the new combination without any modifications. So there will be no need to renew old drill rod magazines and cassettes.

The invention is based on the idea that an annular drill bit can, in the vicinity of the drill bit, be supported with one or two tubular support bars. In order that said support be adequate, drilling dust and cuttings must not, in the vicinity of the drill bet, be packed between the drill rod and the walls of the drillhole being created. Therefore there must also be adequate flushing, so that drilling dust and cuttings will be taken away from said area supporting the drill bit.

Said good flushing and consequently good support are provided by a rod system in which the cross-section of a center flushing channel is essentially as large as the cross-section of an outer flushing channel in order to prevent any constriction. Said way of shaping the rod also makes it possible to make the outer flushing channel relatively narrow; in other words the outer wall of the drill rod is close to the wall of the wall of the drillhole being formed, which is a prerequisite of good support. There will be little room for the drill rod to bend in the drillhole; should the drill deviate from its original direction, the drill rod will touch the wall of the drillhole already drilled, which will prevent the drill from deviating any more. Therefore the deviation will be the smaller the closer the outer surface of the supporting bar is to the wall of the drillhole being formed. Therefore even a relatively short supporting bar section (comprising one or two tubular drill rods) makes it possible to create a straight and smooth-surfaced drillhole.

Said narrowness of the outer flushing channel also prevents stones or other rather large pieces of earth from dropping from the walls of the drillhole into the drillhole. The diameter of the rest of the rods is essentially smaller, which makes the whole combination easy to handle. The smaller is the outer diameter of a rod, the easier it is to fit the rods into a drill rod magazine, as small-diameter rods take essentially less room than rods that are largish in diameter.

Thus a combination in accordance with the invention is, when considering the price of one drilled meter as the reference rate, economically an optimal solution.

An essential feature of a combination in accordance with the invention is that the outer surface of the section of the drill rod system located in the vicinity of the drill bit has essentially no steps. The outer diameter of the drill bit, the outer diameter of the tubular drill rod, and the outer diameter of the broadest point of the connector piece or the conversion connector in accordance with the invention are then essentially equal, which provides a no-constriction passage for the flushing liquid in the outer flushing channel.

Another essential feature of the invention is that it is sufficient to equip the section near the drill bit with a combination which provides good support and good flushing, because it is this section near the drill bit that is the most critical from the point of view of the quality of the drillhole being drilled.

In order to be able to transmit the impacts of the drilling machine as efficiently as possible from a smaller-diameter shaft section to the tubular drill shaft providing support, the rod system must be equipped with a connector piece (conversion connector). This connector piece must be so shaped as to keep the steel cross-section essentially constant when proceeding from the surface of the smaller-diameter rod end mating the connector piece to the surface of the connector piece mating the end of the larger-diameter tubular drill rod. This will prevent reflection of impact energy and shock waves, i.e. impact energy losses. An essential feature of the connector piece is that impact energy is specifically transmitted by the end faces so that the threads will not take the loading; they are only for tightening the rod ends up against the mating surfaces of the connector piece.

An essential feature of a solution in accordance with the invention is that the connector piece is designed as a thread conversion connector;

the external thread at one end of the connector piece mates the internal thread of the tubular supporting rod; the preferable thread system will be described below. The thread system of the internal thread at the other end of the conversion connector can be chosen freely. This kind of conversion connector in accordance with the invention gives flexibility to the drilling equipment combination. The user may then choose a conversion connector, which, at one end, has a thread that mates with the thread of the his drill rod system and the drill rod system connected with the drilling machine.

The principal characteristic feature of the invention is that the drilling equipment is composed of a combination which comprises

- an annular drill bit,

- a tubular drill rod or rod combination, attached to the annular drill bit with a threaded coupling, the outer diameter of said drill rod or rod combination being essentially equal to the outer diameter of the shaft of the annular drill bit, whereupon the outer diameter of the tubular drill rod and the diameter of the center hole or the center flushing channel are such that the cross-section area of the inner hole of the drill rod is essentially equal to the cross-section area of the annular space between the outer surface of the drill rod and the wall of the finished drillhole, i.e. to the cross-section of the outer flushing channel,

- a conversion connector attached to the tubular drill rod with a threaded coupling,

- an essentially tubular drill rod or drill rods, attached to the conversion coupling with a threaded coupling, the outer diameter of these/these drill rod/rods being essentially smaller than the outer diameter of the first-mentioned tubular drill rod.

