Oct. 24, 1933. A. E. ENGLEBRIGHT ET AL 1,932,068

EARTH BORING APPARATUS

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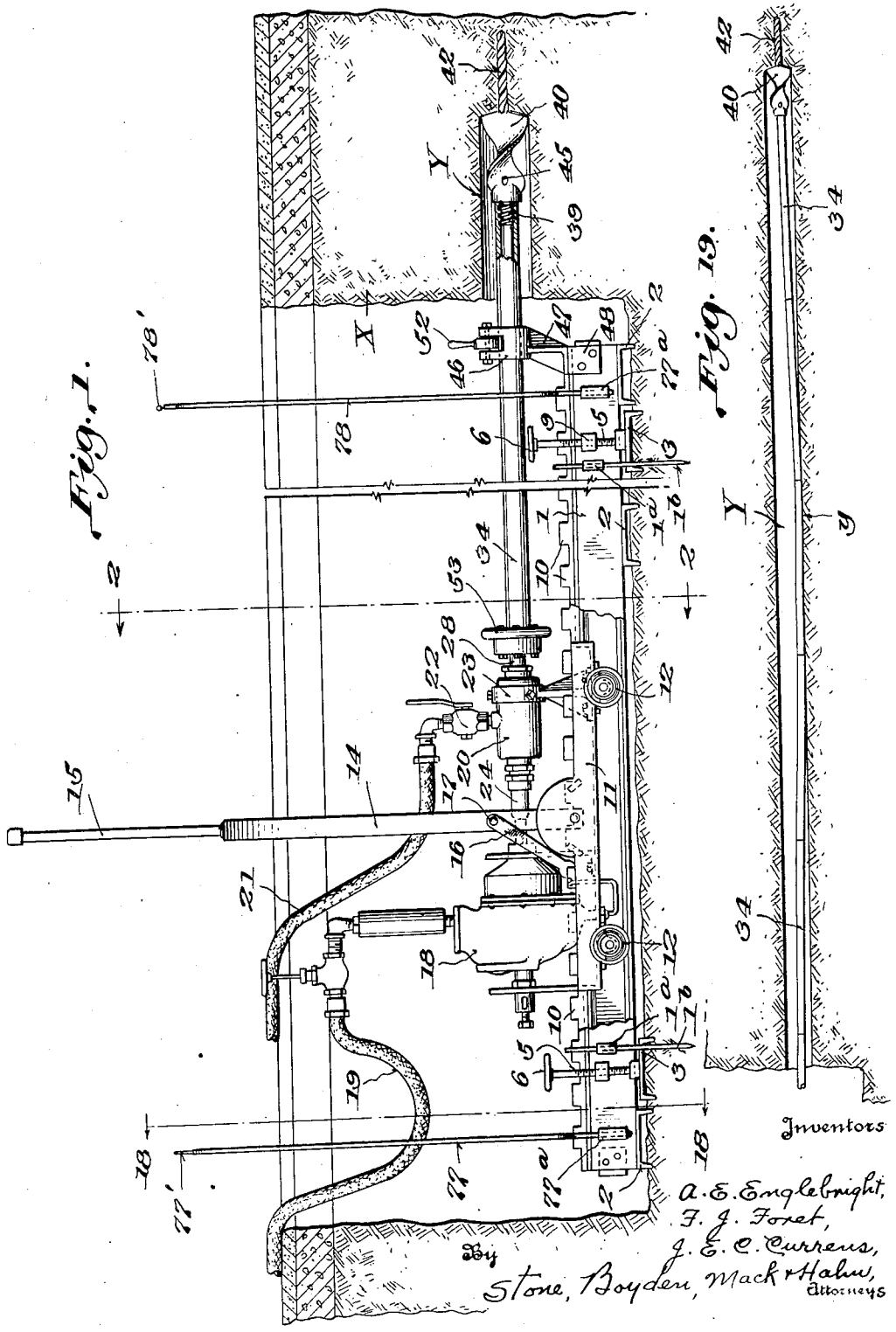

Fig. 1.

Fig. 19.

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EARTH BORING APPARATUS

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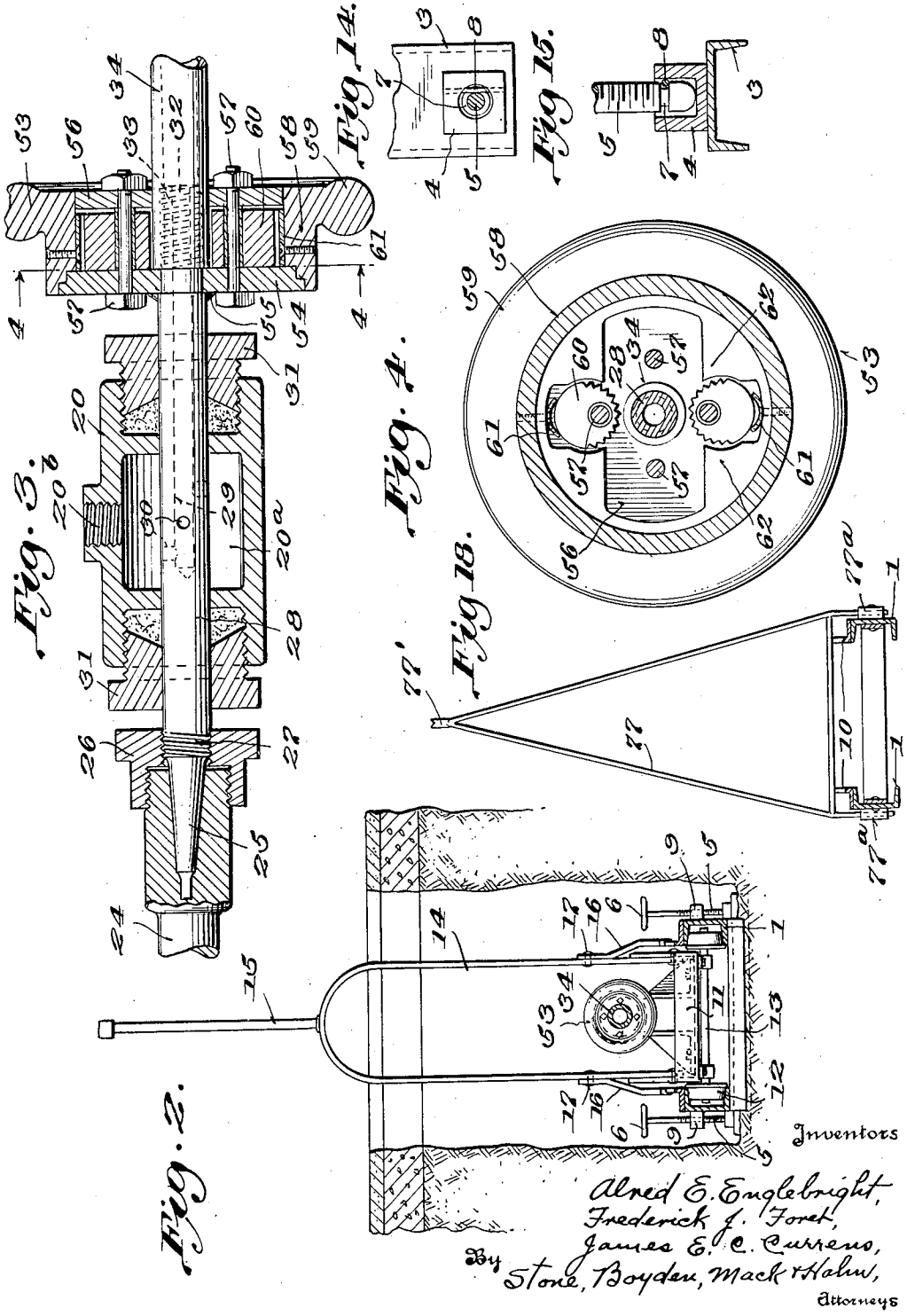

