Sept. 5, 1967 D. F. WINBERG 3,339,980

CENTRALLY OPEN CUTTERHEAD SUPPORT FOR A BORING MACHINE

Original Filed May 31, 1963 5 Sheets-Sheet 1

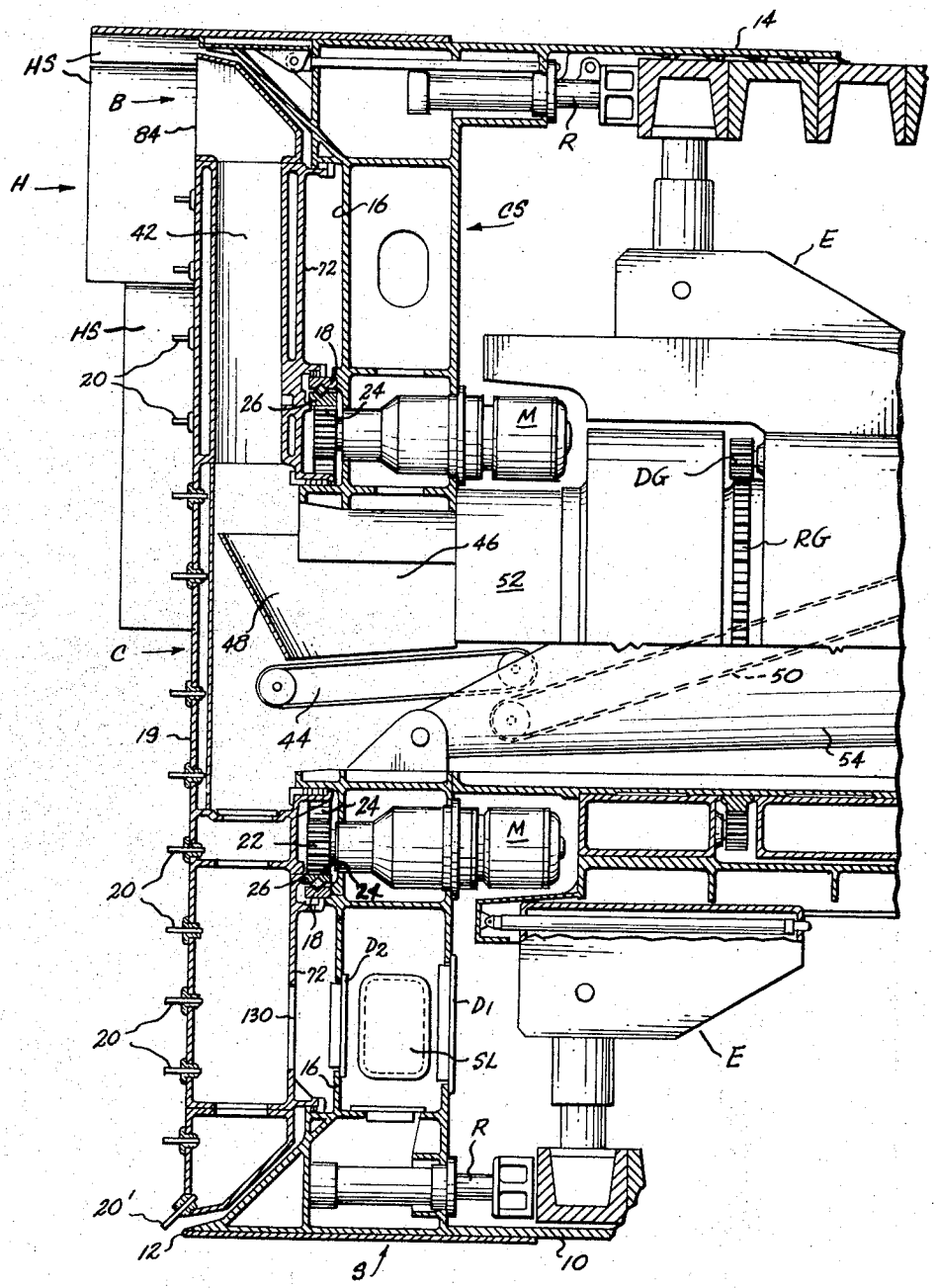


Fig. 1.

