# United States Patent [19]

**Winberg**

[11] **3,776,595**

[45] **Dec. 4, 1973**


[54] **TUNNELING MACHINE HAVING ACCESS PASSAGEWAY AND INVERT CLEANER**


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[73] Assignee: **Subsurface Machine and Manufacturing Inc.,** Durango, Colo.



[22] Filed: **Mar. 14, 1972**

[21] Appl. No.: **234,509**

[52] **U.S. Cl.** ..... **299/31,** 299/56, 299/90

[51] **Int. Cl.** ..... **E01g 3/04**

[58] **Field of Search** ..... 299/31, 33, 56–61, 299/90



[56] **References Cited**

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3,598,445 8/1971 Winberg ..... 299/31

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*Primary Examiner*—Ernest R. Purser

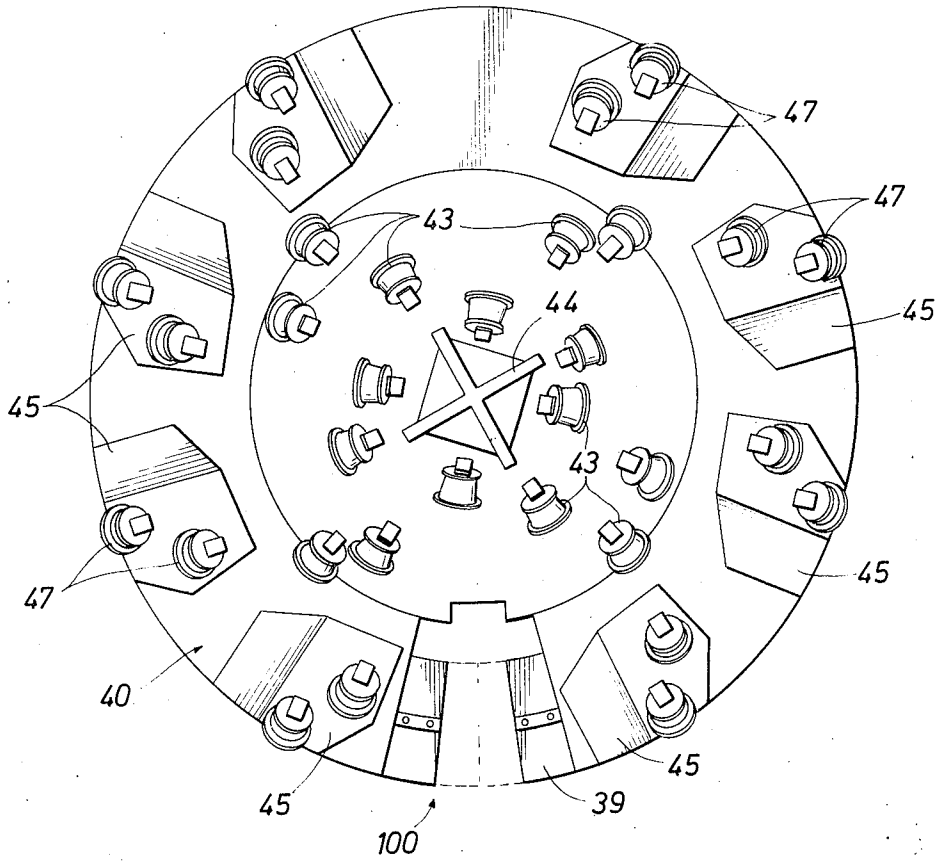
*Attorney*—Ralph R. Browning



[57] **ABSTRACT**

A machine for boring a tunnel in a subterranean formation may comprise: a main beam; a cutterhead support assembly attached to the main beam; a cutterhead assembly mounted for rotation on the cutterhead support assembly; and means connected to the main beam for advancing the cutterhead and cutterhead support assemblies to cut a tunnel through the formation. The cutterhead support assembly may include a blade assembly projecting radially toward the walls of the tunnel for cleaning the invert of the tunnel as the cutterhead support assembly advances therethrough. The cutterhead support assembly may be provided with a passageway communicating with a passageway beneath the main beam to form a continuous human passageway along the invert of the tunnel, throughout the length of the tunneling machine, through which the face of the cutterhead assembly may be reached. The blade assembly may be mounted on the cutterhead support assembly for movement between first and second positions blocking and unblocking the human passageway, respectively.


