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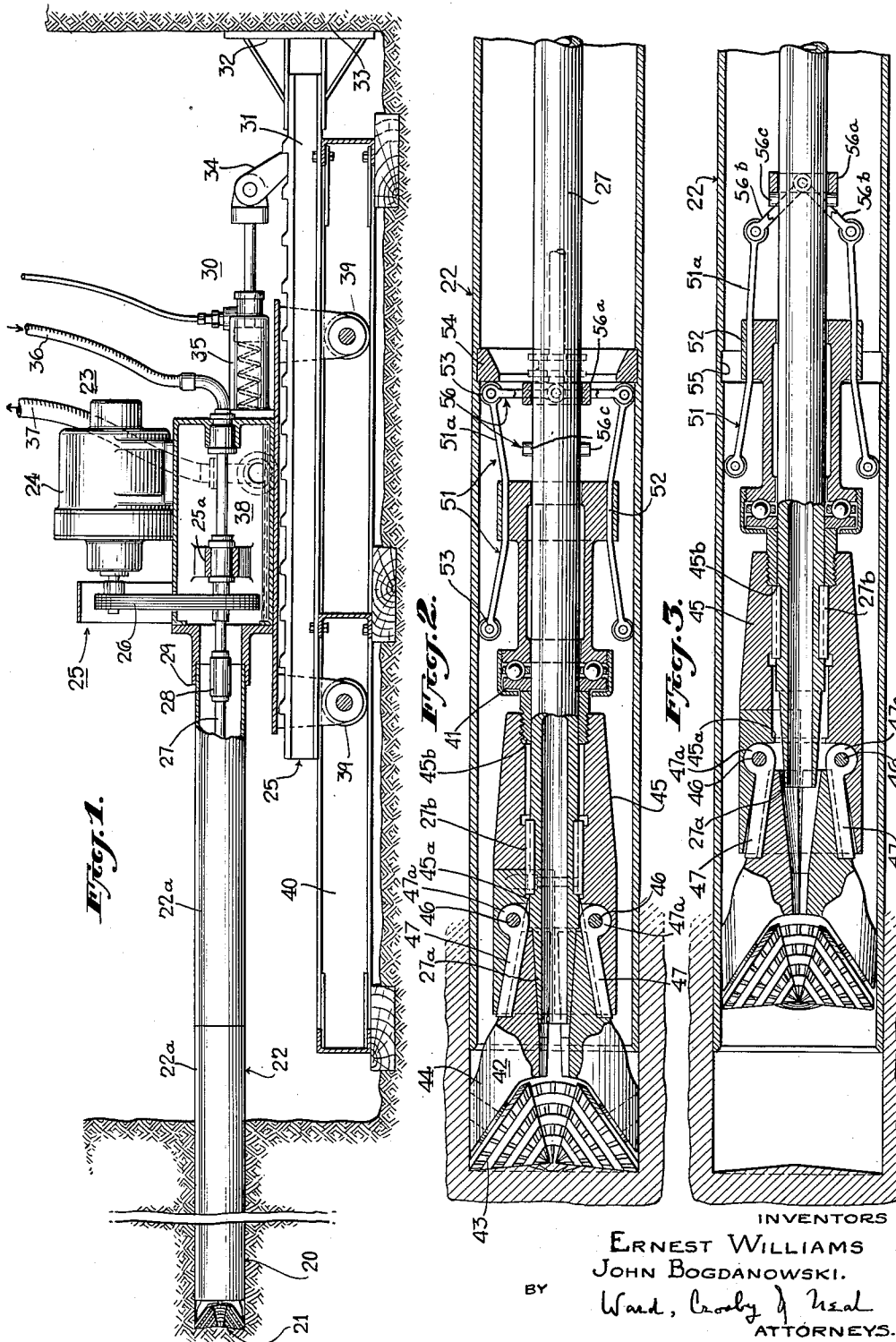
E. WILLIAMS ET AL

