

[54] GAGE SCRAPER

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[51] Int. Cl.:.....**E01g 3/04**

[58] Field of Search**299/86; 175/313, 385, 386, 175/336**

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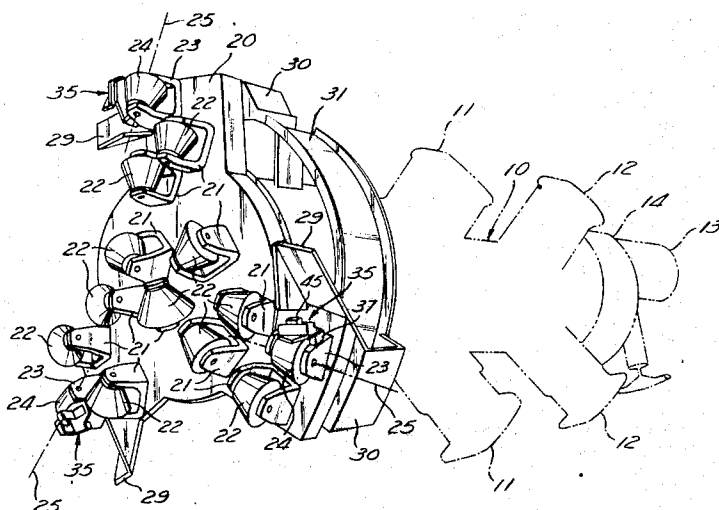
Primary Examiner—Ernest R. Purser

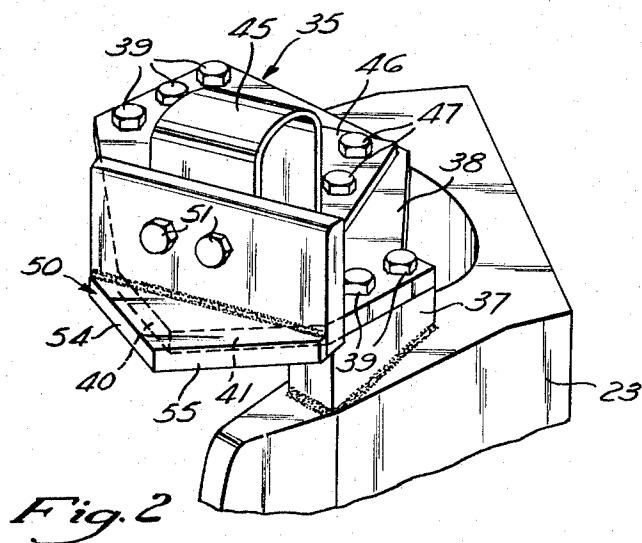
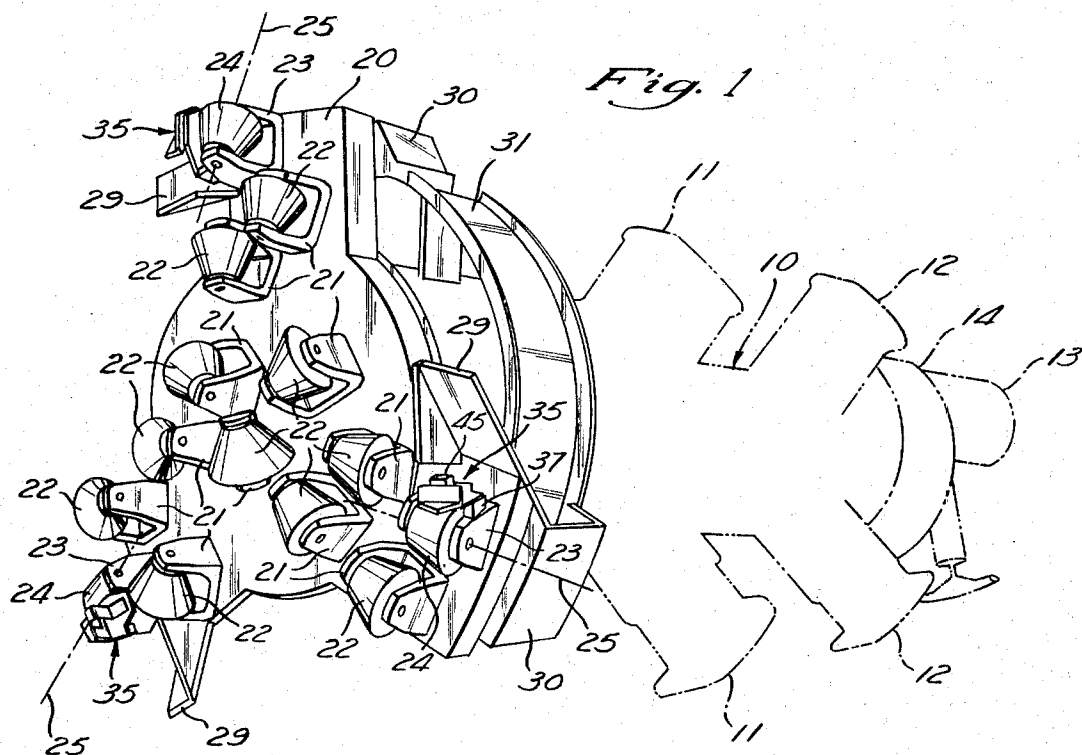
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[57] ABSTRACT

