March 8, 1960 E. L. HUGHES 2,927,624

APPARATUS FOR FORMING TUBULAR ARTICLES

Filed June 29, 1956 4 Sheets-Sheet 1

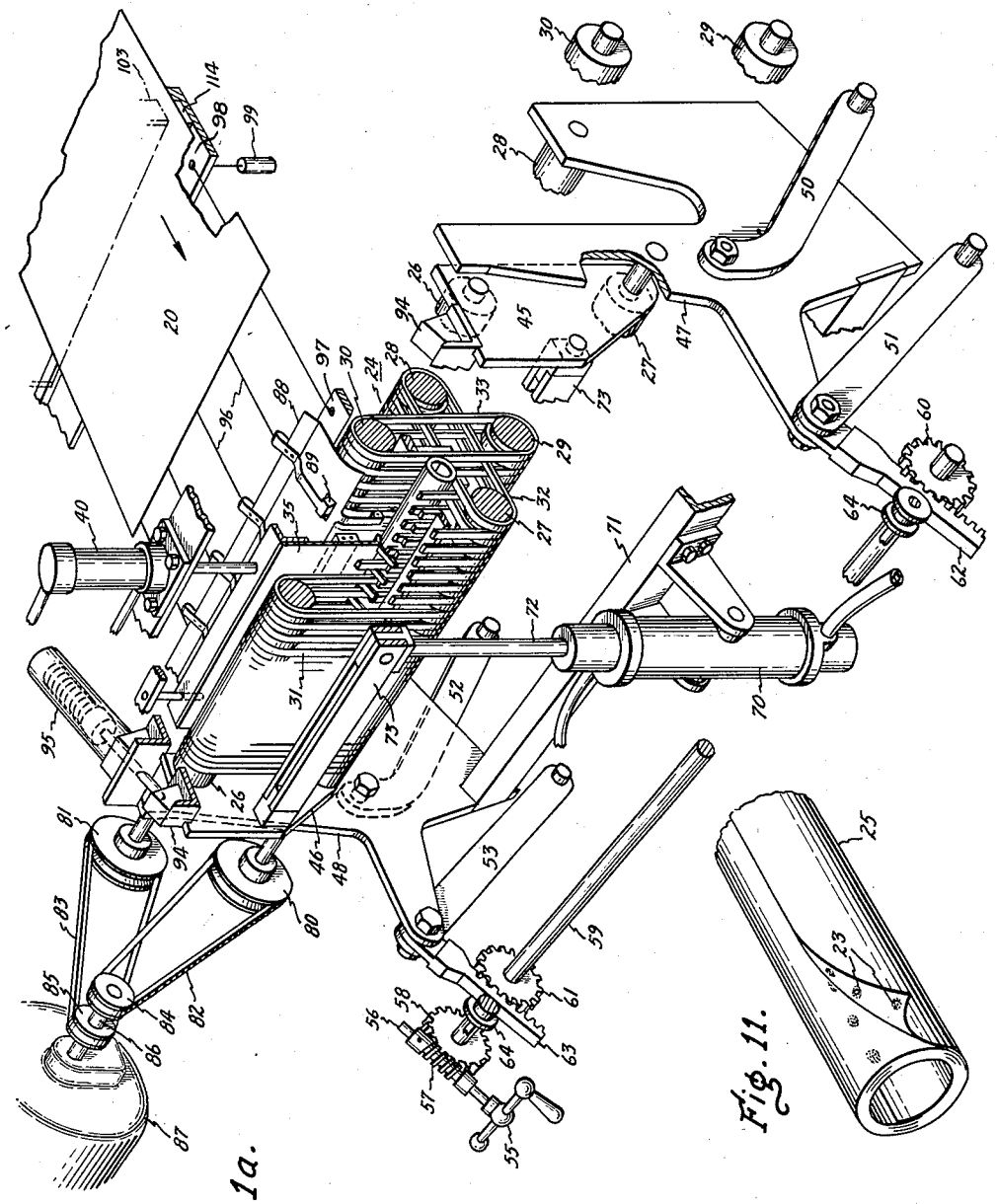


Fig. 1a.

Fig. 11.

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APPARATUS FOR FORMING TUBULAR ARTICLES

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Fig. 6.

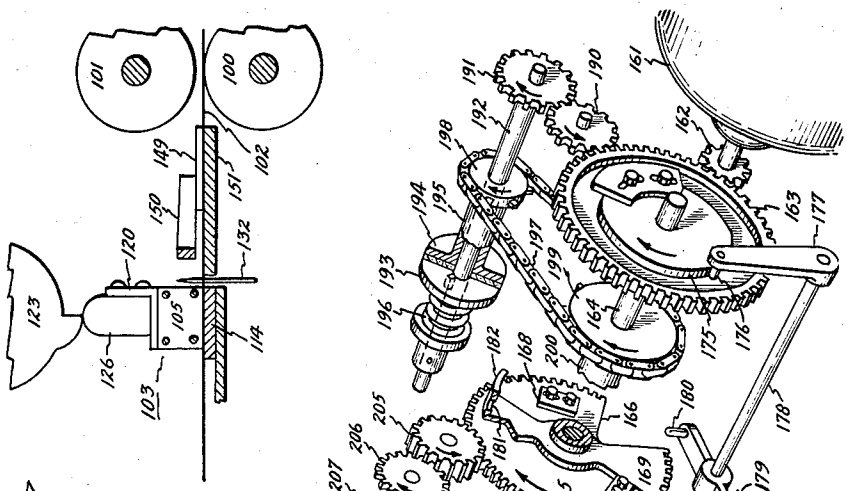
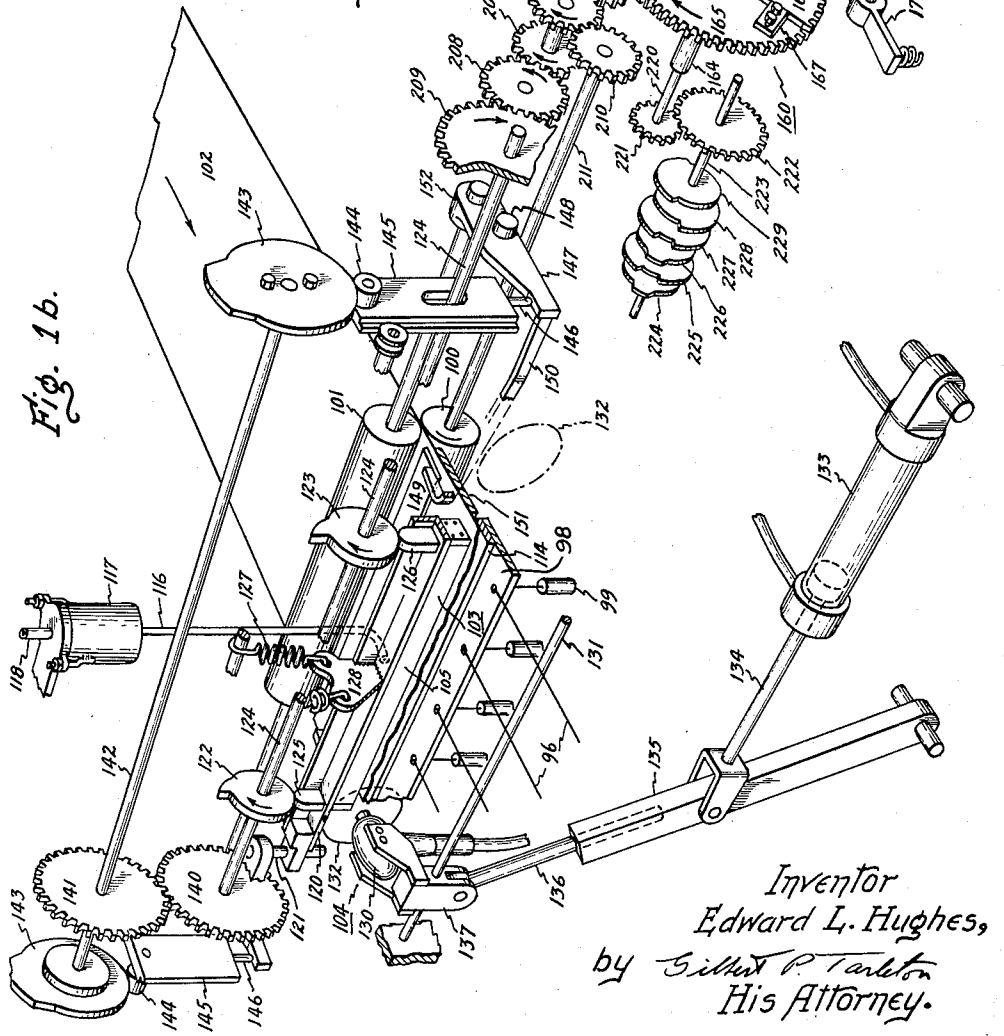