2,588,068

DRILLING APPARATUS

Filed Jan. 9, 1948

2 SHEETS—SHEET 1



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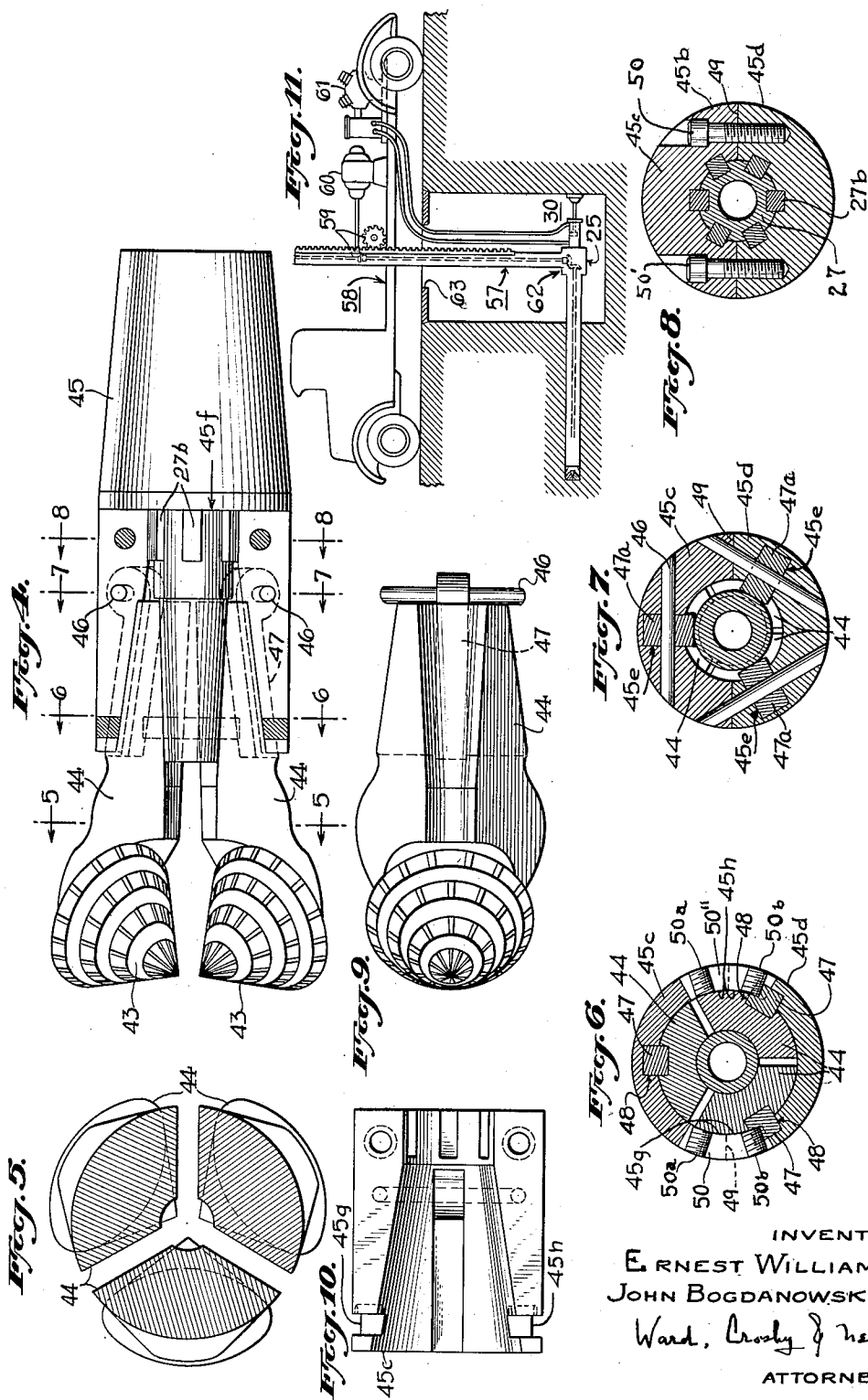
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2 SHEETS—SHEET 2



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DRILLING APPARATUS

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5 Claims. (Cl. 255—20)

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This invention relates to drilling apparatus, and more particularly to apparatus for drilling horizontal or substantially horizontal excavations. The invention also relates to an expandible drill bit which can, in a retracted condition, be thrust through a casing beyond the extremity thereof and there expanded to cut an opening of large enough size to accommodate the casing.