A tunneling machine is disclosed which includes a support frame, a rotatable cutter head, and inside roller cutters and gage roller cutters for cutting or crushing the end face of a tunnel. Each gage cutter is provided with a gage scraper which includes a first scraper portion for engaging the tunnel end face and a second scraper portion for engaging the cylindrical tunnel wall to clear protruding formation particles from the path of the gage cutter. A resilient mounting means resiliently biases the first and second scraper portions against their respective tunnel surfaces to provide substantially continuous contact therewith as the scraper portions become worn, and to permit retraction of the scraper portions if they encounter a formation particle which they cannot remove. A guide plate prevents movement of the resiliently mounted scraper portions toward the gage cutters in the direction of travel of the gage cutters around the tunnel end face to permit mounting the scraper portions on gage saddles immediately adjacent the gage cutters. Intersecting edge portions of the guide plate form fixed scrapers for further protection of the gage cutters.

17 Claims, 4 Drawing Figures





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Fig. 3

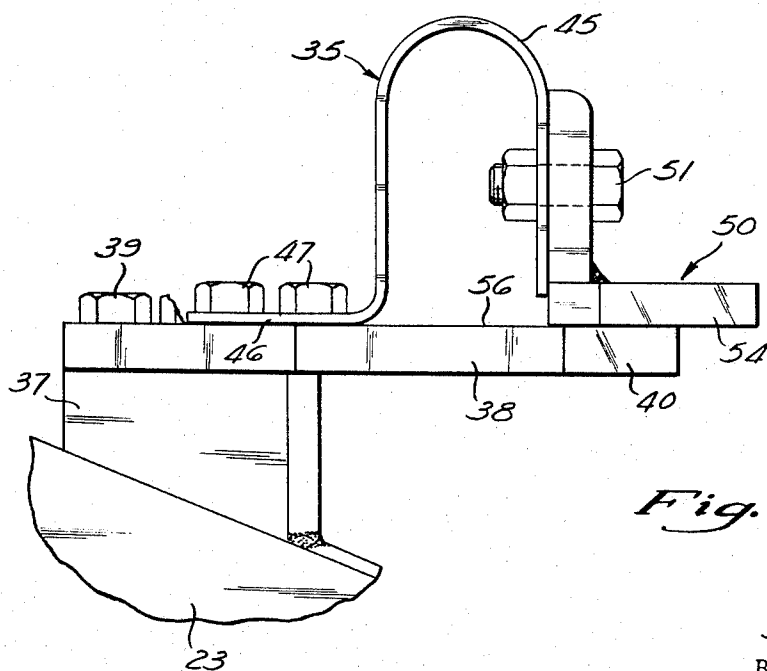
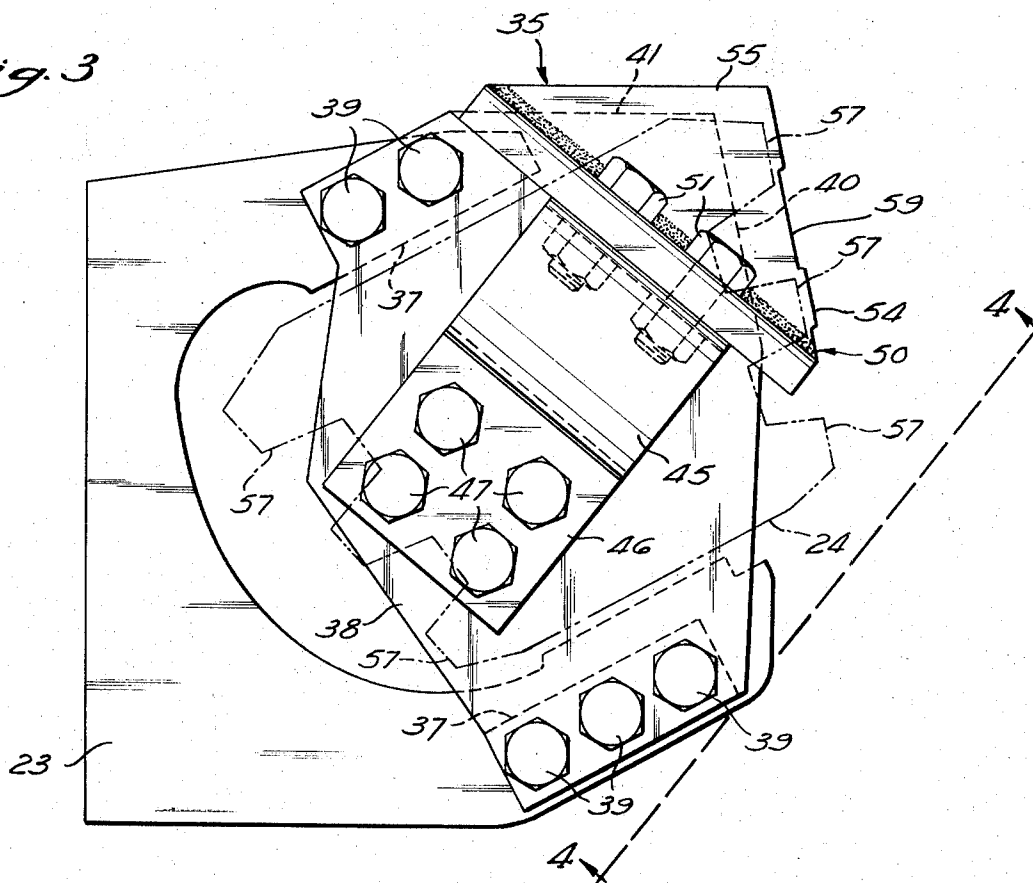


Fig. 4

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1

GAGE SCRAPER

BACKGROUND OF THE INVENTION

This invention relates generally to tunneling machines, and more particularly to tunneling machines having a rotatable cutter head and roller cutters mounted on the cutter head for engaging an end face of a tunnel with rolling contact. Still more particularly, the invention relates to a scraper for clearing materials from the path of such roller cutters.

Tunneling machines generally include a support frame which is anchored in the tunnel and which supports a rotatable cutter head. Roller cutters are mounted on the cutter head, and rotation of the cutter head causes the cutters to travel about the end face of the tunnel with rolling contact to cut or crush the formation encountered in a well known manner.

If the cut or crushed particles of the formation are not quickly removed from the tunnel, they may be encountered by the roller cutter on a subsequent passage about the tunnel end face. This could result in the formation particles accumulating about the cutters and preventing the cutters from rotating so that the cutters are unevenly worn by skidding about the tunnel end face. Furthermore, if a substantially horizontally extending tunnel is being produced, such formation particles may accumulate in the lower portion of the tunnel and cause uneven forces to be applied to the cutter head as the roller cutters pass through the lower portion of the tunnel.

To remove such formation particles and preclude these adverse effects, various methods have been suggested and used by the prior art to carry such formation particles away from the tunnel end face. These prior art methods generally include a liquid drilling fluid which carries the cut or crushed formation particles in suspension. Muck scrapers mounted on the tunnel machine cutter head direct the drilling fluid with the formation particles suspended therein from the lower regions of the tunnel in which the drilling fluid falls to buckets, and the buckets carry the drilling fluid and particles to a conveyor system which carries the material from the tunnel.

