United States Patent

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[54] **METHOD AND APPARATUS FOR SLITTING SHEET MATERIAL**

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[52] **U.S. Cl.** **83/17,** 83/176, 83/186, 83/353, 83/355, 83/443, 83/470, 83/490, 83/508

[51] **Int. Cl.** **B65h 17/20**

[58] **Field of Search**....83/17, 176, 20, 186, 187, 490, 83/470, 678, 508, 436, 353, 443, 355

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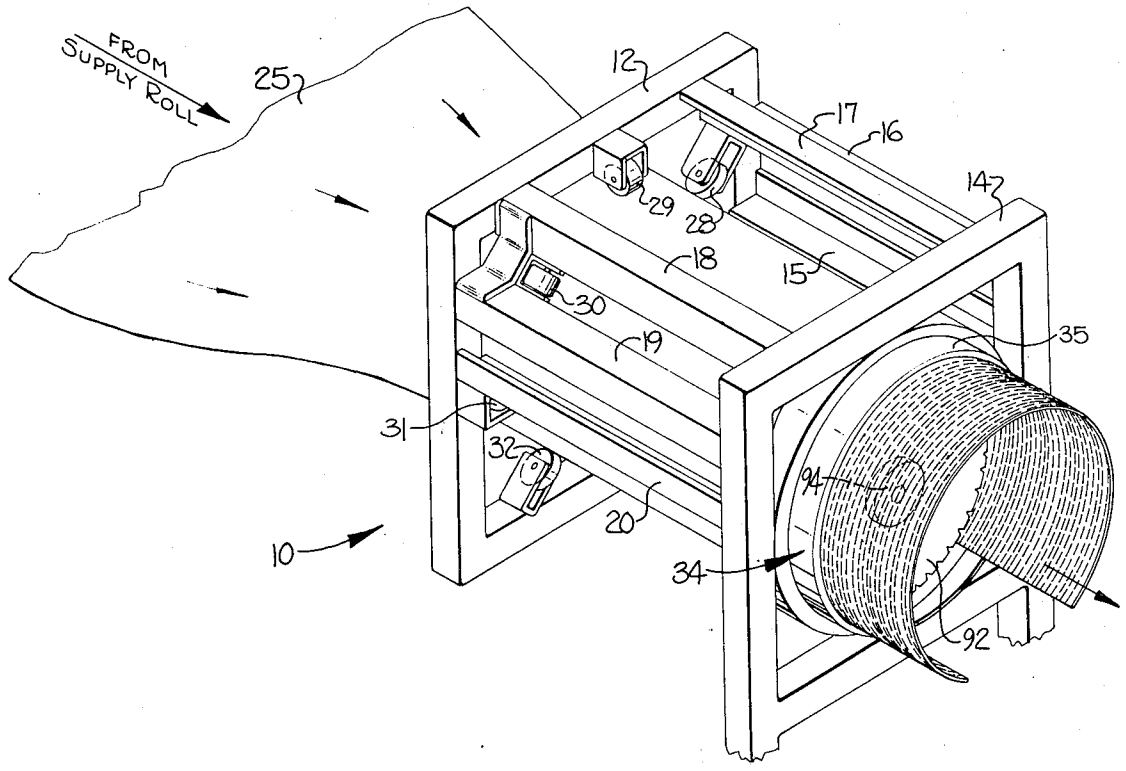
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[57] **ABSTRACT**

A method and apparatus for slitting flexible sheet material of indeterminate length wherein the material is advanced along a predetermined path of travel to and past a slitting station, is formed into a transversely curved configuration as it is advanced, and is slit at the slitting station in a predetermined pattern of spaced, transversely extending rows of spaced slits with the slits in adjacent rows being in predetermined staggered relation. The apparatus includes a circular rotary knife and means for traversing the knife transversely of the curved sheet material. The periphery of the knife blade includes a plurality of spaced cutting edges adapted to penetrate the sheet material to form transverse rows of slits as the material is advanced through the apparatus.

