

June 13, 1961

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2,988,348

ROTARY TUNNELING MACHINES

Filed July 11, 1957

4 Sheets-Sheet 1

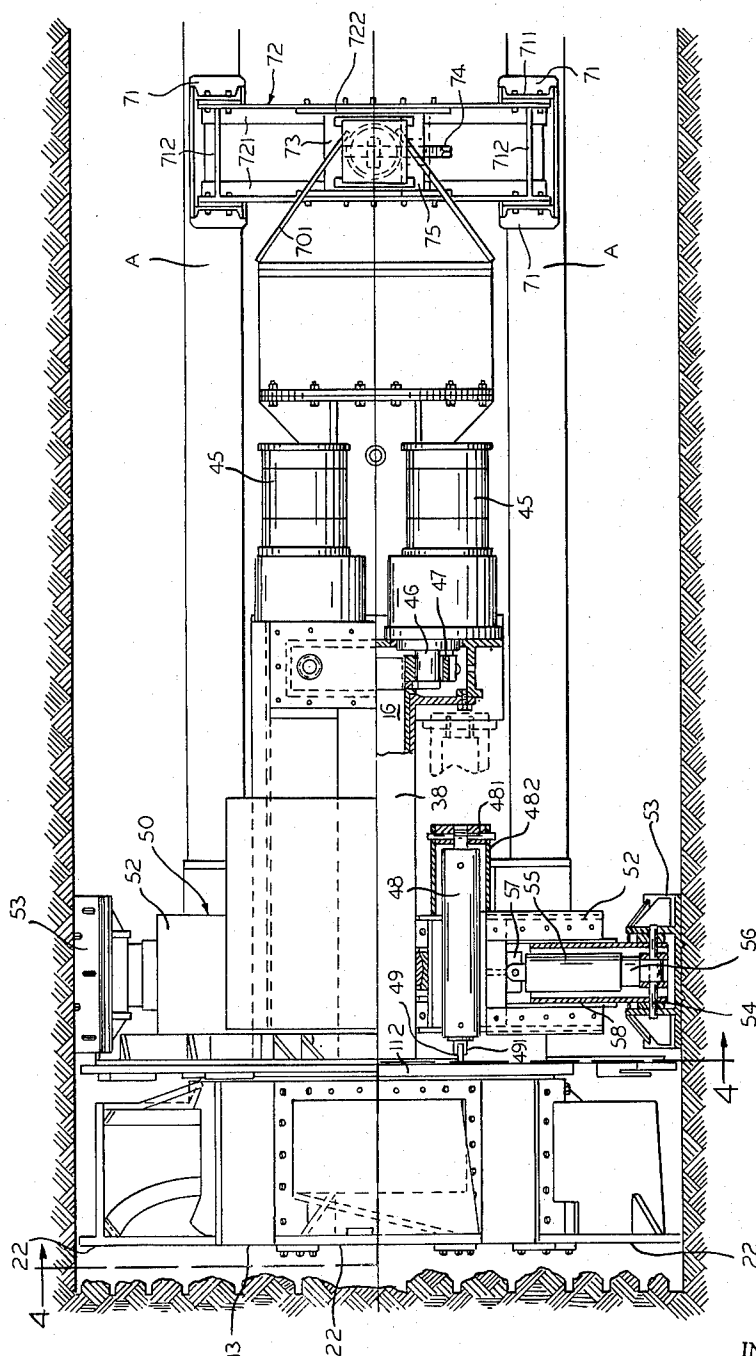


Fig. 1