The invention also relates to the conversion connector, whose principal characteristic feature is that it comprises the first coupling thread located at one end of its body section, and the second coupling thread located at the other end, said threads representing different thread systems.

Other characteristic features and points will be expressed in the claims and in the description below, with reference to the accompanying drawings.

Figure 1A shows a drill bit/rod combination of the Prior Art, which combination does not provide sufficient support of the drill bit for good-quality drillholes.

Figure 1B shows a solution in accordance with the invention, in which a rod providing appropriate support is attached to the drill bit.

Figure 1C shows a drilling equipment combination in accordance with the invention in a drilling situation.

Figure 2 is a side view of a drill bit/rod system/conversion connector combination in accordance with the invention.

Figure 3 is a cross-section view of the conversion connector.

Figure 4 is a top view of the conversion connector.

Figure 1A shows a drill bit/rod combination of the Prior Art, which combination does not provide sufficient support of the drill bit for good-quality drillholes. For instance when the drilling resistance or the need of feeding force changes, the drill tends to deviate, and the narrow rod system does not provide sufficient support.

Figure 1B shows a similar situation using a drill rod system in accordance with the invention. This figure illustrates only the drill bit section and the supporting tubular drill rod section attached to the drill bit section. The supporting rod section now prevents the drill bit from deviating, as the outer surface of the red, should deviating tendency occur, touches the wall of the finished drillhole even when the angular deviation of the drilling direction is small.

Figure 1C shows a drilling equipment combination 25 in accordance with the invention in a drilling situation. The cuttings rise from the bottom s_3 of the drillhole toward the mouth section s_2 of the drillhole. Larger stones or pieces of soil f cannot fall down to the bottom s_3 of the drillhole, as the space between the wall s_1 of the drillhole and supporting rod structure is narrow.

Figure 2 shows a drill equipment combination 25 in accordance with the invention, comprising a drill bit 10 with its shank section 11. The drill bit 10 is fastened by a threaded coupling to a tubular drill rod 12. Said tubular drill rod 12 is fastened to one end of a conversion connector 14 with a threaded joint; another drill rod 13 essentially smaller in diameter than the supporting drill rod 12 is fastened to the other end of said conversion connector 14.

D_1 denotes the diameter of a hole being drilled; D_2 denotes the outer diameter of the drill bit; D_3 denotes the outer diameter of the tubular drill rod fastened to the shaft of the bit at one end and to one end of the conversion connector 14 at the other end. D_4 denotes the largest diameter of the center section of the conversion connector 14, and D_5 denotes the outer diameter of the rod fastened to the other end of the conversion connector with a threaded joint.

There might be 1 to 3 drill rods as required. The number of drill rods 12 depends on their length, for instance. The lenght of one drill rod is preferably between 1500 to 6100 mm.

Diameters D_2 to D_4 as essentially equal to each other for smooth and stepless surface. The narrow outer flushing channel provides a sufficient flushing speed and consequently a sufficiently efficient removal of drilling dust and cuttings, and as this part of the rod system has an essentially smooth outer surface, there will be no constrictions which would impede the removal of drilling dust and cuttings and also have detrimental influence on consumption of energy by the flushing medium.

Figure 2 also shows the tubular rod 12 with a partial section view in order to show the central flushing channel. D_6 denotes the diameter of the central flushing channel. In the middle of the rod system 13 there is also a small-diameter flushing channel system which is not separately illustrated in the figure.

