United States Patent [19]

Crane et al.

[11] **3,840,272**

[45] **Oct. 8, 1974**

[54] **UPWARD TUNNELING**

[75] Inventors: **Clayton H. Crane,** Mercer Island; **Tyman H. Fikse,** Enumclaw, both of Wash.

[73] Assignee: **The Robbins Company,** Seattle, Wash.

[22] Filed: **Nov. 13, 1972**

[21] Appl. No.: **305,912**

[52] **U.S. Cl.** ..... **299/56,** 52/726, 61/41 R, 173/36, 175/103, 175/320, 299/33

[51] **Int. Cl.** **E01q 3/04**

[58] **Field of Search** ..... 299/31, 33, 55, 56, 57; 175/53, 94, 103, 320, 325, 85, 52; 138/111; 61/41 R, 84, 85; 285/137; 52/726; 173/36

[56] **References Cited**

UNITED STATES PATENTS

1,283,191	10/1918	Hughes	175/325 X
3,354,969	11/1967	Ebeling	175/103 X
3,356,167	12/1967	Trent	175/103 X
3,604,754	9/1971	Kampf-Emden	175/94 X

FOREIGN PATENTS OR APPLICATIONS

139,274	9/1961	U.S.S.R.	299/55

Primary Examiner—Ernest R. Purser

Attorney, Agent, or Firm—Graybeal, Barnard, Uhlir & Hughes

[57] **ABSTRACT**

A power tunneler is advanced upwardly by a thrust ram acting on a non-rotating sectional support column connected to the power tunneler from below. While sections are being added to or removed from the support column it is anchored to a holding table situated underground above the thrust ram. The thrust ram is pivotally mounted at its lower end so that it can be swung sideways to be used as a pipe loader.

