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(54) Percussion tool for drilling holes in the soil.

(57) A percussion tool for drilling holes in the soil comprising
a cylindrical housing with a front end (1029) shaped for boring,
a first means on said front end for applying a boring force to the soil.
a second means in said housing for applying a percussive force to said boring force applying means, characterised in that
said housing having front (1021) and rear (1022) portions of a selected outside continuous constant diameter providing two spaced continuous circumferential zones of frictional contact with the soil during boring,
said front and rear portions being operable to reduce friction with the wall of the bore formed by the tool and to permit the tool to turn in its path along a shorter radius.

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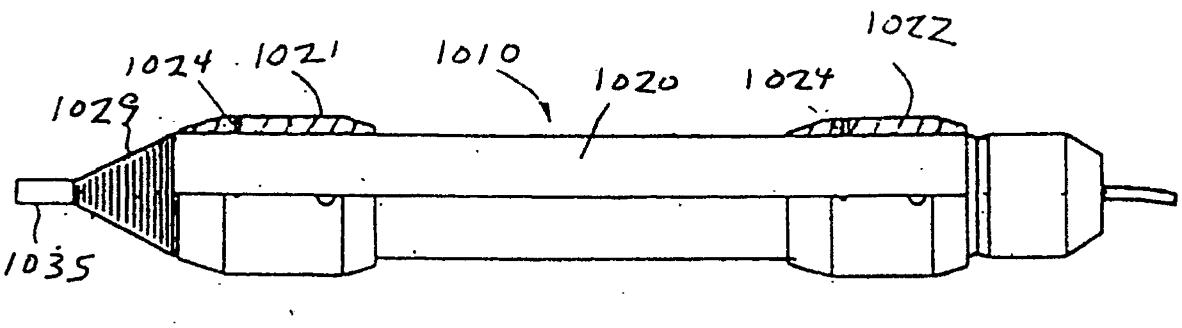

Fig. 2

PERCUSSION TOOL FOR DRILLING HOLES IN THE SOIL

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates generally to percussion tools for drilling holes in the soil.

DESCRIPTION OF THE PRIOR ART

Utility companies often find it necessary to install or replace piping beneath different types of surfaces such as streets, driveways, railroad tracks, etc. To reduce costs and public inconvenience by eliminating unnecessary excavation and restoration, utilities sometimes use underground boring tools to install the new or replacement pipes. Existing boring tools are suitable for boring short distances (up to 60 ft).

Conventional pneumatic and hydraulic percussion moles are designed to pierce and compact compressible soils for the installation of underground utilities without the necessity of digging large launching and retrieval pits, open cutting of pavement or reclamation of large areas of land. An internal striker or hammer reciprocates under the action of compressed air or hydraulic fluid to deliver high energy blows to the inner face of the body. These blows propel the tool through the soil to form an earthen casing within the soil that remains open to allow laying of cable or conduit. From early 1970 to 1972, Bell Laboratories, in Chester, New Jersey, conducted research trying to develop a method of steering and tracking moles. A 4-inch Schramm Pneumagopher was fitted with two steering fins and three mutually orthogonal coils which were used in conjunction with a surface antenna to track the position of the tool. One of these fins was fixed and inclined from the tool's longitudinal axis while the other fin was rotatable.

Two boring modes could be obtained with this system by changing the position of the rotatable fin relative to the fixed fin. These were (1) a roll mode in which the mole was caused to rotate about its longitudinal center line as it advanced into the soil and (2) a steering mode in which the mole was directed to bore in a curved path.

The roll mode was used for both straight boring and as a means for selectively positioning the angular orientation of the fins for subsequent changes in the bore path. Rotation of the mole was induced by bringing the rotatable fin into an anti-parallel alignment with the fixed fin. This positioning results in the generation of a force couple which initiates and maintains rotation.

The steering mode was actuated by locating the rotatable fin parallel to the fixed fin. As the mole penetrates the soil, the outer surfaces of the oncoming fins are brought into contact with the soil and a "slipping wedge" mechanism created. This motion caused the mole to veer in the same direction as the fins point when viewed from the back of the tool.

Published information on the actual field performance of the prototype appears limited to a presentation by J. T. Sibilia of Bell Laboratories to the Edison Electric Institute in Cleveland, Ohio on October 13, 1972. Sibilia reported that the system was capable of turning the mole at rates of 1 to 1.5° per foot of travel. However. the prototype was never commercialized.

However, in spite of these and other prior art systems, the practical realization of a technically and cost-effective steering system has been elusive because the prior systems require complex parts and extensive modifications to existing boring tools, or their steering response has been far too slow to avoid obstacles or significantly change the direction of the boring path within the borehole lengths typically used.

Several steering systems have been developed in an attempt to alleviate this problem by providing control of the boring direction. However, experience indicates that the tool substantially resists sideward movement which seriously limits the steering response. A method is needed by which the tool can travel in a curved path without displacing a significant amount of soil inside the curve. Reducing this resistive side force would provide higher steering rates for the tools. The prior art does not disclose a steerable percussion boring tool having means for reducing friction during boring and turning.

The tools of the prior art have been unsatisfactory to the extent that their traverse has not been accurate or controllable. All too frequently other underground utilities have been pierced or the objective target has been missed by a substantial margin. It has also been difficult to steer around obstacles and get back on course.

It is therefore one object of this invention to provide a cost-effective guided horizontal boring tool which can be used to produce small diameter boreholes into which utilities, e.g., electric or telephone lines, TV cables, gas distribution piping, or the like, can be installed.

It is another object of the present invention to provide a steering system that offers a repeatable and useful steering response in boreholes which is compatible with existing boring equipment and methods and requires only minimal modification of existing boring tools.

Another object of this invention is to provide a boring tool immune to adverse environmental conditions and which allows the boring operation to be conducted by typical field service crews.

A still further object of this invention is to provide a guided horizontal boring tool which requires a minimal amount of excavation for launching and retrieval and thereby reducing the disturbance of trees, shrubs or environmentally sensitive ecosystems.

Another object of this invention is to provide a horizontal tool having reduced friction during turning and arcuate movement.

Another object of this invention is to provide a boring tool which is constructed to permit transmittal of the impact force of the tool to the soil while permitting free rotation of the tool.

Another object of this invention is to provide a boring tool with overgage body sections permitting a 2-point contact (front and rear) of the outer housing of the tool with the soil wall as opposed to the line contact which occurs without the undercut.

Another object of the invention is to provide a percussion boring tool having a body surface configuration permitting the tool to bore in an arc without distorting the round cross-sectional profile of the pierced hole.

