

Oct. 10, 1967

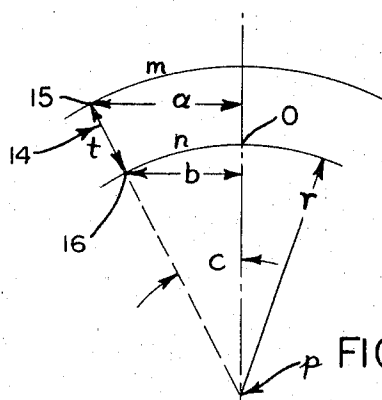
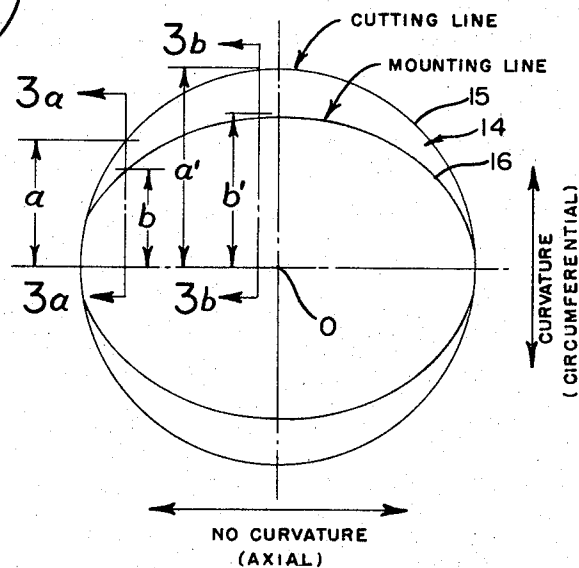
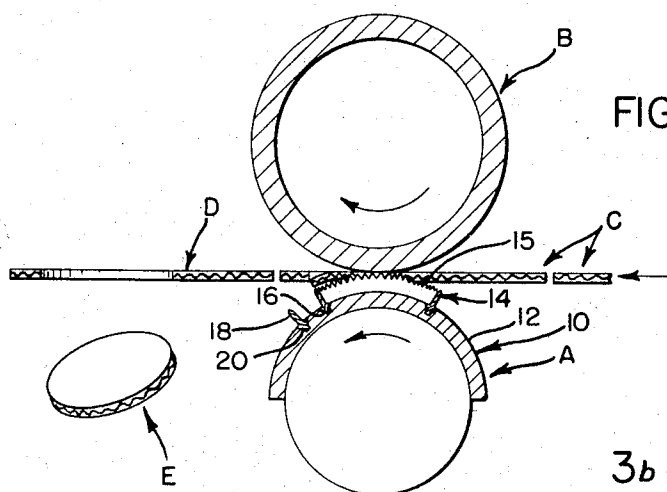
N. E. DOVEY

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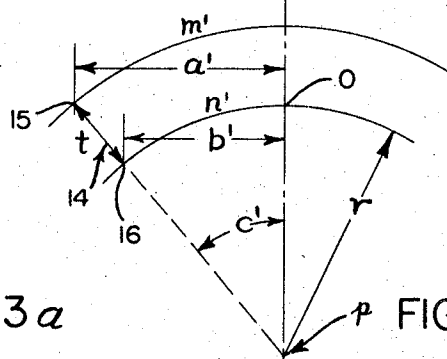
ROTARY KNIFE

