

[54] **APPARATUS FOR FORMING ENVELOPES OF THERMOPLASTIC SHEET MATERIAL**

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[58] Field of Search 156/211, 216-217, 156/227, 292, 443, 499, 510, 535, 538, 578; 136/148; 53/39, 40; 93/11, 84 R

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[57] **ABSTRACT**

A method and apparatus for forming envelopes of thermoplastic sheet material, preferably battery separator blanks. The method includes heating the sheet in a narrow zone, folding the sheet along the heated zone, and sealing the side edges of the folded sheet together to form an envelope open at the top. The apparatus has a heating station which heats a narrow transverse zone or band along a fold line, a folding station having a reciprocating plow member which folds the separator along the fold line, and a heat-sealing station wherein the folded separator is heat-sealed along its side or lateral edges. Where the thermoplastic sheet is a battery separator blank having ribs on one surface thereof, there is provided a grinding station which forms a V-shaped notch in the edge ribs of the separator at the fold line. There is optionally provided a plasticizer applicator station which applies plasticizer to the edge portions of the sheet to enhance heat-sealability thereof.

10 Claims, 19 Drawing Figures

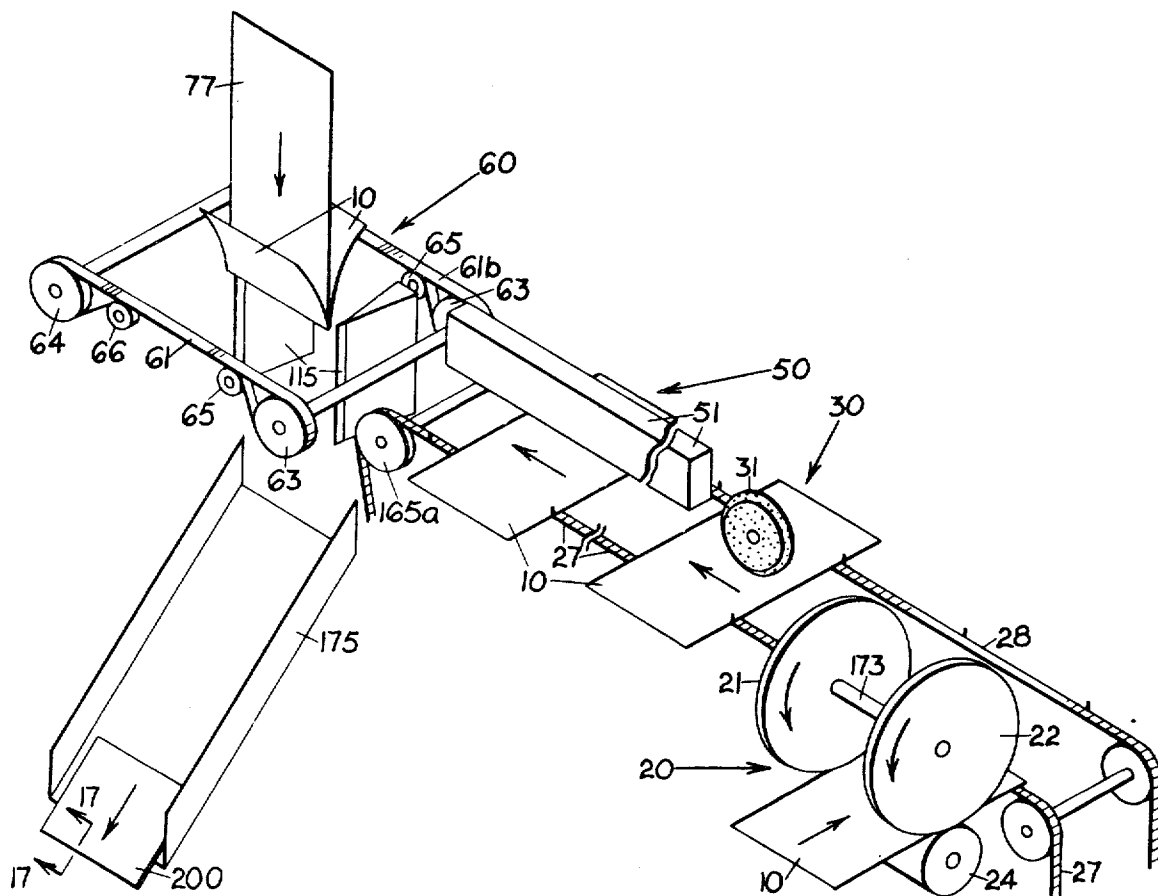


FIG. 12

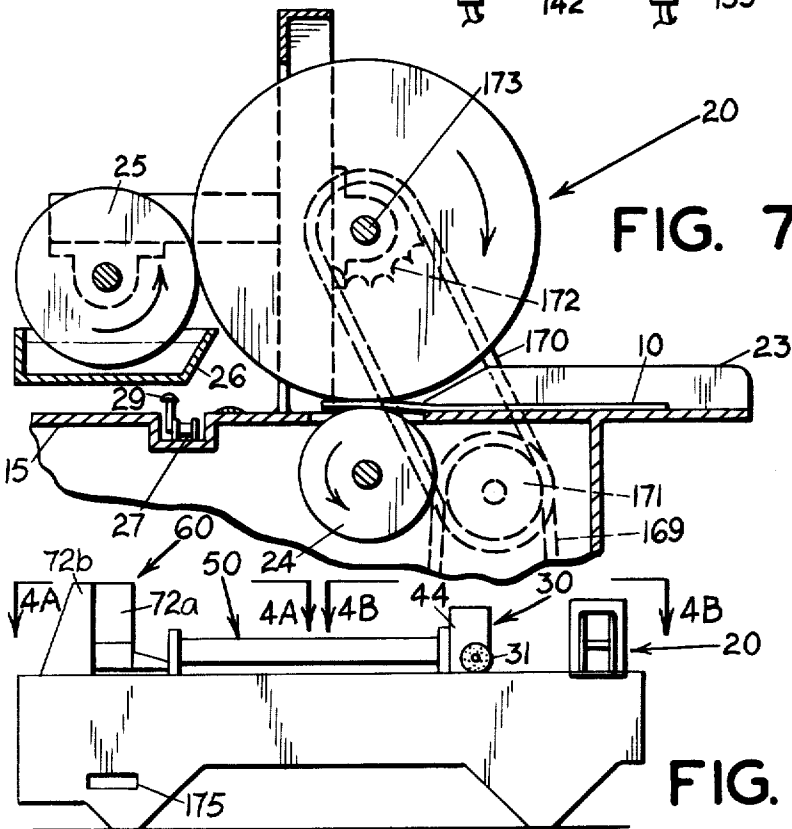
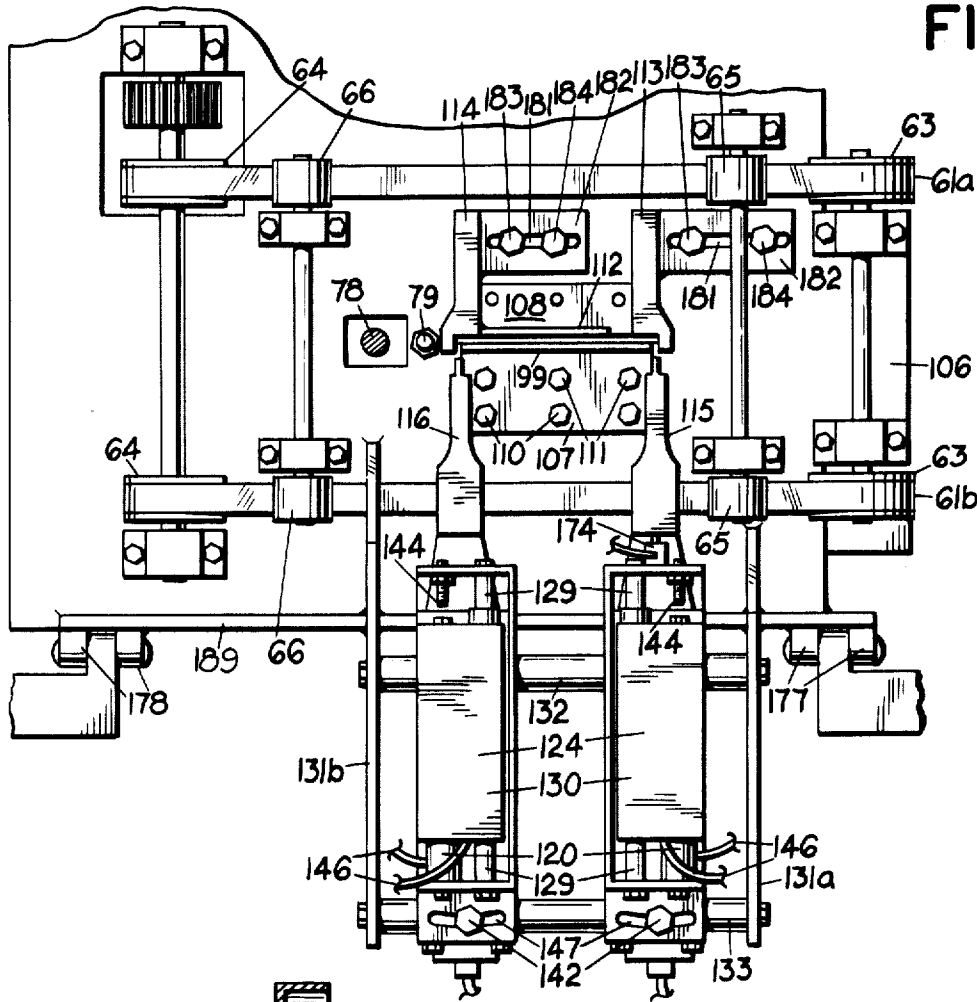