In order to provide adequate flushing and consequently good support the cross-section area of the central flushing channel of the tubular drill bar 12 is made essentially equal to the cross-section area of the outer flushing channel. Then there will be no energy-wasting constrictions. Shaping the rod in the described manner also results in a relatively narrow outer flushing channel, whereat the speed of the flushing medium will be high enough, and also the structure will such as to keep the outer face of the drill rod very close to the wall of the drillhole being formed, which is a prerequisite of good support and minimum tilting of the drill rod in the drillhole. Now there will not be much room for the drill bar to bend in the drillhole; as the drill deviates from its original direction, the drill bar will touch the wall of the drill hole thus preventing the drill from deviating further.

Figure 3 shows a longitudinal section view of the conversion connector 13 in an enlarged scale. The conversion connector is an elongated cylindrical piece, symmetrical as to its longitudinal axis. At one end it has a thread 15 for fastening it to the tubular drill rod 12; at the other end it has a thread 16 for fastening it to the smaller-diameter drill rod 13. The thread 15 is preferably an external thread; the thread 16 is preferably an internal thread. The thread 15 mate the end thread of the

tubular drill rod 12, and it has been selected from a thread system in which the thread angle and the profile height h mainly remain constant independently of the outer diameter D_3 of the tubular drill bar 12, wherat the pitch of the thread and the number of thread heads n increase as the outer diameter D_3 of the tubular drill rod 12 increases. In the thread system in question the thread has been selected as follows: if the outer diameter D_3 of the tubular drill rod 12 is smaller than 70 mm, the thread is one-headed and its pitch is less than 23 mm; if the outer diameter of the tubular drill rod 12 is 70 to 152 mm, the thread is two-headed and its pitch is 23 to 45 mm; if the outer diameter of the tubular drill rod 12 is over 152 mm, the thread is three-headed and its pitch is over 45 mm.

In said thread system, the pitch of the thread is 6° to 8°, preferably approx. 7°, and its profile height is 1.5 to 4 mm. The profile height could preferably be 2 to 3 mm. The flank angle ß of the thread is 25° to 45°, preferably approx. 35°.

On the other hand, the thread system of the thread 16 may be chosen freely.

Thus the conversion connector makes the system flexible, as the rods 13, whose thread may represent different thread systems, may, by means of the conversion connector 14, be easily connected to the tubular and supporting drill rod 12.

In figure 3, showing a section view of the conversion connector 14, there is a circular mating surface 17, against which the end of the rod 13 is turned. The conversion connector 14 also has a plane face 18, against which the end of the rod 12 will lean. The specific object is that impact energy will be transmitted by these mating surfaces instead of the threads. When moving from the smaller-diameter drill rod 13 to the larger-diameter drill rod 12, the intention is to keep the steel cross-section constant in order to avoid reflection of impact energy. Approximately at the middle section of the conversion connector 14, in

its flushing channel section, there is a bevelled channel surface 19 which is aimed at maintaining said steel cross-section as constant as possible and at the same time at promoting the laminarity of the flow of the flushing medium as it flows to the wider flushing channel section of the drill pipe 12.

In the outer-thread end of the conversion connector 14 there is also a guiding section 20 whose diameter is smaller than the bottom diameter of the threaded section; the object of this guiding section 20 is, when the rod 12 and the conversion connector 14 are fitted together, guide their threads to mate. In the conversion connector 14 there is a cylindrical center part 21, which has wrench-flats 24 for opening with hand tools in those exceptional cases when the joint cannot be opened mechanically by shock by disconnecting the rotation movement and leaving the impact drive on.

Figure 4 shows a top view of the conversion connector 14; said wrench-flat 24 can be seen in this figure. 22 denotes the mantle surface of the middle section 21 of the connector. The diameter D_4 of said middle section 21 is essentially equal to the outer diameter D_3 of the tubular drill rod 12. A bevelled surface 23 is bounded by the mantle section 22. It runs obliquely downwards and promotes the laminarity of the flushing medium flow toward the mouth section of the drillhole.