Original Filed July 31, 1962

4 Sheets-Sheet 1



$$\frac{m}{n} = \frac{a}{b} = \frac{t+r}{r}$$



$$\frac{m'}{n'} = \frac{a'}{b'} = \frac{t+r}{r}$$

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ROTARY KNIFE

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4 Sheets-Sheet 2

FIG. 4

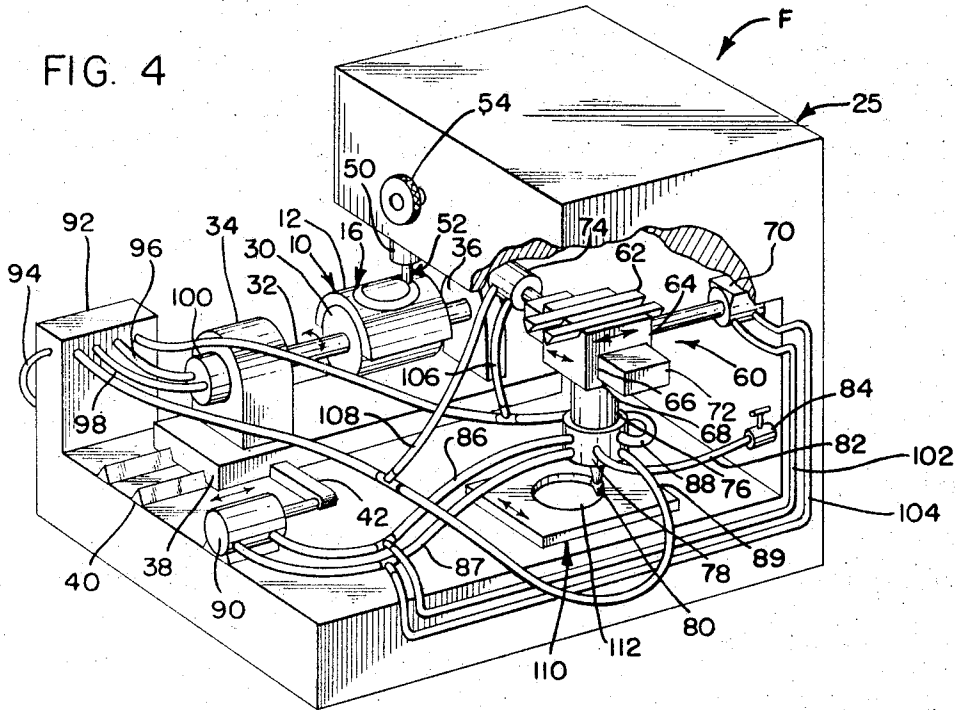


FIG. 5

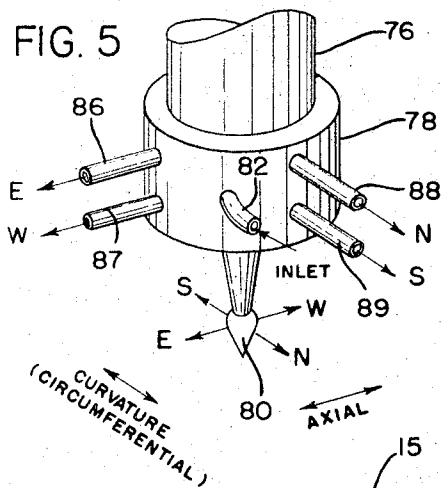


FIG. 6

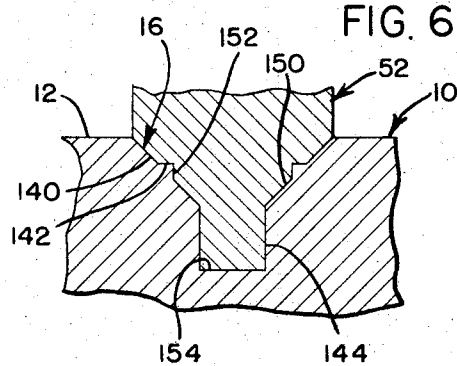
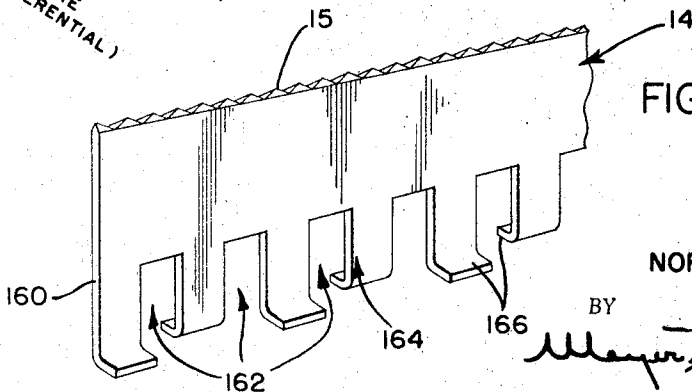


FIG. 7



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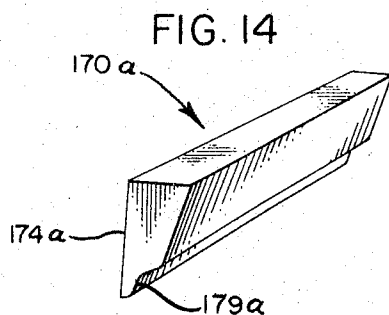
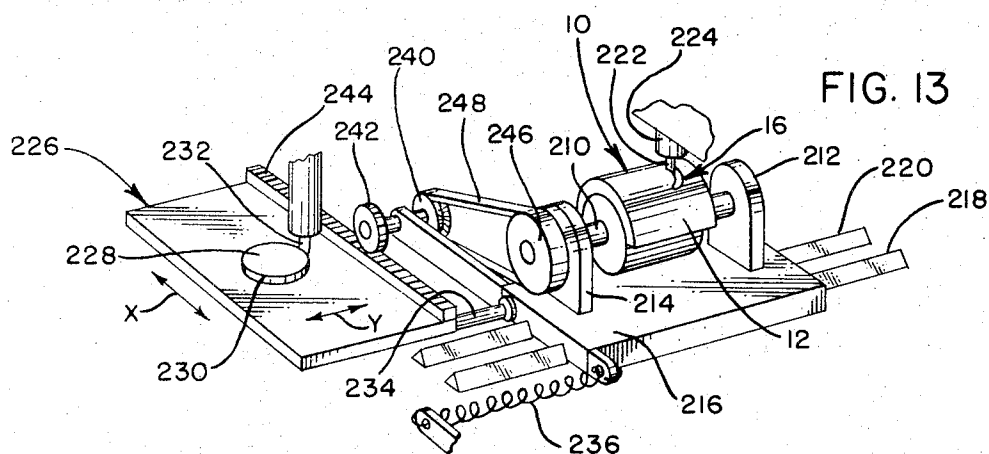
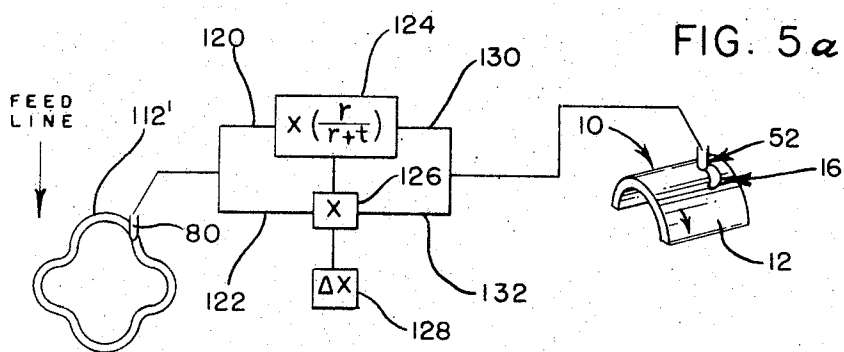
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ROTARY KNIFE