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 14.

Fig. 15.

Fig. 18.

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EARTH BORING APPARATUS

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Fig. 5.

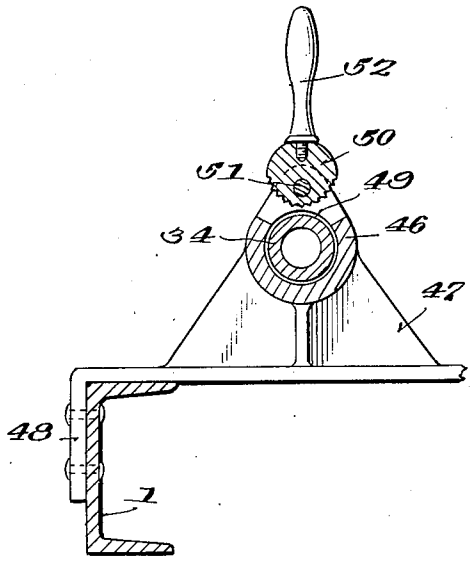


Fig. 6.

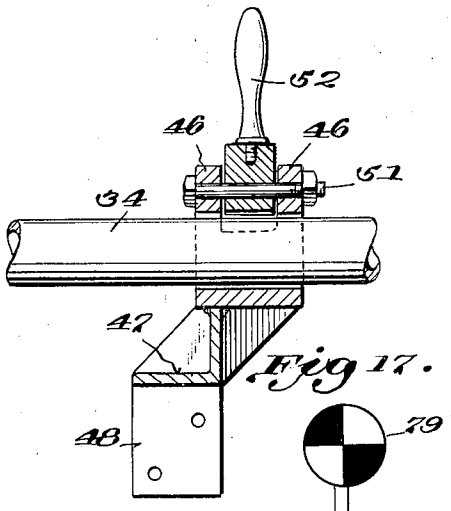


Fig. 17.

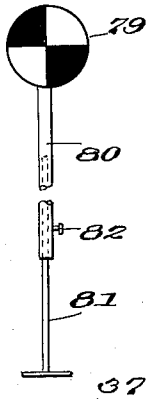
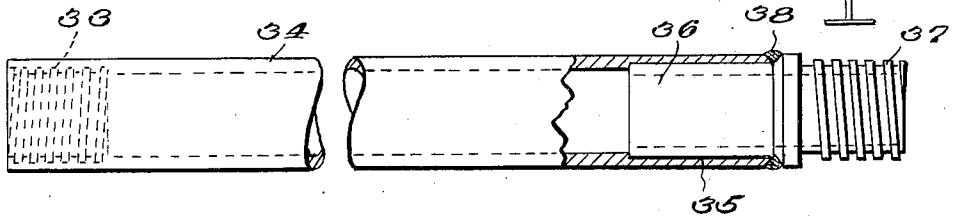


Fig. 7.



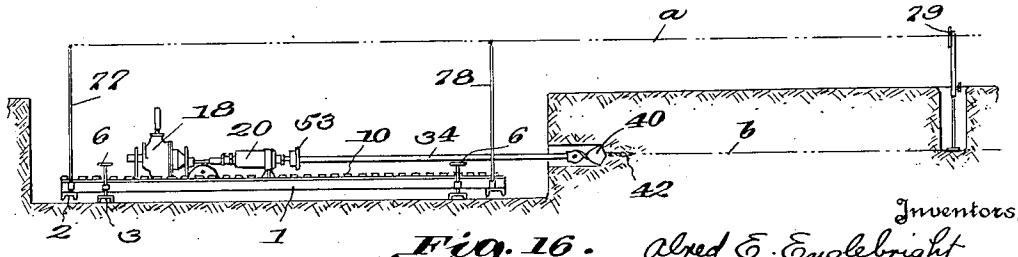


Fig. 16.

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EARTH BORING APPARATUS

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Fig. 8.

