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3,309,142

CUTTERHEAD ASSEMBLY FOR A SHIELD-TYPE TUNNELING MACHINE

Filed May 31, 1963

5 Sheets-Sheet 1

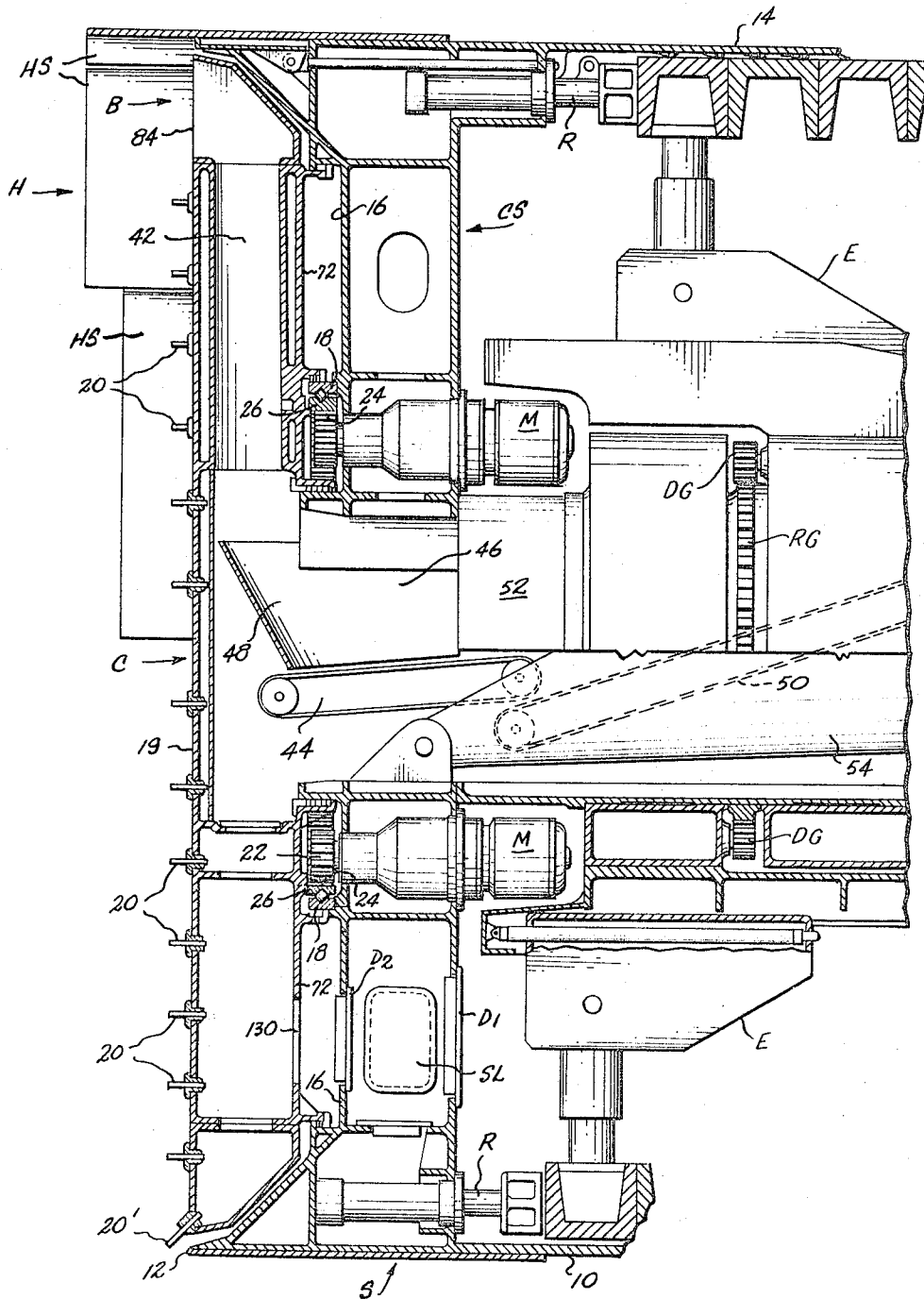


Fig. 1.