FIG. 7

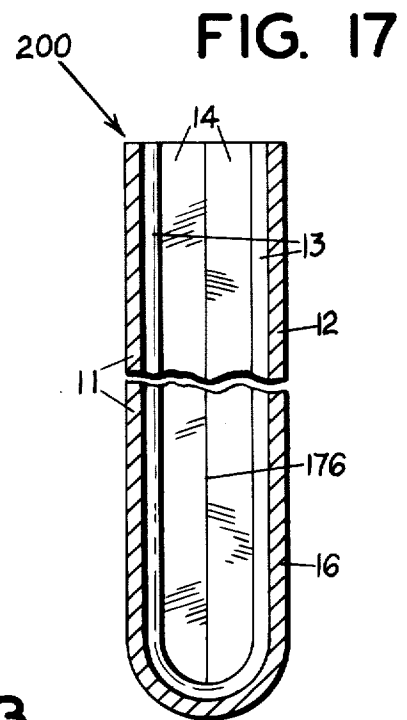


FIG. 17

FIG. 3

FIG. 4A

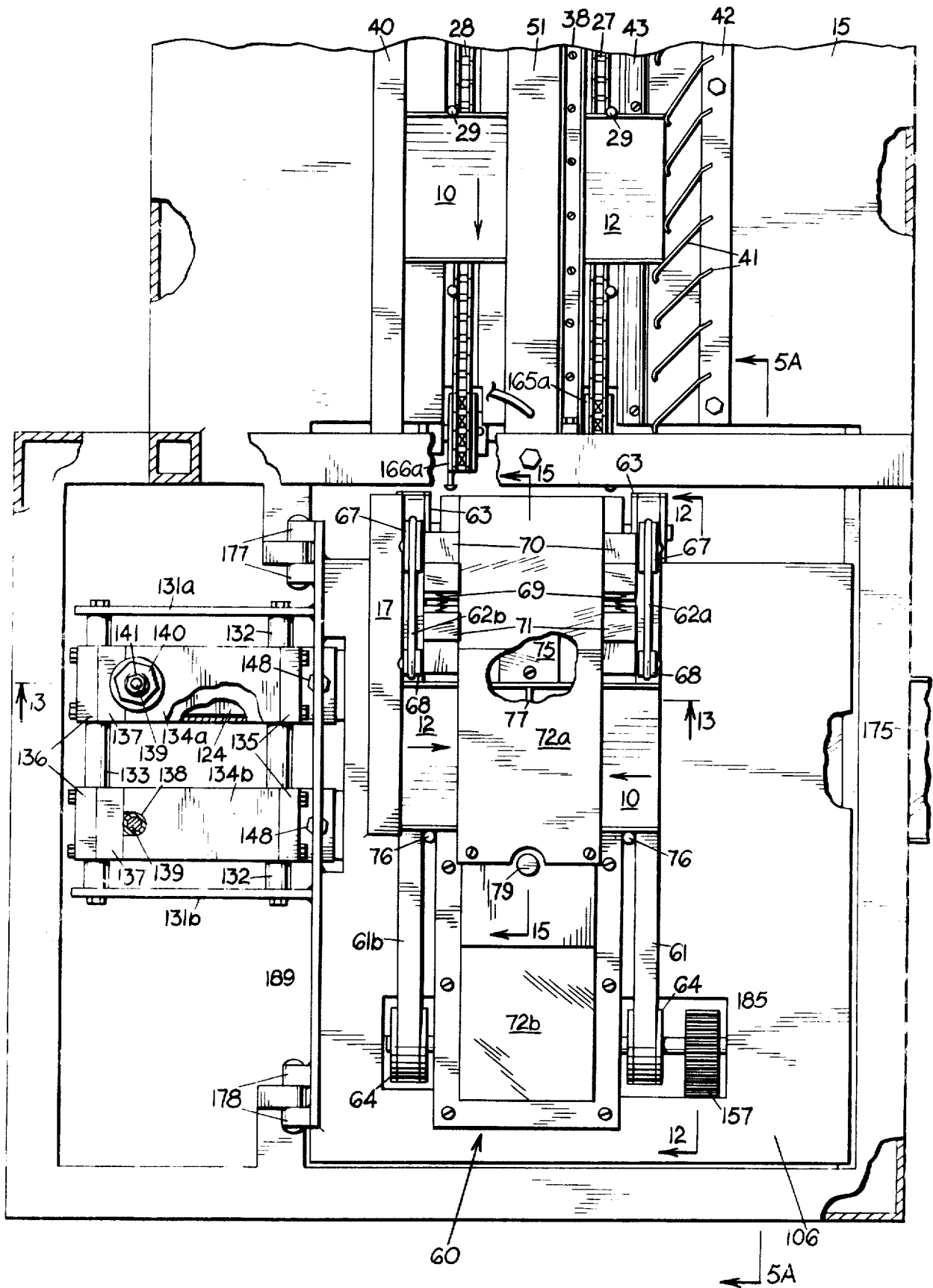