Fig. 1b.



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Fig. 2.

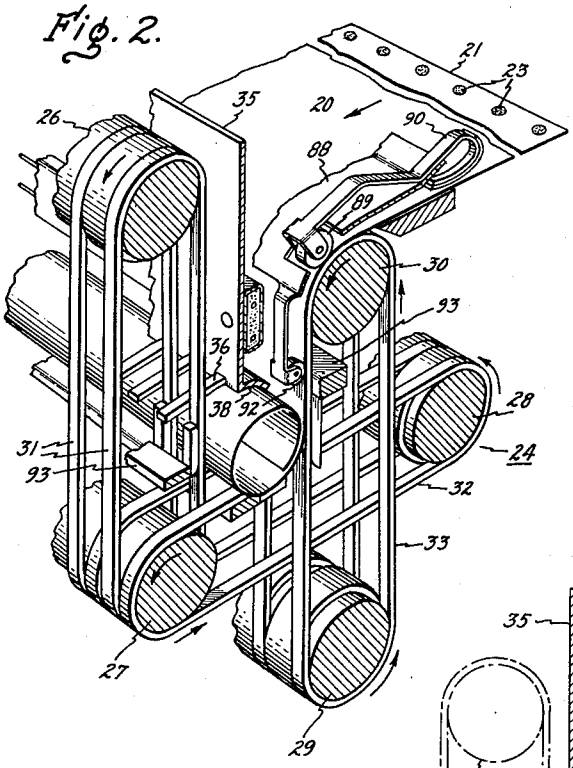
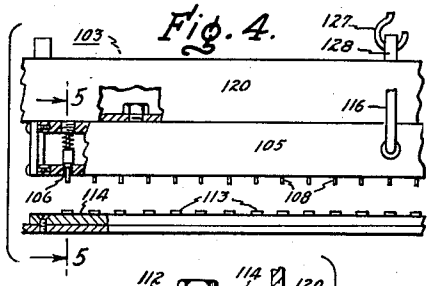


Fig. 4.



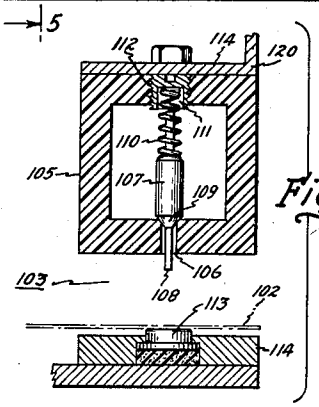
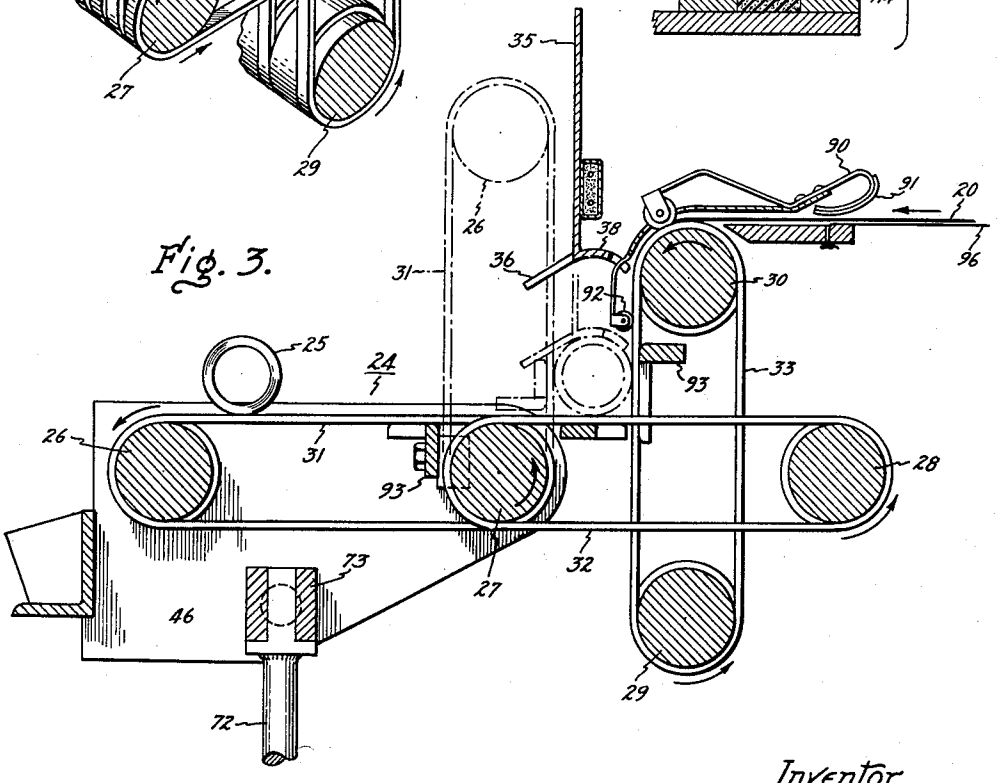


Fig. 5.

