Nov. 2, 1965 G. HANNAUER, JR., ETAL 3,214,795

PERFORATING MACHINE AND METHOD OF PERFORATING

Filed July 6, 1962

3 Sheets-Sheet 1

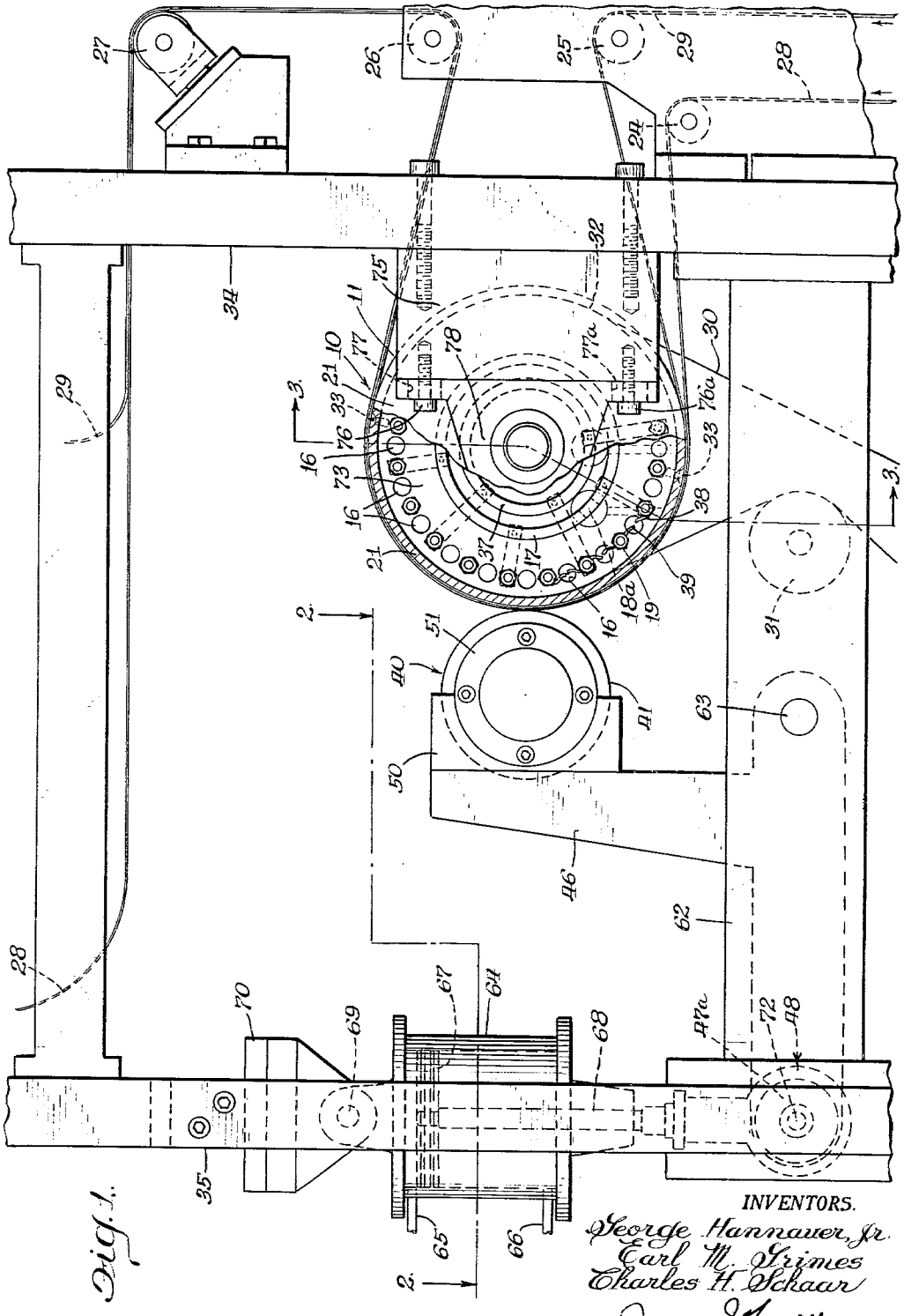

Fig. 1.