25 Claims, 23 Drawing Figures

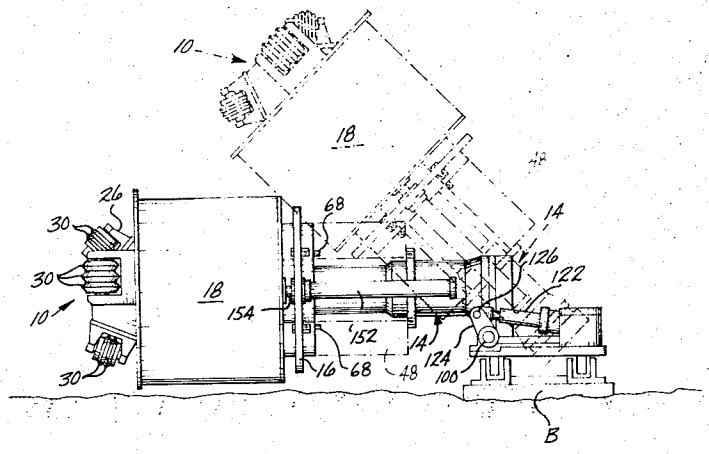


Fig. 1

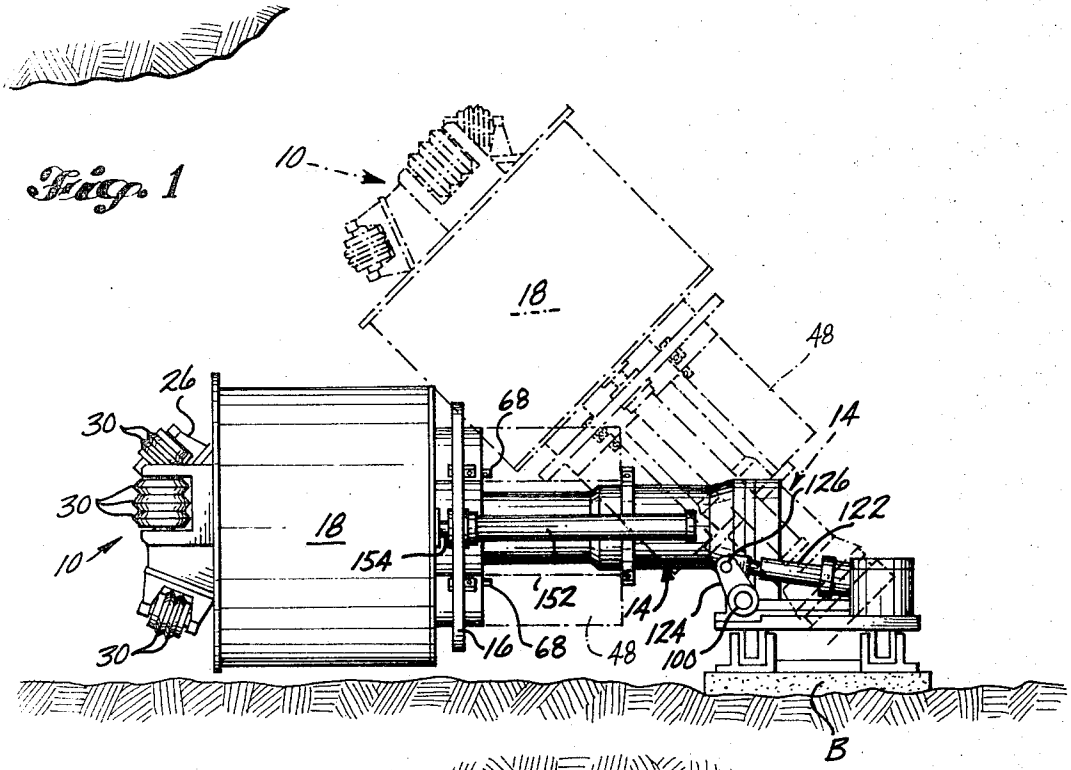

10
18
48
26
30
30
68
14
126
122
18
10
154
152
14
124
30
16
68
48
100
B

Fig. 2

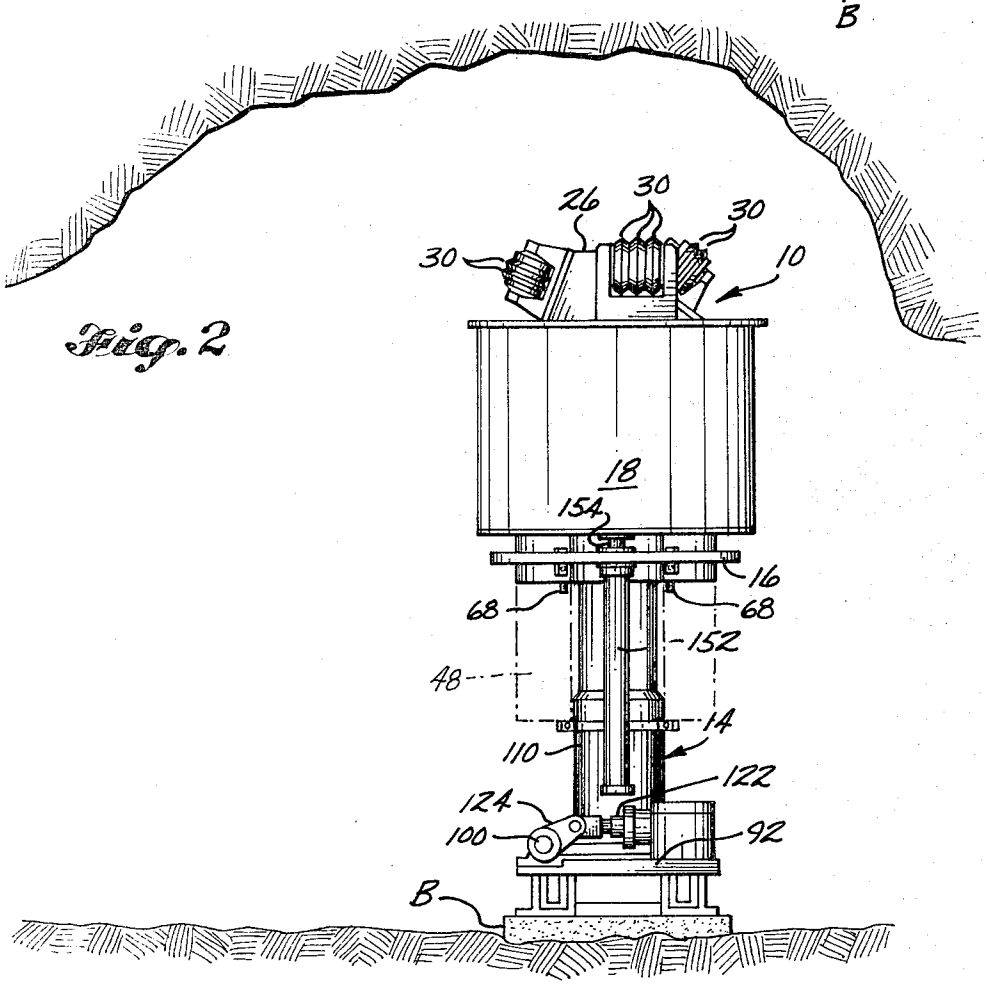

26
30
30
30
10
18
154
16
68
68
152
48
14
110
122
124
100
92
B

Fig. 3

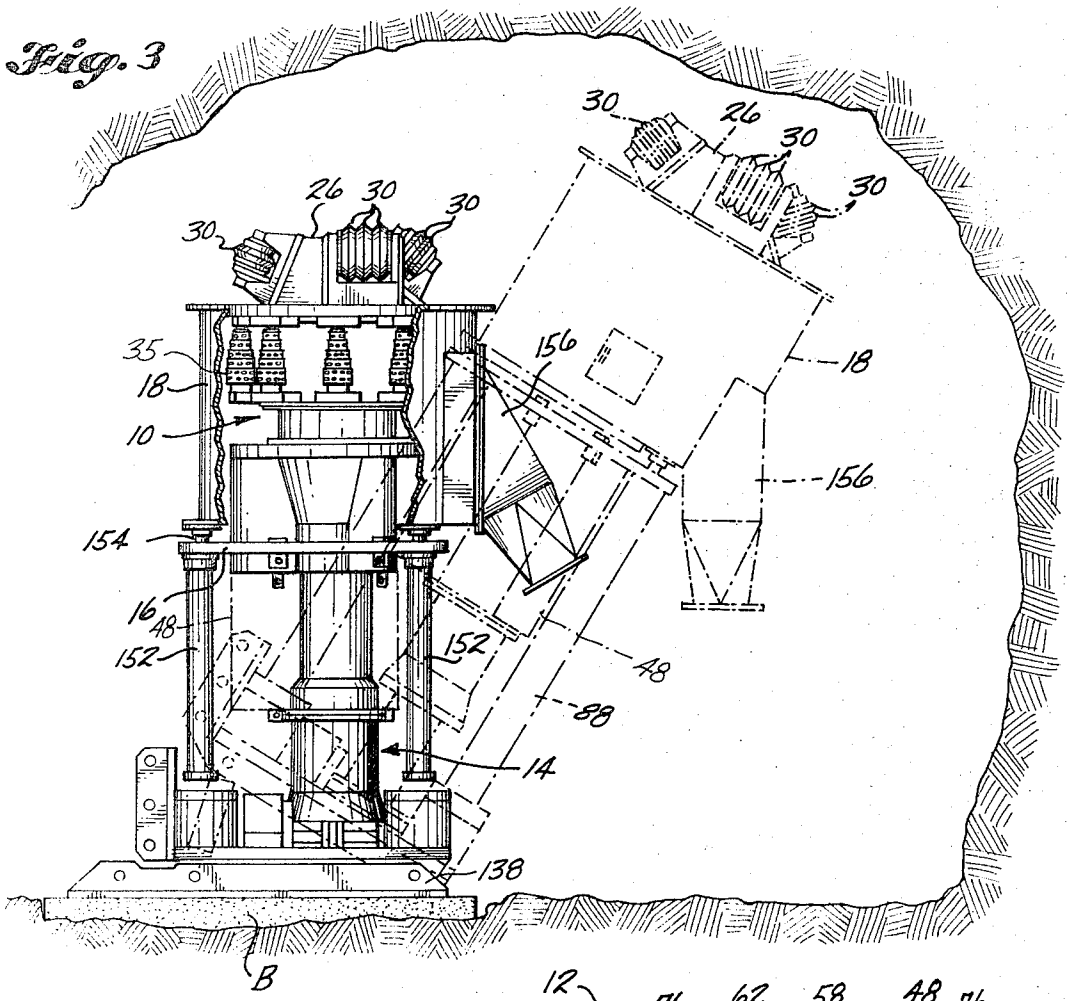


Fig. 5

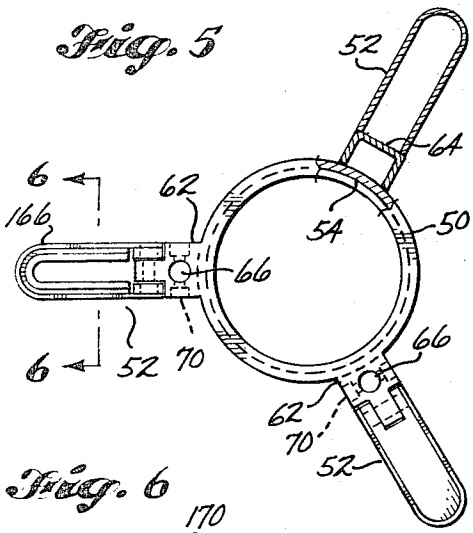
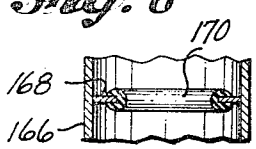


