Aug. 2, 1966 R. G. DEXTER 3,263,390

APPARATUS FOR AND METHOD OF FANNING, ROLLING AND BANDING FLEXIBLE SHEETS

Filed July 5, 1963 6 Sheets-Sheet 1

FIG.2

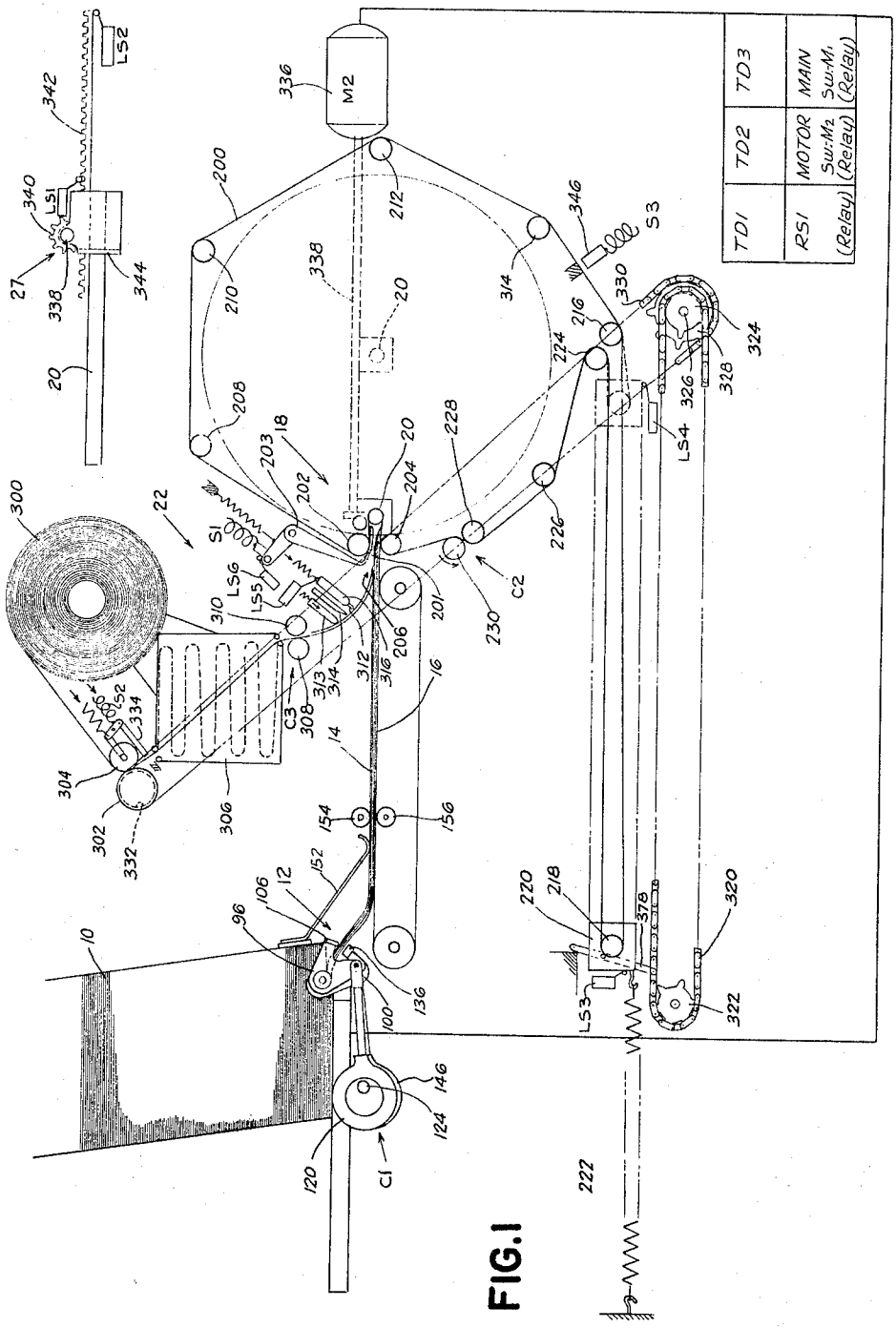


FIG.1

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APPARATUS FOR AND METHOD OF FANNING, ROLLING AND BANDING FLEXIBLE SHEETS

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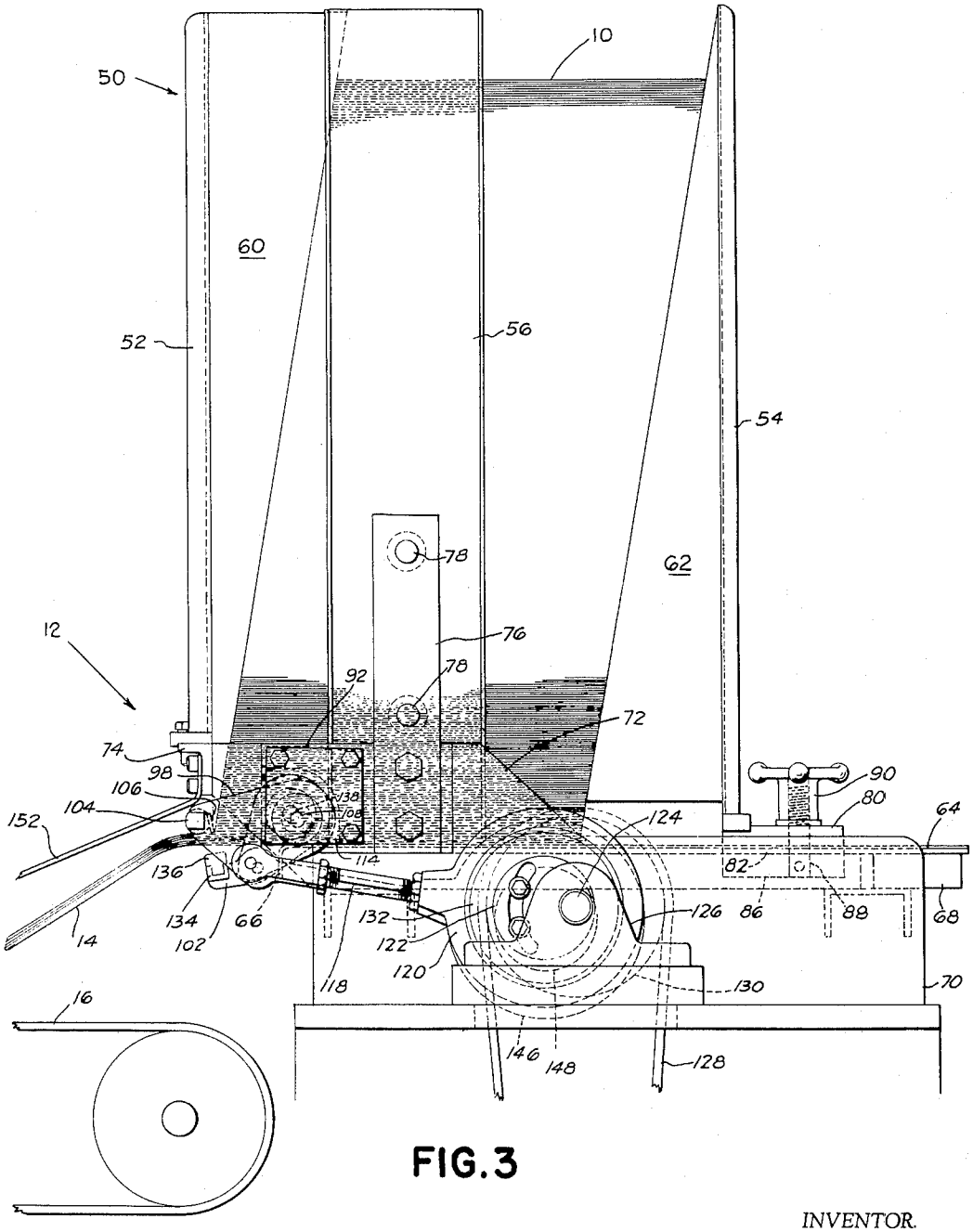


FIG. 3

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APPARATUS FOR AND METHOD OF FANNING, ROLLING AND BANDING FLEXIBLE SHEETS