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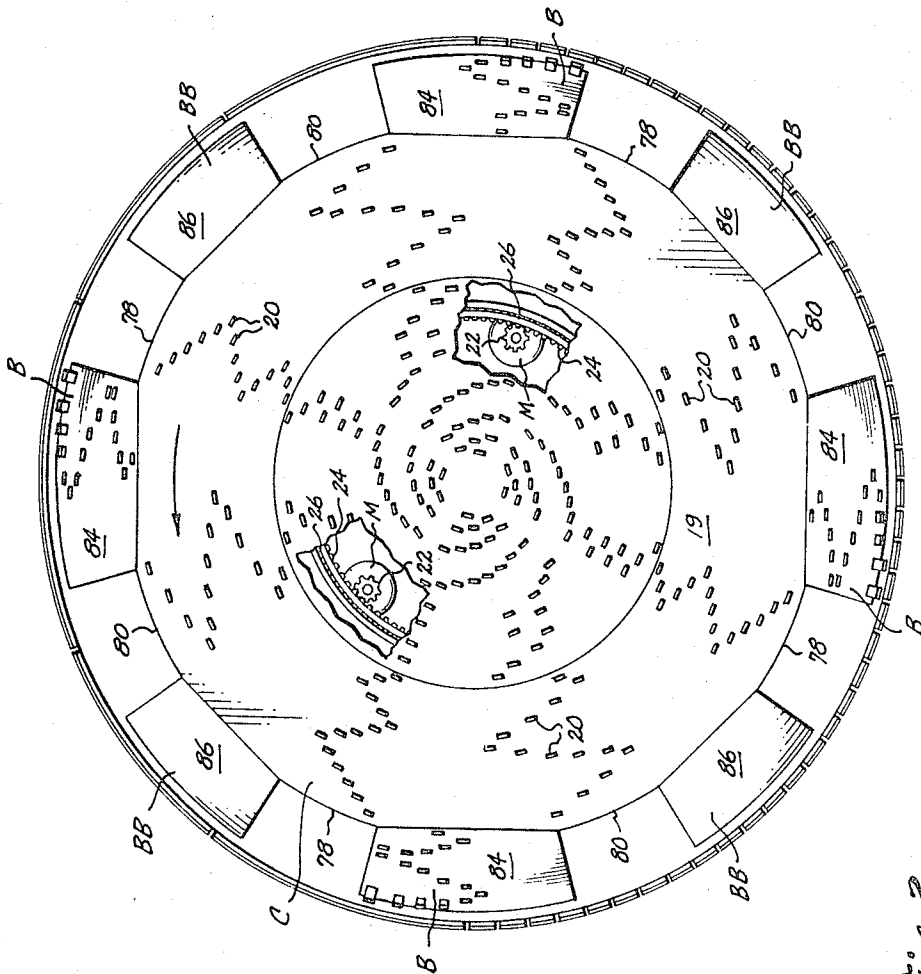


Fig. 3.

