June 29, 1954 J. E. TOTH ET AL 2,682,181

TUBE CUTTING APPARATUS

Filed March 27, 1950 2 Sheets-Sheet 1

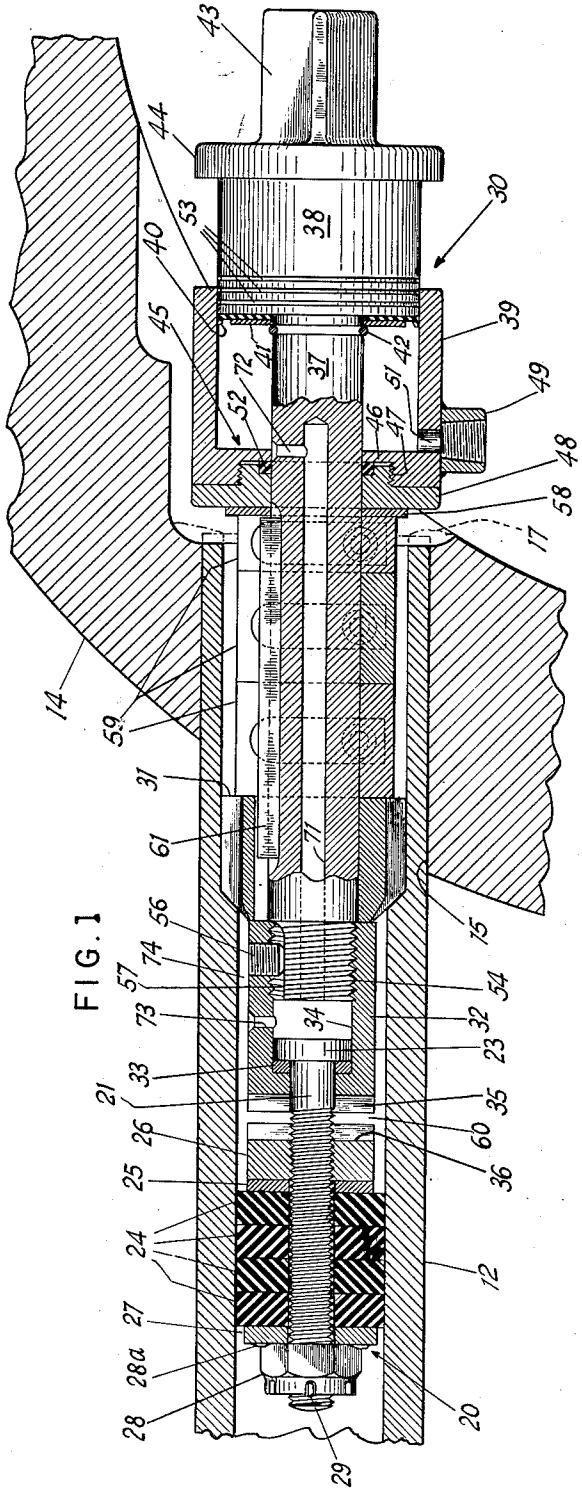

FIG. 1

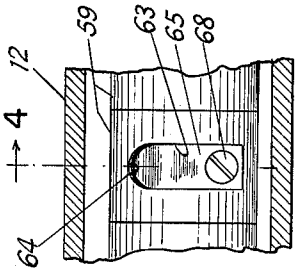

FIG. 3

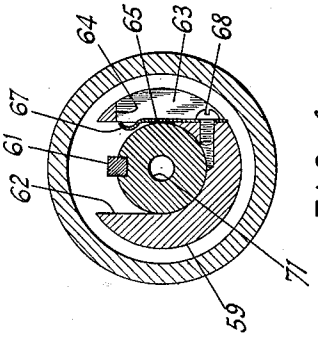

FIG. 4

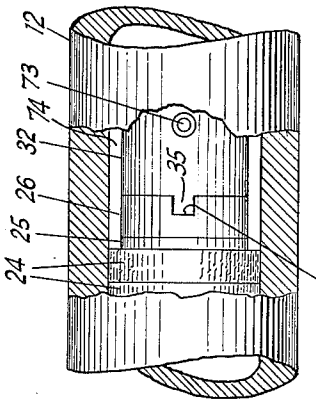

FIG. 2

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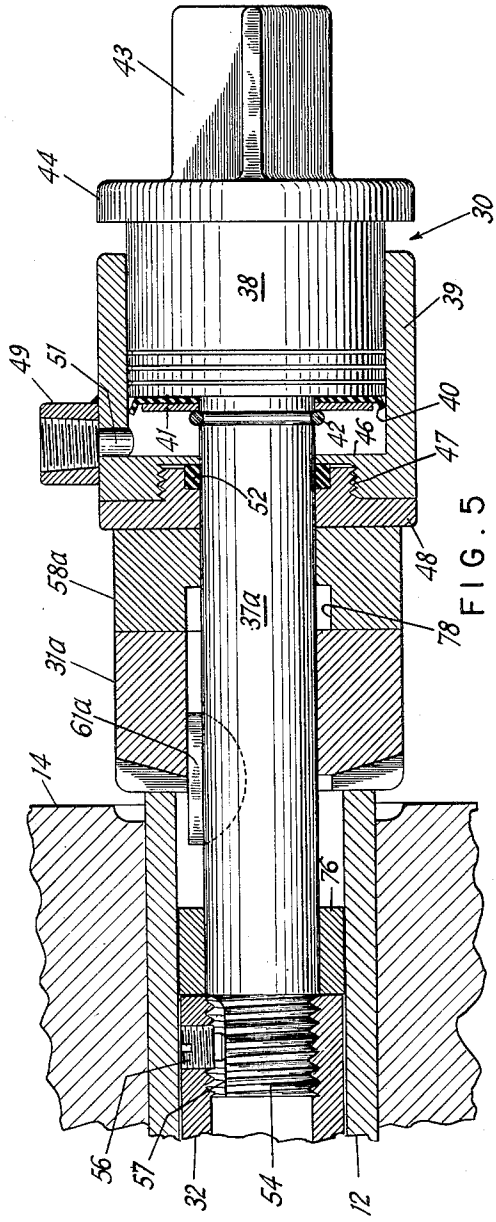

FIG. 5

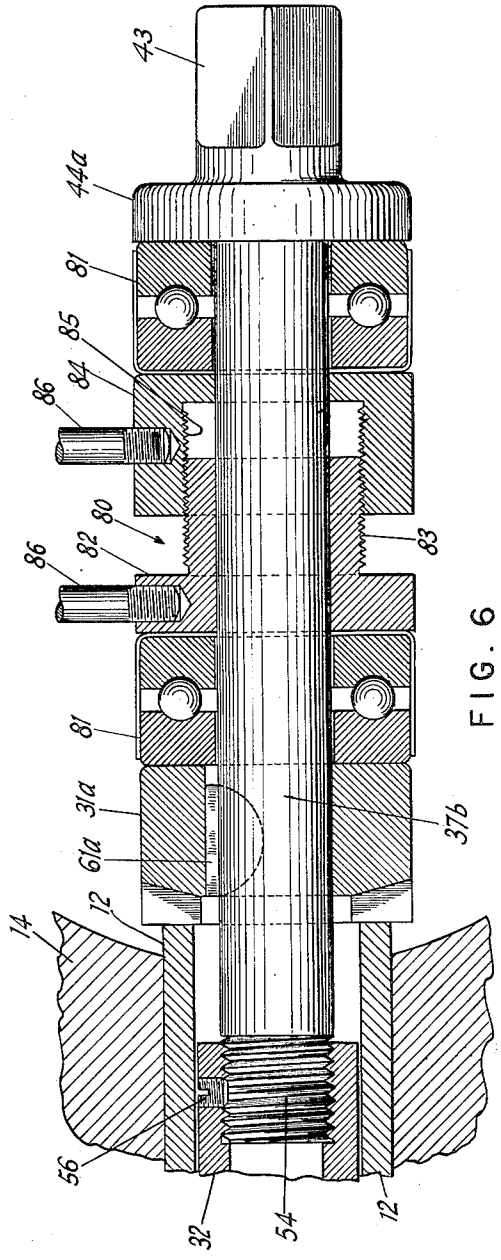

FIG. 6

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TUBE CUTTING APPARATUS

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5 Claims. (Cl. 77—2)

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The present invention relates in general to the construction and operation of tube cutting apparatus and more particularly to apparatus of a portable type adapted to perform various cutting operations on tubes assembled in the walls of pressure vessels. Such tubes are generally expanded within tube seats formed in the walls and, to further assure a fluid tight assembly, the tubes are seal-welded at their inner ends to the surrounding wall metal.