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FIG. 8

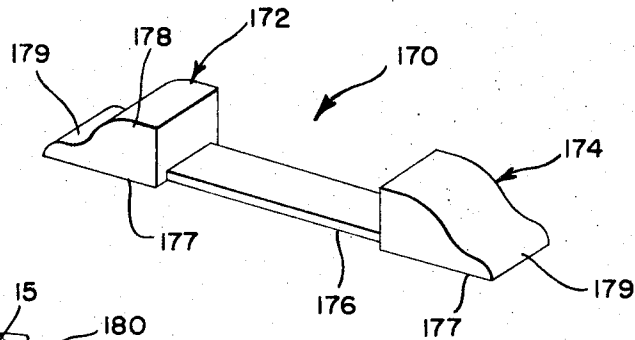


FIG. 9

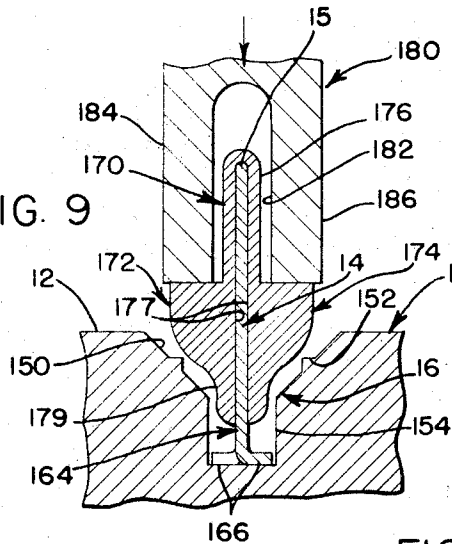


FIG. 10

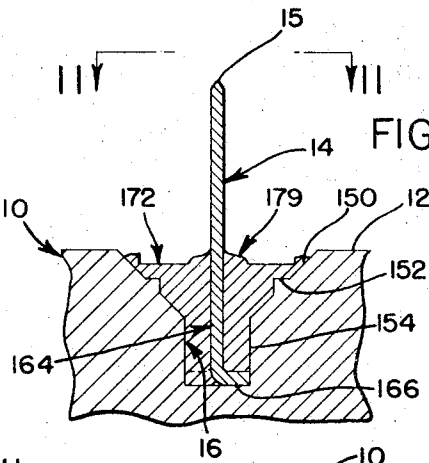


FIG. 11

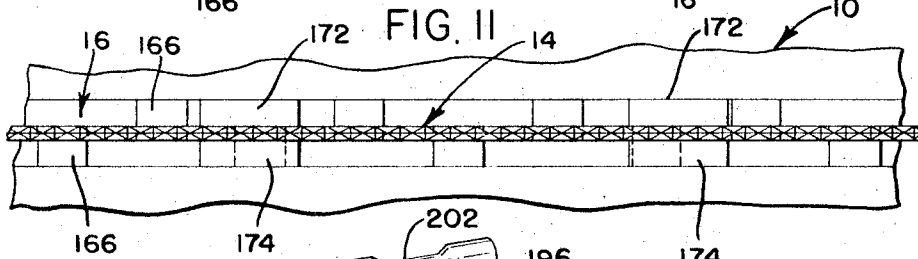
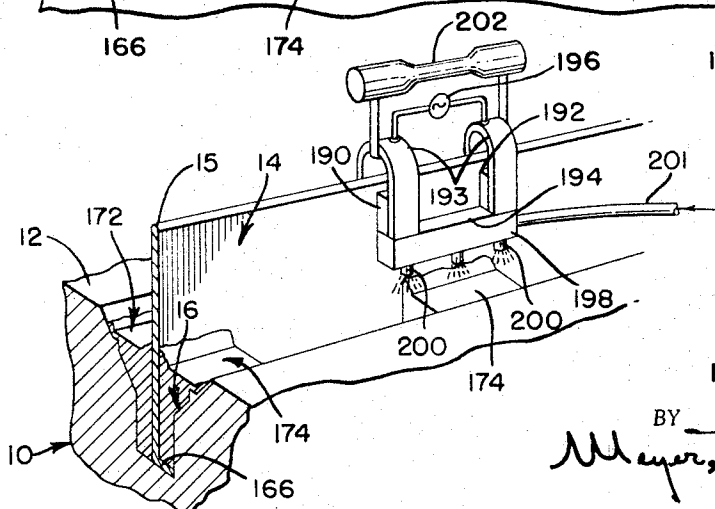


FIG. 12



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ROTARY KNIFE

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Original application July 31, 1962, Ser. No. 213,802.
Divided and this application July 19, 1965, Ser. No.
487,346

3 Claims. (Cl. 83—663)

This application is a divisional application of application S.N. 213,802 filed July 31, 1962, now abandoned.

The present invention pertains to the art of cutting cardboard, paper and like material; and, more particularly, to a method and apparatus for assembling a thin rule knife onto a knife support adapted to be used in an apparatus for cutting blanks from cardboard and similar material.

The present invention is particularly applicable to assembling rule knives onto the outer periphery of a high speed rotary knife support of the type adapted to rotate against a rotary anvil so that cardboard sheets passing between the anvil and the knife support will be cut according to the arrangement of the knives; however, it is to be appreciated that the invention has much broader applications and that certain aspects of the invention can be used for assembling rule knives in various cardboard cutting apparatuses such as moving platen cutters.

In the art of cutting cardboard blanks from elongated cardboard sheets, it has become common practice to mount a rule knife onto the cylindrical outer surface of a knife support which is in turn mounted onto a rotating shaft. The rule knives comprise a flat ribbon of metal with one edge having a cutting surface and the other edge being adapted for securing onto the cylindrical surface of the knife support. Spaced radially from the knife support there is provided a rotary cutting anvil which forms a cutting surface for the knives on the support so that a sheet of cardboard passing between the support and the anvil can be cut according to the pattern of the rule knives. Accordingly, each revolution of the knife support and anvil cuts a blank from the cardboard sheet passing between support and anvil. This provides a high speed cutting apparatus which is quite well adapted for economical mass production of cardboard blanks. Such an apparatus, besides having a fast operating speed, is characterized by low maintenance, relatively low initial apparatus cost and low operating power. With all of these advantages, the widespread adoption of this type of rotary cutting apparatus is quite obvious.

The basic disadvantage in the above-mentioned cutting apparatus is that there is no convenient and inexpensive method of assembling the rule knives onto the outer cylindrical surface of the knife support. In the past, one commonly used method of assembling the knives onto the support required that the knife support be manufactured in a plurality of segments having contours corresponding with the contour of the blank to be cut. Such a procedure for supporting the rule knives was quite expensive and required a substantial amount of precision machining, fitting and assembling. Also, it was nearly impossible to provide complicated shapes since the use of mounting segments seriously limited the possible configurations of the knife being assembled onto the support.

In a rotary cutter, as described, the rule knives extend outwardly from the cylindrical surface of the rotary knife support; therefore, the shape of the cutting edge of the knife is not identical to the supporting shape at the outer periphery of the support. Consequently, it is not possible to machine the knife support with a shape equal to the shape of the blank to be cut from the cardboard. This feature has caused substantial difficulty in locating the

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knives onto the support, and in the past, the trial and error method was used to locate the knives for cutting a desired shape from the cardboard sheets. This was an expensive procedure and greatly increased the cost of the rotary cutting apparatus.

These and other disadvantages are overcome by the present invention which is directed toward a method and apparatus for locating and assembling the rule knives onto the outer cylindrical surface of the rotary knife support which method and apparatus are basically characterized by easily providing a properly shaped groove on the outer surface of the knife support for receiving the rule knife and securing the knife within the groove.