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5 Sheets-Sheet 4

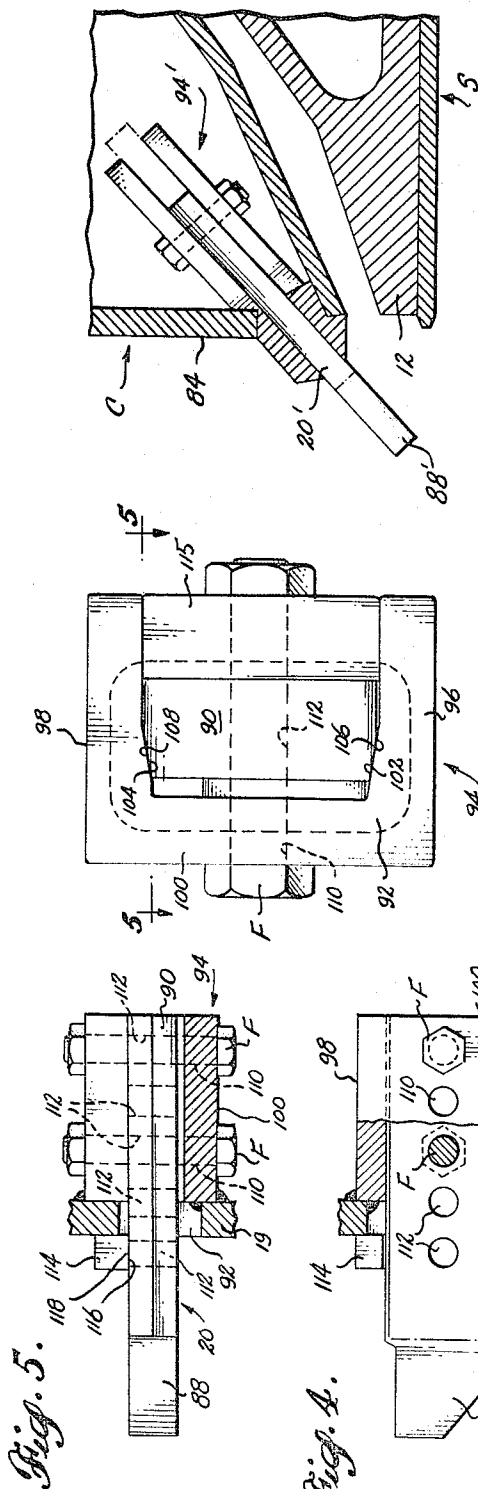


Fig. 7.

Fig. 6.

Fig. 4.

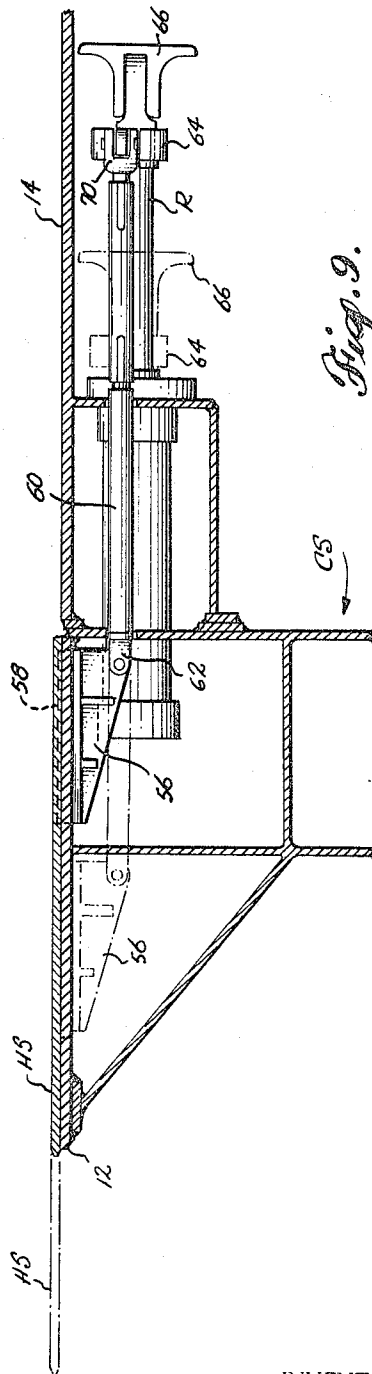


Fig. 9.

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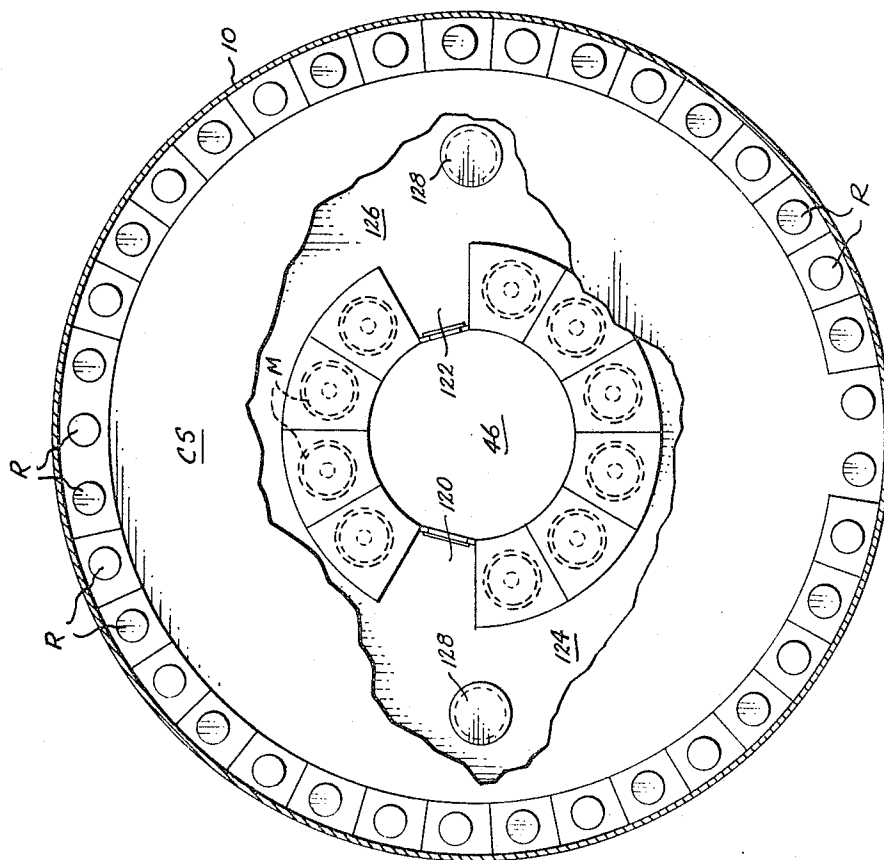