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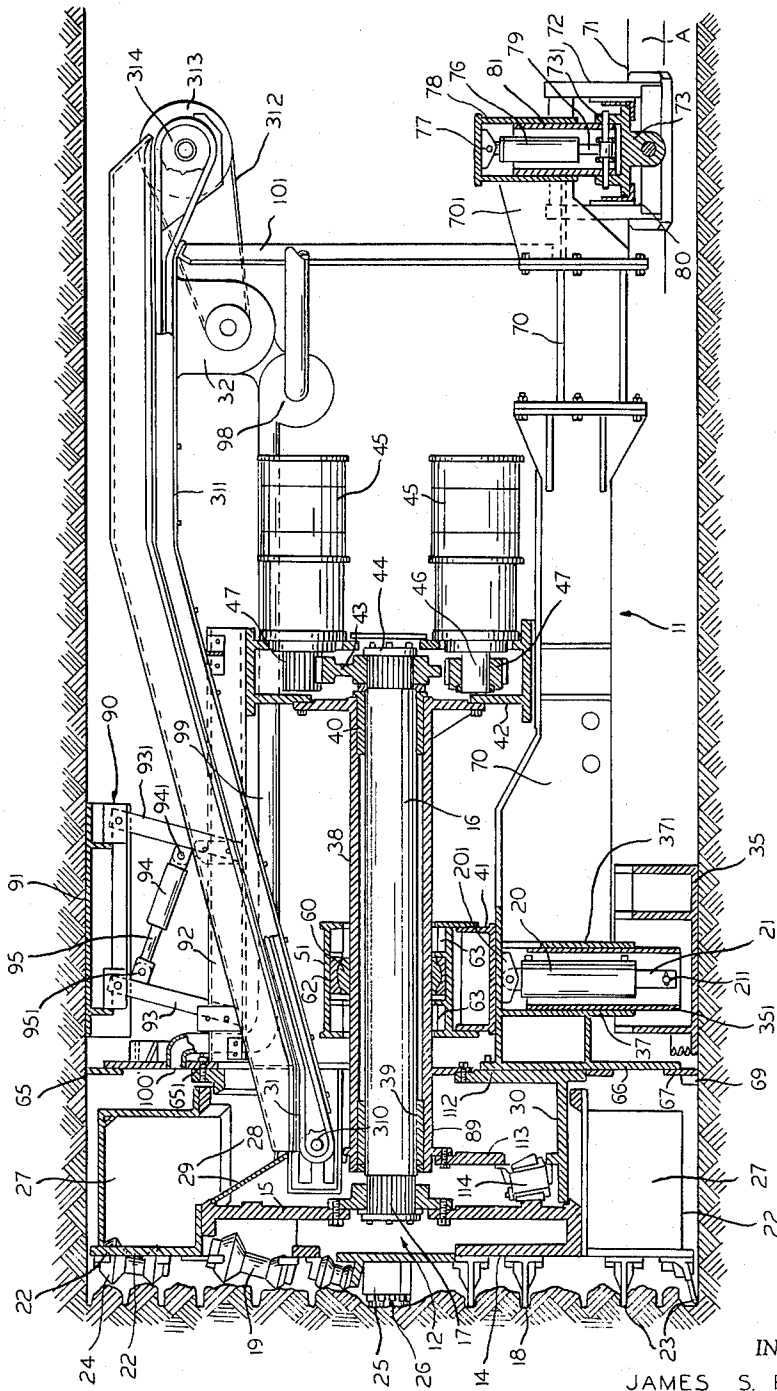


Fig. 2

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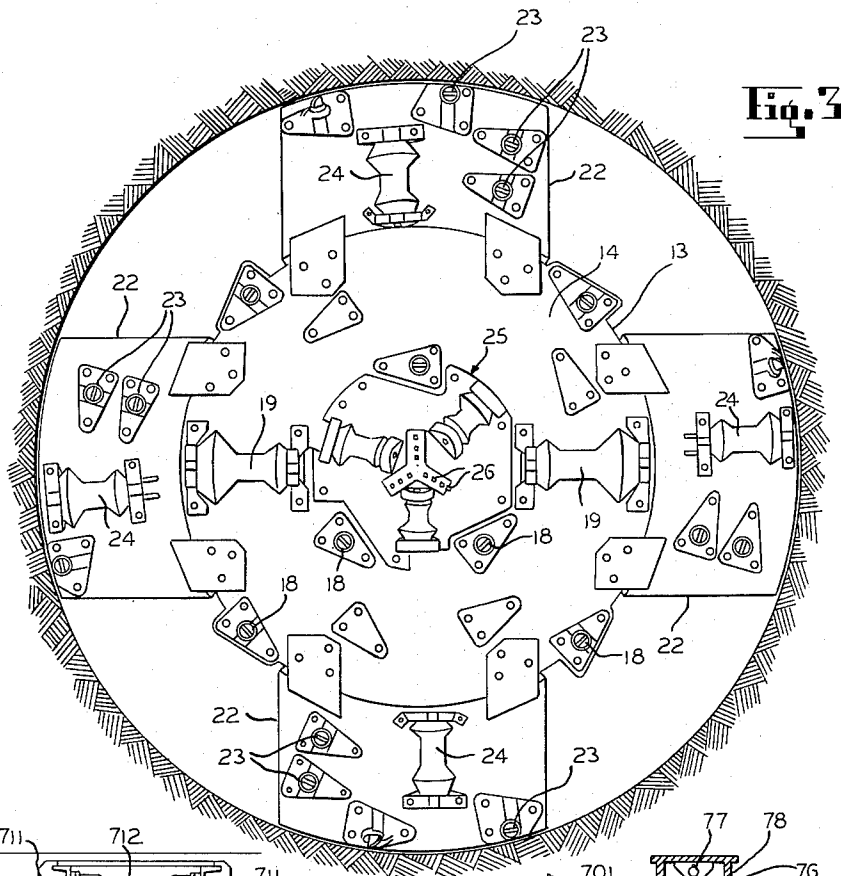