In accordance with the present invention, there is provided a method of manufacturing a knife receiving groove in the outer cylindrical surface of a rotary knife support, which knife is characterized by having a cutting edge defining a shape to be cut into a sheet and the cutting edge of the knife lying in a cylindrical plane coaxial with the cylindrical surface of the support and having a first radius of curvature. The cylindrical surface of the knife support is further characterized as having a second radius of curvature. The method of machining comprises the following steps: mounting the knife support with the cylindrical surface exposed, mounting a cutting tool radially with respect to the cylindrical surface, selecting a first reference point on the surface and a second reference point on the plane of the cutting edge, causing relative movement between the tool and support to define a groove in the cylindrical surface of the support and having a shape corresponding to the shape of the cut to be made into the sheet. Further, the method includes the step of simultaneously controlling the relative movement of the support and tool so that all points in the groove shape correspond with like points in the shape of the cut and at any point on the groove shape in the cylindrical surface, the displacement of the tool in an axial direction from the first reference point is equal to the axial displacement of the corresponding point in the plane from the second reference point and the displacement of the tool in a circumferential direction from the first reference point is equal to the ratio of the second radius of curvature to the first radius of curvature times the circumferential displacement of the corresponding point from the second reference point. The groove so produced in the outer cylindrical surface of the knife support can receive the rule knife in an edgewise position and the shape of the cutting edge will be identical to the shape of the blank to be cut from the sheet.

In accordance with a further aspect of the present invention, there is provided an apparatus for machining a groove in the outer cylindrical surface of a rotary knife support for receiving a knife adapted to cut a preselected shape in a sheet and adapted to extend a given distance from the surface. The cylindrical support surface is generally characterized as having a first radius of curvature. The apparatus comprises a means for mounting the support, a means for mounting a cutting tool radially with respect to the radius of curvature of the surface, means for moving the tool radially into cutting relationship with the support, a template having a guide member substantially identical in shape to the preselected shape, a power means for relatively moving the tool and the support while maintaining the radial disposition of the tool, control means for controlling the relative movement, this control means comprising a follower means movable along the guide member, means operably connecting the follower means and the power means, connecting means driving the power means in accordance with the path of movement of the follower means along the guide member and conversion means in the connecting means for multiplying movement in one direction by the ratio of the summation

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of the radius of curvature of the cylindrical surface and the extended distance to the radius of curvature and means orienting the support and tool so that said multiplying movement is in a circumferential direction on the cylindrical surface of the support.

In accordance with still another aspect of the present invention there is provided a method of locking a thin rule knife into a groove on the outer periphery of a knife support, the groove having a width greater than the thickness of the knife, this method comprising placing the knife edgewise into the groove and forcing a plastically deformable locking device into the groove and against the knife.

In accordance with still a further aspect of the present invention there is provided a device for locking a thin rule knife into a groove on a knife support, the groove having a width substantially greater than the thickness of the knife, the device being formed from a plastically deformable material and comprising a first and second head and a deformable ribbon portion connecting these heads.

In accordance with a further aspect of the present invention there is provided a knife adapted to be mounted into a groove having a width substantially greater than the thickness of the knife, the knife comprising a thin body having an upper cutting edge and a lower support end, and a means adjacent the lower support end for centering said knife in the larger groove.

In accordance with another aspect of the present invention there is provided a knife support for receiving a thin rule knife, the support comprising a knife receiving groove having upwardly, outwardly tapering side walls and a locking rib on at least one of the tapering side walls, the groove being adapted to receive a plastically deformable locking device for wedging the knife into the groove.

In accordance with another aspect of the present invention, there is provided a method of heating the cutting edge of a rule knife mounted in a knife support at a mounting end opposite the cutting edge, the method comprising: causing a short path of current flow in the knife and adjacent the cutting edge, progressing the path along the length of the knife at a speed sufficient to raise the cutting edge of the knife to the desired temperature.

In accordance with still another aspect of the present invention, there is provided an apparatus for heating the cutting edge of a rule knife mounted in a knife support at a mounting end opposite the cutting edge, the apparatus comprising: a first and second electrical contact, means for holding the contact against the knife, the contact being spaced longitudinally along the length of the knife, means for allowing movement of the contact in unison along the length of the knife, and means for introducing a voltage drop across the contact.

The primary object of the present invention is the provision of a method for mounting a rule knife onto the outer cylindrical surface of a rotary knife support, which method is easily performed, and provides the proper configuration of the groove to assure that the upper cutting edge of the knife forms the proper shape and which method can be practiced without extraordinary skills.

A further object of the present invention is the provision of an apparatus for providing a knife groove in the outer cylindrical surface of a rotary knife support, which apparatus automatically provides the proper configuration of the knife supporting groove so that the outer cutting edge of the knife forms the shape to be cut and which apparatus can be operated without a high degree of skill.

Still another object of the present invention is the provision of an apparatus for providing a knife groove in the outer cylindrical surface of a rotary knife support, which apparatus automatically compensates for the curvature of the knife support and provides proper loca-

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tion of the groove so that the outer cutting edge of the knife forms the desired shape.

Another object of the present invention is the provision of an apparatus for providing a knife groove in the outer cylindrical surface of a rotary knife support, which apparatus utilizes a template having a shape corresponding to the shape to be cut in a cardboard or paper sheet and a cutting tool movable along the cylindrical surface of the support wherein movement in one direction along the template is converted into a lesser movement of the tool in a circumferential direction on the support. The diminution of movement is determined by the radius of the knife support and the height that the knife extends from the outer surface of the support.

Another object of the present invention is the provision of an apparatus for providing a knife groove in the outer cylindrical surface of a rotary knife support which apparatus converts the shape of a cut to be made into a cardboard sheet into a first component axial of the cylindrical surface of the knife support and a second component circumferential of the cylindrical surface wherein the second component is reduced by the ratio $r/(r+t)$ wherein r =the radius of curvature of the support surface and t =the extended height of the knife.

Still another object of the present invention is the provision of a method for locking a thin rule knife in a groove on a knife support, which method can be rapidly performed, securely holds the knife in place, allows easy removal of the knife when damaged, is inexpensive, and requires no precision locking devices.

Another object of the present invention is the provision of a method for locking a thin rule knife in a groove on a knife support, which method utilizes a groove having an outwardly inclined wall and a plastically deformable locking device that can be wedged into the groove and against the knife.

Yet another object of the present invention is the provision of a method for locking a thin rule knife in a groove on a knife support, which method utilizes a wedge locking device formed from a plastically deformable material, such as lead, to be wedged into position along the length of the knife for securing the knife in the groove.