16 Claims, 9 Drawing Figures



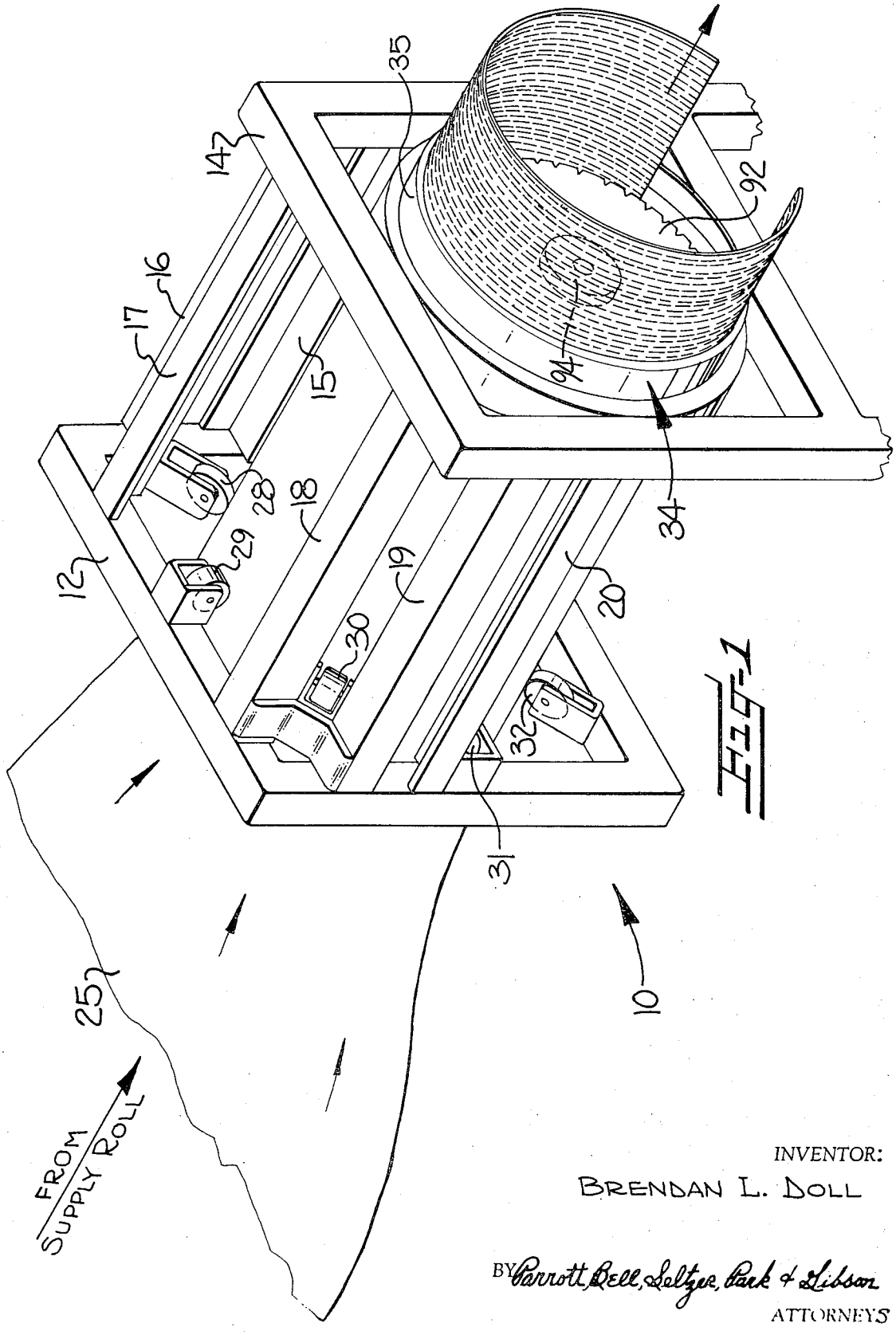


FIG-1

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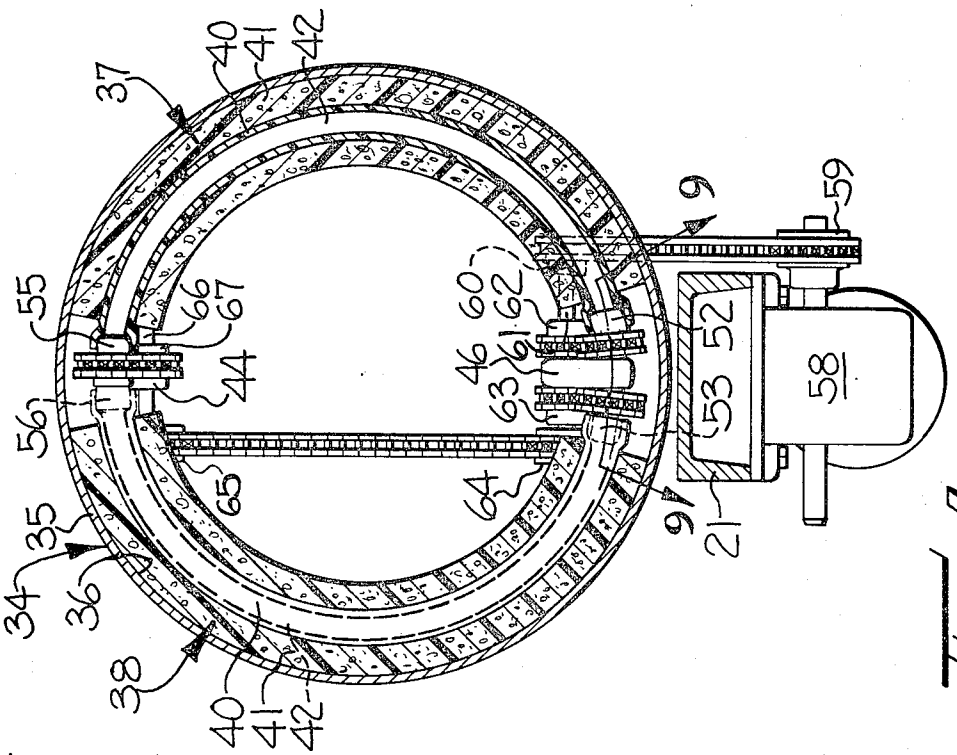