FIG. 4B

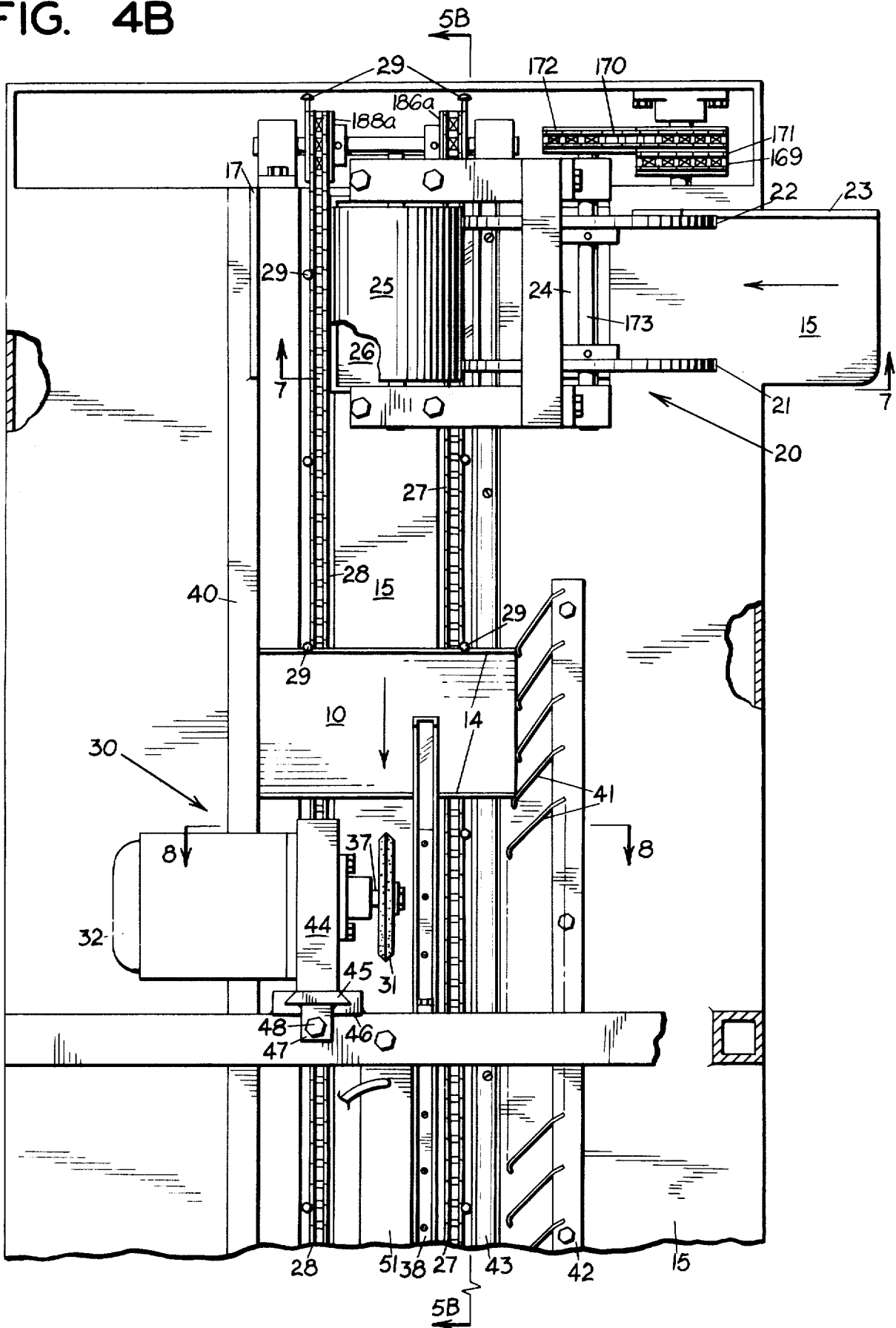


FIG. 5A

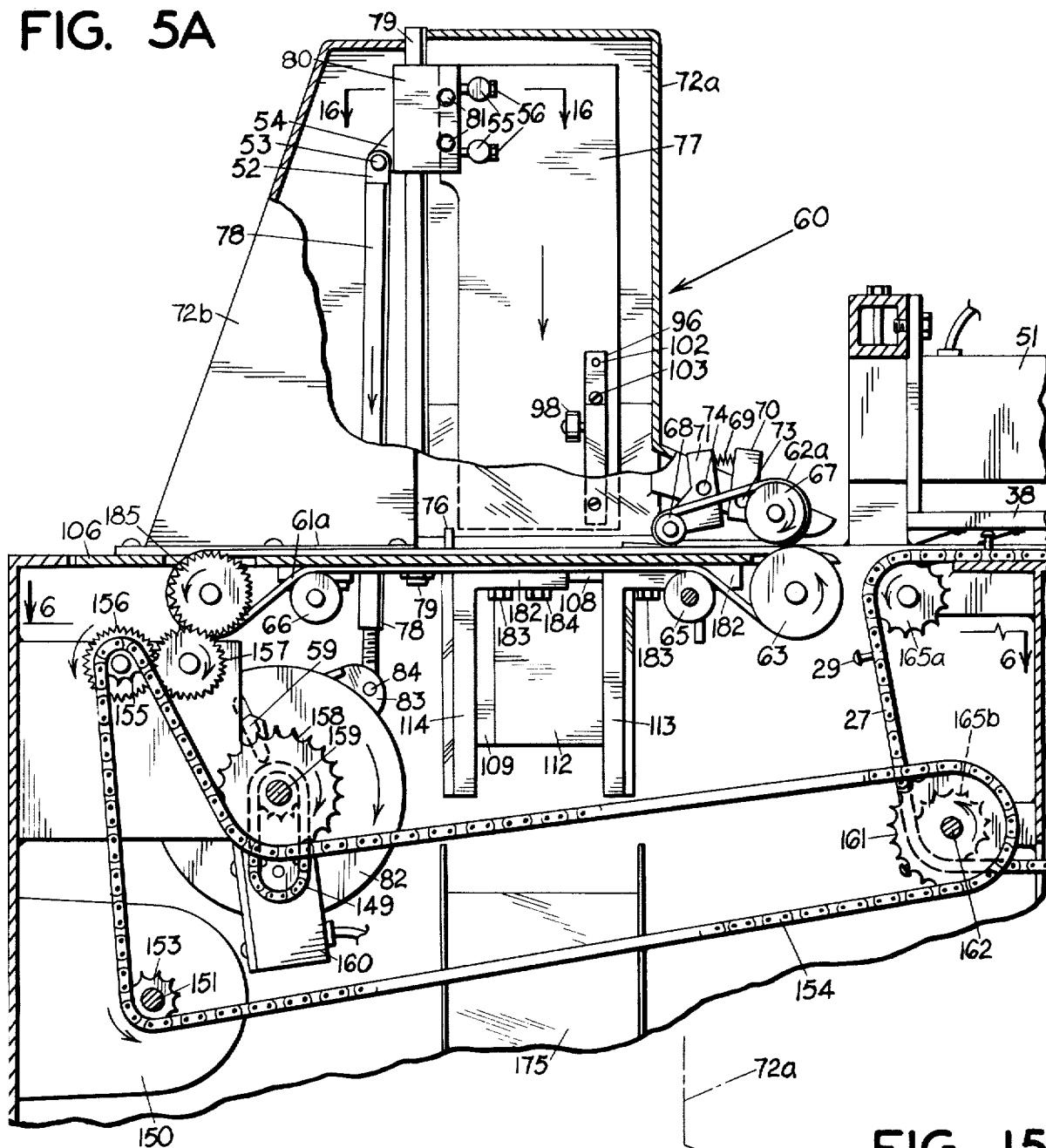