Fig. 8.

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CUTTERHEAD ASSEMBLY FOR A SHIELD-TYPE TUNNELING MACHINE

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Filed May 31, 1963, Ser. No. 284,709

31 Claims. (Cl. 299-33)

The present invention relates to a cutterhead assembly for a tunneling machine, and more particularly to a shield mounted, rotary cutterhead characterized by a generally disk-shaped cutter carrying forward wall; a plurality of buckets circumferentially spaced about the periphery of said forward wall, some of which are constructed to pick up mined material only while the cutterhead rotates in one direction, and others being constructed to pick up mined material regardless of the direction of rotation; a hollow interspace divided into alternately arranged, radially extending bucket chutes and cutterhead service compartments; and a cutter mounting arrangement by which the cutters are detachably mounted onto the rear side of those portions of the forward wall situated in front of the service compartments.

Heretofore, in known tunneling machines of the rotary cutterhead type, it has been the practice to mount the cutters onto the front side of the cutterhead forward wall. With this arrangement, when some or all of the cutters had to be repaired or replaced it became necessary to back the tunneling machine away from the tunnel face and for a workman to crawl into the space formed between the cutterhead front wall and the tunnel face to make the repairs or to replace the cutters. This work was both hazardous and uncomfortable. The workman had to climb up on the cutterhead front wall using the cutters as steps in order to reach the majority of the cutters. There was always constant danger of rocks dislodging from an overhead location and falling on the workman and/or the collapsing of the entire tunnel face.

It is a principal object of the present invention to provide a cutterhead assembly and cutter mounting arrangement wherein the individual cutters are mounted onto the cutterhead from the rear side of the forward wall thereof and the installation and removal of the cutters is performed within the protection of service compartments located in the cutterhead behind said forward wall. Openings are provided in the front wall at each cutter location, and the front end or knife portions of the cutters extend through these openings forwardly of the front wall while the rear end or shank portions of the cutters are bolted or otherwise suitably detachably connected to mounting means mounted on the rear side of the cutterhead forward wall contiguous the openings.

Objects, features, and advantages of the present invention further include the provision of a cutterhead assembly for a shield type tunneling machine wherein:

(a) The cutterhead is adapted for rotation in both the clockwise and counterclockwise directions and is provided with bucket means at its periphery, some of which, termed one-way buckets, have a single scoop opening in the direction of normal rotation, and others of which, termed two-way buckets, have scoops opening in both directions of rotation;

(b) The cutterhead includes radially extending material chutes preferably arranged in alternate fashion with the cutterhead service compartments, said chutes receiving the mined material from the scoops and when in a substantially upright position discharging such material onto a material receiving station located partially at least within a relatively large central opening in the rear wall of the cutterhead, such material receiving station pref-

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erably taking the form of a receiving conveyor forming the first stage of a conveyor system adapted for removal of the mined material from the location of the machine within the tunnel to a depository situated outside of the tunnel;

(c) The mounting means for each cutter comprises an elongated mounting element attached at its front end to the rear side of the cutter carrying wall contiguous a cutter receiving opening in said wall, said mounting element having an elongated open interior and at least one wall with a plurality of openings in it, and each cutter is elongated and includes a knife or blade end and a shank end, with a plurality of openings in said shank end selectively alignable with the openings in the said wall of the mounting element;