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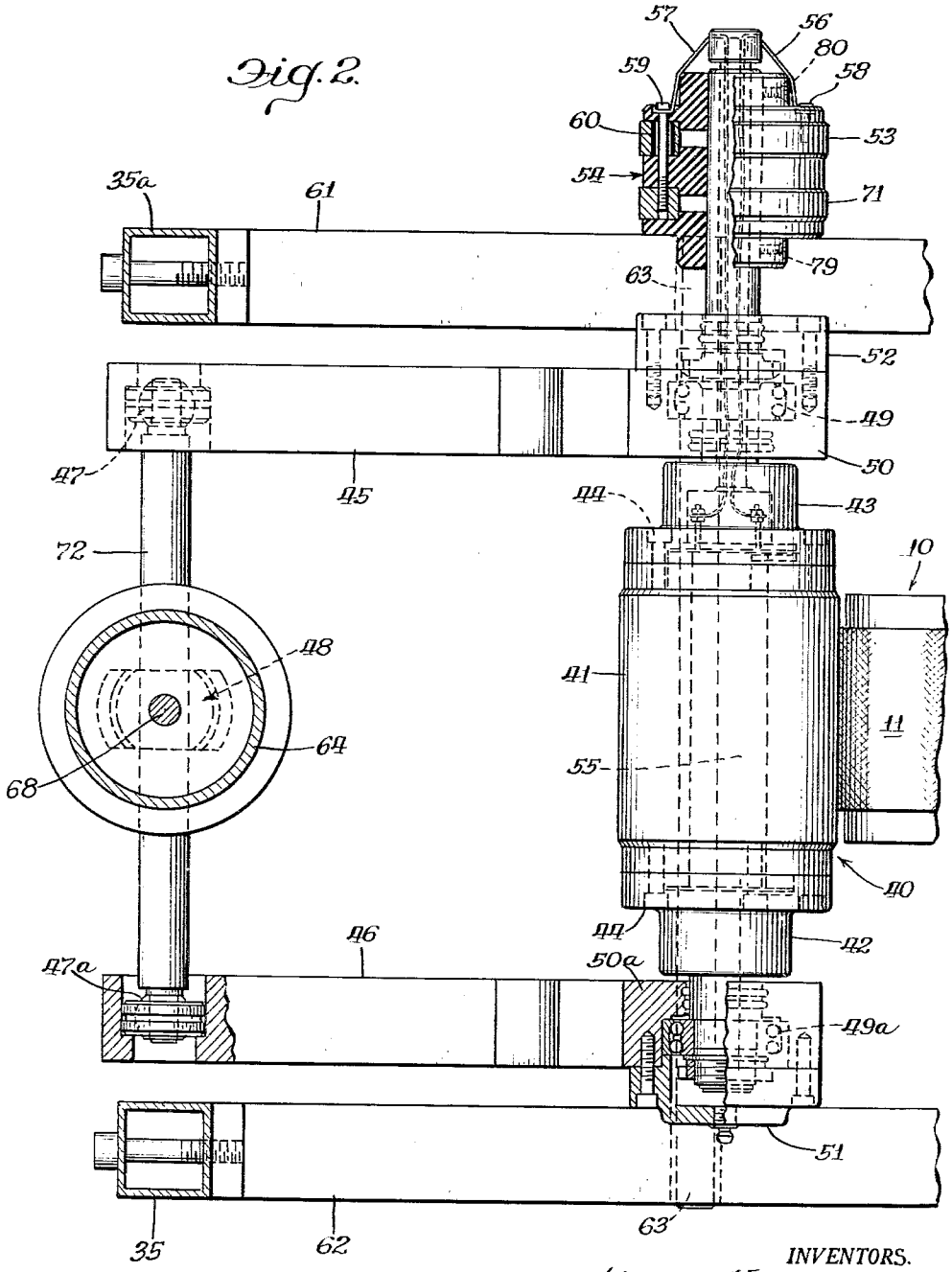
Filed July 6, 1962 3 Sheets-Sheet 2

Fig. 2.



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Filed July 6, 1962 3 Sheets-Sheet 3

Fig. 3.