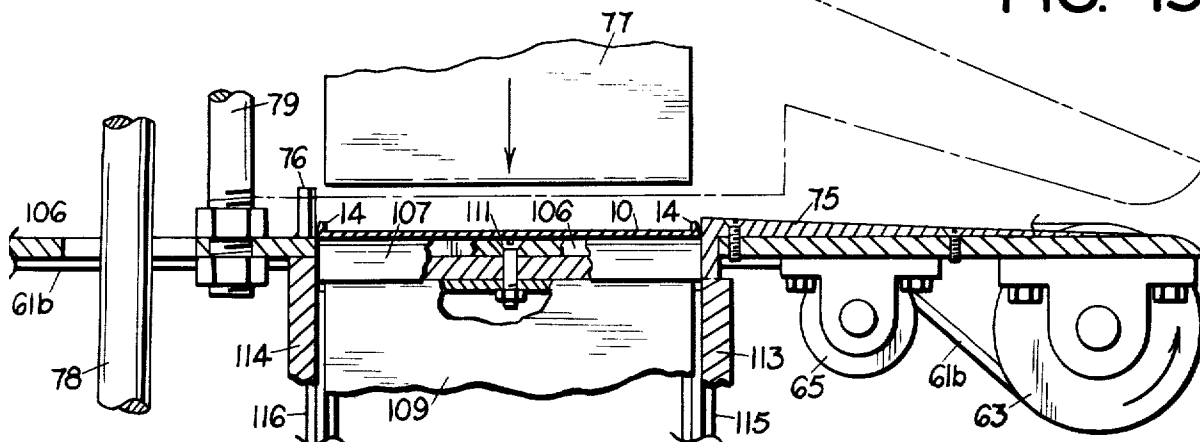
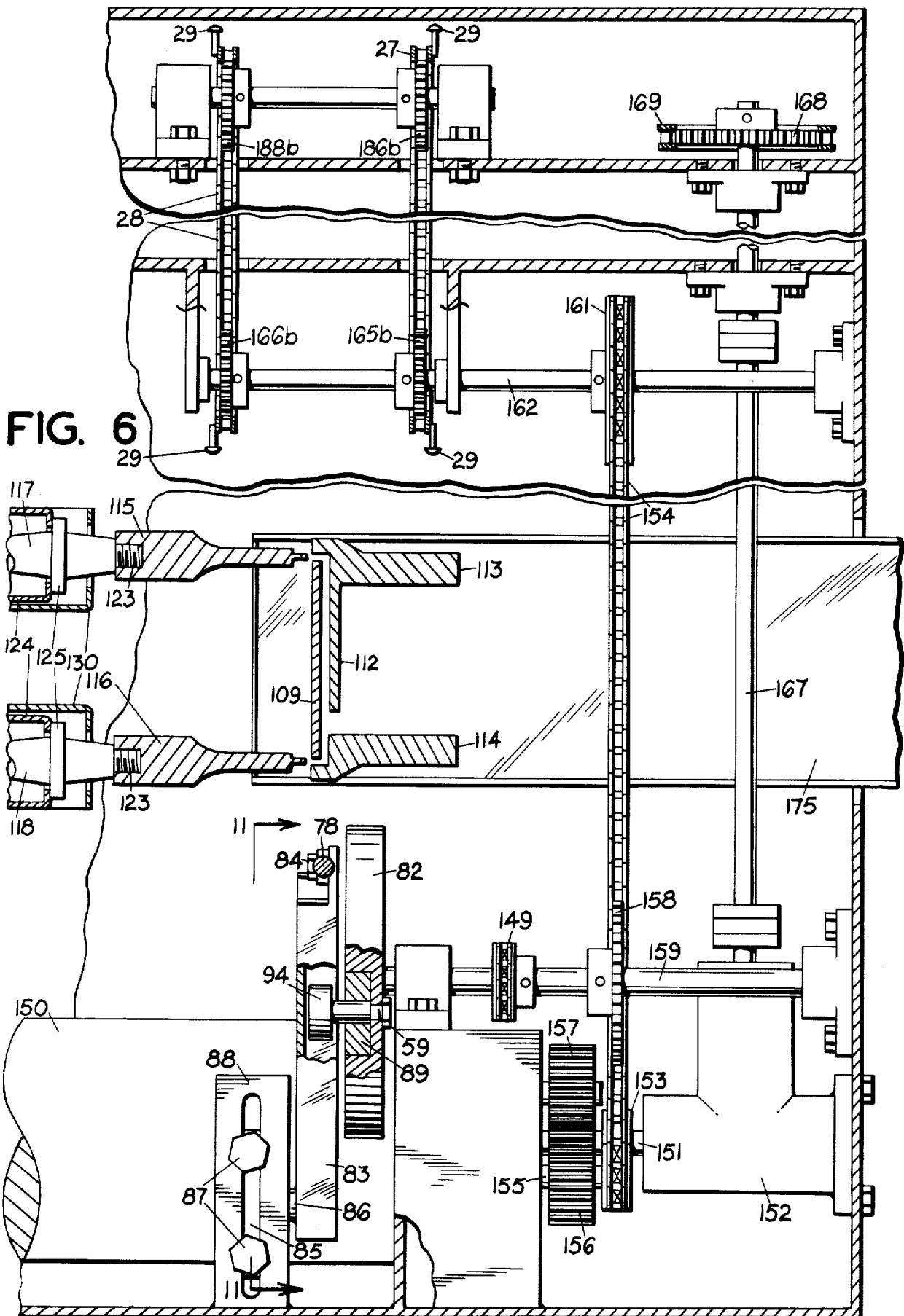
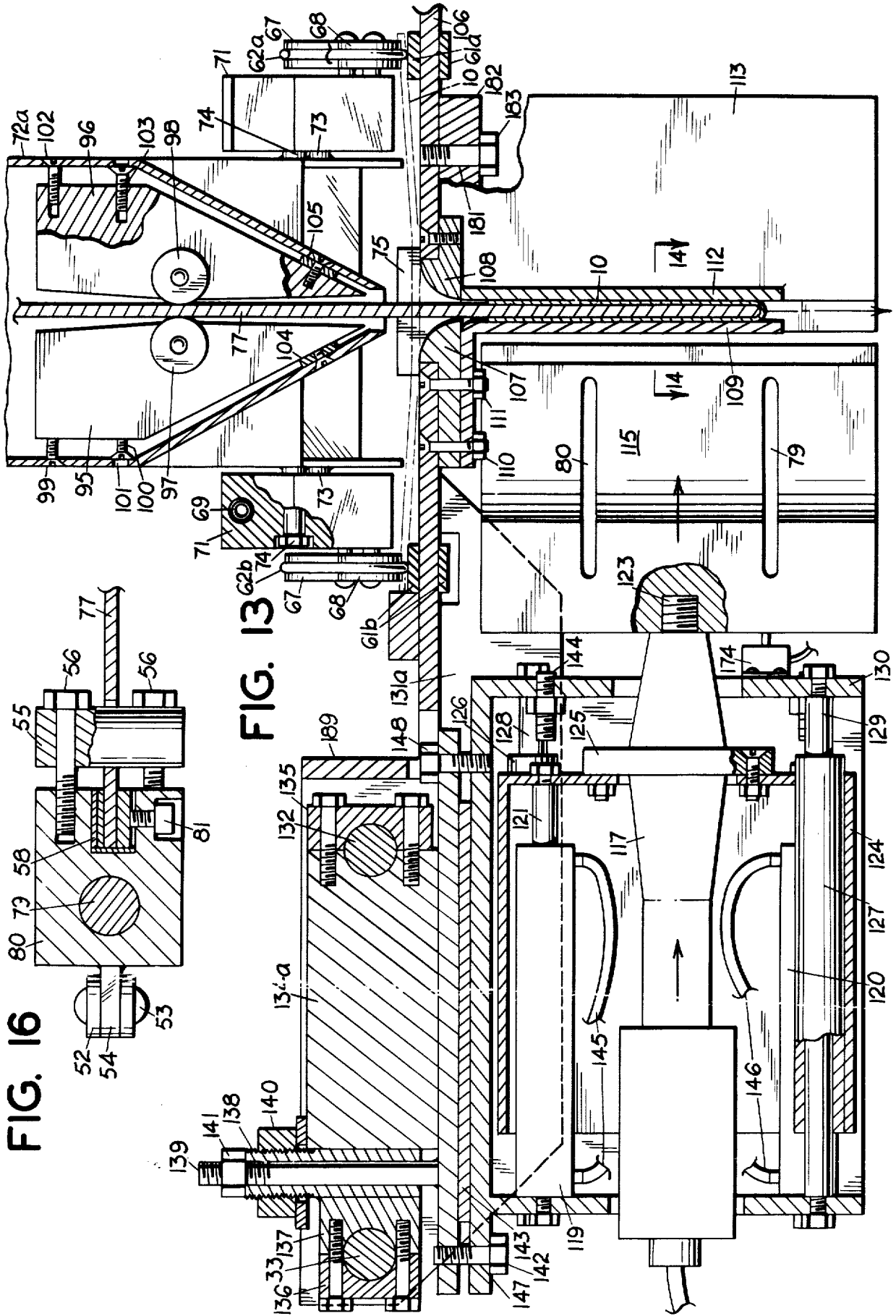