A further object of this invention is to provide a percussion boring tool having a construction in which a higher rate of turning is possible for a given steering force at the front and/or back of the tool since a smaller volume of soil needs to be displaced.

Other objects of the invention will become apparent from time to time throughout the specification and claims as hereinafter related.

A guided horizontal boring tool constructed in accordance with the present invention will benefit utilities and rate payers by significantly reducing installation and maintenance costs of underground utilities by reducing the use of expensive, open-cut trenching methods.

SUMMARY OF THE INVENTION

The above noted objects and other objects of the invention are accomplished by percussion boring tool for boring in the earth at an angle or in a generally horizontal direction.

Accordingly, the present invention provides a percussion tool for drilling holes in the soil comprising

a cylindrical housing with a front end shaped for boring,

a first means on said front end for applying a boring force to the soil,

a second means in said housing for applying a percussive force to said boring force applying means, characterised in that

said housing having front and rear portions of a selected outside continuous constant diameter providing two spaced continuous circumferential zones of frictional contact with the soil during boring,

said front and rear portions being operable to reduce friction with the wall of the bore formed by the tool and to permit the tool to turn in its path along a shorter radius.

The percussion boring tool has a cylindrical body with overgage sleeves located over a portion of the outer body affixed so that they can rotate but cannot slide axially. The overgage areas at the front and back of the tool, or alternately, an undergage section in the centre of the tool body permits a 2-point contact (front and rear) of the outer housing with the soil wall as opposed to the line contact which occurs without the undercut. The 2-point contact allows the tool to deviate in an arc without distorting the round cross-sectional profile of the pierced hole. Thus, for a given steering force at the front and/or back of the tool, a higher rate of turning is possible since a smaller volume of soil needs to be displaced.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view and partial vertical section through the earth showing a guided horizontal boring tool illustrating an alternate embodiment of the percussion boring tool with overgage sections on the tool housing and illustrating the tool as used with a magnetic attitude sensing system.

Fig. 2 is a view, in elevation, of a percussion boring tool having overgage collars, shown in section, secured in fixed positions at the front and rear of the tool housing.

Fig. 3 is a view, in elevation, of a percussion boring tool having overgage collars, shown in section, one in a fixed position at the front and the other supported on bearings for rotation at the rear of the tool housing.

Fig. 4 is a view, in elevation, of a percussion boring tool having overgage collars, shown in section, secured in fixed positions at the front and rear of the tool housing and further showing a slant nosed boring member at the front and spin controlling fins at the rear.

Fig. 5 is a view, in elevation, of a percussion boring tool having overgage collars, shown in section, one in a fixed position at the front and the other supported on bearings for rotation at the rear of the tool housing and further showing a slant nosed boring member at the front and spin controlling fins at the rear.

Figs. 6A, 6B, and 6C are segments in longitudinal cross section of a boring tool as shown in Fig 5 having a slanted nose member and fixed/locable fin arrangement in the unlocked position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention will now be described, by way of example only, with reference to the drawings that follow.

In the applicants copending European Patent Application No EP0202013, an invention is described which provides for control of a percussion boring tool to effect either straight boring or boring along a deviate or arcuate path. The invention may include a slanted nose member or an eccentric hammer to deliver an off-axis impact which produces a turning force to the tool. Either an eccentric hammer or nose member will produce the desired result, since the only requirement is that the axis of the impact does not pass through the frontal centre of pressure. In order to allow the tool to travel in a straight path tail fins are incorporated into the trailing end of the tool which can be selectively moved so that they impart a spinning motion to the tool, which will negate the steering action of the slanted nose member or eccentric hammer.

This embodiment of the present invention consists of an overgage sleeve or sleeves located over a portion of the tool outer surface which are affixed such that they can rotate but cannot slide axially. This pernmits transmittal of the tool's axial impact force from the tool to the soil while allowing free rotation of the tool during spinning operations. The overgage areas are at the front and back of the tool, or alternately, an undergage section in the centre of the tool body. This undercut in the centre of the tool permits a 2-point contact (front and rear) of the tool's outer housing with the soil wall as opposed to the line contact which occurs without the undercut. The 2-point contact allows the tool to deviate in an arc without distorting the round cross-sectional profile of the pierced hole. Thus, for a given steering force at the front and/or back of the tool, a higher rate of turning is possible since a smaller volume of soil is displaced.

In Fig. 1 , there is shown a preferred guided horizontal boring tool 1010, having overgage body sections, used with a magnetic field attitude sensing system. The boring tool 1010 may be used with various sensing systems, and a magnetic attitude sensing system is depicted generally as one example. The usual procedure for using percussion moles is to first locate and prepare the launching and retrieval pits. The launching pit P should be dug slightly deeper than the planned boring depth and large enough to provide sufficient movement for the operator. The boring tool 1010 is connected to a pneumatic or hydraulic source 11, is then started in the soil, stopped and properly aligned, preferably with a sighting frame and level. The tool is then restarted and boring continued until the tool exits into the retrieval pit (not shown).

The boring tool 1010 may have a pair of coils 12, shown schematically at the back end, one of which produces a magnetic field parallel to the axis of the tool, and the other produces a magnetic field transverse to the axis of the tool. These coils are intermittently excited by a low frequency generator 13. To sense the attitude of the tool, two coils 14 and 15 are positioned in the pit P, the axes of which are perpendicular to the desired path of the tool. The line perpendicular to the axes of these coils at the coil intersection determines the boresite axis.

Outputs of these coils can be processed to develop the angle of the tool in both the horizontal and vertical directions with respect to the boresite axis. Using the transverse field, the same set of coils can be utilized to determine the angular rotation of the tool to provide sufficient control for certain types of steering systems. For these systems, the angular rotation of the tool is displayed along with the plane in which the tool is expected to steer upon actuation of the guidance control system.

The mechanical guidance of the tool can also be controlled at a display panel 16. From controls located at display panel 16, both the operation of the tool 1010 and the pneumatic or hydraulic actuation of the fins 1017 can be accomplished as described hereinafter.

As shown in Fig. 1 , the boring tool 1010 includes a steering system comprising a slanted-face nose member 1018 attached to the anvil 1033 of the tool to produce a turning force on the tool and tail fins 1017 on a rotary housing 1019a on the trailing end of the tool which are adapted to be selectively position relative to the body of the tool to negate the turning force. Turning force may also be imparted to the tool by an internal eccentric hammer, as shown in Fig. 41 of the co-pending application referred to above, delivering an off-axis impact to the tool anvil.

