

[54] TUNNELING MACHINE HAVING
SWINGING ARMS CARRYING CUTTER
DISCS

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[58] Field of Search 299/31, 71, 72, 75, 85,
299/86; 175/338, 373, 91, 106

[56] References Cited

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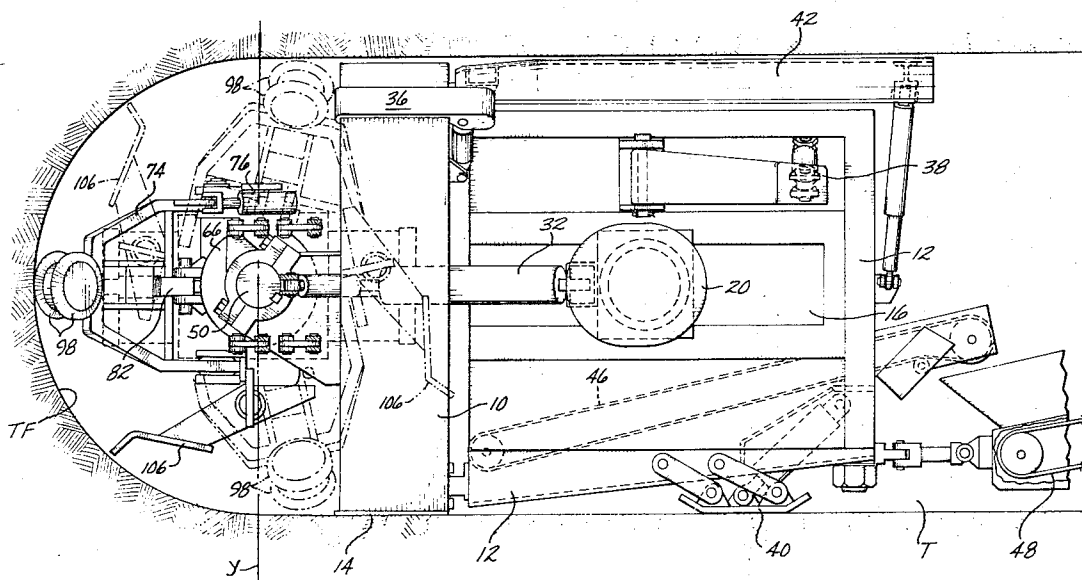
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