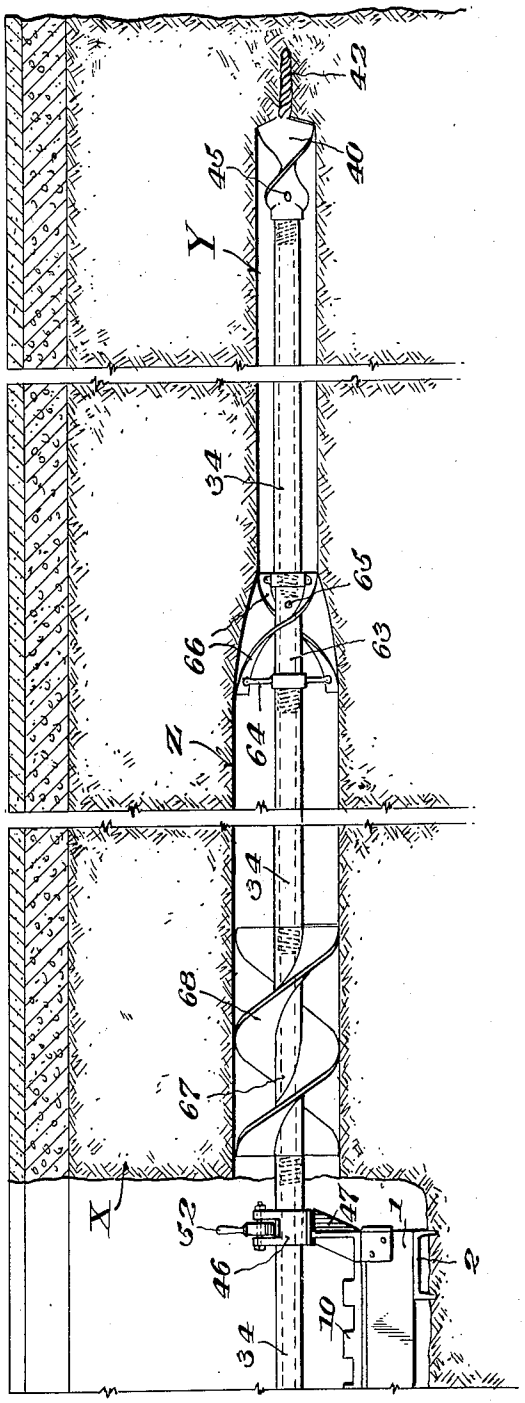
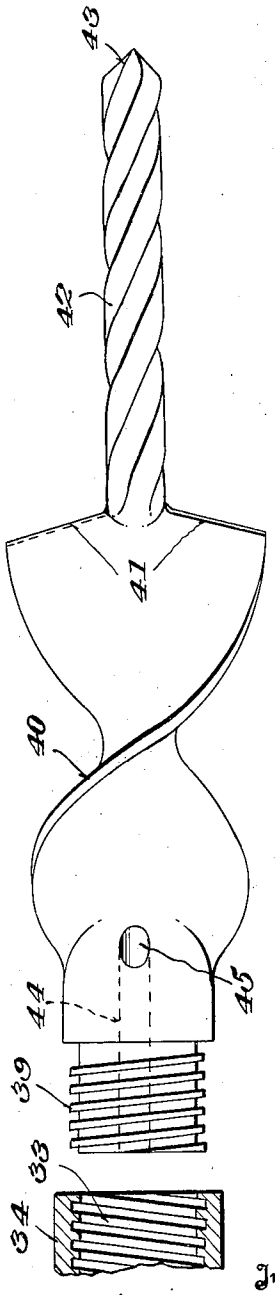


Fig. 9.



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EARTH BORING APPARATUS

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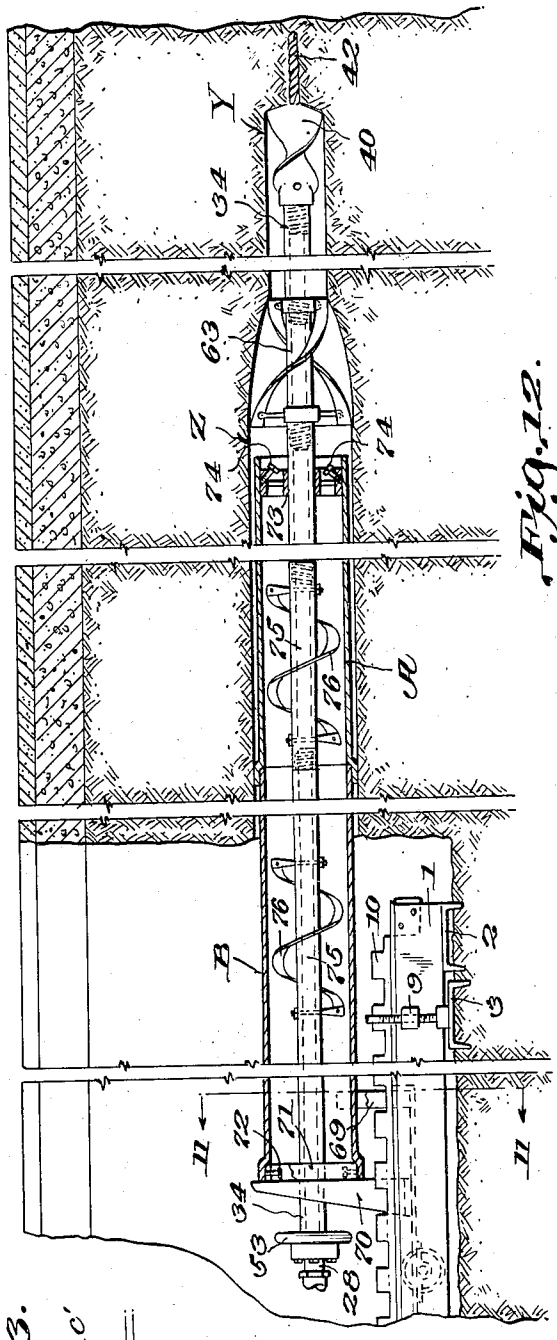

Fig. 10.

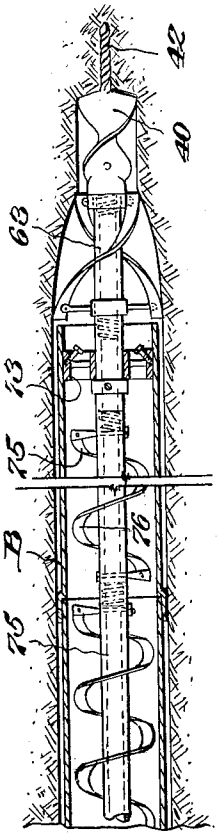

Fig. 12.