For turning the tool, the tail fins 1017 are moved into a position where they may spin about the longitudinal axis of the tool 1010 and the slanted nose member 1018 or eccentric hammer will deflect the tool in a given direction. den the fins 1017 are moved to a position causing the tool 1010 to rotate about its longitudinal axis, the rotation will negate the turning effect of the nose member 1018 or eccentric hammer as well as provide a means for orienting the nose piece into any given plane for subsequent turning or direction change.

The body of the tool 1010 has front 1021 and rear 1022 overgage body sections which give improved performance of the tool in angular or arcuate boring. These overgage sections are fixed longitudinally on the tool body and may be fixed against rotation or may be mounted on bearings which permit them to rotate.

The steering system of the present invention will allow the operator to avoid damaging other underground services (such as power cables) or to avoid placing underground utilities where they may be damaged. The body construction of the tool including the overgage sections cooperates with the steering mechanism to give overall improved performance.

Figs. 2 through 5 illustrate various embodiments of the boring tool with overgage sections on the tool body. In Fig. 2 , there is shown a boring tool 1010 having a body 1020 enclosing the percussion mechanism driving the tool. The front end of body 1020 is tapered as at 1029 and has the external portion 1035 of the anvil protruding therefrom for percussion boring.

Front sleeve 1021 and rear sleeve 1022 are mounted on tool body or housing 1020 by a shrink or interference fit. In this embodiment, overgage sleeves 1021 and 1022 are both fixed against longitudinal or rotational slippage. The sleeves may be pinned in place as indicated at 1024. The rear body portion is connected to a hydraulic or air line for supply of a pressurized operating fluid to the tool.

In Fig. 3, there is shown another embodiment of the boring tool In which one of the overgage sleeves is free to rotate. In this embodiment, boring tool 1010 has a body 1020 enclosing the percussion mechanism driving the tool. The front end of body 1020 is tapered as at 1029 and has the external portion 1035 of the anvil protruding therefrom for percussion boring.

Front sleeve 1021 is mounted on tool body or housing 1020 by a shrink or interference fit The overgage sleeve 1021 is fixed against longitudinal or rotational slippage. The sleeve 1021 may be pinned in place as indicated at 1024. The rear sleeve 1022 is mounted on body 1020 on bearings 1025 for rotary motion thereon. The rear body portion is connected to a hydraulic or air line for supply of a pressurized operating fluid to the tool.

In the embodiments of Figs. 2 and 3 , the protruding anvil portion 1035 was not provided with any special boring surface. In the embodiments of Figs. 4 and 5 , the tool has a slanted nose member which causes the tool to deviate from a straight boring path at an angle or along an arcuate path. The rear of the tool has controllable fins which allow the tool to move without rotation or to rotate about its longitudinal axis. This arrangement is as in our co-pending application referred to above and is described at least partially below.

In Fig. 4 , there is shown a boring tool 1010 having a body 1020 enclosing the percussion mechanism driving the tool. The front end of body 1020 is tapered as at 1029 and has the external portion 1035 of the anvil protruding therefrom for percussion boring. The protruding portion 1035 of the anvil has a slanted nose member 1018 secured thereon for angular or arcuate boring.

Front sleeve 1021 and rear sleeve 1022 are mounted on tool body or housing 1020 by a shrink or interference fit. In this embodiment, the overgage sleeves 1021 and 1022 are both fixed against longitudinal or rotational slippage. The sleeves may be pinned in place as indicated at 1024.

At the rear of body 1020, there is a rotatable housing 1019a on which there are fins 1017. The housing and fin assembly is actuatable between an inactive position in which the tool does not rotate about its axis and an actuated position where the fins cause the tool to rotate. The rear body portion is connected to a hydraulic or air line for supply of a pressurized operating fluid to the tool.

In Fig. 5 , there is shown another embodiment of the boring tool in which one of the overgage sleeves is free to rotate. In this embodiment, boring tool 1010 has a body 1020 enclosing the percussion mechanism driving the tool. The front end of body 1020 is tapered as at 1029 and has the external portion 1035 of the anvil protruding therefrom for percussion boring. The protruding portion 1035 of the anvil has a slanted nose member 1018 secured thereon for angular or arcuate boring.

Front sleeve 1021 is mounted on tool body or housing 1020 by a shrink or interference fit. The overgage sleeve 1021 is fixed against longitudinal or rotational slippage. The sleeve 1021 may be pinned in place as indicated at 1024. The rear sleeve 1022 is mounted on the body 1020 on bearings 1025 for rotary motion thereon.

At the rear of body 1020, there is a rotatable housing 1019a on which there are fins 1017. The housing and fin assembly is actuatable between an inactive position in which the tool does not rotate about its axis and an actuated position where the fins cause the tool to rotate. The rear body portion is connected to a hydraulic or air line for supply of a pressurized operating fluid to the tool.

Figs. 6A, 6 B, and 6 C illustrate a boring tool 1027 having a slanted nose member and fixed/lockable fin arrangement as described generally in reference to Figs. 1 and 2 in our co-pending application referred to above.

As shown, boring tool 1010 comprises an elongated hollow cylindrical outer housing or body 1028. The outer front end of body 1028 tapers inwardly forming a conical portion 1029. Sleeve member 1021 is secured on body member 1028 by a shrink or interference fit and is fixed against longitudinal or rotary slippage as previously described. The outside diameter of body 1028 tapers inwardly near the front end forming a conical surface 1030 which terminates in a reduced diameter 1031 extending longitudinally inward from the front end. The rear end of the body 1028 has internal threads 1032 for receiving a tail fin assembly (see Fig. 6 C).

An anvil 1033. having a conical back portion 1034 and an elongated cylindrical front portion 1035 is positioned in the front end of body 1028. The conical back portion 1034 of anvil 1033 forms an interference fit on the conical surface 1030 of the body 1028, and the elongated cylindrical portion 1035 extends outwardly a predetermined distance beyond the front end of the body. A flat transverse surface 1036 at the back end of the anvil 1033 receives the impact of a reciprocating hammer 1037.

Reciprocating hammer 1037 is an elongated cylindrical member slidably received within the cylindrical recess 1038 of the body 1028. A substantial portion of the outer diameter of the hammer 1037 is smaller in diameter than the recess 1038 of the body 1028, forming an annular cavity 1039 therebetween. A relatively shorter portion 1040 at the back end of hammer 1037 is of larger diameter to provide a sliding fit against the interior wall of recess 1038 of body 1028.

A central cavity 1041 extends longitudinally inward a distance from the back end of the hammer 1037. A cylindrical bushing 1042 is slidably disposed within the hammer cavity 1041, the circumference of which provides a sliding fit against the inner surface of the central cavity 1041'. The front surface 1043 of the front end of the hammer 1037 is shaped to provide an impact centrally on the flat surface 1036 of the anvil 1033. As described above, and more fully in our co-pending European patent application No EP0202013 referred to above the hammer configuration may also be adapted to deliver an eccentric impact force on the anvil.