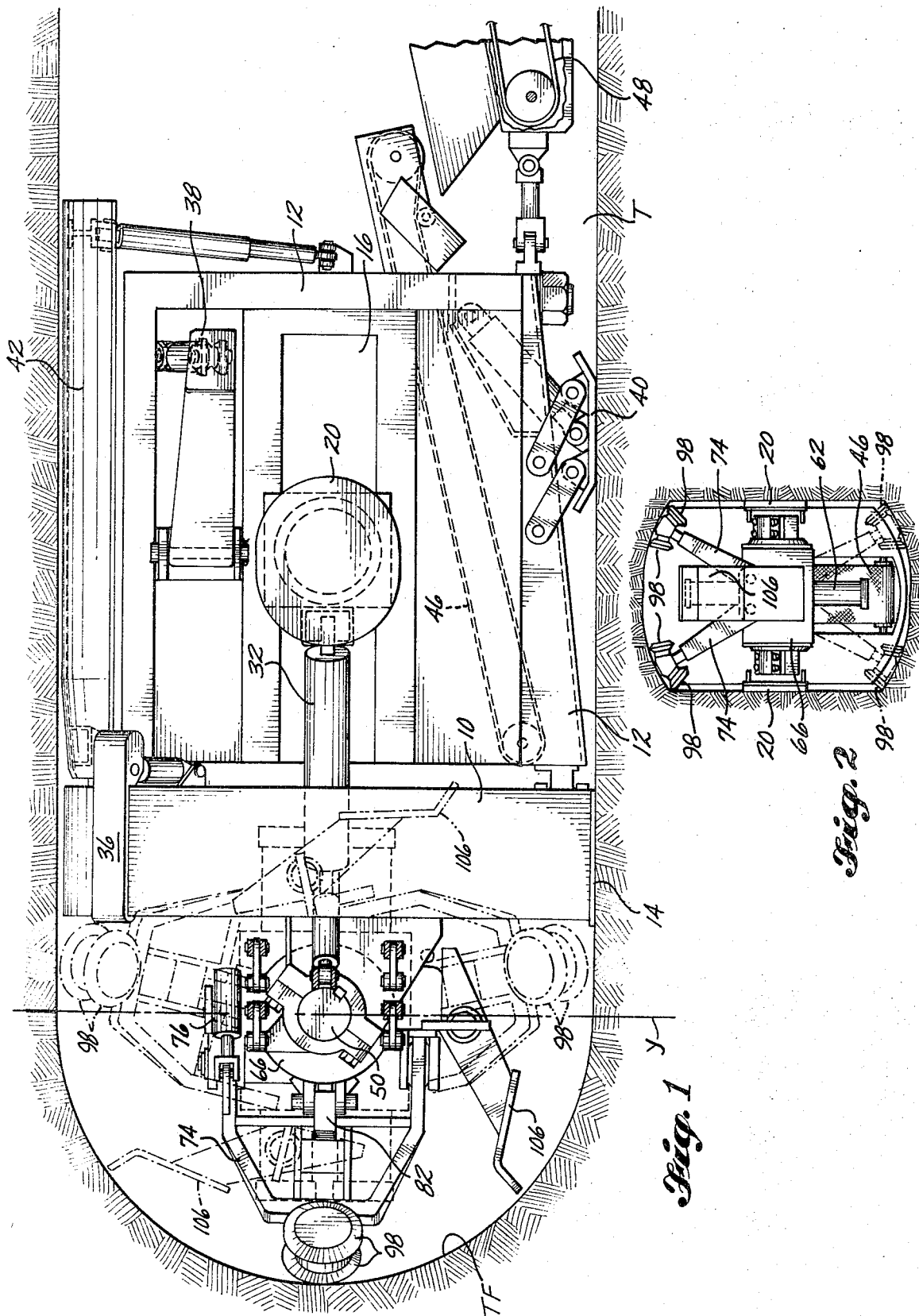
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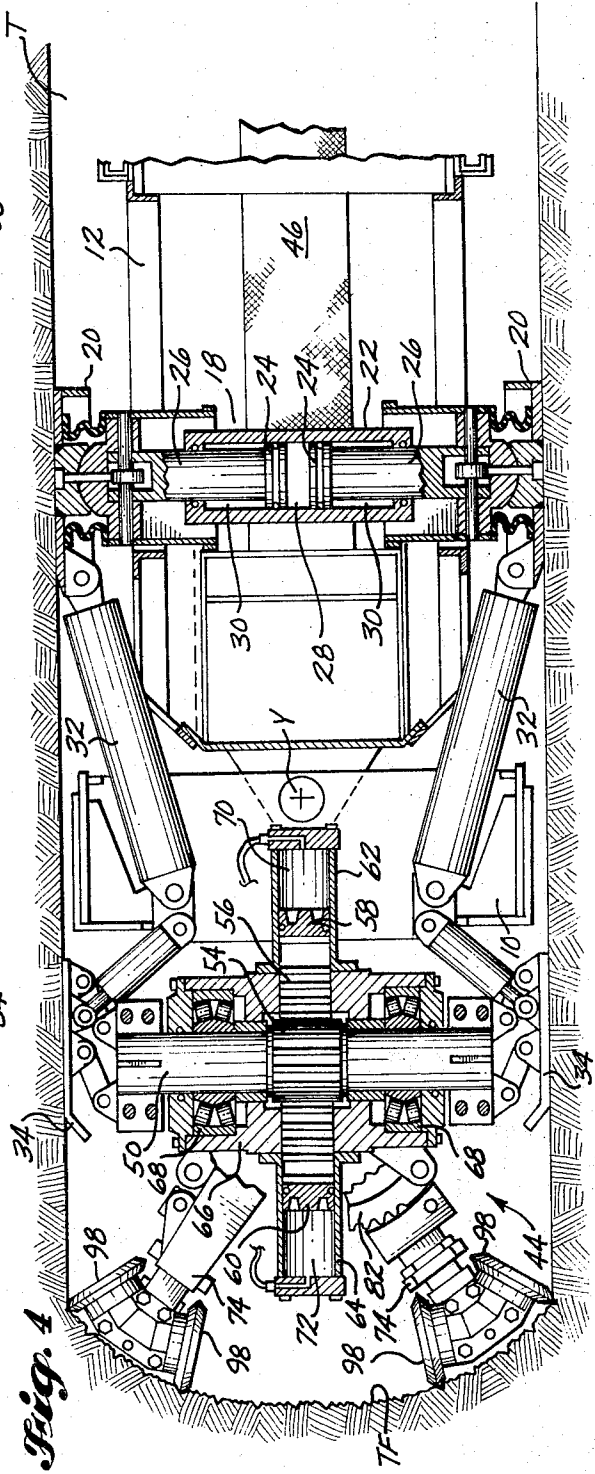
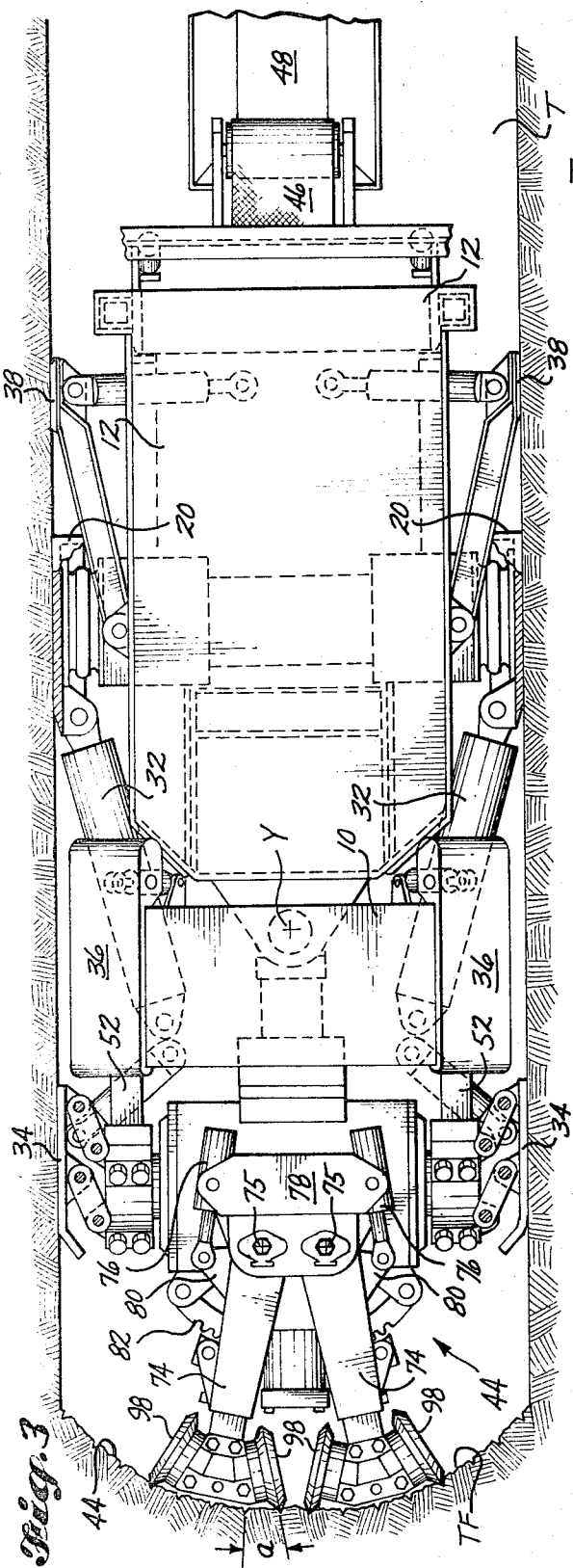
[57] ABSTRACT