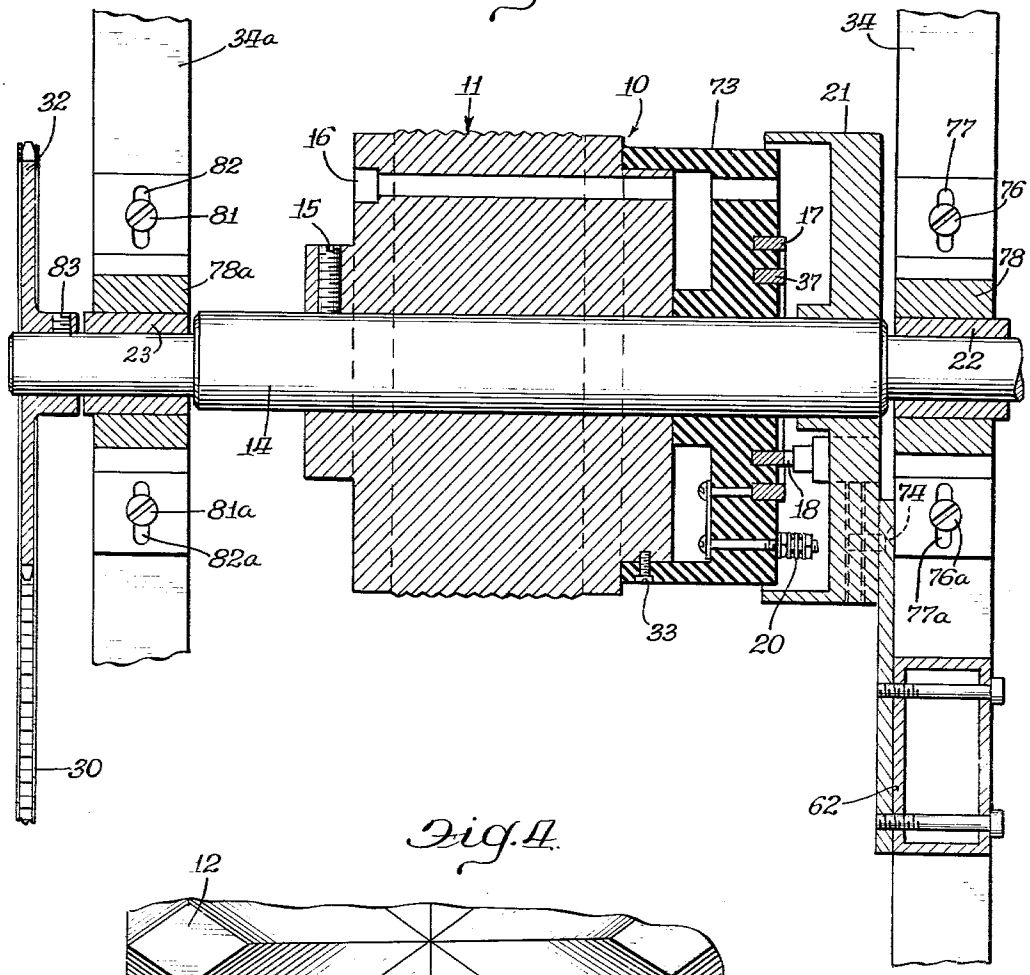
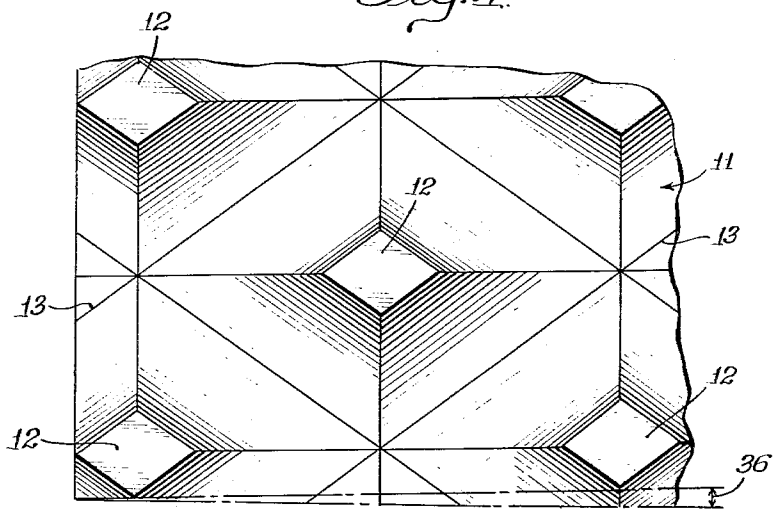


Fig. 4.