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CENTRALLY OPEN CUTTERHEAD SUPPORT FOR A BORING MACHINE

Original Filed May 31, 1963 5 Sheets-Sheet 2

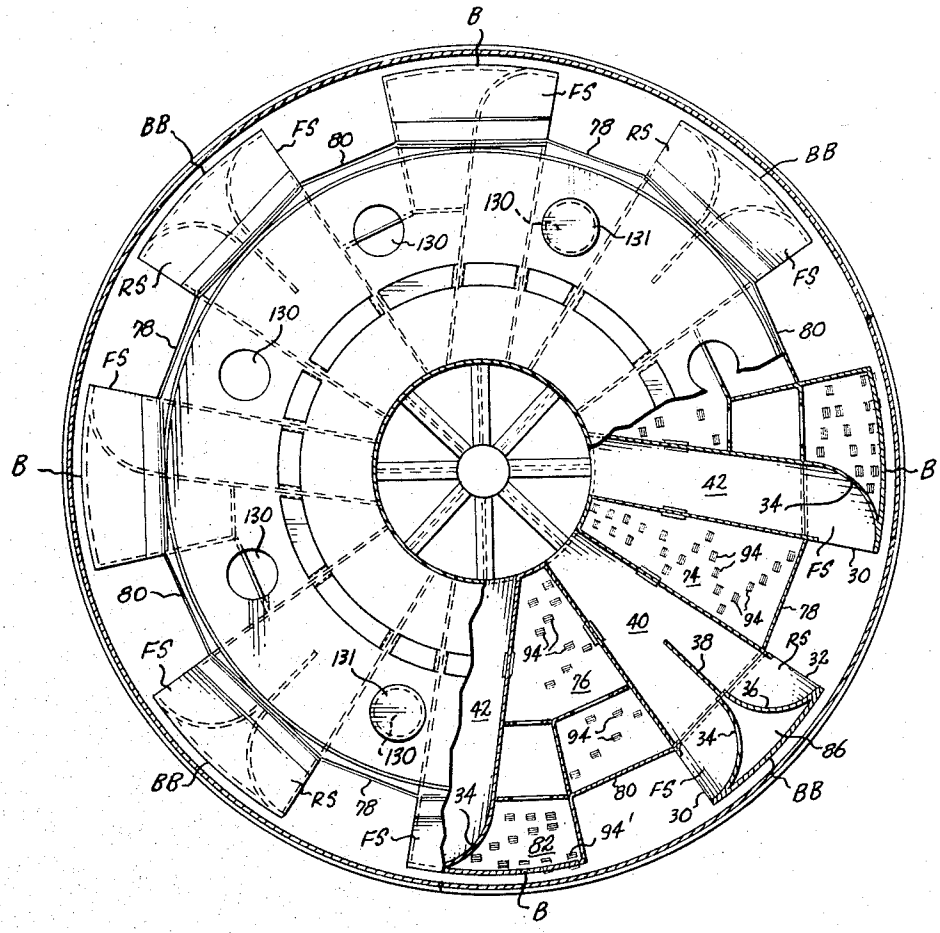


Fig. 2.

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CENTRALLY OPEN CUTTERHEAD SUPPORT FOR A BORING MACHINE

Original Filed May 31, 1963 5 Sheets-Sheet 3

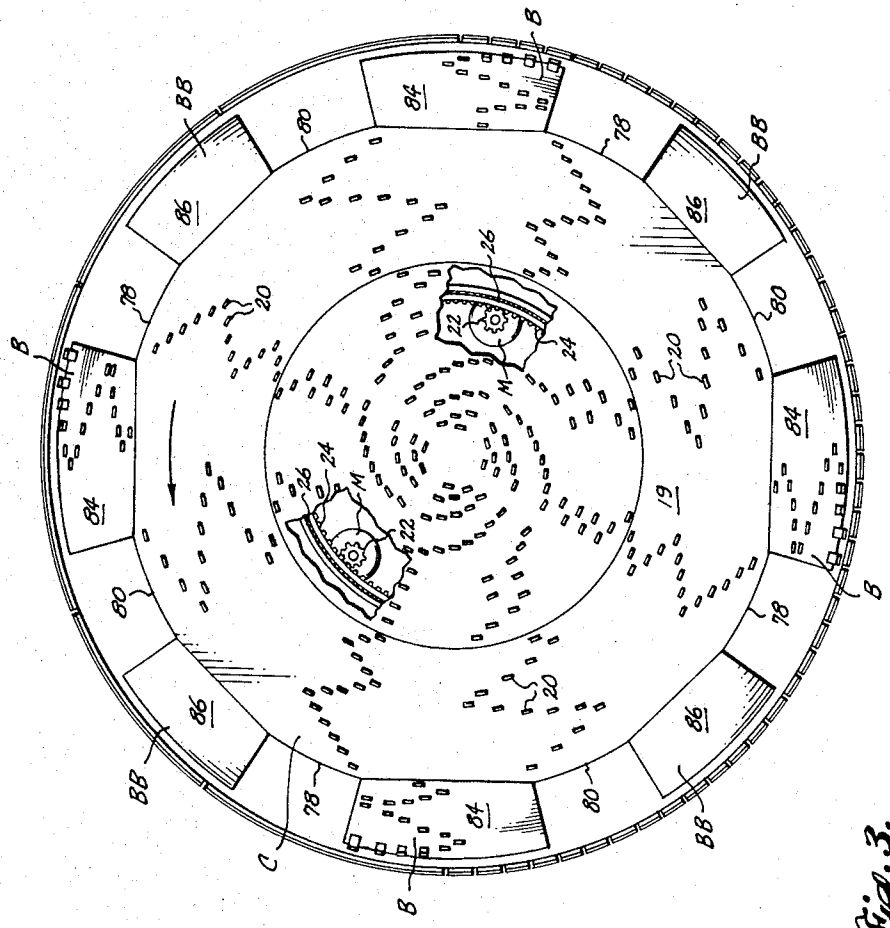


Fig. 3.

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CENTRALLY OPEN CUTTERHEAD SUPPORT FOR A BORING MACHINE

Original Filed May 31, 1963 5 Sheets-Sheet 4

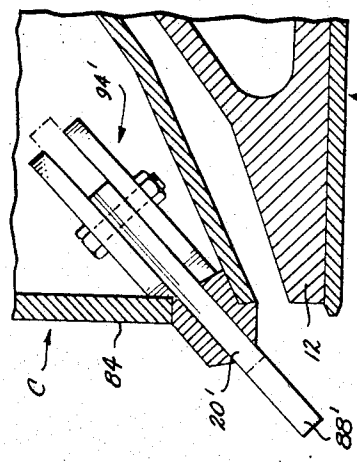


Fig. 7.