Disc cutters are mounted at the forward end of support arms which are connected at their rear ends to a rotor which extends transversely of the tunnel. The rotor is driven to swing the support arms. As the arms move the disc cutters roll along arcuate paths across the tunnel face, each with its cutting edge penetrating into the tunnel face and cutting an arcuate kerf. The support arms are adjustable in position to establish new paths of travel for the disc cutters. Each disc cutter has a generally V-shaped cutting portion adapted to exert a lateral force on the material between a kerf being cut by such cutter and a previously cut adjacent kerf, to in that manner fracture such material and dislodge it from the tunnel face.

14 Claims, 7 Drawing Figures







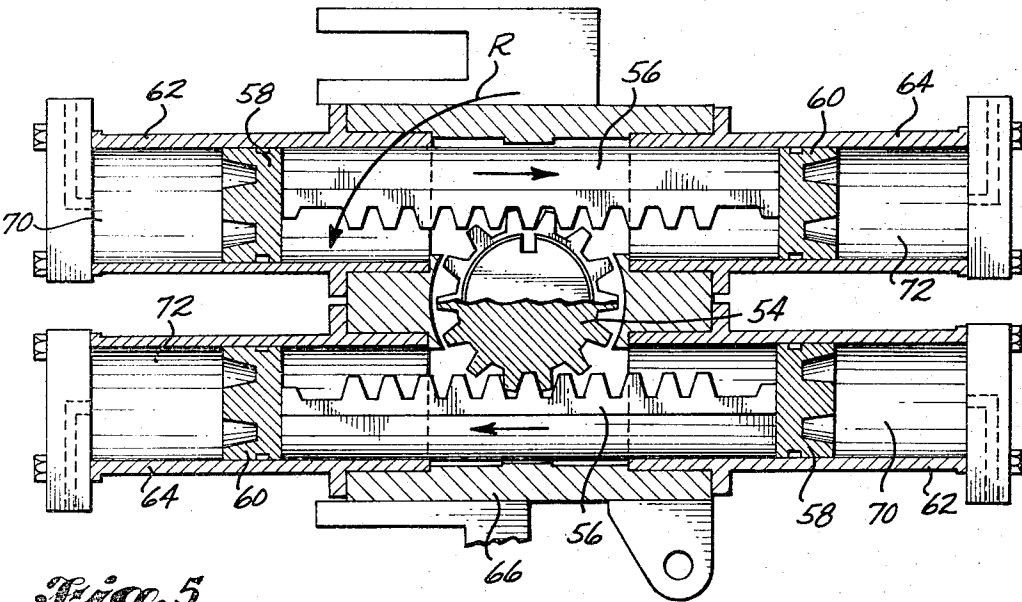
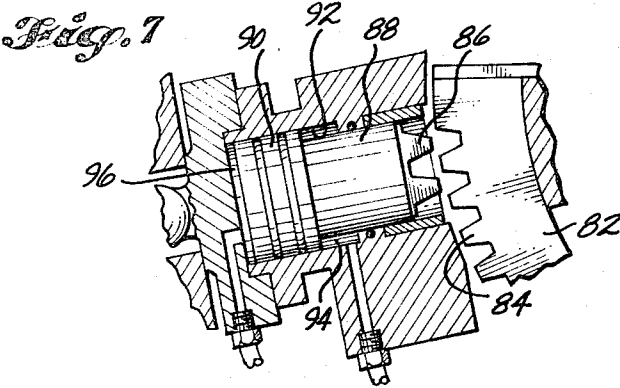
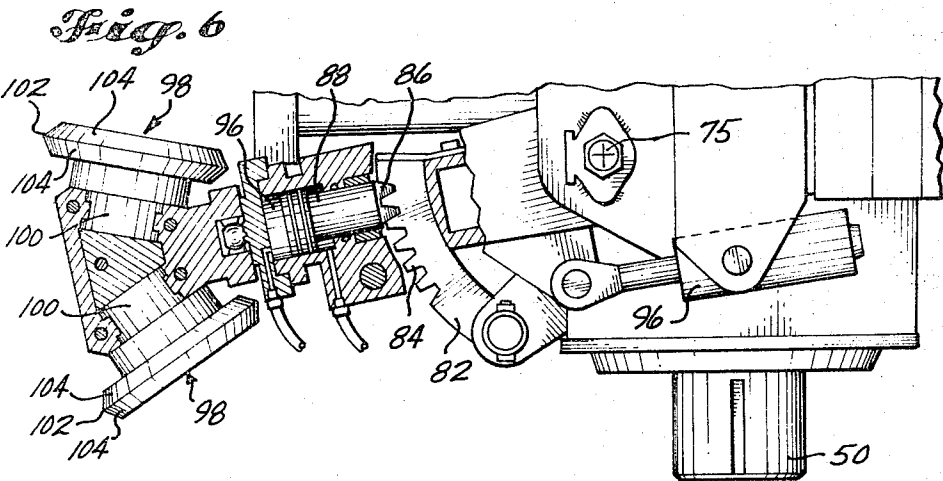


Fig. 5



TUNNELING MACHINE HAVING SWINGING ARMS CARRYING CUTTER DISCS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a machine for tunneling through rock or hard earth, and in particular to a tunneling machine for forming a relatively small size tunnel with flat side walls by use of disc cutters.

2. Description of the Prior Art

It is old to mount a plurality of disc cutters onto a rotary cutter head in such a manner that when the cutter head is rotated the disc cutters will cut concentric kerfs in the tunnel face and dislodge the material between the kerfs. An example of this type of tunneling machine is shown by U.S. Pat. No. 3,237,990, granted Mar. 1, 1966 to Richard J. Robbins and Douglas F. Winberg.