Fig. 3.



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Fig. 7.

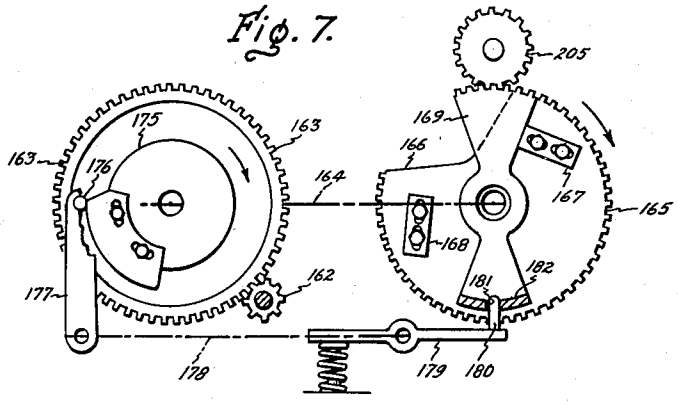


Fig. 8.

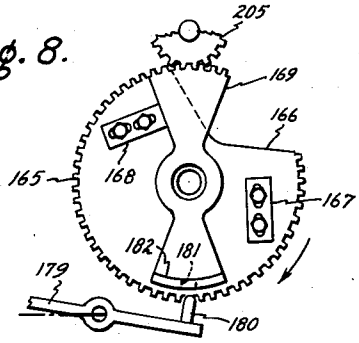
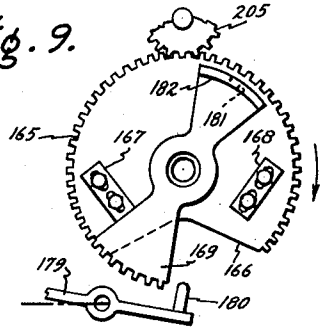


Fig. 9.



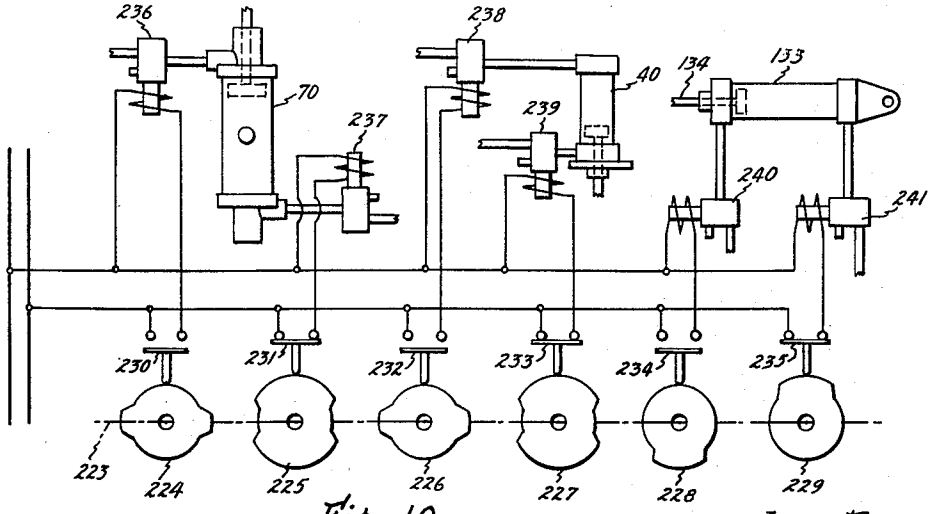


Fig. 10.

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2,927,624

APPARATUS FOR FORMING TUBULAR ARTICLES

Edward L. Hughes, Pittsfield, Mass., assignor to General Electric Company, a corporation of New York

Application June 29, 1956, Serial No. 594,951

16 Claims. (Cl. 154—1.8)

This invention relates to means for forming tubes from sheets of flexible material, and more in particular to an improved apparatus for forming electrically insulating tubes from sheet materials such as paper and the like.

In the fabrication of electrical apparatus, such as transformers, paper tubes are frequently employed on conductors to serve as insulation. In the past it has been common practice to form these paper tubes on a mandrel, for example, by winding the paper on a mandrel, sticking the ends down with a cement, and withdrawing the mandrel before curing the cement. It has been found, however, that tubes formed in this manner are relatively expensive, due to the time and labor required for forming each tube. As a further disadvantage, it has been found that the length of tubes that may be formed in this manner is definitely limited due to the difficulty of withdrawing the mandrel from the formed tube.

It is therefore an object of this invention to provide an apparatus for economically forming tubing from sheets of flexible material.

It is also an object of this invention to provide an apparatus for forming long tubes of a flexible material such as paper and the like.

Another object of this invention is to provide means for forming tubing from sheets of flexible insulating material without the use of a central mandrel.

A further object of this invention is to provide an apparatus for forming tubes from flexible sheet material comprising the plurality of flexible belts crossing one another to impart a winding motion to the sheet of flexible material.

A still further object of this invention is to provide an apparatus for forming tubing from flexible sheet material such as paper and the like comprising three groups of coaxial flexible belts, two of the groups of belts crossing the third group of belts in a perpendicular relationship, wherein the belts are arranged to provide a winding movement to the flexible material.

A still further object of this invention is to provide apparatus coacting with the tube winding apparatus of the previously stated objects for enabling the automatic forming of tubes from a continuous sheet of flexible material such as paper and the like.

Briefly stated, in accordance with one aspect of my invention, I provide an apparatus for winding or forming tubes from sheets of flexible material such as paper or the like comprising a plurality of flexible belts. The belts are arranged into three groups of coaxially mounted belts. The flat circumferential sides of the belts of two of the groups of belts are substantially parallel, at least one flat circumferential side of each of the parallel groups of belts crossing the flat circumferential side of the third group of belts at substantially right angles. Means are provided for feeding a sheet of flexible material between the parallel groups of belts, and the motion of the belts imparts a winding motion to the sheet of flexible material. Means are also provided for cutting the sheet of material into desired length, applying a cement to the tube, and for ejecting the finished tube.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject which I regard as my invention, it is believed that the invention will be better understood from the following description taken in connection with the accompanying drawings in which:

Fig. 1*a* is a perspective partially cross sectional view of a portion of one embodiment of my invention and illustrating the tube forming assembly,

Fig. 1*b* is a perspective cross sectional view of another portion of said one embodiment of my invention and illustrating the sheet cutter, cement applying assembly, and gearing assembly. The drawing of Fig. 1*b* is an extension of the upper right hand corner of the drawing of Fig. 1*a*,

Fig. 2 is an enlarged perspective partially cross sectional view of a portion of Fig. 1*a*,

Fig. 3 is an enlarged cross sectional view of the tube forming assemblies of Fig. 1*a*,

Fig. 4 is a front elevation of the cement applying assembly of Fig. 1*b*,

Fig. 5 is a cross sectional view of the cement applying assembly taken along the lines 5—5 of Fig. 4,

Fig. 6 is a side view of the sheet cutting and cement applying assemblies of Fig. 1*b*,

Fig. 7 is a pictorial representation of a portion of the gear assembly of Fig. 1*b*,

Figs. 8 and 9 are pictorial representations of the timing gear of Fig. 7 shown at different times during the operation of the apparatus of my invention,

Fig. 10 illustrates a typical circuit for accomplishing the timing sequences for the apparatus of my invention, and

Fig. 11 is a perspective view of one end of a tube such as may be formed on the apparatus of my invention, one end being turned back to illustrate the manner in which the cement is applied.