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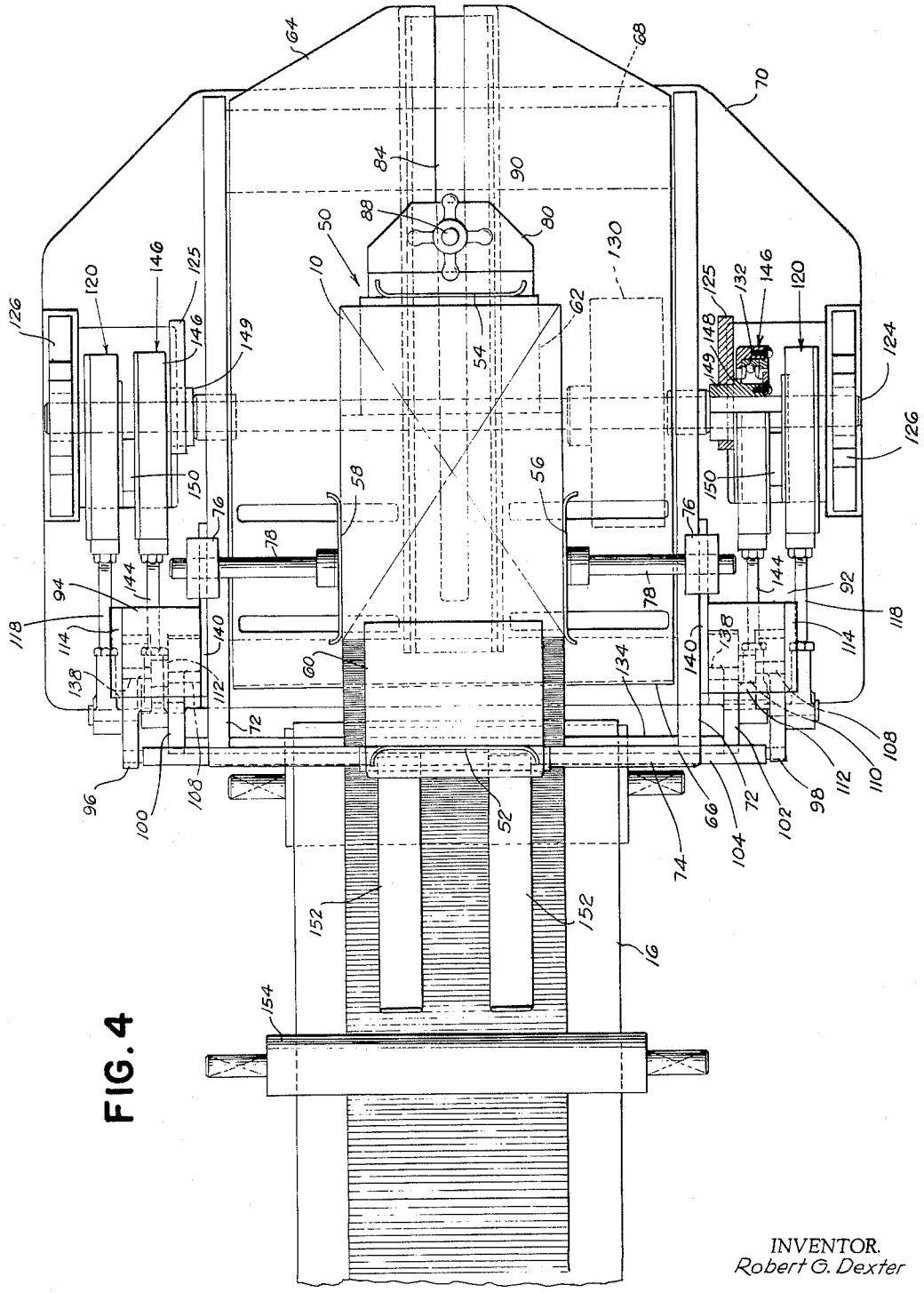


FIG. 4

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APPARATUS FOR AND METHOD OF FANNING, ROLLING AND BANDING FLEXIBLE SHEETS

Filed July 5, 1963 6 Sheets-Sheet 4

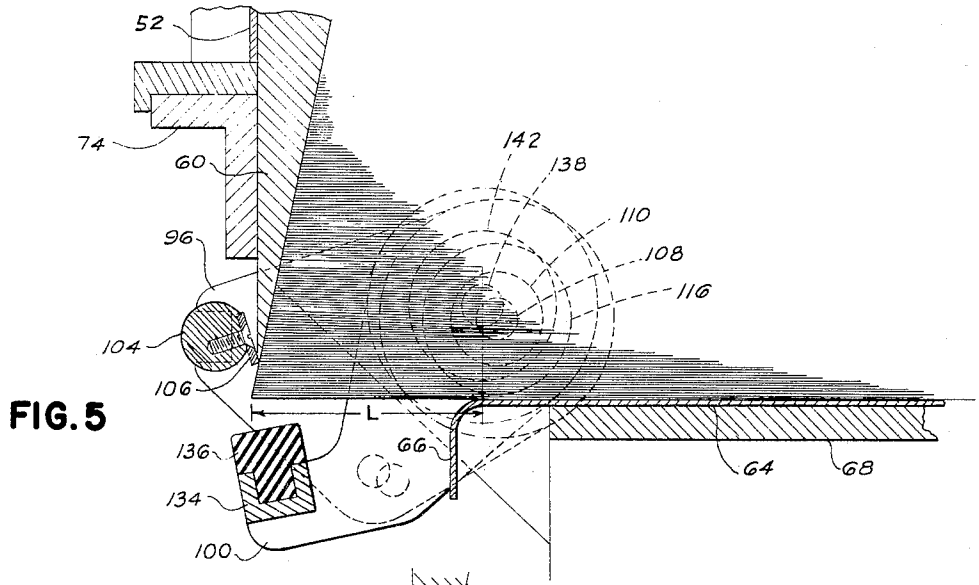
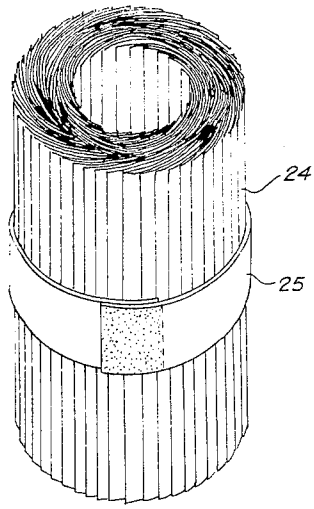


FIG. 5

FIG. 11



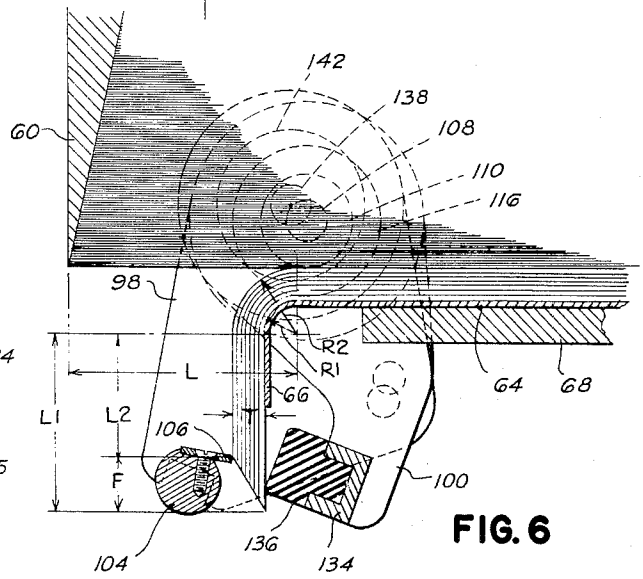


FIG. 6

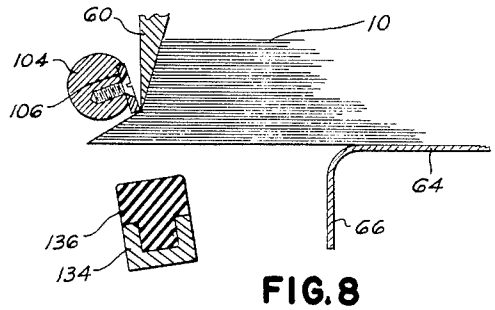


FIG. 8

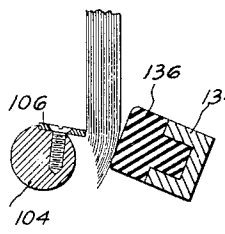


FIG. 7

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APPARATUS FOR AND METHOD OF FANNING, ROLLING AND BANDING FLEXIBLE SHEETS