A further object of the present invention is the provision of a plastically deformable locking device for securing a rule knife in a support groove having tapered side walls, which device is wedged into the groove against the knife to lock the knife in place.

Still another object of the present invention is the provision of a groove in the outer surface of a knife support for receiving a cutting knife which groove has at least one rib on a wall of the groove which rib coacts with a deformable wedge to secure the knife in place on the support.

Yet another object of the present invention is the provision of a rule knife adapted to be received within a groove on the outer surface of a knife support which knife has a lower support end with transversely extending legs for locating the knife within the groove.

Still another object of the present invention is the provision of a rule knife adapted to be received within a groove on the outer surface of a knife support which knife has a lower support end with transversely extending legs and with a plurality of notches along the length adjacent the mounting end which notches allow edgewise bending of the knife as it is being laid into the groove.

Another object of the present invention is the provision of a method of heating only the cutting edge of a rule knife mounted in a knife support at a mounting end opposite the cutting edge, which method prevents heating of the mounting end of the knife.

Still a further object of the present invention is the provision of a method for heating only the cutting edge of a rule knife mounted in a knife support at a mounting end opposite the cutting edge, which method is easily

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executed and requires a relatively inexpensive heating tool.

Still a further object of the present invention is the provision of an apparatus for heating only the cutting edge of a rule knife mounted in a knife support at a mounting end opposite the cutting edge, which apparatus is easily operated and is inexpensive to construct.

A further object of the present invention is the provision of an apparatus for heating only the cutting edge of a rule knife mounted in a knife support at a mounting end opposite the cutting edge, which apparatus heats the cutting edge and simultaneously prevents heating of the mounting end.

Another object of the present invention is the provision of an apparatus for heating only the cutting edge of a rule knife mounted in a knife support at a mounting end opposite the cutting edge, which apparatus heats a short length of the knife at a position adjacent the cutting edge and simultaneously directs a cooling media onto the mounting end for preventing undue heating of such end.

These and other objects and advantages will become apparent from the following description used to illustrate the preferred embodiment of the invention as read in connection with the accompanying drawings in which:

FIGURE 1 is a somewhat schematic side elevational view illustrating a rotary cardboard cutter having a rule knife mounted in accordance with the present invention;

FIGURE 2 is a schematic side view illustrating the location of the cutting knives on the knife support;

FIGURES 3a-b are schematic views taken along lines 3a-3a and 3b-3b of FIGURE 2;

FIGURE 4 is a partially cut away, somewhat schematic, pictorial view illustrating the preferred embodiment of the present invention;

FIGURE 5 is an enlarged, somewhat schematic, pictorial view illustrating the follower means of the preferred embodiment;

FIGURE 5a is a block diagram illustrating schematically the operating principles of the preferred embodiment shown in FIGURE 4;

FIGURE 6 is an enlarged, partial cross sectional view illustrating the cutting tool for machining the knife groove;

FIGURE 7 is a partial, pictorial view illustrating the rule cutting knife;

FIGURE 8 is an enlarged, pictorial view illustrating a locking device constructed in accordance with the present invention;

FIGURE 9 is a partial, cross sectional view illustrating one step in the method of locking the knife into the groove;

FIGURE 10 is a partial, cross sectional view illustrating a further step in the method illustrated in FIGURE 9;

FIGURE 11 is a top plan view as taken along lines 11-11 of FIGURE 10;

FIGURE 12 is a somewhat schematic, pictorial view illustrating the preferred embodiment of an apparatus for heating the cutting edge of the rule knife as it is mounted in a groove;

FIGURE 13 is a somewhat schematic pictorial view illustrating a further preferred embodiment of the present invention, and

FIGURE 14 is a pictorial view of a modification of the locking device shown in FIGURE 8.

Referring now to the drawings, wherein the showings are for the purpose of illustrating preferred embodiments of the invention only and not for the purpose of limiting same, FIGURE 1 shows a rotary cutter A adapted to rotate in unison with an anvil B for cutting desired patterns into a sheet C which in the preferred embodiment is a cardboard sheet of indeterminate length. The cardboard sheet C passes between the cutter and the anvil on a feedline indicated by the arrow in FIGURE 1 and is cut into blanks D having cutouts E which may have various contours; however, in accordance with the

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illustration the cutout E is circular. On the outer surface of cutter A there is provided a knife support 10 having an outer cylindrical surface 12 which support carries a rule knife 14 which protrudes radially outward from surface 12 and is secured onto the support in a manner to be hereinafter described in detail. The rule knife is provided with an outer cutting edge which in the preferred embodiment is serrated to substantially reduce the cutting pressure between the cutter A and the anvil B and the cutting edge of the rule knife lies in a cylindrical plane generally coaxial with the cylindrical surface of the knife support 10. In order to provide a circular cutout E, the cutting edge 15 must form a circular shape in its cylindrical plane. In accordance with the invention, the knife 14 is supported onto knife support 10 by a contoured groove 16 machined in the knife support 10. The method of locating and machining the groove 16 and securing the knife 14 therein will be hereinafter described in detail and these methods are a substantial portion of the present invention. To provide blank D with the proper length, an axially extending cutoff knife 18 is provided in the knife support 10 and is secured within a groove 20 extending axially along the surface of the knife support 10.