Claims

1. Drilling equipment (25) for percussive drilling, said equipment comprising an annular drill bit and a drill rod system attached to the drill bit; the percussive and rotative drive are brought to the drill rod system by equipment located above the ground level, characterized in that the drilling equipment (25) is composed of a combination which comprises

- an annular drill bit (10),

- a tubular drill rod (12) or rod combination, attached to the annular drill bit with a threaded coupling, the outer diameter (D_3) of said drill rod or rod combination being essentially equal to the outer diameter (D_2) of the shaft (11) of the annular drill bit (10), whereupon the outer diameter (D_3) of the tubular drill rod (12) and the diameter (D_6) of the center hole or the center flushing channel are such that the cross-section area of the center hole of the drill rod is essentially equal to the cross-section area of the annular space between the outer surface of the drill rod (12) and the wall of the finished drillhole, i.e. to the cross-section area of the outer flushing channel,

- a conversion connector (14) attached to the tubular drill rod with a threaded coupling (14),

- and a drill rod (13) or drill rods, attached to the conversion coupling (14) by means of a thread, the outer diameter (D_5) of these/these drill rod/rods being essentially smaller than the outer diameter (D_3) of the tubular drill rod (12).

2. Drilling equipment in accordance with claim 1, characterized in that there are 1 to 3 tubular drill rods (12).

3. A conversion connector (14) for joining two drill rod systems, characterized in that it comprises one coupling thread (15) located at one end of its body section, and another coupling thread (16) located at the other end, said threads representing different thread systems.

4. A conversion connector in accordance with claim 3, characterized in that the first thread (15) of the conversion connector (14), arranged to mate the end thread of the tubular rod (12), has been selected from a thread system in which the thread angle ( ) and the profile height h mainly remain constant independently of the outer diameter of the tubular drill rod (12), wherat the pitch of the thread and the number of thread heads n increase as the outer diameter of the tubular drill rod (12) increases.

5. A conversion connector in accordance with claim 4, characterized in that the first thread (15) of the conversion connector (14) is selected from the thread system as follows: if the outer diameter (D_3) of the tubular and supporting drill rod (12) is smaller than 70 mm, the thread is one-headed and its pitch is less than 23 mm; if the outer diameter of the tubular drill rod (12) is 70 to 152 mm, the thread is two-headed and its pitch is 23 to 45 mm; if the outer diameter (D_3) of the tubular drill rod (12) is over 152 mm, the thread is three-headed and its pitch is over 45 mm.

6. A conversion connector in accordance with claim 4 or 5, characterized in that the first thread (15) of the conversion connector (14) is selected from a system in which the pitch ( ) of the thread is 6° to 8°, preferably approx. 7°, and its profile height is 1.5 to 4 mm.

7. A conversion connector in accordance with one of claims 4 to 6, characterized in that the first thread (15) of the conversion connector (14) represents a thread of a system in which the profile height (h) is 2 to 3 mm.

8. A conversion connector in accordance with one of claims 4 to 7, characterized in that the flank angle (ß) of the first thread (15) is 25° to 45°, preferably approx. 35°.

9. A conversion connector in accordance with one of claims 3 to 8, characterized in that the conversion connector (14) comprises an internal and essentially circular mating surface 17, against which the end of the rod (13) can be positioned, and an external, essentially plane face (18), against which the end of the tubular drill rod (12) may be set.

10. A conversion connector in accordance with one of claims 3 to 9, characterized in that the conversion connector (14) comprises a cylindrical guiding section (20) at the end of the first thread (15).

11. A conversion connector in accordance with one of claims 3 to 10, characterized in that the conversion connector (14) comprises a bevelled channel section (19) located in the flushing channel in the middle part of the conversion connector.

12. A conversion connector in accordance with one of claims 3 to 11, characterized in that the conversion connector (14) comprises a bevelled surface (23) bounded by the mantle section (22) of the middle part (22).

13. A conversion connector in accordance with one of claims 3 to 12, characterized in that the first coupling thread (15) is an external thread and the second coupling thread (16) is an internal thread.