It is also known to mount relatively small power driven, disc-like cutterheads onto swing arms which are power driven to move the cutterheads across the tunnel face. Examples of this type of tunneling machine are shown by U.S. Pat. No. 3,446,535, granted May 27, 1969 to Ernest Lauber, and by U.S. Pat. No. 3,695,717, granted Oct. 3, 1972, to Josef Birrer.

SUMMARY OF THE INVENTION

This invention relates to a tunneling machine for forming non-circular tunnels by use of free rolling disc cutters. The disc cutters are mounted on the outer ends of pivotal support arms which are motor driven through a power stroke. As they move the support arms draw the disc cutters along arcuate paths across the tunnel face, each free rolling with its cutting edge penetrating into the tunnel face and cutting an arcuate kerf therein.

According to an aspect of the invention, the support arms are made to be adjustable in position laterally of the general direction of swing, so that the arms can be repositioned to establish new paths for the disc cutters to follow. Each disc cutter has a generally V-shaped cutting edge capable of exerting a lateral force on the material between a kerf being cut by it and a previously cut adjacent kerf, to fracture such material and dislodge it from the tunnel face.

The present invention relates to various aspects of the rock cutter mechanism, and to a particular tunneling machine arrangement utilizing two support arms and two disc cutters carried by each arm, arranged to rapidly sweep across and cut a layer of material from the tunnel face with a minimum of strokes.

These and other features of the invention will be described in greater detail below as part of the detailed description of the preferred embodiment, as shown in the Drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view of an embodiment of the present invention, including a solid line showing of the rock cutter mechanism in an intermediate position and broken line showings of such rock cutter mechanism in upper and lower positions;

FIG. 2 is a reduced scale front elevational view of the tunneling machine;

FIG. 3 is a top plan elevational view of the tunneling machine, showing the two disc cutter support arms in their innermost positions;

FIG. 4 is a view like FIG. 3, but showing the two disc cutter support arms in their outermost positions, showing the drive mechanism for the disc cutter support and the gripper assembly in section;

FIG. 5 is an enlarged scale sectional view of a drive mechanism for the disc cutter support arms;

FIG. 6 is a fragmentary view of a mechanism for positioning the disc cutter support arm, with some parts being cut away and others being shown in section; and

FIG. 7 is a fragmentary view of a mechanism for locking a disc cutter support arm in position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The illustrated embodiment comprises an articulated frame including a front part 10 and a rear part 12. Frame parts 10, 12 are connected together by upper and lower pivot pins, for pivotal movement about a vertical axis y.

Frame part 10 is shaped to substantially conform to the cross-sectional shape of the tunnel T. It includes a lower portion 14 which rests on the floor of the tunnel T. Frame part 12 includes a horizontal open area 16 which is elongated axially of the tunnel. A transverse gripper assembly 18 is received within space 16. Gripper assembly 18 includes a pair of side wall gripping pads 20 and hydraulic means for positioning the pads 20 relative to the side walls of the tunnel T. The hydraulic means may comprise a cylinder 22 housing a pair of pistons 24 and piston rods 26 connecting the pistons 24 to the gripper pads 20. Hydraulic fluid is pumped into chamber 28 (located between the pistons 24) and is exhausted from chambers 30 (located between the pistons 24 and end walls of the cylinder 22) for driving the gripper pads 20 outwardly into tight contact with the side walls of the tunnel T. The flow of hydraulic fluid is reversed when it is desired to retract the gripper pads 20.

A pair of thrust rams 32 are interconnected between the gripper assembly 18 and the frame part 10. The thrust rams 32 are extended at a time when the gripper pads 20 are forced into gripping contact with the side walls of the tunnel T, for advancing the machine forwardly in the tunnel. Extension of the thrust rams 32 forces the frame part 10 forwardly in the tunnel T relative to the anchored gripper mechanism 18. As it moves frame part 10 pulls frame part 12 forwardly with it. The open space 16 about the gripper assembly 18 makes it possible for frame part 12 to move relative to the anchored gripper assembly 18. Following completion of each advancement stroke of the thrust ram 32, the gripper pads 20 are retracted from the tunnel side walls and the thrust rams 32 are retracted, for pulling the gripper assembly 18 forwardly into a new position.

The machine is provided with hydraulically actuated positioning shoes 34, 36, 38, 40 which are suitably manipulated for steering the machine in the tunnel T. The machine also includes a roof shield 42, to provide overhead support when needed.