Drilling apparatus of this type heretofore proposed for the drilling of horizontal or substantially horizontal excavations have been difficult and inaccurate of directional control.

Moreover, apparatus of this character heretofore suggested have not provided a satisfactory drill head capable of easy withdrawal from the drill casing.

Furthermore, prior apparatus have in many instances required drill heads supplementary to the main drill head, such supplementary heads comprising, for example, reamers, the use of which require separate operations for insertion and withdrawal which is time consuming and expensive.

One of the objects of the present invention is to eliminate the above difficulties.

The above and other objects and novel features will more fully appear from the following description when it is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for purposes of illustration only and are not intended as a definition of the invention, reference for this latter purpose being had to the appended claims.

In the drawings:

Fig. 1 is a side elevation illustrating the novel apparatus in position within an excavation;

Fig. 2 is a plan view partly in section and with parts broken away of a novel expandible drill bit embodying the invention;

Fig. 3 is a view of the parts shown in Fig. 2 but with the drill bit collapsed and withdrawn within a casing;

Fig. 4 is a side elevation of the novel expandible drill bit showing the cutting elements in expanded condition, one such element being omitted for purposes of clarity;

Fig. 5 is a sectional view taken on line 5—5 of Fig. 4;

Fig. 6 is a sectional view taken on line 6—6 of Fig. 4;

Fig. 7 is a sectional view taken on line 7—7 of Fig. 4;

Fig. 8 is a sectional view taken on line 8—8 of Fig. 4;

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Fig. 9 is a side view of a cutting element and support member therefor;

Fig. 10 is a plan view of that portion of the drill bit upon which are pivotally mounted the cutting element supports; and

Fig. 11 is a schematic view of a mobile mounting for the drilling device.

The form of the invention illustrated in the accompanying drawings, by way of example, is a device for earth boring in a substantially horizontal direction in a straight line course. The apparatus comprises in combination a central hollow drill shaft having a tapered extremity which extends within a hollow drill casing. A carriage member supports one extremity of the shaft and casing and is provided with forward propulsion mechanism such as an hydraulic jack. Suitable power mechanism rotates the central shaft and thereby also rotates a novel drill head which is associated with the outer tapered extremity of said shaft. This drill head comprises an expandible bit of uniquely short dimensions, for a purpose to appear later, and is constituted by a plurality of cutting elements mounted upon a like plurality of support segments. A drill head sleeve member surrounds said shaft adjacent the outer extremity thereof and has pivotally mounted internally thereon said support segments. Thus the supports for the cutting elements are adapted for angular movement to spread same to a position, when beyond said casing, for drilling a hole sufficiently large to accommodate the casing. The spreading of the cutter elements is accomplished by a forward thrust upon the central shaft whereby said tapered shaft extremity engages and forces the elements outward. The shaft extremity is in a keying association with the drill head by which a predetermined axial movement of the shaft will cause the cutting elements to spread apart and a withdrawal of the shaft will permit a retraction of the elements. A unitary cutter is thus provided, the cutting elements of which by a single thrust can be spread as desired and by a single pull can be retracted. Thrust is preferably communicated to the drill head via the casing near the drill face or outer casing extremity. In order to attain directional control not heretofore possible, a rotatable thrust bearing is located in direct association with said sleeve member and in close proximity to said cutting elements. A thrust transmitting mechanism operatively interconnects the thrust bearing to the casing.