(d) At least some of the radially outermost cutters extend out from the front wall of the cutterhead at an angle and are adjustable so as to occupy an extended position wherein the knife portions thereof are situated in front of the cutting edge of the shield so as to cut a path therefor and a second, retracted position wherein the knife portions of such cutters are situated somewhat radially inwardly of the shield cutting edge; and

(e) A retractable sectional hood is mounted for reciprocal movement in the outside of the cutterhead support portion of the shield skin and the thrust rams located in the vicinity of the hood are utilized as actuators for extending the hood sections.

These and other objects, features, advantages and characteristics of the present invention will be apparent from the following description of typical and therefore non-limitative 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 and

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.

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 (not shown), and the lower race of which is firmly attached to the rear wall of the cutterhead, also by means of nut and bolt assemblies (not shown). In accordance with conventional practice a series of roller or ball members are retained between said inner and outer race portions of the bearing 18. For a more detailed illustration and description of the mounting arrangement of the cutterhead C onto the cutterhead support CS reference is made to the copending application of Larrouze et al., Serial No. 284,604, filed May 31, 1963, now Patent No. 3,266,257, and entitled Shield Tunneling Method and Mechanism.

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 or 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 28 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 di-

rection 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 counter-torque is produced tending to rotate the cutterhead support CS and the other shield components in the counter-clockwise 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 counter-torque, 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, preferably in accordance with the procedures and techniques outlined in the aforementioned copending application Serial No. 284,604. A pair of segment erectors E are mounted on the tube 52 for rotation thereabout. The means for rotating the segment erectors E about tube 52 include 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 ex-

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tended position (shown in broken lines 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 section 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 the 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 said 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

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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 surfaces 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 surfaces 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 afore-

said copending Larrouze et al. application Serial No. 284,604. Also in accordance with the invention forming the subject matter of the said copending Larrouze et al. application Serial No. 284,604, 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 Larrouze et al. application Serial No. 284,604), 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.

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 shield-type tunneling machine comprising:

- (a) a shield having a generally cylindrical skin, and a transverse cutterhead support spanning the interior of said skin and including a relatively large central passageway;
- (b) a rotary cutterhead situated forwardly of said cutterhead support, said cutterhead comprising forward wall means, a plurality of cutters extending forwardly of said forward wall means, a plurality of buckets circumferentially spaced around the periphery of said forward wall means, rear wall means spaced behind said forward wall means and defining therewith a hollow innerspace, said rear wall means being disposed forwardly of the cutterhead support, and including a central opening related generally coaxially to, and situated forwardly of, the passageway in the cutterhead support, and means dividing at least a portion of said cutterhead innerspace into material chutes extending radially inwardly from said buckets;
- (c) mined material receiving means partially situated in the central passageway of said cutterhead support, and extending thence forwardly through the central opening in the rear wall means of said cutterhead

and into the central region of the hollow innerspace of said cutterhead, in position to receive mined material from the material chutes when such chutes are substantially in an overhead position relative to said receiving means;

- (d) means between said cutterhead and the front face of said transverse cutterhead support, rotatably supporting said cutterhead on and forwardly of said cutterhead support; and
- (e) a mined material removal tube connected at its forward end to the cutterhead support, about said central passageway, and extending rearwardly of said cutterhead support and said central opening.

2. A cutterhead assembly for a shield-type tunneling machine in accordance with claim 1, including means for selectively rotating said cutterhead in either direction, and wherein some of said buckets are one-way buckets and include scoop means for scooping up material during rotation of the cutterhead in one direction only, and others of the buckets are two-way buckets and include scoop means for scooping up material during rotation in both directions.

3. A cutterhead assembly for a shield-type tunneling machine in accordance with claim 1, wherein the said means rotatably supporting the cutterhead on a front portion of the cutterhead support includes an annular bearing situated between the rear wall means of said cutterhead and a forward portion of said cutterhead support, in concentric surrounding relationship to the central opening in the rear wall means of the cutterhead.