FIG-4

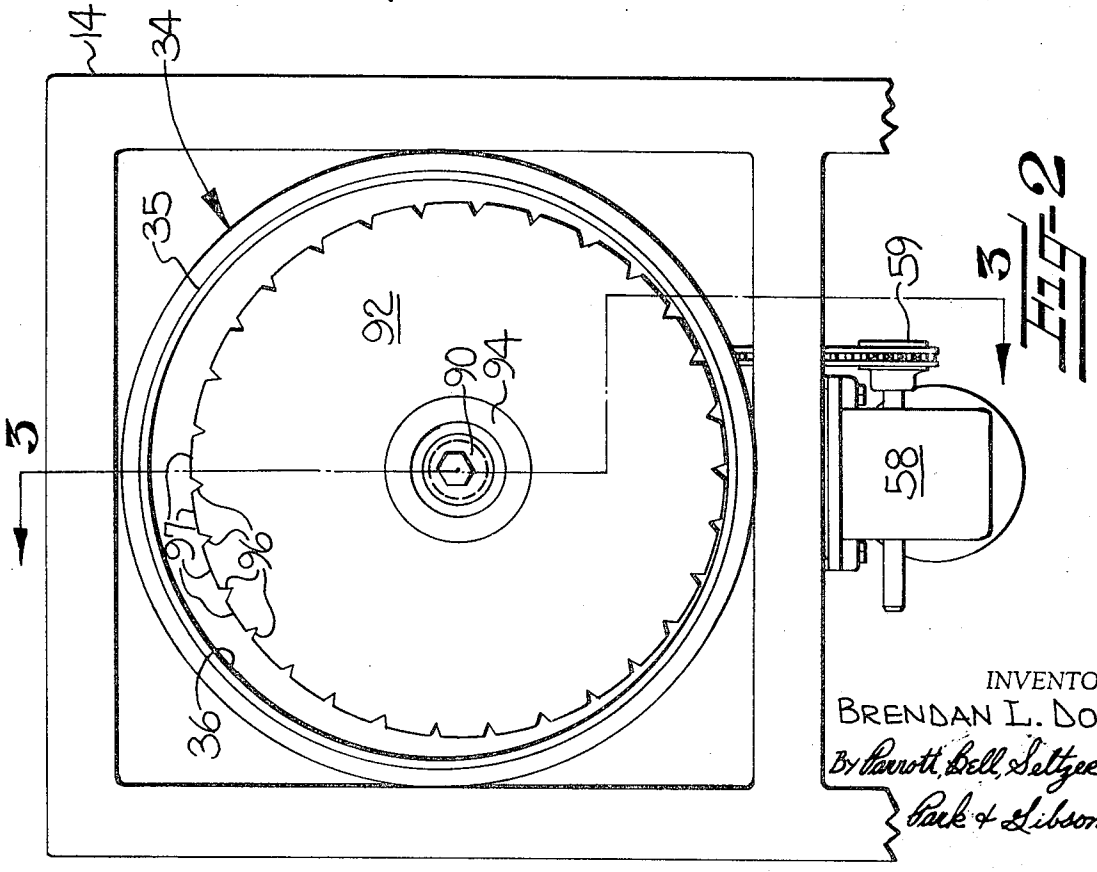


FIG-2

