United States Patent [19]

Fink

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[54] **BIDIRECTIONAL ROLLER CUTTER**

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[52] **U.S. Cl.** **308/8.2,** 175/364, 403/356, 403/362

[51] **Int. Cl.** **E21c 13/12**

[58] **Field of Search** 308/8.2, 23; 175/360, 361, 175/362, 363, 364; 403/356, 358, 362

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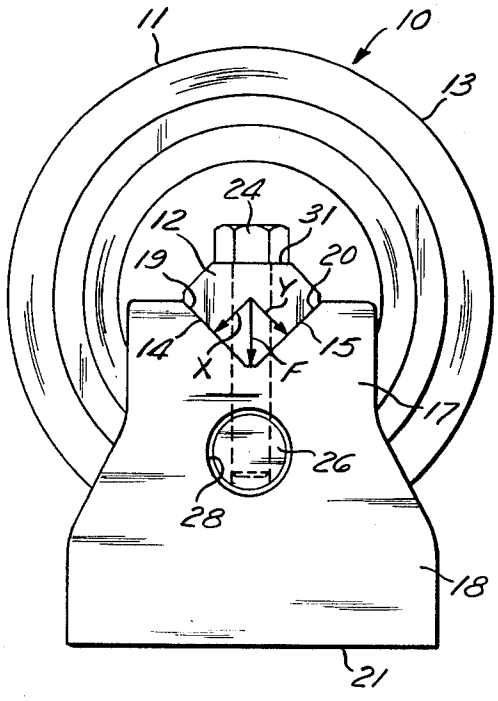
Primary Examiner—Manuel A. Antonakas

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[57] **ABSTRACT**

A bidirectional roller cutter assembly adapted to be fixed to the cutter head of a tunneling machine is disclosed. The cutter assembly includes a cutter rotatably mounted on a shaft so that end portions of the shaft project from the cutter. Each of those projecting end portions has a pair of flat faces the planes of which intersect at an angle of 90°. A generally U-shaped saddle having projecting arm portions mounts the shaft so that the cutter is rotatable on the shaft. Each arm of the saddle has a pair of flat faces the planes of which intersect at an angle of 90° and which engage the faces on a projecting end portion of the shaft. The planes defined by the engaged faces define angles of 45° with respect to the mounting face of the saddle and the engaged faces are clamped together by bolts which exert a clamping force having resultants normal to the engaged faces and on both sides of a plane perpendicular to the mounting face. Those resultants ensure that the shaft is securely clamped to the saddle when the cutter is rotated in clockwise or counterclockwise directions, and ensure that the bolts will not be subjected to excessive shear or tensile loads during the cutting operation.

