Feb. 16, 1960 J. S. ROBBINS 2,925,258

TUNNEL BORING MACHINE HAVING TORSION COUNTERACTING MEANS

Filed July 12, 1957 4 Sheets-Sheet 1

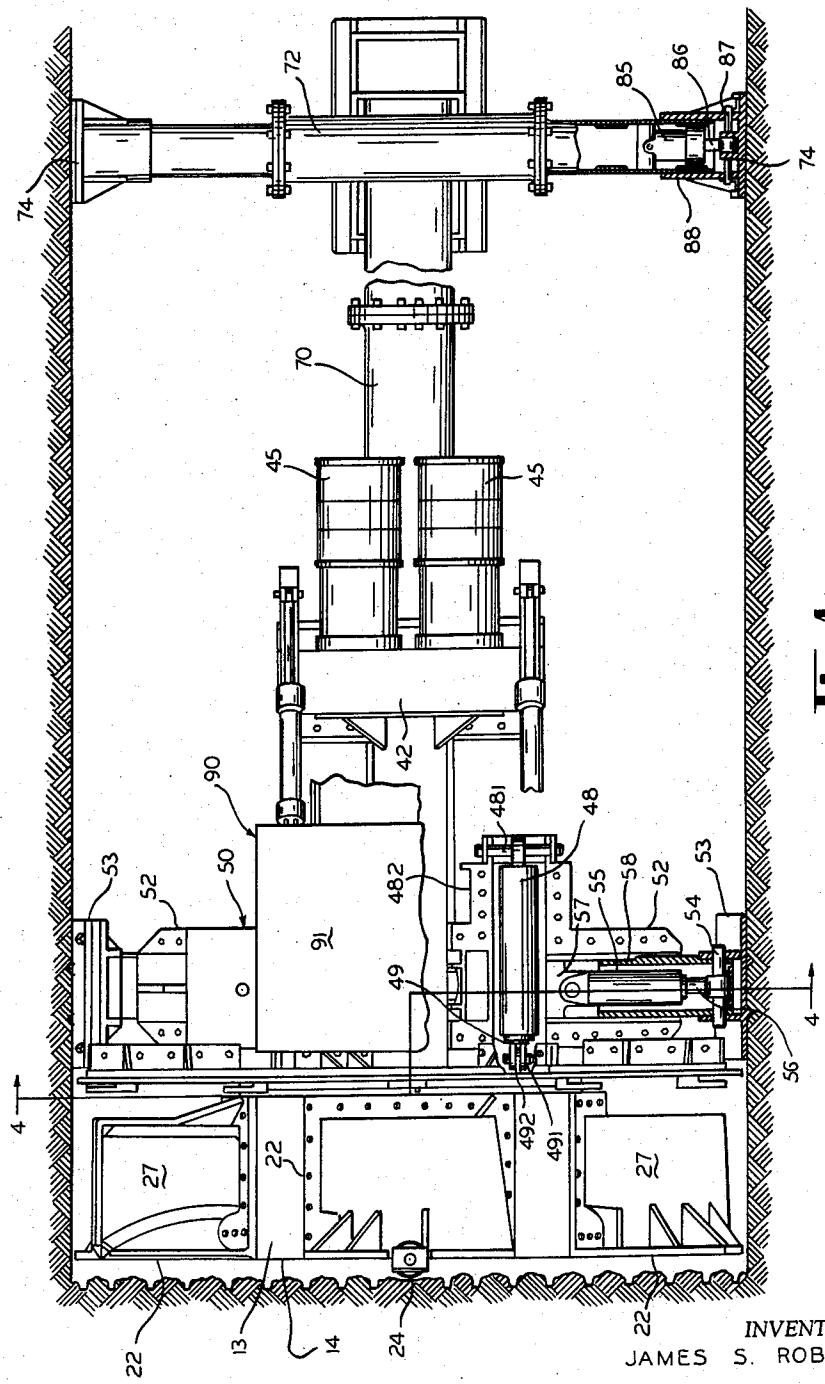


Fig. 1

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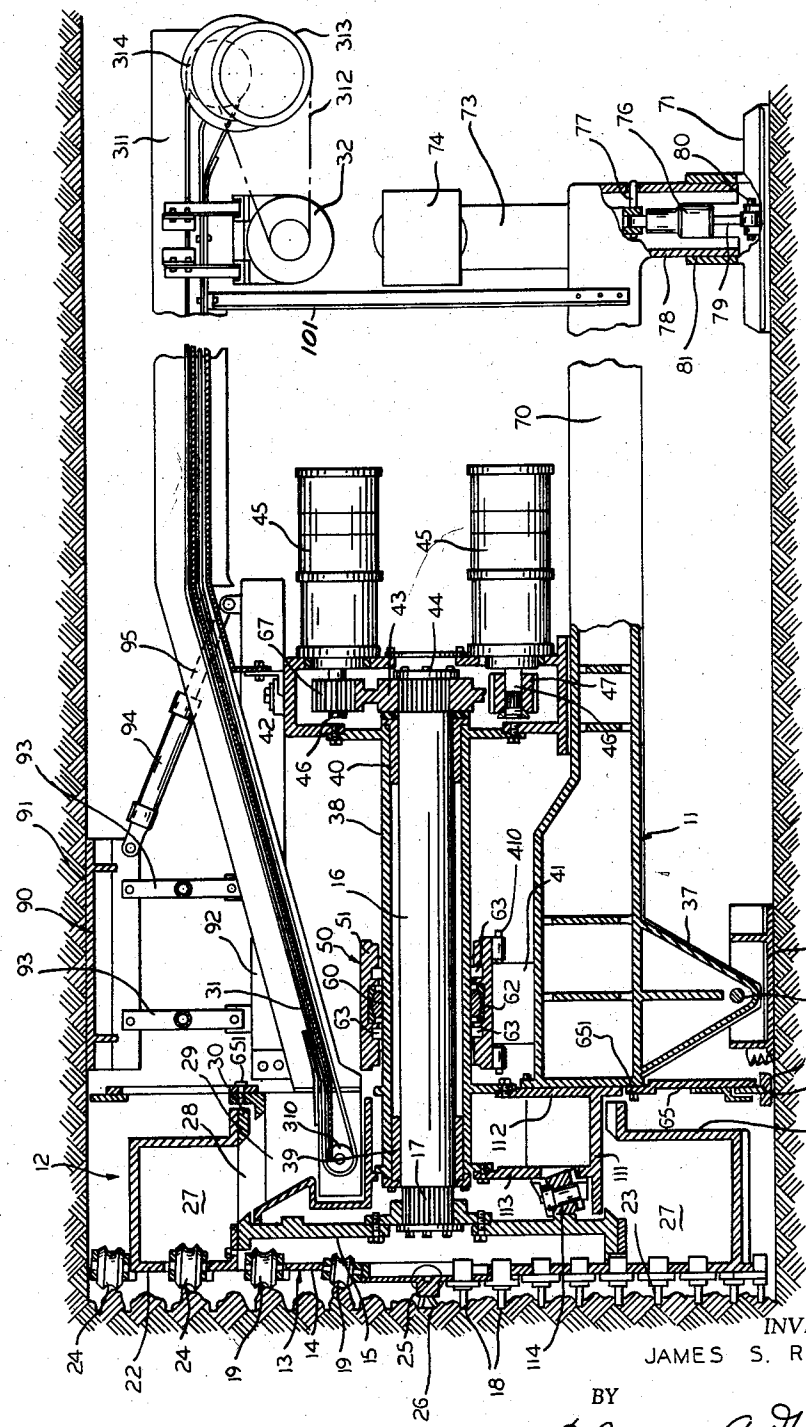