Fig. 6



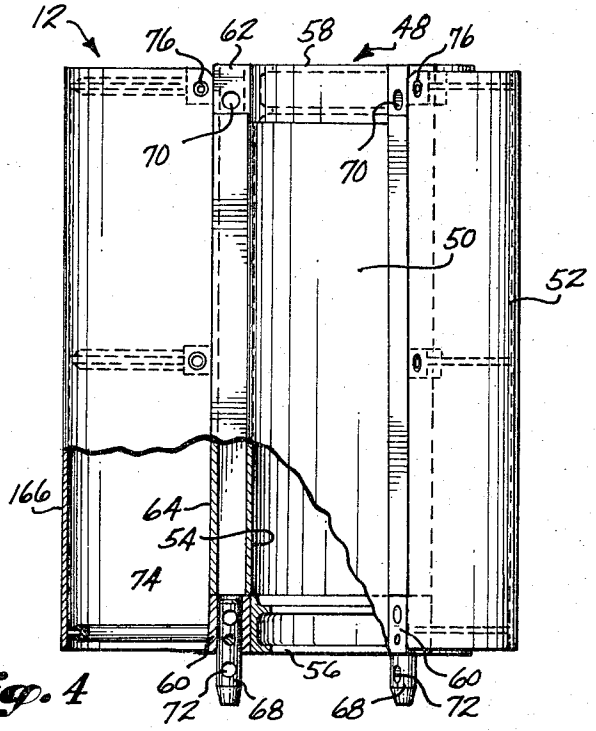


Fig. 4

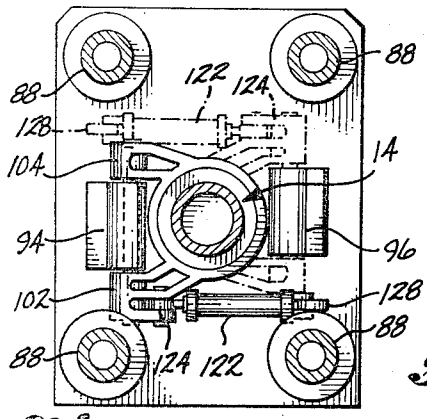


Fig. 10

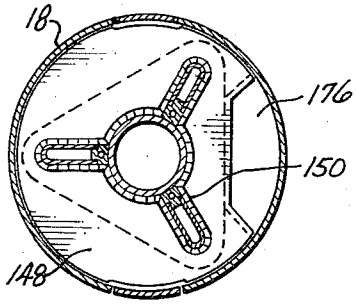


Fig. 9

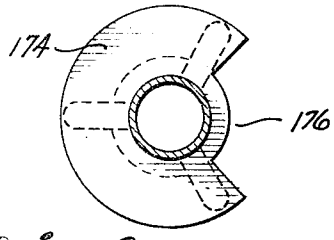


Fig. 8

Fig. 7

Fig. 11

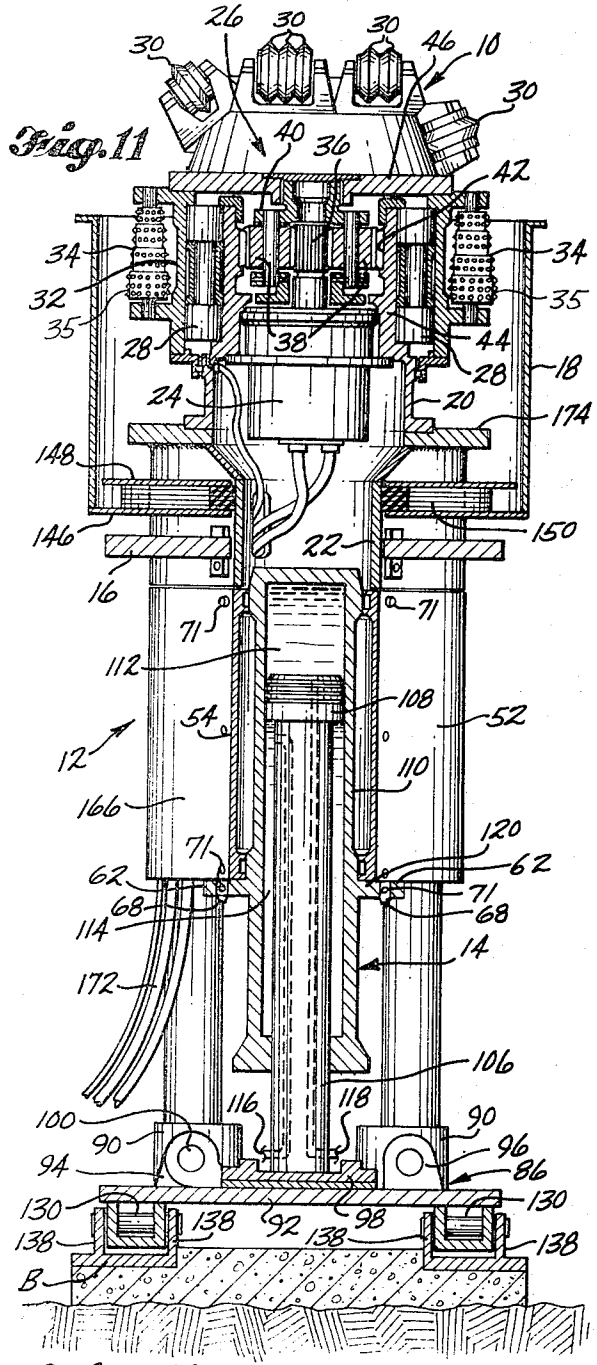
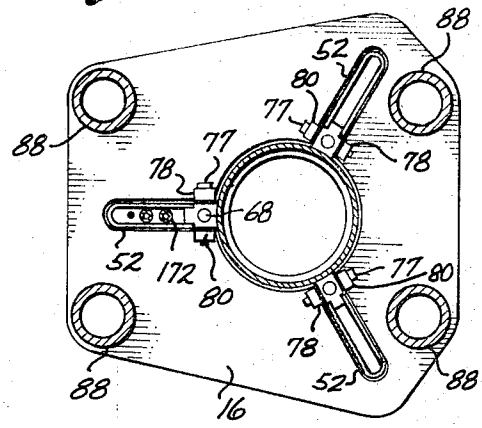