Fig. 3

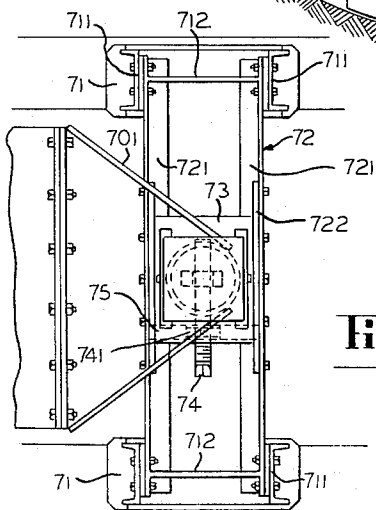


Fig. 6

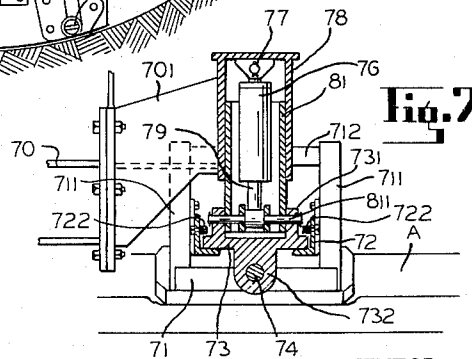


Fig. 7

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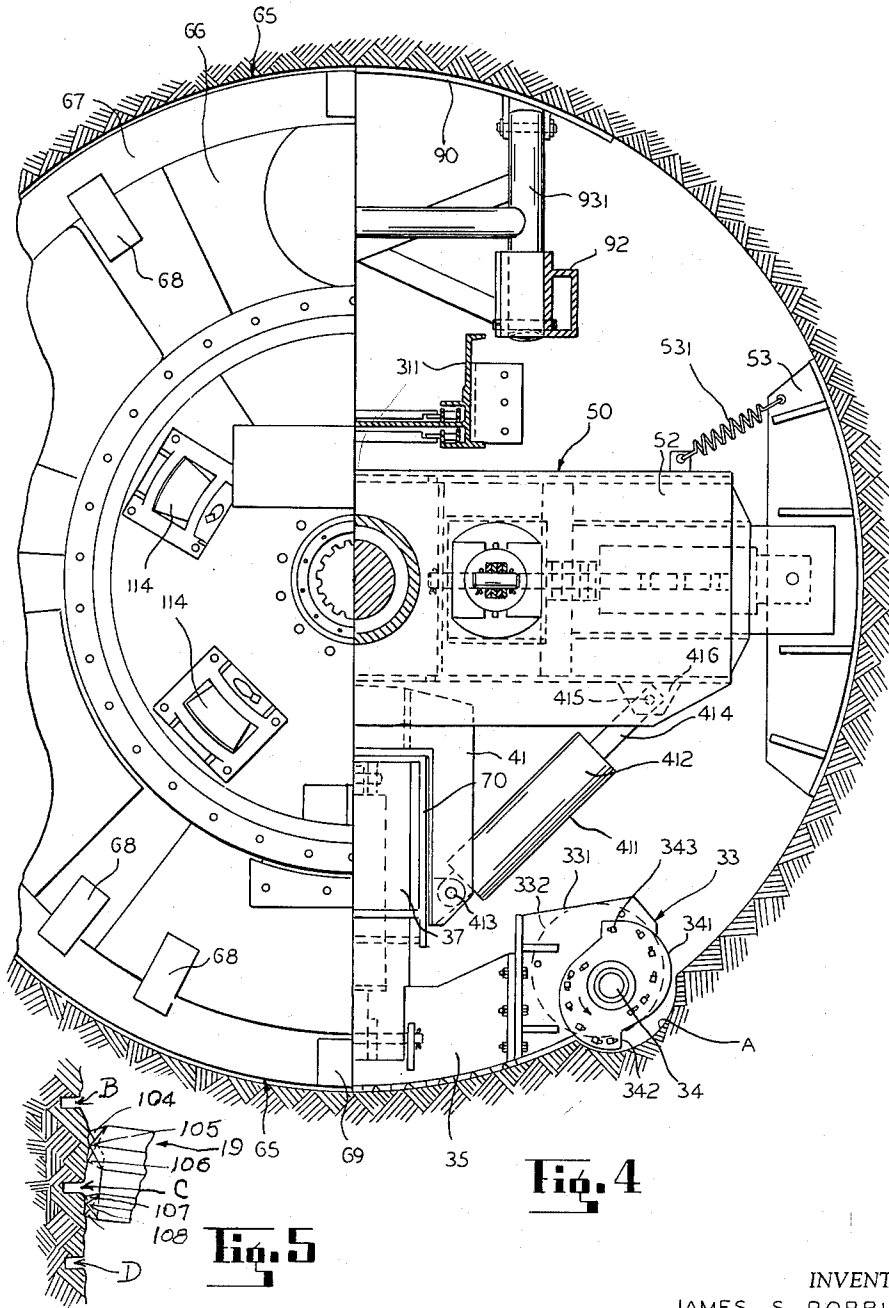
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ROTARY TUNNELING MACHINES

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15 Claims. (Cl. 262-7)

This invention relates to improvements in tunnel boring machines having a rotary cutter head especially adapted for boring directly in relatively hard minerals, and has for its principal object to provide a more efficient machine of this character.

A further object of the invention is to provide improved means for anchoring the main frame of the machine against the tunnel walls so as to counteract the torsion of the rotary cutter head.

A still further object of the invention is to provide improved means associated with the anchoring means, for varying the direction of advance of the machine during its tunneling operation, when desired.

Other objects and advantages of the invention will appear from time to time as the following description proceeds.

The invention may best be understood by reference to the accompanying drawings, in which:

FIGURE 1 is a top view of a machine made in accordance with my invention, with parts broken away or shown in section;

FIGURE 2 is a side view of the machine with most of the parts shown in section; and with portions broken away;

FIGURE 3 is a front view of the machine;

FIGURE 4 is a fragmentary front end view of the machine looking along line 4-4 of FIGURE 1 and showing half of the machine in vertical section;

FIGURE 5 is a detail view showing a modified arrangement of core breaking rollers; and

FIGURES 6 and 7 are detailed plan and longitudinal sections of the rear cross arm structure, drawn to a larger scale than in FIGURES 1 and 2 respectively.