**26 Claims, 13 Drawing Figures**



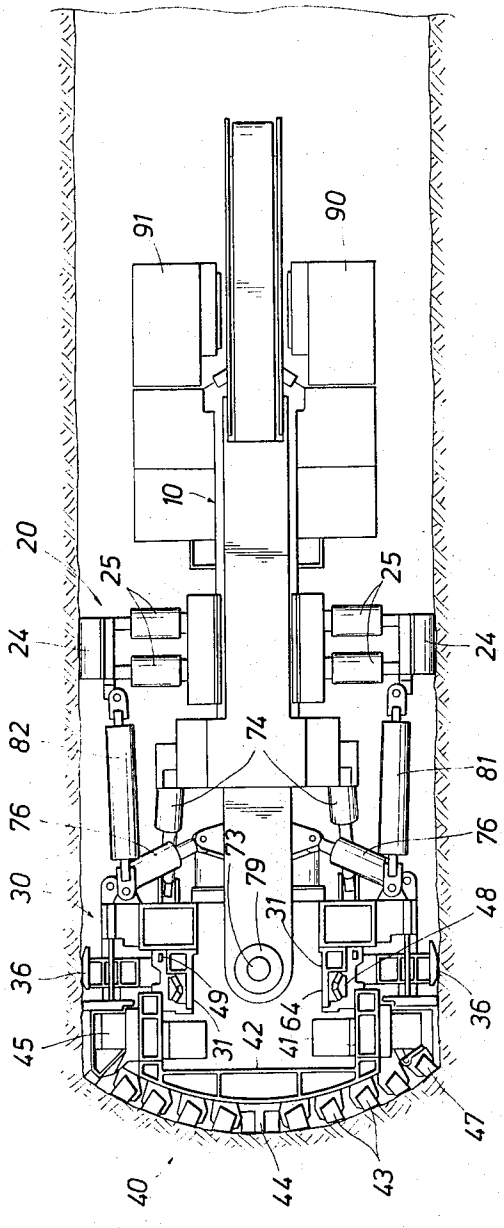

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FIG. 2

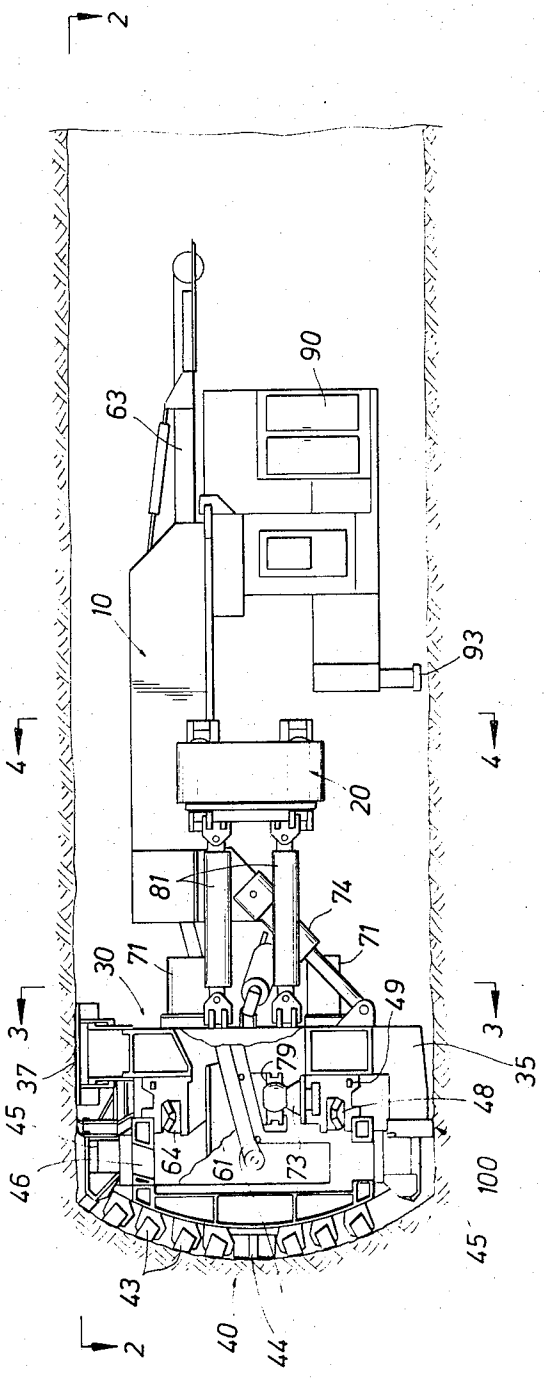

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FIG. 1

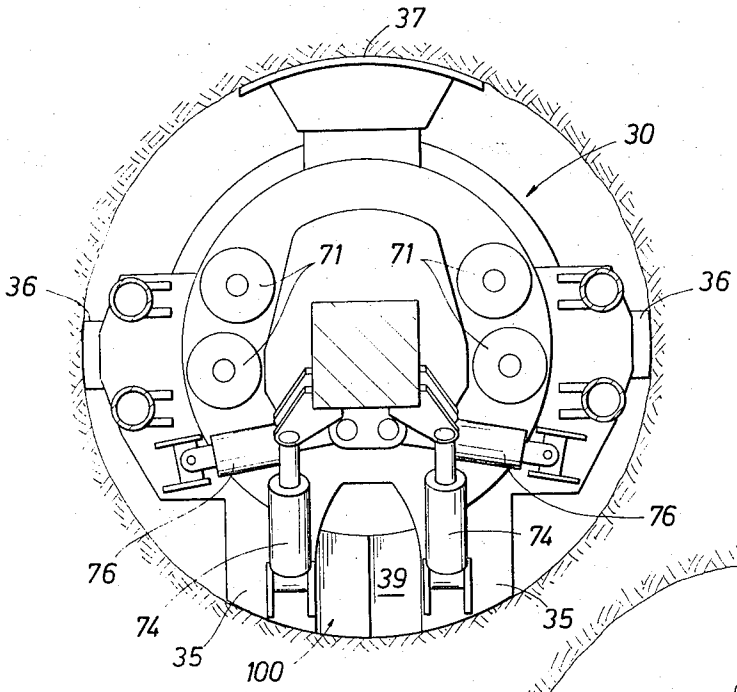



FIG. 3

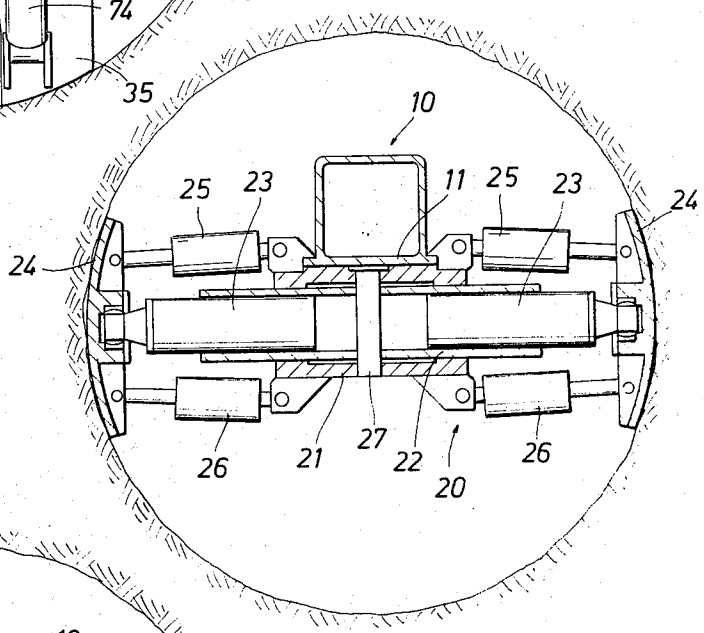



FIG. 4

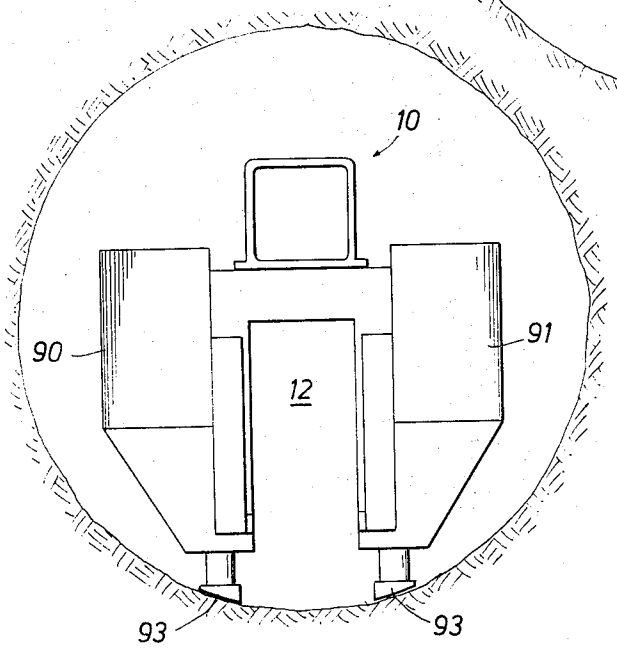



FIG. 5

FIG. 6

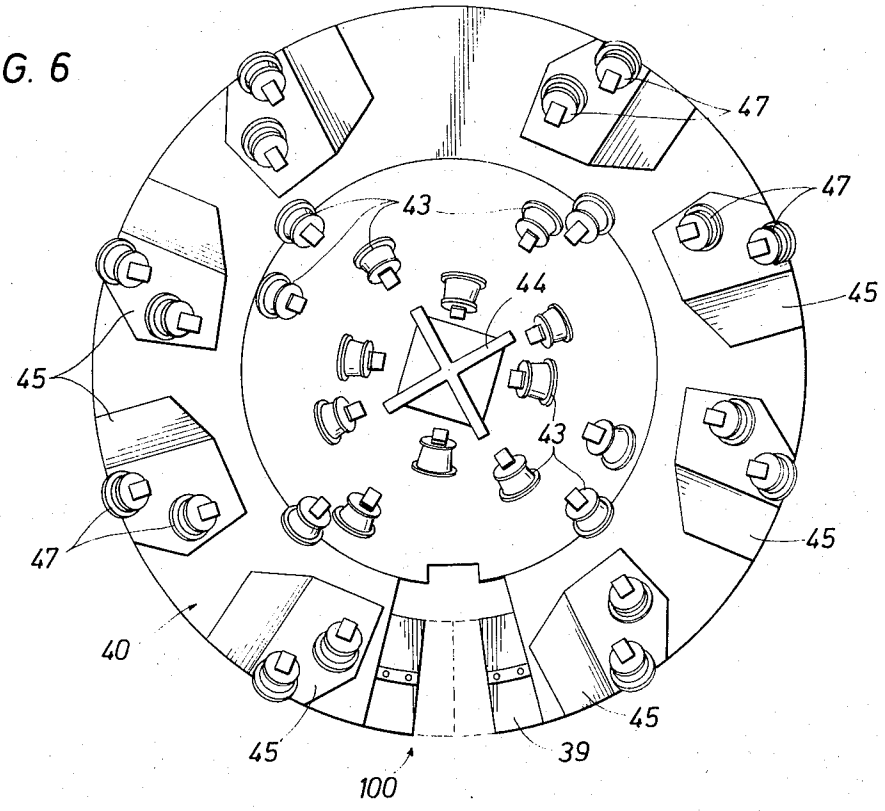

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FIG. 9

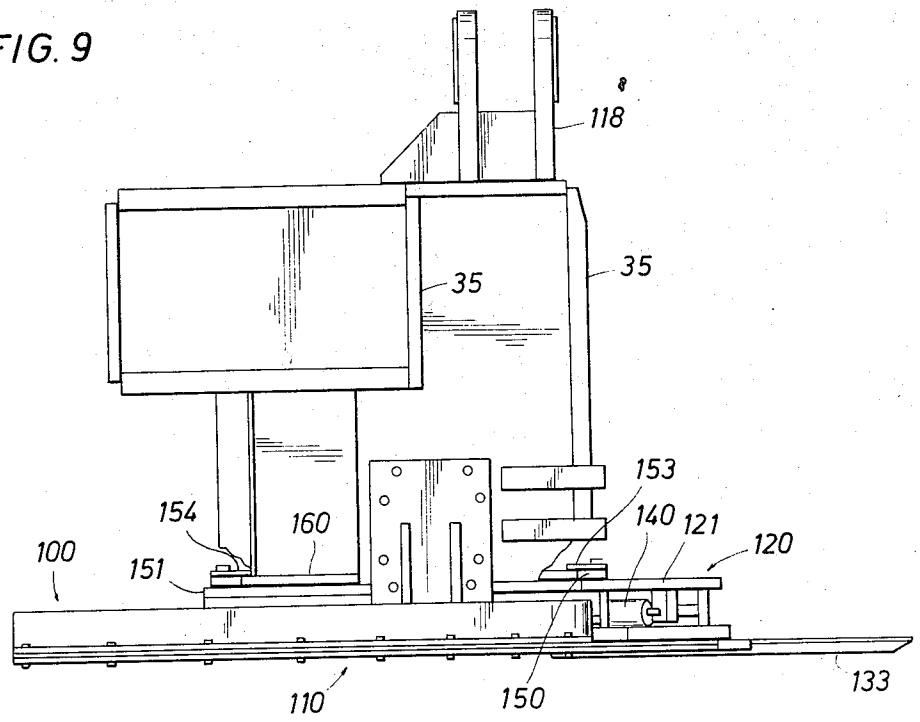