Fig. 13



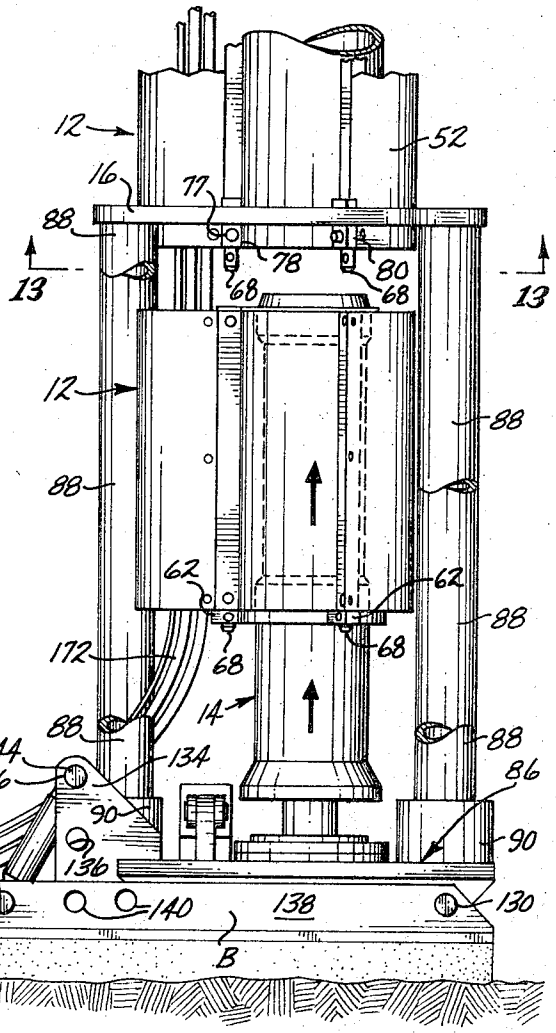


Fig. 14

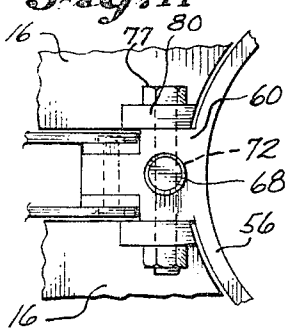


Fig. 12

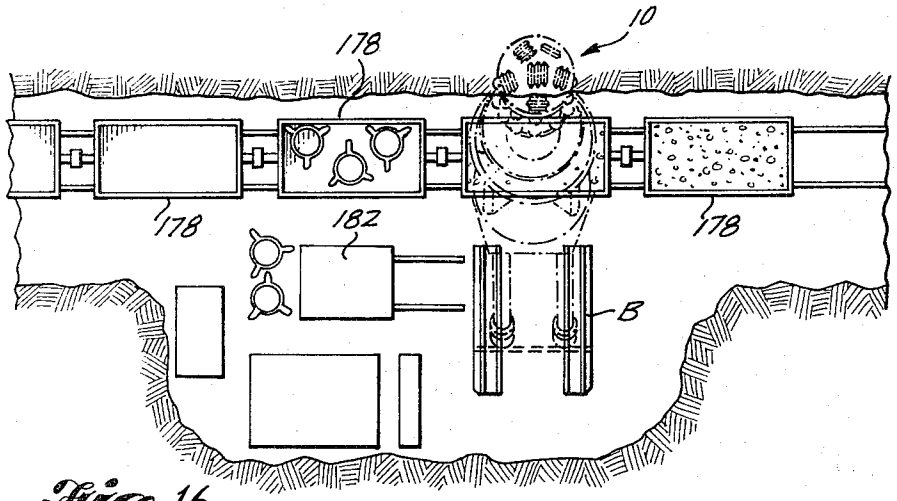


Fig. 16

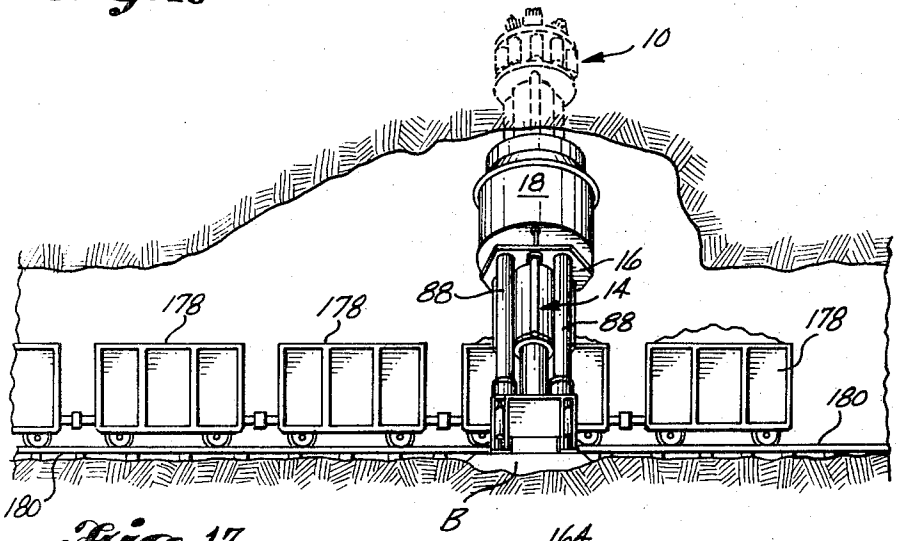


Fig. 17

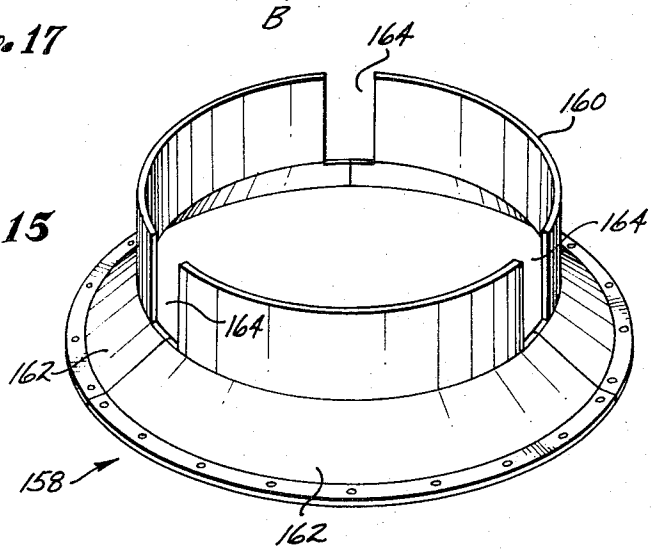


Fig. 15

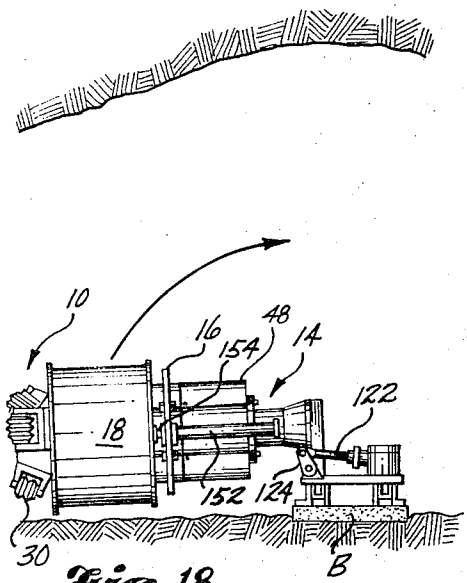


Fig. 18

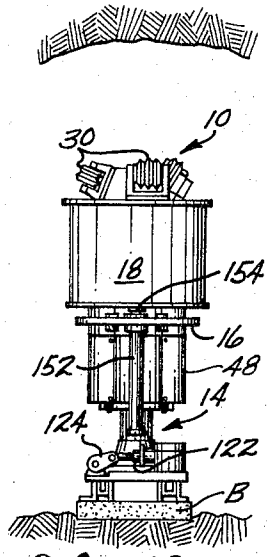


Fig. 19

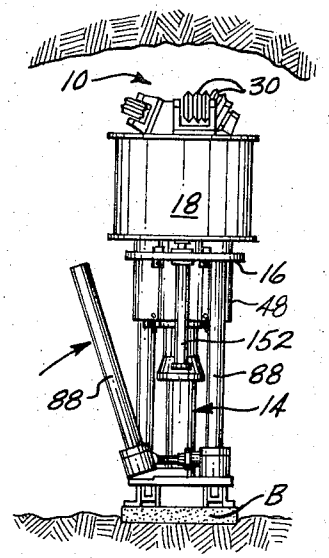


Fig. 20

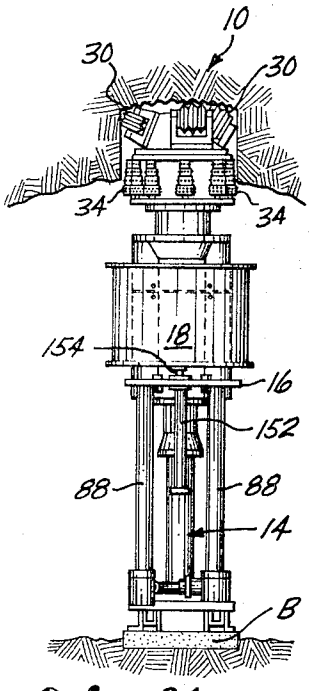


Fig. 21

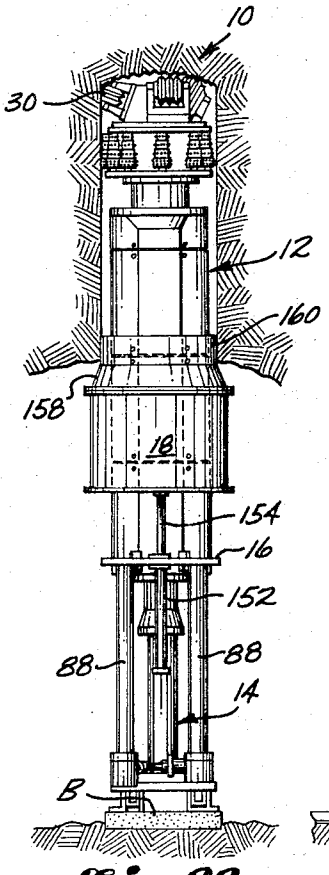


Fig. 22

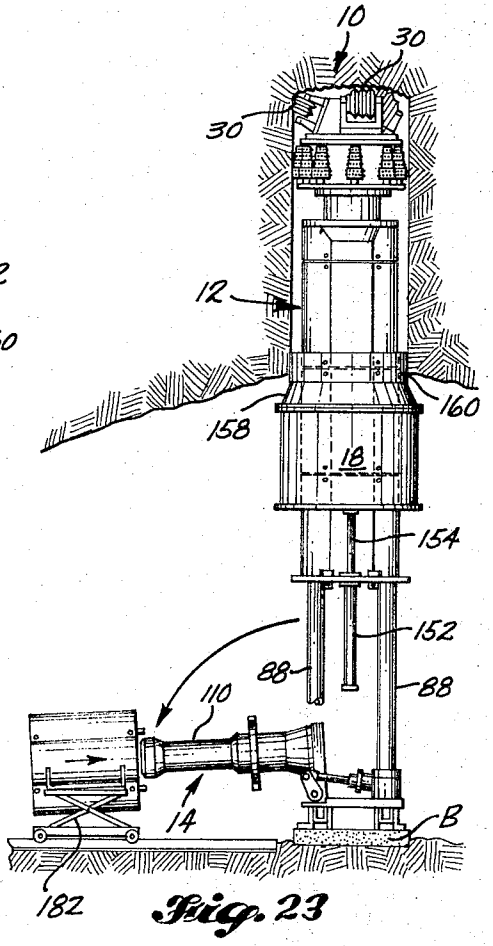


Fig. 23

UPWARD TUNNELING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method and mechanism for mechanically excavating a tunnel upwardly from an underground location.

2. Description of the Prior Art

It is old to mechanically bore a relatively large diameter hole or tunnel upwardly through an earth formation from an underground location. Rotary drilling machines for doing this are disclosed by Stoces, Bohuslav, D.Sc., Introduction to Mining, Vol. II, page 191, London: Lange, Maxwell & Springer Ltd.; and by U.S. Pat. Nos. 2,979,320 and 3,114,425. A disadvantage of these machines is that they all utilize a rotating drill stem which by necessity includes stabilizer sections of substantial size. To add a stabilizer section it is necessary to disassemble the mechanism used for collecting rock chips in order to make room for the stabilizer section. During these periods the workmen handling the drill stem sections are exposed to the hazards of an open raise. Also, the stabilizers drag against the bore wall as they rotate, increasing the torque requirements of the rotary drive mechanism. Further, it is never possible to bore a perfectly straight hole. The drill stem is always slightly curved despite the presence of stabilizers. As a result, the drill stem wobbles during rotation and the drill stem material is alternately subjected to tension and compression forces severely fatiguing such materials. Also, in such machines the mechanism for rotating the drill pipe must be advanced and retracted axially of tunnel. The apparatus required for doing this adds size to the underground machine.