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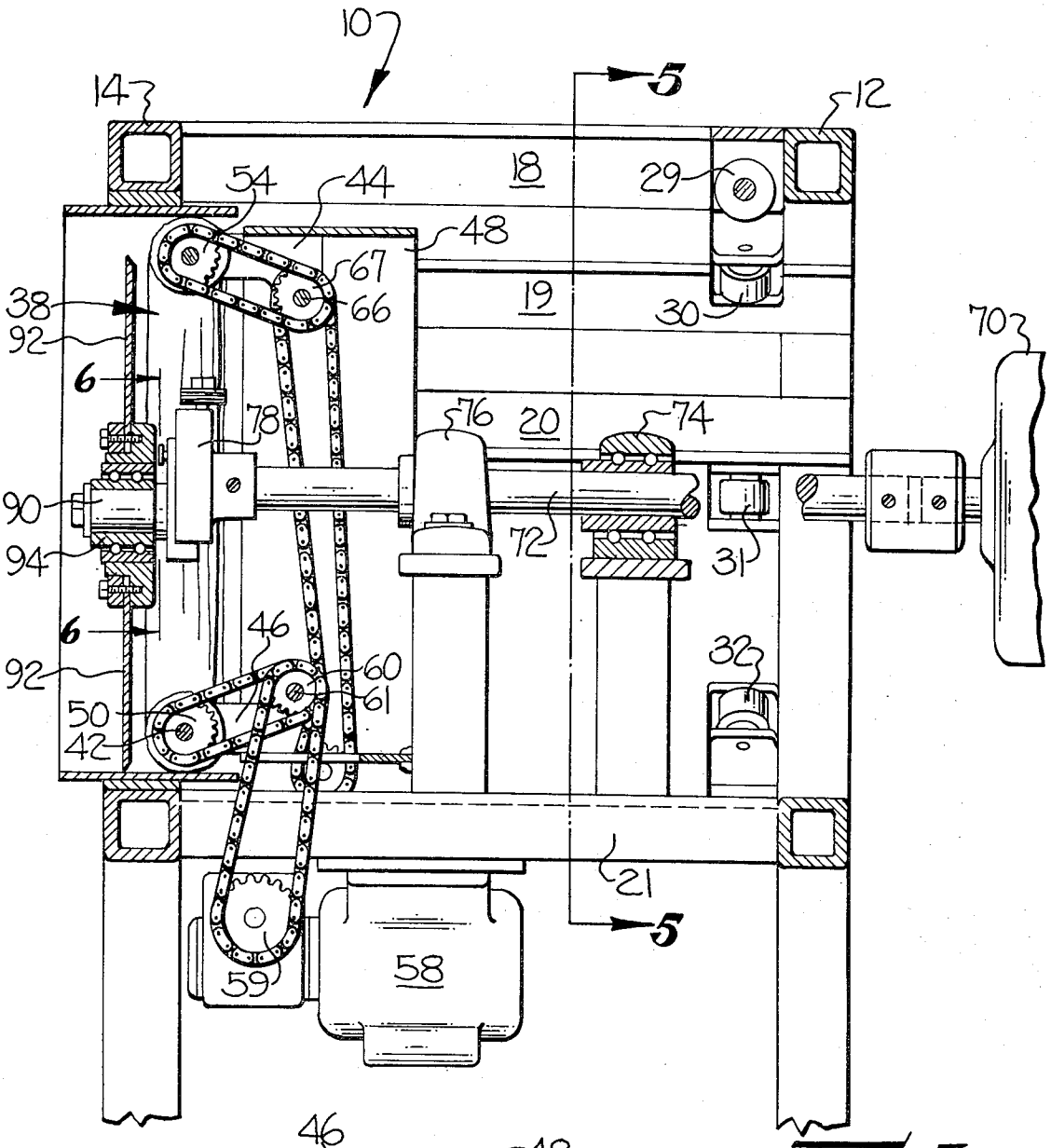