In order to remove a tube, for replacement, for example, the welded connection at the tube end is removed, and the tube thickness within the tube hole reduced to an extent which enables the expanded tube end portion to be collapsed or otherwise suitably deformed so as to permit withdrawal of the tube without damage to the associated tube seat.

Our invention is therefore especially concerned with a form of tube cutting apparatus, or tool, having relatively movable connected components, one of which is adapted to extend interiorly of a tube, and to be maintained stationary therein, while another component is adapted to extend exteriorly of the tube, and to receive and support a cutter for movement relative to the tube. The second named component also incorporates means for effecting anchorage of the first named component within the tube, and further includes separately operable means arranged to effect both translational and rotational movement of the cutter relative to the tube.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described a preferred embodiment of our invention.

Of the drawings:

Fig. 1 is a longitudinal sectional view of a portable tube cutting apparatus or tool of our invention, in operative position relative to a tube;

Fig. 2 is a fragmentary view of the tool shown in Fig. 1, rotated through 90°; and showing components of the assembly in a different position of operation;

Fig. 3 is a fragmentary view of the tool shown in Fig. 1, showing certain details;

Fig. 4 is a sectional view of parts shown in Fig. 3, taken along line 4—4; and

Figs. 5 and 6 are longitudinal sectional views

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showing separate modifications of the cutter-supporting component included in Fig. 1.

In more detail, Fig. 1 shows a portable type of tube cutting apparatus or tool arranged in operative relationship to a tube 12 assembled in the wall of a pressure vessel 14, such as a superheater header of circular cross section. It may be assumed that the end portion of tube 12 has been expanded into contact with the tube seat 15, throughout the thickness of the header wall, so as to form a pressure tight joint connecting the tube to the header. Other tubes, not shown, may be similarly connected. As originally assembled, the tube may project slightly beyond the inner end of tube seat 15, where the inner end of the joint may be sealed by a circumferential deposit of weld metal 17, as represented by broken lines.

The cutter tool, as illustrated, comprises relatively movable, axially coupled components which in terms of their respective functions and relative positions may be termed an inner tube plug, or tube gripping component 20, and an outer, cutter support, or supporting component 30; the cutter 31 being formed as a reamer with a series of flutes or teeth which provide cutting edges at its periphery and also at its forward end. Associated with the component 30 are means for operating the cutter, whereby the cutter is rotated relative to the tube and also moved axially thereof. It may be assumed that the weld deposit 17 has been removed, using a different form of cutter, to be later described, and that the tool is now in position for cutting away metal interiorly of the tube so as to reduce the tube wall thickness and thereby facilitate removal of the tube from within its tube seat 15.

The tube gripping component 20 comprises a central threaded shaft or bolt 21 having a cylindrical head 23 slidable within the cylindrical bore 34 of a coupling 32 which constitutes the terminal element of the cutter supporting component 30. Such a device is known to the art as an internal expanding anchor. The shaft 21 extends through a hole 22 in an end wall of the coupling and a metal bushing 33 is interposed between the end wall and the shaft head 23. Discs 24, of a suitable deformable resilient material, such as rubber, or a combination of rubber and fabric, for example, are mounted concentrically on shaft 21 and clamped between a washer 25 and cylindrical locking nut 26 at one end, and a washer 27 and castle nut 28 at the opposite end; the nut 28 being locked in position by a cotter pin 29. The nut 28 may also be soldered to washer 27 as indicated at 28a. The locking

nut 26 and coupling 32 have their opposing end surfaces formed to provide tongue-and-groove engagement diametrically of the surfaces, as illustrated in Fig. 2, for a purpose hereinafter described. In the form shown, the tongue 35 is provided on coupling 32, and the groove 36, on locking nut 26. Shaft 21 and nut 25 constitute operating means for expanding anchor 20.