Another type of machine for boring upwardly from an underground location is shown by U.S. Pat. No. 2,864,600. Such machine is supported by "gripper" mechanisms which make tight engagement with the tunnel wall rather than by drill pipe. A disadvantage of this type of system is that the gripper mechanisms require ideal ground conditions to be dependable and ideal ground conditions are not always present. U.S. Pat. No. 3,354,969 discloses a similar machine which includes an in hole power tunneler which is driven forwardly by powered drive wheels. This type of machine also requires ideal ground conditions.

U.S. Pat. No. 3,604,754 discloses an overhead boring machine of a type which utilizes both a gripper mechanism for engaging the bore wall and a sectional support column which is erected in the hole below the boring machine. In the system of this patent, the mined material or cuttings are delivered into the hollow interior of the support column. As a result, the machine at the underground site is quite complex because it requires a means for handling the column sections and advancing the column upwardly which must be constructed and positioned to not interfere with the discharge of the mined material out from the support pipe.

SUMMARY OF THE INVENTION

Basically, the overhead tunneling apparatus of this invention comprises a power tunneler which is supported from below by a sectional support column. The sectional support column comprises a tubular center portion and a plurality of radially extending stabilizer fins which brace the support column against bending. The tunneler delivers the mined material into the space between a pair of such stabilizer fins through which space the material falls to a hopper mechanism below. The tunneler and the support column are advanced upwardly by a central thrust ram which also doubles as a support column loader. The support column is moved upwardly through a sealed opening in the bottom of the hopper and the column sections are added to and removed from the column in the space below such hopper. The support column does not rotate so it is not subjected to severe fatigue forces. The bringing of the mined material down the hole between a pair of stabilizer fins makes the use of a central thrust ram possible. The use of a central thrust ram results in a shorter machine at the underground machine site. Also, since the thrust ram is used as a support column loader, an independent column loader is unnecessary.

Additional features and advantages of the overhead tunneling equipment of this invention will be apparent from the following description of the illustrated embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational view of a portion of a preferred embodiment of the invention, shown in the process of being set up at an underground machine site;

FIG. **2** is a view like FIG. **3**, showing a later stage of set-up;

FIG. **3** is an elevational view looking towards the right side of the equipment as pictured in FIG. **2**;

FIG. **4** is an elevational view of a support column section, with lower foreground portions thereof cut away;

FIG. **5** is a top plan view of the support column section shown by FIG. **4**;

FIG. **6** is a fragmentary cross-sectional view taken through a stabilizer fin, substantially along line **6—6** of FIG. **5**;

FIG. **7** is a view taken from the same aspect as FIG. **3**, but showing the power tunneler being advanced upwardly into the overhead ground material and the mined material being loaded into a mine car;

FIG. **8** is a sectional view taken substantially along line **8—8** of FIG. **7**;

FIG. **9** is a sectional view taken substantially along line **9—9** of FIG. **7**;

FIG. **10** is a sectional view taken substantially along line **10—10** of FIG. **7**;

FIG. **11** is a view taken from the same aspect as FIGS. **1** and **2**, with some parts in sections;

FIG. **12** is a fragmentary elevational view of a lower portion of the mechanism, looking towards the right side of the equipment as viewed in FIG. **11**, with some parts cut away;

FIG. **13** is a cross-sectional view taken substantially along line **13—13** of FIG. **12**;

FIG. **14** is an enlarged fragmentary view of an anchor pin station at the holding table;

FIG. **15** is a pictorial view of the lead-in portion of the mined material receiving hopper;

FIG. **16** is a top plan view of a typical underground machine site;

FIG. **17** is an elevational view of the underground site shown by FIG. **16**; and

FIGS. **18–23** are a series of elevational views picturing the sequence of operation of the preferred embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Basically, the overhead tunnel excavating equipment of this invention comprises an in-hole power tunneler **10**; a sectional support column **12**; advancing mechanism including a thrust ram **14**, for forcing the sectional support column **12** upwardly to in that manner forcibly advance the power tunneler **10** into the overhead ground formation; a holding table **16** at the underground location above the thrust ram **14**; and mechanism for collecting the mined material or cuttings, including a hopper **18**.

Referring to FIG. **11** in particular, the power tunneler **10** may comprise a non-rotating frame **20** having a hollow interior and a tail section **22**. A drive motor **24** is shown housed within the hollow interior. As will hereinafter be described in greater detail, the tail section **22** has an external cross-sectional configuration which matches the external cross-sectional configuration of the support column sections. Also, tail section **22** is connectable to the uppermost section of the support column **12** in the same manner that adjacent sections are connected together.

A drum-like boring head **26** is mounted for rotation relative to frame **20** by means of a plurality of roller bearings **28**. Boring head **26** includes an upper portion which carries a plurality of roller-type rock cutters. In the preferred embodiment these cutters are in the nature of the disc cutters **30**. The boring head **26** also includes an outer cylindrical wall portion **32** which carries a plurality of stepped roller cutters **34** of the carbide button type, which cutters are arranged to engage the lateral surface of the tunnel or raise. The disc cutters **30** cut a plurality of concentric kerfs in the hard ground formation and fracture the material between the kerfs. The roller cutters **34** establish the gauge of the tunnel or raise, and also stabilize the tunneler **10** to prevent undesired wobbling or other lateral movement. Thus, the outermost circumferential surface **35** of the cutters may be made without the carbide buttons thereon to enhance this stabilizing function by the flat surfaces **35** engaging the raise wall.

Drive motor **24** includes an output gear **36** which meshes with and drives a plurality of planetary gears **38** which are carried by a rotary carrier **40**. The gears **38** also mesh with a stationary interior ring gear **42** located inside of a cylindrical housing **44**. Housing **44** is a non-rotating part of the frame **20**. The rotating carrier **40** is secured to an upper end wall portion **46** of the boring head **26**. The cylindrical wall **32** which carries the gauge cutters **34** depends from the end wall **46**. The roller bearings **28** are situated between walls **32** and **44**.

Referring now to FIGS. **4** and **5** in particular, the support column sections **48** are shown to each comprise a tubular central portion **50** and a plurality (e.g., three) of radial stabilizer fins **52**. When a column section **48** is in the tunnel T the outer radial boundaries of the fins **52** are contiguous the tunnel wall (FIG. **7**). Each column section **48** is of composite construction. The illustrated embodiment is composed of a length of cylindrical tubing **54** to which a pair of cast end members **56, 58** are welded. Each end member **56, 58** is formed to include a short radial projection or ear **60, 62** for each stabilizer fin **52**. A length of channel stock **64** extends axially along the cylindrical pipe section **54** between each related pair of ears **60, 62** and is rigidly affixed by welding to the pipe section **54**. The ears **60, 62** extend radially beyond the channel members **64** and it is to these extensions that the fins **54** are attached.

Axial sockets **66** are provided in the end members **58** in position to receive axial locator pins **68** which are carried by the tail section **22** of the boring head frame **20**, and by the lower end member **55** of each support column section **48**. As shown by FIGS. **5** and **4**, the radial projections **62** are formed to also include a connector pin opening **70** which extends laterally through its socket **66**. Each locator pin **68** includes a complementary connector pin opening **72** which becomes aligned with pin openings **70** when such locator pin **68** is in socket **66**. The pins and sockets **68, 66** serve to correctly orient the support column section **48** relative to each other or to the tail section **22** of the boring head frame **20** and to transmit torque. Connector pins **71** (FIG. **11**), are inserted through the aligned openings **70, 72** to connect adjacent column sections **48** together, or to connect the upper column section **48** to the tail section **22** of the tunneler **10**.

As will hereinafter be described in detail, the radial ears **60, 62** also include cross-openings **74, 76** which are provided for receiving anchor pins **77** (FIG. **14**), serving to connect the column sections **48** to the holding table **16**.