Fig-3

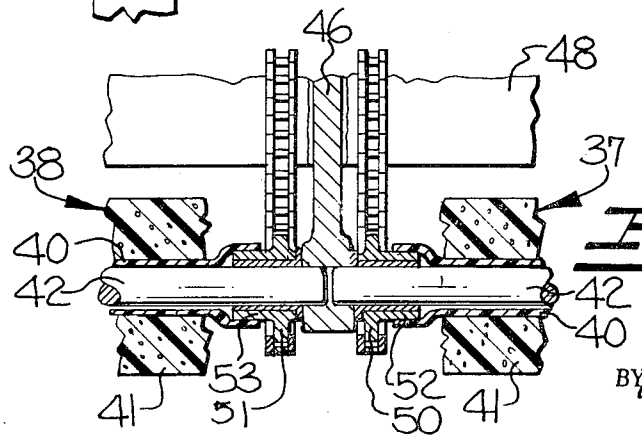


Fig-9

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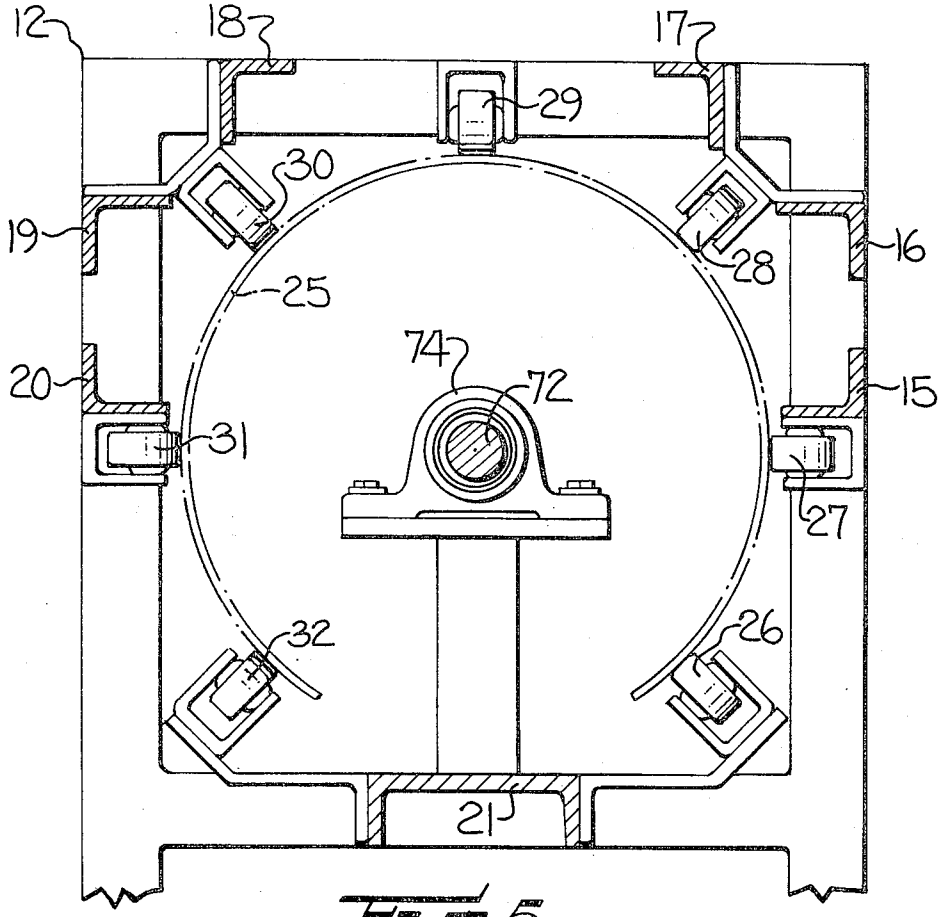


Fig-5

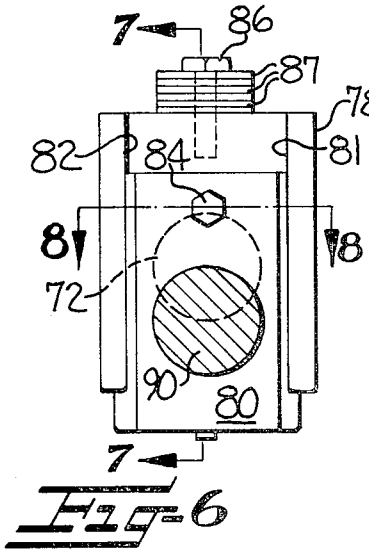


Fig-6

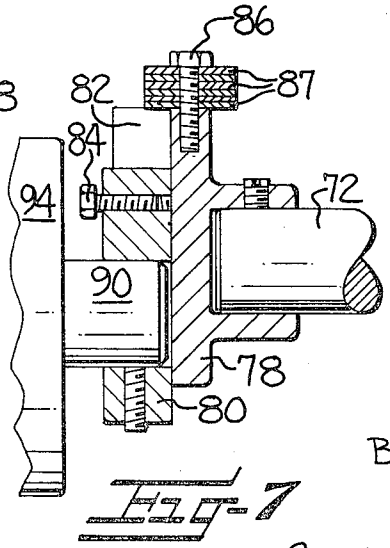


Fig-7

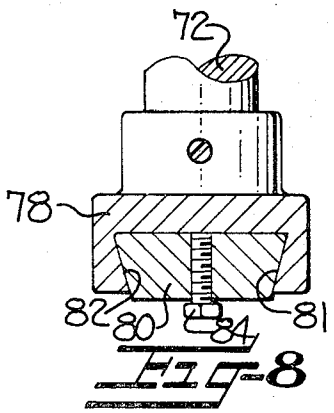


Fig-8

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METHOD AND APPARATUS FOR SLITTING SHEET MATERIAL

The present invention relates to an apparatus and method for processing an indeterminate length of sheet material to form a web capable of being expanded into a relatively open, mesh or net-like structure.

The broad concept of slitting and expanding flexible sheet material, such as paper, metal foil and the like, has been known for a considerable period of time, and is described for example in the present applicant's prior U. S. Pat. No. 2,656,291. As illustrated in this patent, the material is formed with longitudinally spaced, parallel, transverse rows of spaced slits, and with the slits of one row being staggered or off-set with respect to the slits of an adjacent row. The material may then be drawn or expanded in a direction perpendicular to the rows of slits to obtain the desired open, net-like structure.

The full commercial potential of the above material has not been realized however, since presently employed production techniques are relatively slow and expensive. In particular, it is known to form the slits in the material by passing a longitudinal length of the material through reciprocating, opposed knife blades positioned transversely of the advancing material. The cutting edges of the knife blades are interrupted to form a row of spaced slits upon each stroke, and the two blades are operated such that slits of adjacent rows are off-set.

It is believed apparent that the above process is entirely too slow and has limited capabilities for modern production requirements. In particular, the reciprocating knife blades are relatively heavy, and the maximum speed at which they can be reciprocated is therefore limited. Also, the reciprocating blades produce considerable vibration, and require a massive supporting structure. Further, any changes in the pattern of the slits is quite difficult and time consuming.