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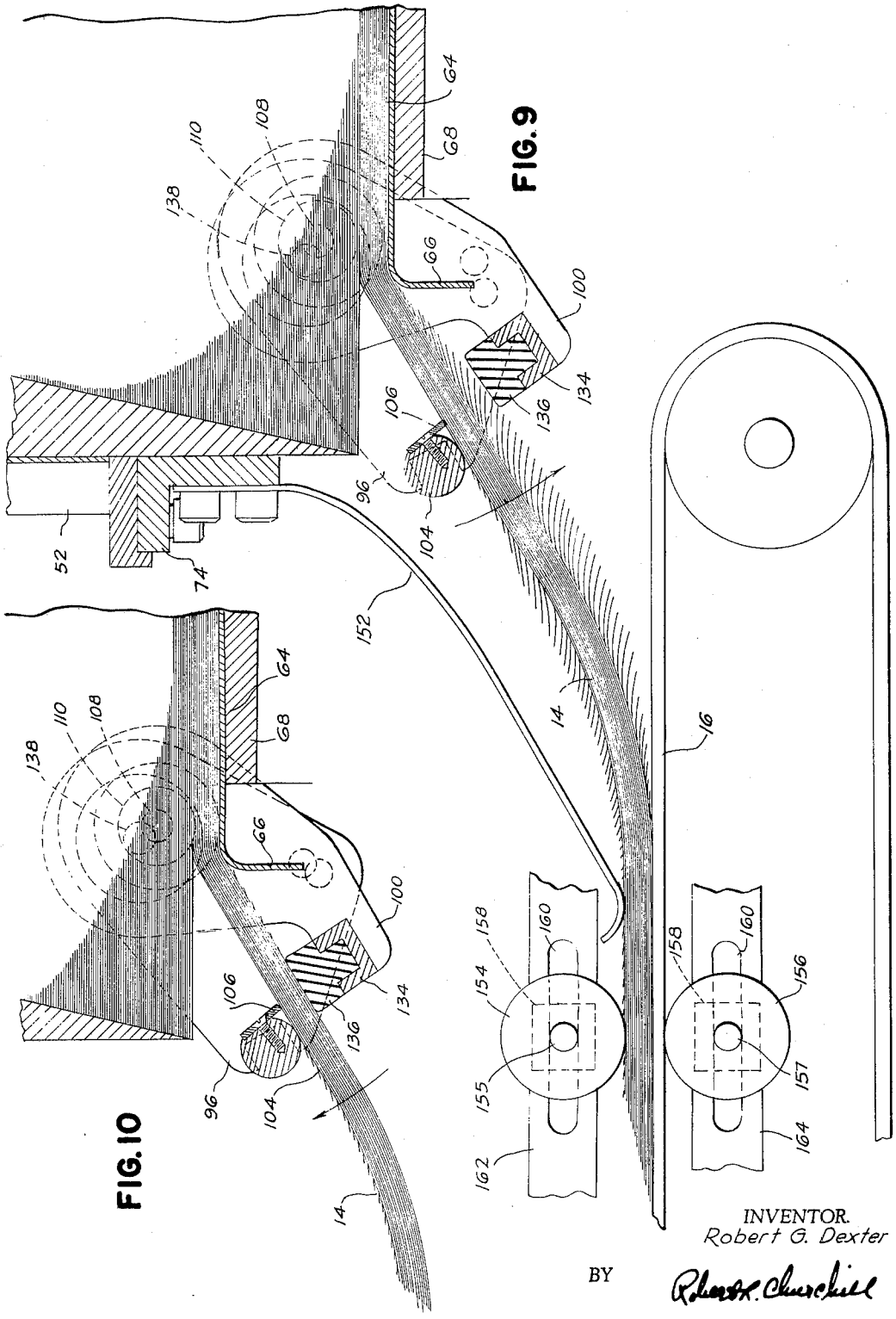


FIG. 9

FIG. 10

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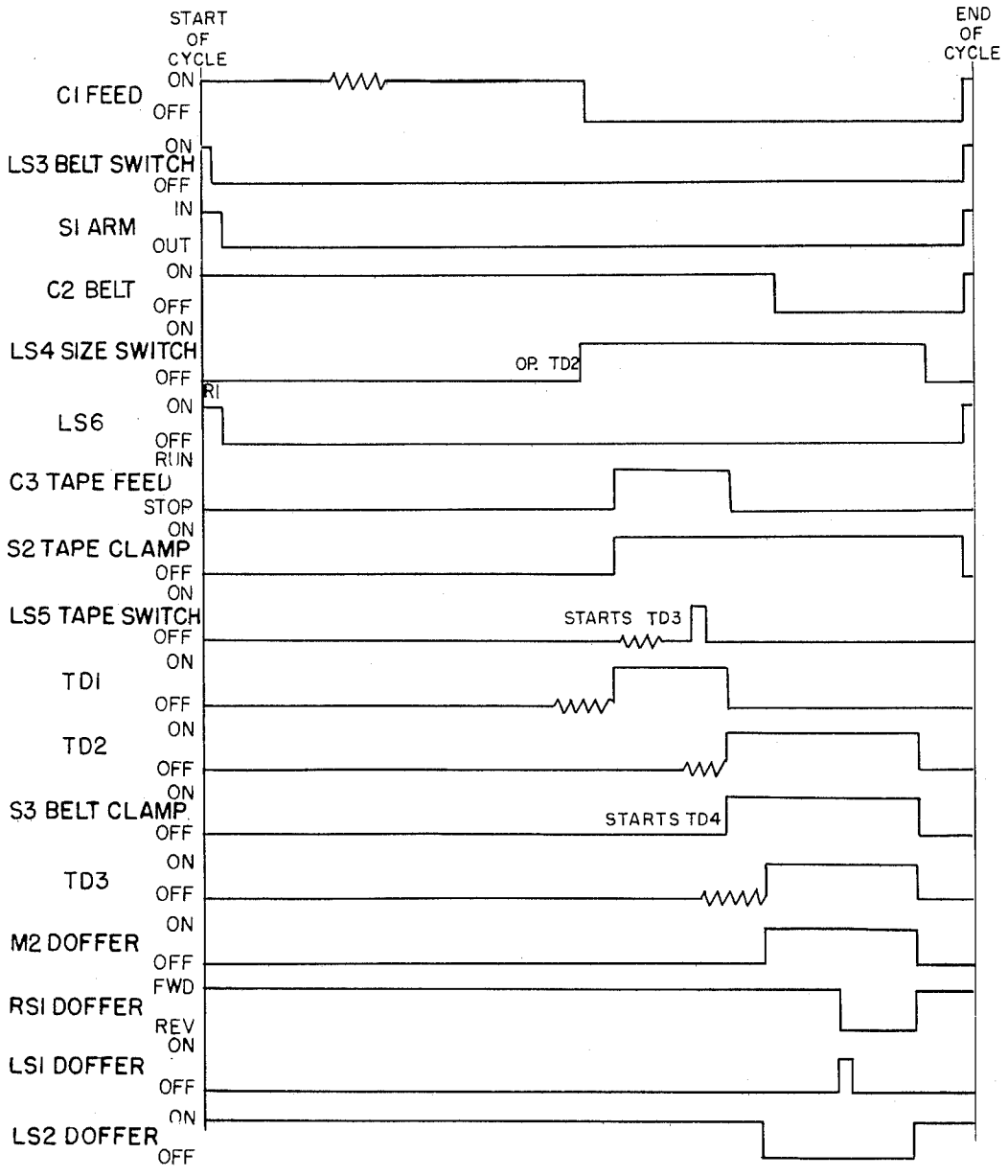


FIG.12

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United States Patent Office 3,263,390 Patented August 2, 1966

3,263,390

APPARATUS FOR AND METHOD OF FANNING, ROLLING AND BANDING FLEXIBLE SHEETS

Robert Gordon Dexter, Harvard, Mass., assignor to Barkley & Dexter, Incorporated, Fitchburg, Mass., a corporation of Massachusetts

Filed July 5, 1963, Ser. No. 292,965
30 Claims. (Cl. 53—21)

This invention relates to apparatus for fanning, rolling and banding flexible sheets, and more particularly to a method of and apparatus for fanning flexible sheets.

The invention has for an object to provide a novel method of and novel and improved apparatus for fanning flexible sheets capable of fanning a stack of flexible sheets in a simple, rapid and efficient manner to form an elongated strip or web of fanned sheets of substantially uniform thickness adapted to be rolled and banded.

The invention has for a further object to provide novel apparatus for fanning, rolling and banding flexible sheets embodying novel banding mechanism and which is also characterized by novel control mechanism arranged to effect automatic operation of the apparatus in a controlled sequence whereby to automatically produce successive banded rolls of fanned sheets.