The holding table **16** includes an opening sized to closely surround the support column **12**. In other words, such opening includes a central circular portion which is only slightly larger in diameter than the central portion **50** of the column section **48** and three equally spaced apart radial cut-outs which are only slightly larger in size than the stabilizer fins **52**.

Referring to FIGS. **13** and **14**, the holding table **16** is provided with a pair of brace plates **78, 80** at the base portion of each cut-out in the table **16** for a related channel section **64**. During tunneling the torque transmitted back to the table **16** by the support column **12** is transferred from the channel sections **64** through the brace plates **78** and **80** to the table **16**. The cut-outs for the fins **52** are large enough radially outward from the brace block **78, 80** so that the weaker outer portions of the stabilizer fins **52** are not in loading bearing contact with the side boundaries of the cut-outs. The brace blocks **78, 80** are provided with aligned openings **82, 84** which are alignable with the holding pin openings **74** in the support column sections **48** and at the lower end of the tail section **22**. As shown by FIGS. **12** and **14**, anchor pins **77** may be inserted through the aligned pin openings **82, 74, 84** for the purpose of firmly anchoring the tail section **22** or a support column section **52** to the holding table **16**. This is something that is done while support column sections **52** are either being added to or removed from the support column **12**.

In the preferred embodiment the holding table **16** is shown to be supported above a lower frame assembly **86** by means of a plurality of frame columns or posts **88**. The lower frame assembly **86** may be provided with a mounting socket **90** for each column **88**. The frame member **86** may also include a top plate **92** which is provided with a pair of upwardly extending, selectively usable mounting lugs **94, 96**. According to the invention, a thrust ram base **98** is pivotally connected to either lug **94** or lug **96** by a pivot pin **100**. In the illustrated embodiment the pivot pin **100** is shown to extend through openings in the lug **94** and also through

openings in a pair of ears **102, 104** which are secured to the thrust ram base **98.**

The lower end of a piston **106** is firmly secured to the thrust ram base **98.** A piston head **108** is provided at the upper end of the piston **106.** A cylinder **110** is mounted on the **106** for movement up and down therealong. The piston **106** and the cylinder **110** together define a double acting linear hydraulic motor, comprising a variable volume fluid chamber **112** located above the piston head **108** and a variable volume fluid chamber **114** located below the piston head **108.** Chamber **114** is the annular space defined by and between the piston **106** and the side wall of the cylinder **110.** The piston **106** and cylinder **110** comprise the thrust ram **14.**

The hydraulic fluid may be introduced into and removed from the chambers **112, 114** in any number of ways. By way of typical and therefore non-limitive example, in FIG. **11** the fluid conduits **116, 118** are shown to be built into the piston **106.** As will be apparent, hydraulic fluid is delivered into chamber **112** and is removed from chamber **114** to drive the cylinder upwardly, i.e., to extend the thrust ram **14.** The direction of flow is reversed to retract the thrust ram **14.**

The cylinder **110** is provided with a radial support flange **120** unto which the lower end of a support column section **48** can rest. This flange **120** is provided with ears **62,** each ear **62** having an axial socket **66** to receive a related pin **68** from a column section **48** above, and a pin opening **70** by which a related pin **68** can be secured to the socket **66.** The portions of the cylinder **110** which are above the flange **120** and engage upper and lower sections **58** and **56** of the column sections **48** are sized to be snugly received within the interior of the tubular center portion **54** of a support column section **48.**

As will hereinafter be described in greater detail, the thrust ram **14** may be swung over about the axis of pin **100** into a substantially horizontal position. While the thrust ram **14** is in such position a support column section **48** is inserted onto the upper portion of the cylinder **110.** The thrust ram **14** is then swung back upwardly into a position placing the base **98** into contact with the top plate **92,** to align such support column section **48** with another section **48** of the support column **12** which is then pin connected to the holding table **16.**

The thrust ram base **98,** and hence the thrust ram **14** carried thereby, may be swung between horizontal and upstanding positions by means of a single double acting hydraulic linear motor **122** (FIGS. **1, 10, 18** and **23**). In FIGS. **1, 10, 18** and **23** a crank arm **124** is shown rigidly affixed to the pivot pin **100.** Pin **100** is in turn rigidly affixed to the ears **102, 104** and is loosely fitted within the opening in lug **94.** One end of the linear hydraulic motor **122** is pivotally attached to the crank arm **124** at a location **126** spaced a substantial distance from the pin **100.** The opposite end of the hydraulic linear motor **122** is pivotally attached to a lug **128** upstanding from the top plate **92.** The linear hydraulic motor **122** is extended to rotate the crank arm **124** in a direction causing movement of the thrust ram **14** from its upright position towards its horizontal position. A retraction of the hydraulic linear motor **122** causes a reverse rotation of the crank arm **124** and hence movement of the thrust ram **14** from its horizontal position towards its upright position.

The base assembly **86** may be pivotally connected to a base structure B, such as by means of pivot pins **130.** A pair of turnbuckles **132** may be interconnected between end portions of the base structure B and upstanding support plates **134** secured to the top plate **92.** This mechanism provides a way in which the main portion of the machine can be adjusted relative to the base structure B. A plurality of spaced apart openings **140** are provided in upstanding side wall portions **138** of the base structure B for receiving connector pins **142** used to connect the lower ends of the turnbuckles **132** to the base structure B. A plurality of similar openings **136** are provided in the upstanding plates **134** to receive similar pins **144** used for connecting the upper ends of the turnbuckles **132** to such plates **134.** As will be apparent, angular adjustment of the base member **86** and the drilling machine apparatus above it relative to the base structure B can be accomplished by both a change in length of the turnbuckles **132** and a change in the mounting holes **136, 140** for the turnbuckles **134.**

In the illustrated embodiment the angular adjustment of the base member **86** and the drilling machine apparatus above it relative to the base structure B occurs at a right angle to the direction of swinging movement of the thrust ram **14.**

The second lug **96** (FIG. **10**) is provided so that the direction of sideways swinging movement of the thrust ram **14** can be reversed. A simple way of changing the mounting of the thrust ram base **98** from lug **94** to lug **96** will now be described. The cylinder **110** is moved upwardly until the ears **62** of its thrust flange **120** can be connected to thrust column locator pins **68** with connector pins **71.** The thrust column **48** is in turn connected to holding table **16** by pins **77.** Next, the pin **100** and the motor **122** are removed and the piston **106** is retracted upwardly into the cylinder **110.** When the ears **102, 104** and the base member **98** are above the lug **94,** the piston **106** is easily rotated about its axis relative to the cylinder **110** until the ears **102, 104** are above lug **96.** Then, the piston **106** is extended until the pin openings in the lugs **102, 104** are aligned with the pin opening in the lug **96.** Then, the cross-pin **100** is installed to pivotally connect the lugs **102, 104** to the lug **96** and the motor **122** is remounted at its new location.

As perhaps best shown by FIG. **11,** the receptacle or hopper **18** for collecting the mined material or cuttings is shown to include outer and inner bottom walls **146, 148** formed to include an opening through which the tail section **22** and the sectional support column pipe **12** may pass. FIG. **9** is a sectional view taken through the hopper **18** and looking downwardly towards the inner bottom wall **148.** The outer bottom wall **146** and the inner bottom wall **148** include openings which are similar in cross-sectional configuration to the tail section **22** and the support column sections **48.** A laminated seal **150** is held between the two bottom walls **146, 148.** As best shown by FIG. **9,** this seal material **150** makes tight contact with the tail section **22** and the support column sections **48** as they move relatively through the hopper **18.**

The hopper **18** is preferrably movable axially of the tunnel relative to the holding table **16.** This movement may be accomplished by linear hydraulic motors interconnected between the table **16** and the hopper **18.** In the illustrated embodiment the cylinder portions **152** of a pair of such linear hydraulic motors are attached to

the holding table **16** on opposite sides of the machine. The piston rods **154** project outwardly from the cylinders **152** and at their outer ends are connected to the base of the hopper **18.** Extension of these rods **154** causes the hopper **18** to move upwardly relative to the table **16.** Retraction of these rods **154** causes movement of the hopper **18** towards the table **16.**

As best shown by FIGS. **7** and **9,** the hopper **18** is equipped with a discharge chute **156** which depends downwardly from a lower side portion of the hopper **18.**

A preferred mode of operation of the illustrated embodiment will now be described:

Firstly, the tunnel is enlarged at the underground machine site in order to provide sufficient room for the machine, the various accessory equipment and the workmen. The base structure B is then put in place. It may comprise a concrete pad to which one or more metal base members are attached or it may be formed by metal base members attached directly to the floor of the tunnel. The base structure B may be surveyed in place so that when the machine proper is attached to it such machine will be properly placed relative to the drill line.