Air passages 1044 in the sidewall of hammer 1037 inwardly adjacent the shorter rear portion 1040 communicate the central cavity 1041 with the annular cavity 1039. An air distribution tube 1045 extends centrally through the bushing 1042 and has a back end 1046 extending outwardly of the body 1028 connected by fittings 1047 to a flexible hose 1048. For reciprocating the hammer 1037, the air distribution tube 1045 is in permanent communication with a compressed air source 11 (Fig. 1). The arrangement of the passages 1044 and the bushing 1042 is such that, during reciprocation of the hammer 1037, the air distribution tube 1045 alternately communicates via the passages 1044, the annular cavity 1039 with either the central cavity 1041 or atmosphere at regular intervals.

A cylindrical stop member 1049 is secured within the recess 1038 in the body 1028 near the back end and has a series of longitudinally-extending, circumferentially-spaced passageways 1050 for exhausting the interior of the body 1028 to atmosphere and a central passage through which the air distribution tube 1045 extends.

A slanted nose member 1018 has a cylindrically recessed portion 1052 with a central cylindrical bore 1053 therein which is received on the cylindrical portion 1035 of the anvil 1033 (Fig. 6A). A slot 1054 through the sidewall of the cylindrical portion 1018 extends longitudinally substantially the length of the central bore 1053 and a transverse slot extends radially from the bore 1053 to the outer circumference of the cylindrical portion, providing flexibility to the cylindrical portion for clamping the nose member to the anvil. A flat is provided on one side of cylindrical portion 1018 and longitudinally spaced holes are drilled therethrough in alignment with threaded bores on the other side. Screws 1059 are received in the holes and bores 1058 and tightened to secure nose member 1018 to anvil 1033.

The sidewall of the nose member 1018 extends forward from the cylindrical portion 1052 and one side is milled to form a flat inclined surface 1060 which tapers to a point at the extended end. The length and degree of inclination may vary depending upon the particular application. The nose member 1018 may optionally have a flat rectangular fin 1061 (shown in dotted line) secured to the sidewall of the cylindrical portion 1052 to extend substantially the length thereof and radially outward therefrom in a radially opposed position to the inclined surface 1060.

Slanted nose members 1018 of 6.4 cm and 8.9 cm diameter with angles from 100 to 400 (as indicated by angle "A") have been tested and show the nose member to be highly effective in turning the tool with a minimum turning radius of 8.4 metres being achieved with a 8.9 cm 15^{o} nose member. Testing also demonstrated that the turning effect of the nose member was highly repeatable with deviations among tests of any nose member seldom varying by more than a few 2.5 cm in 10.5 metres of bore. Additionally, the slanted nose members were shown to have no adverse effect on penetration rate and in some cases, actually increased it.

It has also been found that the turning radius varies linearly with the angle of inclination. For a given nose angle, the turning radius will decrease in direct proportion to an increase in area.

The rear sleeve 1022 is mounted on the rear portion of housing 1028 on bearings 1025 for rotary motion thereon. The front sleeve 1021 and rear sleeve 1022 provide a 2-point sliding contact on movement of the tool through the hole which is being bored. This provides for reduced friction and facilitates both the linear movement of the tool through the soil and on rotation of the tool by the fins. A tail fin assembly 1062 (19a in Fig. 1 is secured in the back end of the body 1028 (Fig. 6C). A fixed/lockable tail fin assembly 1062 is illustrated in the example and other variations will be described hereinafter.

The tail fin assembly 1062 comprises a cylindrical connecting sub 1063 having external threads 1064 at the front end which are received within the internal threads 1032 at the back end of the body 1028. Sub 1063 has a short reduced outside diameter portion 1065 forming a shoulder 1066 therebetween and a second reduced diameter 1067 adjacent the short portion 1065 forms a second shoulder 1068. An O-ring seal 1069 is located on the reduced diameter 1065 intermediate the shoulders 1066 and 1068. The rear portion 1070 of the sub 1063 is smaller in diameter than the second reduced diameter 1067 forming a third shoulder 1071 therebetween and provided with circumferential O-ring seal 1072 and internal O-ring seal 1073. Internal threads 1074 are provided in the rear portion 1070 inwardly of the seal 1073. A circumferential bushing 1075 of suitable bearing material such as bronze is provided on the second reduced diameter 1067.

A series of longitudinal circumferentially spaced grooves or keyways 1076 are formed on the circumference of the rear portion 1070 of the sub 1063. A hollow cylindrical piston 1077 is slidably received on the circumference of the rear portion 1070. A series of longitudinal circumferentially spaced grooves or keyways 1078 are formed on the interior surface at the front portion of the piston 1077 in opposed relation to the sub keyways 1076. A series of keys or dowel pins 1079 are received within the keyways 1076 and 1078 to prevent rotary motion between sub 1063 and piston 1077.

A first internal cavity 1080 extends inwardly from the keyway 1078 terminating in a short reduced diameter portion 1081 which forms a shoulder 1082 therebetween. A second cavity 1083 extends inwardly from the back end 1084 of the piston 1077 terminating at the reduced diameter portion 1081. An internal annular O-ring seal 1085 is provided on the reduced diameter portion 1081. As shown in Fig. 6 C, a series of drive teeth 1086 are formed on the back end of the piston 1077. The teeth 1086 comprise a series of circumferentially spaced raised surfaces 1087 having a straight side and an angularly sloping side forming a ratchet. A spring 1090 is received within the first cavity 1080 of the piston 1077 and is compressed between the back end 1070 of the sub 1063 and the shoulder 1082 of the piston 1077 to urge the piston outwardly from the sub.

An elongated, hollow cylindrical rotating fin sleeve 1091 is slidably and rotatably received on the outer periphery of the sub 1063. The fin sleeve 1091 has a central longitudinal bore 1092 and a short counterbore 1093 of larger diameter extending inwardly from the front end and defining an annular shoulder 1094 therebetween. The counterbore 1093 fits over the short reduced diameter 1065 of the sub 1063 with the O-ring 1069 providing a rotary seal therebetween. A flat annular bushing 1095 of suitable bearing material such as bronze is disposed between the shoulders 1068 and 1094 to reduce friction therebetween.