Referring now to FIGURES 2, 3a and 3b the geometrical aspects involved in supporting the rule knife 14 on the cylindrical surface 12 are illustrated. The cylindrical contour of surface 12 greatly complicates the machining of grooves 16 because these grooves cannot have a shape identical to the shape of the cutout E; to the contrary, the grooves 16 must have a contour which will support radially extending knife 14 so that the knife cutting edge 15 will define a circular shape in the cylindrical plane of the cutting edge. In one known method of supporting the knife 14 the knife was supported on the rotary cutter A by providing a build up of segments which segments had to be fitted by trial and error to provide the proper contour to the cutting edge 15. By constructing the knife support structure in accordance with the prior art, it is often difficult to assure accurate radial disposition of the rule knife 14; therefore, cutting pressures on the knife tended to buckle the knife and cause premature failure of the cutting setup. FIGURES 2, 3a and 3b show that the cutting line of the edge 15 is substantially larger in a circumferential direction along the cylindrical surface 12 than the mounting line of groove 16; however, the cutting line and mounting line substantially coincide in an axial direction along the cylindrical surface 12 i.e. the width of the cutting line in an axial direction equals the width of the mounting line. To better understand the geometry illustrated in FIGURE 2, two randomly selected cross sections of FIGURE 2 are shown in FIGURES 3a and 3b wherein the center of curvature of the cylindrical surface 12 is indicated at P, the radius of curvature of the cylindrical surface 12 is r , the extended height of knife 14 is t , and the center of the desired cutout shape is indicated at O. Referring now more specifically to FIGURE 3a, the arc m indicates the actual radius of the cutout E and extends in the circumferential direction in the plane of the cutting edge 15 and semicord a indicates the perpendicular distance of the cutting edge 15 from the center O. In like manner, the arc n indicates the circumferential distance of groove 16 which will produce a circumferential arc m at the plane of the cutting edge 15 and b indicates the perpendicular distance of the groove from the center O. Angle c is determined by the cross section line 3a-3a of FIGURE 2 and as the cross section line is changed to 3b-3b the angle c is changed to angle c' as shown in FIGURE 3b. The geometry shown in FIGURE 3b is substantially identical to the geometry of FIGURE 3a and will not be described in detail; however, it is noted that the circumferential distance of the cutting edge 15 from center O as measured in the cylindrical plane of the cutting edge bears a fixed ratio to the circumferential distance of

groove 16 from center O when measured along the cylindrical surface 12 in a circumferential direction. The ratio between the position of the cutting edge 15 and groove 16 is important in locating the groove for any desired shape of the outer cutting edge 15 and the ratio between these circumferential distances is the summation of the extended height of the knife 14 and the radius of curvature of surface 12 i.e. $t+r$, to the radius of curvature of surface 12 i.e. r . FIGURES 2, 3a and 3b indicate that the cutting edge 15 and groove 16 have corresponding shapes wherein the distances of corresponding points in an axial direction along the cutting surface are identical but the distance in a circumferential direction is determined by the extended height of the rule knife and the radius of curvature of the cylindrical surface 12 in a fixed ratio of $r/(r+t)$.

Referring now to FIGURES 4, 5 and 5a, there is disclosed a somewhat schematic representation of a rule knife groove machining apparatus F constructed in accordance with the preferred embodiment of the present invention; however, it must be appreciated that the preferred embodiment is utilized for illustrative purposes only and the invention is not intended to be limited by the structural showing thereof. The apparatus F is adapted to machine the knife groove 16 in a cylindrical knife support 10 in such a manner that the configuration of groove 16 produces the desired shape at the cutting edge 15 of rule knife 14 in accordance with the geometry shown in FIGURES 2, 3(a-b). The apparatus is so constructed that the difference between the cutting edge 15 and groove 16 in a circumferential direction is automatically compensated for during the machining of groove 16. In this manner, trial and error methods of producing groove 16 are eliminated and sectional build up of the knife support 10 or other expensive procedures are not necessary. In accordance with the preferred embodiment of the present invention, apparatus F is provided with an appropriate frame 25 onto which the other components of the apparatus are supported. The knife support 10 is secured onto an arbor 30 by any appropriate means such as screws, clamps, etc., and the arbor is fixedly secured onto control shaft 32 extending between two generally vertical upright, journal stands 34, 36 fixedly secured onto the upper surface of table 38. To provide movement in the axial direction along cylindrical knife support 10, there is provided in the preferred embodiment ways 40 on which the table 38 is slidably received. Extending transversely outwardly from the table is an arm 42 the purpose of which will be described later. By so mounting the knife support 10 onto apparatus F, the knife support may be moved axially by table 38 and circumferentially by control shaft 32. Spaced radially upwardly from the knife support 10 there is provided a spindle 50 adapted to receive a cutting tool 52 having the desired cutting surfaces and rotated by appropriate means through spindle 50. To adjust the radial position of tool 52, there is provided on frame 25 an adjusting wheel 54, which wheel adjusts spindle 50 and tool 52 in a manner known in various machine tools.

Apparatus F also includes a follower mechanism 60 comprising axial ways 62 supported on frame 25, movable journal block 64 having a guide 66 in the form of a generally rectangular opening extending through the block and a lower opening 68 in guide 66, control cylinder 70 connected onto the frame for moving block 64 along ways 62, a slide 72 journaled within guide 66, and cylinder 74 connected onto slide 72 and extending to block 64 for movement of the slide with respect to the block and in a direction perpendicular to ways 62. Extending generally downward from slide 72 is a hanger 76 which terminates in a valve unit 78 having a downwardly extending follower stylus 80 which in practice has a conical tip. By so constructing the follower mechanism 60, the

hanger 76 may be moved to various positions by the combined action of cylinders 70 and 74.

The valve unit 78 is not described in detail since the operation thereof did not form a part of the invention and the various types of hydraulic control valves may be used; however, in accordance with the preferred embodiment the valve unit 78 may be provided with an inlet line 82 receiving fluid from an inlet pressure valve 84 connected to an appropriate pump or power means. On the valve unit 78 there is schematically illustrated outlet control lines 86, 87, 88 and 89 in which the fluid volume is controlled by the position of stylus 80. Although various control combinations are possible, in FIGURE 5, movement of stylus 80 in the direction E, W, N, or S, causes a proportional fluid volume increase in control lines 86, 87, 88 or 89 respectively and movement of stylus 80 in a combination of the directions will cause a combined volume build up in two lines; for instance, if stylus 80 is moved in the direction between N and E, volume will be increased in lines 86 and 88 and the proportion of build up in volume will be proportional to the displacement of the stylus between the E and N directions. In this manner, movement of stylus 80 is divided into two components, one in the direction E-W controlling lines 86, 87 and the other in a direction N-S controlling lines 88, 89. For purposes which will be appreciated later, the direction E-W is designated as the axial direction and the direction N-S is designated as the curvature or circumferential direction. Axial indicates movement in an axial direction along support 10 and circumferential indicates movement around the circumference of the support 10. Consequently, the movement of stylus 80 may be a combination of movement axially and circumferentially. The E-W control lines 86, 87 respectively are hydraulically connected to a control cylinder 90 which is supported on frame 25 and controls movement of table 38 through laterally extending arm 42. Accordingly, variations in the fluid volume in lines 86, 87 shifts the table 38 and thus knife support 10 in an axial direction with respect to cutting tool 52. According to the hydraulic connection between the movement of stylus 80 and cylinder 90, the axial movement of support 10 may be equal to a multiple of the movement of stylus 80 and if this multiple is one, the support 10 moves in an axial direction identical to the movement of stylus 80 in the E-W direction.