4. A cutterhead assembly in accordance with claim 1, wherein the means rotatably supporting said cutterhead comprises an annular bearing in concentric surrounding relationship to the central opening in the rear wall means of the cutterhead, and includes inner and outer races, one of which is secured to the cutterhead, and the other is secured to the cutterhead support, with gear teeth on the bearing race that is secured to the cutterhead, and said assembly also includes at least one drive gear positioned between said cutterhead and the said cutterhead support, in mesh with the gear teeth on the bearing race, and motor means for rotating said drive gear, which motor is mounted on said cutterhead support.

5. A cutterhead assembly in accordance with claim 2, wherein the cutterhead includes cutter carrying extensions of the front wall means extending radially outwardly from the periphery of said front wall means and forming forward wall portions of said one-way buckets.

6. A cutterhead assembly for a shield-type tunneling machine in accordance with claim 5, wherein such assembly includes means forming service compartment extensions extending radially outwardly from at least some of the service compartments, and rearwardly of the cutter carrying extensions, and wherein cutter receiving openings extend through said cutter carrying extensions and cutter mounting means are located on the rear side of such cutter carrying extensions at said openings.

7. A cutterhead assembly for a shield-type tunneling machine comprising: a shield having a generally cylindrical skin, and a transverse cutterhead support spanning the interior of said skin, and including a relatively large central passageway; a rotary cutterhead situated forwardly of said cutterhead support, said cutterhead comprising forward wall means, a plurality of cutters extending forwardly of said forward wall means, a plurality of buckets circumferentially spaced around the periphery of said forward wall means, rear wall means spaced behind said forward wall means and defining therewith a hollow innerspace, said rear wall means including a central opening related generally coaxially to the passageway in the cutterhead support, and means dividing at least a portion of said cutterhead innerspace into material chutes extending radially inwardly from said buckets, and a plurality of service compartments alternating in arrangement with said material chutes, with the openings for the cutters ex-

tending through those portions of the cutterhead front walls that also form the front walls of the service compartments, with the cutters being mounted by mounting means situated on the back side of said portions of the cutterhead front wall; access means through which service personnel may enter and leave the service compartments; a mined material receiving station situated partially at least within said cutterhead support central passageway and arranged to receive mined material from the material chutes when such chutes are substantially in an overhead position relative to said station; and means rotatably supporting said cutterhead on and forwardly of said cutterhead support.

8. A cutterhead assembly for a shield-type tunneling machine in accordance with claim 7, also comprising a mined material removal tube connected at its forward end to the cutterhead support, about the central passageway, and extending rearwardly of said cutterhead support and said central passageway.

9. The combination of claim 8, wherein said guide means comprises a pair of opposed, laterally sloping surfaces, each extending lengthwise of the interior opening, wherein the shank portion of the cutter includes matching laterally sloped surfaces relatable to said laterally sloped surfaces of the track means, and wherein said means for detachably connecting the shank portion of the cutter to the mounting means includes alignable, generally laterally extending openings in said shank portion and in said mounting means, a pin-like element insertable through said aligned openings, and means for retaining it therein.

10. The combination according to claim 9, wherein said mounting means includes a plurality of axially spaced, generally laterally extending openings, each selectively alignable with the said generally laterally extending opening in the shank portion of the cutter.

11. The combination according to claim 9, wherein the shank portions of the cutters include a plurality of axially spaced, generally laterally extending openings, each selectively alignable with the said generally laterally extending opening in said mounting means.

12. A shield type tunneling machine usable in a tunneling operation wherein a tunnel lining characterized by axially abutting rings of circumferentially abutting segments is erected generally in the wake of the machine but under cover of the shield skin, said machine comprising:

- (a) a shield comprising:
 - (1) a generally cylindrical skin having a forwardly directed cutting edge and a rearwardly extending tail section,
 - (2) a transverse cutterhead support spanning the interior of said skin intermediate the ends thereof, and
 - (3) a plurality of piston-cylinder actuators mounted around the periphery of said cutterhead support with the pistons thereof extending in a rearward direction to react against the tunnel lining previously erected and in that manner advancing the tunneling machine forwardly into the material to be mined,
- (b) a rotary cutterhead mounted for rotation on said cutterhead support and extending forwardly thereof to be at least partly enveloped by said cutting edge;
- (c) means for rotatably driving said cutterhead;
- (d) hood means reciprocally mounted on approximately the upper one-half of the shield; and
- (e) means for moving said hood means from a retracted position wherein no substantial portion of the hood means extends forwardly of the cutting edge to an extended position wherein a substantial portion of said hood means extends forwardly of the cutting edge.