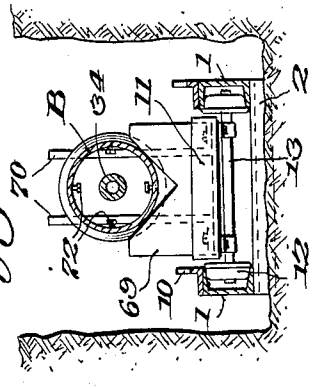

Fig. 11.

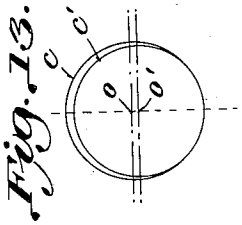

Fig. 13.

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UNITED STATES PATENT OFFICE

1,932,068

EARTH BORING APPARATUS

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Application July 22, 1930. Serial No. 469,906

7 Claims. (Cl. 255—20)

This invention relates to earth boring apparatus, and more particularly to boring apparatus of the horizontal type.

The general object of the invention is to provide a machine of this character which can be readily employed for boring holes under paved streets or highways, railway embankments, etc. for the insertion of water, gas or other pipes, thus avoiding the digging of trenches. The apparatus is also useful in the laying of service pipes to connect buildings with mains in the street.

Another general object of the invention is to provide apparatus of the above character which not only may be employed for boring holes horizontally through the earth, but which may also be utilized in pushing casing into such holes to line the same and prevent them from caving in.

One of the specific objects of the invention is to provide apparatus of the kind described in which the boring bar is formed in sections having screw threaded joints which are interchangeable with similar joints formed at the ends of reamer and conveyor sections so that all of such sections may be assembled in any desired relation and a reamer or conveyor inserted at any desired point in the boring bar. Another object is to provide means whereby the motor which drives the auger may be employed for screwing and unscrewing the boring bar sections. Still other objects are to provide an improved construction of auger bit and an improved type of reamer adapted to cooperate therewith.

In apparatus of the type set forth, as heretofore constructed, difficulty has been experienced in holding the auger to a straight course and in preventing it from drifting downwardly, due to its own weight. A further and important object of the present invention is, therefore, to devise means for preventing such downward drift and for maintaining the auger on a level course. This, we accomplish, by suitably proportioning the relative dimensions of the boring bar and auger as hereinafter described.

With the above and other objects in view, the invention consists in the construction, arrangement and combination of parts as hereinafter described and claimed and illustrated in the accompanying drawings, forming part of this specification, in which drawings:

Figure 1 is a side elevation of one form of our complete earth boring machine, showing the same as it appears in use, parts being in section;

Figure 2 is a transverse section on the line 2—2 of Figure 1, looking in the direction of the arrows;

Figure 3 is a fragmentary longitudinal section on an enlarged scale, showing the hydraulic head and associated parts;

Figure 4 is a transverse section on the line 4—4 of Figure 3, looking in the direction of the arrows;

Figures 5 and 6 are respectively a transverse and longitudinal section of a bar guiding and gripping device employed at the front end of the machine;

Figure 7 is a view partially in side elevation and partially in section, showing our improved method of constructing the boring bar sections;

Figure 8 is a fragmentary side elevation similar to Figure 1, showing the front portion of the machine by illustrating a reamer and conveyor inserted between sections of the boring bar;

Figure 9 is a side elevation on an enlarged scale, showing the improved form of auger bit which we preferably employ;

Figure 10 is a side elevation similar to Figure 8, but illustrating our improved method of inserting a casing or lining into the bore;

Figure 11 is a transverse section on the line 11—11 of Figure 10, looking in the direction of the arrow;

Figure 12 is a fragmentary sectional elevation similar to Figure 10, but showing a slightly modified arrangement;

Figure 13 is a diagram illustrating the relative arrangement of the reamer and casing shown in Figures 10 and 12.

Figures 14 and 15 are a fragmentary plan and a fragmentary vertical section respectively, illustrating on an enlarged scale our improved means for adjusting the elevation of the ends of the machine;

Figure 16 is a diagrammatic view illustrating our method of determining the course to be followed by the auger;

Figure 17 is a front view of the target indicated in Figure 16;

Figure 18 is an end elevation of one of the sighting devices indicated in Figure 16; and

Figure 19 is a diagrammatic view illustrating our improved method of maintaining the auger on a straight or level course.

Referring to the drawings in detail, and more particularly to Figures 1, 2 and 3, our improved machine comprises a track adapted to rest on the bottom of a pit adjacent one end of the bore to be made. This track consists of a pair of spaced parallel longitudinal members 1, preferably consisting of channel beams with their flanges directed inwardly toward each other. These channel members 1 are connected and held in position by cross members 2, placed below the members 1 and welded or otherwise secured thereto.

As the track structure described is designed to sustain the thrust of the boring mechanism, it is desirable to prevent such track structure from slipping longitudinally. The transverse members 2 are therefore preferably provided with

downwardly directed flanges adapted to engage or bite into the earth and thus anchor the track in position. As shown, the members 2 comprise pieces of channel iron with the flanges facing downwardly. Obviously, however, other means of providing transversely extending flanges might be employed.

In order to control and direct the course of the auger as hereinafter described, it is desirable to provide means for independently adjusting the elevation of each end of the track structure. This, we accomplish, by the employment of an additional pair of transverse flanged members 3, one near the front and one near the rear of the machine. To the ends of each of these members on each side of the track we weld or otherwise secure blocks or sockets 4 (see Figures 14 and 15) in which are swivelled the lower ends of screw shafts 5. Each such shaft is provided near its end with a groove 7 in which works a cross pin 8, as clearly shown in the drawings, thus preventing separation of the parts while permitting the shaft to turn in the socket. Each shaft passes through and has threaded engagement with a nut 9, secured to the outside of the track structure and carries at its upper end a hand wheel 6, by means of which it may be turned. It is obvious that by turning the screw shafts 5, the nuts 9 are caused to travel up or down thereon, thus raising or lowering the track frame, as desired.

Rigidly secured, as by welding, to the upper flange of each of the track members 1, is a rack member 10, preferably in the form of an angle iron. As clearly shown in Figure 1, this rack is provided with rectangular or other symmetrical teeth.