13 Claims, 3 Drawing Figures



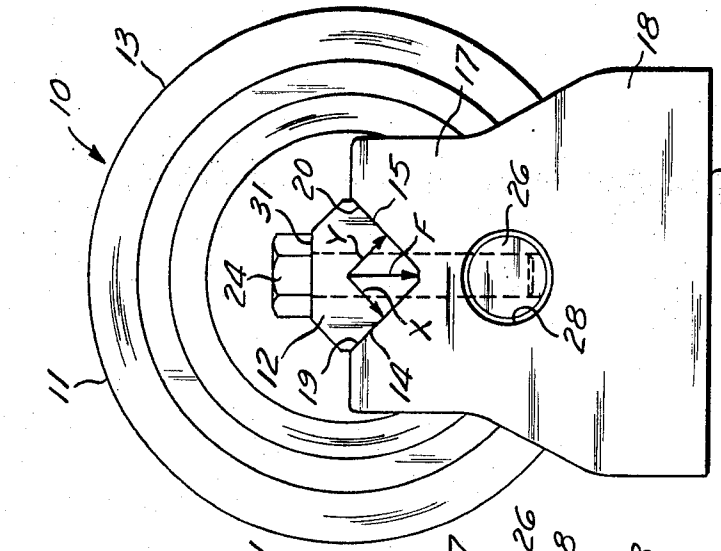


Fig. 2

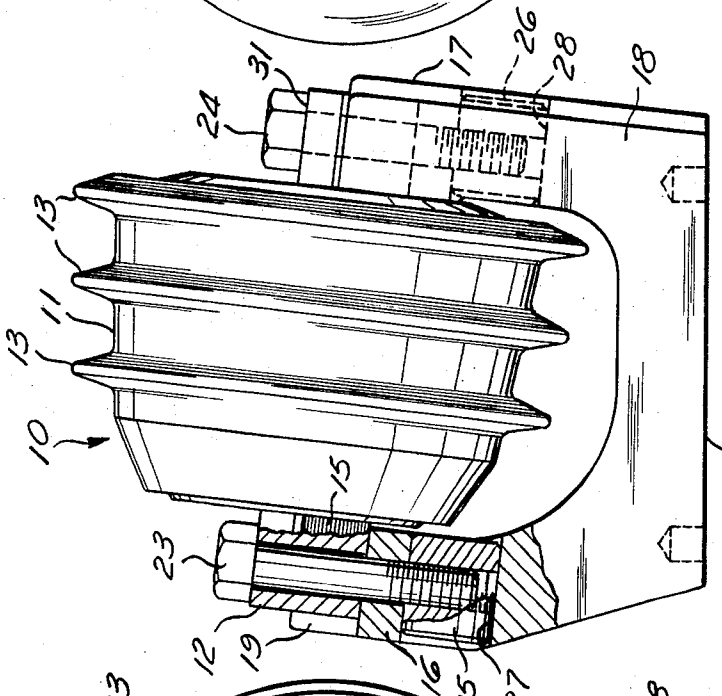


Fig. 1

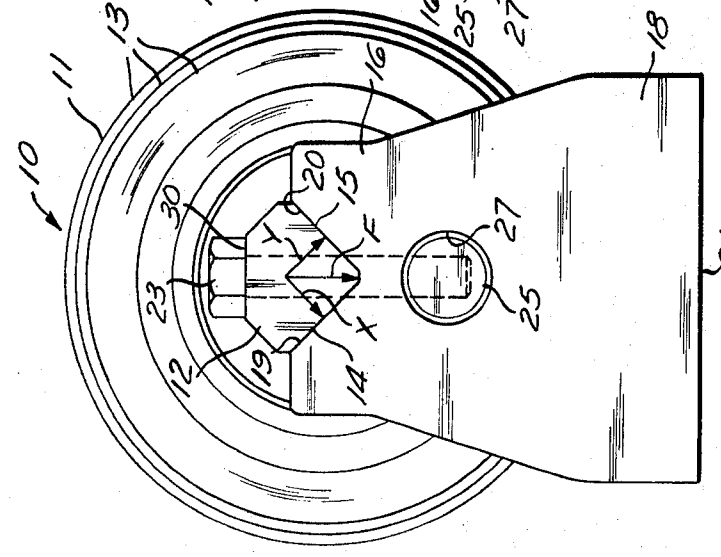


Fig. 3

BIDIRECTIONAL ROLLER CUTTER

BACKGROUND OF THE INVENTION

This invention relates generally to tunneling machines, and more particularly to tunneling machines having rotatable cutter head and roller cutters mounted on the cutter head for engaging an end face of a tunnel with rolling contact in clockwise and counterclockwise directions. Still more particularly, the invention relates to an assembly which includes a cutter mounting saddle having a cutter mounting arrangement which minimizes wear between the shaft of the cutter and the saddle independently of the direction of cutter rotation.

Tunneling machines generally include a support frame which is anchored in the tunnel by radially extensible, hydraulically operated feet which press against the tunnel walls to provide backing for the working thrust of 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 crush the formation encountered in a well known manner. Such machines are designed so that the anchored frame may be moved toward the cutter head after the cutter head bores for a few feet. Prior to this operation, the feet are brought out of engagement with the tunnel wall and when the desired forward position of the frame is attained, the feet are again extended to contact the tunnel wall.

During the cutting operation, much of the rock is crushed to a fine, extremely abrasive powder. Because of the presence of this powder, care must be taken to minimize the number of loose fitting connections between movable portions of the tunneling machine. Since portions of the tunneling machine must be removed for replacement, care must be taken to provide tight connections between such members so that the amount of abrasive material between mating surfaces will be minimized and movement between such members will also be minimized to prevent wear between these surfaces.

Since the cutter teeth will in time wear, the cutters must be replaced. Therefore, the shaft on which the cutter is rotatably mounted is removably mounted on the projecting arms of a U-shaped saddle. Typically, the shaft extends through bores in the saddle arms and is restrained against rotation and axial movement relative to the saddle by shaft lock screws or lock bolts which extend transversely through the bored arm and through one end of the shaft. Since no clamping force exists between the saddle and the shaft, precise tolerances must be maintained between these members and between the saddle arm and the cross pin. To minimize wear between the saddle arm and the shaft, split bushings are normally provided to protect the load bearing area between the shaft and the saddle arm. This particular design has not been entirely successful in minimizing wear between the parts of the assembly. Furthermore, in order to replace a cutter, it is necessary to remove the cross pin and pull the shaft axially from the folds in the saddle arm, thus necessitating removal of the shaft from its cutter.