In Fig. 1 a horizontal excavation at 20 is bored in the earth by means of a drill head 21 which

protrudes slightly beyond a drill casing 22, the latter comprising a plurality of sections 22a and being urged into the bore made by the head. The sections are preferably welded together. Mechanism for rotating drill head 21 is shown at 23 and comprises a suitable power source such as an electric motor 24 mounted upon a carriage 25. Motor 24 is interconnected by a belt 26 to a central hollow shaft 27 to which the drill head 21 is attached. A thrust bearing 25a, mounted on said carriage, is adapted for absorbing the thrust of shaft 27 as the latter is urged forward as will appear hereinafter. It will be shown that during normal operation the major portion of the thrust to the drill head is transmitted thereto through the casing. However, there will be at least a relatively small amount of thrust necessary to urge the shaft 27 along with the casing and it is this thrust which bearing 25a is designed to absorb. Shaft 27 has a tapered extremity at 27a which acts as a wedge to spread apart cutting elements as will appear below. A socket arrangement 28 is provided upon shaft 27 whereby the shaft sections can be inserted one by one as drilling proceeds. The inner end of casing 22 is also secured to carriage 25 by a casing socket 29.

The drill head 21 is urged forward by, for example, an hydraulic jack 30 comprising a toothed rack 31, which is braced at 32 against a firm wall 33, and a pawl 34 driven by an hydraulic cylinder 35.

Water is conveyed to the drill face via a conduit 36 which is connected to the hollow shaft 27. The cuttings are carried away through casing 22 in a conventional manner through an exhaust conduit 37 connected to a chamber 38 communicating with the casing 22.

Carriage 25 is supported as shown by suitable wheels or rollers 39 upon a track 40.

As shown in Figs. 2 and 3, the novel drill head 21 is designed to receive a thrust from the casing 22 through the intermediary of a thrust bearing 41 which is positioned in close proximity to the drill head and cutting elements whereby an accuracy of directional control is attained which was heretofore not possible. The drill head 21 is so designed that it can be easily inserted through or withdrawn from the casing, by virtue of its collapsible cutting elements to be described below, and is axially of relatively small dimension to permit the location of said bearing as near as possible to the drill face.

The drill head 21, associated with the tapered extremity 27a, comprises a bit 42 having a plurality of cutter elements 43 and a like plurality of cutter element support segments 44 for respective of said elements. The segmental contour of the supports 44, as shown in Fig. 9, enables the use of a satisfactorily large cutting element with necessary strength to cut hard rock and of sufficient size to be retracted to a diameter a little smaller than the inner casing diameter.

In order for drill head 21 to receive a thrust from the casing 22, some operative interconnecting mechanism must be provided therebetween at a point near the drill face. A drill head sleeve 45 is provided for this purpose which surrounds the shaft 27 adjacent the tapered extremity 27a and has pivoted internally thereof the several segments 44 by means of transverse pivot pins 46. Sleeve 45 cooperates with another thrust transmitting member to appear below which directly communicates thrust from the casing to said sleeve and thence to said cutting elements 43.

The cutting elements 43 thus are adapted for

angular movement whereby they can be spread or collapsed. When spread, a hole of sufficient diameter can be cut to accommodate the casing 22, and when collapsed the entire drill head can be withdrawn through the casing, for example, for repair or exchange.

The limits of relative axial movement of sleeve 45 and shaft 27 are determined by a pair of shoulders 45a, and 45b and a plurality of keys 27b which are secured within slots in shaft 27 (Fig. 8) and engage complementary slots in sleeve 45. Thus the shaft 27 can transmit a torque to rotate drill head 21 and simultaneously is shiftable axially relative thereto within the limits of internal shoulders 45a, 45b.