Although such prior art methods have been generally satisfactory for removing loose formation particles from the path of the roller cutters, other cut or crushed formation particles occasionally are loosened from the tunnel end face by the roller cutter but do not freely fall from the end face of the tunnel. Such formation particles which adhere to the end face of the tunnel may then cause an uneven force to be applied to the cutter head when the roller cutter, which will be slightly axially advanced from its prior passage, encounters the adhering formation particle on a subsequent passage. This, of course, could result in possible damage to the cutter head, the roller cutter, or other components of the tunneling machine.

This problem is of particular significance with regard to the roller cutters which travel about the radially outermost portion of the tunnel end face adjacent the cylindrical tunnel wall, which are known as gage cutters. In addition to the above discussed problem relating to formation particles which adhere to the end face of the tunnel, such gage cutters may also encounter formation particles which project from the cylindrical tunnel wall adjacent the tunnel end face. Since the gage cutters are adapted only to exert an axial force against the tunnel end face and are not adapted to exert a substantial radially outward force to cut or crush formations encountered in the cylindrical tunnel wall, such formation particles which project from the tunnel wall may cause damage to the gage cutter, the gage cutter mounting means, or other portions of the tunneling machine.

SUMMARY OF THE INVENTION

The present invention overcomes these and other problems of prior art tunneling machines by providing a tunneling machine which includes a rotatable cutter head, roller cutters mounted on the cutter head for engaging an end face of a tunnel with rolling contact, and a scraper leading the gage or radially outermost roller cutters. According to the principles of the invention, the scraper includes a first scraper portion for

2

engaging a surface of the tunnel immediately preceding the roller cutter for clearing materials which may include formation particles from the path of the roller cutter. A mounting means mounts the scraper relative to the rotatable cutter head, and the mounting means includes a resilient means for permitting movement of the first scraper portion away from the tunnel surface against the bias of the resilient means. This insures that the scraper will engage the tunnel surface even after the scraper becomes worn, and permits the scraper to conform to the contour of the tunnel surface as it becomes worn thereby to provide a more effective scraper surface. In this manner, the invention provides a tunneling machine in which loosened formation particles which adhere to and project from a tunnel surface are removed from the tunnel surface immediately prior to the passage of a roller cutter thereover, to preclude recutting or recrushing of such formation particles and to prevent damage to the tunneling machine by such particles.

Further according to the principles of the invention, a tunneling machine having a resiliently mounted scraper portion is provided with a means for limiting movement of the scraper portion toward its associated roller cutter in the direction of travel of the roller cutter around the tunnel end face. This aspect of the invention permits the scraper portion to be located in close proximity to the roller cutter without danger of the scraper portion engaging the roller cutter. In a specific embodiment, the plane of movement of the scraper portion is substantially perpendicular to the end face of the tunnel.

The invention further provides a tunneling machine having a guide surface and a resiliently mounted scraper portion slidably mounted on the guide surface so that the guide surface defines the plane of movement of the scraper portion. In this manner, the guide surface may be utilized to limit movement of the scraper portion toward the roller cutter in the direction of travel of the roller cutter around the tunnel end face. The guide surface is one surface of a mounting plate for the scraper assembly, and an edge portion of the mounting plate is used as a fixed scraper portion for further protecting the roller cutter. The mounting plate is secured to the leading side of a saddle which carries the cutter, so that the scraper is mounted directly on the saddle to preclude the necessity of providing a separate mounting surface for the scraper assembly. A generally U-shaped spring is provided having one end operably connected to the scraper portion and the other end operably connected to the mounting plate to provide the resilient means.