Referring now to details of the embodiment of the invention shown in the drawings, the machine has as its principal elements a main frame 11 having a rotatable cutter head at its forward end indicated generally at 12.

The cutter head 12 includes a central disc 13, having a front wall 14, and a rear wall 15, and also having a plurality, herein four, cutter arms 22 extending radially from the periphery of said central disc. The rear wall 15 of the central disc 13 is fixed to the front end of a main drive shaft 16, as by a splined joint 17. The front wall 14 has a plurality of cutter bits 18, 18 projecting forwardly therefrom, and also has a plurality of core breaking rollers 19, 19 carried thereon in position to break down cores left between adjacent cutter bits 18, 18.

The front faces of the radially extending cutter arms 22, 22 are in substantially the same vertical plane as the front plate 14 of the central disc 13, and each carries a series of kerf cutting bits 23 and a plurality of core breaking rollers 24 generally similar to those on the front face of said central disc. In the center of the disc 13 is a pilot member 25 carrying forwardly projecting cutter bits 26. The general arrangement of the kerf cutting bits and core breaking rollers, just described, is essentially the same as disclosed in my prior Patent No. 2,766,978 so need not be further shown nor described herein.

Each of the radially extending cutter arms 22 carries a material gathering bucket 27 on its rear face. The leading sides of the buckets 27 are open to enable them to scoop up the loose material which drops to the floor of the tunnel as it is removed from the working face.

The main frame 11 includes a longitudinally elongated

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tubular bearing support 38 having bearings 39 and 40 fixed in its front and rear ends in which the drive shaft 16 for the cutter head 12 is journaled. Two generally upright annular plates 112 and 113 are fixed to the front end of the tubular bearing support 38 in longitudinally spaced relation, and have a forwardly projecting annular portion 30 formed integrally therewith, about which buckets 27 on the arms 22 are adapted to rotate, as seen in FIGURE 2. A plurality of bearing rollers 114 are mounted in circumferential spaced relation in the forwardmost plate 113 so as to provide rolling support for the rear face of the inner wall 15 of the cutter head 12.

As each bucket 27 is rotated to a position at the top of the cutter head, the loose material therein falls by gravity through a bucket outlet opening 28, thence through a registering chute 29 formed in the annular forwardly projecting portion 30 of the main frame 11, and on to the front end of an endless belt conveyor 31 trained over an idler 310, the front end of which is disposed within the annular portion 30 of the frame 11. The rear of the conveyor 31 has a frame 311 which is supported along the top of the main frame 11, as by up-rights 101, with its rear end extending beyond said main frame for discharging material upon any suitable conveying means.

Any suitable means may be provided for driving the endless belt conveyor, as by an electric motor 32 suspended from the conveyor frame 311 overhanging the rear end of the machine, and connected as by a belt 312 to a gear reduction mechanism 313, which in turn has driving connections with a belt pulley 314 for the rear end of the belt conveyor. The loose material may thus be continuously removed from the tunnel as rapidly as it is dislodged from the working face.

The main frame 11 is supported on the tunnel floor just rearwardly of the cutter head 12 by a shoe 35 telescopically adjustable with respect to a depending leg 37 formed integrally with said main frame. The bottom face of the shoe 35 is curved transversely of the machine so as to fit on the arcuate bottom of the tunnel.

Vertical adjustment of the shoe 35 relative to the main frame is provided by a hydraulic cylinder 20 connected at its upper end to a bracket 201 fixed to the main frame and having a piston rod 21 connected by a cross pin 211 to a cylindrical member 351 formed integrally with the shoe 35. The cylindrical member 351 is guided for telescopic adjustment in an upright cylindrical bearing 371 forming part of the leg 37.

Fixed at opposite sides of the shoe 35 is a pair of side groove cutters 33 (see FIGURE 4), each consisting of a motor housing 331 enclosing an electric motor 332 having suitable drive connections (not shown) to a shaft 34 on which is mounted a rotary cutter 341 adapted to cut a longitudinal side groove indicated at A in FIGURE 4, radially beyond the bore pattern cut by the cutter head 12. In the form of rotary cutter 341 shown herein, said cutter consists of a plate having generally opposed radial cutting edges 342 in its periphery and also having a plurality of forwardly projecting cutter bits 343 mounted on its front face so as to cut similar grooves A at opposite sides of the shoe 35 as the machine is progressed in its cutting operation. These grooves A serve to aid in stabilizing the machine during its forward progress, as will hereinafter be more fully described.

An enlarged gear case 42 is mounted on the rear end of the tubular bearing support 38, and encloses the gearing for driving a pinion 43 fixed on the rear end of the drive shaft 16, as by a splined connection 44.

In the form shown herein, the drive shaft 16 and its gear 43 are driven by four similar electric motors 45, 45, each mounted on and extending rearwardly from

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the rear face of the gear case 42, and having its motor shaft 46 extending into the gear case, with a pinion 47 thereon meshed with the gear 43 on the drive shaft 16. Suitable electrical connections and controls (not shown) are provided for driving the four motors 45 in unison to rotate the cutter head 12.