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FIG. 8

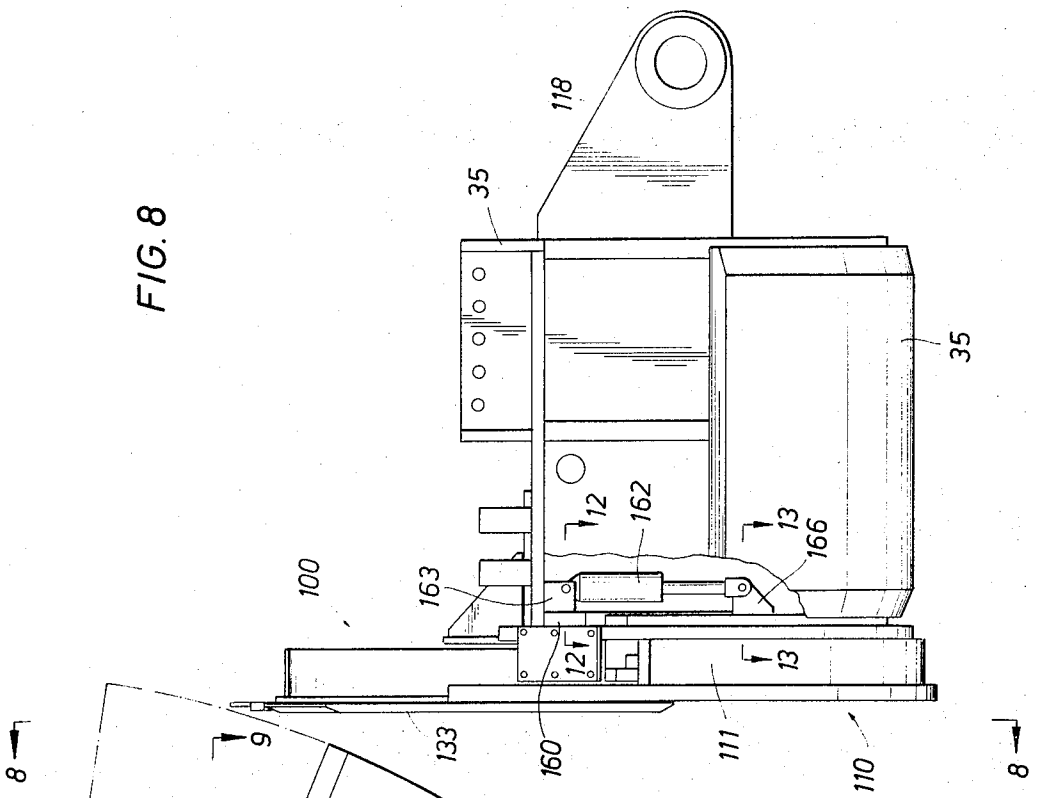

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FIG. 7

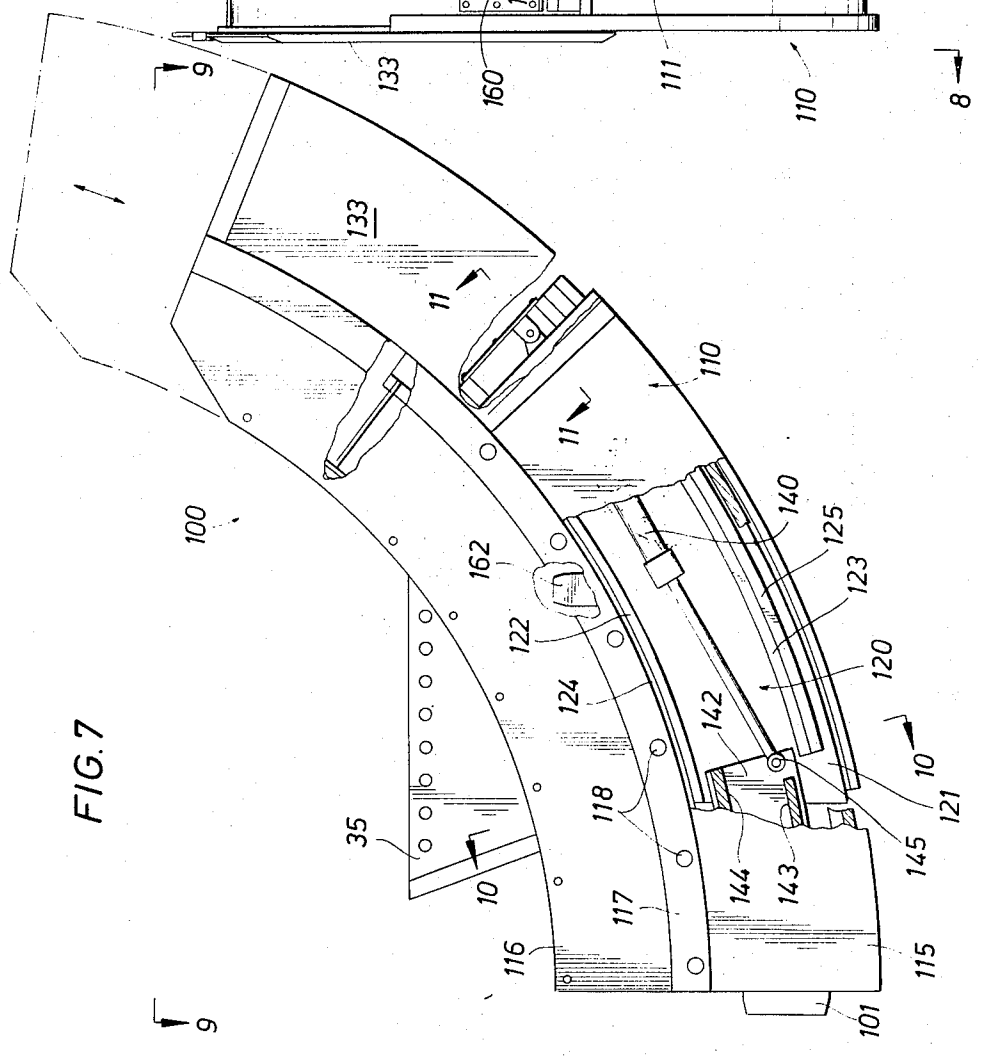
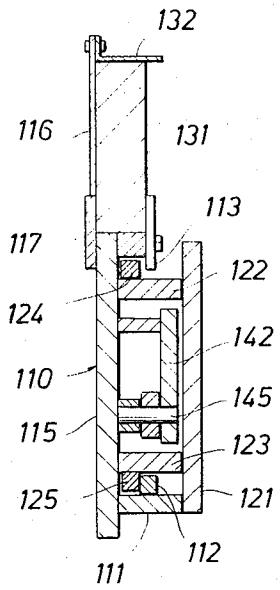

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FIG. 10



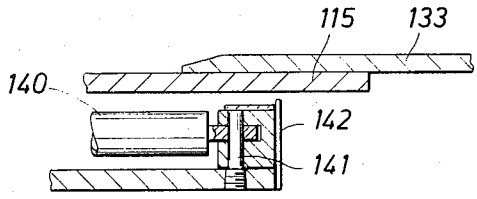




FIG. 11

FIG. 12

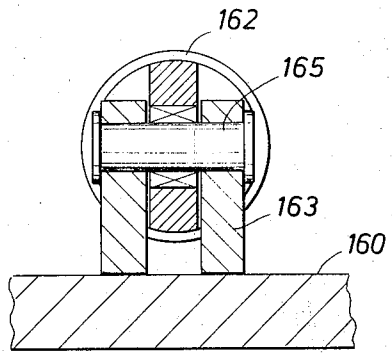
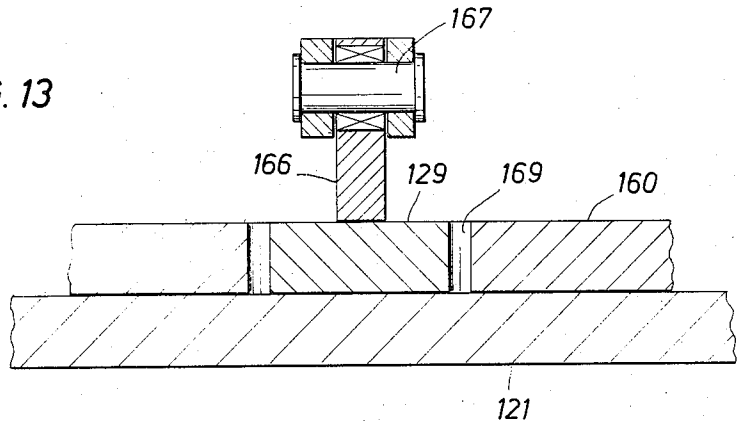



FIG. 13



# TUNNELING MACHINE HAVING ACCESS PASSAGEWAY AND INVERT CLEANER

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to machines for boring tunnels in subterranean formations. In particular, it concerns improvements in such tunneling machines which provide greater accessibility to the cutter face for cutter replacement and service.

2. Description of the Prior Art

Until recent years, underground excavation and tunneling have been done primarily by hand labor. Dynamite and various hand-operated tools have been developed over the years to make such hand labor more productive. Such conventional methods of tunneling still leave much to be desired.