The shoulders 45a, 45b are so disposed that when keys 27b are thrust against the former shoulder the cutter elements 43 are spread apart as in Fig. 2, and when said keys are thrust against the latter shoulder said elements are retractable as in Fig. 3 and can be withdrawn in a manner to appear hereinafter. Thus the length of sleeve 45 is determined by (1) the amount of axial movement of shaft 27 which is necessary to spread the elements 43, and (2) the amount of "overhang" of the sleeve 45 over the segments 44 necessary to restrain their angular movement and provide an outer limit stop therefor of adequate strength. During drilling tremendous forces act to spread the cutting elements still farther beyond the outer limit as shown in Fig. 2. The sleeve 45 comprises a member of sufficient strength to resist these forces.

The sleeve 45 serves another purpose of transmitting torque from the shaft 27 to the segments 44 by means of the above described keys 27b and also by means of segment keys 47 through which transverse pivots 46 pass (Fig. 7). As shown in Fig. 6, the segment keys 47 are rigidly secured to their respective segments and are movable in and out of slots 48 formed within the sleeve 45. The keys 47 thus are in engagement with slots 48 when the segments are expanded (Fig. 2) and are thus prepared for communicating torque from sleeve to segments throughout a substantial part of the length of the latter, for example, about forty per cent thereof. Each of the keys 47, as is well shown in Figs. 2 and 3, is provided at the rear or righthand extremity thereof with a rounded eye or boss as at 47a through each of which passes a transverse pivot 46. The inner frustoconical surface of the sleeve 45 in which are mounted portions of the segments 44 is provided with suitable recesses or concavities 45e (Fig. 7) for the reception of the rounded eyes or bosses 47a.

As shown in Figs. 6, 7 and 8, the portion of sleeve 45 to the left of line 45f of Fig. 4, is divided, for example in halves 45c, 45d, along its longitudinal axis, at line 49. These halves are secured together by suitable bolts 50'. The latter are located substantially removed from the outer or lefthand sleeve extremity as viewed in Fig. 4 and may be placed approximately at the mid-point of the sleeve as viewed in said Fig. 4 and as shown in Fig. 8. The sleeve halves 45c, 45d are secured together at the outer extremities thereof by means of two arcuate strips 50 and 50'' which are mounted respectively in slots 45g and 45h. Each of these slots, for example slot 45g, is formed in aligned cooperating slot halves formed in the sleeve halves 45c, 45d. Portions of such slots 45g and 45h are shown in Fig. 10. Thus a strip as at 50 placed in the slot 45g will overlap portions of the sleeve halves 45c

and 45d and a similar relation between the strip 50'' and such sleeve halves also exists when such strip is in the slot 45h. Each of said strips 50 and 50'' is secured in place by a pair of threaded plugs 50a and 50b. The plug 50a, for example, overlaps the strip 50 and the half section 45c and the plug 50b overlaps the strip 50 and the half 45d. That is, a threaded bore is formed for the plug 50a, one half of which is in the strip 50 and the other half is in the half section 45c. Similarly a threaded bore is formed for the plug 50b, one half of which is in the strip 50 and the other half in the half section 45d. Bores are analogously formed in the strip 50'' and the half sections 45c, 45d for the plugs 50a and 50b for holding same in place. It will be evident, in view of the overlapping relationship of, for example, strip 50 with respect to the sleeve halves 45c, 45d, and the overlapping relationship of the plugs 50a and 50b which cooperate therewith, that the strip 50 will hold together the halves 45c and 45d and will resist radial pressure to separate same. The same is true, of course, of the strip 50'' and its cooperating threaded plugs.

In order to hold the drill head 21 in center relative to casing 22 a center guide member 51 is employed comprising, for example, a plurality of resilient arcuate arms 51a having the centers thereof secured at 52 to a rear portion of the sleeve member 45 and having rollers 53 at the extremities thereof which contact the inside of the casing 22.

The center guide 51 can serve the dual purpose of a thrust transmitting member by virtue of contact with removable thrust ring 54 which is secured to the inside of casing 22 within an internal groove 55 (Fig. 3).

The thrust bearing 41 is interposed between point 52 on the sleeve 45 and the cutting elements.