Designed to travel along the track structure above described is a carriage 11 having four or any other suitable number of wheels 12, carried at the ends of axles 13 (see Figure 2). These wheels are of such form and size as to fit snugly between the flanges of the channel members 1 so that not only is the carriage supported on such flanges, but it is confined between the same and effectively guided thereby. It will, of course, be understood that there is a slight clearance between the top of the wheels and the under side of the upper flange of the channel members, so as to permit the wheels to turn as they roll upon the lower flange.

Pivotally mounted upon the carriage 11 is an oscillatory lever 14 shown as of inverted U-shape, and having at its upper end an operating handle 15. Suitable pawls 16 are operatively connected to the legs of the lever 14 and are shaped at their lower ends to engage the teeth of the racks 10. As shown in the drawings, the pawls 16 are illustrated as being pivoted directly to the lever 14 at 17. In Figure 1, the pawls 16 are shown as inclined rearwardly, and it is obvious that when in this position, the oscillation of the lever 14, 15 will result in forcing the carriage forwardly.

The pawls 16 are reversible, however, and when they are swung over to the right of the lever 14, it will be clear that oscillation of the lever results in moving the carriage rearwardly. Thus, the carriage may be caused to travel in either direction at will by properly positioning the pawls 16 and manually oscillating the operating lever.

Mounted upon the carriage 11 is a power unit shown as a rotary air motor 18, supplied with compressed air from any desired source by means of a suitable hose 19. Projecting from the forward end of this air motor is a driving or motor shaft 24. Obviously an electric or other suitable type of motor may be employed, if desired.

As customary in earth boring apparatus, we contemplate supplying water continuously to the auger for the purpose of lubricating it and of carrying away the cuttings. To this end, we provide a hollow casing or hydraulic head 20, the interior 20^a of which is provided with a threaded opening 20^b to which may be connected a hose 21 for supplying water under pressure, a suitable valve 22 being preferably interposed, for controlling the same. This hydraulic head 20 is supported and properly centered relative to the motor shaft 24 by means of a supporting ring 23, carried by a bracket mounted on the carriage and having a plurality of inwardly directed set screws for engaging the hydraulic head, as shown in Figure 1.

The motor shaft 24 has at its end a socket adapted to receive the tapered end 25 of a driven or power shaft 28, such shaft being coupled to the motor shaft by means of a nut 26, engaging threads on the motor shaft and also engaging threads 27 on the power shaft, or by any other suitable means.

The forward end of the power shaft 28 is provided with a longitudinal bore 29, having radial bores or ports 30, extending therefrom and opening into the chamber 20^a of the hydraulic head 20. The shaft 28 passes centrally through this hydraulic head and a tight joint is provided at each end by means of packing glands and nuts 31, in a well known manner.

The extreme end of the power shaft 28 is provided with external threads 32, adapted to be screwed into and thus coupled with internal threads 33, formed in the end of any one of a plurality of boring bar sections 34.

This boring bar is hollow, constituting, in effect, a pipe, and is formed in sections of convenient length, such, for example, as six or seven feet. One end of each of these sections is, as above stated, provided with internal threads 33, and the other end is formed with external threads of similar size. One method of providing such external threads at the end of each boring bar section is illustrated in Figure 7. As shown in this figure, the end of the boring bar section opposite the threads 33 is reamed out, as indicated at 35, to receive a hollow spud or plug 36, carrying at its free end external threads 37. Preferably the end of the boring bar section 34 is chamfered off, and the spud or plug 36 is formed with a similarly chamfered or beveled shoulder, and, the two parts being assembled, as shown in Figure 7, they are welded together by running welding metal into the V-shaped groove formed by the two chamfered surfaces, as indicated at 38. Other methods of providing an external thread at one end of the boring bar sections may, of course, be employed, but it is desirable that when the sections are assembled, there shall be no enlargement at the joints, the boring bar being smooth and of substantially uniform diameter throughout.

Instead of forming the internal threads 33 directly in the pipe, as shown, it is obvious that they may be formed in a special fitting similar to 36 and similarly welded in the pipe end.

It will, of course, be understood that the external threads 32 formed at the end of the power shaft 28, are identical with the threads 37 formed at one end of the boring bar sections, thus producing a standard coupling, the parts of which are interchangeable.

Referring now more particularly to Figure 9,

the improved type of auger which we preferably employ will now be described. This auger is provided at its rear end with a shank or stud having an external thread 39 similar in all respects to the external thread 37 shown in Figure 7, so that the auger may be screwed into the internal threads 33 at the end of a boring bar section.

The auger itself comprises a main body 40 of the double helicoidal type, and, while shown in Figure 9 as comprising only half a turn, may, of course, consist of one or more complete turns, if desired. This auger body has at its forward end a pair of symmetrically disposed radial cutting edges 41, inclined rearwardly and outwardly from the axis.

Extending centrally and forwardly from the cutting edges 41 of the auger is a pilot 42. This is preferably similar in construction to the well known twist drill employed for boring metals, and has at its forward end a conical point 43. We have found that an angle of 45° serves best for this point. This type of drill or pilot is very effective in holding the auger to its course and is not easily deflected by encountering stones or other obstructions.

The shank of the auger is provided with a longitudinal bore 44 terminating at each side of the auger in discharge ports 45, through which water is delivered. It will be particularly noted that this water is delivered to the auger at a point adjacent the rear end thereof while the entire pilot remains dry. By maintaining the pilot dry, we find that it holds better to its course and by our improved arrangement, we are enabled to secure the advantages of a dry pilot while at the same time utilizing water to carry away the cuttings from the rear end of the auger.

From the foregoing, it will be understood that in operation, the auger is rotated by the motor 18 while water is supplied to it through the hollow boring bar and ports 45, and at the same time, the carriage is advanced along the track by oscillating the lever 15. In this connection, it may be pointed out that this type of manual feed enables the operator to feel to some extent the character of material being encountered, and to permit the pilot drill and auger to "mill around" while progressing very slowly, in order to penetrate hard material. After the auger has progressed a distance equal to the length of the first section of the boring bar, it is of course necessary to uncouple this section, move the carriage back and insert another section of bar. While it is of course possible to perform these coupling and uncoupling operations manually by means of suitable wrenches, we find that it is very desirable to employ the power of the motor for this purpose. We have therefore devised means for doing this and have also perfected an arrangement whereby even the manual holding of the forward section of the bar by means of a wrench has been made unnecessary. In order to employ the power of the motor for screwing and unscrewing the sections of boring bar, as above mentioned, we have devised what we may designate as front and rear bar gripping devices. The front device comprises a casting 46 having an opening 49 through which the bar may freely pass and is supported on a bracket 47 having ears 48 at each side which are bolted or otherwise secured to the track members 1, as clearly shown in Figures 5 and 6. In the upper part of the casting 46 is pivotally mounted on a bolt 51 an eccentric toothed dog 50 having an operating handle 52. It will be readily seen that when this dog is swung to one side or the other, as viewed in Figure 5, the teeth will bind against the bar 34 and thus grip it and hold it against rotation, the action being similar to that of a pipe vise.