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PERFORATING MACHINE AND METHOD OF PERFORATING

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4 Claims. (Cl. 18—10)

This invention is concerned with perforating methods and with machines for carrying out the methods, particularly with that class of perforating machines which is designed to perforate faced thermoplastic adhesive tapes without perforating the facing. In the past, various methods have been proposed for perforating plastic pressure-sensitive adhesive tapes, some of which have utilized hot needles and some of which have used die punching methods, but none of the methods and machines previously employed have utilized the principles employed in the methods and machines of this invention.

It is an object of this invention to provide a machine and method which will rapidly and consistently perforate plastic adhesive tapes without perforating the adhesive-protective facing thereon.

It is a second object of this invention to provide a machine and method which will consistently perforate only through the backing and adhesive of faced plastic adhesive tapes without forming incompletely perforated areas where the holes are covered by thin veils of backing material.

Referring to the drawings:

In FIGURE 1 is shown an assembled side view of the perforating device.

FIGURE 2 is the top view of the hot roll and its aligning and supporting structure.

FIGURE 3 is a cross-sectional view of the pattern roll of the device.

FIGURE 4 is an enlarged view of a portion of the pattern roll surface.

One of the problems associated with the perforation of thermoplastic adhesive tapes without perforating the adhernt facing is that of variations in the machine direction in thickness of the facing and of the tape. Both the adhesive tape and the facing normally exhibit some variation in thickness. A perforating system with a nip gap adjustment which will achieve perforation where the adhesive tape is relatively thinner and the facing relatively thicker will not achieve perforation with the same nip gap where the adhesive tape is relatively thicker and the facing relatively thinner.

Another of the problems is the necessity for constant alignment of the nip elements of the two rolls in parallel relationship with the opposite sides of the facing sheet. This is especially critical because unless near perfect parallelism exists at the nip between the raised portions of the pattern roll and one side of the facing and the surface of the hot roll and the other side of the facing, uniformity in perforation across the width of the adhesive tape will be impossible. For instance, if the nip elements are not respectively parallel to the sides of the facing sheet they cannot be the proper distance apart for perforation of the tape adhered to the facing except in one small area. On either side of this area or on one side if the area occurs at the end, perforations will occur in the adhesive but the backing will only be embossed and thinned where the perforations should be.

Similarly, where a sheet in addition to the faced tape is interposed between the rolls, the variation in thickness which may exist across the material in the nip and lengthwise thereof is further amplified.

This invention, therefore, provides means for constantly adjusting the nip both with respect to nip gap distance and to parallelism or minor departures from parallelism of the nip elements of the two rolls to accommodate the variations in thickness of the material in the nip.

The embodiment of the invention illustrated in the drawings provides a pattern roll whose adjustable bearings may be moved at either or both ends and locked so that its nip elements are in the same plane as the nip elements of the hot roll. The hot roll continuously and automatically adjusts itself so that its nip element parallels the nip element of the pattern roll or departs somewhat from parallelism depending upon the nip contents. This is accomplished in the illustrated embodiment by fluid pressure exerted through a ball joint at the mid-point of a pressure shaft. This shaft swivels about the central ball joint and causes independent movement of pivoted pressure arms through ball joints at each end. The pressure arms pivoting about a common shaft act upon the respective end hub shafts of the hot roll through spherical ball bearings and constantly urge the hot roll ends toward the pattern roll while the machine is in operation.