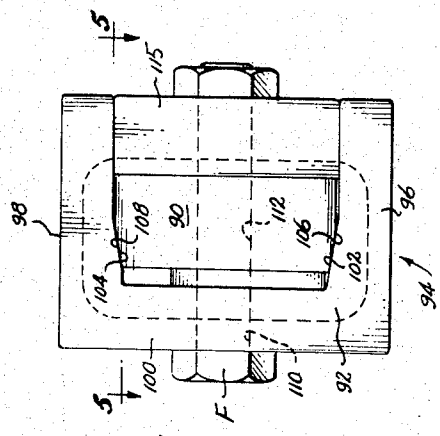


Fig. 6.

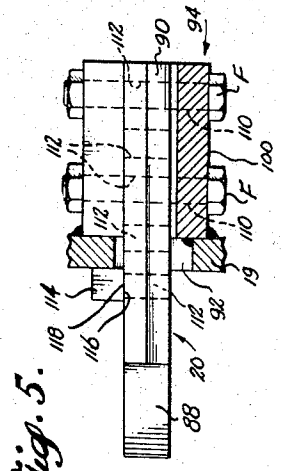


Fig. 5.

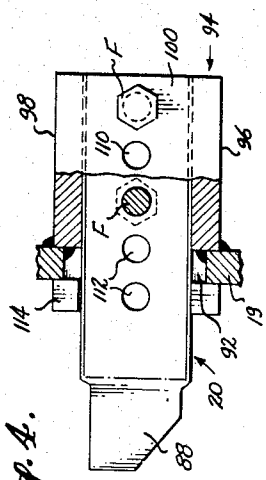


Fig. 4.

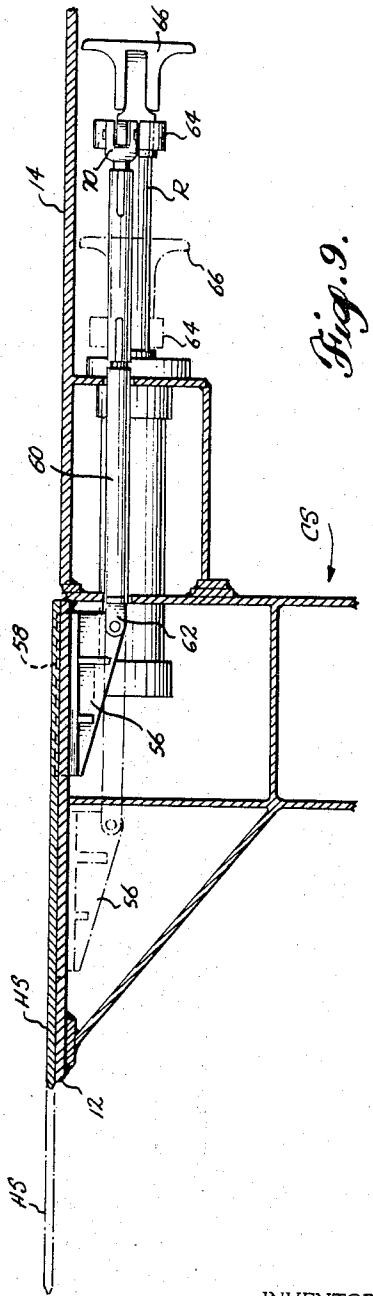


Fig. 9.

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CENTRALLY OPEN CUTTERHEAD SUPPORT FOR A BORING MACHINE

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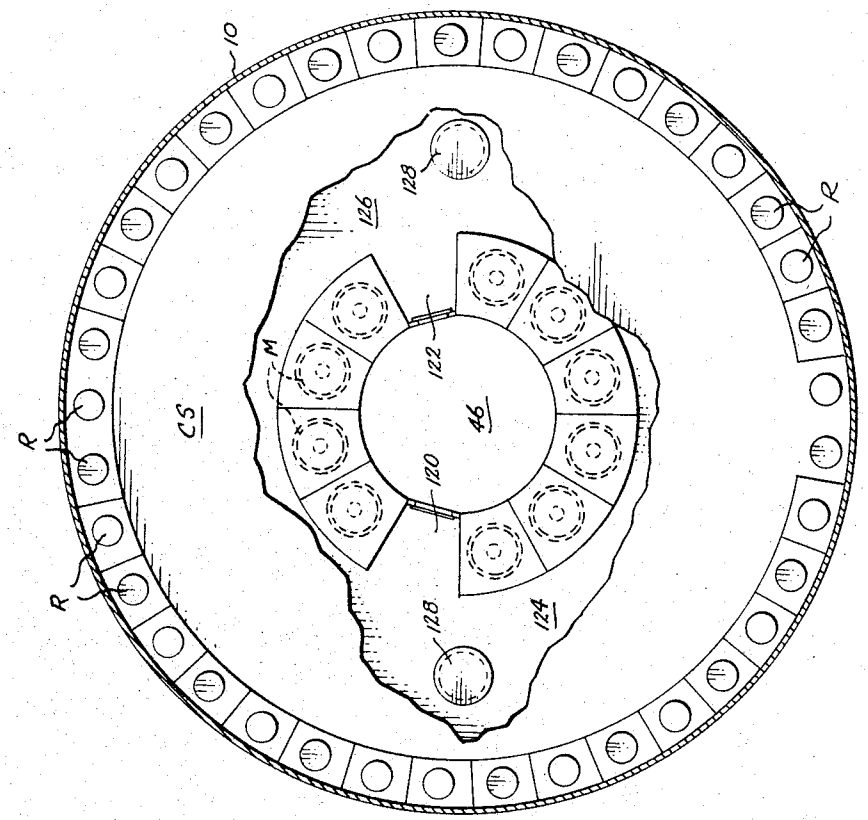


Fig. 8.