The rear gripping device is designated in its entirety by the reference numeral 53 and is shown in detail in Figures 3 and 4. It comprises a plate 54 welded or otherwise rigidly and permanently secured to the power shaft 28, as indicated by the numeral 55, at a point just back of the threads 32 thereof. Another plate 56 having a central opening of a size to freely receive the boring bar 34 is secured to the plate 54 in spaced parallel relation therewith by means of bolts 57. An annular rim 58, carrying a hand wheel 59, surrounds the plates 54 and 56, and is capable of turning relative thereto. This rim has two pairs of shoulders or projections 62, extending inwardly therefrom and forming pockets in which are located a pair of swinging toothed dogs 60, eccentrically mounted on a pair of the bolts 57. A friction spring 61, carried by the rim, bears against each dog so as to maintain it in the position to which it is moved. The dogs are so proportioned that the distance between the lowest points thereof is sufficient to freely admit the boring bar 34.

Bearing in mind the above described construction of the front and rear gripping device, the operation of coupling and uncoupling the boring bar sections will be readily understood. After the carriage has moved to the forward limit of its travel, the lever 52 is swung to one side so as to grip the first section of the boring bar and the motor then reversed. This immediately uncouples the bar from the power shaft at the point 32, 33, as seen in Figure 3. The carriage is then run rearwardly back to its starting position, and another section of boring bar inserted between the power shaft and the end of the first section. When the motor is started again in the original direction, the two screw couplings will be immediately tightened up.

If it be desired to take the strain off of the threads 32 of the power shaft during this screwing up or subsequent driving operation, it is only necessary to turn the hand wheel 59 in such a direction as to cause the dogs 60 to grip the boring bar section 34, as the power shaft rotates in the given direction. Thus, the driving of the adjacent section 34 will be by way of the plate 54 and dogs 60, and not through the screw threads 32.

When the bore has been completed and it is desired to withdraw the auger from the hole, the operator proceeds as follows. The carriage is first forced rearwardly pulling with it the string of boring bar sections and the auger. It is moved far enough to cause the first joint between boring bar sections to lie just to the left of the front gripping device 46. The handle 52 is then operated to grip the second section of bar, so as to hold it against rotation. The hand wheel 59 is then turned in such a direction as to cause the dogs 60 to grip and turn the first boring bar section 34 when the motor is reversed. Upon reversal of the motor, therefore, the first boring bar section is positively driven by means of the dogs 60 and the second section being rigidly held by the gripping device 46, the joint between the first and second sections is immediately "broken" or loosened. The carriage is then fed forwardly again slightly, so as to bring the end of the first bar section into position to be gripped by the dog

50. Thereupon, the hand wheel 59 is moved so as to release the dogs 60 and bring them to central or neutral position, as shown in Figure 4, and then, upon further rotation of the motor in the reverse direction, it is clear that the joint at 32 is immediately loosened. After the first section of bar has been removed, the carriage is moved forwardly again and coupled to the end of the second section, whereupon it is forced rearwardly once more and the operation repeated.

From the foregoing, it will be particularly noted that the rear grip device 53 constitutes means for positively ensuring that the joint between the two sections of boring bar is loosened or broken before the joint between the first section of boring bar and the power shaft. Thus, the joint at the power shaft is always the last to be loosened. If it were not for the gripping device 53, either joint might be the first to loosen, upon reversal of the motor, but by positively driving the first section of boring bar in a reverse direction, as described, we make certain that the other joint is released before that at the power shaft, and we regard this as an important feature of our invention, from a practical standpoint. By the use of our improved front and rear gripping devices, not only is much manual labor avoided, and much time saved, but the hazard incident to the possible slipping of wrenches and injury to the crew is eliminated.

In prior attempts which have been made to drill relatively long holes or tunnels through earth by means of a horizontal auger, difficulty has been experienced in keeping the auger on a level course, due to its tendency to sink or drift downwardly, owing to its own weight. We have made the important discovery that this tendency to drift downwardly can be overcome by so proportioning the dimensions of the auger, pilot and boring bar, that the sagging of the boring bar in the hole serves to direct the pilot upward to an extent sufficient to counteract the "dipping" of the auger. This is illustrated in Figure 19, in which it will be seen that the boring bar 34 is relatively small compared with the diameter of the auger 40. This results in providing a clearance around the boring bar, which permits it to sag until it rests upon the bottom of the hole. In the drawings, X designates the material being bored through, Y the bore or hole, and *y* (Fig. 19) illustrates the point at which the boring bar engages the lower side or bottom of the hole. It will be understood that after the bar has thus engaged the bottom of the hole, it can sag or bend no further, and that from this point onward, the inclination of the forward portion of the bar, and consequently of the auger and pilot, remains constant.

It is difficult, if not impossible, to give accurate and definite figures regarding the relative dimensions of the auger and boring bar necessary to produce the result referred to, because these will necessarily vary to some extent with the nature of the material being bored through, but we may give examples of figures which have been successfully used by us in actual practice.

In one of the smaller sizes of machines, constructed in accordance with the present invention, the standard boring bar has a diameter of 1 and 1⅛ inches and with this size boring bar, we find that an auger having a diameter of 2¾ inches gives a satisfactory result. In fact, under different conditions, the diameter of the auger may vary from 2 and ¼ to 3¼ inches. In this case, we prefer to employ a cylindrical pilot of from ½ to 1 inch in diameter, preferably ¾ of an inch, and of a length varying from 2 and ¼ to 5 inches, preferably 4 inches. A little consideration will show that the above figures mean that the boring bar must have a diameter of from one-half to two-thirds of that of the auger, while the pilot should have a diameter of from one-fourth to one-third of that of the auger, and a length equal to from one to two times the diameter of the auger.