With these general objects in view and such others as may hereinafter appear, the invention consists in the sheet fanning mechanism as embodied in apparatus for fanning, rolling and banding flexible sheets in the sequential control mechanism, and in the various structures, arrangements and combinations of parts hereinafter described and particularly defined in the claims at the end of this specification.

In the drawings illustrating the preferred embodiment of the invention:

FIG. 1 is a schematic view of apparatus for fanning, rolling and banding paper sheets;

FIG. 2 is a side elevation of a portion of the apparatus shown in FIG. 1;

FIG. 3 is a side elevation of the sheet fanning mechanism;

FIG. 4 is a plan view of the same;

FIG. 5 is a cross sectional detail view illustrating the sheet fanning elements in a position to initiate the fanning of a stack of paper sheets;

FIG. 6 is a similar view showing the fanning elements at the end of their first downward stroke;

FIG. 7 is a detail view in cross section showing the fanning elements in clamping engagement with the fanned sheets;

FIG. 8 is a detail view in cross section showing the fanning elements at the end of the upstroke and illustrating the fanned arrangement of the sheets at the end of the first fanning cycle;

FIG. 9 is a cross sectional view of the fanning mechanism after continued fanning operations, the fanning elements being shown in an intermediate position during the down stroke;

FIG. 10 is a view similar to FIG. 9 showing the relative position of the fanning elements in an intermediate position during their upstroke;

FIG. 11 is a perspective view of a rolled and banded group or package of fanned sheets; and

FIG. 12 is a timing diagram to be referred to.

In general the present invention contemplates novel apparatus for fanning, rolling and banding flexible sheets embodying novel fanning mechanism adapted to spread or fan flexible sheets outwardly from the bottom of a stack thereof to produce an elongated web or length of fanned sheets of a predetermined and substantially uniform thickness adapted to be rolled and banded. The term "fanned" or "fanning" as used herein is intended

to define a lateral spreading of a group of stacked sheets to separate the edges thereof uniformly. In practice such rolls of fanned and banded sheets may comprise rolls or packages of information leaflets adapted to be unbanded and released from an airplane, the fanning of the sheets facilitating the separation of the sheets when discharged from the airplane whereby to provide wider distribution of the leaflets as they fall and when they reach the ground.

In the illustrated embodiment of the invention provision is made for supporting a stack of sheets to be fanned and for bending downwardly from a horizontal to a vertical position the forward portion of a group of the lowermost sheets at the bottom of the stack so that the lower edge of the group assumes an angular formation wherein the edges of the sheet are fanned out a relatively small initial distance. Provision is then made for clamping the forward portion of the group and retaining the same in its fanned position while the group is returned to a horizontal position. As a result the group of sheets in the bottom of the stack will be pulled forwardly a distance equal to the amount that the edges of the individual sheets are spread or fanned relative to the uppermost sheet of the group. Thus, the uppermost sheet of the group will be returned substantially to its initial position while the lowermost sheet will be pulled forwardly a maximum distance, intervening sheets being pulled forwardly in progressively lesser amounts. Subsequent bending down, clamping and returning operations, accomplished with great rapidity, will effect progressively increased fanning or separation of the edges of the sheets and advancing movement of the group from the bottom of the stack until the lowermost sheets are entirely withdrawn from the stack whereupon additional sheets are added to the group from the stack as the lowermost sheets are advanced whereby to provide an elongated web or length of uniformly fanned sheets of predetermined thickness adapted to be rolled and banded.

Referring now to the drawings and particularly to FIG. 1 illustrating a schematic outline of the entire fanning, banding and rolling apparatus, **10** represents a stack of flexible sheets or leaflets to be fanned, and **12** represents the fanning mechanism which is arranged to fan and withdraw a group of the lowermost sheets in the stack and to advance the fanned sheets in the form of a continuous length or web **14** onto a conveyer **16**. The web **14** is carried by the conveyer **16** to rolling or winding mechanism, indicated generally at **18**, where provision is made for rolling the web about a mandrel **20** to form a roll of the fanned sheets of a predetermined diameter. Thereafter, provision is made for applying a band about the roll of sheets by banding mechanism, indicated generally at **22**, and which includes means for feeding a predetermined length of the banding material, winding the band around the roll, applying adhesive to the trailing end of the band and cutting the band. The trailing end of the band is arranged to overlap the leading end thereof as it is wound about the roll to adhesively secure the ends and thereafter the banded roll of fanned sheets is removed from the mandrel to produce the roll **24** shown in FIG. 11.

Referring now to FIGS. 3 and 4, illustrating the fanning mechanism **12**, the stack of sheets **10** is supported in a magazine, indicated generally at **50**, having a fixed front wall **52**, an adjustable rear wall **54**, and adjustable side walls **56**, **58** to accommodate different sizes of the paper sheets to be fanned. The stack **10** may be vertical or, as illustrated in FIG. 3, the front and rear walls may be provided with wedge shaped fillers **60**, **62** respectively arranged to support the stack in a rearwardly inclined position so that the front edges of the sheets will be initially arranged at a slight angle in the direction in which the sheets are to be fanned. The bottom of the stack is

supported on a horizontal table which includes a flat shelf or plate **64** having a turned-down forward edge **66** which terminates a predetermined distance rearwardly from the forward edge of the bottom of the stack and over which the sheets are bent to perform the fanning operation. The plate **64** may be supported on the machine platen **68** forming a part of the machine frame **70** as shown.

The side walls of the frame **70** are extended upwardly and forwardly at the front end of the machine as indicated at **72**, and an angle member tie piece **74** extending between the extended portions forms a support for the upstanding front wall **52** and the filler piece **60** of the magazine which may be secured to the front wall. Opposed upstanding brackets **76**, also secured to said extended portions **72**, are arranged to adjustably support rods **78** connected to the side walls **56**, **58** of the magazine to permit lateral adjustment thereof. The rear wall **54** of the magazine is mounted on a support **80** which overlies the plate **64** and is provided with a depending tongue **82** fitted into and adjustably movable in an elongated slot **84** formed in the plate **64** and platen **68**. A cooperating clamping member **86** overlying the underside of the platen is provided with a corresponding tongue fitted into the slot **84**. The member **86** is provided with an upstanding threaded bolt **88** which extends through an opening in the upper support **80**, and a clamp unit **90** cooperates with the bolt to clamp the unit in its adjusted position.

The extended portions **72** of the frame also support opposed bearing blocks **92**, **94** in which a pair of outer rocker arms **96**, **98** and a pair of inner rocker arms **100**, **102** are pivotally supported. The outer rocker arms **96**, **98** have extended between them a rod **104** which carries a blade member **106** arranged to engage the forward edges of a group of lowermost sheets in the stack and bend them downwardly from a horizontal to a vertical position about the corner or radius of the forward edge of the supporting plate **64** and parallel to the depending portion **66** thereof. As shown in FIGS. 5 and 6, the lower end of the front wall portion **60** of the magazine terminates a predetermined distance above the bottom of the stack. In a preferred embodiment of the invention this distance may be about one quarter of an inch, and the bottom of the stack may extend beyond the forward end of the plate **64** about one and one-half inches. When the blade member **106** is rocked downwardly it engages the forward end of the stack about one quarter of an inch above the bottom of the stack, as shown, to bend the overhanging sheets downwardly over the edge of the plate **64** to the position shown in FIG. 6. Each outer rocker arm **96**, **98** is pivotally mounted on a stationary pin **108** formed integrally with an enlarged diameter portion **110** fixed in the bearing brackets **92**, **94**, and each arm **96**, **98** is confined from lateral movement by an intermediate web **112** of its bearing block and by a cover member **114** as shown. Each arm **96**, **98** is also provided with a ball bearing **116** fitted over its pivot pin **108**. The ball bearings **116** may preferably be of the aircraft type shielded and sealed double row bearings to exclude paper dust.

The outer rocker arms **96**, **98** are connected by similar links **118** to eccentric straps **120** mounted to cooperate with eccentrics **122** adjustably secured to the outer ends of a shaft **124**. The shaft **124** is journaled in bearing brackets **126** attached to the machine frame, and the shaft may be continuously rotated by an electric motor, not shown, connected by a belt **128** to a pulley **130** fast on the shaft. The straps **120** may also be provided with ball bearings **132** as indicated in cross section in FIG. 4 to reduce friction to a minimum.