The machine has laterally extending supporting means for engaging the side walls of a tunnel, which includes a cross arm or member, indicated generally at 50. Said cross arm or member has an annular bearing portion 51 at its center which surrounds the tubular bearing support 38 of the main frame. The two opposite ends 52, 52 of said cross member have laterally movable arcuate shoes 53, 53 adapted for engagement with the side walls of the tunnel, as seen in FIGURES 1 and 3. Each of the shoes 53 is pivotally connected by a longitudinally disposed pin 54 to a piston rod 56 of a hydraulic cylinder 55. The inner end of the cylinder 55 is connected to a bracket 57 fixed in the arm 52. Each cylinder and piston are enclosed in a cylindrical member 58 which is telescopically movable relative to the outer end of its arm 52, so as to provide a guide means for the shoe, and to protect the cylinder and its adjacent parts from ingress of dirt and the like.

The hydraulic cylinders 55 have suitable controls and connections (not shown) for extending or retracting their pistons 56 either simultaneously or individually, for purposes which will presently be described.

The annular central bearing portion 51 of the cross member 50 is slidably mounted on the tubular bearing support 38 of the main frame 11 by a modified ball-and-socket joint, herein consisting of an annular ring 60 slidable along the tubular support 38, and with its peripheral surface formed with a circular, convex cross section, as shown in FIGURE 2. The inner periphery of the annular portion 51 has a reversely shaped concave ring 62 mounted therein and engaged on the outer face of the ring 60 on the tubular support 38. With this arrangement, limited rocking movement is afforded between the cross member 50 and the main frame 11 to permit limited deviations in the direction of advance of the cutter head, as will presently be described.

The inner periphery of the annular portion 51 is preferably provided with a pair of annular recesses 63, 63 at opposite sides of the ball-and-socket joint, just described, adapted to contain suitable flexible sealing means around the tubular support to protect the ball-and-socket joint from ingress of dirt and the like.

The main frame 11 and the cutter head 12 are advanced as a whole relative to the cross arm 50 by means of a pair of hydraulic cylinders 48, the rear ends of which are pivotally connected to transversely disposed pins 481 fixed in rearwardly extending projections 482 carried by the cross member 50 at opposite sides of and adjacent the tubular support 38 of the main frame 11 (see FIGURE 1). Each of the hydraulic cylinders 48 has a piston rod 49 at its front end which is pivotally connected by a pin 491 to the upright plate 112 of the main frame 11. With this arrangement, the cross member 50 is adapted to be anchored in the tunnel by extending the shoes 53, 53 into engagement with the side walls and with the piston rods 49 of cylinders 48 in retracted position. Thereafter, by applying fluid pressure to the rear ends of the cylinders 48, the main frame 11 and cutter head 12 are advanced bodily toward the working face, while the cross member 50 remains stationary. During such advancing movement, the tubular support 38 of the main frame 11 passes through the central annular portion 51 of said cross member.

The main frame 11 has an inverted U-shaped guide member 41. The lower ends of said U-shaped guide member 41 are each connected by upwardly and outwardly extending struts 411, each having a hydraulic cylinder 412 pivoted thereto at 413, and a piston rod 414 in each cylinder pivotally connected as by pin 415 to an ear 416 on the under face of the adjacent end por-

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tion 52 of the cross arm 50. The purpose of the guide member 41 and the diagonally disposed struts 411 will be presently described.

Between the cutter head 22 and the cross member 50 is mounted an annular shield 65, the outer periphery of which is of substantially the same diameter as the cutting diameter of the cutter head 12. This shield is suitably supported on the main frame 11 as by bolts 651 (see FIGURE 2). This shield is provided to crowd the material deposited on the floor of the tunnel into position for loading into the buckets 27, and also to confine the dust produced the cutting operation to the area adjacent the working face. In the form shown herein, the shield consists of a central body portion 66 with a floating annular extension 67 which is slidably mounted about the periphery of said body portion 66 by a plurality of retainer plates 68 spaced outwardly of the body portion 66 and cooperating with said body portion to form outwardly opening slotted guides for said annular extension. This slotted connection permits the annular ring portion 67 to shift itself radially of the body portion 66, as may be required from time to time to adjust said ring to the tunnel walls. An auxiliary supporting shoe 69 is connected to the bottom edge of the annular ring 67 (see FIGURE 2) in position so that the bottom edge of the floating ring portion 67 will normally rest on the tunnel floor to prevent the loose material which is deposited on said tunnel floor in front of said shield from escaping rearwardly of the shield 65.

As will be seen from FIGURES 1 and 2, the rearwardly extending beam 70 of the main frame 11 passes below the gear case 42 and has a cross arm 72 at its rear end having a pair of arcuate longitudinally extending shoes 71 at its outer ends, which shoes are adapted to ride in side grooves A which have been previously formed in the tunnel wall by the groove cutters 33.

The cross arm 72 consists essentially of a pair of spaced angle bars 721, 721, which have upright channel bars 711, 711 connected at their outer ends to which the shoes 71 are rigidly connected at their lower ends. Each pair of channel bars 711, 711 are connected near their top ends by a bar 712 so as to form, in effect, cradles adjacent the opposite ends of the cross arm 72 for the reception of ballast means when such ballast means may be desired to stabilize the rear end of the machine as a whole.

