

May 5, 1964

M. O. SCHUR

3,131,615

TUBE WINDER AND PROCESS

Filed Feb. 15, 1963

3 Sheets-Sheet 1

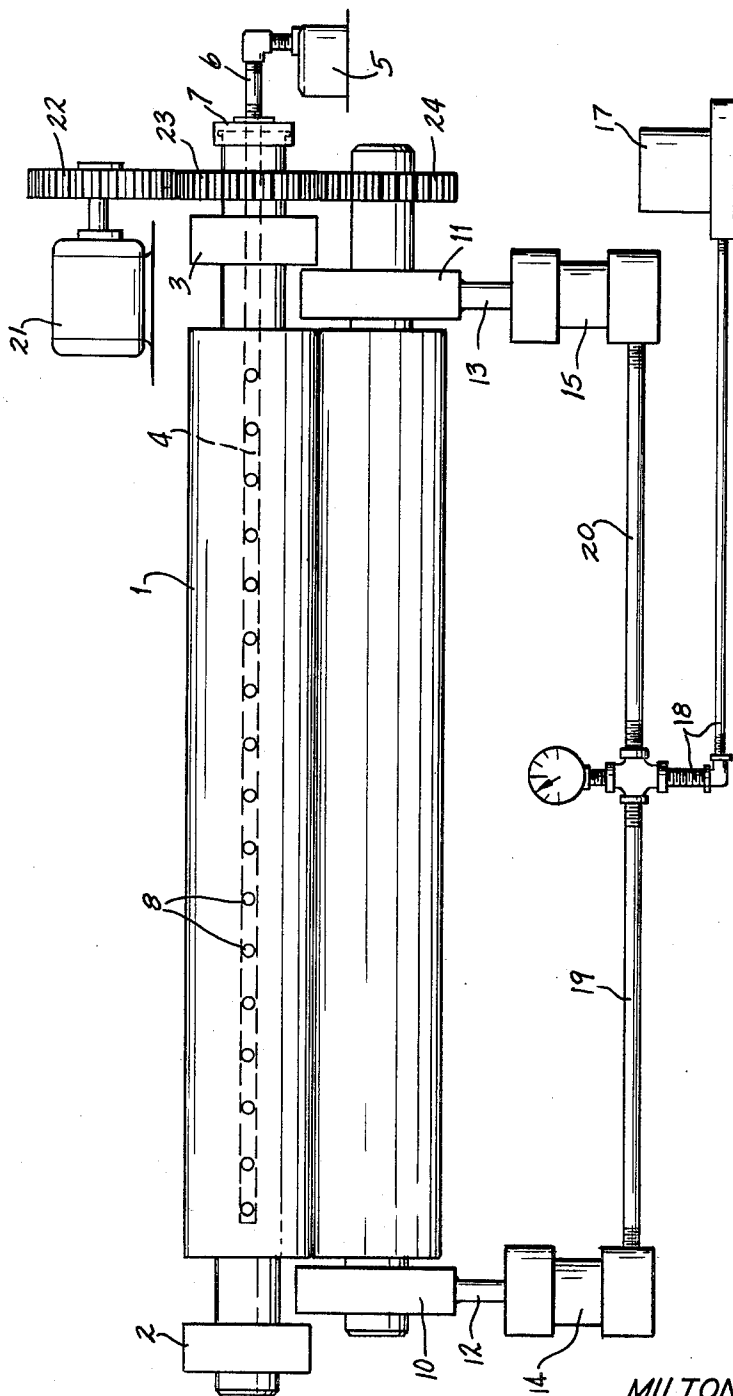


FIG - 1

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3 Sheets-Sheet 2

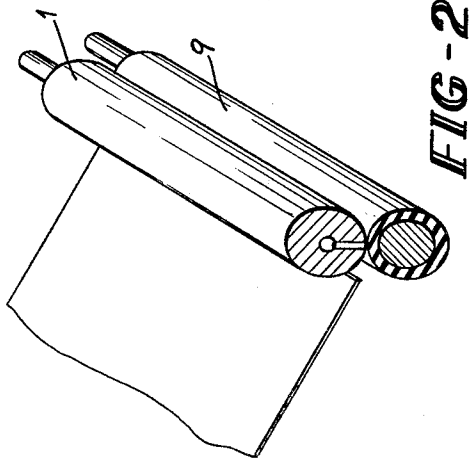


FIG-2

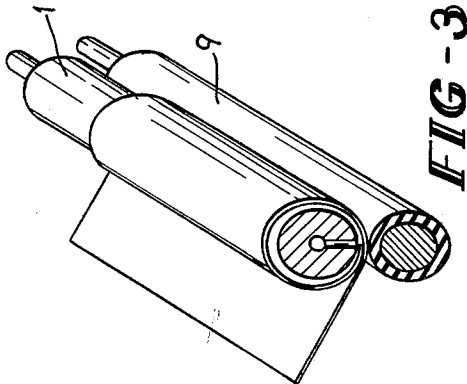