The inner rocker arms **100**, **102** have extended between them a clamping member **134** arranged to cooperate with the blade member **106**. The clamping member is preferably provided with a resilient rubberlike clamping element **136**, and the rocker arms are similarly mounted on pivot pins **138** extended from the opposite face of the enlarged diameter portions **110**. The pivot pins **138** are offset upwardly and outwardly from the pivot pins **108** as shown to obtain efficient coordination between the clamping member and the blade member during the fanning operation. Each arm **100**, **102** is confined between the intermediate web **112** of its bearing block on one side and on the other side by a face plate **140** secured to the upwardly extended portions **72** of the frame and may also be provided with ball bearings **142** as shown. The inner rocker arms **100**, **102** are similarly connected by links **144** to eccentric straps **146** mounted to cooperate with eccentrics **148** adjustably secured to opposite ends of the shaft **124** and separated from the eccentrics **122** by spacers **150**. The straps **146** may also be provided with ball bearings similar to those shown at **132**. Also provided for the shaft **124** are a pair of eccentric weights or disks **125** fast on hub portions **149** of the inner eccentrics **148** and which are adjusted relative to the eccentrics **122**, **148** to serve the purpose of statically and dynamically balancing the eccentrics on the shaft to avoid excessive vibration. It will be noted that the provision of duplicate eccentric mechanism at both ends of the shaft **124** to rock the arms **96**, **98** and **100**, **102** at both ends of the blade member **106** and the clamping element **136**, respectively, serves to prevent torsional deflections in the arms.

In practice the eccentrics or eccentric cams **122**, **148** are adjusted out of phase with each other so as to space the high points of the cams an arcuate distance of about fifteen degrees apart on the shaft **124**. This out of phase relationship of the fanning elements is arranged in a manner such that the blade **106** and the clamp **136** are spaced apart during the downstroke to permit the group of sheets to freely assume their spread or fanned condition as they are bent downwardly about the rounded edge of the plate **64** and such that the blade and the clamp cooperate to clamp the sheets therebetween during the upstroke to maintain the same in their fanned condition during their return to a horizontal position. In other words the clamp **136** starts its downstroke before the blade **106** and also starts its upstroke before the blade **106**. The centers **108**, **138**, respectively, and the radii of the blade arms **96**, **98** and the clamp arms **100**, **102** are so disposed that the top sheet of the group will be returned to its original position, and the bottom sheet will be advanced an amount equal to the fanning produced on the downstroke. As a result the underlying sheets are pulled forwardly so that during subsequent fanning operations, accomplished with great rapidity, the sheets are fed forwardly an additional and equal amount each cycle of operation to increase the distance between the edges of adjacent sheets until the bottom sheet of the group feeds completely out from under the stack and off the shelf **64**. Thereafter, additional sheets are added to the group from the stack each cycle of operation as successive underlying sheets are completely withdrawn from the bottom of the group, and continued fanning operations will produce the elongated strip **14** of uniformly fanned sheets of predetermined and substantially uniform thickness adapted to be rolled and banded.

FIGS. 5 and 6 illustrate the initial bending and clamping operations upon a group of lowermost sheets supported in the stack. The position of the fanning and clamping elements shown in FIG. 5 is such that the clamping element **136** has started its downward stroke, and the blade member **106** has also started its downward stroke from the upper limit of its stroke to a position where it has just engaged the edge of the lowermost sheet forming the group to be fanned. The position of the fanning elements shown in FIG. 6 is such that the blade member **106** has reached the limit of its downward stroke, and the clamping element **136** has already started its return stroke to engage the lowermost sheet of the group to clamp the fanned end of the group of sheets between the blade and the clamp. FIG. 7 shows the clamping element **136** in resilient clamping engagement with the group, and during

the upward stroke the fanning and clamping elements maintain the sheets in their fanned condition so that when the sheets are returned to their initial position the group will retain their fanned condtiion, as shown in FIG. 8, and wherein the fanning and clamping elements are disposed in the same position as in FIG. 5 at the start of a second fanning cycle.

The illustrated method of fanning is based on the principle that when one end of a group of sheets of predetermined thickness, one quarter of an inch in thickness for example, is bent over a right angle corner, fanning of the ends of the sheets results. This phenomenon is explained by the fact that the outer sheet bend around a larger radius than the inner sheets, thus shortening the ends of the outer sheets.

The amount of shortening of the end of the outer sheet in comparison with the inner sheet can be computed as follows:

Where

R_1 equals bend radius of inner sheet
R_2 equals bend radius of outer sheet
T equals thickness of stack
L equals length of ends of both sheets before bending
L_1 equals length of end of inner sheet beyond bend
L_2 equals length of outer sheet beyond bend
F equals difference in length of inner and outer sheet beyond bend equals total fanning of stack
Length used up in bend (inner sheet) equals $2\text{pi}R_1/4$
Length used up in bend (outer sheet) equals $2\text{pi}R_2/4$
L_1 equals $L-2\text{pi}R_1/4$, L_2 equals $L-2\text{pi}R_2/4$
F equals L_1-L_2 equals $L-2\text{pi}R_1/4-L$ plus $2\text{pi}R_2/4$ equals $\text{pi}/2\ (R_2-R_1)$
but R_2-R_1 equals T; therefore, F equals $\text{pi}T/2$
Therefore, the amount of fanning for a 90° bend equals F equals $\text{pi}T/2$

and is dependent only on the pile thickness and not the radius of bend.

Therefore, for a ¼ inch thick pile, a 90° bend will produce a fanning of the pile of $3.14/8$ inches or approximately ⅜ inch.

For 50 pound offset paper, there are approximately 268 sheets in one inch of thickness or 67 sheets in ¼ inch thickness—each sheet is approximately .0037 inch thick.

Thus, one 90° bend will fan each sheet approximately

$$\frac{3.14}{8\times 67} \text{ equals .0058 inch (approximately)}$$

In practice ¼ inch of the bottom of the stack of leaflets will be bent down 90° over the shelf near the front end of sheets to produce this effect.

If, after bending down, the ¼ inch pile is tightly gripped at its front edge and restraightened so that its top sheet reutrns to its original position, the sheets beneath will be fanned forward a total of $3.14/8$ inch.

A repetition of the above cycle will produce the same amount of fanning again.

If 5½ x 8 inch sheets are being run and the bottom sheet is advanced $3.14/8$ inch at each cycle, the bottom sheet will feed completely out from under the stack and off the shelf in

$$\frac{6\frac{1}{4}\times 8}{3.14} \text{ equals 16 cycles}$$

where shelf is 1¾ inch from sheet end.

The amount of fanning between any two sheets at this time will be

$$\frac{6.25}{67} \text{ equals .093 inch}$$

Once the bottom sheet clears the shelf, each cycle will feed the bottom of the web of fanned sheets ahead $3.14/8$ inch and with the sheets fanned .093 each

$$\frac{3.14}{8\times .093} \text{ equals 4 plus}$$

or slightly more than four new sheets will be fed at each cycle.

To feed 2000 sheets per minute would then require 500 cycles per minute and 4000 sheets per minute can theoretically be fed at 1000 cycles per minute.

As herein shown, the continuous length or web of fanned sheets **14** thus produced is received and advanced on the conveyer **16** to the rolling device **18**. Since the bending of the sheets at the fanning station **12** will cause rapid oscillations of the web both up and down and endwise and a scrubbing between sheets will occur, the conveyer **16** is preferably disposed below the shelf **64** and provision is made for controlling the upward bounce of the web. For this purpose, flat springs **152** may be provided, as shown in FIGS. 4 and 9, which may be secured at one end to the machine frame, the free ends of the flat springs extending over the web to confine the sheets and to limit the upward movement of the web during the fanning operations. Also, in order to control the feed of the sheets and to retain the sheets in the web after they are entirely withdrawn from the stack, a pair of nip rolls **154, 156** may be provided. In practice the nip rolls must be positioned at a distance of one sheet length from the end of the shelf **64** so that just as the trailing end of a sheet leaves the shelf the forward or leading end thereof will enter the nip rolls. The nip rolls **154, 156** may be carried by shafts **155, 157**, respectively, journaled in bearing blocks **158** mounted for adjustment longitudinally of the web in slots **160** provided in upper and lower support bars **162, 164** as indicated in FIG. 9. The conveyer **16** may be driven in any usual or preferred manner (not shown) to maintain the speed of advance of the web withdrawn from the magazine, and the nip rolls **154, 156** may likewise be rotated at a circumferential speed equal to the linear speed of the conveyer.