The cutter support component 30 includes a central drive shaft 37 having an enlarged cylindrical outer end portion 38 which is received within the open end of an operating cylinder 39; the enlarged shaft portion 38 constituting an end closure or piston and being sealed to the inner circumferential wall of the cylinder by a leather plunger cup 40, suitably held in assembled position against the face of the piston by a washer 41 and a retaining spring 42, the latter fitting a groove in the shaft. Piston 38 and cylinder 39 constitute elements of the cutter feeding means. The shaft 37 terminates in an outermost end portion or shank 43, of square or other suitable form of cross section, for connection to an air motor, for example, not shown, or other known driving means for rotating the shaft and thereby the cutter 31. The flange 44 serves as a stop to limit contracting telescoping movement of cylinder 39 relative to piston 38. The inner end of shaft 37 extends through the cylinder end wall 45, of which the inner wall portion 46 is integral with the body of clinder 39, and is recessed and threaded at 47 to receive a correspondingly threaded removable end wall portion, or cylinder cap 48. A pipe coupling 49 is secured to the lateral wall of the cylinder in registry with a hole 51 through which an operating fluid, normally air, is introduced under pressure. A deformable packing ring 52 is clamped between the cap 49 and the inner end wall portion 46 so as to form a fluid seal circumferentially of shaft 37. The forward end of drive shaft 37 is threaded at 54 into the threaded open end of coupling 32. Various means may be employed to lock the coupling in position on shaft 37, for example, a headless set screw 56 which extends through the wall of coupling 32 and engages a chordal flat 57 on the threaded shaft portion 54.

A thrust washer 58 is assembled on shaft 37 against the outer face of the cylinder end wall 45 and, for the cutting operation indicated, the entire longitudinal space between the washer and the cutter 31 is occupied by spacer blocks 59 of various thicknesses. The cutter is keyed to shaft 37 by means of a key 61 which extends from a point adjacent the outer face of thrust washer 58 to a point intermediate the ends of cutter 31, when the cutter is in its extreme forward position on the shaft.

Each spacer block 59, as detailed in Figs. 3 and 4, is slotted longitudinally as at 62 to enable the block to be assembled on shaft 37 in a transverse or radial direction; the width of slot 62 being slightly greater than the diameter of shaft 37 at the point of assembly, and the base of the slot being semi-circular in form to correspond to the peripheral surface of the shaft. Each block 59 is also formed with a transverse slot 63 which extends to a depth sufficient to provide an opening into the longitudinal slot 62 adjacent an end wall 64 of the transverse slot 63. A snap spring 65, having an inwardly curved end portion 67, is assembled within slot 63 and secured to block 59 by means of a screw 68. The spring 65 thus maintains the block in operative position on shaft 37, and also enables the block

to be snapped into or out of position over the full diameter of the shaft.

The drive shaft 37 is formed with an axial bore or passage 71 which extends from the innermost end of the shaft to a point adjacent but spaced from the piston enlargement 38. A radial port or passage 72 in shaft 37 penetrates inwardly to the axial bore 71 to provide communication between the interior of cylinder 39 and the interior shaft passage 71. A similar radial port 73 in the circumferential wall of coupling 32 extends the path of communication to the annular space 74 which separates coupling 32 from the inner surface of tube 12.

When a tube 12 is to be reamed, as indicated in Fig. 1, before inserting the tool within the tube, the cylinder 39 is first moved along the shaft 37 toward the shank end 43 and, with all spacer blocks 59 removed, the cutter 31 moved back in the same direction. It should also be made certain that the rubber discs 24 are not expanded. If the discs are found to be expanded, the clamping pressure on the discs should be relieved by moving the shaft 37 forward to cause the coupling 32 to engage the locking nut 26, through the tongue-and-groove connection 35, 36, and then rotating the drive shaft counter-clockwise while holding the rubber discs and locking shaft 21 stationary. The pipe fitting 49 is then connected, by means of an air hose for example, to a source of operating air, under pressure of about 100 p. s. i.

To insert the cutting tool within tube 12, the coupling 32 is moved into engagement with the locking nut 26, with tongue 35 seated within groove 36, and the tool then pressed into the tube until the cutter 31 bears against the end of the tube. Then with a small wrench engaging the shank 43, the drive shaft 37 is turned clockwise, with enough pressure being exerted axially of the shaft to cause the coupling elements 26 and 32 to remain engaged until the tube gripping assembly 20 is anchored within the tube in operative position. The drive shaft 37 is then pulled out to a position where it may be rotated freely by hand, as a result of the tongue-and-groove coupling connection having been opened, and thereby providing a clear axial space 60 between tongue 35 and the adjacent end surface of coupling element 26. The cylinder 39, thrust washer 58, and cutter 31, are then moved forward by hand, as a unit, until the cutter is brought into contact with the tube.