13. The combination of claim 12, wherein the means for moving the hood means between retracted and extended positions includes at least some of the piston-cyl-

der actuators located in the vicinity of the hood means.

14. In a cutterhead assembly for a tunneling machine:

- (a) a rotary cutterhead having a cutter carrying forward wall;
- (b) a generally hollow interior including at least one service compartment and at least one radially extending material chute;
- (c) bucket means at the periphery of said cutter carrying wall, said bucket means including a scoop having an open mouth portion and a curved material turning portion, said scoop being disposed to discharge material into the radially extending chute means, said bucket means also including a cutter carrying portion mounted adjacent to the said material turning wall means, and said cutter carrying portion including a forward wall having at least one cutter receiving opening therein and cutter mounting means on the rear side of said wall contiguous the opening;
- (d) cutter means attached to said mounting means and including a knife portion extending through the opening forwardly of the forward wall a predetermined distance;
- (e) service compartment means situated rearwardly of the forward wall of the cutter carrying portion of the bucket and communicating with the service compartment in the cutterhead; and
- (f) access means permitting ingress to and egress from the service compartments from a location to the rear of said cutterhead.

15. In a cutterhead assembly for a tunneling machine: a rotary cutterhead comprising a cutter carrying wall; openings in said wall at a plurality of locations; cutter mounting means situated on the rear side of said wall generally contiguous said openings; a cutter extending through each of said openings, said cutters having knife and shank end portions, with the knife end portion extending forwardly of said wall; and means detachably connecting the shank portion of each cutter to its mounting means, with the shank ends of the cutters being substantially elongated and the mounting means comprising an axially elongated element attached at its front end to the rear side of the cutter carrying wall, said element including an axially extending interior opening and guide means in said opening for said cutter.

16. A cutterhead assembly for a tunneling machine comprising a rotary cutterhead including a cutter carrying wall, openings at a plurality of locations in said wall, cutter mounting means situated on the rear side of said wall generally contiguous each said openings, a cutter extending through each of said openings, and insertable into position forwardly through its opening from the rear side of said wall, said cutters having knife and shank end portions, with the knife end portion extending forwardly of said wall, means detachably connecting the shank portion of each cutter to its mounting means, a rear wall spaced rearwardly of the front wall to form a hollow cutterhead interior, with at least one service space compartment provided within said interior, with said forward wall spanning across the forward end of said service compartment and forming a forward closure therefor, and a barrier to prevent material from the tunnel face from entering the said service compartment, with said cutter mounting means being accessible from said service compartment, and access means permitting ingress to and egress from said service compartment.

17. A cutterhead assembly for a tunneling machine in accordance with claim 16, wherein the generally hollow interior is divided into a plurality of generally radially extending service compartments, the access means permitting ingress to and egress from said service compartments extends through the said rear wall of said cutterhead, and the cutter receiving openings extend through those portions of the cutterhead front wall forming the forward boundaries of said service compartments.

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18. The combination of claim 17, wherein each said cutter mounting means comprises an elongated mounting element fixed at its front end to the rear surface of the cutterhead forward wall, said mounting element including a channel receiving the shank portion of the cutter element, and defined in part by a side member in juxtaposition with said shank, said side member and said shank including generally coaxially alignable transverse openings; and wherein a bolt means extends through said openings and secures said cutter element to the mounting means.

19. The combination of claim 16, wherein the shank ends of the cutters are substantially elongated and the mounting means comprises an axially elongated element attached at its front end to the rear side of the cutter carrying wall, said element including an axially extending socket and guide means in said socket for said cutter.

20. The combination of claim 19, wherein said guide means comprises a pair of opposed, laterally sloping surfaces, each extending lengthwise of the interior opening, wherein the shank portion of the cutter includes matching laterally sloped surfaces relatable to said laterally sloped surfaces of the guide means, and wherein said means for detachably connecting the shank portion of the cutter to the mounting means includes alignable, generally laterally extending openings in said shank portion and in said mounting means, a pin-like element insertable through said aligned openings, and means for retaining it therein.