The N-S control lines 88, 89 respectively are hydraulically connected to a hydraulic integrator 92, or conversion means, having a return line 94 extending to the hydraulic fluid reservoir and control lines 96, 98 which receive fluid from integrator, 92 which fluid has a volume which is a multiple of the ratio $r/(r+t)$ wherein r is the radius of curvature of surface 12 and t is the extended height of knife 14 above surface 12. Again if the multiple of this ratio is one, the movement of stylus 80 in the N-S direction will result in a fluid volume in lines 96, 98 corresponding to one times the above-mentioned ratio. By connecting lines 96, 98 to a rotary hydraulic cylinder 100 for controlling the angular position of shaft 82, the circumferential distance travelled by rotating support 10 is equal to the distance moved by stylus 80 in the N-S direction times the above-mentioned ratio which will assure that knife 14 when positioned within groove 16 will have the cutting edge 15 at the circumferential position determined by the displacement of stylus 80. The control lines 86, 87, 88 and 89 are connected with follow up lines 102, 104, 106 and 108 respectively so that the fluid volume in these follow up lines corresponds with the fluid volume in the control lines.

To control the movement of stylus 80, a template 110 is secured in appropriate position adjacent the stylus and is provided with a guide member 112 having the desired shape of the cut to be made in the cardboard sheet C. The template is positioned under the stylus 80 so that the arrows on the template as shown in FIGURE 4 which indicate the feedline of the sheet C are in direction N-S,

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i.e. in the direction of the stylus corresponding to a circumferential direction on the support 10. The guide member 112 of template 110 need not have the exact size of the blank to be cut from the cardboard sheet C; however, it must have substantially an identical shape so that the multiple between the movement of the stylus and axial and circumferential movement of the support, is so chosen that the resulting groove 16 machined into the knife support will support the knife in a position to cut the desired shape and size from the sheet C. This feature is illustrated in FIGURE 5a wherein a predetermined guide member 112' is appropriately positioned with respect to the direction of the feedline as indicated by the arrow. Although the shape of guide member 112' is substantially the shape of the desired cut to be made in the sheet C, it is not necessarily identical in size to such a cut. The stylus 80 moves along guide member 112' and the movement is divided into a circumferential component represented in the block diagram of FIGURE 5a as line 120 and the axial component is represented as line 122. These components of movement pass through integrators or conversion means 124, 126 respectively with the indicated multiplying factors and exit as circumferential control line 130 and axial control line 132, which components are combined to move tool 52 along the surface of support 10 to produce groove 16. Of course, it is understood that relative movement of the support and tool can be accomplished by moving the support 10 as indicated in FIGURE 4 or by moving the tool 52 as is indicated in FIGURE 5a without departing from the intended spirit and scope of the invention. As the size of the desired cut is changed, proportioning device 128 is adjusted to change the multiple of integrators 124, 126 in any desired manner. As is indicated in FIGURE 5a, the pick up and control circuit for the apparatus may be of any appropriate construction and may be driven hydraulically, electrically or mechanically to name only a few arrangements.

Basically the operation of the apparatus F comprises moving the stylus 80 around guide member 112, which in practice is a straight edge or French curve positioned on a print of the shape to be cut, so that the movement of stylus 80 is divided into a circumferential and an axial component which components control the movement of tool 52 along the outer surface of support 10. The follower mechanism 60 moves the hanger 76 along with the stylus so that slight movement of the stylus will have the desired controlling effect on movement of the support 10. By using groove machining apparatus F, complicated knife configuration may be provided without requiring sectional build up of the knife support. This is a substantial advance in the art of securing rule knives onto rotary cutters.

In accordance with the invention, groove cutting tool 52 may have various construction; however, in accordance with another aspect of the present invention, the preferred embodiment which is shown in FIGURE 6, the tool 52 is provided with a conical portion 140 having a circumferentially extending groove 142 and a cylindrical tip 144 which tool produces a groove 16 having tapered side walls 150, a locking rib 152, the function of which will be described later, and a trough 154. The groove 16 extends along the surface of knife support 10 to provide a means for securing a knife 14 onto the knife support 10.

In accordance with another aspect of the present invention, the rule knife 14, as shown in FIGURE 7, is provided at the mounting end 160 with a means for centering the knife within groove 16 which means may take a variety of structural shapes; however, in accordance with the preferred embodiment, a plurality of notches 162 defining spaced tabs 164 each of which terminates in a transversely extending lug 166. In accordance with this preferred embodiment, alternate lugs 166 are bent in opposite transverse directions. Since the knife 14 is to be assembled into the trough 154 of groove 16, it is necessary that the overall extended width of lug 166 does not exceed

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the thickness of trough 154. It is even preferred that the combined thickness of the lugs 166 be somewhat smaller than the thickness of the trough 154 so that there can be relative movement between the trough and the lugs while the knife is being assembled into the groove 16 although the lugs do tend to center the knife and form a substantial base to absorb radial forces. Provision of the notches 162 allows edgewise bending of the knife 14 so that it can conform to the outer cylindrical shape of the knife support.

FIGURES 8-11 illustrate a preferred embodiment of a further aspect involved in the present invention which aspect is directed toward assembling the rule knife 14 into the groove 16 machined in the outer cylindrical surface of knife support 10. In accordance with this preferred embodiment, there is provided a locking device 170, the preferred embodiment of which is shown in FIGURE 8 wherein the locking device is formed from a molded, plastically deformable material such as lead and comprises opposed head members 172, 174 connected by an integrally molded deformable ribbon portion 176. Each of the heads is provided with a flat under surface 177, a body 178 and a nose 179 substantially less thick than the body. In accordance with the present invention, the rule knife 14 is assembled into groove 16 with lugs 166 resting on the bottom of trough 154 as is shown in FIGURE 9. After the knife is so positioned, and at spaced intervals along the length thereof, the locking device is folded over the cutting edge of the knife with the heads 172, 174 extending downwardly toward the tapered walls 150 of groove 16. After so spacing the locking devices along the length of knife 14, an appropriate tool is positioned behind heads 172, 174 and, in accordance with the preferred embodiment of the invention, there is provided for this purpose a bifurcated tool 180 having a knife receiving recess 182 and spaced anvils 184, 186 which anvils are adapted to contact the rear surface of heads 172, 174. By applying a pressure in the direction of the arrow in FIGURE 9 onto the tool 180, the heads 172, 174 are driven into groove 16 as is indicated in FIGURE 10. The ribbon portion 176 may be broken away after the assembly operation. Since the fastening device 170 is formed from a plastically deformable material such as lead, the heads 172, 174 flow into engagement with the tapered walls 150 and trough 154 and are wedged against knife 14 to securely mount the knife within the groove 16. The ribs 152 provide auxiliary holding means to prevent removal of the heads 172, 174. This method provides a rapid means for assembling the knife into the groove and it is obvious that certain changes could be made without departing from the intended scope of the invention; for instance, the configuration of the groove could be changed as long as a wedging action was obtained when the deformable heads 172, 174 are forced into the groove and against the knife. Further, as is shown in FIGURE 14, the locking device may be a strip of deformable material 170a having a body 174a and an upset nose 179a that is laid along the knife and wedged between the knife and the groove. The tabs 166 allow accurate location of the knife 14 so that the cutting edge 15 is in the proper position with respect to the sheet C as it advances between the rotary cutter A and the anvil B.