In the past few years, mechanical boring equipment has been developed in both the mining and construction industries, having many advantages over conventional methods, e.g., more rapid advance, reduced labor, increased safety, faster muck removal, reduced overbrake and reduced roof and wall support. With mechanical boring, it is not unusual to double the rate of advance as compared with conventional methods. The speed of mechanical boring reduces the total manhours required to complete a project. Mechanical boring eliminates the use of explosives and the walls and backs of the tunnel remain virtually undisturbed requiring little or no support. If support is required, it may be installed while the machine is boring. In addition, mechanical boring permits use of a continuous, more efficient muck removal system.

Although several mechanical boring machines have been developed, one of the most efficient, maneuverable and flexible machines is the type invented by the present applicant, which is described in U.S. Pat. NO. 3,598,445 issued on Aug. 10, 1971. Such a machine comprises a rotary cutterhead, a cutterhead support, a main beam and a gripper. Cutters are mounted on the front of the cutterhead for fracturing the rock. The cutterhead support provides journal mounting for the cutterhead and is centrally connected to the forward end of the main beam by a ball and socket joint. Thus, angular movement between the cutterhead support and the main beam is permitted in all directions, namely, X–Y–Z axes. The main beam extends rearwardly from the cutterhead support and is connected by a slideway to the gripper. The gripper, which is a force reaction member of the machine, bridges across the tunnel providing a rear pivoting support for the main beam about the X and Y axes and rigidly fixes the location of the pivot axis in the approximate center of the tunnel. Through associated hydraulic cylinder assemblies and the slideway connected between the main beam and gripper, the main beam and cutterhead support and cutterhead itself may be advanced in a longitudinal direction to cut a tunnel through a subterranean formation.

The tunneling machine disclosed in the aforementioned U.S. Pat. No. 3,598,445 is unique in that a passageway is provided along the invert of the tunnel beneath the main beam permitting an operator or worker to walk on the floor of the tunnel from the rear of the machine to the back part of the cutterhead support.



## SUMMARY OF THE INVENTION

One object of the present invention is the development of a mechanical boring machine which has a passageway throughout the entire length of the machine along the tunnel invert through which the cutterhead face is accessible. Another object of the invention is to provide a means of selectively blocking and unblocking access to the cutterhead face. Still another object of the invention is to provide a means for cleaning the invert of the tunnel being bored as the machine advances therethrough.

In the present invention, a passageway is provided through the cutterhead support assembly providing access to the cutterhead face. This passageway is in communication with a passageway along the invert of the tunnel beneath the main beam of the machine so that a continuous passageway is formed throughout the length of the tunneling machine. A blade assembly, similar to a bulldozer blade, but of an arcuate configuration, is mounted on the cutterhead support assembly for movement between first and second positions in which the passageway through the cutterhead support is blocked and unblocked, respectively. The blade assembly may be mounted for arcuate movement, relative to a cross-section of the tunnel, between the blocking and unblocking positions.

In addition to serving as a closure for the passageway through the cutterhead support, the blade assembly cleans the invert of the tunnel as the cutterhead support assembly advances through the tunnel. The blade assembly may also be mounted for vertical or radial movement away from the floor of the tunnel, independently of the cutterhead support assembly, to permit riding over projections from the tunnel floor and adjustment of the blade for various conditions.

In addition to the objects and advantages of the invention specifically enumerated herein, other objects and advantages will be apparent upon reference to the accompanying drawings and the specification and claims which follow.

FIG. 1 is a side elevation view, partially in section, of a tunneling machine, constructed according to a preferred embodiment of the invention;

FIG. 2 is a longitudinal plan view of the tunneling machine shown in FIG. 1, showing the cutterhead and cutterhead support assembly in section to better illustrate the invention;

FIG. 3, taken along line 3—3 of FIG. 1, is a vertical lateral cross section view of the tunneling machine, looking toward the cutterhead support assembly;

FIG. 4, taken along line 4—4 of FIG. 1, is a lateral vertical cross section view of the tunneling machine, looking toward the cutterhead support assembly and illustrating the gripper assembly for providing reactions for the propelling mechanism and for supporting the aft end of the main beam;

FIG. 5 is a rear elevation view of the tunneling machine of FIG. 1 and 2;

FIG. 6 is a front elevational view of the tunneling machine showing the cutterhead face and illustrating the passageway through the cutterhead support assembly which provides access to the face;

FIG. 7 is a fragmentary front elevational view of the left-hand portion of the blade assembly and an associated support shoe for attachment to the cutterhead support assembly of the tunneling machine of FIGS.

1–6, according to a preferred embodiment of the invention;

FIG. 8 is a fragmentary side elevational view of the blade assembly and support shoe of FIG. 7;

FIG. 9 is a plan view of the blade assembly and support shoe of FIGS. 7 and 8;

FIG. 10, taken along line 10—10 of FIG. 7, is a cross-sectional view of the blade assembly, illustrating the relationship of the blade and carriage thereof;

FIG. 11, taken along line 11—11 of FIG. 7, is a cross-sectional view of a portion of the blade and carriage showing the connection of the hydraulic ram suitable for effecting arcuate movement of the blade relative to the carriage;

FIG. 12, taken along line 12—12 of FIG. 8, is a cross-sectional view showing the connection of the hydraulic ram to the cutterhead support assembly for effecting vertical movement of the entire blade assembly relative to the cutterhead assembly; and

FIG. 13, taken along line 13—13 of FIG. 8, is a cross-sectional view illustrating the lower connection of the vertical ram to the blade assembly carriage.

## DESCRIPTION OF A PREFERRED EMBODIMENT

Referring first to FIGS. 1–6, a general description will be given of a machine for boring tunnels in a subterranean formation. Such a machine preferably comprises four main assemblies: a main beam **10**, gripper assembly **20**, cutterhead support assembly **30** and cutterhead assembly **40**. The purpose of the rotating cutterhead assembly **40** is, of course, to bore through a subterranean formation to form a tunnel therein. The cutterhead support assembly **30** supports the cutterhead assembly **40** and provides the necessary components for imparting rotary motion thereto. The gripper assembly **20** provides reactions for propelling the cutterhead assembly and cutterhead support assembly **30** through the tunnel and restrains and controls the aft end of the main beam **10** relative to the tunnel. The main beam **10** ties the cutterhead support assembly **30** together with the gripper assembly **20** and provides support for various auxiliary equipment.