FIG. 15







APPARATUS FOR FORMING ENVELOPES OF THERMOPLASTIC SHEET MATERIAL

BACKGROUND OF THE INVENTION

Battery separators are commonly employed as a permeable insulating diaphragm interposed between plates of opposite polarity in a battery so that the electrolyte forms the sole conducting path therebetween. The typical separator is a porous diaphragm with parallel longitudinal ribs on one surface thereof. The ribs are normally adjacent the positive plate and the flat side of the diaphragm is adjacent the negative plate.

One type of separator is the so-called "sintered PVC" separator formed by sintering granular polyvinyl chloride on a moving belt, the rib pattern being formed prior to sintering by suitable die means. One method of making such a separator is described in U.S. Pat. No. 3,450,571.

SUMMARY OF THE INVENTION

The method of the present invention comprises heating a thermoplastic sheet material along a narrow zone, folding the sheet along a fold line located in the heated zone, and sealing together juxtapositioned side edges. The method also contemplates removing a V-shaped notch from the edge ribs where the sheet is a battery separator blank, and also contemplates applying a plasticizer to edges of the sheet to aid sealing.

The envelope forming apparatus of the present invention comprises a heating station wherein the sheet material, preferably a battery separator blank, is heated along a narrow zone or band transversely across the sheet along the line about which it is to be folded (generally in the center thereof), a folding station wherein the heated sheet is folded by the action of a reciprocating plow means, and a heat-sealing station wherein juxtapositioned lateral edges of the folded sheet are heat sealed together, thereby forming an envelope open along the top edge, closed at the bottom edge along the fold line, and closed along the lateral edges at the heat seals. The apparatus also preferably provides a plasticizer application station wherein a plasticizer for the thermoplastic material forming the sheet is applied along the longitudinal edges of the unfolded separator to aid in the heat-sealability thereof. Where the sheet is a battery separator blank, there is provided a grinding station wherein the ribs of the separator blank located along the longitudinal edges thereof are ground away in a V-shaped pattern at the fold line.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an end elevation of an unfolded battery separator blank;

FIG. 2 is a diagrammatic perspective view of the apparatus of the present invention;

FIG. 3 is a front elevation of the apparatus of the present invention;

FIG. 4A is a top, plan elevation of the heating and folding stations taken along lines 4A—4A of FIG. 3;

FIG. 4B is a top, plan elevation of the plasticizer applicator and grinding stations taken along lines 4B—4B of FIG. 3;

FIG. 5A is a front section of the folding and heat-sealing stations taken along lines 5A—5A of FIG. 4A;

FIG. 5B is a front section of the grinding station taken along lines 5B—5B of FIG. 4B;

FIG. 6 is a fragmentary plan section of the heat-sealing station and drive areas taken along lines 6—6 of FIGS. 5A and 5B;

FIG. 7 is a fragmentary side section of the plasticizer applicator station taken along lines 7—7 of FIG. 4B;

FIG. 8 is a fragmentary side section of the grinding station taken along lines 8—8 of FIG. 4B;

FIG. 9 is a fragmentary front section of the grinding wheel acting upon a separator blank taken along lines 9—9 of FIG. 8;

FIG. 10 is a fragmentary side section of the grinding wheel acting upon a separator blank taken along lines 10—10 of FIG. 9;

FIG. 11 is a fragmentary section of the folding plow drive means taken along lines 11—11 of FIG. 6;

FIG. 12 is a fragmentary bottom section of the heat-sealing station taken along lines 12—12 of FIG. 4A with the folding and heat-sealing assembly deck tilted upward in the vertical direction;

FIG. 13 is a fragmentary transverse section of the heatsealing station taken along lines 13—13 of FIG. 4A;

FIG. 14 is a fragmentary plan section of the heat-sealing means taken along lines 14—14 of FIG. 13;

FIG. 15 is a fragmentary front section of the folding station taken along lines 15—15 of FIG. 4A;

FIG. 16 is a fragmentary plan section of the plow support member taken along lines 16—16 of FIG. 5A; and

FIG. 17 is a section view of a separator envelope taken along lines 17—17 of FIG. 2.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following description is directed to the preferred embodiment of the present invention, which is employing the disclosed apparatus in forming envelopes from battery separator blanks. However, it is clear that the disclosed apparatus may be employed in forming envelopes from other thermoplastic sheet material.

Referring now to FIG. 1, an unfolded battery separator blank 10 of the type suitable for being formed into an envelope on the apparatus of the present invention is illustrated in cross-section. The separator blank 10 is flat on side 11 and has a plurality of central ribs 13 and longitudinal edge ribs 14 formed on ribbed side 12, the ribs 13 and 14 all extending upwardly from the main body 16 of the separator blank.

In FIG. 2 there is illustrated a perspective view of the apparatus of the present invention. As is seen by reference to FIG. 2, an unfolded separator blank 10 is fed in the direction shown by the arrow through a plasticizer applicator station 20 where a suitable plasticizer is applied to longitudinal edge ribs 14 by applicator rolls 21 and 22. The plasticizer applicator station 20 is shown in more detail in FIGS. 4B and 7. As shown in these latter figures, the battery separator blank 10 is fed from the right against back stop 23 between applicator rolls 21 and 22 and backup roll 24. A doctor roll 25 applies plasticizer to applicator rolls 21 and 22 by virtue of its passing through a bath of a suitable plasticizer carried in pan 26. The separator blank 10 passes through plasticizer applicator station 20 into abutment with back stop 17 and onto conveyor chains 27 and 28, only one of which is shown in FIG. 7. Conveyor chains 27 and 28 carry positioning pins 29 for moving the separator blanks 10 through the apparatus at a predetermined spacing.