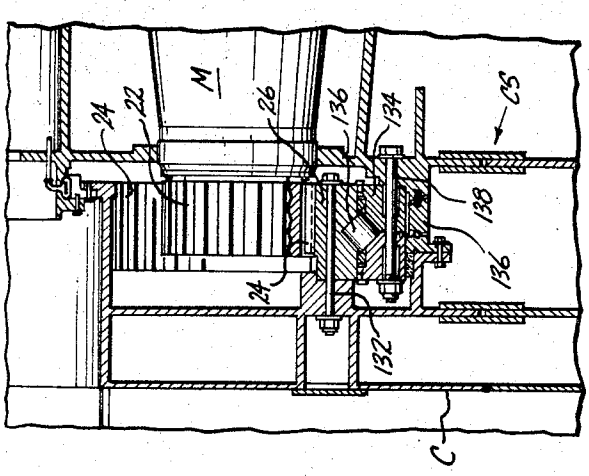


Fig. 10.

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United States Patent Office 3,339,980 Patented Sept. 5, 1967

3,339,980

CENTRALLY OPEN CUTTERHEAD SUPPORT FOR A BORING MACHINE

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Original application May 31, 1963, Ser. No. 284,709, now Patent No. 3,309,142, dated Mar. 14, 1967. Divided and this application Aug. 15, 1966, Ser. No. 572,291

6 Claims. (Cl. 299—33)

ABSTRACT OF THE DISCLOSURE

A boring machine with a cylindrical skin, a transverse support wall open at its center, an open center cutterhead mounted forwardly of the support wall and supported thereon by an annular bearing concentrically surrounding the central opening in the support wall, and adapted to carry both radial and axial loads; a non-rotatable material removable tube enveloping the central opening in the support wall and extending rearwardly therefrom; a drive gear formed integral with one of the races of the annular bearing, and a plurality of reversible drive motors carried by the support wall at locations radially outwardly from the central opening in said wall and including drive gears in mesh with said annular gear; a pair of segment erectors mounted for rotation about the material removable tube; cutter elements insertable into place from the rear side of the front wall of the cutter-head and including mounting means on the rear side of such wall; radial material chutes extending inwardly from peripheral buckets, and alternated with service compartments positioned rearwardly of the cutter mounting zones; adjustable straight shank cutters provided with a series of openings and cutter mounting means comprising a guide way for the cutter shank on the rear side of the cutterhead front wall including an opening or openings alignable with an opening or openings in the cutter shank, and a bolt or bolts for securing the cutter shank to the guide; an extensible hood including means interconnectable between the hood and a thrust ram, normally functioning to move the machine forwardly by reacting against the constructed tunnel lining, whereby such ram can be used for positioning the hood; and said cutterhead including peripheral buckets opening in both directions of rotation.

This is a division of my copending application Ser. No. 284,709, filed May 31, 1963, now Patent No. 3,309,142 and entitled, Cutterhead Assembly for a Shield-Type Tunneling Machine.

The present invention relates to a cutterhead for a boring machine, and more particularly to a mounting arrangement and a drive assembly for such a cutterhead.

Cutterhead assemblies according to the present invention comprise a transverse cutterhead support including a relatively large central passageway; a rotary cutterhead situated forwardly of said cutterhead support, and including cutter means and means for directing the mined material towards the central passageway in said cutterhead support; material receiving means situated in the central passageway of said cutterhead support, in position to receive the mined material; an annular bearing in concentric surrounding relationship to the central passageway in said cutterhead support, said bearing including inner and outer races, one of which is secured to the cutterhead, and the other is secured to an adjacent portion of the cutterhead support; and annular gear secured to the cutterhead; at least one drive gear positioned between said cutterhead and said cutterhead support, which drive gear is in mesh with the teeth of said annular gear;

and motor means for rotating said drive gear, which motor means is mounted on said cutterhead support.

In preferred form, the annular gear secured to the cutterhead is an integral part of the bearing race secured to the cutterhead; one of the bearing races concentrically surrounds the other; and the bearing also includes bearing elements between the races which are capable of carrying both radial and axial loads, so that such bearing is both a radial bearing and a thrust bearing; and the assembly further comprises a non-rotating material removable tube, separate from the cutterhead, extending axially from the central passageway in the cutterhead support, away from the cutterhead.

Tunneling or boring machines constructed according to the present invention are capable of being used for forming tunnels, shafts, raises or any other ground passageway of a horizontal, vertical or in between attitude. However, the principles of the present invention are particularly applicable to horizontal tunneling machines, and in particular to such machines of the shield type.