The cross arm 72 is connected to the rear end of the beam 70 of the main frame 11 by a bracket 701, and vertical and lateral adjustment means shown in detail in FIGURES 6 and 7. The bracket 701 carries a vertically disposed cylindrical casing 78 in which a cylindrical member 81 is telescopically mounted. The lower end of the cylindrical member 81 is pivotally connected to upstanding ears 731 of a slidable plate 73 by a longitudinally disposed pin 811. Said plate 73 has its front and rear edges slidably mounted on the angle bars 721 so as to permit lateral adjustment of the cross arm 72 with respect to the bracket 701 and the beam 70 of the main frame. The plate 73 is restrained against vertical movement relative to the angle bars 721 by a pair of guide bars 722, 722 fixed to the opposed inner faces of said angle bars 721 (see FIGURES 6 and 7).

Lateral adjustment of the cross arm 72 relative to the supporting plate 73 and the rear end of the main frame 70 may be effected by a screw 74. Said screw has a non-threaded end portion pinned to a collar 741 which is retained between downwardly extending flanges of a cross bar 75 connected between the spaced angle irons 721, 721 at one side of the supporting plate 73, as seen in FIGURE 6. The threaded end portion of the screw 74 is threadedly engaged in a depending ear 732 of the sliding plate 73 (see FIGURE 7). The arrangement just described is such that by rotating the screw 74 in one direction or the other, the cross arm 72 may be adjusted transversely relative to the rear end of the beam 70 of the main frame 11, so as to aid in lateral steering

movement of the boring head of the machine, as will presently be more fully described.

Vertical adjustment of the rear end of the machine relative to the cross arm 72 and its shoes 71, is effected through a hydraulic cylinder 76 and a piston 79. The upper end of the cylinder is connected by a pin 77 to the upper end of the cylindrical casing 78. The piston 79 is connected to the pivot pin 811, which pin also connects the cylindrical member 81 to the supporting plate 73, as previously described. Thus, the rear end of the beam 70 can be raised or lowered with respect to the cross arm 72 by operation of the hydraulic cylinder 76 through suitable pressure supply means and controls (not shown). It will be further observed that the pivot pin 811 provides a connection between the lower end of the cylindrical member 81 and the sliding support plate 73 which permits limited lateral tilting movement of the beam 70 relative to the cross arm 72, as may be necessary from time to time.

A relatively light spring 531 is preferably connected under tension between the outer end 52 of the cross member 50 and the adjacent pivoted shoe 53 so as to control excessive pivotal movement of said shoes when they are disengaged from the side walls of the tunnel (see FIGURE 4).

A roof support indicated generally at 90, consists of a plate 91 curved to fit against the roof of the tunnel and connected to a longitudinal frame member 92 on the main frame 11 by two pairs of links 93, 93. Vertical adjustment of the roof support is effected by a hydraulic cylinder 94 pivotally connected to a cross bar 941 adjacent the lower end of the rearwardmost pair of links 931. The hydraulic cylinder 94 has a piston rod 95 pivotally connected to a cross bar 951 adjacent the upper ends of the forwardmost pair of links 93. The arrangement is such that by extending or retracting the piston 95 through the conventional fluid pressure controls, the two pairs of parallel links 93, 93 may be raised or lowered.

Means is provided for withdrawing excessive dust from in front of the shield 65 while the machine is in operation. This means consists of a blower 98 suitably mounted on the main frame and having an exhaust duct 99 leading to an inlet 100 formed in the shield, preferably near the upper edge thereof (see FIGURE 2). An exhaust line 101 leads from the blower 98 to a suitable point near the rear of the machine. The air duct inlet 100 is positioned so that a large proportion of the flying dust can be withdrawn from in front of the shield without affecting heavier particles of dust which tend to drop by gravity on the floor of the tunnel to be picked up by the buckets 27 and discharged in the usual way by the conveyor belt 31.

FIGURE 5 shows diagrammatically a modified arrangement of core breaking rollers 19 and their relation with the cutter bits 18 of the cutter head, which has special advantages in the dislodging of certain types of mineral from a solid tunnel face. With this modified arrangement, the cutter bits 18 on the cutter head are arranged as usual to cut well defined annular kerfs B, C and D in the working face, but a plurality of breaker rollers 19 which follow the cutter bits to break out the cores left between said kerfs are arranged with their V-shaped cutting edges disposed at different radial distances along said rollers, so as to attack each core at different radii instead of at a single radius, as has heretofore been common practice. In the arrangement shown diagrammatically in FIGURE 5, three different rollers are each provided with V-shaped cutting edges 103, 104 and 105 respectively, to attack the annular cores left between kerfs B and C, and also with three different V-shaped cutting edges 107, 108 and 109 for attacking the cores left between kerfs C and D.

The use and operation of the machine is as follows: To advance the cutter head toward the working face, the

two shoes 53, 53 at opposite ends of the cross member 50 are forced into anchoring relation against the side walls of the tunnel, with the cross member in a position near the front end of the tubular member 38 on the main frame, as seen in FIGURES 1 and 2. Hydraulic pressure is then exerted on the two forwardly extending hydraulic cylinders 48 to feed the cutter head and main frame forwardly toward the working face with the cutter head rotating. During this feeding movement the cross member 50 will remain in its initial anchored position until the main frame has been advanced relative to the cross arm through a distance corresponding to the working stroke of the piston rods 49 of feeding cylinders 48.