Fig. 2

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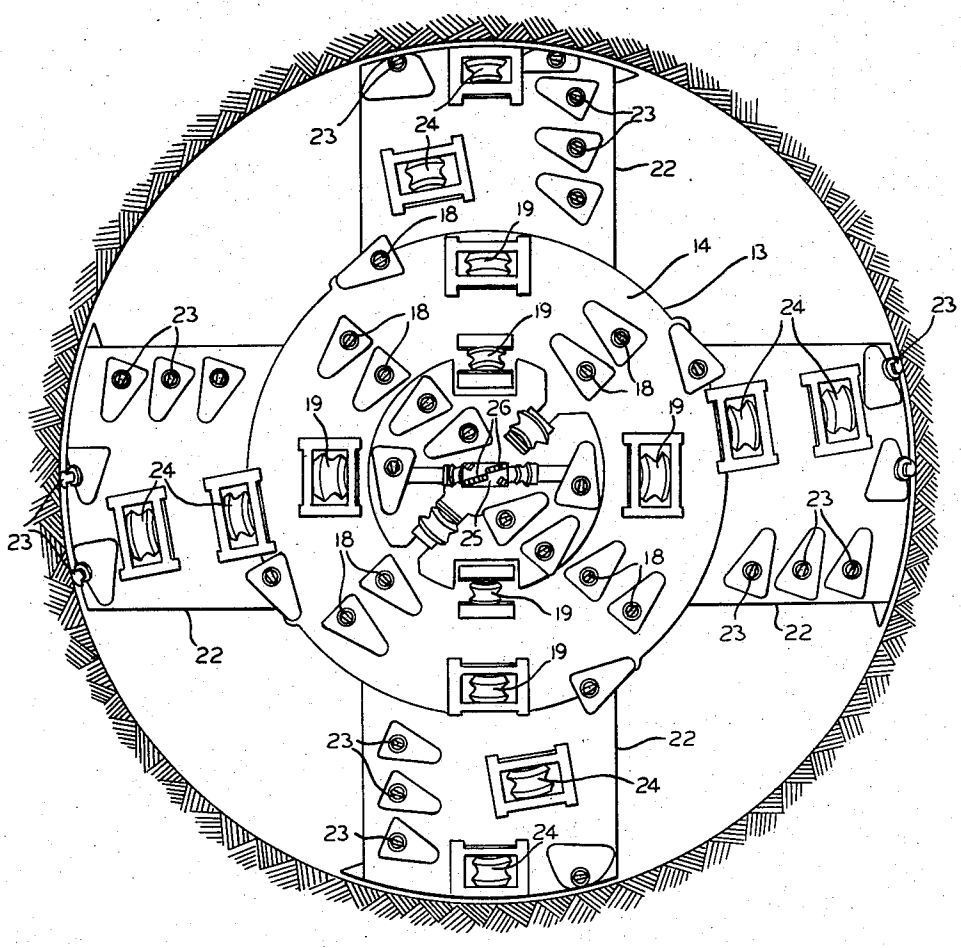


Fig. 3

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Filed July 12, 1957 4 Sheets-Sheet 4