The cutterhead assembly may be constructed in any one of several ways. In the exemplary embodiment, the cutterhead assembly comprises a cylindrical support shell **41** at the forward end of which is a spherical segment support head **42**. Mounted on the support head **42** at predetermined radial locations is a plurality of cutters **43**. A central cutter assembly **44** may be mounted in the geometric center of the support head **42**. Mounted around the periphery of cylindrical support **41** is a plurality of buckets **45** the purpose of which is to scoop and carry rock and mud from the bottom of the tunnel bore to the top of the cutterhead assembly **40**. At the top of the cutterhead assembly the collected rock and muck drop through a hole **46**, in support shell **41**, and a hopper **61**, onto a conveyor **63** by which it is carried through the main beam **10** to the rear of the machine for removal from the tunnel. (See FIG. **1**). Other cutters **47** may be attached to the back of buckets **45** so as to provide continuous cutting throughout the entire radius of the cutterhead assembly **40**.

The cutterhead assembly **40** is mounted for rotation on the cutterhead support assembly **30**. This mounting is accomplished through a set of bearings **64** which are retained in an annular space between a rearward extension **48** of cutterhead assembly **40** and a forward extension **31** of cutterhead support assembly **30**. Also attached to the rearward extension **48** of the cutterhead assembly is a ring gear **49** which is engaged by pinion gears (not shown) connected through proper gear assemblies (not shown) to a source of driving power, such as D.C. electric motors **71**, carried by the cutterhead support assembly. (See FIGS. **1** and **3**). Although it is not required that D.C. electric motors be used, they do offer a great many operational advantages, such as infinitely variable control of cutterhead rotation speed. Thus, it can be seen that cutterhead assembly **40** rotates on and is driven by components supported by the cutterhead support assembly **30**.

The cutterhead support assembly **30** is supported on the forward end of main beam **10** by a ball-swivel arrangement which permits the cutterhead support assembly **30** to pivot both horizontally and vertically about the main beam **10** at the approximate geometric center of the tunnel. The ball **73** may be attached to the forward extension **31** of the cutterhead support assembly **30** while the cooperating socket or swivel **79** is carried by the forward end of main beam **10**. To position the cutterhead support assembly **30**, and consequently, cutterhead **40**, in a particular attitude, the machine may be provided with a pair of vertical hydraulic steering rams **74** and a pair of horizontal hydraulic steering rams **76**. The vertical steering rams **74**, as best seen in FIGS. **1** and **3**, are universally connected at one end to the main beam **10** and at the opposite end to corresponding lower steering shoes **35**. In like manner, the horizontal steering rams **76** are universally connected at one end to main beam **10** and at the opposite end to side steering shoes **36**. Very simply stated, the vertical steering rams **74** control vertical pivoting about ball member **73** while the horizontal steering rams **76** control horizontal pivoting. The ball-swivel arrangement in conjunction with the steering shoes **35, 36** and steering rams **74, 76** permit extremely accurate attitude control for steering the machine in the desired direction.

It should be mentioned at this time that the lower steering shoes **35** and side steering shoes **36** are structurally attached to the cutterhead support assembly **30**. An upper shoe **37** also helps centralize the cutterhead and support. The lower shoes **35** support most of the weight of the cutterhead support assembly **30** and cutterhead assembly **40** and may be compared with the struts of an airplane. These struts or shoes **35** are spaced apart to provide a passageway **39** therebetween. (See FIG. **3**). This passageway communicates with a passageway **12** (See FIG. **5**) beneath the main beam **10** to form a continuous passageway along the invert of the tunnel in which the machine is disposed. This is a very important feature of the invention and will be more fully discussed hereafter.

Also carried by the cutterhead support assembly **30** directly in front of lower shoes **35** is a blade assembly **100** which is also another very important feature of the invention. The blade assembly **100** will be described in detail hereafter. However, for the present it is sufficient to note that the blade assembly **100** projects radially toward the walls of the tunnel for cleaning the invert of the tunnel as the cutterhead support assembly advances therethrough. The radially moving buckets **45** pick up any muck collected in front of the blade assembly. In addition, the blade assembly **100** provides a means by which the passageway **39** may be blocked or unblocked. When the blade assembly **100** is in the un-

blocked position, access is provided through the passageway 39 to the face of the cutterhead assembly 40 for servicing or replacing the cutters 43, 47 and buckets 45.

To cut a tunnel through a subterranean formation, there must of course be a means of advancing the cutterhead support 30 and cutterhead assembly 40 through the formation. It is this function which is provided by the gripper assembly 20. As previously mentioned, the gripper assembly 20 is slide mounted to the main beam 10 in a spline-like connection between lower flange 11 and gripper carriage 21. (See FIG. 4). Thus, a fore-aft sliding relationship is established between the gripper assembly 20 and the main beam 10. Positioned within gripper carriage 21 for limited rotation about a vertical pin 27 is a tubular receiver 22. Telescopically received for sliding extensible and retracting movement within receiver 22 is a pair of gripper beams 23. Attached by a universal ball joint connection to the outer ends of each gripper beam 23 is a gripper shoe 24. The gripper shoes are rigid pads having outer faces which match the circular tunnel walls. Universally connected at one end to gripper carriage 21 and at the opposite end to gripper shoes 24, above beam 23, are four upper hydraulic rams 25. Universally connected at one end to gripper carriage 21 and at the opposite end to shoes 24, below gripper beams 23, are four lower hydraulic rams 26. By applying pressure to the hydraulic rams 25 and 26, the shoes 24 may be caused to firmly grip the walls of the tunnel or to be retracted therefrom. When the gripper shoes 24 are firmly gripping the tunnel walls they restrain the aft end of the main beam 10 relative to the tunnel.

Furthermore, the gripper assembly 20, when firmly gripping the tunnel walls, provides reactions for longitudinal forces necessary to advance the cutterhead 40 through the formation in which the tunnel is being bored. This forward motion is accomplished through two pairs of hydraulic propelling rams 81, 82 on opposite sides of the main beam 10. These propelling rams 81 and 82 are universally connected at one end to a corresponding gripper shoe 24 and at the opposite end to a portion of the cutterhead support assembly 30. With the gripper shoes 24 firmly gripping the side of the tunnel, the propelling rams 81 and 82 may be extended from an initial retracted position simultaneously with the rotation of cutterhead 40, causing the cutterhead support 30 and cutterhead 40 to be advanced through the formation. This is made possible by the sliding connection between the gripper assembly 20 and the main beam 10. When the propelling rams 81 and 82 are fully extended, the gripper shoes 24 may be retracted from the tunnel walls and the propelling rams 81 and 82 may be contracted causing the gripper assembly 20 to be advanced to a forward position, as in FIGS. 1 and 2, where shoes 24 are once again extended to firmly grip the tunnel walls for repeating the cycle.

In addition to providing a sliding connection for the gripper assembly 20 and support for the cutterhead, the main beam 10 serves additional purposes. It may support an operator's cab 90 from which the machine may be operated and controlled. The various hydraulic system components, electrical power and controls necessary for operation of the drive motors 71 and hydraulic rams 25, 26, 74, 76, 81 and 82 may also be carried in suitable compartments 91 along with the operator's cab. The operator's cab 90 and equipment compartments 91 are mounted so as not to interfere with the passageway 12 along the tunnel invert beneath main beam 10. Rear shoes 93 may be provided also to give support to the aft part of the machine when gripper assembly 20 is not gripping the tunnel walls.