Again, in a larger machine, the standard size of boring bar is 2 and ¾ inches. With this boring bar, we can use an auger of from 4 to 5 and ¼ inches in diameter, (preferably 4 and ½ inches) and a pilot having a diameter of from 1 to 1½ inches (preferably 1 and ¼ inches) and a length of from 4 to 7 inches (preferably 5 inches).

Here, again, when reduced to comparative figures, it will be seen that the boring bar, as in the first case, has a diameter of from one-half to two-thirds that of the auger while the pilot has a diameter of from one-fourth to one-third that of the auger and a length equal to from one to two times the diameter of the auger.

We believe that the above formulæ express the relation as accurately and definitely as it is possible to express it in view of varying conditions met with in actual practice, and we find that an adherence to the relative dimensions given will result in substantially, if not absolutely, preventing the downward drifting of the auger and in substantially, if not absolutely, maintaining it on a straight course.

In boring relatively large holes, we find that it is easier and requires less power to produce such a hole by means of an auger and a reamer than it does to have the auger itself of the required size. The reamer which we preferably employ is constructed somewhat after the manner of the revolving arms employed in an ordinary lawn mower, except that these arms are tapering or inclined. Such a reamer is shown at 63 in Figure 8 and comprises spiders or end pieces 64 and a plurality of relatively narrow helical tapering blades 66. The core or body 63 of the reamer is of course hollow, like the boring bar, and may be provided with two or more discharge ports 65 for delivering water to the cutting blades for carrying away the material. It will be understood that the reamer body 63 is provided at its respective ends with internal and external threads identical with the threads 33 and 37, shown in Figure 7, so that this reamer may be connected between any two sections of the boring bar.

We find, further, that it is highly desirable to dispose the reamer at a considerable distance from the auger itself, in order to assist in holding the auger on a straight course. To state it as accurately as possible, we may say that the reamer should be spaced from the auger a distance at least equal to from four to six times the diameter of the auger. This is illustrated in Figure 8, in which a boring bar section 34 is shown as interposed between the auger 40 and the reamer 63.

The construction of the reamer, formed as it is with an open center, not only permits the material cut by the reamer to fall down through it, and be carried away by the water, but also affords free passage for the stream of material flowing rearwardly from the auger itself.

Under some conditions, we find it desirable

to employ, in addition to the reamer, one or more spiral or helical conveyor sections. One of such sections is illustrated in Figure 8, and comprises a core or body 67, and one or more helical flanges 68. It will be understood that the body 67 of each conveyor section is provided at its ends with internal and external threads similar in every respect to the threads 33 and 37 shown in Figure 7, so that these conveyor sections are interchangeable with the boring bar sections, and with the reamers. By thus employing an auger, boring bar sections, reamers, and conveyor sections, all having standard interchangeable couplings, it is possible to connect these various elements together in any desired relation whatsoever. Thus, a plurality of conveyor sections may be connected together or a conveyor section may be connected directly with a reamer, without the interposition of any boring bar section, and the auger itself may be connected directly to the reamer or to a conveyor section, if desired.

In many cases, especially where the bore is relatively large and the material being excavated is soft, it becomes highly desirable to insert a lining or casing into the bore as it is formed, in order to prevent the walls from caving in. This can be accomplished by the method shown in Figures 10 to 13.

Referring to Figure 10, we have shown a V-block 69, mounted on the carriage and in this block the casing to be inserted rests. In Figure 10, two sections of casing A and B are illustrated and these are shown as provided at their ends with slip joints of the bell and spigot type.

A pair of upstanding posts or thrust members 70 are also mounted on the carriage to the rear of the V-block 69 and these posts are adapted to engage and push against the rear end of the casing sections. In order to prevent relative rotation of the casing and carriage and to properly position the parts, we preferably provide a ring 71 secured to the posts 70 and adapted to fit within the rear end of the casing sections. Set screws 72 pass radially through this ring and engage the interior walls of the casing so as to hold the same.

In practice, we employ an auger 40 and a reamer 63 in order to form an enlarged hole or bore Z to receive the casing. The first section of casing is placed in position on the V-block 69 and ring 71 around the boring bar, the front grip device 46 of Figure 1 having been removed from the machine, and a guide ring or centering device 73 is slipped over the boring bar and firmly secured in the forward end of the casing by means of set screws 74, it being understood, of course, that the boring bar is free to turn within this guide member. The auger is then started and the carriage fed forward, thus forming the bore and at the same time pushing the casing section into the same. When the first section has been inserted, the boring bar is uncoupled from the power shaft, as described in connection with Figure 1, and the carriage moved rearwardly. Another section of boring bar is then added and another section of casing placed in position. Thus, the operation can be repeated indefinitely.

In order to assist in moving the excavated material rearwardly through the casing as the boring progresses, it is often desirable to employ spiral conveyor sections. Two of such sections are shown in Figure 10, and each comprises a core or body 75 coupled between two sections of boring bar, and a narrow helical blade 76, preferably spaced from the core, as shown, which may or may not extend the length of the core. It will be understood that the guide member 73 is in the nature of an open spider and this, together with the skeleton construction of the conveyor sections 75, 76, permits the material excavated by the auger and reamer to be carried rearwardly through the casing by the water. The conveyors assist in propelling the material along through the casing and prevent clogging of the same.

It will, of course, be understood that the conveyor section bodies 75, above described, which, of course, are of substantially the same length as the casing sections, are provided at their ends with internal and external threads identical with the threads 33 and 37, shown in Figure 7, so that these conveyor sections are interchangeable with boring bar sections and may be coupled to such sections or to each other, or to the reamer, as desired.

In some types of material, it is possible to work the apparatus dry, without the use of any water. Figure 12 shows the auger, reamer and conveyor sections assembled for dry operation, and in this case, it will be noted that the auger is coupled directly to the reamer and the conveyor sections are coupled directly together so as to form in effect a continuous conveyor. This is necessary for the reason that the conveyor sections are relied upon entirely as the means for moving the excavated material, when operating without water.