The thrust ring 54 can be divided into two halves which are collapsible and thus removable. A suitable toggle mechanism (not shown) can hold the halves in position in groove 55.

As shown in Fig. 2 the inner surface of ring 54 is beveled to permit forward insertion of center guide 51 to the cutting position but not withdrawal from such a position. The ring 54 can be removed for the latter purpose, if desired, or a linkage as at 56 can be provided for retracting arms 51a to allow same to pass over the ring 54. Said linkage can constitute, for example, a collar 56a loosely surrounding shaft 27 and having pivotally secured thereto arms 56b which when extended as in Fig. 2 hold rollers 53 on arms 51a against the inner surface of the casing 22. Two diametrically opposed pins 56c protrude from the shaft 27 and are fixedly positioned thereon at such a point that they will engage said collar 56a and pull inwardly the arms 51a just before the keys 27b strike the shoulder 45b when the shaft 27 is withdrawn to the right as viewed in Fig. 3.

In operation, the drill head fixed to shaft 27 and a first section 22a are removably secured at sockets 28 and 29, respectively, and positioned before the region to be excavated and by means of the hydraulic jack 30 are urged thereagainst. As shown in Fig. 1, the first shaft section is slightly longer than the first casing section so that the drill head will protrude slightly from the outer extremity of said casing when said shaft section and casing section are initially secured to the apparatus at sockets 28 and 29, respectively. At the outset of the drilling and before the hydraulic jack urges the drill head against the region to

be excavated it is most likely that the sleeve 45 will be at its outermost axial position relative to the tapered shaft portion 27a. Thus such urging provides an axial thrust upon drill head 21 and shaft 27 which forces the tapered extremity 27a to spread cutting elements 43 to the position of Fig. 2. That is, the sleeve 45 is forced relatively inwardly of the casing until righthand rollers 53 engage ring 54 (Fig. 2). Thus keys 27b are moved into contact with shoulder 45a and a forward thrust is communicated to the cutters from the carriage 25 via casing 22, the ring 54, center guide 51, thrust bearing 41, and sleeve 45.

A suitable lubricant such as water is fed to the drill face through shaft 27 and the cuttings are removed through casing 22.

When it is desired to withdraw the drill head, a pull on shaft 27 will retract arms 51a via linkage 56 to clear ring 54, and will force keys 27b to their righthand limit of motion relative to sleeve 45 whereby the cutting elements are collapsed and the entire drill head removable without disturbing the casing. Of course, prior to such drill head withdrawal, the carriage 25 must be disengaged from the casing 22 at socket 29, and moving the carriage to the right (Fig. 1), thereby makes the interior of said casing accessible for the removal of ring 54 if desired.

Another operative procedure is as follows: the excavation can be commenced by securing a section 22a of casing 22 to the carriage by means of the socket 29, and thereafter urging said casing, via hydraulic pressure of cylinder 25, into the earth for a small distance, for example, a few inches. Then the casing section 22a is detached from the carriage at socket 29 and the carriage is withdrawn. Thereafter, a section of shaft 27 with drill head 21 thereon is inserted into the open end of the section 22a, its base is secured at socket 28 to the base shaft portion which rests in thrust bearing 25a and said drill head is urged up to the face of the excavation by the hydraulic jack. The length of said shaft section, as shown in Fig. 1, is somewhat longer than said first casing section. Consequently, the hydraulic jack must urge the drill head to a point as shown in Fig. 1 beyond the casing extremity before the casing socket 29 can be re-engaged as in said figure. Motor 24 is energized to rotate shaft 27 and drill head 21 whereby the combination of drill thrust to left (Fig. 1) and drill head rotating will enable the drill head to proceed beyond the extremity of casing section 22a. During this initial positioning of the drill head, the thrust bearing 25a absorbs the thrust of shaft 27. When drill head 21 clears the extremity of casing section 22a, the segments 44 are able to spread under the action of tapered portion 27a acting on the inner surfaces of said segments. Casing 22 can now be secured to the carriage at socket 29. Thus an excavation can thereafter be cut which is equal in diameter to that of the casing.