In summary, the cutterhead assembly 40 of the tunneling machine is mounted on a cutterhead support assembly 30 at the forward end of a main beam 10. The ball-swivel connection to the main beam permits the cutterhead 40 to be positioned by steering rams and shoes at a desired attitude for advancing through a formation. The gripper assembly 20 provides a means by which the cutterhead 40 may be advanced through the formation. This is permitted by the slide connection between the gripper assembly 20 and main beam 10 and the propelling rams attached to the gripper assembly and the cutterhead support assembly 30. Other specific details of a similar machine are described in the aforementioned U.S. Pat. No. 3,598,445.

Referring particularly now to FIGS. 6–13, the blade assembly 100, briefly referred to heretofore and generally shown in FIGS. 1 and 3, will be discussed in detail. As previously mentioned, the blade assembly 100 provides a means by which the invert of the tunnel may be cleaned as the cutterhead assembly is advanced therethrough. In addition, the blade assembly 100 provides a means of blocking or unblocking the passageway 39 through the cutterhead support assembly 30. When the passageway 39 is unblocked, as shown in FIG. 6, and the cutterhead assembly 40 is properly positioned access through the passageway 39 and between buckets 45 is permitted to the face of the cutterhead assembly 40.

Although the blade assembly 100 may be constructed as a single blade, it is preferred that it include a pair of blade assemblies arcuately movable from a first position (shown by dotted lines in FIG. 6) blocking the passageway 39 to a second position as shown in FIG. 6, unblocking the passageway 39. A left-hand assembly of a preferred embodiment of the invention, in which there are a pair of such assemblies, will be described with reference to FIGS. 7–13. Since the right-hand assembly is substantially identical to the left, except for being a reversed image thereof, only the left-hand assembly will be described.

As previously mentioned, the blade assembly 100 is carried by the cutterhead support assembly 30. Specifically, it is carried just forward of an associated lower support shoe and strut 35. The support shoe and strut 35 are of course provided with a means of connection to the entire cutterhead support assembly 30 and one of the steering rams (74 in FIG. 3), e.g., mounting bracket 118.

The blade assembly 100 comprises two main components: an arcuate blade 110 and the carriage 120. The carriage 120 is affixed to the support shoe and strut 35, in a manner to be more fully understood hereinafter, while the blade 110 is mounted on the carriage 120 for radial projection toward the walls of the tunnel and arcuate movement relative to a cross-section of the tunnel in which the tunneling machine is disposed.

Carriage 120 may comprise an arcuate support plate 121 from which extends a pair of parallel arcuate flanges 122 and 123. Projecting upwardly from the upper flange 122 and downwardly from the lower flange 123 are a pair of guide lips 124 and 125, respectively.

The blade **110** is provided with an arcuate lower flange **111** to which is attached a guide lip **112** which corresponds with and lies adjacent to the guide lip **125** of carriage **120.** (See FIG. **10**). The blade **110** is also provided with another guide lip **113** which corresponds with and is adjacent to carriage guide lip **124.** The guide lips of the blade **110** and carriage **120** allow sliding arcuate movement of the blade **110** relative to the carriage **120.** Although the blade **110** may be made in one piece, it is preferably constructed similar to a bulldozer blade having a lower section **115** and an upper section **116** connected by retainer strip **117** and a plurality of cap screws **118.** A blade retainer **131** and top flange **132** may also be provided. In addition, a raised blade tip **133** may be provided.

To effect the arcuate movement of blade **110** relative to carriage **120,** a hydraulic cylinder **140** is provided which is pivotally attached at one end to the carriage **120** by pin member **141.** (See FIG. **11**). A pin retainer **142** holds the pin in place. The opposite end of the cylinder **140** is attached to a mounting assembly which may be welded to the back of lower blade section **115.** This mounting assembly, as best seen in FIGS. **7** and **10,** may comprise a plate **142** attached to the blade section **115** by a pair of ribs **143, 144.** A pin member **145** provides the pivoting connection between the mounting assembly and the cylinder **140.** Thus, it can be seen that on contraction and extension of the cylinder **140,** the blade **110** will be forced to move in an arc between a first position, as shown in FIG. **7,** and a second position, indicated by the dotted lines in FIG. **7.** In the first position, the lower end of blade **110** is contiguous to the lower end of the corresponding blade of the right-hand blade assembly. In the second position, the lower end of the blades **110** are separated from each other as shown in FIG. **6,** unblocking the passageway **39** to the cutterhead support assembly **30.** A tongue member **101** may be affixed to the end of blade **110** for engagement with a suitable groove (not shown) on the right-hand assembly.

Arcuate movement only of the blade **110** is necessary to block or unblock the passageway through the cutterhead support assembly. However, it is desirable to provide for limited vertical movement of the entire blade assembly **100** away from the tunnel invert, independently of movement of the cutterhead support assembly. To permit such vertical movement, a pair of vertical guide strips **150** and **151** (See FIG. **9**) are attached to the carrier plate **121** upon opposite sides of a vertical plate **160** which is a portion of the cutterhead support assembly shoe and strut **35.** A pair of guide retainers **153** and **154** are attached to the strips **150** and **151** overlapping the plate **160** so that a vertical sliding connection is established between the carriage **120** and the cutterhead support assembly plate **160.** The upper end of a hydraulic cylinder **162** is attached to the cutterhead support plate **160** by mounting bracket **163** and pin **165.** (See FIGS. **8** and **12**). The lower end of the cylinder **162** is attached to a vertical guide bar **129,** welded to the back of carriage plate **121,** by a mounting bracket **166** and pin **167.** (See FIG. **13**). The cutterhead support assembly plate **160** is provided with a vertical groove and slot **169** in which the vertical guide bar **129** is disposed. Thus, by applying pressure to cylinder **162,** the entire left-hand blade assembly **100** can be moved vertically between an upper position completely clearing the tunnel floor and a lower position firmly engaging the floor. This movement could also be described as radial movement relative to the center line of the tunnel. The guide strips **150, 151,** guide retainers **153, 154,** guide bar **129** and guide slot **169** provide the means by which the left-hand blade assembly **100** can be moved in a predetermined vertical path.

The foregoing description of the left-hand blade assembly **100** is also applicable to the right-hand blade assembly (not shown). Thus, the right and left-hand blade assemblies are independently movable in the vertical direction and the blade members of each assembly are independently movable in an arc about the approximate center of the tunnel.

As best seen in FIG. **6,** the arcuate movement of the blade assemblies **100** provide a means for blocking and unblocking the passageway through the cutterhead support assembly. When the cutterhead is rotating and the tunneling machine is advancing through a formation the blade assemblies **100** move along with the cutterhead support assembly cleaning the invert of the tunnel. The vertical movement of the blade assemblies **100** permits the blades to ride over ridges that may lie in the way.