A rock cutter mechanism 44 is located forwardly of the frame part 10. Frame part 12 supports an endless belt type conveyor 46 which serves to pick up the rock

particles which are cut from the tunnel face TF by the mechanism 44 and delivers them onto another conveyor mechanism 48 which trails the machine in the tunnel T.

Referring now to FIGS. 3 and 4 in particular, a transverse fixed shaft 50 is supported at its ends by frame members 52 which extend forwardly from the frame of part 10. Shaft 50 includes a stationary central pinion 52 which meshes with a pair of reciprocating racks 56 (FIG. 5). Pistons 58, 60 are connected to the opposite ends of each rack 56. The pistons 58, 60 are mounted to travel within cylinders 62, 64 which are attached to a rotor housing 66. A pair of bearing assemblies 68 mount the rotor 66 for rotational movement about the fixed shaft 50. As will be apparent, when fluid pressure is introduced into each chamber 70 (FIG. 5) and relieved from each chamber 72, the racks 56 are moved endwise in the direction indicated by the arrows in FIG. 5. Since the pinion 54 is fixed, such movement of the racks 56 causes the rotor assembly 66 to rotate about the pinion 54 in the direction indicated by the arrow R. Rotation of the rotor assembly 66 in the opposite direction is accomplished by reversing the racks 56. This type of drive mechanism is well known and therefore will not be described in any greater detail. An example of this type of drive is disclosed in some detail by U.S. Pat. No. 2,844,127, granted on July 22, 1958 to Carl Steiner.

According to one aspect of the invention, a pair of disc cutter support arms 74 are pivotally connected at their rear ends to the rotor assembly 66. These support arms 74 are pivotally mounted for pivotal movement about axes 75 which are perpendicular to the axis of rotation of the rotor assembly 66. Double acting linear hydraulic cylinders 76 are interconnected (by pivot pin means) between a support 78 affixed to the rotor assembly 66 and ears 80 attached to the support arms 74. An articulate tooth bar 82 is supported in the rotor assembly 66. It includes forwardly extending teeth 84 which are provided to be engaged by similar teeth 86 carried by a lock piston 88. Each piston 88 includes a piston head 90 which is received within a piston chamber 92 carried by a disc cutter support arm 74. Fluid pressure is introduced into a chamber 94 and is relieved from a chamber 96 when it is desired to retract the piston 88, to disengage lock teeth 86 from teeth 84. When this is done, the linear hydraulic motor 76 is operated to swing the support arm 74 into a new position. Then, pressure is introduced into chamber 96 and relieved from chamber 94, for extending piston 88 to in turn move the lock teeth 86 into engagement with a new set of the teeth 84 on bar 82.

According to one aspect of the invention, each support arm 74 carries a pair of disc cutters 98 at its forward end. Each disc cutter 98 may be of the overhung type and is supported for free rotation about its own support shaft 100. Preferably, each disc cutter 78 has a continuous peripheral cutting edge 102 which is flanked by a pair of conical "breaker" surfaces.

A rake type mechanism 106 may be attached to the rotor assembly 66 in a position to lead the disc cutters 98 as they travel through a downward and rearward stroke. The function of the mechanism 106 is to draw or rake the cuttings rearwardly onto the pickup conveyor 46.

The operation of the illustrated embodiment will now be described.

Let it be assumed that the two support arms 74 occupy their innermost positions (FIG. 3) and are in the lower position shown by broken lines in FIG. 1, and the machine has just been advanced forwardly an amount equal to the depth of cut of the disc cutters 98. The drive mechanism 54, 56, etc. is operated to swing both arms 74 upwardly together. As such arms 74 move they draw with them the disc cutters 98. The generally V-shaped peripheral portions of the disc cutters 98 penetrate into the tunnel face Tf and cut kerfs in such face TF as they move. The disc cutters 98 independently rotate freely about their individual axes as the arms 74 move them. The disc cutters are moved along arcuate paths (see FIG. 1) which are about 200° in length. The end positions (the uppermost and lowermost positions in the illustrated embodiment) of the disc cutters 98 are located rearwardly of the transverse plane y in which the rotational axis of shaft 50 is situated. When the disc cutters 98 are in their end positions they are inwardly of the tunnel from the tunnel wall and can be shifted in position axially. When the cutters 98 are being swung through the 180° arc forwardly of plane y they are in curve cutting contact with the tunnel face.