Referring once more to the drawings: In FIGURES 1 and 2, the pattern roll **10**, shown in cross-section in FIGURE 3, has a pattern surface **11**, FIGURE 4, comprising cylindrical portions forming pattern plateaus **12** surrounded by slopes terminating in pattern valleys **13**. The pattern roll drive shaft **14** rotates in bearings **22** and **23** in adjustable bearing housings **78** and **78***a*. The adjustable features of the pattern roll bearing housings are shown in FIGURE 3. Bearing housings **78** and **78***a* are equipped with slotted bolt holes **77** and **77***a* and **82** and **82***a*, respectively. It is obvious that either or both ends of the pattern roll may be shifted by loosening the bolts **76**, **76***a*, **81** and **81***a* and shifting the roll and tightening the bolts again to bring the nip elements of the rolls in the same plane. Spacer elements **75** at either end to which the bearing housings are bolted are in turn bolted to frames **34** and **34***a*, FIGURE 1. The set screw **15**, FIGURE 3, rigidly attaches the pattern roll to the drive shaft **14**. A hole for the heaters **16** of which there may be **20**, more or less is illustrated. The heaters have their terminals **38** and **39**, FIGURE 1, attached to slip rings **17** and **37** on insulation terminal and slip ring block **73**, FIGURE 3, through terminal posts **20** and connective posts **19**. Two heaters are thus connected in series and the pairs of heaters are in parallel electrically. Brushes **18** and **18***a* are carried in cover and brush holder cap **21** which is fastened to the frame **62** by bolt **74**. Idler rollers **24**, **25**, **26** and **27** are used for feeding the faced tape **28** and the interposed sheet **29** and for carrying them away from the perforator. Drive chain **30** drives a sprocket **32**, FIGURES 1 and 3, and is tightened by chain tightener sprocket **31** which is adjustable. Sprocket **32** drives the pattern roll drive shaft, being fastened to the latter by set screw **83**. Vertical frames **34**, **34***a*, **35** and **35***a* and horizontal frames **61** and **62** support the perforating mechanism.

In the pattern face of the pattern roll, the perforated raised portions **12** lie in parallel rows which are off-set angularly from the pressure line between the two rolls. This angle **36**, FIGURE 4, is necessary in order to insure a reasonable constant pressure line between the cylindrical raised areas **12** of the pattern roll and the hot roll as the film moves between the two rolls. In the absence of such offset, the hot roll drops off into each valley and then rises to the next row of raised areas so that excessive wearing of the raised pattern occurs. It has been found that a very desirable offset, across the roll face, is about the distance between adjacent raised faces on the same circumferential line so that the nip elements of the pattern roll intersect at least two rows of raised pattern areas.

The hot roll **40** consists of a heater roll sleeve **41** and two hub shafts **42** and **43** all of which are bolted together by bolts **44**. The heater roll sleeve is hollow and contains the heater **55**. Wires **56** and **57** from the heater terminals pass out through the hollow portion of the hub shaft **43** and are fastened respectively to slit rings **53** and **71** in insulation assembly **54** by screws **58** and **59**, the latter passing through insulation ring **60**. The insulation assembly **54** consists of three insulation rings held together by set screws **79** and **80** which lock the assembly to the hub shaft **43** and hold the slip rings in place. Stationary brushes attached to the bearing housing carry the current to the heater and make sliding contact with the slip rings. At opposite ends of the hot roll assembly are spherical ball bearings **49** and **49***a* which support the hot roll in the bearing housings **50** and **50***a*. These bearings are protected by bearing end cap **51** and bearing cover **52**. Bearing housings **50** and **50***a* in turn are bolted to hot roll pressure arms **45** and **46** which are pivoted between frame members **61** and **62** by pivot shaft **63**. The ends of the hot roll thus pivot about the pivot shaft **63** and move toward and away from the pattern roll depending upon the position of the pressure arms **45** and **46**. The pressure arms in turn are actuated by the piston **67** in fluid cylinder **64** which has fluid ports **65** and **66** and is supported by horizontal member **70** by means of pivot pin **69**. The piston **67** is moved in the cylinder depending upon which of the ports is acting as an entrance port and which is acting as an exhaust port. Piston rod **68** is fastened to spherical rod end bearing **48** through which hot roll pressure shaft **72** passes. Hot roll pressure shaft **72** in turn is fitted at its ends with spherical bearings **47** and **47***a* which engage the pressure arms **45** and **46**. When fluid enters the port **65** and exhausts from port **66**, the spherical end bearing **48** forces the shaft **72** downwardly and causes the pressure arms **45** and **46** to rotate counterclockwise, as shown in FIGURE 1, about the pivot shaft **63** thus drawing the hot roll away from the pattern roll. When, however, the fluid under pressure enters port **66** and exhausts from **65** forcing the piston **67** upwardly as shown in FIGURE 1, the hot roll pressure shaft **72** is also forced upwardly and the pressure arms **45** and **46** pivoting around pivot shaft **63** force the hot roll against the material separating it from the pattern roll. The combination of spherical bearings **47**, **47***a*, spherical rod end bearing **48** and spherical ball bearings **49** and **49***a* cause the hot roll surface to press against the interposed material across its width uniformly regardless of normal web thickness variations. Thus, if the axis of the hot roll is not parallel to the surface of the interposed material, the pressure arm on the non-contacting side causes the hot roll to pivot about its contact point with the material and move toward the pattern roll until contact across the roll is achieved.