Ring 54 is then installed in groove 55 and thrust is thereafter communicated to the cutting head via the casing 22, ring 54, member 51 and thrust bearing 41.

Carriage 25, instead of resting upon the wheels 39 on track 40 can be supported from above, as in Fig. 11, by means of a boom 57 mounted upon a truck 58. The boom can be raised or lowered, for example, by a rack and pinion device 59 and suitable mechanism is provided for pivotally mounting the boom to permit angular movement about a horizontal axis as the boring progresses. Torque is transmitted to shaft 27 from a motor

60 by means of suitable gear and shaft interconnection. An oil pump 61 is mounted upon the truck to actuate jack 30. The latter can be pivotally mounted to the boom at 62 to permit a "folding" of the jack against the boom to permit withdrawal through manhole 63.

Although only two embodiments of the present invention have been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes may be made in the design and arrangement of the parts without departing from the spirit and scope of the invention, as the same will now be understood by those skilled in the art.

What is claimed is:

1. In a horizontal drilling apparatus, the combination comprising: a carriage member; a drill shaft rotatably secured at an inner extremity thereof to said carriage member and having a tapered outer extremity; power means for rotating said shaft; a hollow casing surrounding said shaft and also secured at one extremity thereof to said carriage; mechanism for urging said carriage substantially horizontally; a drill head associated with the outer extremity of said shaft and casing comprising, a plurality of cutter elements, a like plurality of cutter element support members associated with respective of said cutter elements, a sleeve member for pivotally supporting the inner extremities of said support members, said sleeve member being axially shiftable between preselected limits relative to said shaft, mechanism for pivotally mounting said support members upon said sleeve member whereby the former are adapted for angular movement about the pivots thereof for spreading said cutter elements to a drill hole diameter substantially equal to the outer diameter of said casing, said cutter elements being retractable to an overall diameter less than the inner diameter of said casing; said support members having portions positioned around and spaced from the longitudinal axis of said sleeve member for cooperating with the tapered outer extremity of said shaft, the latter being coaxial with said sleeve member, said support members being spreadable in response to the thrusting of said tapered extremity centrally of said supports against said portion; keying mechanism for associating said shaft with said sleeve member for rotation therewith; thrust bearing mechanism for operatively interconnecting said casing and sleeve for transferring a thrust from said casing to said sleeve; and a rotatable thrust bearing interposed between said mechanism and said sleeve.

2. In horizontal drilling apparatus, the combination comprising a central drill shaft element having a tapered outer extremity, a hollow casing surrounding said shaft; a carriage member for supporting the inner extremities of shaft element and casing; a sleeve element surrounding said shaft element adjacent the outer extremity thereof, a plurality of segmental members pivotally mounted upon said sleeve element near the outer extremity thereof and adapted for angular movement thereupon; a like plurality of cutters mounted on respective of said segmental members; key means for connecting said sleeve element for rotation with said shaft element, said key means being secured to one of said elements and movable in a slot formed in the other element whereby said shaft element is axially movable relative to said sleeve element within predetermined limits; said segmental members being movable by said shaft to a protruding position relative

to said casing whereby said such segmental members are spreadable apart by said tapered shaft extremity in response to movement of said shaft element towards its outer limit of motion relative to said sleeve element, said segmental members being retractable toward the axis of said shaft element in response to relative axial movement of said shaft element to the opposite limit of its relative axial movement; a removable thrust ring mounted internally of said casing adjacent said sleeve element, a guide member secured to said sleeve element for centering the latter within said casing, said guide member being constructed and arranged for engagement with said thrust ring for communicating a thrust from said casing to said cutter elements via said sleeve member; a thrust bearing upon said sleeve member interposed between said cutter elements and said guide member; and means for advancing said carriage to urge said shaft and casing into the earth.