The rolling of the web of fanned sheets **14** may be accomplished in a conventional manner and, as schematically indicated in FIG. 1, the rolling mechanism **18** includes an endless rolling belt **200** which may be guided around upper and lower rolls **202, 204** and around the mandrel **20**. The upper and lower rolls **202, 204** form a pocket **206** into which the leading end of the web is received to be wrapped around the mandrel. The belt **200** is also guided around idler rolls **208, 210, 212, 214** defining a generally hexagonal area within which the roll is free to expand during the rolling operation. The endless rolling belt **200** then passes over a roll **216** and a belt takeup or tensioning roll **218** carried by a horizontally movable block **220** which is urged in a direction to take up the slack in the belt by an elongated spring **222**. The belt then passes around rolls **224, 226** and between cooperating drive rolls **228, 230** and then up to the roll **204** forming the bottom roll of the pocket **206**.

The mandrel **20** may be mounted in bearings arranged to move horizontally during the winding operation from a position shown in full lines at the start of the winding operation to a central position shown in broken lines in FIG. 1 at the end of the winding operation. In operation, after the leading end of the web **14** enters the pocket **206**, the leading end will be carried around the mandrel by the rolling belt **200**. At this point the belt may be relaxed sufficiently to permit entry of the web between the belt and the mandrel. In order to guide the leading end of the web **14** into the nip of the belt **200** and the underside of the mandrel **20** a curved guide plate **201** is arranged to enter the pocket **206** at this time. The plate **201** is carried by a solenoid operated bell crank **203** and is arranged to be withdrawn after the initial winding or rolling operation. As the leading end of the web makes its first revolution it will contact the incoming web and be carried around again to continue the winding operation. As the roll being wound increases in diameter the horizontally movable mandrel **20** will be automatically moved to the right by the increase in diameter of the roll. When the roll diameter reaches a predetermined size, provision is

made for automatically stopping the fanning mechanism. The banding mechanism **22** will then be automatically activated to apply a band **25** around the roll, and the completed roll may then be stripped from the mandrel by doffing mechanism indicated generally at **27** in FIG. 2. It will be noted that in rolling the web further fanning occurs since the sheets on the underside of the fanned web which lead the sheets on the upper side of the web have to travel farther as they are rolled by an amount depending on the thickness of the web. This effect is cumulative as the web is rolled. For each rotation of the roll with a web of "T" thickness, this gain is 2 pi T, or for a one-quarter inch web pi/2 equals 1.57 inches.

From this it will be seen that the bottom of the web which contacts the rolling belts must run faster than the top of the web. Hence, in practice the rolling belt **200** is run faster than the conveyer **16**. The difference in speed of the outside and inside of the web in rolling, and hence the difference in speed of the top and bottom of the web, as it enters the rolling pocket **206**, is not constant since at the beginning of the rolling operation more revolutions per inch of web occur than at the end. Thus, in practice the rolling belt **200** is run fast enough to provide the maximum speed differential so as to keep the web under tension at all times as the roll increases in diameter, and as a result will produce additional fanning rather than cause buckling of the web.

In general, as diagrammatically indicated in FIG. 1, the banding mechanism **22** may include means for supporting a roll of banding tape **300**; a pair of feed rolls **302, 304** for automatically prefeeding and looping a length of tape in an amount related to the circumference of the completed roll into a magazine **306**; feed rolls **308, 310** for advancing the prefed tape along a curved guide **312** and into the nip of the rolling belt **200** and the outside diameter of the roll of fanned sheets. The tape is thus also guided into operative position to a spring loaded guide **313**, a stationary serrated knife blade **314** and an adhesive applying head **316**.

The mechanism for prefeeding and looping a length of banding tape in an amount related to the circumference of the roll includes a connection such as a lever **318** carried by the belt tension block **220** and connected at its lower end to an endless chain **320** which runs over sprockets **322, 324**. The sprocket **324** is mounted on a shaft **326** which has a second sprocket **328** connected by a chain **330** to a sprocket **332** to drive the prefeeding roll **302** at a ratio of 2 to 1.

It will be observed that during the rolling operation the belt takeup block **220** moves from its full line position at the left to its dotted line position at the right shown in FIG. 1 which comprises a distance equal to one half the change in circumference of the roll as it increases in diameter in the rolling belt. Thus, the prefeed roll **302** will be rotated through the 2 to 1 drive to prefeed a length of banding tape equal to the circumference of the roll. In practice the drive ratio will be slightly over 2 to 1 to provide an additional length for overlapping the ends of the tape and adhesively securing the same together.

While the tape prefeeding rolls **302, 304** are feeding and looping the tape into the magazine **306**, the tape advancing rolls **308, 310** are idle, and the tape is clamped therebetween. When the roll of fanned sheets reaches its predetermined diameter the feed roll **304** will be moved away from its cooperating roll **302** and simultaneously therewith, a solenoid operated clamping member **334** will be actuated to clamp the tape at the upper end of the magazine. The banding cycle will now be initiated by rotation of the tape advancing rolls **308, 310** to push feed the prefed tape through the curved deflector guide **312** and into the nip of the rolling mechanism. The tape is thus wound around the roll of fanned sheets until all of the slack in the preformed loop is taken up whereupon the tape will become taut between the clamp **334** and the rolling mechanism.

When the tape tightens it will attempt to lie in a straight line between the clamp **334** and the rolling mechanism and will thus overcome the spring of the spring loaded guide **313** and depress the nozzle of the adhesive applying head **316** allowing adhesive to flow onto the tape. As the tightening progresses the tape will engage the blade of the fixed serrated knife **314**, and the tape will be severed. Once the tape is severed it will continue to feed into the rolling mechanism and be wound around the roll, the adhesively coated and overlapping the leading end and becoming adhesively secured thereto. The cut end of the tape will be stripped from the serrated knife blade **314** by the return of the spring loaded guide **313** in readiness to be advanced during a succeeding cycle of banding operation. It will thus be seen that the taping mechanism is capable of automatically prefeeding the correct length of banding tape for any size roll.

The completed rolled and banded package is then stripped from the mandrel **20** by the doffing mechanism **27** which may include a motor **336** having an elongated shaft **338** provided with a pinion **340** arranged to cooperate with a rack **342**. The rack **342** is provided with a pusher plate **344** movable along the mandrel **20**, and when the banding operation is completed the motor **336** is energized to push the completed roll off the end of the mandrel. The removed roll may be discharged into a chute, not shown, to deliver the completed rolls to a suitable packaging or storage area. Prior to removing the completed roll from the mandrel the rolling belt **200** is arranged to be held stationary at a point between the guide rolls **214, 216** by a solenoid operated clamping mechanism indicated at **346**. At this time the belt driving rolls **228, 230** will pull the spring load tensioning block **220** to the right and as a result the belt **200** will become relaxed between the roll **230** and the roll **214**, thus relaxing the portion of the belt wrapped around the banded roll of fanned sheets to permit the roll to be removed from the mandrel.

All of the above operations may and preferably will be sequentially controlled as indicated by the timing diagram shown in FIG. 12 and as diagrammatically indicated in FIG. 1. The sequence of operation may be described as follows: At the start of a cycle the belt tension control block **220** is in its extreme left hand position, as shown in FIG. 1, and rests against a belt control switch **LS3**. When the circuit is energized, closing of the control switch LS3 effects engagement of clutch **C1** to start rotation of the fanning mechanism shaft **124**; actuates solenoid **S1** moving the web control arm **203** in; engages a clutch **C2** to start operation of the rolling belt **200**; and releases the tape clamp solenoid **S2**.

After an initial increase in diameter of the roll of fanned sheets switch **LS6** operates solenoid **S1** rocking the web control arm **203** out. The fanning mechanism **12** and the rolling mechanism **18** now continue in operation until nearly the full predetermined diameter of the roll is reached, at which time the belt tension control block engages a manually adjustable limit switch **LS4**. Switch LS4 disengages clutch **C1** stopping the fanning mechanism **12** and, simultaneously therewith, a time delay switch **TD1** is actuated. After a suitable time interval, about two and one-half seconds, switch TD1 actuates the tape clamp solenoid **S2** and also the tape feed clutch **C3**. Tape is now applied around the roll of fanned sheets until the tape tightens and operates limit switch **LS5** which cooperates with the adhesive applying head **316**.

Closing of the circuit at LS5 actuates a time delay switch **TD2**. After a suitable time interval, about one and one half seconds, switch TD2 restores the time delay switch TD1 which disengages the tape feed clutch C3. Switch TD2 also actuates the belt clamp solenoid

S3 to hold the belt at this point and to permit relaxation of the portion of the belt about the roll preparatory to removing the roll from the mandrel. Switch TD2 also actuates time delay switch TD3. After a suitable time interval, about one-fifth of a second, switch TD3 shuts off belt clutch C2, and also starts the doffing motor M2. Doffing now occurs, shutting off a limit switch LS2, and when the doffer completes its stroke it engages a limit switch LS1 which actuates the doffing motor reversing switch RS1.