Further according to the principles of the invention, a tunneling machine is provided with a resiliently mounted scraper assembly which includes a first scraper portion for engaging an end face of a tunnel and a second scraper portion for engaging the side wall of the tunnel for clearing materials from the path of the roller cutter. The first and second scraper portions are resiliently mounted and are normally biased to an axially advanced position and a radially outward position, respectively, to insure continuous engagement with their respective tunnel surfaces. A guide plate is provided to prevent movement of either of the scraper portions toward the roller cutter to permit mounting the scraper portions in close proximity to the roller cutter. The first and second scraper portions are intersecting edge portions of a scraper plate member, and intersecting edge portions of the guide plate provide fixed scraper portions for further protecting the roller cutter.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects, principles and advantages of this invention will become readily apparent to those skilled in the art upon a comprehensive understanding of the preferred embodiment of the invention shown in the accompanying drawings, wherein:

FIG. 1 is a perspective view of a tunneling machine according to the principles of the invention, portions of which are shown in phantom;

FIG. 2 is an enlarged perspective view of a gage scraper used on the tunneling machine shown in FIG. 1;

FIG. 3 is a further enlarged plan view of the gage scraper shown in FIG. 2, but with portions of the scraper shown in a worn condition; and

FIG. 4 is an elevational view of the gage scraper shown in FIG. 3 taken along reference view line 4—4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings in greater detail, FIG. 1 shows a tunneling machine of the type disclosed in U.S. Pat. No. 3,383,138 to Victor J. Scravilli et al. The tunneling machine includes a support frame 10 which is braced against the cylindrical tunnel wall by hydraulically actuated forward holding feet 11 and hydraulically actuated rearward holding feet 12 to position the machine in proper alignment and absorb the torque produced by the machine. A movable carriage frame (not shown) is carried on the support frame by articulated torque arms (not shown) so that the movable carriage frame may be displaced axially relative to the support frame 10 by push cylinders (not shown) which act between the support frame 10 and the movable carriage frame. Drive motors 13, only one of which can be seen in FIG. 1, are mounted on the rearward portion of the movable carriage frame and provide the power for driving a central drive shaft through gears contained in the gear housing 14. However, it is understood that this invention can be applied to any machine having roller cutters, and the foregoing description of a particular machine has been for purposes of illustration only and otherwise forms no part of the present invention.

Rotatably journaled on the forward end of the movable carriage frame and driven by the central drive shaft is a rotatable cutter head 20. A plurality of inside saddles 21 are located in predetermined positions on the forward end face of the cutter head 20 by locating dowel pins (not shown) and welded to the cutter head 20. Each inside saddle 21 carries an inside roller cutter 22. In a similar manner, three gage saddles 23 are located in predetermined positions on the front face of the cutter head 20 by locating dowel pins (not shown) and suitably welded to the cutter head. A gage roller cutter 24 is rotatably journaled in a suitable manner to each of the gage saddles 23. In the preferred embodiment, the gage saddles 23 support the gage cutters 24 in such a manner that the axis of rotation 25 of the gage cutters 24 is at an angle to the axis of rotation of the inside cutters 22, so that the tunnel end face is provided with a slightly relieved portion adjacent the cylindrical tunnel wall.

The inside cutters 22 and the gage cutters 24 may be of any desired type and are chosen in a well known manner. For example, when tooth type cutters are to be used and soft formations such as clay and soft shale are expected to be encountered, the cutters must have teeth large enough to produce a gouging action in the formation. Tooth type cutters for medium hard formations such as limestone and sandstone must have a larger number of slightly smaller teeth to prevent breakage. For extremely hard igneous formations such as diorite, granite, quartzite or basalt, tooth type cutters having individually mounted tungsten carbide inserts in the cutting face may be used. If desired, a circumferential tooth, kerf type cutter may be used for a wide range of soft to medium hard formations. The principles of the invention may be practiced regardless of the type of roller cutter used.

When the hydraulically actuated holding feet 11 and 12 are extended radially outwardly to grip the cylindrical wall of the tunnel and prevent movement of the support frame 10 relative thereto, the drive motors 13 are actuated to rotate the cutter head 20 in the clockwise direction as viewed from the rearward portion of the tunneling machine facing forwardly. As the cutter head 20 rotates, suitable push cylinders (not shown) advance the movable carriage frame (not shown) axially forwardly to force the roller cutters 22 and 24 against the tunnel end face with rolling contact to cut or crush the formation being encountered. A liquid drilling fluid is supplied to