These and other objects, features, advantages and characteristics of the present invention will be apparent from the following description of typical and therefore non-limitive embodiments thereof, wherein like letters and numerals refer to like parts, and wherein:

FIG. 1 is a fragmentary side elevational view of the shield tunneling machine in operation, with the cutterhead and cutterhead support presented in longitudinal section;

FIG. 2 is a cross-sectional view taken through the cutterhead, substantially along line 2—2 of FIG. 1, such view showing the alternate arrangement of radially extending material chutes and cutterhead service compartments;

FIG. 3 is an elevational view of the front face of the cutterhead, with parts of such cutterhead broken away to show the bull gear that is attached to the rear side of the cutterhead in mesh with two of the pinion gears which drive the same, such view also illustrating that the cutters or knives are only located in the portions of the cutterhead forward wall that constitute the front walls of the cutterhead service compartments, including those cutters located in the portions of the cutterhead forward wall that immediately trail the one-way buckets;

FIG. 4 is an enlarged scale view of an individual knife or cutter and its mounting arrangement, such view presenting the cutter in side elevation with parts in longitudinal section;

FIG. 5 is a top plan sectional view of the cutter assembly of FIG. 4, taken substantially along line 5—5 of FIG. 6;

FIG. 6 is an end elevational view looking towards the rear of the cutter assembly of FIGS. 4 and 5;

FIG. 7 is an enlarged scale fragmentary view of one of the obliquely oriented cutters located at the periphery of those portions of the cutterhead forward wall that trail the one-way buckets;

FIG. 8 is a view taken from the rear of the cutterhead support with a portion of the back wall of such cutterhead support removed to present a clear showing of certain interior regions of the cutterhead support, such view showing the radially extending crawl spaces interconnecting the central passageway extending through the cutterhead support with interior portions of said cutterhead support located radially outboard of the compartments in which the motors for driving the cutterhead are mounted;

FIG. 9 is an enlarged scale fragmentary view of an upper portion of the cutterhead support, with a hood section shown in such view in both its retracted (solid lines) and extended (broken lines) positions; and

FIG. 10 is an enlarged scale sectional view of the bearing and gear means located between the rotary cutterhead and the stationary cutterhead support.

Referring now to the figures of the drawings in more detail, the tunneling machine shown in FIG. 1 includes a shield S characterized by a generally cylindrical skin **10** having a nose section equipped with a cutting edge **12**, which may be conventional per se; a tail section **14**; and a transverse cutterhead support CS spanning the interior of the skin **10** intermediate the ends thereof. A rotary cutterhead C is mounted for rotation on the anterior wall **16** of the cutterhead support CS, preferably by means of an annular bearing **18**, the upper race of which is securely fastened to the cutterhead support CS, as by nut and bolt assemblies, and the lower race of which is firmly attached to the rear wall of the cutterhead, also by means of nut and bolt assemblies. A series of roller or ball members are retained between said inner and outer race portions of the bearing **18**, as will hereinafter be explained in greater details.

As clearly shown in FIG. 3, for example, the front wall **19** of the cutterhead C is provided with a plurality of forwardly projecting cutters, some of which are designated **20** for sake of example. The cutters **20** are placed at different distances from the center of the cutterhead C, and when the cutterhead C revolves such cutters **20** cut concentric grooves in the face of the tunnel, resulting in a complete breakaway of the face of the tunnel to the depth of the cut. The particular mounting arrangement of the cutters **20** and the pattern of layout of the same are hereinafter described more fully.

The cutterhead C is revolved by means of a plurality of pinion gears, some of which are designated **22** in FIGS. 1 and 3, for example, which mesh with a large bull gear **24** forming an integral part of the inner race **26** (FIG. 3) of the annular bearing **18**. The motive power is furnished by a plurality of reversible motors M, a particularly advantageous number of them being 10, arranged four above and six below the horizontal center line of the cutterhead support CS.

A plurality of buckets B, BB (FIGS. 2 and 3, for example), are circumferentially arranged about the generally disk-shaped front wall 2B of the cutterhead C. The buckets B are termed one-way buckets since they only open in the direction of normal rotation of the cutterhead C which, as viewed from the rear of the cutterhead C, is preferably clockwise. Buckets BB open in both directions of rotation and are termed two-way buckets. Referring to FIG. 2, the scoop portions FS, RS (forward scoop and rearward scoop, respectively, relating to the direction of normal rotation) have open mouth portions **30**, **32**, respectively, and curved rear wall portions **34**, **36**, respectively, for turning the mined material inwardly. In addition, the two-way buckets BB include a partition or dividing member **38** extending radially inwardly a short distance from where the inboard ends of the two material turning elements **34**, **36** substantially meet. Elements **38** prevent the material that is scooped up by the leading scoops from flowing right out through the trailing scoop, i.e. it serves to guide or direct the mined material far enough into the bucket chutes **40** that it will continue to move through the chutes **40** rather than reversing its direction of movement and flowing out through the trailing scoops.

Assuming that the tunneling machine is operated in normal fashion and the cutterhead C is rotating clockwise, as viewed from the rear of the cutterhead C, both the one-way buckets B and the two-way buckets BB are picking up mined material from the ground at the tunnel face, during advancing movement of the cutterhead C into the working face of the tunnel. The buckets BB, B have radially inwardly extending discharge chutes **40**, **42**, respectively, associated therewith, ultimately discharging the mined material onto a receiving conveyor **44** located partially at least within a central passageway **46** extending through

cutterhead support CS. A deflector **48** of appropriate construction is used to guide the mined material dropped from the chutes **40**, **42** onto the receiving conveyor **44**.

During the tunneling operation, and particularly during those stages of the operation when the cutters are moving against hard material offering substantial resistance to rotation of the cutterhead, a substantial countertorque is produced tending to rotate the cutterhead support CS and the other shield components in the counterclockwise direction.