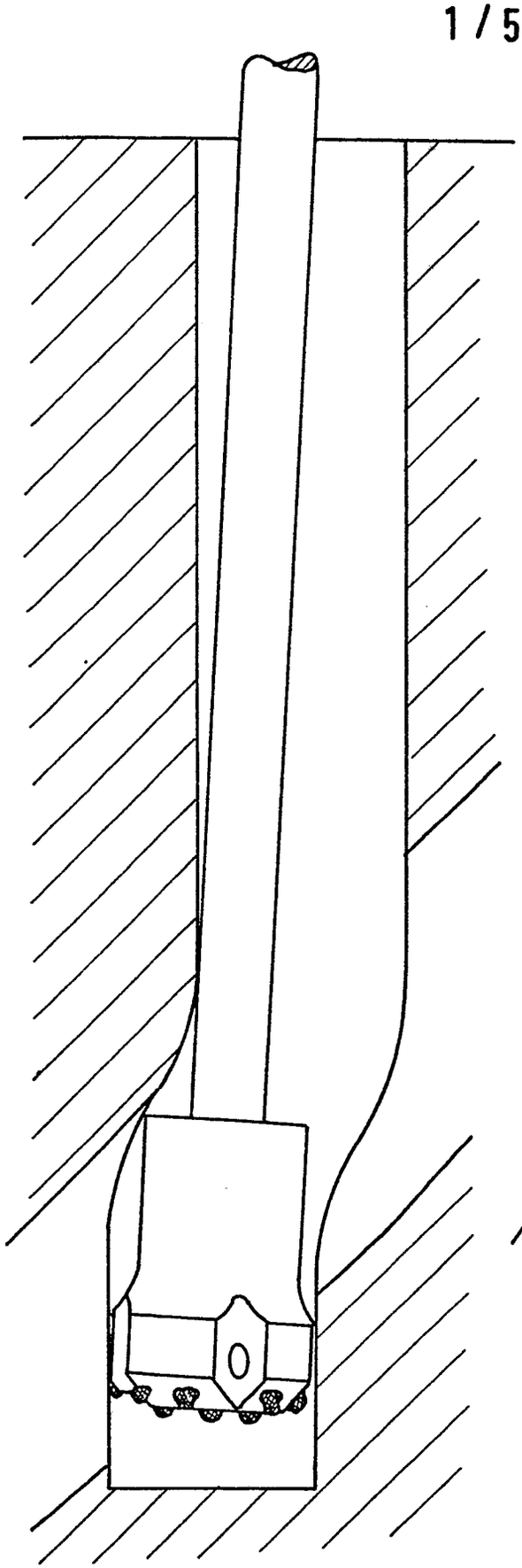

FIG.1A

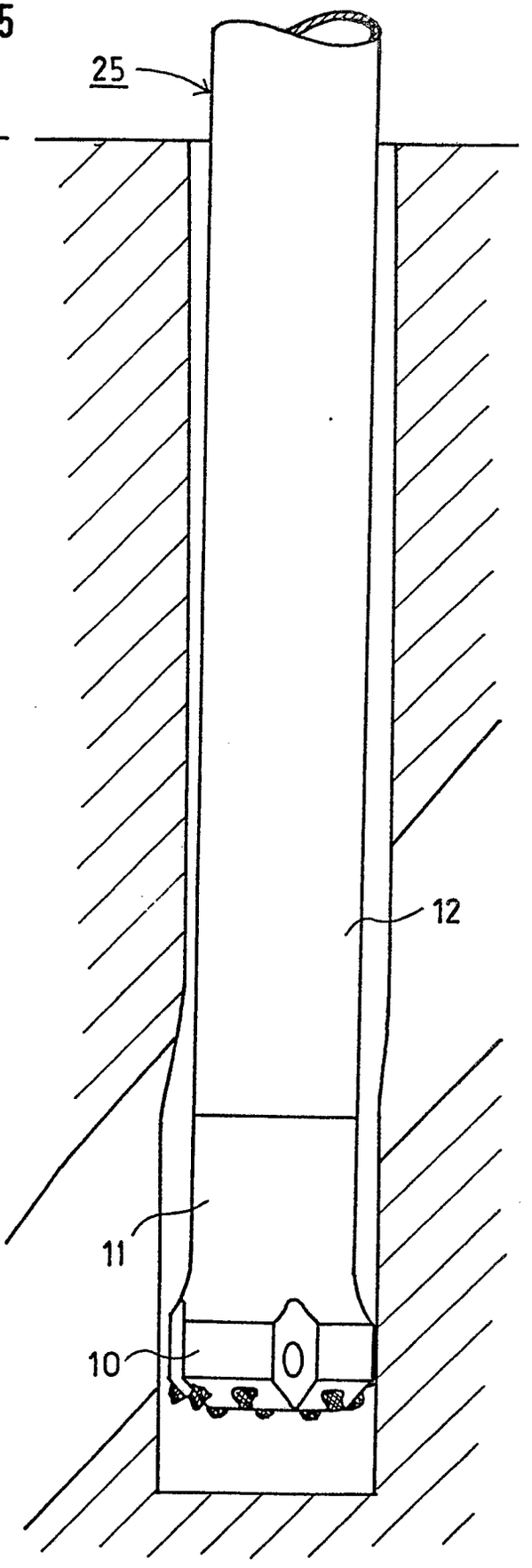