remove the formation particles that have been cut or crushed from the tunnel end face. This prevents the formation particles from being recut by the roller cutters, and prevents the formation particles from accumulating between the saddles and the cutters to reduce the possibility of clogging the cutters and to reduce the possibility of any of the cutters ceasing to rotate and being worn by skidding about the tunnel end face. This liquid drilling fluid accumulates in the bottom of the tunnel bore, and muck deflectors 29 deflect this accumulation of formation particles and drilling fluid into muck buckets 30 as the cutter head 20 rotates. A muck ring 31 is rigidly mounted on the support frame 10 and provides one wall for each bucket 30. As each bucket 30 rotates from the lower portion of the tunnel to the upper portion of the tunnel, it reaches the end of the ring 31 so that the contents of the bucket are dropped onto a conveyor (not shown) which is mounted on top of the tunneling machine to convey the material to the rear of the machine.

Although the liquid drilling fluid and muck-removal devices discussed above may satisfactorily remove loose formation particles from the path of the roller cutters, other cut or crushed formation particles occasionally are loosened from the tunnel end face by the roller cutter but do not freely fall from the end face. Such formation particles which adhere to the end face of the tunnel may then cause an uneven force to be applied to the cutter head when the roller cutter, which will be slightly axially advanced from its prior pass, encounters the projecting formation particle on a subsequent pass. This could result in damage to the cutter head, or the roller cutter, or other components of the tunneling machine. This problem is particularly significant with regard to the gage cutters 24 which travel about the radially outermost portion of the tunnel end face adjacent the cylindrical tunnel wall. In addition to the problem relating to formation particles which project from the end face of the tunnel, such gage cutters may be subject to a more serious problem by formation particles which project from the portion of the cylindrical tunnel wall adjacent the tunnel end face. Since the gage cutters are adapted only to exert an axial force against the tunnel end face and are not adapted to exert a radially outward force to cut or crush formations encountered in the cylindrical tunnel wall, such formation particles which project from the tunnel wall may cause serious damage to the gage saddle, the gage cutter, or other portions of the tunneling machine.

To overcome these problems, the present invention provides each gage cutter 24 with a scraper assembly or gage scraper 35. As will become more readily apparent hereinafter, a scraper assembly 35 according to the principles of this invention may also be used in cooperative relationship with an inside cutter 22 if desired. Each gage scraper 35 is mounted directly to a gage saddle 23 so that it immediately precedes its associated roller cutter 24 as the roller cutter 24 travels about the end face of the tunnel. In this manner, the invention permits the scraper 35 to be located in close proximity to the cutter 24 and also precludes the necessity for providing a separate support for mounting each gage scraper 35 to the cutter head 20. As shown in FIG. 2, two spacer blocks 37 are preferably welded to the gage saddle 23 to space the gage scraper 35 from the cutter 24. A generally flat mounting plate 38 is bolted to the spacer blocks 37 and the gage saddle 23 by suitable means such as cap screws 39. As best seen in FIG. 4, the mounting blocks 37 are arranged to position the mounting plate 38 in a plane that is substantially perpendicular to the end face of the tunnel and parallel to the longitudinal axis of the tunnel. The mounting plate 38 includes two intersecting edge portions which provide a first fixed portion 40 arranged to be parallel to and spaced from the tunnel end face and a second fixed portion 41 arranged to be parallel to and spaced from the cylindrical tunnel wall to provide maximum support for the movable scraper as described below.

The gage scraper 35 is further provided with a resilient support means which, in the preferred embodiment, is a generally U-shaped leaf spring 45. One end of the spring 45 is provided

with a bent projecting end portion 46 which is operably connected to the mounting plate 38 by cap screws 47. The other end of the spring means 45 is operably connected to a movable scraper 50 by cap screws and nuts 51. The movable scraper 50 includes a first movable scraper portion 54 for engaging the end face of the tunnel, and a second movable scraper portion 55 for engaging the wall of the tunnel immediately adjacent the tunnel end face. The scraper portions 54 and 55 slide on a guide surface 56 of the mounting plate 38, so that the surface 56 defines the plane of movement of the scraper portions 54 and 55 to be substantially perpendicular to the end face of the tunnel and substantially parallel to the longitudinal axis of the tunnel.