21. The combination according to claim 20, wherein said mounting means includes a plurality of axially spaced generally laterally extending openings, each selectively alignable with said generally laterally extending opening in the shank portion of the cutter.

22. The combination of claim 20, wherein the shank portions of the cutters include a plurality of axially spaced, generally laterally extending openings, each selectively alignable with the said generally laterally extending opening in said mounting means.

23. A shield tunneling machine usable in a tunneling operation wherein a tunnel lining characterized by axially abutting rings of circumferentially abutting segments is erected generally in the wake of the machine but under cover of the shield skin, said machine comprising:

- (a) a shield comprising
 - (1) a skin having a forwardly directed cutting edge,
 - (2) cutterhead support means spanning the interior of said skin, and
 - (3) a plurality of piston-cylinder actuators mounted around the rear periphery of said cutterhead support, with the pistons thereof extending rearwardly to react against the tunnel lining previously erected and in that manner advance the tunneling machine forwardly,
- (b) a rotary cutterhead mounted for rotation on and forwardly of said cutterhead support;
- (c) means for rotating said cutterhead;
- (d) hood means mounted on the shield skin for reciprocal movement axially of the tunnel; and
- (e) means for moving said hood means from a retracted position, wherein no substantial portion of it extends forwardly of the cutting edge, to an extended position wherein a substantial portion of said hood means extends forwardly of the cutting edge.

24. The combination of claim 23, wherein the cutterhead is at least partially enveloped by the shield cutting edge, and said cutterhead includes at least one peripheral cutter mounted on said cutterhead for adjustment between a first position, in which the cutting edge of said cutter is generally forwardly of the shield cutting edge and in a position of interference with said hood means, and a second position in which the cutting edge of said cutter is radially inwardly in a position of interference with said hood means.

25. The combination of claim 23, wherein the means for moving the hood means between retracted and ex-

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tended positions includes at least one of the piston-cylinder actuators located in the vicinity of the hood means.

26. The combination of claim 23, wherein the means for moving the hood means includes a push-pull rod interconnected between said hood means and each piston-cylinder actuator used for moving the hood means.

27. In a cutterhead assembly for an earth boring machine; a reversible cutterhead, cutterhead support means mounting said cutterhead for rotation about a center axis, reversible drive means for selectively rotating the cutterhead in either direction about said axis, and means for moving the cutterhead assembly axially forwardly into an earth formation, said cutterhead comprising a forward wall, forwardly directed cutter means on said wall for cutting and dislodging the earth formation during cutterhead rotation, in either direction, at least one peripheral bucket having an axially forwardly directed inlet opening and a scoop which opens in one direction of cutterhead rotation, and scoops up earth formation cuttings during cutterhead rotation in such direction, at least one other peripheral bucket having an axially forwardly directed inlet opening and a scoop which opens in the opposite direction of cutterhead rotation, and scoops up earth formation cuttings during cutterhead rotation in such direction, each said scoop occupying a fixed position on the cutterhead and including wall means for turning and directing the scooped earth formation cuttings generally radially inwardly, and an elongated material chute extending generally radially inwardly from each said bucket.

28. The combination of claim 27, wherein at least one of said buckets includes two scoops, one opening in each direction of rotation, and said scoops both discharge into the material chute of said bucket, and wherein the wall means of each said scoop for turning the earth formation cuttings each commences at the outer radial boundary of the scoop, near its inlet, and thence curves both radially inwardly and toward the wall means of the other scoop, and substantially meets the other such wall inside said chute.

29. The combination of claim 28, wherein the material chute further includes a partition extending radially inwardly therethrough a substantial distance from the point of substantial contact of said curved walls, said partition serving to direct the earth formation cuttings radially inwardly into the chute, thereby preventing such cuttings, when scooped up by the leading scoop, from moving generally tangentially and from said chute through the trailing scoop.

30. The combination of claim 29, wherein a cutter carrying wall portion is situated circumferentially adjacent at least one of the bucket inlets, and at least one cutter is mounted on said cutter carrying wall.

31. The combination of claim 29, wherein the said bucket inlets are peripheral openings in the forward wall between adjacent peripheral portions of said forward wall, and each said scoop is circumferentially spaced from its bucket inlet and is behind one of said peripheral portions of said forward wall.

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