A hollow cylindrical sleeve 1097 is secured within sleeve 1091 by suitable means such as welding. The sleeve 1097 has a central bore 1098 substantially the same diameter as the second cavity 1083 of the piston 1077 and a counterbore 1099 extending inwardly from the back end defining a shoulder 1100 therebetween. As shown in Fig. 6C, a series of drive teeth 1101 are formed on the front end of the sleeve 1097. The teeth 1101 comprise a series of circumferentially spaced raised surfaces 1102 having a straight side and an angularly sloping side forming a one-way ratchet configuration. The teeth correspond in opposed relationship to the teeth 1086 of the piston 1077 for operative engagement therewith.

A series of flat radially and angularly opposed fins 1105 are secured to the exterior of the fin sleeve 1091 to extend radially outward therefrom. (Fig. 6 C) The fins 1105 are secured at opposing angles relative to the longitudinal axis of the sleeve 1091 to impart a rotational force on the sleeve.

An elongated hollow cap sleeve 110 having external threads 1107 at the front end is slidably received within the sliding piston 1077 and the sleeve 1097 and threadedly secured in the internal threads 1074 at the rear portion 1070 of the sub 1063. The cap sleeve 1106 extends rearwardly from the threads 1107 and an enlarged diameter portion 1108 forms a first shoulder 1109 spaced from the threaded portion and a second enlarged diameter 110 forms a second shoulder 1111 spaced from the first shoulder. An O-ring seal 1112 is provided on enlarged diameter 1108 near shoulder 1109 and a second O-ring seal 1113 is provided on the second enlarged diameter 1110 near the second shoulder 1111. The O-ring 1112 forms a reciprocating seal on the interior of the second cavity 1083 of the piston 1077 and the O-ring 113 forms a rotary seal on the counterbore 1099 of the sleeve 1097. The O-ring 1085 in the piston 1077 forms a reciprocating seal on the extended sidewall of the cap 1106.

An annular chamber 1114 is formed between the exterior of the sidewall of the cap 1106 and the second counterbore 1083 which is sealed at each end by the O-rings 1085 and 112. A circumferential bushing 115 is provided on the first enlarged diameter 1108 and an annular bushing 116 on the second enlarged diameter 110 is captured between the shoulders 1100 and 1111 to reduce friction between the sleeve 1097 and the cap 1106. The rear portion of the cap 1106 has small bores 1117 arranged to receive a spanner wrench for effecting the threaded connection. A threaded bore 1118 at the back end of cap 1106 receives a hose fitting (not shown) and small passageway 1119 extends inwardly from threaded bore 1118 to communicate annular chamber 1114 with a fluid or air source (not shown). A flexible hose extends outwardly of the cap 1106 and is connected to the fluid or air source for effecting reciprocation of the piston 1077. A second small passageway 1120 communicates first cavity 1080 with atmosphere to relieve pressure which might otherwise become trapped therein. Passage 120 may also be used for application of pressure to the forward end of piston 1077 for return movement.

OPERATION

The tool described above is capable of horizontal guidance, has overgage body sections, and is preferably used with a magnetic field attitude sensing system. The boring tool may be used with various sensing systems, and a magnetic attitude sensing system is depicted generally as one example. The overgage sleeves may be fixed or rotatable on bearings as described above. Likewise, the overgage sleeves may be used with any percussion boring tool of this general type and is not limited to the particular guidance arrangement, i.e., the slanted nose member and controllable tail fins, described above. It is especially noted that any of the arrangements described in our co-pending patent application referred to above can be used with overgage sleeves to obtain the desired advantages.

The procedure for using this percussion tool is to first locate and prepare the launching and retrieval pits. As described above, the launching pit P is dug slightly deeper than the planned boring depth and large enough to provide sufficient movement for the operator. The boring tool 1010 is connected to a pneumatic or hydraulic source 11, is then started in the soil, stopped and properly aligned, preferably with a sighting frame and level. The tool is then restarted and boring continued until the tool exits into the retrieval pit (not shown).

The tool can move in a straight direction when used with an eccentric boring force, e.g., the slanted nose member or the eccentric hammer or anvil, provided that the fins 1017 are positioned to cause the tool the rotate about its longitudinal axis. When the fins are set to allow the tool to move without rotation about the longitudinal axis, the eccentric boring forces cause it to move either at an angle or along an arcuate path.

As previously described, the overgage sleeves, which are located over a portion of the tool outer surface, are affixed such that they can rotate but cannot slide axially. This permits transmittal of the axial impact force from the tool to the soil while allowing free rotation of the tool during spinning operations. The overgage areas are at the front and back of the tool, or alternately, an undergage section in the center of the tool body. This undercut in the center of the tool permits a 2-point contact (front and rear) of the tool's outer housing with the soil wall as opposed to the line contact which occurs without the undercut. The 2-point contact allows the tool to deviate in an arc without distorting the round cross-sectional profile of the pierced hole. Thus, for a given steering force at the front and/or back of the tool, a higher rate of turning is possible since a smaller volume of soil needs to be displaced.

In the embodiment shown, for turning the tool, the tail fins 1017 are moved into a position where they may spin about the longitudinal axis of the tool 1010 and the slanted nose member 1018 or eccentric hammer will deflect the tool in a given direction. When the fins 1017 are moved to a position causing the tool 1010 to rotate about its longitudinal axis, the rotation will negate the turning effect of the nose member 1018 or eccentric hammer as well as provide the means for orienting the nose piece into any given plane for subsequent turning or direction change.

The front 1021 and rear 1022 overgage body sections give improved performance of the tool both in straight boring and in angular or arcuate boring. These overgage sections are fixed longitudinally on the tool body and may be fixed against rotation or may be mounted on bearings which permit them to rotate.

While the overgage sleeves can be used with any percussion boring tool, they have been shown in combination with one of the embodiments of our co-pending application referred to above. The operation of this percussion boring tool 1027 is as follows. Under action of compressed air or hydraulic fluid in the central cavity 1041, the hammer 1037 moves toward the front of the body 1028. At the foremost position, the hammer imparts an impact on the flat surface 1036 of the anvil 1033.

In this position, compressed air is admitted through the passages 1044 from central cavity 1041 into the annular cavity 1039. Since the effective area of the hammer including the larger diameter rear portion 1040 is greater than the effective area of the central cavity 1041, the hammer starts moving in the opposite direction. During this movement, the bushing 1042 closes the passages 1044, thereby interrupting the admission of compressed air into annular cavity 1041.

The hammer 1037 continues its movement by the expansion of the air in the annular cavity 1039 until the passages 1044 are displaced beyond the ends of the bushing 1042, and the annular cavity exhausts to atmosphere through the holes 1050 in the stop member 1049. Then the cycle is repeated.