FIG.1B

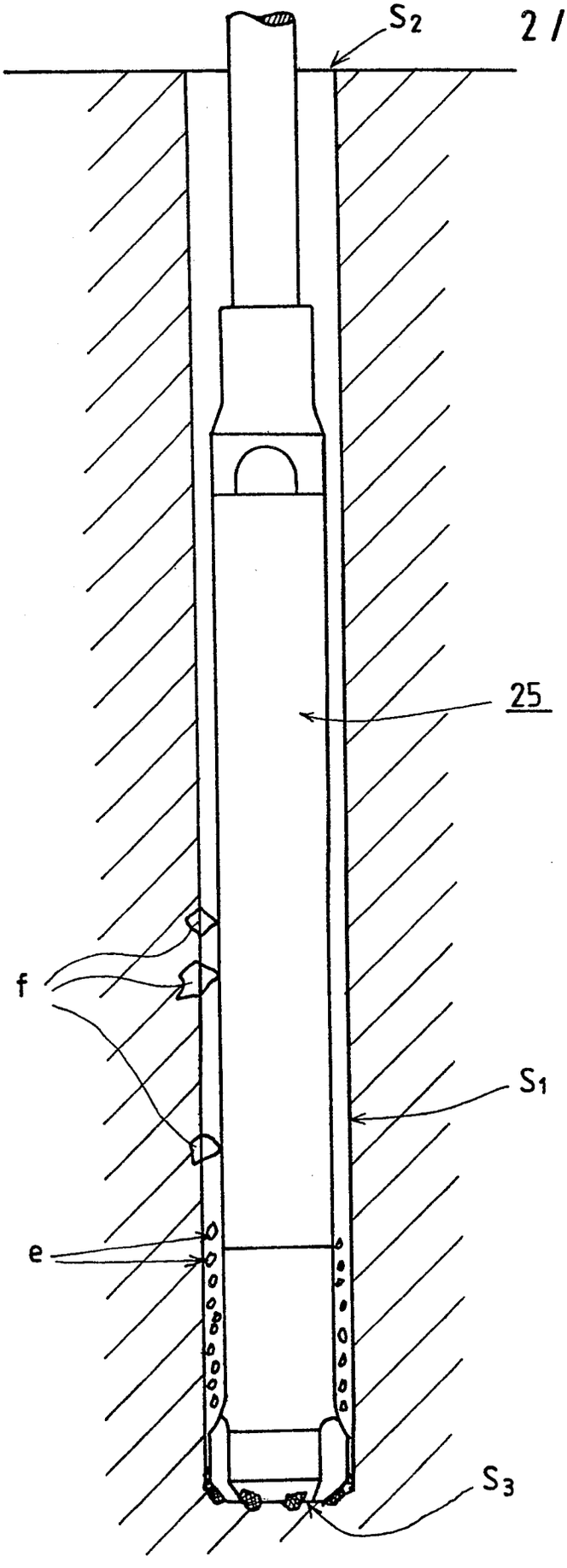

FIG.1C