For various reasons it is desirable for the cutterhead support CS to substantially maintain its original orientation throughout the tunneling operation. When reactive roll or counter-rotation of the shield S does occur due to the reactive torque or countertorque, the cutterhead is stopped and then rotated in the opposite direction by the reversible motors M. During such counter-rotation of the cutterhead C, the reactive torque is advantageously used to rotate the shield S back into its original position, at which time the reverse rotation of the cutterhead C is ceased and normal operation of the same resumed. Of course, during the period of reverse rotation of the cutterhead C, the rear scoops RS of the two-way buckets BB are digging material and discharging it through the chutes **40** onto the receiving conveyor **44**.

The receiving conveyor **44** preferably comprises an endless belt of metal pads linked together so as to be durable and able to resist the shock of the mined material falling on it from the chutes **40**, **42**. Conveyor **44** feeds the mined material onto a longer conveyor **50** comprising an endless belt constructed of rubber or a similar material. Conveyor **50**, is encased partially within what is termed the erector tube **52** and partially within a conveyor tube **54** extending rearwardly out of said erector tube **54** and communicating at its rearmost end with a hopper type apparatus (not shown) into which conveyor **50** discharges and which apparatus in turn serves to discharge the mined material onto a tunnel conveyor leading from the location of the tunneling machine to the outside of the tunnel, all in accordance with procedures not necessarily forming a part of the present invention.

The tunnel is lined as it is dug. A pair of segment erectors **E1**, **E2** are mounted on the tube **52** for rotation thereabout. The means for rotating the segment erectors **E1**, **E2** about tube **52** includes an annular reaction gear RG which encircles and is fixed to the tube **52**, and motor drive gears DG carried by the segment erectors and arranged to mesh with reaction gear RG. The shoving, driving, or moving forward of the shield S and the rotary cutterhead C carried thereby is accomplished by means of thrust rams R attached to the shield structure and reacting against the tunnel lining previously erected (FIG. 1).

A hood or visor H extends along the outside of the cutterhead support portion of the shield skin and is mounted thereon for reciprocal movement from a retracted position (shown in solid lines in FIG. 9) to an extended position (shown in broken line in FIG. 9). The hood H is constructed in sections HS (FIG. 3), and at least some of the thrust rams R located to the rear of each hood sections HS are used as actuators for extending the same. The means connecting the hood sections HS with the thrust rams include a generally radially extending pin plate **56** fixed along its upper edge to the inner surface of a hood section HS and extending radially inwardly from said section to ride in a longitudinally extending slot **58** provided in the cutterhead portion of the shield skin. With a hood section HS retracted and the piston portions of the thrust rams R extended, a connecting rod **60** (one for each thrust ram R used) preferably of sectional construction, is attached at its forward end to the pin plate **56**, as by a clevis **62**, or the like, and at its rearward end to a collar **64** located on the piston closely adjacent the ram shoe portion **66** thereof. Such collar **64** includes an upstanding ear **68**,

or the like, onto which a clevis **70**, or the like, on the rearward end of the connecting rod **60**, is attached. In operation, the pistons of the thrust rams R are retracted and as they move they carry with them the hood sections HS, moving the same to their extended positions. The hood sections HS are then firmly anchored to the cutterhead support and the connecting rod **60** is detached so that the thrust rams can once again be used for their primary function of moving the tunneling machine forward.

A plurality of bar-like spacers SB of the same thickness as the hood sections HS are circumferentially spaced around the lower half of the cutterhead support CS (FIG. 3) so as to make the outside radius of such lower half equal to the outside radius of the upper half which includes the thickness of the hood sections. This arrangement centers the tunneling machine with respect to the tunnel.

In addition to front wall **19**, cutterhead C includes a generally annular rear wall **72**. The said walls **19**, **72** define between them a cutterhead interspace or interior chamber, in which the bucket chutes **40**, **42** are housed.

As previously described, the bucket chutes **40**, **42** extend generally radially of the cutterhead C. Interposed between or alternated with the bucket chutes **40**, **42** are a plurality of compartments **74**, **76** termed cutterhead service compartments. The cutterhead service compartments designated **74** are situated to open side of the one-way buckets B and terminate generally at the periphery of the cutterhead front wall **19**, having as a boundary at such location a peripheral wall **78**. The cutterhead service compartments designated **76** are located to the closed sides of the one-way buckets B and include as a partial peripheral closure a peripheral wall **80**. Also, on the closed side of the one-way buckets B but radially outboard of the periphery of cutterhead wall **19**, are located what may be termed bucket service compartments **82**, such compartments in effect being extensions of the cutterhead service compartments **76**. As best shown in FIGS. 1 and 3, the forward walls **84** of the bucket service compartments **54** carry a plurality of cutters **20'**; walls **84** constituting radial continuations of the front wall **19** of the cutterhead C. The walls **84** are preferably of plate construction and they extend laterally to also form the front sidewall of the forward scoops FS. It is to be noted at this point that the two-way buckets BB include walls **86** of plate construction, also constituting radial extensions of cutterhead wall **19**. Walls **86** are configured similar to the side walls **84**, but of course do not include cutters.

FIGS. 5 and 6 show the cutters **20** as each including a knife portion **88** and a shank portion **90**. A generally rectangular (but not necessarily) opening **92**, preferably having rounded corners (FIG. 6), extends through cutterhead forward wall **19** at each cutter location. An elongated mounting member **94**, preferably in the form of a section of channel, is attached to the rear surface of wall **19** at the opening **99** (as by welding) and extends rearwardly of and substantially normal to the rear surface of wall **19**. The mounting member **94** is shown in FIG. 6 as including spaced apart flange portions **96**, **98** and a web **100** interconnecting therebetween. The interior surfaces of flanges **96**, **98** are preferably provided with longitudinally extending guide means for the cutter **20**. As shown in FIG. 6, the guide means may suitably take the form of laterally sloping guide surface **102**, **104**, with the passage formed between said guide surfaces **102**, **104** diverging from the inside (adjacent web **100**) to the outside ends of the flanges **96**, **98**.