Referring to FIGS. **1** and **18,** the machine may be brought to the underground site with its frame columns **88** removed. The tunneler **10** is secured to one column section **48,** which is in turn secured to the cylinder **110** of the ram **14.** For convenience of illustration this first column section **48** is shown in broken lines in FIGS. **1, 2, 3, 18, 19** and **20.** The machine may be supported on its side until the lower frame assembly **86** is attached to the base structure B and the hydraulic motor assembly **122, 124, 126** is installed. Then, the linear motor **122** may be used for raising the thrust ram **14** and the machine parts connected thereto into an upright position (FIGS. **3** and **19**). At this time the power tunneler **10** and the thrust ram **14** are in fixed position relative to the holding table **16** and the hopper **18.** Next, the thrust ram **14** is extended a sufficient amount to permit installation of the columns **88** and such columns **88** are installed (FIG. **20**).

The thrust ram **14** is extended, with support column sections **48** being added as needed, until the disc cutters **30** on the boring head **26** of the power tunneler **10** are in contact with the tunnel roof overhead. The drive motor **24** is then operated to rotate the boring head **26** while the power tunneler **10** is advanced upwardly by the thrust ram **14.** Each time the lower end of a support column section **48** reaches the brace plates **78, 80** on the holding table **16,** thrusting is temporarily stopped, pins **77** are inserted to secure such column section **48** to the work table **16,** and the thrust ram cylinder **110** is retracted. Then the motor **122** is operated to swing the thrust ram **14** over on its side to receive another support column section **48** (FIG. **23**).

After the overhead tunnel or raise has been excavated a sufficient amount to locate the power tunneler **10** therein, an upper section **158** is installed onto the hopper **18.** This upper section **158** may be constructed in three parts **162** which may be bolted or otherwise firmly secured to the upper end of the hopper **18.** Axial cut-outs **164** are provided between upstanding neck sections **160** of the parts **162.** Following installation of the upper section **158** the entire hopper assembly is moved upwardly relative to the holding table **16** to place the neck members **160** snugly into the overhead raise or tunnel (FIG. **22**). This raising of the hopper assembly **18, 158** is accomplished by extension of the hydraulic motors **152, 154.** The cut-outs **164** are provided to provide clearance for the stabilizer fins **52** which, like the outer surface of the neck parts **160,** are contiguous the wall of the overhead raise or tunnel. This upper section **158** effectively seals the lower end of the tunnel about the upper end of the hopper assembly **18, 158.**

During the tunneling operation the rock chips or cuttings (i.e., the mined materials) are moved by the rotating boring head **26** towards the lower side of the tunnel and into the passageway **176,** which is defined two fins **52** and the adjacent portion of the tunnel wall. Such mined material falls by gravity through this passageway **176** into the hopper **18** and from the hopper **18** through the discharge chute **156** into a mining car **178** positioned below. The mining car **178** is supported on rails **180** in conventional fashion.

As mentioned above, the tight fit of the neck portion **160** of the hopper's upper section **158** with the lower end of the tunnel wall results in all of the mined material being directed into the hopper **18.** A cover plate **174** perpendicular to the tunnel axis and connected to the tail section **22** of the tunneler **10** provides an upper barrier which serves to direct the mined material into the chute **176.**

Owing to the side placement of the discharge chute **176** a central thrust ram **14** may be used. The positioning of the discharge chute **176** also makes it possible to swing the thrust ram **14** so that it can double as a column section loader, making a separate loader unnecessary. Since the mined material is not dropped downwardly through the center of the support column it is not necessary to provide a way of removing the mined material from the support column at its lower end or to co-ordinate such means with the advance mechanism for the support column so that neither one of these mechanisms interferes with the other. It is believed that the side discharge of the mined material and the central thrust ram arrangement results in a size (and particularly a height) saving in the machine.

Another advantage of the overhead raise excavating machine of this invention is that the hollow center of the support column **12** can be used as a survey avenue during times when the thrust ram **14** is swung over on its side.

According to the invention, one of the outer portions **166** of a stabilizer fin **52** is removable so that the power lines **172** leading to the drive motor **24** may be housed within the passageway formed through an axial series of such housings **166** (FIG. **7**). Each support column section **48** may be installed on the thrust ram **14** with its housing **166** removed so that the motor lines **172** can be properly placed relative to such section **48.** Then, the housing **166** is installed while the pipe section **48** is in the position shown by FIG. **11,** before such support column section **48** is moved upwardly. In the illustrated embodiment there are three motor lines **172.** One is a supply line to the hydraulic motor **24,** a second is a return line from such motor **24,** and the third is a drain line which carries away hydraulic oil which is permitted to leak upwardly from the motor **24** into the region of the gearing **36, 38, 40, 42** and the bearings **28.** Of course, in some other installation utilizing a different type of motor or dirve assembly the motor line requirements may be different.

Referring to FIGS. 5 and 6, a plurality of flanges **168** may be provided on the inner walls of each housing **166** to receive an elastomeric "rub" member **170.** These "rub" members are provided as a means against which the motor lines **172** may contact or rub during their ascent and descent. As will be appreciated, this arrangement prevents such lines **172** from rubbing against sharp edges and metal parts which could in time damage them through chafing.

What is claimed is:

1. Mechanism for tunneling upwardly from an underground location, comprising:

a power tunneler; and

means for advancing said power tunneler upwardly into the ground, said means comprising a sectional support column below said power tunneler having at least one longitudinal external rib thereon, thrust ram means positionable at the underground location for forcing said sectional support column upwardly to in that manner forcibly advance the power tunneler upwardly, a holding table positionable at the underground location above said thrust ram means, said holding table including means for restraining said sectional support column against rotation during such advancement of said sectional support column and said power tunneler, said means including a fixed guide through which said external rib moves during advancement of said sectional support column, and means for securing said sectional support column to said holding table while a section is being added or removed from it.

2. Tunneling mechanism according to claim **1,** wherein said support column comprises a tubular central portion which is substantially smaller in cross-section than the tunnel, so that a substantial space exists between said tubular portion and the tunnel wall, and a plurality of stabilizer fins spaced about and radiating outwardly from said tubular central portion, and wherein said power tunneler includes means for delivering the mined material into a space defined angularly between an adjacent pair of said stabilizer fins and radially between said central portion and the tunnel wall.

3. Tunneling mechanism according to claim **1,** wherein a radial space exists between said sectional support column and the tunnel wall and said power tunneler includes means for delivering mined material into said space for travel downwardly therethrough to the underground location.

4. Tunneling mechanism according to claim **1,** comprising:

lower frame means below said thrust ram means, and means pivotally connecting the lower end of the thrust ram means to such lower frame means, for pivotal movement between a first position generally in line with the sectional support column and a second position generally over on its side, so that the thrust ram means can be swung downwardly out of line with the sectional support column into said section position to receive a section of the column thereon and then be swung upwardly back into line with the sectional support column.

5. Mechanism for tunneling upwardly from an underground location, comprising:

a power tunneler; and

means for advancing said power tunneler upwardly into the ground, said means comprising a sectional support column below said power tunneler thrust ram means positionable at the underground location for forcing said sectional support column upwardly to in that manner forcibly advance the power tunneler upwardly, a holding table positionable at the underground location above said thrust ram means, said holding table including means for restraining said sectional support column against rotation during such advancement of said sectional support column and said power tunneler, and means for securing said sectional support column to said holding table while a section is being added to or removed from it, wherein a radial space exists between said sectional support column and the tunnel wall and said power tunneler includes means for delivering mined material into said space for travel downwardly therethrough to the underground location, said mechanism further comprising hopper means above the support table for receiving the mined material, said hopper means including a discharge chute through which the collected mined material can be discharged into a transporter.