When the arms 74 are in their uppermost positions (shown by broken lines in FIG. 1) the disc cutters 98 are within a full width portion of the tunnel. The lock pistons 88 are retracted and then the linear hydraulic motors 96 are retracted an amount sufficient to swing the arms 74 laterally outwards by the angular amount α (FIG. 3). The lock pistons 88 are then extended to lock the arms 74 in their new positions. Then, the drive mechanisms 54, 56, etc. is driven in the opposite direction to swing the arms 74 downwardly and in so doing draw the disc cutters 98 along new arcuate paths which are sufficiently close to the previously formed kerfs that the V-shaped cutting portions of the disc cutters 98 will dislodge the material between the new and old kerfs.

When the arms 74 have reached the lower end of their movement they are again adjusted outwardly another angular amount α . Then, the arms 74 are driven upwardly again so that the disc cutters 98 will cut a new set of kerfs. This procedure is repeated until the arms 74 finish a stroke while in their outermost positions (FIG. 4).

According to an aspect of the invention, each support arm 74 carries a pair of disc cutters 98 which are spaced apart by an angular distance which is a multiple of the angle α . Such distance is equal to α plus α times the number of strokes through which each arm 74 must travel between the start of cut when the arms are in the position shown by FIG. 3 and the end of cut when the arms are in the position shown by FIG. 4. In the illustrated embodiment the disc cutters 98 of each pair are spaced four units α apart and three strokes are necessary to complete one complete sweep of the tunnel face TF. After a complete sweep of the tunnel face TF the machine is advanced forwardly again an amount equal to a new depth cut of the disc cutters 98.

Although the invention has been described in a preferred form with a certain degree of particularity, it is to be understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination arrangement parts may be re-

sorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. Rock cutter mechanism for a tunneling machine, comprising:

a cutter carrier mountable at the forward end of the tunneling machine, for bidirectional swinging movement about a swing axis that extends transversely of the tunnel;

a disc cutter including a peripheral cutting edge; means mounting said disc cutter onto said cutter carrier radially outwardly from the swing axis, for free rotation about an axis that extends across the path along which the disc cutter moves during swinging movement of the cutter carrier, with its cutting edge directed towards the tunnel face;

motor means for driving said cutter carrier through swing strokes to roll the disc cutter along an arcuate path across the tunnel face, with its cutting edge penetrating into the tunnel face and cutting an arcuate kerf therein;

means for shifting the disc cutter in position axially at the end of a stroke of the cutter carrier, so that when the cutter carrier is moved through its next stroke the disc cutter will be positioned to cut a new kerf in the tunnel face which is offset from the previous kerf cut thereby; and

wherein said disc cutter has a generally V-shaped sectional shape at its cutting edge, whereby it exerts a lateral force on the material between a kerf being cut by such cutter and a previously cut adjacent kerf, to fracture such material and dislodge it from the tunnel face.

2. Rock cutter mechanism according to claim 1, including means for advancing the cutter carrier forwardly in the tunnel between strokes of the disc cutter, by increments corresponding to the depth of cut of the disc cutter.

3. Rock cutter mechanism according to claim 1, wherein said disc cutter is swung by said motor means back and forth between two end positions which are across the tunnel from each other and are both located rearwardly of a plane which is perpendicular to the axis of the tunnel and includes the swing axis of the cutter carrier, each time through a 180° cutting arc which is located forwardly of said plane, wherein said disc cutters are within the tunnel and make no contact with the tunnel wall when in their end positions, and wherein said disc cutter is shifted in position axially only when it is in an end position.

4. Rock cutter mechanism according to claim 1, including a plurality of disc cutters mounted on said cutter carrier radially outwardly from the swing axis, each for free rotation about an axis that extends across the path along which it moves during swinging movement of the cutter carrier, and each with its cutting edge directed towards the tunnel face, so that during each stroke of the cutter carrier each disc cutter will roll along an arcuate path across the tunnel face.

5. Rock cutter mechanism according to claim 1, wherein said cutter carrier comprises a rotor including support shaft means having an axis coinciding with the swing axis, and a disc cutter support arm having an inboard end connected to the rotor and an outboard end onto which the disc cutter is mounted.

6. Rock cutter mechanism according to claim 5, wherein the inboard end of the disc cutter support arm

is pivotally attached to the rotor, for swinging movement about an axis that is perpendicular to said swing axis, and said mechanism includes means interconnected between said disc cutter support arm and the rotor for adjusting the disc cutter support arm in position about its axis, to in that manner establish the path of travel of the disc cutter.