During the advance movement of the cutter head and main frame, the side groove cutters 33 will form grooves A, A along opposite sides of the front shoe 35. The front shoe 35 will slide forwardly along the tunnel floor while the shoes 71 on the rear cross arm 72 will ride in the side grooves A, A during the feeding movement. The speed of feed is controlled by the operator, depending upon the kind of mineral being cut.

When the feed piston rods 49 have reached the forward end of their normal stroke, the advance of the machine frame is temporarily discontinued and the side shoes 53 on the cross member 50 are withdrawn from anchoring engagement with the side walls of the tunnel. The piston rods 49 are then retracted to slide the cross member forwardly on the tubular member 38 to its initial feeding position relative to the main frame, as shown in FIGURES 1 and 2. The anchoring shoes are then extended so as to anchor the cross member 50 in a new, advanced position, whereupon the feeding movement of the main frame and cutter head can be resumed by again applying pressure to the rear ends of the feeding cylinders 48.

When it is desired to change the direction of advance of the cutter head in the tunnel either at an increased or decreased angle or gradient, the rear cross arm 72 is vertically extended or retracted in the desired direction by the hydraulic cylinder 76. Such extension or retraction of the cross arm 72 will cause the main frame to tilt about the ball-and-socket joint 60, 62 carried on the front cross arm 50 which is anchored to the side walls.

The advance of the machine can also be deviated laterally toward one side or the other of the tunnel by extending one of the shoes 53 on the cross member 50 while the opposite shoe 53 is being retracted. Lateral deviation in advance of the machine can also be aided when desired by adjusting the cross arm 72 laterally with respect to the rear end of the beam 70 by means of the adjusting screw 74.

The roof supporting plate 91 is adapted to be moved into elevated position in sliding engagement with the roof of the tunnel when fault zones, or weak or broken roof areas are encountered while the machine is being advanced. It may also be used in lowered position as a working platform from which a permanent roof support can be erected for such weak areas, or used as a platform for other tunneling operations adjacent the roof.

Due to the torque reaction from the cutter head as it rotates in a clockwise direction, as indicated in the drawings, the entire main frame will tend to tilt or turn in the opposite or counterclockwise direction about the axis of rotation of the cutter head.

It has been found in practice that this torque reaction may be sufficient to cause the several shoes 35, 53 and 71 to "creep" circumferentially of the tunnel walls, so that the machine as a whole will slowly tilt or turn in a counterclockwise direction.

To restore the main frame to its normal upright position when necessary, the anchoring shoes 53 on the cross member 50 are withdrawn from the side walls of the tunnel and the hydraulic cylinders 412 of the two struts 411, which connect the opposite ends of the cross arm 411, are actuated in mu-

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tually opposite directions so as to restore the cross member 50 to its normal horizontal position. The anchoring shoes 53 are then reengaged in anchoring position against the side walls of the tunnel and the hydraulic cylinders 412 are then actuated in mutually reversed directions so as to rotate or tilt the main frame in a clockwise direction until it is restored to its normal upright position in the tunnel, at right angles to the normal horizontal position of the cross member 50. During this turning movement of the frame, the two side groove cutters 33 are actuated so as to facilitate such turning movement and restore the supporting shoe 35 and the groove cutters to proper centered position in the tunnel. The two hydraulic cylinders 412 will then be maintained under balanced pressures when the boring operation of the machine is resumed so as to maintain the cross member 50 and the U-shaped guide 41 on leg 37 in right-angled relation to each other until such time as they may again be employed to restore the main frame to its normal upright position.

Although I have shown and described a certain embodiment of my invention, it will be understood that various changes and modifications may be made without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. In a tunneling machine, a frame having a shoe adjacent the front end thereof for slidably supporting said frame on the floor, a rotary cutter head for cutting a bore in advance of the machine, said cutter head having a drive shaft, said frame having a longitudinally extending bearing member in which said drive shaft is journaled, a cross member slidably mounted on said bearing member for longitudinal slidable movement relative thereto, extensible and retractable shoes at the ends of said cross member adapted to anchor said cross member to opposite sides of the tunnel, and power means connecting said cross member and frame for advancing said frame and its cutter head toward the working face of the tunnel.

2. The structure of claim 1, wherein the cross member is slidably mounted on the longitudinal bearing member by a ball-and-socket connection.

3. The structure of claim 1, wherein a gear case is fixed on the rear end of the longitudinal bearing member, and motor drive means is fixed on said gear case having operative connection with the drive shaft through gearing enclosed in the gear case.

4. The structure of claim 3, wherein the motor drive means consists of a plurality of motors each having geared connection with the drive shaft.