Other typical arrangements permit removal of the cutter and its shaft as a unit from the saddle. In some of those arrangements, the cradle formed by the saddle arms is open-topped and each shaft is retained therein by a bolt which extends through the arms and through the shaft end. In other of those arrangements, the cradled shaft end is retained therein by one or more clamping members which cover or substantially cover the non-cradled portion of the shaft end between the saddle arms and which are bolted to at least one of the saddle arms. Although all of these arrangements permit removal of the cutter and its shaft as a unit from the saddle, certain problems have existed. No significant clamping force obtains where the bolt extends through the arms and the shaft and the employment of one or more clamping members increases the interface area, which may collect abrasive powder.

In my copending application Ser. No. 390,012, filed Aug. 20, 1973, there is disclosed a cutter assembly which overcomes the foregoing prior art problems by providing a cutter rotatably mounted on a shaft so that end portions of the shaft project from the cutter. Each of those projecting end portions has a pair of flat faces the planes of which intersect at an angle of 90°, with one face being substantially normal to the intended cutting plane and the other face being substantially parallel to that plane. A generally U-shaped saddle having projecting arm portions mounts the shaft and has a face adapted to be secured to the cutter head. Each arm of the saddle has a pair of flat faces the planes of which intersect at an angle of 90° and which engage the faces on a projecting end portion of the shaft. The engaged faces are clamped together by bolts, each of which exerts a clamping force having components normal to the faces and each of which is more nearly horizontal than vertical with respect to the intended cutting plane and with respect to the mounting face of the saddle. A clamping bolt projects through each arm and through each end portion of the shaft at an angle so that force components force the faces into tight engagement, thus eliminating the need for maintaining precise tolerances between those faces.

While the arrangement set forth in my copending application overcomes the previously mentioned problems, it is designed to work on a tunnel face in a single rotative direction. In some applications, it is desirable to reverse the rotative direction of the cutter head periodically. Those operations include operations where a shield tunneler is employed to cut soft earth or a combination of soft earth and hard rock. The relatively soft tunnel wall is not able to hold the machine frame against the tremendous torque loads imposed on the frame by the cutter head and the frame tends to rotate in a direction opposite to the rotative direction of the cutter head. It is therefore necessary to reverse the direction of the cutter head periodically to realign the machine frame. The cutter assemblies according to my copending application are not entirely suited for such reversals, since excesive tensile loads would be placed upon the mounting bolts of the cutter shaft. The previously described prior art arrangements are not entirely suitable for such use, since there would tend to be back-and-forth movement of the cutter shaft upon direction reversal, which would trap abrasive particles between the shaft and its mount.

SUMMARY OF THE INVENTION

The present invention overcomes these and other problems of prior art tunneling machines by providing a cutter assembly having an improved connection between the shaft and the saddle arms which is suited for bidirectional cutting operations. According to the principles of the invention, the connection may be effected

without maintaining precise tolerances between the mating surfaces and the connection itself positively clamps the shaft to the saddle arms. According to the teachings of this invention, a cutter assembly comprises a cutter rotatably mounted on a shaft so that end portions of the shaft project from the cutter. Each of those projecting end portions has a pair of flat faces the planes of which define an inclined angle of preferably 90°. A generally U-shaped saddle having projecting arm portions mounts the shaft and has a mounting face adapted to be secured to a cutter head. At least one of the projecting arm portions has first and second flat faces which are non-parallel with respect to each other and with respect to the mounting face and which respectively engage the first and second faces of an end portion. The flat faces of the arms preferably define an included angle of 90°, and define angles of 45° with respect to the saddle mounting face. A bolt clamps the faces together and the bolt preferably bisects the 90° included angle defined by the engaged faces. The resulting arrangement produces a clamping force having resultants normal to the engaged faces and on both sides of a plane perpendicular to the mounting face. Those resultants ensure a tight connection during either clockwise or counterclockwise rotation of the cutter head.

BRIEF DESCRIPTION OF THE DRAWING

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 drawing, wherein:

FIG. 1 is an elevational view, partly in section, of a cutter assembly according to the principles of the invention;

FIG. 2 is a right end view of the cutter assembly shown in FIG. 1; and

FIG. 3 is a left end view of the cutter assembly illustrated in FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawing in greater detail, a cutter assembly **10** is illustrated. The assembly **10** includes a cutter **11** rotatably mounted on a shaft **12** so that end portions of the shaft project from the cutter. The illustrated cutter **11** is a circumferential disc, kerf-type cutter having a plurality of discs **13**. It should be appreciated, however, that other cutter configurations may be employed depending upon the type formation to be cut. Suitable conventional bearings and bearing seals are provided between the shaft **12** and the cutter **11** to permit relative rotation between the cutter **11** and the shaft **12**, while preventing abrasive grit from entering the bearing area.