Referring back to FIG. 2, the separator blank 10 is next conveyed to a grinding station 30 which is shown in more detail in FIGS. 4B, 5B, and 8. Grinding station 30 is comprised of a grinding wheel 31 having a generally V-shaped grinding edge which is driven by a grinder motor 32 via drive shaft 33, pulley 34, pulley belt 35, and pulley 36 which operate to turn grinder shaft 37. The action of grinding wheel 31 upon separator blank 10 is shown in more detail in FIGS. 9 and 10, wherein it is shown that grinder wheel 31 cuts a generally V-shaped notch in longitudinal edge ribs 14 of separator blank 10. The V-shaped notch is cut in the edge ribs to a depth extending down to the main body 16 of the separator blank 10 and at the place where the folding of the separator blank is to occur, i.e., along the fold line. The purpose of the V-shaped notch is to permit the separator blank to be folded without buckling the edge ribs. The grinding wheel 31 may also cut notches into central ribs 13, although this is not essential since central ribs 13 do not extend as far from surface 12 of separator blank 10 as do edge ribs 14.

During the passage of the separator blank 10 through grinding station 30, and subsequently heating station 50, the separator blank is accurately positioned and held down by the action of pins 29 carried on chain conveyors 27 and 28 in conjunction with a hold-down frame 38 carrying a plurality of holddown springs 39 thereon, as best illustrated in FIGS. 5B and 8. Hold-down springs 39 urge the separator blank flat against the upper surface or deck 15 of the apparatus. Also acting in conjunction therewith to accurately position the separator blanks 10 is a stop 40 running the length of the machine along the back side as shown, and a plurality of leaf springs 41 held by spring holder 42 which act to urge the backside end of separator blank 10 against stop 40. A raised land 43 also runs the length of the machine along the front side, the purpose of which is to raise the front side end of the separator blank into contact with the plurality of leaf springs 41.

The housing 44 containing the grinder assembly 30 is vertically adjustable by virtue of a tongue 45 and groove 46 assembly which is suitably attached to the frame of the apparatus and the housing 44. Adjustment of the tongue 45 in the groove 46 is effected by positioning lug 47 of tongue 45 along threaded member 48 by a suitably positioned nut 49 which is welded to lug 47.

After passing through grinding station 30, battery separator blank 10 passes to a heating station 50 as shown in FIGS. 2, 4A, 4B, 5A, and 5B. Heating station 50 is comprised of a line heater 51. Any suitable heating means which will heat the battery separator blank along a narrow band or zone along the intended fold line is suitable for employment in the present invention. A suitable type of line heater is an infrared heater manufactured by Research, Inc., of Minneapolis, Minnesota, Model No. 5193. It may be desirable to have such a heater placed on both sides of the separator as it passes through the heating station 50. The purpose of heating station 50 is to soften the thermoplastic separator blank along the fold line so that it may be folded without cracking. The heated area should, however, be kept as narrow as possible to avoid detrimentally affecting the separator.

The battery separator blank 10 is next passed to folding station 60, generally shown in FIG. 2. The accurate positioning of the battery separator blank in the folding

station is very important since the separator must be folded precisely along the predetermined fold line previously heated by heating station 50. The separator blank 10 is conveyed into folding station 60 by a pair of lower conveyor belts 61A and 61B, and a pair of upper conveyor belts 62A and 62B, as best shown in FIG. 5A, wherein only the front belts are shown, the rear belts being identically configured. Lower conveyor belt 61A is trained around a leading pulley 63, a trailing pulley 64, and idler rolls 65 and 66. The lower conveyor belts 61A and 61B are driven by a drive means which is described later. Upper belt 62A is trained around leading pulley 67 and trailing pulley 68, and is urged apart and downwardly by spring 69 acting on holddown arms 70 and 71 retained on a forward projection of housing 72 by suitable stub shafts 73 and 74. The pair of upper belts 62A and 62B act to form a conveying nip with lower belts 61A and 61B, and the upper belts are driven only by the passage of separator blanks therethrough.

A separator blank 10 is conveyed by the aforementioned conveying system up ramp 75 (as best shown in FIG. 15) and against stop 76. The separator blank rests in the space between stop 76 and the trailing edge of ramp 75, which is just large enough to accommodate the separator, as shown. The separator blank 10 is then ready for the folding step effected by the downward action of a plow 77, which folds the separator in a manner to be described.

Plow 77 is a thin, plate-like member generally rectangular in shape. Plow 77 is moved in a reciprocating motion in a plane perpendicular to the plane of a separator blank to be folded, with the plane of the plow intersecting the separator blank along the predetermined fold line.

Referring specifically to FIGS. 5A, 13, 15, and 16, it is seen that plow 77 is fastened to a drive arm 78 by a plow support member 80. Plow support member 80 is attached to plow 77 by a pair of clamping bolts 81. Plow support member 80 is attached to a clevis 52 located on the upper portion of drive arm 78 by means of a cross pin 53 passing through a lug 54 extending from support member 80, as best shown in FIG. 16. A pair of stub shafts 55 pass through plow 77 and are clamped to plow support member 80 by clamping bolts 56. The plow 77 can be accurately positioned within channel 57 of plow support member 80 by use of appropriate shims 58. Vertical support shaft 79 passes through plow support member 80 and is bolted at the bottom to tilting deck 106 as shown in FIG. 15.

Drive arm 78 is attached to a drive wheel 82 (best shown in FIG. 11) by means of a rocker arm 83 and detachable bolt 84. The other end of rocker arm 82 is attached to a bearing 85 via a stub shaft 86, and bearing 85 is attached to the frame of the machine by means of bearing bolts 87 fastened to lug 88 of the frame. The downward limit of motion of plow 77 may be controlled by means of adjusting block 89 attached to rocker arm 83, which is adjustable within a channel 90 of drive wheel 82 by means of a threaded bolt 91 located within slot 92 of drive wheel 82, and lock nut 83 carried on threaded bolt 91. Adjusting block 89 is rotatively attached to drive wheel 82 by roller 94 (shown in FIGS. 6 and 11) and clamping bolt 59 (shown in FIG. 5A).

During downward motion, plow 77 is accurately guided by a pair of upper guide members 95 and 96, as

best shown in FIG. 13. Upper guide members 95 and 96 carry rollers 97 and 98, respectively, which are urged against plow 77 and accurately guide it during downward and upward motion. Upper guide member 95 may be adjusted by a pair of adjustable screws 99 and 100 located relative to plow housing 72 as shown. Adjusting screw 99 extends through housing 72 whereas adjusting screw 100 abuts against the inner surface of housing 72 and is accessible for adjustment through an opening 101. Similarly, upper guide member 96 may be adjusted by means of adjusting screws 102 and 103. All adjusting screws 99, 100, 102, and 103 are carried in threaded bores located within upper guides 95 and 96, as shown in the cutaway section of upper guide 96 in FIG. 16. The lower portions of upper guides 95 and 96 are spaced from the wall housings 72 by means of spacer shims 104 and 105, which are held in place by appropriate fastening means.

Attached to the lower surface of tiltable deck 106 (which is not connected to the upper surface of deck 15 of the rest of the machine) are lower guides 107 and 108. Lower guides 107 and 108 are beveled as shown to assist the folding of separator 10 as it is folded downwardly therebetween by the downward motion of plow 77. During the downward motion of plow 77, separator blank 10 is folded around plow 77 and between an L-shaped wall 109 (which is attached to deck 106 through lower guide 107 by suitable nuts and bolts 110 and 111) and a wall 112 which projects from leading anvil 113, as best illustrated in FIG. 6. Spaced from and parallel to leading anvil 113 is a trailing anvil 114.