It is accordingly an object of the present invention to provide a method and apparatus for forming an expandable web of sheet material at greatly increased production speeds, and which is capable of producing a wide variety of patterns of slits in a wide variety of materials.

It is a further object of the present invention to provide a method and apparatus for forming an expandable sheet material which obviate the aforementioned difficulties heretofore encountered.

It is another object of this invention to utilize a circular cutting blade which acts upon the sheet material while it is maintained in a transversely curved configuration.

These and other objects and advantages of the present invention are achieved in the embodiment illustrated herein by the provision of means for continuously advancing the sheet material along a path of travel, and means for forming the advancing material into a transversely curved configuration. A circular knife blade having an interrupted cutting edge is disposed within the curved sheet material and is driven to traverse the cutting edge across the sheet material as the material is advanced to thereby form transverse rows of spaced slits.

Some of the objects and advantages of the invention having been stated, others will appear as the description proceeds, when taken in connection with the accompanying drawings, in which

FIG. 1 is a fragmentary perspective view illustrating the apparatus of the present invention;

FIG. 2 is a front elevational view of the apparatus shown in FIG. 1;

FIG. 3 is a sectional view taken substantially along the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary sectional view taken substantially along the line 4—4 of FIG. 3;

FIG. 5 is a fragmentary sectional view taken substantially along the line 5—5 of FIG. 3;

FIG. 6 is a fragmentary sectional view taken substantially along the line 6—6 of FIG. 3;

FIG. 7 is a fragmentary sectional view taken substantially along the line 7—7 of FIG. 6;

FIG. 8 is a fragmentary sectional view taken substantially along the line 8—8 of FIG. 6; and

FIG. 9 is a fragmentary sectional view taken substantially along the line 9—9 of FIG. 4.

Referring more specifically to the drawings, the apparatus of the present invention is illustrated generally at **10** and includes a frame comprising a generally square rear frame member **12** and an aligned generally square forward frame member **14**. A number of longitudinally extending interconnecting members **15, 16, 17, 18, 19, 20,** and **21** (FIG. 5) maintain the assembly of the rear and forward frame members.

The material to be formed by the present invention is illustrated generally at **25** in FIG. 1 and comprises an indeterminate length of flexible sheet material, such as paper, plastic, metal foil and the like. As the material is advanced from a suitable supply (not shown) to a slitting station, it is formed into a transversely curved configuration for further processing by forming means illustrated in FIG. 5. As there shown, the forming means includes circularly arranged rollers **26, 27, 28, 29, 30, 31** and **32** which are suitably mounted adjacent the rear end of the machine, and are each disposed to freely rotate relative to the surface of the advancing sheet material.

At the slitting station, anvil means **34** for supporting the sheet material during slitting is provided and preferably comprises a right cylindrical supporting ring **35** mounted to the front frame member **14** and defining an internal curved anvil surface **36** having a diameter corresponding generally to the diameter of the circle defined by the rollers **26–32**. Thus the rollers **26–32** and anvil means **34** form and maintain the sheet material in a transversely arcuate configuration. The curved anvil surface **36** will be seen to have a circumferential length somewhat greater than the width of the sheet material **25**.

Means for advancing the sheet material through the apparatus, preferably in a continuous is provided and comprises a pair of flexible, curved drive rollers **37** and **38** mounted inside the rear portion of anvil surface **36** and cooperating with the interior surface thereof to form nips through which the sheet material passes as seen in FIG. 4. Each of the rollers comprises a flexible plastic tubular inner member **40** and an outer sheath **41** of relatively soft foam rubber which has a high coefficient of friction to not only facilitate the advancement of the sheet material but to prevent transverse movement of the sheet material as it passes the slitting station. The inner member **40** of each roller extends axially beyond the ends of the sheath **41** and is loosely carried on a split circular rod **42** such that the rod **42** forms the central core of each roller.

The rod 42 is retained at its upper portion by the bracket 44 and at its lower portion by the bracket 46, note FIGS. 4 and 9. The brackets 44 and 46 are in turn secured to a fixed cylindrical guide ring 48 having an outer surface adapted to engage the inside surface of the advancing sheet material to guide the same into the nips formed by the anvil ring 35 and rollers 37 and 38.