The doffer now returns and turns on limit switch LS2 which shuts off doffing motor M2. Switch LS2 also restores the doffing motor reversing switch RS1. Limit switch LS2 also restores the time delay TD3 to "off" position; releases the belt clamp solenoid S3; and restores switch TD2 to "off" position. The belt tension control block 220 now moves outward after the belt clamp S3 is released, and this restores the limit switch LS4 to "off" position. When the block 220 reaches its outer position, it contacts limit switch LS3, restarting the cycle.

From the above description it will be seen that the present apparatus for fanning, rolling and banding flexible sheets embodies novel fanning mechanism capable of rapidly and efficiently fanning and advancing successive lowermost sheets or groups of sheets from a stack thereof to provide an elongated web of fanned sheets adapted to be rolled and banded. It will also be seen that the present apparatus embodies novel control mechanism for effecting operation of the apparatus in a predetermined sequence so as to permit automatic operation to produce successive rolled and banded packages of fanned sheets.

While the preferred embodiment of the invention has been herein illustrated and described, it will be understood that the invention may be embodied in other forms within the scope of the following claims.

Having thus described the invention, what is claimed is:

1. In apparatus of the character described, in combination, means for supporting a stack of flexible sheets, means for bending a marginal edge of a group of lowermost sheets to effect fanning of the edges of the sheets in the group relative to each other, and means for clamping the fanned edges of the sheets and returning the same to their initial position whereby to effect longitudinal advancing movement of the underlying sheets in the group from the stack in an amount equal to the fanning.

2. In apparatus of the character described, in combination, means for supporting a stack of flexible sheets, means for bending a marginal edge of a group of lowermost sheets to effect fanning of the edges of the sheets in the group relative to each other, and means for clamping the fanned edges of the sheets and returning the same to their initial position whereby to effect longitudinal advancing movement of the underlying sheets in the group from the stack in an amount equal to the fanning, repeated bending, clamping and returning operations effecting progressively increased fanning and longitudinal movement of the sheets in the group to provide an elongated web of fanned sheets adapted to be rolled and banded.

3. In apparatus of the character described, in combination, means for supporting a stack of flexible sheets, means for bending a marginal edge of a group of lowermost sheets to effect fanning of the edges of the sheets in the group relative to each other, and means for clamping the fanned edges of the sheets and returning the same to their initial position whereby to effect longitudinal advancing movement of the underlying sheets in the group from the stack in an amount equal to the fanning, repeated bending, clamping and returning operations progressively increasing the fanning of the edges of the sheets in the group relative to each other and progressively increasing the advancing movement relative to the stack until the lowermost sheets of the group are entirely withdrawn from the stack, additional sheets being supplied by gravity from the stack to join the group as the underlying sheets are withdrawn whereby to provide a continuous elongated web of fanned sheets adapted to be rolled and banded.

4. In apparatus of the character described, in combination, means for supporting a stack of flexible sheets, means for bending a marginal edge of a group of lowermost sheets to effect fanning of the edges of the sheets in the group relative to each other, and means for clamping the fanned edges of the sheets and returning the same to their initial position whereby to effect longitudinal advancing movement of the underlying sheets in the group from the stack in an amount equal to the fanning, repeated bending, clamping and returning operations progressively increasing the fanning of the edges of the sheets in the group relative to each other and progressively increasing the advancing movement relative to the stack until the lowermost sheets of the group are entirely withdrawn from the stack, additional sheets being supplied by gravity from the stack to join the group as the underlying sheets are withdrawn whereby to provide a continuous elongated web of fanned sheets adapted to be rolled and banded, means for supporting and advancing the web thus produced, and means disposed to engage the leading edges of the web to retain the sheets in their web formation when the trailing edges of the sheets leave the stack supporting means.

5. In apparatus of the character described, in combination, means for supporting a stack of flexible sheets, means for bending a marginal edge of a group of lowermost sheets to effect fanning of the edges of the sheets in the group relative to each other, and means for clamping the fanned edges of the sheets and returning the same to their initial position whereby to effect longitudinal advancing movement of the underlying sheets in the group from the stack in an amount equal to the fanning, repeated bending, clamping and returning operations effecting progressively increased fanning and longitudinal movement of the sheets in the group to provide an elongated web of fanned sheets adapted to be rolled and banded, said stack supporting means comprising a magazine having a front wall terminating a predetermined distance from the lower end of the stack for limiting the thickness of the group, and having a bottom wall terminating a predetermined distance rearwardly from the forward end of the stack and over which said marginal edge is bent to effect the fanning operation.

6. In apparatus of the character described, in combination, a magazine for supporting a substantially vertical stack of flexible sheets, said magazine having a front wall terminating a short distance above the bottom of the stack leaving a group of lowermost sheets exposed, and having a bottom wall terminating a predetermined distance rearwardly from the forward end of the stack over which the forward edges of the group overhang, means arranged to engage and bend downwardly over the edge of said bottom wall the exposed and overhanging forward edges of the group to fan the edges of the sheets in the group, means for clamping the fanned edges of the group and returning the same to its initial position to effect advancement of the group out of the stack in an amount equal to the fanning of the sheets, repeated fanning operations effecting progressively increased fanning and advancement of the group to effect withdrawal of the lowermost sheets of the group from the magazine and lowering of the stack to provide additional sheets to the top of the group whereby to provide an elongated web of fanned sheets of predetermined thickness adapted to be rolled and banded.

7. The combination as defined in claim 6 wherein the magazine is arranged to support the stack at a rearwardly inclined angle to present the forward edges of the group in a slightly prefanned condition.

8. The combination as defined in claim 6 which includes a conveyer for receiving and advancing the web, and a pair of nip rolls cooperating with the web and disposed a sheet length forwardly of the edge of said bottom wall to retain the sheets in their web formation when the trailing edges of the sheets leave the magazine.

9. The combination as defined in claim 8 which includes guide means disposed above the web between the fanning elements and the nip rolls for confining the upward movement of the web during the fanning operation.

10. The combination as defined in claim 6 wherein bending and clamping means include pivotally mounted rocker arms, and means for rocking said arms in a manner such as to maintain the bending and clamping elements in spaced relation during the downstroke and in clamping engagement with the web during the upstroke.

11. The combination as defined in claim 10 wherein the means for rocking said arms includes a pair of eccentrics, one eccentric being out of phase with the second eccentric whereby to effect said spaced relationship of the bending and clamping elements during the downstroke and clamping relationship during the upstroke.

12. The combination as defined in claim 10 wherein the bending arm and the clamping arm are mounted on different centers disposed so that during the upstroke the top sheet of the group will be returned to its original position and the underlying sheets will be advanced an amount equal to the fanning produced during the downstroke.

13. The combination as defined in claim 10 wherein the bending means includes an elongated blade carried by its rocker arm, and the clamping means includes an elongated resilient element carried by its rocker arm.

14. The combination as defined in claim 11 which includes a shaft on which said eccentrics are mounted, means for rotating said shaft, and means mounted on said shaft for statically and dynamically balancing the shaft to avoid excessive vibration.

15. In apparatus of the character described, means for supporting a stack of flexible sheets, and means for progressively fanning and longitudinally advancing a group of a predetermined thickness of the lowermost sheets from the bottom of the stack to effect eventual withdrawal of successive lowermost sheets upon repeated fanning and advancing operations, additional sheets being supplied from the stack to join the top of the group upon withdrawal of the lowermost sheets whereby to form a continuous elongated web of fanned sheets adapted to be rolled and banded.

16. The method of producing an elongated web of fanned sheets from a stack thereof which consists in bending downwardly the forward edges of a group of lowermost sheets in the stack to spread the forward edges relative to each other, then clamping the spread edges and returning the group to its initial position to effect forward movement of the underlying sheets of the group relative to the stack in an amount equal to the spread of the edges, and repeating the bending, clamping and returning operations to increase the spreading and forward movement of the group whereby to provide an elongated web of spread sheets adapted to be rolled and banded.

17. The method of producing an elongated web of fanned sheets from a stack thereof which consists in bending downwardly the forward edges of a group of lowermost sheets in the stack to spread the forward edges relative to each other, then clamping the spread edges and returning the group to its initial position to effect forward movement of the underlying sheets of the group relative to the stack in an amount equal to the spread of the edges, and repeating the bending, clamping and returning operations to increase the spreading and forward movement of the group to effect withdrawal of the lowermost sheets of the group and additions of sheets to the top of the group from the stack whereby to provide a continuous elongated web of spread sheets adapted to be rolled and banded.