Although the blade assembly disclosed herein was designed primarily for use with a tunneling machine, it is not so limited. Such a blade assembly could be used in any situation where scraping or cleaning of a cylindrical channel or excavation might be required. Furthermore, there are many variations of the invention which may be made by those skilled in the art without departing from the spirit of the invention. It is therefore intended that the scope of the invention be limited only by the claims which follow.

I claim:

**1.** A machine for boring a tunnel in a subterranean formation comprising:

a. a cutterhead support assembly;

b. a cutterhead assembly mounted for rotation on said cutterhead support assembly; and

c. means connected to said cutterhead support assembly, including a main beam, for advancing said cutterhead and cutterhead support assemblies to cut said tunnel through said formation;

d. said main beam extending into said cutterhead support assembly and connecting with said cutterhead support assembly by a multidirectional pivot means whereby said cutterhead and cutterhead support assembly may be turned in any direction about said pivot means;

e. said cutterhead support assembly including blade means projecting radially toward the walls of said tunnel for cleaning the invert of said tunnel as said cutterhead support assembly advances therethrough.

**2.** A tunneling machine as set forth in claim **1** in which said cutterhead assembly comprises a plurality of bucket means movable along the walls of said tunnel on rotation of said cutterhead assembly to collect rock and muck for removal from said tunnel, said blade means being adjacent to said bucket means.

**3.** A tunneling machine as set forth in claim **1** in which said blade means comprises a blade member mounted on said cutterhead support assembly for movement independently of the movement of said cutterhead support assembly.

**4.** A tunneling machine as set forth in claim **3** in which said cutterhead support assembly is provided

with a human passageway through which the face of said cutterhead assembly may be reached along the invert of said tunnel.

**5.** A tunneling machine as set forth in claim **4** in which said blade member is movable between first and second positions blocking and unblocking said human passageway respectively.

**6.** A tunneling machine as set forth in claim **5.** in which said blade means comprises a carriage on which said blade member is mounted for arcuate movement along the walls of said tunnel between said first and second positions.

**7.** A tunneling machine as set forth in claim **6.** in which said blade means comprises a pair of said blade members and carriages, said blade members being contiguous to each other in said first position and separated from each other in said second position to permit access to said cutterhead assembly face through said human passageway.

**8.** A tunneling machine as set forth in claim **1** in which said cutterhead support assembly is provided with a human passageway through which the face of said cutterhead assembly may be reached along the invert of said tunnel.

**9.** A tunneling machine as set forth in claim **8.** in which there is a clear space along said tunnel invert, beneath said main beam, communicating with said human passageway to provide a continuous passageway for humans along the invert of said tunnel throughout the entire length of said tunneling machine.

**10.** A tunneling machine as set forth in claim **8** in which said blade means comprises an arcuate blade member mounted on a carriage for arcuate movement, relative to a cross-section of said tunnel, between first and second positions blocking and unblocking said human passageway, respectively.

**11.** A tunneling machine as set forth in claim **10** in which said blade member and said carriage are also mounted on said cutterhead support assembly for limited radial movement between said tunnel walls and the center line of said tunnel.

**12.** A tunneling machine as set forth in claim **10.** in which said blade means comprises a pair of said arcuate blade members and carriages, each of said blade members being movable between a position in which said blade members are contiguous to each other and blocking said human passageway to a position in which said blade members are separated providing access to said cutterhead face through said human passageway.

**13.** A tunneling machine as set forth in claim **12.** in which said means for advancing said cutterhead and cutterhead support assemblies includes a longitudinal main beam beneath which there is a clear space along said tunnel invert communicating with said human passageway to provide a continuous passageway for humans along the invert of said tunnel throughout the entire length of said tunneling machine.

**14.** A machine for boring a tunnel in a subterranean formation comprising:

a. a main beam;

b. a cutterhead support assembly attached to said main beam;

c. a cutterhead assembly mounted for rotation on said cutterhead support assembly;

d. means connected to said main beam for advancing said cutterhead support and cutterhead assemblies to cut said tunnel through said formation;

e. a first passageway through said cutterhead support assembly;

f. a second passageway beneath said main beam communicating with said first passageway;

g. said first and second passageways forming a continuous human passageway along the invert of said tunnel throughout the length of said tunneling machine, through which the face of said cutterhead assembly may be reached.

**15.** A tunneling machine as set forth in claim **14.** in which said main beam extends into said cutterhead support assembly and connects therewith by a multidirectional pivot means whereby said cutterhead and cutterhead support assembly may be turned in any direction about said pivot means.

**16.** A tunneling machine as set forth in claim **14.** characterized by blade means carried by said cutterhead support assembly projecting radially toward the walls of said tunnel for cleaning said tunnel invert on said advancing of said cutterhead support and cutterhead assemblies.

**17.** A tunneling machine as set forth in claim **16** in which said blade means comprises a blade member mounted on a carriage member for movement between first and second positions blocking and unblocking said first passageway, respectively.

**18.** A tunneling machine as set forth in claim **17** in which said blade means is mounted on said cutterhead support means for limited radial movement toward and away from the approximate center of said tunnel.

**19.** A tunneling machine as set forth in claim **18.** in which said carriage member and another portion of said cutterhead support assembly are provided with guide means for guiding said blade means in said radial movement.

**20.** A tunneling machine as set forth in claim **19.** comprising power means connected to said carriage member for effecting said radial movement.

**21.** A tunneling machine as set forth in claim **17.** in which said blade and carriage members are provided with cooperating guide means for guiding said blade member in an arcuate path, relative to a cross-section of said tunnel, between said first and second positions.

**22.** A tunneling machine as set forth in claim **21** comprising power means connected to said blade member and said carriage member for effecting said movement of said blade member between said first and second positions.

**23.** A tunneling machine as set forth in claim **21** in which said cutterhead assembly comprises a plurality of bucket means movable along the walls of said tunnel on rotation of said cutterhead assembly to collect rock and muck for removal from said tunnel, said blade member being adjacent to said bucket means.

**24.** A tunneling machine as set forth in claim **21** in which there are a pair of said blade and carriage members, each of said blade members being independently movable in said arcuate path and in opposite directions from said first position to said second position, said blade members being contiguous to each other when in said first position and separated from each other when in said second position to permit access to said cutterhead assembly face through said first passageway.

**25.** A tunneling machine as set forth in claim **24** in which each pair of said blade and carriage members are mounted on said cutterhead assembly for independent vertical movement toward and away from the floor of said tunnel.

**26.** A tunneling machine as set forth in claim **25.** in which each pair of said blade and carriage members are provided with power means for effecting said independent arcuate and vertical movements.

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