The tube rolling assembly

Referring now to the drawings, and more particularly to Figs. 1*a*, 2 and 3, therein is shown a sheet of flexible material **20** such as paper or the like. The sheet **20** has been cut into the desired length by means which will be disclosed in more detail in the following paragraphs, and the trailing edge **21** of the sheet (see Fig. 2) has been provided with a plurality of spots **23** of an adhesive on its upper surface. The means for applying these spots of adhesive will also be disclosed in more detail in the following paragraphs. In Fig. 1*a* the sheet **20** is shown prior to its entry into the tube forming assembly, denoted generally by the numeral **24**. In Fig. 2 the sheet is shown after a portion of it has entered the tube forming assembly, and in Fig. 3 a completely formed tube **25** wound from the sheet **20** is shown as it is being ejected from the forming assembly **24**.

The tube forming assembly is comprised of a plurality of flexible belts, such as rubber belts, extending between grooved rollers **26**, **27**, **28**, **29** and **30**. The belts are divided into three groups, with a first group of belts **31**, extending between rollers **26** and **27**, a second group of belts **32** extending between rollers **27** and **28**, and a third group of belts **33** extending between rollers **29** and **30**.

In the tube forming position of the belts (Figs. 1*a* and 2) the flat circumferential sides of the first group **31** and the third group **33** of belts are preferably substantially parallel and substantially perpendicular to the circumferential flat sides of the second group **32** of belts. It will be obvious, however, that the angular relationship heretofore described between the sides of the groups of belts is not critical and that more groups of belts may

also be employed. The belts of the first and second groups of belts, **31** and **32** respectively, are alternately disposed on the roll **27**. For the purpose of forming the tubes it is not necessary that the groups of belts **31** and **32** have a common roll, but as will be disclosed in more detail in the following paragraphs, this arrangement facilitates the ejection of the fully formed tubes. It is also preferred that the belts of the third group of belts **33** pass between adjacent belts of the second group of belts **32**. In order to provide flexibility of the apparatus in the forming of different sizes of tubing, as will be described in more detail in the following paragraphs, it is preferred that the rolls **29** and **30** of the third group of belts **33** be disposed on opposite sides of the second group of belts **32**.

Still referring to Figs. 1*a* and 2, a plate **35** is provided extending between the first and third groups of belts **31** and **33** respectively and parallel to the flat circumferential sides of these groups of belts. The end of the plate **35** extending between the first and third groups of belts is provided with comb-like projections on one side thereof **36** extending between the belts of the first group of belts **31**. The other side of the plate **35** is provided with a curved guide **38** extending to within a short distance of the third group of belts **33**. Means such as a hydraulic cylinder **40** (Fig. 1*a*) are provided in order to enable the vertical movement of the plate **35** between the first and third groups of belts.

The rolls **26** and **27** are journaled in end plates **45** and **46**, and the ends of the roll **27** extend through the plates **45** and **46** and are also journaled in end plates **47** and **48**, thereby providing means for a relative angular movement of the plates **45** and **46** and roll **26** about the axis of the roll **27**.

The ends of the rolls **29** and **30** are journaled in the frame of the apparatus (not illustrated for the sake of clarity), and these rolls therefore have a fixed position. Parallel arms **50**, **51**, **52** and **53** are provided extending between the end plates **47** and **48** and the frame of the apparatus, in order to permit the changing of the position of the rolls **26**, **27**, and **28**, with respect to the rolls **29** and **30** without changing the angular relationship between the belts of the three groups of belts.

The position of the rolls **26**, **27** and **28** with respect to the rolls **29** and **30** is controlled by means of a control knob **55** having a rotatable shaft **56** pinned to a worm gear **57**, the teeth of the worm gear **57** engage a gear **58** which is pinned to a shaft **59**. A pair of gears **60** and **61** rigidly fastened to the shaft **59** engage a pair of racks **62** and **63** respectively, the racks each having one end pivoted to the frames **47** and **48** respectively. Rollers **64** are provided to maintain engagement between the teeth of the racks and their respective gears.

The angular position of the plates **45** and **46** about the axis of the roll **27** is controlled by means of a hydraulic cylinder **70** which is pivotally mounted on a rigid member **71** extending between the end plates **47** and **48**. The piston **72** of the hydraulic cylinder **70** is connected to a bar **73** rigidly extending between the end plates **45** and **46**.

One end of the roll **27** extends through the end plate **48** and is provided with a pulley **80**. Similarly one end of roll **30** is provided with a pulley **81**. A pair of belts **82** and **83** are provided extending between the pulleys **81** and **80** respectively and pulleys **84** and **85** respectively fixed to the shaft **86** of a motor **87**. The rolls **26**, **28** and **29** are journaled for free rotation about their respective axes.

In the arrangement illustrated in Figs. 1*a* and 2, each of the rolls **26**, **27**, **28**, **29** and **30** have a counterclockwise rotation, so that the flat circumferential sides of the third group **33** of belts facing the first group **31** of belts has a downward motion, the flat circumferential sides of the first group of belts facing the third group of belts has an upward motion, and the uppermost flat circumferential side of the second group of belts **32** has a motion from the third group of belts toward the first group of belts.

In order to guide the sheet **20** into the belt arrangement a curved guide plate **88** is provided spaced from the roll **30**, and the guide plate **88** has a plurality of spring rollers **89** to hold the material **20** against the third group of belts where they pass over the roll **30**. Curved spring members **90**, covered with a material **91** to which the adhesive will not stick, such as polytetrafluoroethylene, may also be provided attached to the guide plate **88** in order to hold the sheet **20** away from the guide plate **88** and thereby prevent the deposits of the adhesive from collecting on the guide plate. Additional guide rollers **92** may also be provided affixed to the guide plate **88** for holding the sheet **20** against the third group of rollers in the space between the first and third group of belts above the lower edge of the plate **35**. Rigid backing bars **93** may also be provided behind the groups of belts in order to compensate for the flexibility of the belts, thereby insuring the formation of the desired diameter of tubing.