The shank portion **90** of each cutter **20** is suitably provided with longitudinally extending chamfer surfaces **106**, **108** related in slope or angularity to the said guide surfaces **102**, **104**. A plurality of openings **110** extend laterally through the web **100** and are selectively alignable with similar openings **112** extending laterally through the shank portion **90** of the cutters **20**. Bolt type fastening means or the like (designated F) are inserted through one or more aligned pairs of openings **110**, **112** and a nut attached to its or their threaded ends to firmly secure the cutter **20** to the mounting member **94**, with the degree of penetration of the knives **88** out from the front surface of wall **19** being determined by the selective alignment of the openings **110**, **112**. A filler piece **115** may be used as shown in the drawing. Cutter **20** is snugly accommodated within the interior portion of mounting member **94** by virtue of the surface to surface contact between chamfers **106**, **108** and guide surface **102**, **104**. This feature lends stability to the cutter **20** and prevents it from "rolling" within the interior of the mounting member **94**. At the location of each opening **92** a cutter rest **114** is attached to the front surface of wall **19**, as by welding, with a surface **116** (FIG. 5) of such rest **114** abutting against a surface **118** of the cutter **20**.

In most respects, the cutters **20'** and the mounting means therefor are identical in construction to the cutters **20** and their mounting arrangement, just described. However, at least some of the outermost or peripheral cutters **20'** (FIG. 3) are obliquely oriented so as to lean somewhat radially outwardly away from wall **18** as well as to project forwardly thereof (FIGS. 1 and 7). When the tunneling machine is operating in hard material at least some of the said peripheral cutters **20'** are set so that their knife portions **88'** extend in front of and cut a path for the circumferentially extending cutter edge **12** of the shield S. When contact is made with sandy material or material that is generally considered to be easily mined, the peripheral cutters **20'** are retracted to the extent that the knife portions **88'** thereof (FIG 7) are to the inside of the skin **10** a sufficient distance to allow the hood sections HS to be extended.

The back side mounting arrangement of the cutters **20**, **20'** onto wall **19** facilitates their installation, removal and replacement. In addition, and a marked advantage of this arrangement, installation and removal of the cutters **20**, **20'** are done within the protection of service compartments **74**, **76**, **82** and not in the space forwardly of the cutterhead C between the tunnel face and the front surface of the cutterhead, where working conditions are uncomfortable and extremely hazardous due to the constant danger of overhead pieces of rock dislodging and falling on the workman or the entire face of the tunnel collapsing, etc., as is the case in known conventional machines wherein the cutters are mounted onto the front side of the cutterhead face.

Preferably, but not necessarily, the anterior wall **16** of the cutterhead support CS is a bulkhead and at least the largest portion of the region forwardly of such wall **16** is pressurized while the main portion of the tunnel rearwardly thereof is not. For a detailed description of this arrangement and the various techniques and mechanisms involved therewith, reference is made to the Larrouze et al. application Ser. No. 284,604, now Patent No. 3,266,257. Also in accordance with the invention forming the subject matter of said Patent No. 3,266,257, the material compartment (of which erector tube **52** is a part) is interiorly pressurized and the rear portion of such material compartment includes material lock means adapted for removal of the mined material from the material compartment without depressurizing the same.

In the illustrated form of the invention two ways are provided for gaining access to the service compartments **74**, **76**. As shown in FIG. 8, crawl spaces **120**, **122** are provided between the upper and lower sets of reversible motors M. Such crawl spaces **120**, **122** are provided with openings at their ends and serve to interconnect the central passageway **46** with interior compartments **124**, **126** of the cutterhead support CS. At least one, but preferably a plurality of openings **128** are provided at circumferentially spaced locations in the anterior wall **16** of the cutterhead support CS. These openings **128** are

alignable with similar openings **130** (FIG. 2) extending through the cutterhead rear wall. When not in use, the openings **130** may be covered by plates **131**, or the like. In an arrangement wherein the material compartment is pressurized (as described in the aforementioned Patent No. 3,266, 257), access to the interior of central passageway **46** may be by means of a man lock (not shown) located toward the rear of the material compartment. The second manner of gaining access to the cutterhead service compartments **74, 76** is provided by one or more emergency service locks SL (FIG. 1) extending through cutterhead support CS and including the usual pair of doors **D1, D2,** which in the present installation are alignable with the openings **130** in the rear wall **72** of the cutterhead C. In other installations not requiring a bulkhead in combination with cutterhead support CS, as in those installations wherein the entire tunnel is pressurized and the regions on opposite sides of the cutterhead support CS are at the same pressure, a set of access doors, or an arrangement utilizing but one door, may be substituted for the service locks SL and used for gaining access to the cutterhead service compartments **74, 76** from the tunnel region rearwardly of the cutterhead support CS. Also, in these installations the man lock is not necessary for gaining access to passageway **46.**

Referring to FIG. 10, the inner race **26** of annular bearing **18,** with bull gear **24** attached, is shown securely fastened to the rotary cutterhead C by means of a series of nut and bolt assemblies **132.** The outer race **134** of the bearing **18** is suitably supported by an annular member **136,** constituting part of the cutterhead C, and is securely attached to the cutterhead support CS by means of a series of nut and bolt assemblies **138,** for example. A series of roller type bearing elements **136** are situated between the inner and outer bearing races **26, 134,** respectively. As is readily apparent from FIGS. 1 and 9, the roller elements **136** are canted so that they assume both radial and axial trust. The annular bearing **18** is suitably sealed in a region between said inner and outer races **26, 134,** respectively.