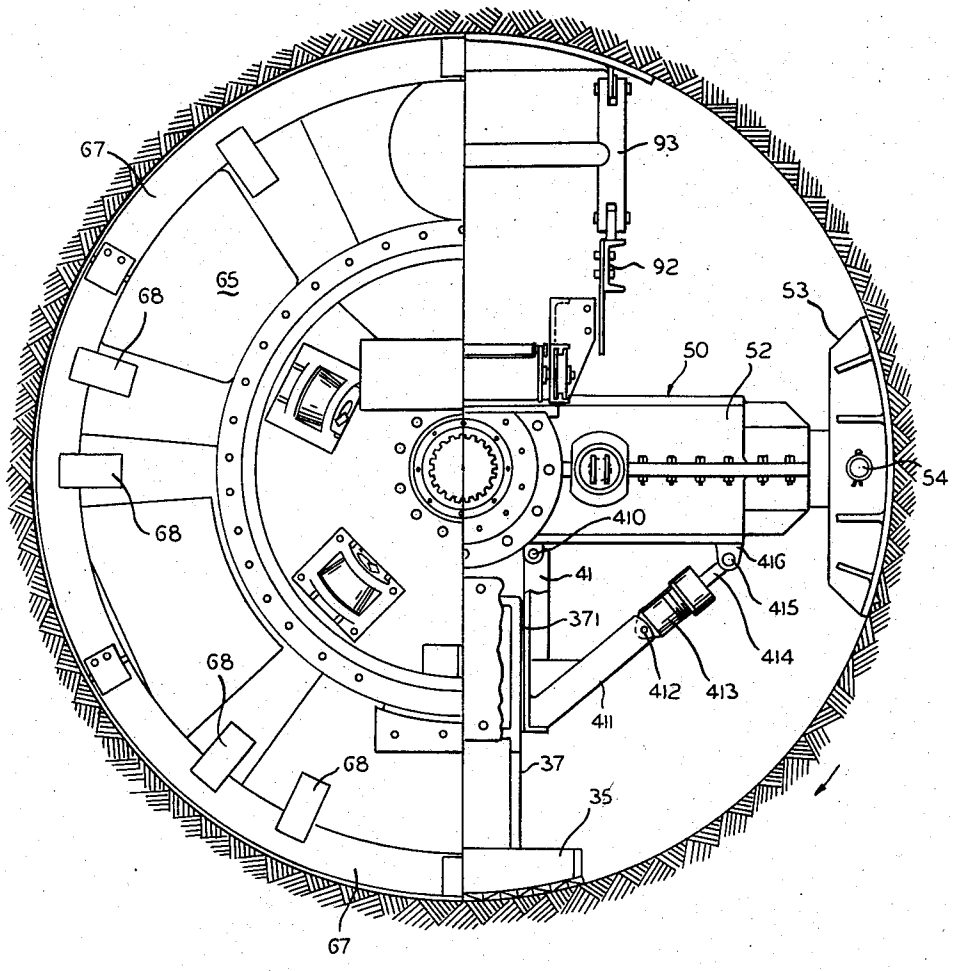


Fig. 4

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TUNNEL BORING MACHINE HAVING TORSION COUNTERACTING MEANS

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Application July 12, 1957, Serial No. 671,574

4 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 more particularly to tunnel boring machines of the kind disclosed in my copending application bearing Serial No. 671,258, filed July 11, 1957, 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 and aid in restoring the main frame to its proper upright position when it gets out of proper angular relation to the tunnel bore.

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.

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; and

Figure 4 is a section taken generally along line 4—4 of Figure 1.

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 burster 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 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 journalled. 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 uprights 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 pivotally connected on a transverse pin 36 to a depending leg 37 formed integrally with said supporting frame. As seen in Figure 4, the bottom face of the shoe 35 is curved transversely of the machine so as to fit on the arcuate bottom of the tunnel.

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 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, indicated generally at 50. Said cross arm 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 arm have laterally movable arcuate shoes 53, 53 adapted for engagement with the side walls of the tunnel, as seen in Figures 1 and 4. 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 arm 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 arm 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 arm 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 arm 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 arm 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 arm.

Each end member 52 of the cross arm 50 has a depending guide plate 41 pivotally connected by pin 410 adjacent the leg 37 of the main frame. The two guide members have lateral sliding engagement with the adjacent side face 371 of said depending leg 37, as seen in Figure 4. The lower end of each guide plate has an upwardly and outwardly inclined strut 411 with a hydraulic cylinder 413 pivoted thereto at 412, and a piston rod 414 in said cylinder pivotally connected as by pin 415 to an ear 416 on the under face of the adjacent end portion 52 near its outer end. The purpose of these guide members 41 and the diagonally disposed struts 411 will be presently described.