Referring now to Fig. 3, the first group **31** of belts is therein shown in position for ejection of a finished tube from the forming assembly. In this position, the piston rod **72** of hydraulic cylinder **70** (Fig. 1*a*) has effected the rotation of the plates **45** and **46** about the axis of roll **27**, so that the axis of roll **26** lies substantially within the plane of the axes of the rolls **27** and **28**. In this position it should be noted that the direction of movement of the upper sides of the first and second groups of belts is from right to left, thereby carrying the finished tube **25** away from the third group of belts.

In order to prevent damage to the forming assembly as a result of action of the hydraulic cylinder **70**, the plates **45** and **46** may be provided with bumpers **94** (Figs. 1*a* and 3) which engage the pistons of dashpots **95** (Fig. 1*a*) in the tube forming position of the assembly **24**.

A plurality of wires **96** extending between rigid bars **97** and **98** serve to support the sheet **20** prior to the forming of the tube, and the wires **96** may be held taut by any convenient means such as weights **99** attached to one end thereof.

Adhesive applying assembly

Referring now to Fig. 1*b*, a drive roll **100** and a pressure roll **101** for holding a sheet of flexible material **102** against the drive roll **100**, are shown mounted for feeding the uncut sheet of material **102** through the adhesive applying assembly **103** and the sheet cutting assembly **104**. The uncut sheet of material **102** may originate from a roll of such material mounted by any convenient means.

The adhesive applying assembly (Figs. 1*b*, 4 and 5) is comprised of header **105** extending transversely of the sheet **102**. The lower side of the header **105** is provided with a plurality of spaced apart ports **106**. Valve rods **107** within the header **105** have a reduced diameter portion **108** extending through the port **106** below the bottom of the header **105**, the portion **108** having a diameter less than the diameter of the port **106**. Adjacent the reduced diameter portion **108** of the valve rod **107** is a tapered portion **109** which engages a tapered valve seat at the upper end of the port **106**. The tapered portion **109** is held against the valve seat by means of a valve spring **110** which extends between a shoulder on the valve rod **107** and a cup **111** in the lower end of a screw **112** extending through the upper wall of the header **105**. A resiliently mounted button **113** is positioned below each of the valve rods in a plate **114** under the sheet of material **102**.

The header **105** is connected by means of a pipe **116** to an adhesive reservoir **117** (see Fig. 1*b*). Pressure is maintained in the reservoir **117** by any convenient means, such as a gas pressure supply (not illustrated) connected by means of a pipe **118** to the upper portion of the reservoir **117**.

The header 105 is rigidly mounted under a rigid member 120, the rigid member 120 being restrained for vertical movement by guides 121 on either end thereof (only one of the guides 121 is illustrated in Fig. 1b for the sake of clarity of the drawing). The header 105 is preferably made from a material to which the adhesive does not adhere, such as polytetrafluoroethylene.

A pair of cams 122 and 123 mounted on a shaft 124 extending transversely of the sheet 102 are positioned above the plate 120 and cam followers 125 and 126 rigidly affixed to the plate 120 engage the cams 122 and 123 respectively. The cam followers 125 and 126 are held against their respective cams by means of springs 127 which extend from suitable fixed supports to a plate 128 affixed to the upper side of the member 120.

Cutting assembly

The cutting assembly 104 (Figs. 1b and 6) is comprised of a pneumatic motor 130 mounted for movement transversely of the sheet 102 on a shaft 131. The shaft of the motor 130 is connected to a circular rotating cutting knife 132. The motor 130 is preferably mounted below the sheet 102 with the cutting knife 132 extending upwardly through the plane of the sheet 102 and in a plane normal to the plane of the sheet and perpendicular to the longitudinal edges of the sheet 102. The cutting knife 132 is driven back and forth to effect the cutting of the sheet 102 from a position beyond one edge of the sheet 102 (as in Fig. 1b) to a position beyond the other end of the sheet 102 (illustrated in Fig. 1b) by means of a pneumatic cylinder 133 having its shaft 134 pivotally connected to a lever 135. The lever 135 has an expandable end extension 136 which is pivotally connected to mounting means 137 for the motor 130.

It will be obvious, of course, that the motor 130 is not necessarily of the pneumatic type, and may be, for example, an electric motor.

Sheet clamping assembly

The shaft 124 (Fig. 1b) is connected on one end thereof to a gear 140, the gear 140 being in engagement with another gear 141 to drive a shaft 142. The shaft 142 is provided on each end with a cam 143, the cam 143 engaging cam followers 144 mounted on plates 145 adapted for vertical movement.

The plates 145 have pins 146 projecting downwardly and engaging one end of the levers 147 centrally pivoted on fixed pivot points 148. A clamping plate 149 extending transversely above the sheet 102 is rigidly connected by means of suitable arms 150 between the ends of the levers 147 engaging the pins 146. A rigid backing plate 151 parallel to the plate 149 is provided beneath the sheet 102. The pressure roll 101 is journaled for free rotation in bearings 152 located in the other ends of the levers 147.

Gear drive assembly

In the gear drive assembly (Fig. 1b), denoted generally by the numeral 160, a motor 161 is provided having its shaft affixed to pinion gear 612. A main gear 163 is provided engaging the teeth of the pinion gear 162 for effecting the rotation of shaft 164. An intermittent drive gear 165 having one sector 166 removed is affixed to the shaft 164. A pair of adjustable stop plates 167 and 168 are affixed to one face of the gear 165 a short distance from opposite edges of the removed segment 166. A sector gear 169 is mounted for free rotation on the shaft 164 adjacent the face of gear 165 having the stop plates 167 and 168. The sector gear 169 has the same radius as the gear 165, and the teeth of the sector 169 match the teeth of the gear 165. The sector gear 169 is mounted to engage the stop plates 167 and 168 in a manner to be disclosed more fully in the following paragraphs. The teeth of the sector gear 169 extend adjacent the portion of the face of the gear 165 having the removed sector 166.

A cam track 175 is provided on the main drive gear 163 and the cam follower pin 176 attached to arm 177 rides in the cam track 175. The arm 177 is affixed to one end of a shaft 178 and the other end of the shaft 178 is affixed to a spring biased arm 179 having a detent 180. The detent 180 is mounted for engagement with a notch 181 (see Figs. 7, 8 and 9) on an extension 182 of the gear sector 169.

A gear 190, engaging the teeth of the main drive gear 163, also engages the teeth of a gear 191 to effect the rotation of a shaft 192. A clutch plate 193 mounted for rotation with shaft 192 is resiliently held against another clutch plate 194 on a free running shaft 195 by means of a spring 196. A chain drive 197 extends between a sprocket 198 affixed to free running shaft 195 and sprocket 199 affixed to a free running shaft 200 surrounding shaft 164. The shaft 200 is affixed to the gear sector 169.