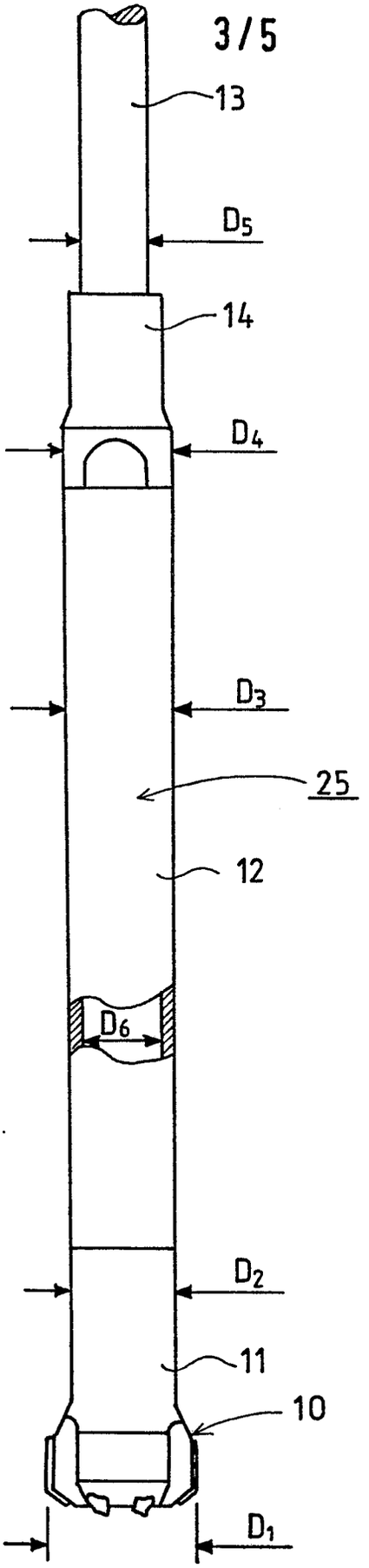

FIG. 2

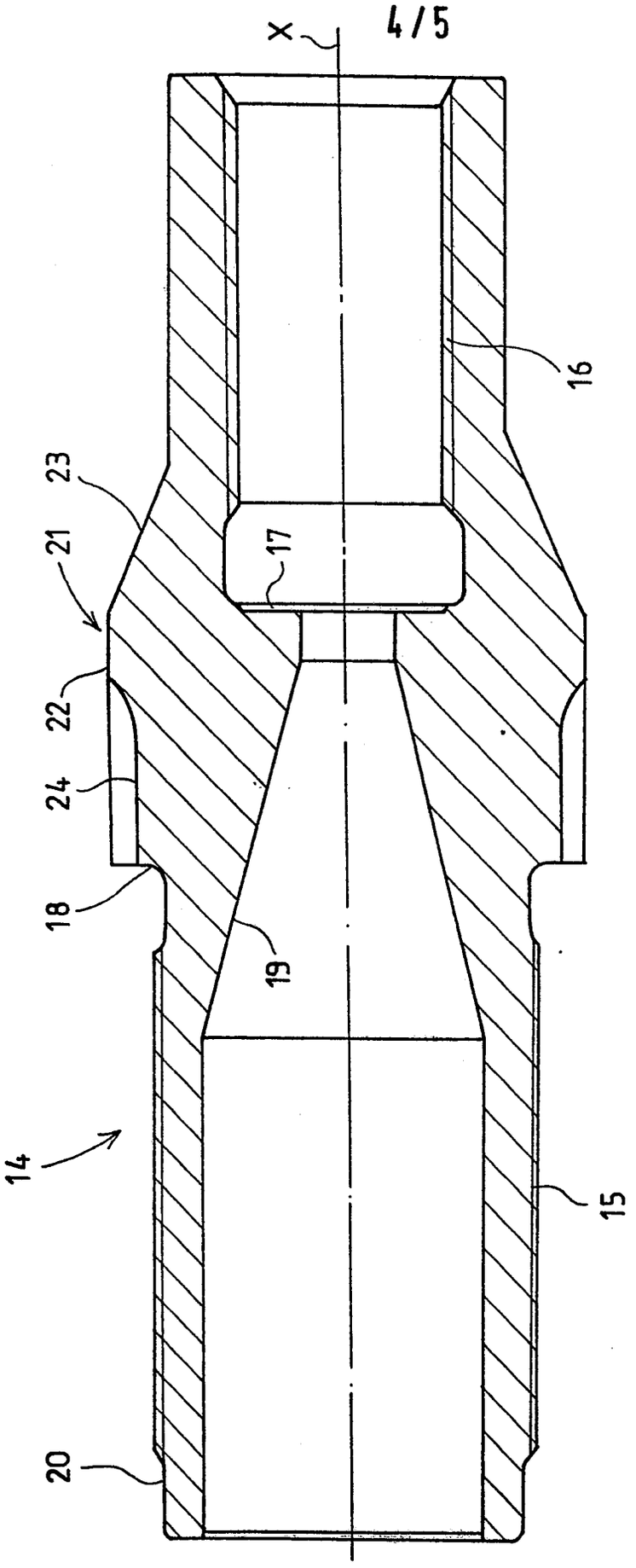