Between the cutter head 22 and the cross arm 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 during 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 outwardly slotted clamps 68 fixed to the latter. 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 main frame 11 has a rearwardly extending beam 70 passing below the gear case 42 and having a supporting shoe 71 adapted to rest on the tunnel floor. Said rear supporting shoe 71 is vertically adjustable relative to the main frame by a hydraulic cylinder 76 pivotally connected at its upper end to a longitudinally extending pin 77 pivotally connected in a cylindrical casing 78 depending from the rear end of the beam 70. Hydraulic cylinder 76 also has a piston rod 79 pivotally connected at its lower end by pin 80 connected to the upper face of the shoe 71. The shoe 71 also has an upstanding cylindrical member 81 telescopically mounted on a depending cylindrical member 78 rigid with the beam 70 so as to guide the shoe for vertical adjustment, and also to enclose the hydraulic cylinder and its associated parts, and protect them from ingress of dirt or the like.

The beam 70 has a cross bar 72 which is mounted on an upright standard 73 at its rear end. Said cross bar has extensible supporting shoes 74, 74 at each end thereof, which are adapted to engage the side walls of the tunnel midway between the roof and floor, for slidably supporting the rear end of the main frame 11 as the machine is advanced or retracted in the tunnel.

Each end of the rear cross bar 72 has a hydraulic cylinder 85 with its inner end fixed in said cross bar, and a piston rod 86 pivotally connected by a horizontally disposed pin 87 to the base of the adjacent shoe 74, as seen in Figure 1. Each shoe 74 also has an inwardly extending cylindrical portion 88 telescopically adjustable on the outer end of the cross arm 72 so as to guide the shoe for horizontal adjustment, and also to enclose the hydraulic cylinder 85 and its associated parts to protect them from ingress of dirt and the like.

Suitable pressure supply means and controls (not shown) are provided for the hydraulic cylinders 76 and 85. The controls for the cylinders 85 on opposite ends of the cross bar 72 are such as to actuate the piston rods 86 in either direction, either simultaneously or independently of each other, so as to cooperate in slidably supporting the rear end of the main frame 10 in centered position in the tunnel, or, when desired, to aid in effecting limited lateral steering movement of the machine as a whole to varying conditions, as will presently be described.

A roof support indicated generally at 90 consists of a plate 91 curved to fit against the roof at the tunnel, and connected to a longitudinal frame member 92 on the main frame 11 by two pairs of parallel links 93, 93. Vertical adjustment of said roof support is effected by a hydraulic cylinder 94 pivotally connected to the rear end of the supporting plate 91 and having a piston rod 95 pivotally connected to the rear end of the frame member 92, as seen in Figures 2 and 3.

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 said cross arm are forced into anchoring relation against the side walls of the tunnel, with the cross arm 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 arm 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. The front shoe 35 and the rear shoe 71 slide forwardly along the tunnel floor 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 arm 50 are withdrawn from anchoring engagement with the side walls of the tunnel. The piston rods 49 are then retracted to slide the cross arm 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 arm 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 vertical angle or gradient, the rear shoe 71 is vertically extended or retracted in the proper direction by the hydraulic cylinder 76. Such extension or retraction of the shoe 71 will cause the main frame to tilt about the pivot pin 36 connected to the front supporting shoe 35. It will be noted that such tilting movement of the main frame can be effected, if desired, while the cross arm 50 is anchored to the side walls, and the machine is being fed forwardly, since said cross arm is slidably mounted on the tubular member 38 by the ball-and-socket joint 60, 62.

The advance of the machine can also be deviated laterally toward one side or the other of the tunnel by two different methods, working either independently or in conjunction with each other. One of these methods consists in utilizing the two extensible shoes 74, 74 at opposite ends of the cross arm 72 at the rear end of the machine, by extending one of said shoes while simultaneously retracting the other shoe. The entire machine can be steered to a limited degree toward one side or the other during its feeding movement, with the cross arm 50 at the front end of the machine in anchored relation with the side walls.