18. In apparatus of the character described, in combination, means for fanning and advancing from the lower end of a stack a continuous web of fanned leaflets, means for rolling the web including a mandrel and a belt wrapped around the mandrel by and between which the web is received and rolled, means for driving the belt, belt tension takeup mechanism permitting the belt to expand about the roll as the diameter of the roll increases, and control means responsive to said belt tension takeup mechanism for discontinuing the operation of the fanning means when the roll reaches a predetermined diameter.

19. In apparatus of the character described, in combination, means for fanning and advancing from the lower end of a stack a continuous web of fanned leaflets, means for rolling the web including a mandrel and a driven belt wrapped around the mandrel by and between which the web is received and rolled, means movable into engagement with the leading end of the web to guide the same into the nip of the belt and the mandrel at the start of the rolling operation, means responsive to an initial increase in diameter of the roll for withdrawing said guide means, belt tension takeup mechanism permitting the belt to expand about the roll as the diameter of the roll increases, and control means responsive to said belt tension takeup mechanism for discontinuing the operation of the fanning means when the roll reaches a predetermined diameter.

20. In apparatus of the character described, in combination, means for fanning and advancing from the lower end of a stack a continuous web of fanned leaflets, means for rolling the web including a mandrel and a belt wrapped around the mandrel by and between which the web is received and rolled, means for driving the belt, belt tension takeup mechanism permitting the belt to expand about the roll as the diameter of the roll increases, and control means responsive to said belt tension takeup mechanism for discontinuing the operation of the fanning means when the roll reaches a predetermined diameter, means for applying a band about the roll including means operatively connected to said belt tension takeup mechanism for prefeeding a predetermined length of banding tape in an amount related to the circumference of the roll during the rolling operation, means also responsive to said belt takeup mechanism after a predetermined time interval for clamping the trailing end of said tape and for feeding and guiding the leading end of the tape into the nip of the belt and the roll, continued winding of the tape around the roll causing the tape to become taut between the clamping means and the roll, adhesive applying means disposed to engage and apply adhesive to the trailing end of the tape when the latter becomes taut, and a stationary blade also engaging the taut tape to sever the same upon continued pull of the tape against the blade during the winding operation.

21. In apparatus of the character described, in combination, means for fanning and advancing from the lower end of a stack a continuous web of fanned leaflets, means for rolling the web including a mandrel and a belt wrapped around the mandrel by and between which the web is received and rolled, means for driving the belt, belt tension takeup mechanism permitting the belt to expand about the roll as the diameter of the roll increases, control means responsive to said belt tension takeup mechanism for discontinuing the operation of the fanning means when the roll reaches a predetermined diameter, means for applying a band about the roll including means operatively connected to said belt tension takeup mechanism for prefeeding a predetermined length of banding tape in an amount related to the circumference of the roll during the rolling operation, means also responsive to said belt takeup mechanism after a predetermined time interval for clamping the trailing end of said tape and for feeding and guiding the leading end of the tape into the nip of the belt and the roll, continued winding of the

tape around the roll causing the tape to become taut between the clamping means and the roll, adhesive applying means disposed to engage and apply adhesive to the trailing end of the tape when the latter becomes taut, and a stationary blade also engaging the taut tape to sever the same upon continued pull of the tape against the blade during the winding operation, means responsive to the operation of said adhesive applying means after a predetermined time delay during which the tape is completely wound about the roll and the ends of the band adhesively secured for discontinuing the operation of said tape feeding means and for clamping a portion of the belt to effect relaxing of the portion of the belt wrapped around the roll preparatory to removal of the roll from the mandrel.

22. In apparatus of the character described, in combination, means for fanning and advancing from the lower end of a stack a continuous web of fanned leaflets, means for rolling the web including a mandrel and a belt wrapped around the mandrel by and between which the web is received and rolled, means for driving the belt, belt tension takeup mechanism permitting the belt to expand about the roll as the diameter of the roll increases, control means responsive to said belt tension takeup mechanism for discontinuing the operation of the fanning means when the roll reaches a predetermined diameter, means for applying a band about the roll including means operatively connected to said belt tension takeup mechanism for prefeeding a predetermined length of banding tape in an amount related to the circumference of the roll during the rolling operation, means also responsive to said belt takeup mechanism after a predetermined time interval for clamping the trailing end of said tape and for feeding and guiding the leading end of the tape into the nip of the belt and the roll, continued winding of the tape around the roll causing the tape to become taut between the clamping means and the roll, adhesive applying means disposed to engage and apply adhesive to the trailing end of the tape when the latter becomes taut, and a stationary blade also engaging the taut tape to sever the same upon continued pull of the tape against the blade during the winding operation, means responsive to the operation of said adhesive applying means after a predetermined time delay during which the tape is completely wound about the roll and the ends of the band adhesively secured for discontinuing the operation of said tape feeding means and for clamping a portion of the belt to effect relaxing of the portion of the belt wrapped around the roll preparatory to removal of the roll from the mandrel, means also responsive to the operation of said adhesive applying means after a further predetermined time interval for discontinuing driving of the belt and for removing the completely banded roll from the mandrel, means responsive to movement of the roll removing means for reversing the movement of the same, and means responsive to return of the roll removing means for discontinuing the movement thereof and for releasing said belt clamp means, and means responsive to return of the belt tension takeup means to its initial position upon removal of the roll and release of the belt clamp for initiating a succeeding cycle of fanning, rolling and banding operations.

23. In apparatus of the character described, in combination, means for rolling a web of leaflets including a mandrel and a driven belt wrapped around the mandrel by and between which the web is received and rolled, belt tensioning takeup mechanism permitting the belt to expand about the roll as the diameter of the roll increases, and means for applying a band of tape around the completed roll including means operatively connected to said belt tension takeup mechanism for prefeeding a length of tape from a supply thereof in an amount related to the circumference of the roll during the rolling operation, means for clamping the trailing end of said tape, means for feeding the leading end of the tape into the nip of said belt and the roll, continued winding of the tape around the roll causing the tape to become taut between the clamping means and the roll, adhesive applying means disposed to engage and apply adhesive to the trailing end of the tape when the tape becomes taut, and a stationary blade also engaging the taut tape to sever the same upon continued pull of the tape against the blade during the winding operation, said tape continuing to wind about the roll to present the trailing end of the tape in overlapping relation to and adhesive engagement with the leading end thereof.

24. In apparatus of the character described, in combination means for supporting a roll having a driven belt wrapped thereabout effecting rotation of the roll, and means for applying a band of tape about said roll including means for prefeeding a length of tape from a supply thereof in an amount related to the circumference of the roll, means for clamping the trailing end of the prefed tape, means for feeding the leading end of the tape into the nip of said belt and the roll to effect winding of the tape about the rotating roll, continued winding of the tape around the roll causing the tape to become taut between the clamping means and the roll, adhesive applying means disposed to engage and apply adhesive to the trailing end of the tape when the tape becomes taut, and a stationary blade also engaging the taut tape to sever the same upon continued pull of the tape against the blade during the winding operation, said tape continuing to wind about the roll to present the trailing end of the tape in overlapping relation and adhesive engagement with the leading end thereof.

25. The combination as defined in claim **24** which includes a magazine into which the prefed tape is deposited preparatory to winding the same about the roll.

26. The combination as defined in claim **24** wherein the prefeeding means is deactivated upon clamping of the trailing end of the tape.

27. The combination as defined in claim **26** wherein the tape feeding means is deactivated upon application of adhesive to and severance of the trailing end of the tape.

28. The combination as defined in claim **24** wherein provision is made for stripping the new leading end of the severed tape from the blade preparatory to a succeeding banding operation.

29. In apparatus of the character described, in combination means for applying a band of tape about a roll including means for prefeeding a length of tape in an amount related to the circumference of the roll, means for clamping the trailing end of the prefed tape, means for feeding the leading end of the tape into operative position to be wound about the roll, winding of the tape about the roll causing the tape to become taut between the clamp and the roll, and a stationary blade disposed to be engaged by the taut tape and arranged to sever the tape upon continued pull of the tape against the blade during the winding operation.

30. The combination as defined in claim **29** which includes means for applying adhesive to the trailing end of the tape, said trailing end being subsequently engaged in overlapping relation to the leading end of the tape and adhesively secured thereto.

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