Referring now to Figs. 7, 8 and 9, it may be seen that the teeth of the sector gear 169 are in alignment with the teeth of the intermittent drive gear 165 when the sides of the sector gear 169 engage either of the stop plates 167 or 168.

Referring again to Fig. 1b, the teeth of the intermittent drive gear 165 are connected by way of a gear train comprised of gears 205, 206, 207, 208 and 209 to effect the rotation of shaft 124, the gear 209 being affixed to the gear 124. The gear 206 and the gear 207 are affixed to the same shaft. The teeth of the gear 206 also engage the teeth of the gear 210 which is connected to a shaft 211 to effect the rotation of drive roll 100.

Cam timing assembly

Still referring to Fig. 1b, an extension 220 of the shaft 164 is affixed to a gear 221, the gear 221 being mounted so that its teeth engage the teeth of a gear 222 to effect the rotation of the shaft 223 upon which are mounted cams 224, 225, 226, 227, 228 and 229.

Referring now to Fig. 10, it is therein illustrated that the cams 224, 225, 226, 227, 228 and 229 cooperate with their respective cam followers to operate switches 230, 231, 232, 233, 234, and 235 respectively thereby energizing solenoid valves 236, 237, 238, 239, 240 and 241 respectively. Solenoid valves 236 and 237 control the operation of hydraulic cylinder 70 for effecting the angular movement of frames 45 and 46 about the axis of roll 27. Solenoid valves 238 and 239 control the hydraulic cylinder 40 for effecting the vertical movement of the plate 35, and solenoid valves 240 and 241 control hydraulic cylinder 133 to move the hydraulic motor 130 transversely of the sheet 102. The cams 225 and 227 are identical, and the cams 224 and 226 are identical, the cams 225 and 227 each having two opposed land areas corresponding to the valley areas of cams 224 and 226, and two opposed valley areas corresponding to the land areas of cams 224 and 226. The solenoid valves are arranged so that when the first group of belts 31 are in tube forming position, the plate 35 will be in its lowermost position, and similarly when the first group of belts 31 is in its tube ejecting position the plate 35 will be in its uppermost position.

The cams 228 and 229 each have one land area corresponding to sectors of opposite land areas of the cams 225 and 227. These solenoid valves are arranged to effect the movement of the hydraulic motor transversely of the sheet 102 shortly after each time the first group of valves 31 has returned to tube forming position and the plate 35 has returned to its lowermost position.

The directions of angular motion of the various gears and shafts are illustrated by the arrows of Fig. 1b. Thus, main gear 163 and intermittent drive gear 165 rotate in a clockwise direction, and sector gear 169 is provided with an angular movement tending to hold it against the stop plate 167, by means of sprockets 198 and 199 which have a clockwise motion. The gear train comprised of gears 205, 206, 207, 208 and 209 provide a clockwise motion for the cams 122 and 123, and gear 210 provides a counterclockwise rotation for the driving roll 100.

Referring now to Fig. 11, therein is illustrated a typical tube such as may be formed on the apparatus disclosed in the preceding paragraphs. One corner of the trailing edge of the sheet of which the tube is formed is shown folded back to illustrate the spots 23 of adhesive material.

Operation

By means that will be disclosed in more detail in the following paragraphs, an intermittent rotary motion is applied to the shafts 124 and 211 (see Fig. 1*b*). Rotation of the shaft 211, which is connected to the drive roll 100, effects the feeding of the uncut sheet 102 of flexible material such as paper or the like, through the adhesive applying assembly 103. Rotation of the shaft 124 effects the rotation of shaft 142 by means of gears 140 and 141, thereby causing the rotation of cams 143. When the land areas of cams 143 contact the cam followers 144, the plate 145 is forced downwardly, thereby forcing lever 147 in a counterclockwise direction by means of the pin 146. The counterclockwise motion of the lever 147 results in the lifting of the pressure roller 101 from contacting engagement with the sheet 102, and also the clamping of the ends of the sheet 102 between the clamping plate 149 and the clamping plate 150. This clamping prevents the sheet 102 from being driven further than desired due to the action of the driving roller 100 and also from being pulled backwardly due to backlash or tension when the sheet 102 originates from a roll of such material. Therefore, it is obvious that the length of the sheet 102 which is to be cut off is determined by the length of the land area on the cams 143, with increases in land area of these cams corresponding to decrease in length of the sheets cut off.

Subsequent to the clamping of the sheet 102, by the rotation of shaft 124 and its cams 122 and 123, the projections of the cams 122 and 123 engage their respective cam followers 125 and 126 to force the plates 120 downwardly against the action of the springs 126. The plate 120 is guided in its vertical motion by means of the guides 121. Referring now to Fig. 5, the downward motion of plate 120 results in the moving of the header 105 toward the sheet 102. When the header 105 is forced downwardly for a sufficient distance that the reduced portions 108 of the valve rods 107 are in contacting relationship with the sheet 102 (backed up by the buttons 113), the tapered portion of the rods 107 are lifted from their valve seats and a small amount of adhesive is forced through the ports 106, due to the pressure exerted upon the adhesive in the adhesive reservoir 117. The amount of adhesive emitted from the ports 106 is determined by the diameter of the port and the diameter of the reduced portions 108 of the rods 107. Upon further downward movement of the header 105 the lower edge of the header is forced against the sheet 102, thereby spreading out the adhesive that has been forced through the port 106, and also preventing the further escape of adhesive from the header 105.

While the header 105 is still held against the sheet 102, the hydraulic cylinder 133 is actuated by means of one of the cams 228 or 229 and their respective switches 234 and 235 and solenoid valves 240 and 241 to draw the pneumatic motor 130 transversely across the sheet 102 by means of the lever 135, thereby causing the sheet to be cut by the circular knife 132.

After the sheet 102 has been cut, further rotation of the shaft 124 advances the projections of cams 122 and 123 beyond their respective cam followers, and the header 105 is rapidly pulled to its uppermost position by means of the springs 127. At this time the leading edge of the cut sheet 20 (Figs. 1*a*, 2 and 3) extend between the spring rollers 89 and the third group 33 of belts passing over the roll 30. Previously, further forward movement of the sheet has been prevented either by the action of the clamping plate 149 or by the clamping action of the header 105 and resilient buttons 113. Now, however, since the uncut sheet 102 has been cut to a sheet 20 of the desired length, and since the clamping action of the header 105 has been released, the sheet 20 is free to enter the tube forming assembly 24 of Figs. 1*a*, 2 and 3.

Reflecting back for a moment, it has been previously stated that the length of the sheet which is cut off is determined by the shape of the cams 143. In view of the necessity that the sheet be provided with further movement following the cutting operation, it is preferred that any variation of the shape of the cams 143 be accompanied with a change in the distance between the tube forming assembly 24 and the cutting and gluing assemblies so that the leading edge of the sheet 20 is in position to be pulled into the tube forming assembly. A convenient method for accomplishing this has been found to be in the mounting of the assemblage of Fig. 1*b* for movement on a track (not illustrated for the sake of clarity), and utilizing wires 96 as an extendable support for the sheet. The wires 96 are free to move in the holes in the plate 98 below the sheet 102 so that the weights 99 on the ends of the wires 96 can take up any slack in the wires 96. The wires 96 are firmly held in holes in plate 97 of the tube forming assembly.