FIG.3

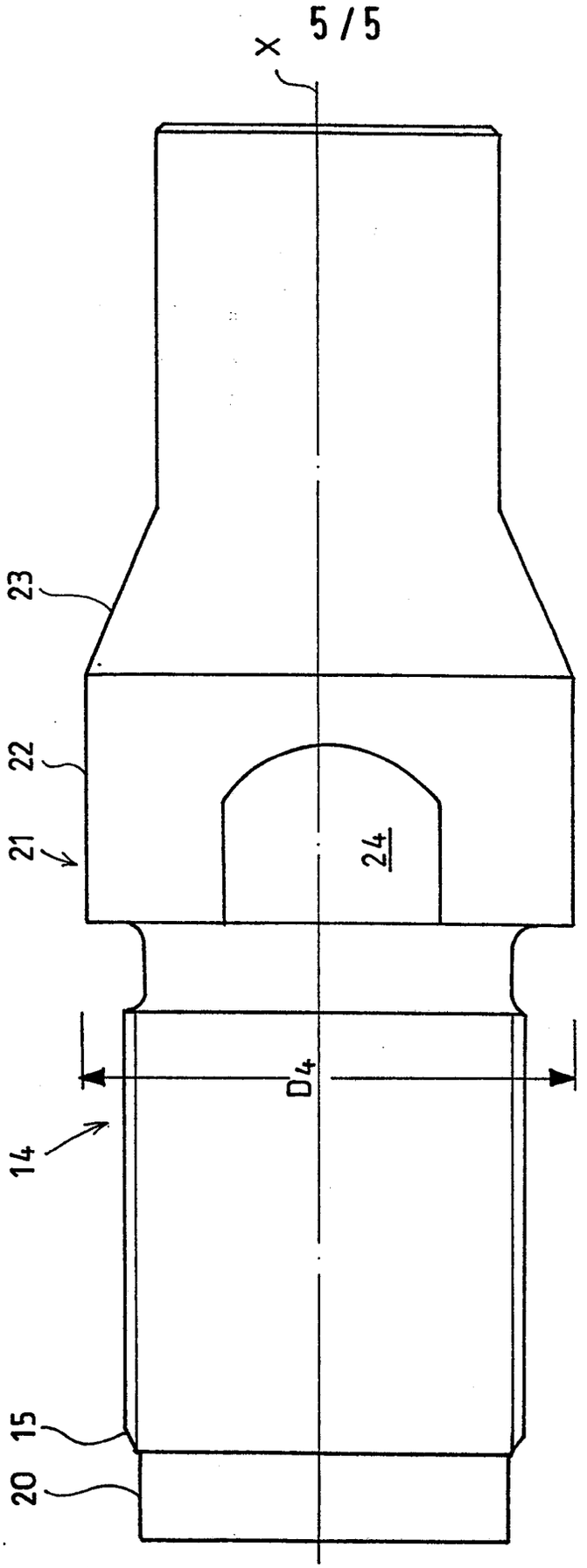

FIG. 4