6. Tunneling mechanism according to claim **5,** wherein said hopper includes an upper portion sized to snugly fit within the tunnel so that substantially all of the mined material will have to fall into the hopper.

7. Tunneling mechanism according to claim **6,** further including means for moving the hopper upwardly relatively to the support table.

8. Tunneling mechanism according to claim **5,** wherein said hopper includes a bottom wall having an opening therein through which the sectional support column extends during advancement of the power tunneler, and seal means for sealing between said bottom wall and the sectional support column.

9. A section of a sectional support column used for supporting and applying an upward thrust to an upwardly advancing power tunneler, said section comprising:

a tubular body which is substantially smaller in cross-section than the tunnel in which it is to be used, and a plurality of stabilizer fins radiating outwardly from said body substantially to the diameter of the tunnel in which the section is employed, with at least one of said fins making a strong, rigid connection to said body throughout the full length of said body, so that at such location of connection it can support bracing against rotation, and connector means at each end of said section for use in connecting it to an end of a similar section of the sectional support column.

10. A support column section according to claim **9,** wherein at least one of said fins is hollow and is defined by a housing which is removably secured to said tubular body, so that such housing can be placed about control line means and then be secured to said tubular body.

11. A sectional support column section according to claim **9,** wherein the connector means at one end of the section comprises:

a plurality of axial sockets in said tubular body and the connector means at the opposite end of the section comprises a plurality of complementary locator pins for insertion into the sockets of a second section, and wherein the wall means defining such

sockets includes a transverse passageway, and the locator pins also include transverse passageways alignable with the transverse passageways in the walls of its socket, so that a transverse locking pin can be inserted through such aligned passageways for locking adjacent support column sections together.

12. For use in a mechanism for tunneling upwardly from an underground location in which the tunneling is done by successively constructing a sectional support column below a power tunneler and by thrusting said support column upwardly, to in that manner forcibly advance the power tunneler, while restraining said support column against rotation;

a thrust ram means for forcing said sectional support column upwardly, said thrust ram means comprising a linear piston-cylinder hydraulic motor having a first end with means for end-wise engaging a section of the support column and a second end which is pivotally securable to a frame situated at the underground location below said sectional support column, for pivotal movement of the hydraulic motor between a thrusting position in which it is coaxial with the support column and a side position for pickup of a column section.

13. For use in a mechanism for tunneling upwardly from an underground location in which the tunneling is done by successively constructing a sectional support column below a power tunneler and by thrusting said support column upwardly, to in that manner forcibly advance the power tunneler, while restraining said support column against rotation;

a thrust ram means for forcing said sectional support column upwardly, said thrust ram means comprising a linear piston-cylinder hydraulic motor having a first end with means for end-wise engaging a section of the support column and a second end which is securable to a frame situated at the underground location below said sectional support column; and

support shoulder means at said first end for receiving a lower end portion of a support column section, and pin means at said first end insertable into the interior of said support column section.

14. For use in a mechanism for tunneling upwardly from an underground location in which the tunneling is done by successively constructing a sectional support column below a power tunneler and by thrusting said support column upwardly, to in that manner forcibly advance the power tunneler, while restraining said support column against rotation:

a thrust ram means for forcing said sectional support column upwardly, said thrust ram means comprising a first end adapted for engaging a section of the support column and a second end which is securable to a frame situated at the underground location below said support column, said first end including support shoulder means for receiving a lower end portion of the support column section, and means insertable into the interior of said support column section; and

means for pivotally connecting the second end of said thrust ram means to a frame member situated at the underground location, so that the thrust ram means when retracted, can be swung sideways out of line with the support column and into a position to receive a new section of the support column, so that the new section can be secured to the support column and the thrust ram means can again be used for advancing the support column and the power tunneler supported thereby.

15. A power tunneler which during use is progressively moved upwardly from an underground location by a sectional support column which is itself moved endwise upwardly by thrust ram means, said power tunneler comprising:

a non-rotating body portion securable to the support column, a rotary cutter carrier mounted on said body portion, cutters on said carrier, motor means mounted on said body portion, means drivenly connecting said motor means to said cutter carrier, and a tail section adapted for connection to the upper section of the sectional support column, said tail section comprising a tubular central portion which is substantially smaller in cross-section than the bore formed by the cutters, so that a substantial space will exist between said tubular portion and the bore wall, and a plurality of fins radiating outwardly from said tubular central portion, said power tunneler including means for directing the mined material into a space that is defined angularly between an adjacent pair of said fins and radially between said central portion and the tunnel wall.

16. A power tunneler which during use is progressively moved upwardly from an underground location by a sectional support column which is itself moved endwise upwardly by thrust ram means, said power tunneler comprising:

a non-rotating body securable to the support column, motor means mounted within said body, a rotary cutter carrier mounted on said body said cutter carrier comprising an end portion which is positioned endwise of said body and a side portion which extends about said body, cutters on said carrier including face cutters on said end portion and gage cutters on said side portion, means drivenly connecting said motor means to said cutter carrier, and a tail section extending rearwardly from said body which is adapted for connection to the upper section of the sectional support column.

17. A power tunneler according to claim **16,** wherein said tail section includes a tubular central portion which is substantially smaller in cross-section than the bore formed by the cutters, so that a substantial space will exist between said tubular portion and the bore wall, and at least one fin which extends radially outwardly from said tubular central portion, and power supply lines for said motor extending from the motor through an opening in said tubular portion and into said fin.

18. A power tunneler according to claim **16,** wherein said tail section includes means strong enough to withstand bracing imposed thereon for preventing rotation of said tail section and said body portion.

19. A power tunneler according to claim **16,** wherein said tail section includes means for receiving a transverse pin which is used for affixing the tunneler in position relative to a fixed support table.

20. Mechanism according to claim **16,** wherein said cutter carrier comprises an upper end portion which is positioned endwise of said body and a side portion which extends about said body, and wherein the cutters

on said carrier include face cutters on said end portion and gage cutters on said side portion.

21. A power tunneler which during use is progressively moved upwardly from an underground location by a sectional support column which is itself moved endwise upwardly by thrust ram means, said power tunneler comprising:

a non-rotating body, motor means mounted on said body, a rotary cutter carrier mounted on said body, cutters on said carrier, means drivenly connecting said motor means to said carrier, and a tail section on said body including means for detachably connecting it to the upper section of the sectional support column, said tail section generally corresponding in cross sectional shape to the sectional support column with which it is used; and

hopper means for receiving the mined material, said hopper means including sidewall means and a bottom together defining an interior space which is large enough to receive a substantial portion of the tunneler, said bottom having an opening therein sized to receive the tail section of the tunneler, and seal means for sealing between said bottom and the tail section, said seal means accommodating axial movement of the tunneler relative to the hopper.

22. In mechanism for boring upwardly from an underground location, by use of a rotary cutterhead that is forced upwardly by means including a sectional support column which is moved axially upwardly as sections are added to it, said sections including longitudinal external ribs, wherein the mined material is dropped downwardly through a space between the support column and the bore wall, a material gathering hopper positionable at the underground location, comprising:

a bottom;

side wall means connected to the bottom and extending upwardly therefrom, to with the bottom form a receiving chamber for the mined material;

a support column passageway in said bottom, corresponding in cross-sectional shape to the sectional support column, through which said support column moves during boring; and

a discharge passageway from said hopper spaced laterally outwardly from said support column passageway.

23. Mechanism according to claim 22, including a holding table that is positionable at the underground location below the bottom of the hopper, said holding table comprising:

means defining an opening through which said support column moves as it is advanced upwardly, including a guide avenue for the longitudinal external ribs;

means adjacent said guide avenue for contacting said ribs during boring and restraining said support column against rotation; and

means for securing said sectional support column to said holding table while a section is being added to or removed from it.

24. Mechanism according to claim 23, comprising hydraulic cylinder means interconnected between the hopper and the support table, for adjusting the hopper in position relative to the support table and the entrance to the borer.

25. Mechanism according to claim 22, wherein the bottom of the hopper includes seal means surrounding the support column passageway, for sealing against substantial leakage of material from the hopper through such passageway.

* * * * *