7. Rock cutter mechanism according to claim 6, including a plurality of spaced apart disc cutters mounted on said cutter carrier radially outwardly from the swing axis, each for free rotation about an axis that extends across the path along which it moves during swinging movement of the cutter carrier, and each with its cutting edge directed towards the tunnel face, so that during each stroke of the cutter carrier each disc cutter will roll along an arcuate path across the tunnel face, and indexing means for the disc cutter support arm operable to establish adjacent positions of the disc cutter support arm the spacing of which is smaller than the spacing of the disc cutters.

8. Rock cutter mechanism according to claim 5, wherein the motor means for driving said cutter carrier through swing strokes is attached to and acts on said rotor.

9. Rock cutter mechanism for a tunneling machine, comprising:

a rotor including support shaft means mountable at the forward end of the tunneling machine, to support said rotor for movement about a swing axis that extends transversely of the tunnel;

a pair of disc cutter support arms symmetrically mounted on the rotor, each said support arm having an inboard end and an outboard free end, means pivotally attaching the inboard end of each support arm to the rotor for pivotal movement of such arm about an axis that is perpendicular to the axis of said swing axis;

each support arm carrying at least one disc cutter which includes a peripheral cutting edge;

means mounting each disc cutter onto the outboard end of its support arm, for free rotation about an axis that extends across the path along which the disc cutter moves during swinging movement of the rotor, with its cutting edge directed towards the tunnel face;

motor means for driving said rotor and the support arms carried thereby through swing strokes, to in that manner roll the disc cutters carried by the support arms along arcuate paths across the tunnel face, with the cutting edge of each disc cutter penetrating into the tunnel face and cutting an arcuate kerf therein;

means interconnected between each support arm and the rotor for adjusting the support arm in angular position relative to the swing axis, to in that manner establish the paths of travel of the disc cutters; and

wherein each said disc cutter has a generally V-shaped sectional shape at its cutting edge, whereby it exerts a lateral force on the material between a kerf being cut by such cutter and a previously cut adjacent kerf, to fracture such material and dislodge it from the tunnel face.

10. Rock cutter mechanism according to claim 9, wherein a plurality of disc cutters are mounted at the outboard end of each support arm, each for free rotation about an axis that extends across the path along

which it moves during swinging movement of the support arm, and each with its cutting edge directed towards the tunnel face, so that during each stroke of its cutter arm each disc cutter will roll along an arcuate path across the tunnel face.

11. Rock cutter mechanism according to claim 10, comprising a pair of disc cutters at the outboard end of each support arm, with the general plane of each disc cutter intersecting the swing axis at a perpendicular and being separated from the general plane of the other disc cutter by an acute angle.

12. Rock cutter mechanism according to claim 11, including indexing means for the support arms operable to establish adjacent positions of the support arms which are separated by acute angles which are smaller than the acute angular spacing of the disc cutters.

13. A tunneling machine, comprising:

a frame movable forwardly in a tunnel;

a cutter carrier mounted onto the forward portion of the frame, for bidirectional swinging movement about a swinging axis that extends transversely of the tunnel;

a disc cutter including a peripheral cutting edge;

means mounting said disc cutter onto said cutter carrier radially outwardly from the swing axis, for free rotation about an axis that extends across the path along which the disc cutter moved during swinging movement of the cutter carrier, with its cutting edge directed towards the tunnel face;

motor means for driving said cutter carrier through swing strokes to roll the disc cutter along an arcuate

ate path across the tunnel face, with its cutting edge penetrating into the tunnel face and cutting an arcuate kerf therein;

means for moving the frame forwardly by increments corresponding to the depth of cut of the disc cutter;

means for shifting the disc cutter in position axially at the end of a stroke of the cutter carrier, so that when the cutter carrier is moved through its next stroke the disc cutter will be positioned to cut a new kerf in the tunnel face which is offset from the previous kerf cut thereby; and

wherein said disc cutter has a generally V-shaped sectional shape at its cutting edge, whereby it exerts a lateral force on the material between a kerf being cut by such cutter and a previously cut adjacent kerf, to fracture such material and dislodge it from the tunnel face.

14. Rock cutter mechanism according to claim 13, wherein said disc cutter is swung by said motor means back and forth between two end positions which are across the tunnel from each other and are both located rearwardly of a plane which is perpendicular to the axis of the tunnel and includes the swing axis of the cutter carrier, each time through a 180° cutting arc which is located forwardly of said plane, wherein said disc cutters are within the tunnel and make no contact with the tunnel wall when in their end positions, and wherein said disc cutter is shifted in position axially only when it is in an end position.

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