As best seen in FIG. 3, the spring means 45 normally biases the first movable scraper portion 54 to an axially advanced position axially forward of tooth portions 57 of the roller cutter 24. In this manner, the invention insures that the first scraper portion 54 will engage the end face of the tunnel even after the scraper portion 54 has become worn. In addition, the spring means 45 permits the first scraper portion 54 to conform to the contour of that portion of the tunnel end face which it scrapes. For purposes of illustration, FIG. 3 shows the first scraper portion 54 worn in such a manner as to conform to the contour of the tunnel end face produced by the teeth 57 of the roller cutter 24. In a similar manner, the spring means 45 biases the second scraper portion 55 to a radially outward position radially outward of the tunnel wall to insure that the scraper portion 55 engages the tunnel wall even after it has become worn. Furthermore, the spring means 45 permits the second scraper portion 55 to conform to the contour of the tunnel wall as it is abraded by the tunnel wall.

As the cutter head 20 rotates and pushes the roller cutters 22 and 24 against the end face of the tunnel with rolling contact, the first scraper portion 54 is biased against the tunnel end face by the spring and the second scraper portion 55 is biased against the portion of the tunnel side wall immediately adjacent the tunnel end face. The spring means 45 permits movement of the scraper portions 54 and 55 toward and away from the tunnel end face and tunnel wall, respectively, to accommodate any unevenness of these tunnel surfaces and to accommodate wear of the scraper portions. Any formation particles which project from the tunnel end face or tunnel wall, or other materials in the path of the roller cutter 24 are cleared from the path of the roller cutter 24 by the first scraper portion 54 or the second scraper portion 55. If either the first scraper portion 54 or the second scraper portion 55 engages a formation particle which it cannot remove from the path of the roller cutter 24, the particle may push the scraper portions away from their adjacent tunnel surfaces against the bias of the spring means 45. If this happens, the scrapers will not be damaged and the next roller cutter will crush and remove the particles.

Since the scraper portions 54 and 55 are slidably mounted on the guide surface 56 of the mounting plate 38, the scraper portions 54 and 55 cannot be displaced toward the roller cutter 24 in the direction of travel of the roller cutter around the tunnel end face. This permits mounting the scraper portions immediately adjacent the roller cutters, yet prevents the scraper portions from contacting or interfering with the roller cutter.

Because the movable scraper is resiliently mounted, it is able to compensate for wear as a result of its abrading contact with the tunnel wall surfaces. Because cutter rollers make cutting engagement with the tunnel end face only at the radially spaced zones of the cutter teeth 57 (it being understood that other cutters act at the intervening spaces) the tunnel face has circular ridges and grooves. Thus, the scraper face 54 can wear to provide a close fitting or mating engagement and then may acquire grooves as shown at 59 wherever raised ridges occur on the tunnel face. This insures that the scraper face will maintain close contact with the tunnel face throughout its full length. In addition, after the movable scraper has been worn to an excessive degree, it can be

repaired without replacement by suitable means such as welding to build up the wall surfaces, and yet it will quickly wear itself in to a conforming fit in a minimum length of time.

Although a preferred embodiment of the invention has been shown and described in detail, it is to be understood that various modifications and rearrangements may be made without departing from the scope of the invention, which is defined in the following claims.

What is claimed is:

1. A tunneling machine comprising a rotatable cutter head, a roller cutter mounted on said cutter head for engaging an end face of a tunnel with rolling contact, a scraper leading said roller cutter and including a scraper portion for engaging a surface of said tunnel for clearing materials from the path of said roller cutter, a mounting means mounting said scraper relative to said rotatable cutter head, said mounting means including resilient means for permitting movement of said scraper portion relative to said cutter head radially and axially away from said tunnel surface against the bias of said resilient means.

2. A tunneling machine as set forth in claim 1 wherein the plane of movement of said scraper portion relative to said cutter head is substantially parallel to the longitudinal axis of said tunnel.

3. A tunneling machine as set forth in claim 1 wherein said mounting means includes means for limiting movement of said scraper portion relative to said cutter head toward said roller cutter in the direction of travel of said roller cutter around said tunnel end face.