The air motor drive, previously mentioned, is then attached to the shank 43 and the motor run in the proper direction for normal cutter operation. To feed the cutter, air is admitted to the interior of cylinder 39 under pressure of about 100 p. s. i., whereby the cylinder is moved forward relative to its piston 38, and the cutter 31 moved in unison therewith, in accordance with the rate at which tube metal is cut away. As the cutting operation progresses, a point is reached where it becomes necessary to insert a spacer block 59 in order to extend the range of cutter travel axially of the tube. Several oil grooves 53, which are provided in piston 38 adjacent its forward end, also serve to indicate when cylinder 39 is approaching a predetermined limit of its stroke at which further forward movement should be arrested so as to avoid damage to certain parts of the tool, for example, by key 61 rubbing against the face of thrust washer 58. Accordingly, when cylinder 39 has been moved forward to a point where the groove 53 nearest flange

44 becomes visible, the air pressure is cut off and the cylinder moved back by hand toward flange 44, and a spacer block 59 inserted, for resumption of operation as before. When the first, outermost groove 53 is again uncovered, an additional block 59 is inserted, and so on, until the required axial length of cut has been completed.

Throughout these operations, the space 60 between the coupling elements 26 and 32 remains open, due to air pressure within the cylinder, and no change is required in the position of the tube gripping component 20. During operation of the tool, a certain amount of the cylinder air tends to escape around shaft 37 where it passes through the cylinder wall 45. However, this leakage air, instead of passing direct to the outside atmosphere, flows into the port 72 and thence through the central shaft passage 71, and port 73, into the annular space 74 where it is directed toward the cutter and thus toward the open end of the tube. The air in flowing both interiorly and exteriorly of the shaft serves to keep the tool cool and to blow the metal cuttings from the inside of the tube. Furthermore, when cylinder 39 has reached its maximum stroke, the port 72 is uncovered and the air freely escaping through the port automatically reduces the pressure in the cylinder to the extent that feeding action stops. When cutting operations are completed, and the air pressure is cut off, the shaft 37 may readily be moved forward and the tongue-and-groove coupling connection 35, 36 again established, whereupon the shaft is rotated counterclockwise to relieve the clamping pressure on discs 24 and thus permit removal of the tool from within the tube.

Fig. 5 illustrates a modified form of tool adapted to perform a cutting operation on the end of tube 12, such as the cutting away of a circumferential deposit of weld metal (not shown) by which the end of tube 12 is sealed to the wall 14, as described in connection with Fig. 1. The tool may also be used to resurface the end of a tube, or to reduce the length of tube extension beyond the wall 14, prior to or after the deposition of such weld metal. Parts having a form and function equivalent to those illustrated in Fig. 1 are identified by the same reference characters. The associated tube-gripping component 20, not shown, is to be understood as being of the same construction as detailed in Fig. 1, including the releasable tongue-and-groove connection to coupling 32. In the structure of Fig. 5, the spacer blocks 50 are omitted, and a shorter key 61*a* is required, because of the shorter axial distance of cutter travel involved. Cutter 31*a* is of a form particularly adapted for tube end cutting, the cutter teeth being formed on the end of the cutter and thereby providing cutting edges confined mainly to an end portion of the cutter. A thrust bearing 58*a* is substituted for the thrust washer 58 of the previously described embodiment. The bearing 58*a*, although of considerable overall thickness, is formed with a counterbore 78 to permit increased forward travel of cutter 31*a* along shaft 37*a*. A pilot ring 76 is included to afford support for the drive shaft 37*a* within tube 12 at a location between coupling 32 and the adjacent end of the tube. The pilot is dimensioned so as to provide a close sliding fit with respect to both the shaft 37*a* and the inner wall of tube 12.