The operation of the tail fin assembly 1062 is best seen with reference to Fig. 6 C. The compressed air or fluid in the annular cavity 1114 moves the piston 1077 against the spring 1090 and toward the front of the sub 1063. In the foremost position, the front end of the piston 1077 contacts the shoulder 1071 and the drive teeth 1086 and 10101 become disengaged. In this position, compressed air or fluid is admitted through the passage 1119 from the source into the annular chamber 1114. The fin sleeve 1091 is then free to rotate relative to the tool body. Pressure which may otherwise become trapped in the first cavity 1080 and hinder reciprocation is exhausted through the pressure relief passage 1120 to atmosphere.

When the air or fluid pressure within the chamber 1114 is relieved, the force of the spring 1090 moves the piston 1077 in the opposite direction. During this movement, the drive teeth 1086 and 1101 become engaged once again and the fin sleeve 1091 becomes locked against rotational movement relative to the tool body. The cycle may be selectively repeated as necessary for proper alignment the slanted nose member 1018 and attitude adjustment of the tool. It should be understood that the passage 1120 may also be connected to a fluid source, i.e. liquid or air, for moving the piston to the rearward position.

The reciprocal action of the hammer on the anvil and nose member as previously described produces an eccentric or asymmetric boring force which causes the tool to move forward through the earth along a path which deviates at an angle or along an arcuate path when the tool is not rotating. When the tool is rotated by operation of the fins, it moves along a substantially straight path (actually a very tight spiral). The overgage sleeves support the tool housing at two separ ated points. This 2-point contact (front and rear) of the tool housing with the soil wall allows the tool to deviate in an arc without distorting the round cross-sectional profile of the pierced hole. Thus, for a given steering force at the front and/or back of the tool, a higher rate of turning is possible since a smaller volume of soil needs to be displaced and the helix length is reduced.

Other types of boring or drilling systems can be used in conjunction with the present invention, such as hydraulic percussion tools, turbo-drill motors (pneumatic or hydraulic) or rotary-drill type tools.

It should be noted that the present invention may also be used in conjunction with the guidance system described in our co-pending European patent application No (Agents ref: PB/GRI Case II)

Claims

1. A percussion tool for drilling holes in the soil comprising
a cylindrical housing with a front end shaped for boring,
a first means on said front end for applying a boring force to the soil,
a second means in said housing for applying a percussive force to said boring force applying means, characterised in that
said housing having front and rear portions of a selected outside continuous constant diameter providing two spaced continuous circumferential zones of frictional contact with the soil during boring,
said front and rear portions being operable to reduce friction with the wall of the bore formed by the tool and to permit the tool to turn in its path along a shorter radius.

2. A percussion tool for drilling holes in the soil according to claim 1 characterised in that
said first and second means being cooperable to apply rotary motion of said housing about its longitudinal axis and allowing said housing to have a predetermined curved path through the soil and another position causing said housing to rotate about its longitudinal axis to cause the same to have a straight path through the soil.

3. A percussion tool for drilling holes in the soil according to claim 1 characterised in that
said first and second means being cooperable to apply an asymmetric boring force,
a plurality of guide fins positioned on the exterior of

said housing at the rear end thereof and having a first position permitting non-rotative movement through the soil and a second position causing said housing to rotate about its longitudinal axis on movement through the soil, and
means for moving said fins between said first and second positions.

4. A controllable percussion tool according to claim 3 characterised in that
said first means comprises an anvil having a striking surface inside said housing and a boring surface outside said housing comprising a cylindrical nose portion having a side face extending longitudinally from the tip at an acute angle thereto, and
said second means comprises a reciprocally movable hammer positioned in said housing to apply a percussive force to said anvil striking surface.

5. A percussion tool according to any preceding claim characterised in that
said housing is cylindrical,
said front and rear portions of selected outside diameter comprise sleeve members secured to the outside of said housing at the front and rear ends thereof.

6. A percussion tool according to claim 5 characterised in that
said sleeve members are secured on said housing against longitudinal movement thereon.

7. A controllable percussion tool according to claim 6 characterised in that
at least one of said sleeve members is secured on said housing for rotary movement thereon.

8. A controllable percussion tool according to claim 7 characterised in that
said housing includes a friction bearing member on the outer surface thereof in bearing relation with said at least one sleeve member to permit rotary movement thereof.