In previous attempts to push a lining or casing into a horizontal hole being bored by means of an auger or reamer, difficulty has been experienced due to the fact that the forward end of the casing tends to dig downwardly, due to its own weight, and it has been found almost impossible to maintain a straight course.

We have found that this difficulty can be overcome by arranging the boring bar eccentrically of the axis of the casing so that there is slightly more clearance provided above the casing than below the same.

This is diagrammatically illustrated in Figure 13, in which c represents the hole bored by the reamer and c' the end of the casing. These two circles are eccentric to each other, the circle c being slightly larger and having its center at the point o, while the circle c' has its center at the point o'. Thus, the center of the reamer is located slightly above the center of the casing.

This can be accomplished, in practice, by forming the central opening in the guide member 73 somewhat eccentric to the rim of such guide member. The top of the guide member may then be distinguished by means of some identifying mark, so that it may be properly inserted in the casing by the operator. We regard this eccentric arrangement as an important part of our invention, since without it, the insertion of casing in a bore is attended by almost insuperable difficulties.

In order to properly direct and determine the course of the auger, we find it desirable to provide sighting devices, together with an adjustable target such as employed by civil engineers in elevation work.

Referring to Figures 1 and 18, we provide adjacent the front and rear of the track frame a pair of sockets 77^a and in these sockets are held the lower ends of triangular sighting devices 77 and 78. The device 77 carries at its upper end a

V-notch 77' similar to the rear sight of a rifle, while the device 78 carries at its upper end a ball or the like 78' similar to the front or globe sight of a rifle. A target 79 is employed and is supported on a telescoping or other vertically adjustable stand 80, 81, held in adjusted position by means of a set screw 82 (see Figure 17).

By reference to Figure 16, the method of determining the course of the auger will be clear. The target 79 is set up at some point in advance of the machine and adjusted so that its height is equal to the distance between the line of sight *a* and the axis of the auger *b*. Obviously, when the target is so placed that the line of sight *a* is centered thereon, the base of the target will lie on the line *b* and will indicate the depth at which the auger will come out. Or, to state it another way, if it be desired to run the auger to a point, say, three feet below the surface of the ground, the target will be set into the ground to this depth, and the machine then adjusted until the line of sight *a* is centered upon the target. It will be apparent that by means of the screws 5 and hand wheels 6, the front or rear of the track frame may be raised or lowered as desired, in order to center the line of sight upon the target and to direct the auger to the proper point.

Referring again to Fig. 1, we may in some cases find it desirable to weld or otherwise secure to the sides of the track frame 1 a plurality of hollow lugs 1^a, conveniently formed of pipe sections, through which lugs anchor rods 1^b may be driven down into the ground to aid in holding the track against slipping, and to maintain it in position laterally as well as longitudinally.

From the foregoing, it will be seen that we have provided an exceptionally simple and practical apparatus for boring substantially horizontal holes through earth and the like and for inserting casing into such holes, and it is thought that the many advantages of our improved construction will be fully appreciated without further discussion.

What we claim is:

1. In an earth boring machine of the horizontal type, the combination with a track, a carriage movable therealong, and a boring bar formed of sections having screwed joints, of a reversible motor mounted on said carriage and normally driving said boring bar, and a bar-gripping device secured to said track for engaging said bar at a point beyond the first section and holding it against rotation, whereby said motor, when reversed, serves to unscrew said joints.

2. In an earth boring machine of the horizontal type, the combination with a track, a carriage movable therealong, and a boring bar formed of sections having screwed joints, of a reversible power shaft journalled in said carriage and having at its end one member of a screw joint adapted to engage with a complementary member on the end of the first section of boring bar, whereby said bar is normally driven, a fixed bar-gripping device for engaging said bar at a point beyond the first section and holding it against rotation, whereby, upon reversal of said power shaft said joints are thereby unscrewed, and releasable means for positively preventing the unscrewing of the joint between the boring bar and power shaft, so as to ensure the loosening of the next joint first.

3. In an earth boring machine of the horizontal type comprising a track, a carriage movable therealong, a motor mounted on the carriage, and an auger driven by the motor and carried at the end of a boring bar made up of a series of sections connected by screw threaded joints, means for utilizing the power of the motor for screwing, and unscrewing such joints comprising a fixed bar-gripping device adjacent the forward end of the track, and a rotary bar-gripping device positively driven by said motor in both directions and movable with the carriage.

4. In an earth boring machine of the horizontal type, the combination with a track, a carriage movable therealong, a boring bar formed in sections screwed together, and having an auger at its end, a power shaft journalled in said carriage and having at its end a screw coupling adapted to receive said boring bar, a rotary gripping device rigidly secured to said power shaft adjacent said coupling for rotation therewith in either direction and adapted to grip said boring bar, and a stationary gripping device mounted on said track, through which device, when released, said boring bar is free to move.

5. In an earth boring machine of the horizontal type, the combination with a track, a carriage movable therealong, a boring bar formed in sections screwed together, and having an auger at its end, a power shaft journalled in said carriage and having at its end a screw coupling adapted to receive said boring bar, means rigidly secured to said power shaft so as to rotate therewith in either direction and operable at will to grip said boring bar at a point adjacent said coupling to positively turn the same, and a fixed gripping device mounted on the track and capable of holding said bar against rotation when desired.

6. In an earth boring machine of the horizontal type, the combination with a track, a carriage movable therealong, a boring bar formed in sections screwed together, and having an auger at its end, a power shaft journalled in said carriage and having at its end a screw coupling adapted to receive said boring bar, means independent of said coupling for establishing a positive driving connection in either direction between said power shaft and bar, and means attached to a fixed support for holding said bar against rotation when desired.

7. An earth boring machine of the horizontal type comprising a track formed of a pair of spaced, parallel, inwardly facing commercial rolled channel beams, a carriage movable along said track and having wheels confined in and substantially filling the space between the flanges of said beams, said wheels running on the lower of said flanges, an auger connected with the carriage, means exerting a thrust against said track to propel the carriage, and a plurality of connecting members extending transversely between and below said beams, said connecting members comprising commercial rolled shapes having downwardly directed flanges adapted to bite into the ground on which the machine rests and thus hold the track against longitudinal movement.

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