Each of the projecting end portions of the shaft **12** has a pair of flat faces **14** and **15** which are angularly related to each other at an angle of 90°. The projecting end portions are mounted on the ends of projecting arm portions **16** and **17** of a U-shaped saddle **18** so that the cutter **11** may rotate relative to the shaft. Each arm of the saddle **18** has a pair of flat faces **19** and **20** which are angularly related at an angle of 90° and which respectively engage the flat faces **14** and **15** of the shaft. The planes defined by the engaged faces **14, 19, 15,** and **20** form angles of 45° with respect to a mounting face **21** of the saddle **18,** which is adapted to be affixed to a cutter head. Clamping means are provided at each end of the shaft to respectively clamp the faces **14** and **15** to the faces **19** and **20** of the projecting arm portions **16** and **17.**

According to this invention, the clamping means comprises bolts **23** and **24.** The bolts **23** and **24** extend through the projecting end of the shaft **12** and into the arms **16** and **17,** and the axis of each bolt **23** and **24** bisects the 90° angle defined by the engaged faces **14, 19, 15,** and **20.** The bolts **23** and **24** are threadedly engaged with barrel nuts **25** and **26,** respectively, and have heads which engage flat faces **30** and **31** of the shaft end portions. As may be seen most clearly in FIG. **1,** the barrel nuts **25** and **26** are cylindrical and are received within cross bores **27** and **28.** Although the bolts could be retained by threaded engagement with tapped bores in the saddle **18,** the barrel nut arrangement disclosed herein is preferable, since it is less costly to replace a barrel nut if the threads of that nut are stripped than to replace an entire saddle in the event of thread strippage therein.

As may be seen in FIGS. **2** and **3,** each bolt **23** and **24** exerts a clamping force F having resultants X and Y which are respectively perpendicular to the engaged faces **14** and **19** and the engaged faces **15** and **20.** These resultants are on both sides of a plane perpendicular to the mounting face **21** so that force resultants exist in two directions with respect to the two rolling directions of the cutter along the tunnel face. According to the preferred illustrated aspect of the invention, each force F is perpendicular to the mounting face **21** and bisects the angle defined by the engaged faces so that the resultants X and Y are of equal magnitude.

While I have described my invention in connection with specific embodiments thereof, it is to be clearly understood that this is done only by way of example, and not as a limitation to the scope of my invention as set forth in the objects thereof and in the appended claims.

What is claimed is:

1. A roller cutter assembly comprising a cutter rotatably mounted on a shaft so that end portions of said shaft project from said cutter, each end portion having first and second flat angularly related faces, a generally U-shaped saddle having projecting arm portions mounting said shaft and having a mounting face adapted to be secured to a cutter head, at least one of said projecting arm portions having first and second flat faces which are non-parallel with respect to each other and with respect to said mounting face and which respectively engage the first and second angularly related faces of an end portion, means for clamping said angularly related faces to said flat faces with a clamping force have resultants normal to the engaged faces and on both sides of a plane perpendicular to said mounting face.

2. A roller cutter assembly according to claim **1,** wherein said resultants are of equal magnitude.

3. A roller cutter assembly according to claim **1,** wherein said clamping means comprises a bolt extending through said end portion and into said arm portion.

4. A roller cutter assembly according to claim **3,** wherein said bolt is subject to substantially pure tensile loads during rolling action of said cutter in either direction.

5. A roller cutter assembly according to claim 1, wherein said engaged faces define substantially equal angles with respect to said mounting face.

6. A roller cutter assembly according to claim 5, wherein said angles are at least 45°.

7. A roller cutter assembly according to claim 3, wherein said bolt bisects the angle included between said engaged faces.

8. A roller cutter assembly according to claim 7, wherein said bolt is substantially normal to said mounting face.

9. A roller cutter assembly according to claim 8, wherein said inclined angle does not substantially exceed 90°.

10. A roller cutter assembly comprising a cutter rotatably mounted on a shaft so that end portions of said shaft project from said cutter, each end portion having first and second flat faces defining an angle of about 90°, a generally U-shaped saddle having projecting arm portions mounting said shaft and a mounting face adapted to be secured to a cutter head, each projecting arm portion having first and second flat faces which define an angle of about 90° with respect to each other and each of which defines an angle of about 45° with respect to said mounting face, said first and second faces of each of said end portions respectively engaging the first and second faces of each of said arm portions, bolt means clamping said engaged faces together, the axis of said bolt means bisecting the 90° angle defined by said engaged faces.

11. A roller cutter assembly according to claim 10, wherein each of said end portions has a third flat face parallel to said mounting face and wherein said bolt means has a flat head at one end engaging said third face.

12. A roller cutter assembly according to claim 11, wherein the other end of said bolt means threadedly engages a nut associated with said U-shaped saddle.

13. A roller cutter assembly according to claim 12, wherein said nut comprises a cylindrical shaft received within a bore in saddle and having a transverse threaded bore threadedly engaging said bolt means.

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