Disposed opposite anvils 113 and 114 are a pair of ultrasonic heat-sealing horns 115 and 116, as best shown in FIG. 6. Ultrasonic horns 115 and 116 are attached to suitable ultrasonic generators 117 and 118. A suitable ultrasonic horn and generator is one manufactured by Branson Sonic Power Company of Danbury Connecticut, Model 227; and reference is further made to U.S. Pat. Nos. 3,328,610 and 3,524,085.

Reference is made to FIG. 13 for a detailed illustration of one such ultrasonic horn and generator configuration, the other being of identical construction. In FIG. 13 it is seen that the generator 118 and horn 116 are movable in a horizontal direction by the action of air cylinders 119 and 120 and associated pistons, only one of which (piston 121) is shown. Ultrasonic horn 116 is a solid member having resonating openings 179 and 180 therein and is attached to ultrasonic generator 118 by means of a threaded stud 123. Horns 115 and 116 terminate in a long, narrow edge at their forward (heat-sealing) ends, the width thereof determining the width of the heat seal to be effected. Ultrasonic generator 118 is attached to movable frame 124 by means of a mounting flange 125 which is attached to movable frame 124 by a suitable fastening means. Movable frame 124 is attached to the pistons of air cylinders 119 and 120 by a suitable fastening means. The movable frame 124 is also attached to guide tubes 126 and 127 through which run guide rods 128 and 129, respectively. The guide rods 128 and 129 are attached to fixed frame 130 by suitable means.

Since the horns 115 and 116 must be very accurately positioned against the folded separator blank to be heat-sealed, means are provided for accurately adjusting the horns in several directions. These means are best shown by reference to FIGS. 4A, 12, and 13.

As shown in FIGS. 4A, 12, and 13, there are provided a pair of frame arms 131A and 131B, and attached therebetween are a pair of mounting shafts 132 and 133. Adjustably mounted on shafts 132 and 133 are a pair of identical blocks 134A and 134B. Since blocks 134A and 134B are identical in construction, reference will be made to only one block which will be generally referred to as block 134. Block 134 is attached to shafts 132 and 133 by means of forward clamp block 135 and end clamp block 136 which are attached to block 134 by suitable clamp bolts as shown. End clamp block 136 is clamped to a central block 137 by suitable clamping bolts. Central block 137 is integral with a threaded stub shaft 138 through which runs an end threaded stud 139 integral with block 134. By means of clamping nut 140 and adjusting nut 141, block 134 may be slightly adjusted vertically relative to mounting shaft 133 by pivoting about mounting shaft 132. Block 134 is attached to frame 130 by means of adjustable clamp bolt 142. A suitable shim 143 is located between frame 130 and block 134.

Frame 130 further carries a stop means 144 for stopping the forward motion of movable frame 124. Air cylinders 119 and 120 further contain flexible conduits 145 and 146, respectively, for feeding a supply of air thereto. Ultrasonic generators 117 and 118 are connected to suitable sources of electricity.

The ultrasonic horn assembly may also be adjusted by means of adjusting clamp bolt 142 located in slot 147, as shown in FIG. 12. By loosening adjusting clamp bolt 142, the assembly may be pivoted about pivot bolt 148.

The position of anvils 113 and 114 may be adjusted as shown in FIG. 12. As shown therein, anvil 114 is attached to the underside of tiltable deck 106 by means of bolts 183 and 184 extending through slot 181 in leg 182 of anvil 114. Anvil 113 is adjustably attached in the same manner.

All moving parts of the apparatus of the present invention, except for grinding wheel 31 and upper conveyor belts 62A and 62B, are driven by a single power source, motor 150. Referring to FIG. 6, it is seen that the output shaft 151 of motor 150 is connected to gear box 152. Also attached to output shaft 151 is a sprocket 153 which drives power chain 154. As is best seen in FIG. 5A, power chain 154 is trained around an upper sprocket 155 which drives a pair of meshing gears 156 and 157, gear 156 being coaxial with sprocket 155. Gear 157 in turn drives a gear attached to and coaxial with trailing pulley 64 which, in turn, drives lower conveyor belt 61A.

Power chain 154 also powers drive wheel 82 via sprocket 158 attached thereto and around which power chain 154 is trained.

Sprocket 158 also carries coaxially thereon a smaller sprocket 159 which operates a linear switchbox 160 via chain 149. Linear switchbox 160 will not be described in detail; its purpose is to effect pneumatic and electrical actuation of the ultrasonic heat-sealing horns 115 and 116 by means of conventional solenoids located therein.

Power chain 154 is also trained around a sprocket 161 located on shaft 162 which runs in a transverse direction across the machine, as best illustrated in FIG. 6. Shaft 162 is supported by appropriate journal bearings 163 and 164, and powers conveyor chains 27 and 28 via sprockets 165B and 166 located thereon.

Gear box 152 drives a bottom drive shaft 167 which powers the plasticizer applicator station 20. Referring to FIGS. 4B, 6, and 7, it is seen that drive shaft 167 has a sprocket 168 located at the end thereof which actuates lower drive chain 169 which, in turn, actuates upper drive chain 170 via sprocket 171. Upper drive chain 170 actuates plasticizer applicator rolls 21 and 22 via sprocket 172 located on the end of shaft 173.

In order to provide easy access to the heat-sealing station, tiltable deck 106 may be rotated upwards in a vertical direction by means of hinges 177 and 178, as best shown in FIG. 12. Prior to tilting deck 106 upwardly, drive arm 78 must be disconnected from rocker arm 83 by removing detachable bolt 84.

The operation of the apparatus will now be described. Unfolded separator blanks 10 are fed into plasticizer applicator station 20 by hand or other suitable feeding means with one longitudinal edge in contact with back stop 23 and with the ribbed side facing in the upward direction, the direction of the ribs being parallel to the planes of rolls 21 and 22. Applicator rolls 21 and 22 pull the separator blanks 10 through the applicator station 20 against backup roll 24. A narrow band of plasticizer is applied to both edge ribs 14 of the separator blank 10 by rolls 21 and 22. Plasticizer is applied to rolls 21 and 22 via doctor rolls 25 which picks up the plasticizer from pan 26.

After passing through the plasticizer applicator station 20, the separator blanks 10 are stopped by back stop 17 and are conveyed by conveyor chains 27 and 28 along the longitudinal axis of the apparatus due to the action of positioning pins 29 acting against the trailing edge thereof. The separator blanks are accurately positioned at predetermined intervals by the action of pins 29 acting in conjunction with hold down springs 39, leaf springs 41 and stop 40.

The separator blanks 10 are conveyed through grinding station 30 with the longitudinal direction of the ribs being perpendicular to the plane of grinding wheel 31. Grinding wheel 31 grinds a V-shaped notch in the edge ribs 14, as best illustrated in FIGS. 9 and 10, at the intended fold line.

Next, the notched separator blanks 10 are conveyed through a heating station 50 and beneath line heater 51 which heats a very narrow band of the separator blank 10 along the intended fold line. The intended fold line is perpendicular to the ribs and located generally at the middle of the separator.