3. In a horizontal drilling apparatus, the combination comprising: a central hollow drill shaft having a tapered extremity; a hollow drill casing surrounding said shaft; a carriage member for supporting one extremity of said shaft and casing; forward propulsion mechanism for said carriage member; power mechanism for rotating said shaft; a drill head associated with the tapered extremity of said shaft comprising, a bit having a plurality of cutter elements and a like plurality of cutter element support segments for respective of said elements, a drill head sleeve member surrounding said shaft adjacent the extremity thereof, means for pivotally mounting each of said cutter element support segments upon said sleeve member thereby adapting the elements of the drill head for angular movement to spread same to a position for drilling a hole sufficiently large to accommodate said casing, said cutter elements being angularly movable to retract same to enable withdrawal of said bit through said casing, said sleeve having a pair of spaced shoulders therein, mechanism for operatively interconnecting said sleeve to said shaft for rotation therewith, said mechanism being so arranged that said shaft can shift axially relative to said sleeve member between said internal pair of shoulders whereby said segments and cutter elements are spread apart by the tapered extremity of said shaft when the latter is at one limit of its axial motion relative to the sleeve member and said segments and are retractable in response to axial movement of said shaft relative to the sleeve member at the opposite limit of relative axial movement; a guide member associated with said sleeve member for holding the latter centered relative to said casing; a thrust ring associated with said casing adapted for communicating a thrust to said guide member and thence to said drill head; and a thrust bearing interposed between said guide member and said cutter elements; said hollow drill shaft comprising a conduit for a liquid to said cutter elements and said casing comprising a conduit for conducting said water and products of drilling away from the drill head.

4. In a horizontal drilling apparatus the combination comprising: a central drill shaft having a tapered extremity; a hollow casing surrounding said shaft; a carriage member for supporting one extremity of said shaft and casing; mechanism for advancing said carriage substantially horizontally; power mechanism for rotating said central shaft; a drill head associated with the tapered extremity of said shaft comprising a bit

having a plurality of cutting element support segments, one for each cutting element, a sleeve member surrounding said shaft adjacent the extremity thereof, means for pivotally mounting each of said segments internally of said sleeve member for angular movement to spread or retract said elements; mechanism for connecting said sleeve member to said shaft for rotation therewith and for axial movement relative thereto between predetermined limits, said segments cooperating with said tapered shaft extremity whereby the former are spread in response to a forward thrust upon said shaft, and are retractable toward the shaft axis in response to a withdrawal of said shaft to its inner limit of axial movement relative to said sleeve member; a thrust ring on said casing, and a guide member mounted upon said sleeve member for holding same centered relative to said casing and for communicating a thrust to said drill head in response to a forward thrust on said casing.

5. In apparatus of the class described, a rotatable drill shaft having a tapered extremity at the drill end thereof; mechanism for rotating said shaft; a carriage member for supporting the driven end of said shaft, said carriage member being mounted for substantially horizontal movement; a casing secured at one extremity of said carriage member and surrounding said shaft substantially throughout its length; a sleeve member associated with the boring extremity of said shaft, mechanism for keying said sleeve member to said shaft for rotation therewith whereby the shaft can shift axially within said sleeve member within

predetermined limits; a drill bit having a plurality of cutter elements and a plurality of cutter element mounting segments, one segment for each element, mechanism for pivotally mounting each segment upon said sleeve member, said segments being cooperable with said tapered drill shaft extremity to spread the cutter elements of said bit in response to a drill thrust upon said shaft, said segments and elements being retractable towards the shaft axis in response to a withdrawal of said tapered extremity relative to the sleeve member in response to a withdrawal thrust thereon; a thrust ring associated with said casing; a guide member associated with said sleeve for holding same centered within said casing and for contacting said thrust ring for communicating a thrust from the casing to said bit via said sleeve; and a thrust bearing mounted on said sleeve member between said bit and said guide member.

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