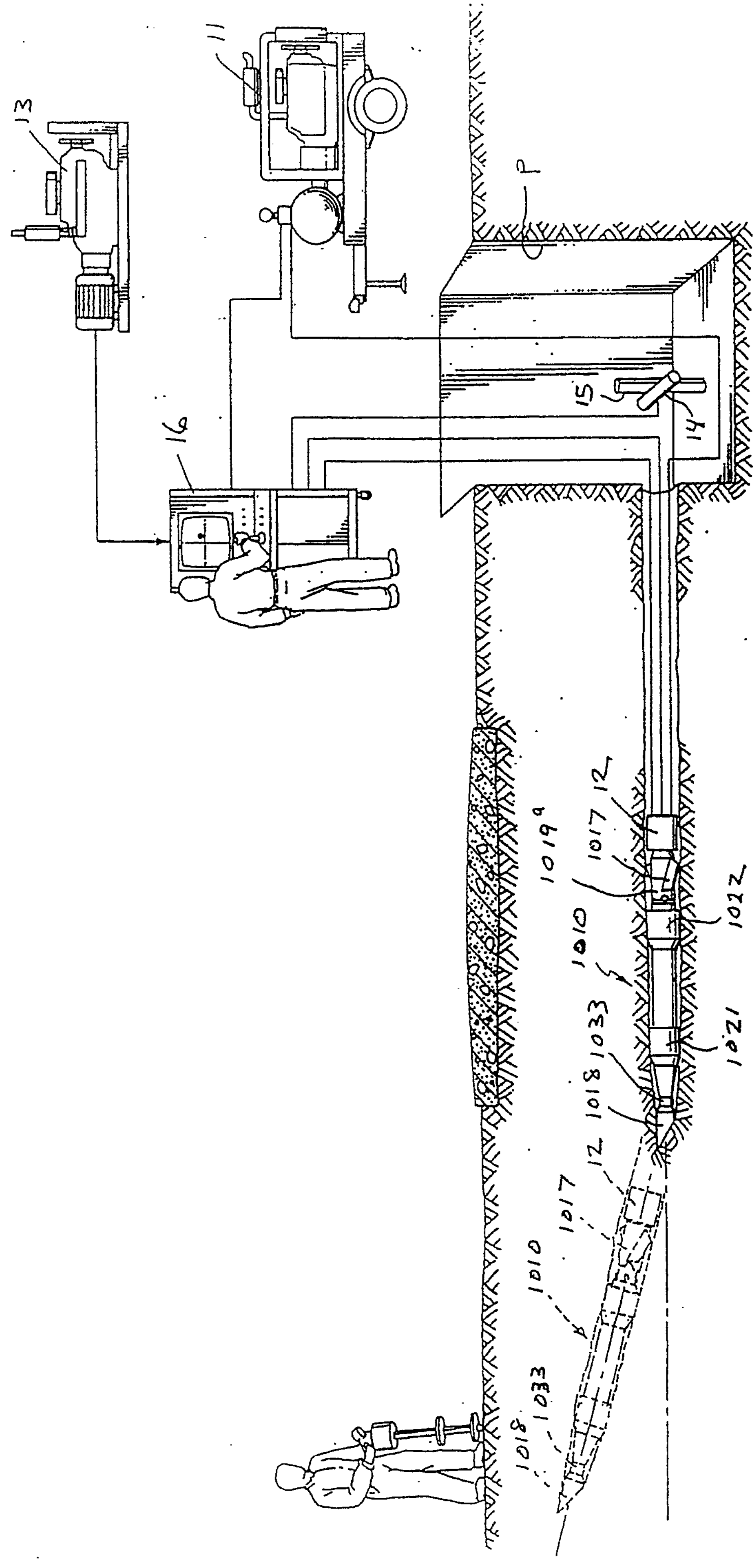

Fig. 1

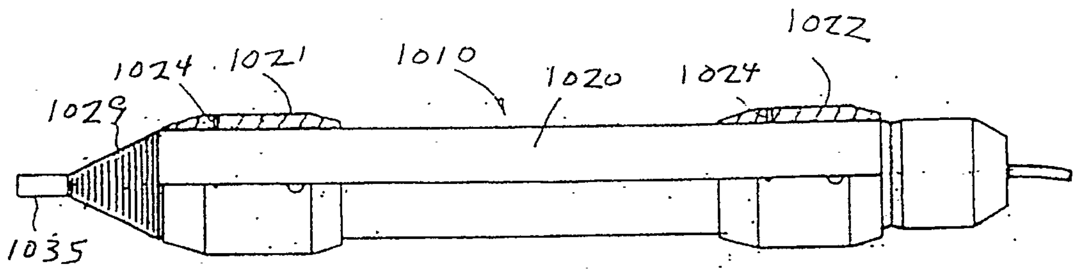

Fig. 2

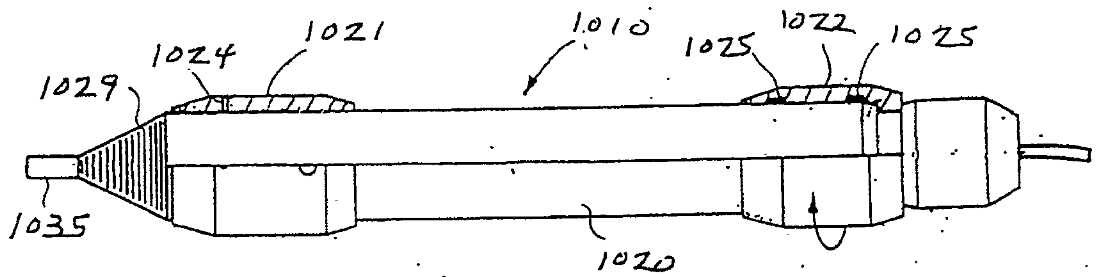

Fig 3

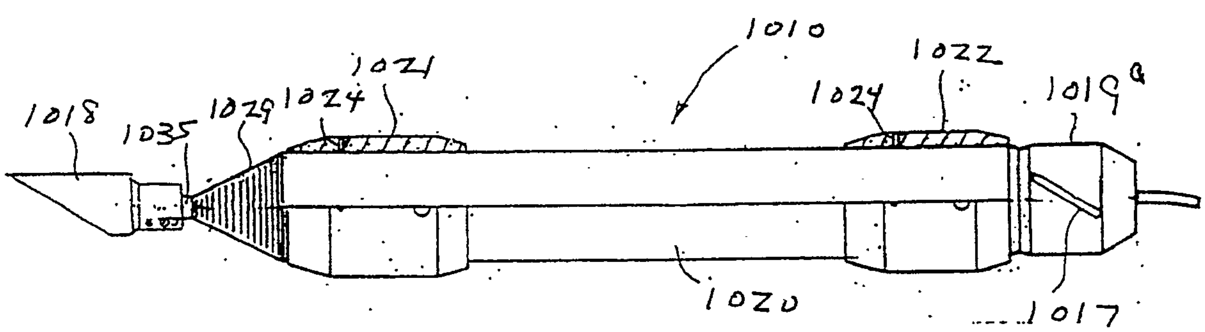

Fig. 4

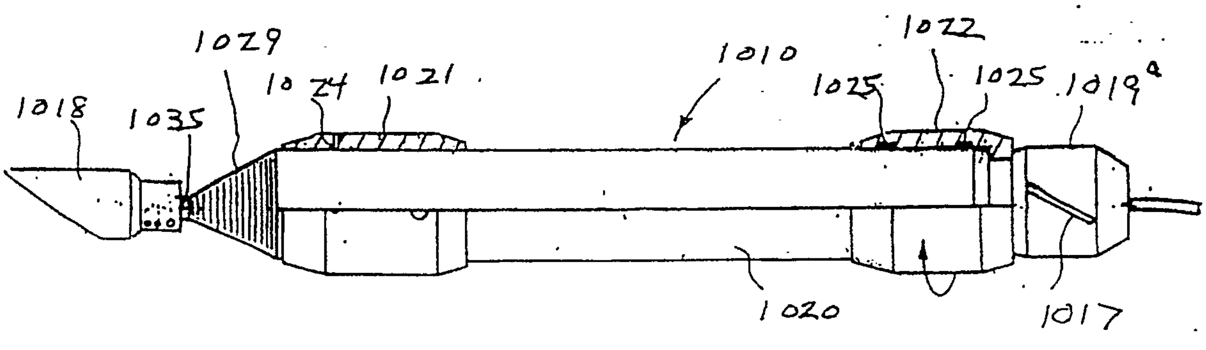

Fig. 5

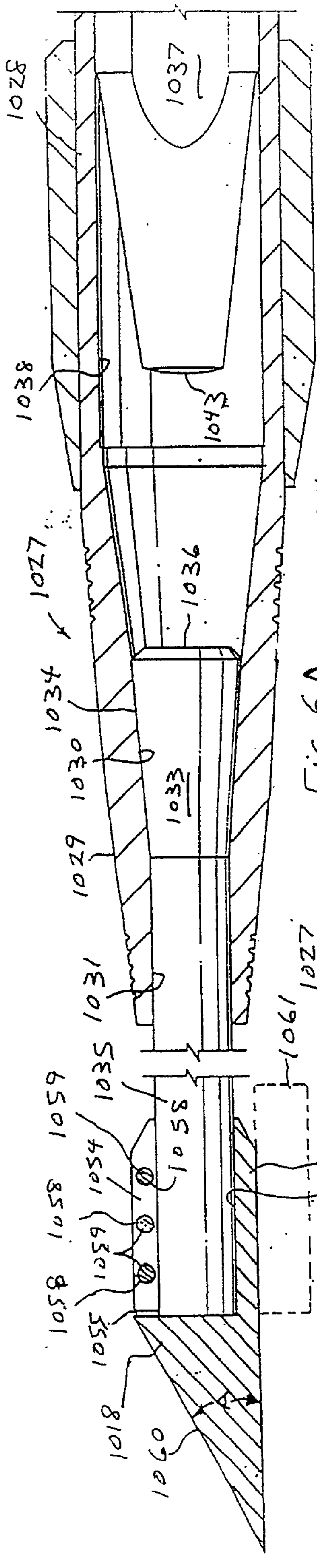

Fig. 6A

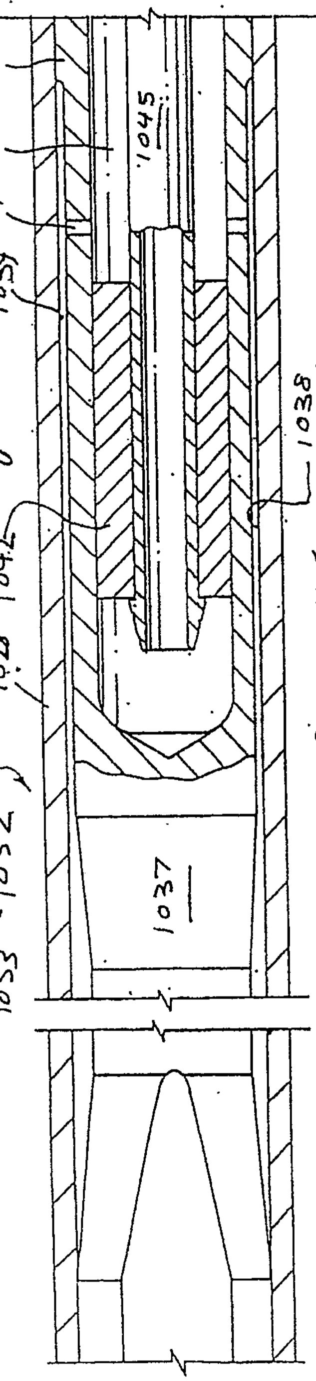

Fig. 6B

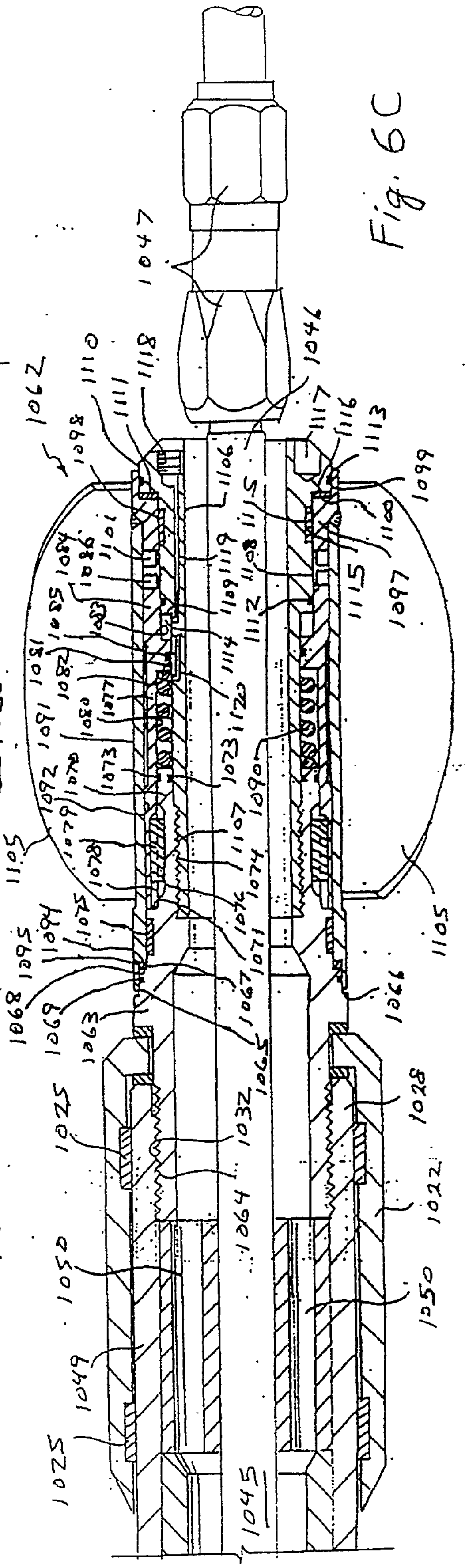

Fig. 6C

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PARTIAL EUROPEAN SEARCH REPORT

which under Rule 45 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application number: EP 90 12 2531

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-4 396 073 (REICHMANN)		E 21 B 7/26 E 21 B 7/06
	* Abstract; column 3, line 37 - column 4, line 6; column 6, line 49 - column 5, line 4; figures *	1	
Y		3,4	
	--		
Y	DE-A-2 911 419 (DRESDNER BANK AG)		
	* Page 14, line 25 - page 16, line 17; figure 3 *	3,4	
	--		
Y	US-A-3 794 128 (GAGEN)		
	* Abstract; figures *	3,4	
	--		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	US-A-3 525 405 (COYNE)		E 21 B
	* Abstract; figures * ./.	1	
	--		

INCOMPLETE SEARCH

The Search Division considers that the present European patent application does not comply with the provisions of the European Patent Convention to such an extent that it is not possible to carry out a meaningful search into the state of the art on the basis of some of the claims.

Claims searched completely:

Claims searched incompletely:

Claims not searched: 2

Reason for the limitation of the search:

Claim 2 discribes first (bit) and second (hammer) means turning the tool around longitudinal axis, which is wrong.

Place of search	Date of completion of the search	Examiner
THE HAGUE	01-02-1991	WEIAND

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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PARTIAL EUROPEAN SEARCH REPORT

Application number
EP 90 12 2531
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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	US-A-3 952 813 (CHEPURNOI) * Abstract; figures * --	1	
A	US-A-3 888 319 (BOURNE) * Abstract; figures * ----	1	TECHNICAL FIELDS SEARCHED (Int Cl.4)

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