Referring once more to the pattern roll **10** and particularly to the surface **11**, it is obvious that the diamond shape of the raised cylindrical portions constituting plateaus **12** of the roll is shown only for purposes of illustration. The raised cylindrical portions may take any shape or size or any combination of shapes and sizes. The raised portions may be circular or oval or square or triangular or they may be in the form of complicated designs such as lacework designs. Generally, the area of perforation is in the range of 1 to 15% of the total tape surface area. Obviously, where the perforations are small, a large number may be made in a small space. With holes constituting 6% of the surface area as many as 450 to 500 holes per square inch may be formed without difficulty.

With regard to the depth of the valleys **13**, it has been found that if the depth is as much as 1½ times the thickness of the material in the nip including the tape backing thickness, the adhesive thickness, the adhesive protective sheet facing thickness and the sheet thickness interposed between the pattern roll and the faced tape, excellent perforation of the tape but not the facing occurs. The angle of slope from the plateaus to the valleys is not critical providing the acute angle between the tangents to the raised surface and the slope line is at least 30° where the slopes commence. A 90° angle is satisfactory but not preferred.

With regard to temperatures of the hot roll, it is preferred to operate the hot roll at a temperature of 600° F. although this temperature may be altered considerably depending upon the material to be perforated. At this temperature, the pattern roll becomes heated to a temperature of 180–200° F. after several hours of operation. To make the conditions as constant as possible, therefore, the pattern is warmed to 180° to 200° F. before operations are commenced. Heaters should be selected to maintain the above temperatures depending upon the size of the rolls and the speed and thickness of the material through the machine.

The preferred embodiment of the machine of the invention and the method of operation is illustrated in the drawings. In this preferred embodiment, the hot roll is the smooth roll, while the pattern roll is fixedly adjusted so that the two rolls have their nip elements in the same plane. The hot roll is the roll whose ends are adjusted to adjust the nip gap and nip parallelism. However, it is obvious that all of the adjustable features could be assigned to one roll or could be reversed from the preferred machine without departing from the invention. Thus, the hot roll could be fixed and all of the adjustments made to the pattern roll or vice versa. Likewise, the hot roll could be fixedly adjusted so that the nip elements are in the same plane and the pattern roll could have its ends moved to adjust the nip gap and nip parallelism. Likewise, the hot roll could be the pattern roll.

By the preferred method, the tape, faced preferably with cellophane, is placed facing toward the hot roll while a sheet of polyethylene is interposed between the tape backing and the pattern roll. The hot roll does not affect the cellophane facing but the heat is passed through the facing to the adhesive and to the backing. Both backing and adhesive soften in the areas where the hot roll presses the material in the nip against the raised pressing surfaces of the pattern roll. The pressure squeezes out the softened adhesive and backing onto areas of less pressure thus creating perforations.

It is obvious that the mechanism of this invention is not dependent for operation upon its position in space and the location of particular elements in horizontal, vertical or other positions is a matter of choice well within the scope of the invention.

The pressure which is exerted on the hot roll is preferably fluid pressure but other means such as springs and weights may be utilized.