To assemble the knife 14 into groove 16 the knife should be annealed to allow proper shaping in accordance with the configuration of groove 16; however, in use the cutting edge 15 should be hardened to prolong the life of the edge and maintain the smoothness of the cut into cardboard sheet C. In accordance with another aspect of the present invention, there is provided a method of heating the cutting edge 15 of the knife 14 which comprises passing a short path of current flow into the knife and adjacent the cutting edge, progressively moving the path along the length of the knife at a speed sufficient to raise the temperature of the cutting edge to the proper heat treating temperature, and simultaneously directing a cooling media onto the lower portion of the knife. An apparatus for accomplishing this method is shown in FIGURE

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12 wherein contacts 190, 192 are held in engagement with the upper portion of knife 14 by resilient straps 193. Adjacent the lower portion of contacts 190, 192 there is provided an insulating member 194 for electrically isolating the contacts. To provide a voltage differential between the contacts, there is provided appropriate means such as a generator, schematically represented as 196, connected across straps 193. Adjacent the insulating member 194 there is provided a quench box 198 having nozzles 200 for directing a cooling fluid from line 201 onto the lower portion of the knife. To progress the heating apparatus along the length of knife 14, there is provided appropriate means such as handle 202. In operation, the voltage differential is established between contacts 190, 192 and this causes a current flow through the upper portion of knife 14 adjacent the cutting edge 15. The device is progressed along the knife 14 at a sufficient speed so that the temperature of the cutting edge 15 is sufficient so that air cooling of the cutting edge results in the proper hardness along edge 15. The speed may be judged by the color of the knife as it is heated. The cooling fluid emanating from nozzles 200 prevents heating adjacent the lower end of the knife so that the plastically deformable heads 172, 174 will not tend to be melted and thereby loosened. In most instances, the cooling fluid is not needed because the temperature at the base of the knife is not sufficient to adversely affect the locking device. Further, if it is desired to quench the knife it is possible to direct the nozzles 200, or similar nozzles, toward the trailing end of the apparatus.

Referring to FIGURE 13, there is illustrated a further embodiment of the present invention for providing groove 16 in the outer cylindrical surface of support 10. In accordance with the invention, support 10 is rotatably secured onto shaft 210 journaled in bearings on stands 212, 214 which are in turn affixed onto table 216 movable in a direction axial with respect to support 10 on ways 218, 220. Radially positioned with respect to the cylindrical surface of support 10 is tool 222 driven by spindle 224. To move the support 10 with respect to the tool 222 there may be provided a variety of control means; however, in accordance with the preferred embodiment shown in FIGURE 13, there is provided a floating table 226 having a template 228 with guide surface 230 adapted to be moved along a fixed follower 232. Movement of table 226 in the direction indicated by arrows X as the guide surface 230 is moved along follower 232 is transmitted to table 216 by a sliding arm 234 contacting a flat surface on table 226. To maintain the arm 234 in contact with the table 226, spring 236, or any other appropriate bias or cam means, may be used. The arrows Y indicate the feedline of sheet material over the support 10 and the circumferential dimensions of groove 16 are determined by the displacement of the table 226 in the Y direction as the follower 232 passes along guide surface 230. As was previously discussed in detail, the circumferential dimension of groove 16 does not equal the movement of table 226 in the Y direction; to the contrary, the movement of table 226 in this direction must be multiplied by the ratio $r/(r+t)$ wherein r is the radius of curvature of the support surface and t is the extended

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height of the blade. To multiply the movement of the table, FIGURE 13 illustrates a pulley 240 and a pinion 242 mounted on table 216 with the pinion engaging rack 244 on the table 226 and pulley 240 driving pulley 246 mounted on shaft 210 by a belt 248. The ratios of the pulleys may be adjusted to provide the proper circumferential dimension for groove 16. The operation of the mechanism is adequately apparent from the above description and the showing of FIGURE 13.

The invention as described provides a convenient and economical method for mounting a rule knife onto the outer cylindrical surface of a knife support and the particular structural embodiments utilized in illustrating the invention were not intended to limit same; and various structural changes may be made without departing from the intended spirit and scope of the present invention as defined by the appended claims.

Having thus described my invention, I claim:

1. In the combination of a rotary knife support with an outer cylindrical surface, said knife support having a knife mounting groove defined by side walls spaced a given distance apart and a bottom wall extending between said side walls; and a thin rule knife formed from a single piece of sheet metal having a thickness substantially less than said distance, said knife being mounted in said groove and having an upstanding body portion, an upper cutting edge, and a lower support end, the improvement comprising: notches axially spaced along and terminating at said lower support end of said knife; said notches defining sheet metal tabs spaced along said lower end of said knife; said tabs having terminal portions bent to extend transversely of said knife and form a plurality of spaced sheet metal lugs with outboard locating edges generally parallel to said cutting edge of said knife; and each of said locating edge abutting one of said side walls to locate said body portion in a selected position in said groove.

2. The improvement as defined in claim 1, wherein a first group of said lugs extend in one transverse direction and a second group of said lugs extend in the other transverse direction, said locating edges of said first group of lugs abutting one of said side walls and said locating edges of said second group of lugs abutting the other of said side walls whereby said knife is spaced from both of said side walls.

3. The improvement as defined in claim 2, wherein said lugs have equal transverse length whereby said knife is centered within said groove.

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