4. A tunneling machine as set forth in claim 3 wherein said means for limiting movement includes a guide surface, said scraper portion is slidably mounted on said guide surface, and said guide surface defines the plane of movement of said scraper portion and prevents movement of said scraper portion relative to said cutter head toward said roller cutter in the direction of travel of said roller cutter around said tunnel end face.

5. A tunneling machine as set forth in claim 4 including a saddle secured to said cutter head carrying said roller cutter, and said mounting means mounts said scraper portion directly on said saddle.

6. A tunneling machine as set forth in claim 5 wherein said guide surface is one surface of a mounting plate which is connected to the leading side of said saddle, and said resilient means includes a spring operating between said mounting plate and said scraper portion.

7. A tunneling machine as set forth in claim 1 wherein said tunnel surface is a tunnel end face, said scraper portion is normally biased by said resilient means to a first axially advanced position, and said resilient means permits movement of said scraper portion to a second position axially rearward of said axially advanced position when said roller cutter is forced against said tunnel end face by said cutter head.

8. A tunneling machine as set forth in claim 1 wherein said tunnel surface is a tunnel wall, said scraper portion is normally biased by said resilient means to a first radially outward position, and said resilient means permits movement of said scraper portion to a second position radially inward of said radially outward position when said roller cutter is forced against said tunnel end face by said cutter head.

9. A tunneling machine comprising a rotatable cutter head, a roller cutter carried within a saddle mounted on said cutter head for engaging an end face of a tunnel with rolling contact, a scraper leading said roller cutter and including a scraper portion for engaging a surface of said tunnel for clearing materials from the path of said roller cutter, a mounting means mounting said scraper directly on said saddle, said mounting means including a mounting plate having a guide surface which defines the plane of movement of said scraper portion and resilient means for permitting movement of said scraper portion relative to said cutter head away from said tunnel surface against the bias of said resilient means, said resilient means comprising a leaf spring having a generally U-shaped

portion, one end of said U-shaped portion being operably connected to said scraper portion, and the other end of said U-shaped portion being operably connected to said mounting plate.

10. A tunneling machine comprising a rotatable cutter head, a roller cutter mounted on said cutter head for engaging an end face of a tunnel with rolling contact, a scraper leading said roller cutter, and a mounting means mounting said scraper relative to said rotatable cutter head, said scraper including a first scraper portion for engaging said tunnel end face for clearing materials from the path of said roller cutter and a second scraper portion for engaging a tunnel wall of said tunnel for clearing materials from the path of said roller cutter, said mounting means includes resilient means, said resilient means normally biases said first scraper portion to axially forward position and said second scraper portion to a radially outward position, and said resilient means permits movement of said first scraper portion away from said tunnel end face to a position axially rearward of said axially advanced position and movement of said scraper portion away from said tunnel wall to a position radially inward of said radially outward position.

11. A tunneling machine as set forth in claim 10 wherein the plane of movement of said first and second scraper portions relative to said cutter head is substantially parallel to the longitudinal axis of said tunnel.

12. A tunneling machine as set forth in claim 10 wherein said first and second scraper portions are intersecting edge portions of a scraper plate member.

13. A tunneling machine as set forth in claim 10 wherein

said mounting means includes means for limiting movement of said first and second scraper portions relative to said cutter head toward said roller cutter in the direction of travel of said roller cutter around said tunnel end face.

14. A tunneling machine as set forth in claim 13 wherein said means for limiting movement includes a guide surface, said first and second scraper portions are slidably mounted on said guide surface, and said guide surface defines the plane of movement of said first and second scraper portions and prevents movement of said first and second scraper portions relative to said cutter head toward said roller cutter in the direction of travel of said roller cutter around said tunnel end face.

15. A tunneling machine as set forth in claim 14 including a saddle secured to said cutter head carrying said roller cutter, and said mounting means mounts said first and second scraper portions directly on said saddle.

16. A tunneling machine as set forth in claim 15 wherein said guide surface is one surface of a mounting plate which is connected to the leading side of said saddle, and said resilient means includes a spring operating between said mounting plate and said first and second scraper portions.

17. A tunneling machine as set forth in claim 16 wherein said spring is a leaf spring having a generally U-shaped portion, one end of said U-shaped portion is operably connected to said first and second scraper portions, and the other end of said U-shaped portion is operably connected to said mounting plate.

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