5. In a tunneling machine, a frame having a rotary head journaled thereon for cutting a bore in advance thereof, said rotary head having cutting means projecting forwardly therefrom and having material gathering buckets projecting rearwardly therefrom, support means adjacent said boring head for slidably supporting said frame and boring head on a tunnel wall, means for crowding the material deposited on the tunnel floor into said material gathering buckets and confining the dust and cuttings to the working face comprising an annular shield mounted on said frame adjacent the rearward end portions of said buckets and having a stationary body and a floating annular extension slidably mounted on and projecting radially outwardly of said body for free movement with respect thereto in circumferential and radial directions, and accommodating angular movement of said frame and boring head and vertical and lateral steering movement thereof.

6. The structure of claim 5, wherein the annular extension has a support shoe slidably engageable with the tunnel floor.

7. The structure of claim 5, wherein the body portion has slotted connecting means thereon forming slidable guides for said annular extension and wherein said an-

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nular extension has a supporting shoe having supporting engagement with the tunnel wall.

8. In a tunneling machine, a frame having a rotary head journaled thereon for cutting a bore in advance of the machine, said frame having a shoe adjacent the front end thereof and closely adjacent said boring head for slidably supporting said frame on the floor, a cross member mounted on said frame independently of said shoe for longitudinal slidable movement relative thereto, extensible and retractable shoes at the ends of said cross member adapted to anchor said cross member to opposite sides of the tunnel wall, power means connecting said cross member and frame for advancing said frame and said rotary head toward the working face of the tunnel, auxiliary supporting means for said frame spaced rearwardly of said cross member and having slidable engagement with the tunnel wall, the longitudinally slidable connection between said cross member and said frame including a pivotal connection accommodating angular movement of said frame with respect to said cross member about horizontal and vertical axes, and the auxiliary supporting means rearwardly of said cross member being adjustable for changing the direction of advance of said frame and its rotary head, centered about said pivotal connection.

9. The structure of claim 8, wherein the slidable connection between said cross member and said frame includes a ball and socket joint and wherein the auxiliary supporting means includes a cross arm having laterally spaced shoes adapted for slidable engagement with the tunnel wall, and means for adjusting the cross arm laterally with respect to said frame.

10. The structure of claim 8, wherein the auxiliary supporting means includes a cross arm having laterally spaced shoes adapted for slidable engagement with the tunnel wall and wherein vertically adjustable supporting means is provided for supporting the rear end portion of the frame on said cross arm and tilting said frame about said pivotal connection.

11. In a tunneling machine, a frame having a rotary head journaled thereon for cutting a bore in advance of the machine, said frame having slidable floor supporting means, and anchoring means extending from opposite sides of said frame having longitudinal sliding engagement with said frame, said anchoring means having extensible and retractable shoes at its outer ends, adapted for anchoring engagement with the side walls of the tunnel, and the sliding connection between said anchoring means and said frame including a ball-and-socket connection affording limited universal tilting adjustment between the anchoring means and the frame.

12. In a tunneling machine, a frame having a rotary head journaled thereon for cutting a bore in advance of the machine, said frame having a shoe adjacent the front end thereof and closely adjacent said boring head for slidably supporting said frame on the floor, a cross member mounted on said frame for longitudinal slidable movement relative thereto and for tilting movement with respect thereto about an axis extending transversely of said frame, extensible and retractable shoes at the ends of said cross member adapted to anchor said cross member to opposite sides of the tunnel, power means connecting said cross member and frame for advancing said frame and its cutter head with respect to said cross member toward the working face of the tunnel, auxiliary supporting means for said frame spaced rearwardly of said cross member and adapted for slidable engagement with the tunnel wall, and a tilting jack supporting said frame on said auxiliary supporting means and tilting said frame and rotary head about said transverse axis.

13. The structure of claim 12, wherein the slidable connection between the cross member and the frame includes a ball-and-socket joint, and the auxiliary supporting means rearwardly of said cross member is laterally adjustable for changing the direction of advance of the

frame and its cutter head, centered about said ball-and-socket joint.

14. The structure of claim 13, wherein the auxiliary supporting means includes a cross arm having laterally spaced shoes adapted for slidable engagement with the tunnel wall, a support plate for said frame mounted on said cross arm for slidable movement therealong, and means for adjusting said cross arm along said support plate and laterally relative to said frame and for holding said cross arm in fixed relation with respect to said support plate.

15. The structure of claim 13, wherein the auxiliary supporting means includes a cross arm having laterally spaced shoes adapted for slidable engagement with the tunnel wall, and wherein a tilting jack is provided for supporting said frame on said cross arm and for adjusting said frame vertically relative to said cross arm.

References Cited in the file of this patent

UNITED STATES PATENTS

368,883 Forbes ----- Aug. 23, 1887

20

944,001

Temple ----- Aug. 29, 1911
 Hodgson ----- Sept. 28, 1920
 Johansen ----- Oct. 11, 1927
 Gottschalk et al. ----- Aug. 9, 1932
 Ramsay ----- Sept. 4, 1945
 Calder ----- Nov. 9, 1954
 Calder ----- July 24, 1956
 McIntyre ----- July 24, 1956
 Kirkpatrick ----- July 24, 1956
 Mayo ----- Aug. 28, 1956
 McCarthy ----- Dec. 25, 1956
 Kandle ----- July 9, 1957
 Biedess ----- June 3, 1958
 Frye ----- Nov. 4, 1958
 Kirkpatrick ----- Dec. 16, 1958

FOREIGN PATENTS

Germany ----- June 7, 1956