In the tube forming operation, the leading edge of the sheet 20 is fed downwardly by the action of the third group of belts 33, then horizontally by the motion transmitted thereto by the second group of belts 32, and thence upwardly by the motion transmitted thereto by the first group of belts 31. Upon further movement of the sheet 20, the leading edge thereof is directed by means of the comb-shaped projections 36 and curved plate 38 into contacting relationship with a following portion of the sheet 20, the stiffness of the sheet 20 serving to maintain a circular cross section. Upon further movement of the sheet 20, the remaining portions of the sheet are wound over the initially formed tube, and the adhesive spots 23 (see Fig. 2) firmly adhere to the portion of the tube which they contact.

After the tube has been fully formed, as illustrated in Fig. 1*a*, the plate 35 is moved vertically upward by operation of the hydraulic cylinder 40 so that the projections 36 and curved guide 38 are moved out of contacting relationship with the tube. Simultaneously, or shortly thereafter, operation of the hydraulic cylinder 70 effects the rotation of end plates 45 and 46, thereby angularly displacing the roller 26 through an arc of about 90° to the position illustrated in Fig. 3. At this time, as illustrated in Fig. 3, the tube 25 is carried by the belts 32 and 31 away from the tube rolling assembly. A suitable rack or basket may be provided to catch the tube 25 after it passes beyond the roller 26. Then the plate 35 is returned to its former position and the end plates 45 and 46 are rotated to the position illustrated in Figs. 1*a* and 2, and the tube rolling assembly 24 is in position to commence the forming of another tube.

The adhesive applying and sheet cutting operations may be occurring on one sheet of material simultaneously with the rolling of another sheet of material in order to increase the number of tubes produced by the machine in a given time. Then, as soon as the plate 40 has returned to its lowermost position and the plates 45 and 46 have rotated to their tube rolling position, release of the next sheet of material by the adhesive applying assembly permits the rolling of another tube to start with a minimum of delay.

The intermittent rotation of shafts 124 and 211, as provided by the gear assembly 160, has been employed in order to provide sufficient time for completion of the adhesive applying operation. The shafts 124 and 211 cease rotating for a short period of time immediately following the depression of the adhesive applying header 105. The intermittent operation of the shafts 124 and 211 also prevents the movement of the sheet 102 during the cutting operation in the event that the sheet 102 has not been clamped sufficiently.

The intermittent rotation of these shafts is provided as follows:

Rotation of the pinion gear **162** is normally transmitted by way of main drive gear **163**, shaft **164**, and gear **165** to gear **205**, and thence through gears **206, 207, 208** and **209** to shaft **124**, and from gear **206** and **210** to shaft **211**. When, during the rotation of gear **165**, the teeth of gear **205** approach the removed segment portion **166** of gear **165**, the teeth of the gear **205** mesh with the teeth of the sector gear **169**, the sector gear **169** being held against the stop **167** on gear **165** by the friction clutch assembly so that the teeth of the sector gear **169** and the teeth of the gear **165** are in line.

The rotation of gear **163** is transmitted to shaft **192** by way of gears **190** and **191**, and the rotation of shaft **192** is transmitted through friction clutch plates **193** and **194** to shaft **195**, and thence by way of sprocket **198**, chain **197**, sprocket **199**, and shaft **200** to the sector gear **169**.

When, upon further rotation of gear **165**, the teeth of gear **205** leave the teeth of gear **165**, the gear **205** is locked from further rotation, as illustrated in Fig. 7 by the detent **180** entering the notch **181** of the extension **122** of the sector gear **169**. The movement of the detent **180** has been effected by rotation of the shaft **168** as a result of movement of the cam follower **176** in the cam track **175** of main drive gear **163**. During the time that rotation of the sector gear **169** is restrained by the detent **180** the friction clutch is permitted to slip.

The sector gear **169** holds the teeth of the gear **205** in position so that, upon further rotation of the gear **165** to the trailing edge of the removed segment portion **166**, the teeth of the gear **205** mesh accurately with the teeth of the gear **165**. The stop **168** on the gear **165** enables the accurate meshing of the teeth of the gears **205** and **165**. Simultaneously with the contacting once again of the teeth of gears **205** and **165**, the detent **180** is removed from the notch **181** in the sector gear **169**, thereby releasing the gear **205** for rotation with gear **165**. After the teeth of the gear **205** have ceased contacting the teeth of sector gear **169** due to rotation of the gear **165**, the sector gear **169** is driven by friction clutch assembly into contacting relationship with the stop **167**.

Therefore, the sector gear **169** serves to firmly lock the gear **205**, and therefore the shafts **124** and **211** from rotation, and also serves to enable the accurate remeshing of the teeth of the gears **205** and **165** at the trailing edge of the removed segment portion **166**.

It will be understood, of course, that, while the form of the invention herein shown and described constitutes the preferred embodiment of my invention, it is not intended herein to illustrate all of the possible equivalent forms or ramifications thereof. It will also be understood that the words used are words of description rather than of limitation, and that various changes may be made without departing from the spirit or scope of the invention herein disclosed, and it is aimed in the appended claims to cover all such changes as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An apparatus for forming tubular articles from sheets of a flexible material comprising a plurality of parallel groups of parallel rollers, a plurality of groups of flexible belts extending between the rollers of the respective groups of rollers, said belts being positioned with their flat sides forming the sides of a tube forming region with each group of belts forming a separate side of said region, and means for feeding a sheet of flexible material into said region.

2. An apparatus for forming tubular articles from sheets of a flexible material comprising a plurality of parallel groups of parallel rollers, a plurality of groups of flexible belts extending between the rollers of the respective groups of rollers, said belts being positioned with their flat sides forming the sides of a tube forming region with belts of said groups being alternately disposed in said region, each group of belts forming a separate side of said region, and means for feeding a sheet of flexible material into said region.

3. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel pairs of parallel rollers, a plurality of groups of flexible belts extending between the rollers of the respective pairs of rollers, said belts being positioned with their flat sides forming the side of a tube forming region with belts of said groups being alternately disposed in said region, each group of belts forming a separate side of said region, means for feeding a sheet of flexible material into said region, and means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region.

4. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel pairs of parallel rollers, a plurality of groups of flexible belts extending between the rollers of the respective pairs of rollers, said belts being positioned with their flat sides forming the sides of a tube forming region with belts of said groups being alternately disposed in said region, each group of belts forming a separate side of said region, means for feeding a sheet of flexible material into said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region.

5. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, a plurality of groups of flexible belts extending between said rollers, said belts being arranged so that a flat circumferential side of each of said group of belts defines a side of a tube forming region with belts of said groups being alternately disposed in said region, means for feeding a sheet of flexible material into said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region.

6. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, three groups of flexible belts extending between said rollers, each of said groups having a plurality of coaxial flexible belts, said belts being arranged so that a flat circumferential side of each of said group of belts defines a side of a tube forming region with belts of said groups being alternately disposed in said region, means for feeding a sheet of flexible material into said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region.

7. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, first, second, and third groups of flexible belts extending between said rollers, each of said groups having a plurality of coaxial flexible belts, at least one flat circumferential side of said first group being substantially parallel to at least one flat circumferential side of said second group, and substantially normal to at least one flat circumferential side of said third group, curved guide means, said curved guide means and said at least one flat circumferential sides of said groups of belts defining a tube rolling region with belts of said groups being alternately disposed in said region, means for feeding a sheet of flexible material into said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region.

8. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of paral-

lel rollers, first, second and third groups of flexible belts extending between said rollers, each of said groups having a plurality of coaxial flexible belts, at least one flat circumferential side of said first group being substantially parallel to at least one flat circumferential side of said second group, and substantially normal to at least one flat circumferential side of said third group, curved guide means, said curved guide means and said flat circumferential sides of said groups of belts defining a tube rolling region with belts of said groups being alternately disposed in said region, the flat circumferential sides of said belts of said second group passing alternately through the belts of said first and third groups, means for feeding a sheet of flexible material into said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region.

9. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, first, second and third groups of flexible belts extending between said rollers, each of said groups having a plurality of coaxial flexible belts, at least one flat circumferential side of said first group being substantially parallel to at least one flat circumferential side of said second group, and substantially normal to at least one flat circumferential side of said third group, curved guide means, said curved guide means and said flat circumferential sides of said groups of belts defining a tube rolling region, said belts of said first and second groups of belts having a common roll with belts of said first and second groups being disposed alternately on said common roll, belts of said third group being arranged to pass alternately through the belts of said second group, means for feeding a sheet of flexible material into said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheets in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region comprising means for rotating said first group of belts about the axis of said common roll.

10. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, first, second and third groups of flexible belts extending between said rollers, each of said groups having a plurality of coaxial flexible belts, at least one flat circumferential side of said first group being substantially parallel to at least one flat circumferential side of said second group, and substantially normal to at least one flat circumferential side of said third group, curved guide means, said curved guide means and said flat circumferential sides of said groups of belts defining a tube rolling region, the belts of said first and second groups having a common roller with the belts of said first and second groups being alternately disposed on said roller, the flat circumferential side of said third group of belts passing alternately through the flat circumferential side of said second group of belts, means for feeding a sheet of flexible material into said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region comprising means for rotating said first group of belts about the axis of said common roll, and means for varying the position of said first and second groups with respect to said third group for varying the dimensions of said regions.

11. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, a plurality of groups of flexible belts extending between said rollers, said belts being positioned with their flat sides forming the sides of a tube forming region with belts of said groups being alternately disposed in said region, means for feeding a sheet of flexible material into said region, means for applying an adhesive material to one side of the end of said sheet that last enters said region, and means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region.

12. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, a plurality of groups of flexible belts extending between said rollers, said belts being positioned with their flat sides forming the sides of a tube forming region with belts of said groups being alternately disposed in said region, means for feeding a sheet of flexible material into said region, means for applying a plurality of spots of adhesive to one side of the end of said sheet that last enters said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region.

13. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, a plurality of groups of flexible belts extending between said rollers, said belts being positioned with their flat sides forming the sides of a tube forming region with belts of said groups being alternately disposed in said region, means for feeding a sheet of flexible material into said region, means for rotating said rollers, means for applying a plurality of spots of adhesive to one side of the end of said sheet that last enters said region, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet into a tubular shape, and means for ejecting said rolled sheet from said region, said adhesive applying means comprising adhesive reservoir means spaced from said sheet, a plurality of port means in said reservoir means, valve means in said port means, and means for moving said reservoir means into and out of contacting relationship with said sheet, said valve means having extended portions arranged to be operated by contact with said sheet before said reservoir means contacts said sheet so that a predetermined quality of said adhesive is released from said reservoir means.

14. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel rollers, a plurality of groups of flexible belts extending between said rollers, said belts being positioned with their flat sides forming the sides of a tube forming region with belts of said groups being alternately disposed in said region, means for feeding a sheet of flexible material into said region, means for applying a plurality of spots of adhesive to one side of the end of said sheet that last entered said region, means for rotating said rollers, said belts being arranged to impart a generally circular motion to said sheet in said region to roll said sheet in tubular shape, means for ejecting said rolled sheet from said region, and means for intermittently actuating said adhesive applying means comprising a first shaft, cam means on said first shaft engaging said adhesive applying means to provide movement of said adhesive applying means into and out of engagement with said sheet, first gear means on said shaft, second gear means adapted for continuous rotation and engaging the teeth of said first gear means, said second gear means having a removed sector portion, sector gear means mounted for free rotation on the axis of said second gear means and having an arc less than the arc of said removed sector portion, the teeth of said sector gear means matching the teeth of said second gear means, means for limiting the angular displacement of said second gear means with respect to said sector gear means, means for stopping said sector gear means when said removed sector portion is adjacent said first gear means, and means for angularly biasing said sector gear means for rotation in the same direction as said second gear means.

15. An apparatus for forming tubular articles from sheets of flexible material comprising a plurality of parallel pairs of parallel rollers, groups of coaxial belts extending between the rollers of the respective pairs of rollers with flat circumferential sides of the groups of belts being arranged in planes angularly displaced relative to each other and for relative directions of rotation so as to provide upon rotation thereof a tube forming region wherein successive contact areas of the respective belt groups describe a continuously whirling circular course, and means for feeding a sheet of flexible material into said region.

16. Means for providing an intermittent rotary motion to a first shaft comprising first gear means on said shaft, second gear means adapted for continuous rotation and engaging the teeth of said first gear means, said second gear means having a removed sector portion, sector gear means mounted for free rotation on the axis of said second gear means and having an arc less than the arc of said removed sector portion, the teeth of said sector gear means matching the teeth of said second gear means and arranged to engage the teeth of said first gear means, stop means on said second gear means, said stop means being positioned to limit the angular displacement of said sector gear means with respect to said second gear means to a region slightly larger than said removed sector portion, a portion of the teeth of said sector gear being aligned with a portion of the teeth of said second gear when said sector gear engages said stop means, means for stopping said sector gear means when said removed sector portion is adjacent said first gear means, and means for angularly biasing said sector gear means against said stop means comprising friction clutch means coupled to said second gear means, said friction clutch means imparting an angular velocity to said sector gear means that is greater than the angular velocity of said second gear means.

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