Fig. 6 illustrates an additional modification, also of a form particularly adapted for tube-end cutting. The main distinction over the form detailed in Fig. 5 is the provision of mechanical means, instead of fluid pressure means, for advancing the cutter 31*a* toward the work during the cutting operation. In this form, the drive shaft 37*b* is of uniform diameter throughout, except for the flange 44*a* and the drive-attachment end 43. The cutter feeding means, generally indicated at 80, is positioned between the cutter 31*a* and flange 44*a*, and separated therefrom by a ball thrust bearing 81 at each end. The feeding means includes a flanged feed-screw 82 having an externally threaded sleeve portion 83, and a feed nut 84 having an internally threaded recessed portion 85; the screw 82 and the nut 84 having axially aligned bores for assembly of the parts on drive shaft 37*b*. Each of the parts 82 and 84 is provided with one or more radially extending rods or handles 86 for use in rotating one part relative to the other so as to regulate the overall axial dimension of the assembly and thereby advance the cutter 31*a* relative to the end of tube 12.

It is apparent from the present disclosure that each of the above described tools provides a compact assembly, and in each assembly a cutter feeding means is included as an integral component. Each form of tool is also arranged for the convenient attachment of a suitable power means for effecting cutter rotation. A feature of each assembly is the provision of an integral tube gripping component for resisting the reaction of the cutter during operation. These are features which enable the tool to be manipulated and operated within a header, or in various other locations where the tool may not be readily accessible. Provision is also made for performing different cutting operations such as tube end cutting and reaming. In this connection, it is to be noted that although one form of tool is shown for one type of cutting operation, and another form for a different operation, the same basic arrangement of parts is common to all.

While in accordance with the provisions of the statutes we have illustrated and described herein the best form of our invention now known to us those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by our claims, and that certain features of our invention may sometimes be used to advantage without a corresponding use of other features.

We claim:

1. Apparatus for removing metal from a tube comprising, in combination, a support shaft adapted to be inserted in a tube; an internal expanding anchor including a rotatable operating means for expanding said anchor; said operating means being connected to the inner end of said shaft with a lost motion connection providing for axial and rotational movement of said shaft relative to said operating means; interlocking coupling means on the axially adjacent ends of said shaft and said operating means engageable by axial movement of said shaft toward said operating means to couple said shaft to said operating means for rotation of the latter by said shaft to expand said anchor to grip the inner surface of the tube; a cutter mounted on said shaft and fixed against rotation relative thereto, said cutter being movable axially along said shaft; and cutter feeding means including a first element fixed to said shaft, a second element mounted on and movable axially along said shaft and operatively engaged with said cutter, and means operable to force said elements apart

axially of said shaft to feed said cutter along said shaft; the reaction of said last named means on said first element urging said shaft axially away from said anchor, to maintain said coupling means disengaged during feeding of said cutter to provide for rotation of said shaft and cutter.

2. Apparatus as claimed in claim 1 including spacer means removably mounted on said shaft between said cutter and said second element to maintain such operative engagement between said cutter and said second element during extended feeding of said cutter.

3. A tool as defined in claim 1 wherein said cutter support shaft is formed as a piston adjacent its outer end to form said first element and said second element comprises an open-ended cylinder telescoping with said piston and having fluid inlet means arranged to admit fluid under pressure into said cylinder.

4. A tool as defined in claim 3 wherein said cutter support shaft is formed with an axially extending interior passage communicating at its outer end with the interior of said cylinder at a point on said shaft spaced substantially from said piston, said passage communicating at its opposite end with the atmosphere surrounding said tool at a point inwardly of the path of movement of the cutter along said shaft.

5. A tube cutting tool having axially aligned interconnected components of which one is formed as an inner tube plug adapted to grip the interior of a tube and another comprises an outer cutter support shaft arranged for rotation about the axis of alignment and for axial adjustment of

a cutter therealong, a stop on said shaft, cutter feeding means positioned inwardly of said stop and comprising a member mounted on and movable along said shaft, and spacer means mounted on said shaft inwardly of said movable feeding means member for maintaining the cutter at a predetermined minimum distance from said member during normal cutting operations, said spacer means comprising a block having a slot therein of a width and depth enabling the block to be assembled on the cutter support shaft in a direction transversely thereof, and spring means associated with said block for releasably maintaining said block in operative position on the shaft, said spring means having a substantial portion of its length flat and lying parallel to the depth of said slot.

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