The heated separator blanks 10 are next conveyed to a folding station 60. The separator blanks 10 are conveyed into the folding station by means of a pair of lower conveyor belts 61A and 61B and a pair of upper conveyor belts 62A and 62B. During traverse into the folding station, the separator blanks 10 rise up a slight incline formed by ramp 75 until they come to rest against stop 76. The distance between stop 76 and the trailing edge of ramp 75 is the same as the separator width so that the separator is securely and accurately held in position prior to folding.

Plow 77 then is caused to descend by a downward motion of drive arm 78 actuated by drive wheel 82 acting upon rocker arm 83. The motion of plow 77 is guided by vertical support shaft 79 (as shown in FIGS. 5A and 15), by the action of accurately positioned rollers 97 and 98 carried by upper guides 95 and 96, respectively, by the action of lower guides 107 and 108 and walls 109 and 112. As best seen in FIGS. 5A and

16, plow 77 contacts the ribbed surface of separator blank 10 along the previously heated fold line, causing the separator blank 10 to fold upwardly in a direction away from the upper surface of tilting deck 106, and, ultimately, into a position completely folded about plow 77 by the time the plow 77 reaches its lower limit of motion, as shown in FIG. 13. The width of plow 77 is less than the width of the separator so that in the completely folded position at the lower reach of plow 77, folded edge ribs 14 are in adjacent, face-to-face or juxtapositioned contact. In this position, as best shown in FIGS. 6 and 14, the folded separator blank 10 is accurately positioned in the space formed by walls 109 and 112 and against the shoulders of anvils 113 and 114.

Linear switchbox 160 then actuates air cylinders 119 and 120, and the associated pistons thereof then move movable frame 124 carrying ultrasonic horns 115 and 116 toward anvils 113 and 114. The forward, horizontal motion of the frame 124 and, thus of horns 115 and 116, is limited by stop 144, which is appropriately positioned to provide the desired contact between the horns and the edges of the folded separator blank. The ultrasonic horns 115 and 116 are energized by ultrasonic generators 117 and 118 which are actuated by a suitable solenoid means contained within the linear switchbox 160. A time delay switch 174 may be employed to hold the ultrasonic horns in the heatsealing position a predetermined length of time. The action of the ultrasonic horns 115 and 116 is to seal the folded separator blank 10 along the lateral edges thereof. Plow 77 is then withdrawn upwardly and, due to the loose fit of the heatsealed separator envelope 200 about the plow 77, the heat-sealed separator envelope 200 falls in a downward direction and is carried outside the sealing station by chute 175.

A sectional view of a heat-sealed separator envelope 200 is illustrated in FIG. 17 where it is seen that folded edge ribs 14 are heat-sealed along line 176 in a face-to-face relationship. Thus, an envelope is formed that is open at the top edge, closed at the bottom edge along the fold line, and closed along the side or lateral edges by heat seals.

I claim:

1. An apparatus for forming an envelope from an individual thermoplastic sheet comprising heating means for heating the sheet solely along a narrow, transverse zone constituting a predetermined fold line; folding means for folding the sheet along the heated zone, said folding means comprising a plow member, a pair of guide members, and means for imparting a reciprocating motion to the plow member to move said plow member from a position away from said guide members to a position between said guide members to thereby fold said sheet about said plow member; heat-sealing means for heat-sealing the folded sheet along the lateral longitudinal edges thereof while said sheet is folded about said plow member; and means for conveying the sheet from said heating means to said folding means.

2. The apparatus of claim 1, wherein the heatsealing means comprises a pair of ultrasonic horns and a pair of anvils disposed opposite said horns; the horns and anvils being disposed so that the plow member at its farthest reach between said guide members positions the folded sheet therebetween with the lateral longitudinal edges of the folded sheet lying between opposed

horns and anvils; and means for moving the horns from a non-sealing position removed from said anvils to a sealing position closely adjacent thereto, and means for activating the horns to seal said folded sheet when in the sealing position.

3. The apparatus of claim 1 including a plasticizer applicator for applying plasticizer to the lateral edges of the sheet prior to the heat-sealing means.

4. The apparatus of claim 1 including a grinding means located before the heating means for grinding V-shaped notches in ribs located along each lateral edge of the thermoplastic sheet.

5. An apparatus for forming a battery separator envelope from a porous thermoplastic sheet having ribs along at least the longitudinal edges thereof comprising: grinding means for grinding a V-shaped notch in the ribs along at least the longitudinal edges of the sheet; heating means for heating a narrow, transverse zone across the sheet in a line between the V-shaped notches in the ribs; folding means for folding the sheet along the heated zone, said folding means including a plow member and means for reciprocating said plow member in a plane from a non-folding reach to a folding reach for said sheet; conveying means for conveying the sheet into contact with the grinding means, past the heating means and into position beneath said plow member in a plane substantially perpendicular to the plane of the plow and at a location approximately midway between the limits of reach of the plow; and heat-sealing means comprising a pair of movable ultrasonic horns and a pair of stationary anvils disposed opposite said horns, the horns being disposed so that the plow at its farthest folding reach positions the folded sheet therebetween with the lateral longitudinal edges of the folded sheet lying between opposed horns and anvils and said sheet being folded about said plow member, means for moving the horns toward said anvils and into heat-sealing proximity to the lateral longitudinal edges of the sheet folded about said plow member, and means for activating said horns to seal said sheet folded about said plow member in said heat-sealing proximity.

6. The apparatus of claim 5 wherein guide means are provided for accurately guiding the plow during its reciprocating motion.

7. The apparatus of claim 6 including a plasticizer applicator means located ahead of the heat-sealing means to apply plasticizer to the edge ribs of the sheet.

8. An apparatus for forming a battery separator envelope from a sintered polyvinyl chloride sheet having a

smooth surface on one side and a plurality of parallel, longitudinal ribs on the other side including a rib along each longitudinal edge of the sheet comprising: a grinding station, a heating station, a folding station, a heat-sealing station, and conveying means for conveying the sheet from the grinding station through the heating station to the folding station with said ribs being perpendicular to the direction of travel of said conveying means; the grinding station comprising a grinding wheel having a generally V-shaped grinding edge for grinding a generally V-shaped notch in the middle portion of each edge rib, and means for rotating said grinding wheel; the heating station comprising a line heater parallel to the direction of the motion of the conveyor means and located to heat a narrow, transverse zone perpendicular to the ribs in the middle portion of a sheet conveyed by said conveyor means; the folding station comprising a plow, means for reciprocating the plow in a plane generally perpendicular to the plane of the conveying means from a first position above the plane of the conveyor means to a second position intersecting the plane of the conveyor means, the plow intersecting the sheet conveyed by said conveyor means along the zone of the sheet heated by said heating means as said plow moves from said first position to said second position to thereby fold said sheet about said plow; the heat-sealing means comprising a pair of movable ultrasonic horns and a pair of stationary anvils located opposite and in line with said horns, the pair of horns and pair of anvils being spaced apart a distance sufficient to permit the plow to descend therebetween during traverse from its first position to its second position, means for moving said horns toward said anvils into heat-sealing proximity to the lateral longitudinal edges of the sheet folded about said plow in said second position, and means for activating said horns to seal the sheet folded about said plow.

9. The apparatus of claim 8 wherein said conveying means includes a pair of conveyor chains having a plurality of positioning pins located thereon for spacing the sheets a predetermined distance apart.

10. The apparatus of claim 8 wherein the apparatus includes a stop running parallel to one side of the conveying means and against which one end of the sheet rests during traverse along the conveying means, a plurality of leaf springs positioned to push against the other end of the sheet, and a plurality of hold down members for urging the sheet downwardly against the conveying means.

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