From the foregoing, various further modifications, arrangements and adaptations of the present invention will occur to those skilled in the art to which the invention is addressed, within the scope of the following claims.

What is claimed is:

1. A cutterhead assembly for a boring machine comprising: a bore wall contacting guide means; a non-rotating transverse cutterhead support structure extending radially inwardly from the bore wall contacting guide means to a central portion of said support structure having a central passageway therein extending axially of the bore, said support structure extending transversely of the path of travel of the machine and the bore made thereby; a rotary cutterhead on one side of and radially overlying said cutterhead support structure, and including cutter means and means for directing the mined material towards the central passageway in said cutterhead support structure; material receiving means partially situated in the central passageway of said cutterhead support structure, in position to receive the mined material; annular bearing means between said cutterhead and said cutterhead support structure, in concentric surrounding relationship to the central passageway in said cutterhead support structure, said bearing means rotatively supporting the cutterhead on a forward portion of the cutterhead support structure; gear means between said cutterhead and said cutterhead support structure in concentric surrounding relationship to the central passageway in said cutterhead support structure, and secured to the cutterhead; at least one drive gear in mesh with said gear means; motor means mounted on said cutterhead support structure radially outwardly of said central opening, and rotating said drive gear; and a non-rotating material removal tube, separate from the cutterhead, extending axially from the central passageway in the cutterhead support structure and away from the cutterhead, with said material receiving means being a mechanical conveyor means in said tube for transporting the material away from the cutterhead area.

2. A cutterhead assembly according to claim **1,** wherein said gear means is position radially inwardly of said bearing means and includes radially inwardly directed teeth, and said drive gear means is positioned radially inwardly of the bearing means.

3. A cutterhead assembly for a boring machine comprising: bore wall contacting guide means; a generally radial non-rotating cutterhead support structure extending radially inwardly from the bore wall contacting guide means to a central portion of said support structure having a central passageway therein which extends axially of the bore, said cutterhead support structure extending transverse to the path of travel of the machine and the bore made thereby; a rotary cutterhead on one side of and radially overlying said cutterhead support structure, and including cutter means and means for directing the mined material towards the central passageway in said cutterhead support structure, material receiving means partially situated in the central passageway of said cutterhead support structure, in position to receive the mined material; an annular bearing between said cutterhead and said cutterhead support structure, and having inner and outer races in concentric surrounding relationship to the central passageway in said cutterhead support structure, with one of said races being secured to a rear portion of the cutterhead and the other being secured to a radially adjacent forward portion of the cutterhead support structure, and bearing elements between the races capable of carrying both radial and axial loads; an annular gear between said cutterhead and said cutterhead support structure, in concentric surrounding relationship to the central passageway in said cutterhead support structure, radially inwardly of the peripheries of said cutterhead and said cutterhead support structure, and secured to the cutterhead, said gear having radially directed teeth; at least one drive gear positioned between said cutterhead and said cutterhead support structure, in mesh with the gear teeth of said annular gear; and motor means for rotating said drive gear, which motor means is mounted on said cutterhead support structure radially outwardly of said central opening, with the axis of the drive gear being parallel to the axis of the cutterhead.

4. A cutterhead assembly according to claim **3,** including a non-rotating material removal tube, separate from the cutterhead, and extending axially from the central passageway in the cutterhead support structure, away from the cutterhead, and wherein the material receiving means is a mechanical conveyor means in said tube for transporting the material away from the cutterhead area.

5. A cutterhead assembly for a boring machine comprising: bore wall contacting guide means; a non-rotating transverse cutterhead support structure extending radially inwardly from the bore contacting guide means to a central portion of said structure having a central passageway therein extending axially of the bore, said cutterhead support structure extending transverse to the path of travel of the machine and the bore made thereby; a rotary cutterhead situated forwardly of and radially overlying said cutterhead support structure, and including cutter means and means for directing the mined material towards the central passageway in said cutterhead support structure; material receiving means situated in the central passageway of said cutterhead support structure, in position to receive the mined material; an annular antifriction bearing having inner and outer races in concentric surrounding relationship to the central passageway in said cutterhead support structure, with one of said races being secured to a rear portion of the cutterhead

radially inwardly from the periphery of said cutterhead, and the other being secured to a radially forward portion of the cutterhead support structure, with the bearing race that is secured to the cutterhead being provided with gear teeth; bearing elements between the races capable of carrying at least radial loads; at least one drive gear positioned between said cutterhead and said cutterhead support structure, in mesh with the gear teeth on the bearing race; and motor means for rotating said drive gear, which motor means is mounted on said cutterhead support structure radially outwardly of said central passageway.

6. A cutterhead assembly according to claim 5, wherein said bore wall contacting means is a tubular member

and said transverse cutterhead support structure spans the interior of said member.

References Cited

UNITED STATES PATENTS

537,899	4/1895	Mitchell	299—31
837,552	12/1906	Ennis	299—61
1,338,237	4/1920	Mack	61—84
1,511,957	10/1924	Freda	299—87 X

FOREIGN PATENTS

159,318	2/1921	Great Britain.

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