In perforating an adhesive tape with a 3 mil backing of a copolymer of vinyl acetate and vinyl chloride, a quite common tape, the pressure of the fluid means may vary from 15 to 45 pounds per square inch depending upon the area of the perforations. Translated into force in the nip area, this amounts to approximately 50 to 150 pounds per linear inch of nip length. Thicker materials and materials with higher softening points may require more pressure. Thus, a force per linear inch of approximately 100 to 300 pounds is utilized in perforating 5 mil cellulose acetate cloth-backed adhesive tape.

Products of the general type produced by the device and methods of this invention are described and claimed in a patent application of Charles H. Schaar, SN 48,225, filed August 8, 1960, now Patent No. 3,073,304.

We claim:

1. A machine suitable for perforating faced thermoplastic sheet material including a rotatable relatively smooth roll and a rotatable pattern roll, one of said rolls being positively driven, raised pressing areas constituting rigid cylindrical portions of said pattern roll surrounded by depressed areas, at least one of said rolls

being a hot roll maintained at a temperature above the softening point of the thermoplastic sheet material to be perforated, means for fixing the axis of one of said rolls so as to parallel the movable axis of the other roll when the rolls are in contact thus creating a nip between said rolls, pressure means constantly acting against the shaft ends of said other roll to move them with positive pressure toward the fixed axis roll, said pressure means including a piston moving between two ports by fluid pressure, a piston rod actuated by said piston, a pressure shaft attached by a ball joint at its midportion to said piston rod, pressure rocker arms attached by a ball joint each to an end of said pressure shaft, said pressure rocker arms each individually pivoting about a pivot shaft intermediate its ends, spherical ball bearing joints joining the shaft ends of said other roll having said movable axis to said pressure rocker arms, said spherical ball bearing joints permitting said roll and its shaft to rotate on an axis automatically variably positioned from parallelism with the axis of the fixed axis roll to parallelism with the surface of sheet material interposed between said rolls, each pressure rocker arm individually transmitting force from said piston through said piston rod and pressure shaft to its respective roll shaft end and together acting to align the axis of said other roll having said movable axis to parallelism with the nearest surface of sheet material interposed between said rolls and to urge the surface of said other roll toward the surface of the fixed axis roll whereby the faced thermoplastic sheet material is softened by the hot roll and as it is drawn into the nip is squeezed from its facing in the discrete areas between the smooth roll and the raised pressing areas of the pattern roll.

2. The machine of claim 1 wherein the cylindrical pressing areas of the pattern roll are arranged in separated rows extending across said roll, each row forming an acute angle with intersecting lines in the cylindrical surface parallel to the roll axis of said roll whereby each line intersects at least two rows.

3. The machine of claim 1 wherein the slope lines of the depressed areas of the pattern roll form acute angles of at least 30° with the tangents to the pressing areas where the slopes commence.

4. A machine suitable for perforating faced thermoplastic sheet material comprising a positively driven pattern roll rotating in adjustable but fixed bearings, raised pressing areas constituting rigid cylindrical portions of said pattern roll surrounded by depressed areas, a piston moving between two ports by fluid pressure, a piston rod actuated by said piston, a pressure shaft attached by a ball joint at its mid-portion to said piston rod, pressure rocker arms attached by a ball joint each to an end of said pressure shaft, said pressure rocker arms each individually pivoting about a pivot shaft intermediate its ends, a hot roll maintained at a temperature above the softening point of the sheet material to be perforated, spherical ball bearing joints joining the shaft ends of said hot roll to said pressure rocker arms, said spherical ball bearing joints permitting said hot roll and its shaft to rotate on an axis automatically variably positioned from parallelism with the axis of said pattern roll to parallelism with the surface of sheet material contacting said hot roll and interposed between said hot roll and said pattern roll, each pressure rocker arm individually transmitting force from said piston through said piston rod and pressure shaft to its respective hot roll shaft end and together acting to align the axis of said hot roll to parallelism with the surface of sheet material contacting said hot roll and interposed between it and said pattern roll and to urge the surface of said hot roll toward the raised pressing areas of said pattern roll with positive pressure whereby when the facing side of the faced thermoplastic sheet material contacts the hot roll in its approach to the nip, the thermoplastic sheet material is softened and as it is drawn into the nip is squeezed from the discrete areas between the hot roll and the raised pressing areas of the pattern roll, creating perforations in the discrete areas of the thermoplastic sheet material.

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