To rotate the rollers 37 and 38, a pair of sprockets 50, 51 are rotatably positioned on the rod 42 with one sprocket on each side of the lower bracket 46. Each sprocket includes a hub 52, 53 respectively for mounting the exposed ends of the inner member 40. A third sprocket 54 is rotatably positioned on the rod 42 adjacent the upper bracket 44 and includes a pair of oppositely facing hubs 55, 56 each receiving an exposed end of the adjacent inner member 40. The sprockets 50, 51 and 54 are rotated by an arrangement which includes a drive motor 58 and sprocket 59, a following sprocket 60 mounted on shaft 61, sprockets 62 and 63 mounted on shaft 61 and cooperating with sprockets 50 and 51 respectively, sprocket 64 on shaft 61 cooperating with sprocket 65 on shaft 66, and sprocket 67 on shaft 66 cooperating with sprocket 54. Conventional chains (not numbered) are connected between the various pairs of cooperating sprockets. Thus the drive motor 58, which may be of the variable speed type, acts to rotate the sprockets 50, 51, and 54, which in turn rotate the plastic inner member 40 and foam rubber sheath 41 of each drive roller about the stationary rod 42. The flexibility and resilience of the inner member 40 and sheath 41 permit the same to be rotated about the curved rod while substantially maintaining engagement of the sheath with the anvil surface 36.

The means for slitting the advancing sheet material includes a variable speed drive motor 70 which is rotatably connected to a shaft 72. The shaft 72 extends along and is concentric with the longitudinal central axis defined by the rollers 26–32 and ring 35, and is rotatably mounted to the frame by a pair of spaced bearings 74 and 76. The forward end of the shaft 72 mounts a flange 78 which is adapted to adjustably mount a slide 80. As best seen in FIGS. 6, 7 and 8, the flange 78 and slide 80 are interconnected by an arrangement which includes a pair of dovetailed side walls 81 and 82 carried by the flange 78. The slide 80 includes correspondingly shaped side edges, and may be moved laterally in either direction in relation to the shaft 72. To lock the slide in a preselected position, a threaded member 84 is carried by the slide and is adapted to engage the flange 78 as seen in FIG. 7. It will be noted that the upper portion of the flange 78 mounts a threaded member 86 and a number of weights 87 to serve as an adjustable counter-balance for the purposes to become apparent. The slide 80 further mounts a second shaft 90 and a circular knife 92. The axis of the shaft 90 is parallel to the axis of shaft 72 but will normally be somewhat axially off-set or eccentric in the manner shown in FIG. 3. The knife 92 has a diameter somewhat less than the diameter of the anvil surface 36, and is connected to the shaft 90 by a bearing 94 such that the knife is essentially free wheeling. The periphery of the knife includes a plurality of spaced interruptions 96 defining a plurality of spaced cutting edges 97. By design, the central axis of the knife (or axis of shaft 90) is eccentric to the axis defined by the ring 35 and shaft 72 by an amount substantially equal to the difference between the radius of the knife and that of the anvil surface 36. Thus as the shaft 72 is rotated, the radially outermost portion of the knife 92 "walks" along or circumscribes the anvil surface 36 and rotates an increment of a revolution in a direction opposite to the rotation of shaft 72 for each revolution of the shaft 72. The relative diameters of the anvil surface 36 and knife 92 are so chosen that the increment of a revolution which the knife 92 rotates for each revolution of shaft 72 provides the predetermined staggered relation of the slits in adjacent rows.

In operation, the sheet material 25 is withdrawn from its supply roll and continuously advanced along a path of travel extending through the apparatus by the drive rollers 37 and 38. The material enters the rear end of the apparatus, is rolled or formed into a transversely curved configuration by the idler rollers 26–32 riding on the exterior surface of the material, and is maintained in this configuration by the guide ring 48 and also by the drive rollers 37–38 and ring 35.

As the material 25 passes through the ring 35, the radially outermost cutting edges 97 of the circular knife blade 92 will circumscribe the circumference of the advancing sheet material. Since the outer periphery of the knife blade substantially engages the anvil surface 36 of the ring 35, the cutting edges 97 will penetrate the material 25 and form a plurality of spaced slits along the circumference of the sheet material. The process is repeated as the material is advanced to form parallel transverse rows of spaced slits when the material is laid flat after leaving the ring 35. If the material 25 is continuously advanced, the transverse rows will extend thereacross on a slight bias which will vary depending upon the relative speeds of advancement of the material and rotation of knife 92.

It will be apparent that the apparatus is easily adapted to fabricate any desired configuration of slits in the material. In this regard, the knife 92 can easily be replaced by a knife having a somewhat different edge design or diameter, and the speed of either feed drive motor 58 or slitting motor 70 can be varied to adjust the spacing between the transverse rows. Preferably however, the blade will be designed so as to be rotated an increment of a revolution upon each traversal of the cutting surface of the material 25 so that the slits in adjacent rows will be in a predetermined staggered relation.

In the drawings and specification, there has been set forth a preferred embodiment of the invention, and although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation.

I claim:

1. An apparatus for slitting sheet material of indeterminate length in a predetermined pattern of spaced apart rows of spaced slits with the slits in adjacent rows being in predetermined staggered relation to form a web capable of being expanded into a relatively open, net-like structure, said apparatus comprising

means for advancing the sheet material longitudinally along a predetermined path of travel to and past a slitting station,

means operatively associated with said advancing means for forming the sheet material being fed to the slitting station into a transversely curved configuration and

means operatively associated with said advancing means for slitting the transversely curved sheet material at the slitting station to form transversely extending, spaced rows of spaced slits with the slits in adjacent rows being in predetermined staggered relation.