Lateral steering movement of the main frame and cutter head can also be effected by extending one of the shoes 53 on the cross arm 50 while the opposite shoe 53 is retracted. Since the shoes 74 on the rear cross arm 72 are normally slidable along the tunnel walls during the advance feeding movement of the machine, said last named shoes 74, 74 will not interfere with the steering movement effected through the front anchoring shoes 53.

It will be further noted that, if desired, both the rear sliding shoes 74, 74 and the front anchoring shoes 53, 53 can be operated simultaneously to effect lateral steering of the cutter head.

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 enough to cause the several shoes 35, 53, 71 and 74 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, as may be necessary from time to time, the anchoring shoes 53 on the cross arm are withdrawn from the side walls of the tunnel and the hydraulic cylinders 413 of the two struts which connect the opposite ends of the cross arm to the depending guide plates 41 are actuated in mutually opposite directions so as to restore the cross arm 50 to its normal horizontal position. The required change in angle between the ends of the cross arm and the guide plates 41 is permitted by the pivotal mountings of said guide plates on the main frame. The anchoring shoes 53 are then reengaged in anchoring position against the side walls of the tunnel and the hydraulic cylinders 413 are 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 arm 50. The two hydraulic cylinders 413 will then be maintained under balanced pressures while the machine is in operation so as to maintain the cross arm 50 and the depending leg 37 on the main frame in right-angled relation to each other until such time as they may again be used 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 rotary head journalled thereon for cutting a bore in advance of the machine, said frame having slidable floor supporting means, and anchoring means slidably and pivotally mounted thereon for adjustment about an axis extending longitudinally thereof and extending from opposite sides of said frame and having extensible and retractible shoes at the outer ends thereof adapted for anchoring engagement with the side walls of the tunnel, power means connecting said anchoring means with said frame for advancing said frame and rotary head toward the working face of the tunnel upon anchoring of said anchoring means, said anchoring means also having guide means pivotally connected thereto and normally extending at an intermediate angle for longitudinal sliding movement along said frame, and extensible and retractable strut means connecting said pivoted guide means with said anchoring means for varying the angle between said anchoring means and said pivoted guide means upon release of said anchoring means from the wall of the tunnel, and adjusting said frame relative to said anchoring means into a horizontal position upon engagement of said anchoring means with the wall of the tunnel.

2. In a tunneling machine, a frame having a rotary boring head journalled thereon for rotation about a longitudinal axis for cutting a bore in advance of the machine, slidable floor supporting means supporting said frame for slidable movement along the tunnel floor, an anchoring member extending transversely of said frame and slidably and pivotally mounted thereon for movement about an axis coaxial with the axis of rotation of said boring head, extensible and retractable shoes at the outer ends of said anchoring member, and means engaging said shoes with the side wall of the tunnel, and extensible and retractable strut means having slidable engagement with opposite side portions of said frame, in spaced relation with respect to the pivotal axis of said anchoring member, and having operative connection with opposite outer end portions of said anchoring member, and operable to vary the angle of said anchoring member with respect to said frame upon release of said shoes from the tunnel wall and to bring said frame into a hori-

zontal position upon engagement of said shoes with the tunnel wall.

3. The structure of claim 2, wherein laterally spaced guide members are pivotally connected to said anchoring member and depend therefrom and have slidable engagement with said frame in spaced relation with respect to the pivotal axis of said anchoring member and along opposite side portions of said frame, and wherein the strut means are connected between the lower end portions of said guide members and opposite outer end portions of said anchoring member.

4. The structure of claim 3, wherein the frame has a beam extending longitudinally therealong and forming a slidable support therefor and wherein the guide members slidably engage opposite sides of said beam and the extensible and retractable strut means connected between said guide members and said anchoring member react

against said beam and anchoring member to bring said frame into a horizontal position upon the anchoring of said shoes with the side wall of the tunnel.

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