2. An apparatus for slitting sheet material of indeterminate length in a predetermined pattern of spaced apart rows of spaced slits with the slits in adjacent rows being in predetermined staggered relation to form a web capable of being expanded into a relatively open net-like structure, said apparatus comprising

knife means mounted for rotation about an axis and having a cutting surface for forming closely spaced rows of spaced slits in the sheet material

means for advancing the sheet material along a path of travel parallel to said axis of said knife means, and

means for successively traversing the cutting surface of said knife means transversely of the sheet material to form successive rows of spaced slits, the knife means being rotated an increment of a revolution upon each traversal of the cutting surface of the sheet material so that the slits in adjacent rows are in predetermined staggered relation.

3. Apparatus according to claim 2 wherein advancing means comprises feed means for feeding the sheet material past said knife means and variable drive means connected to said feed means for driving said feed means at a variable rate to vary the spacing between adjacent rows of slits.

4. Apparatus according to claim 2 wherein said traversing means traverses the cutting surface of said knife means transversely of the sheet material at a variable rate relative to the rate at which the sheet material is advanced to vary the spacing between adjacent rows of slits.

5. Apparatus according to claim 2 including anvil means cooperating with said knife means and said advancing means for supporting the sheet material during slitting thereof.

6. Apparatus according to claim 5 wherein said knife means is generally circular and the cutting surface thereof includes circumferentially spaced cutting edges of predetermined circumferential lengths corresponding to the desired lengths of the slits to be formed.

7. Apparatus according to claim 6 wherein said anvil means defines a curved anvil surface of larger radius than said knife means, and wherein said advancing means cooperates with said anvil means in forming the sheet material into a transversely curved configuration corresponding to the curve of said anvil surface.

8. An apparatus for slitting sheet material of indeterminate length in a predetermined pattern of spaced apart rows of spaced slits with the slits in adjacent rows being in predetermined staggered relation to form a web capable of being expanded into a relatively open, net-like structure, said apparatus comprising

a circular knife mounted for rotation about a central axis and having a cutting surface defined by circumferentially spaced cutting edges of predetermined circumferential length for forming successive rows of spaced slits in the sheet material,

means defining a curved anvil surface surrounding at least a portion of said knife and having a circumferential length at least as great as the width of the sheet material and a radius greater than the radius of said knife,

means for advancing the sheet material along a path parallel to said axis of said knife and between said curved anvil surface and said knife means and cooperating with said curved anvil surface for forming the sheet material into a transversely curved configuration corresponding to the curve of said anvil surface, and

means mounting said knife for eccentric rotation about an axis concentric with said curved anvil surface with the amount that said central axis of said knife is eccentric to said concentric axis being substantially equal to the difference between the radius of said knife means and said curved anvil surface so that upon rotation of the knife means about said concentric axis the cutting surface of the knife means will be traversed along said curved anvil surface and transversely of the sheet material to form successive rows of slits therein.

9. Apparatus according to claim 8 wherein said advancing means comprises at least one curved roll contiguous to said curved anvil surface rearwardly of said knife but adjacent thereto for advancing the sheet material while maintaining the same against the anvil surface as the knife slits the same.

10. Apparatus according to claim 8 wherein said anvil surface is substantially right cylindrical.

11. Apparatus according to claim 10 wherein said advancing means comprises a pair of circumferentially spaced, curved rolls contiguous to said cylindrical anvil surface rearwardly of but adjacent to said knife for advancing the sheet material while maintaining the same against the anvil surface as the knife slits the same and means connected to said curved rolls for driving the same.

12. Apparatus according to claim 8 wherein said mounting means for said knife includes a first shaft mounted concentric with said curved anvil surface, a second shaft concentric with said knife and mounting said knife thereon, and means mounting said second shaft on said first shaft and in eccentric relation thereto.

13. Apparatus according to claim 12 wherein said means mounting said second shaft on said first shaft is adjustable to vary the amount of eccentricity between the first and second shafts so that knives of varying diameter may be used with said anvil surface.

14. A method of slitting sheet material of indeterminate length in a predetermined pattern of spaced apart rows of spaced slits with the slits in adjacent rows being in predetermined staggered relation to form a web capable of being expanded into a relatively open, net-like structure, said method comprising

advancing the sheet material longitudinally in a predetermined path of travel to a slitting station while forming the sheet material into a transversely curved configuration, and

slitting the transversely curved sheet material at the the slitting station to form transversely extending, spaced rows of spaced slits with the slits in adjacent rows in predetermined staggered relation.

15. A method according to claim 14 wherein the sheet material is formed into a transversely arcuate

configuration and wherein the sheet material is slit by traversing the sheet material with a rotary knife means.

16. A method according to claim 14 wherein the sheet material is advanced longitudinally at a variable rate to vary the spacing between adjacent rows of slits.

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