FIG-3

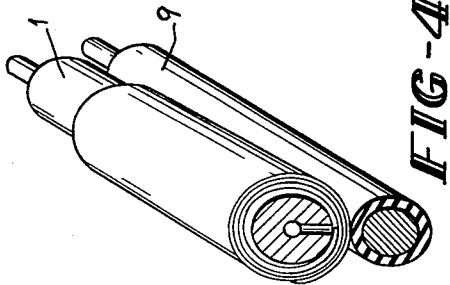


FIG-4

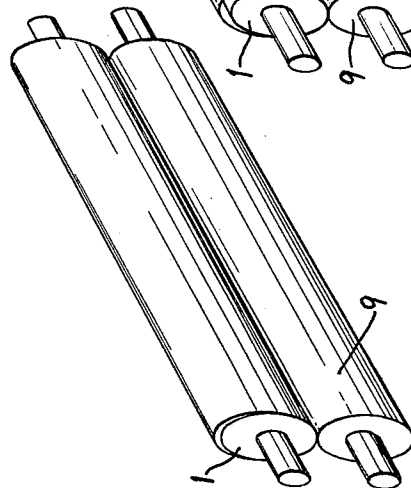


FIG-5

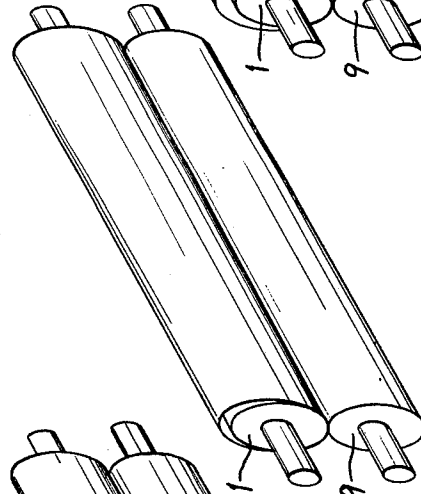


FIG-6

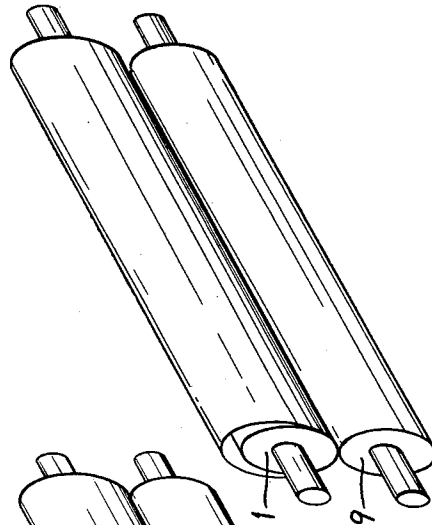


FIG-7

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FIG - 10

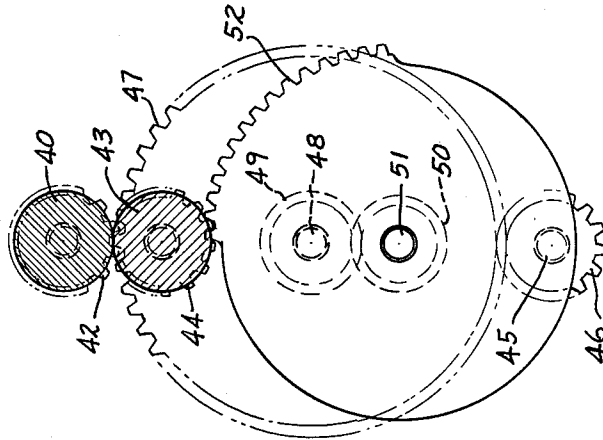


FIG - 9

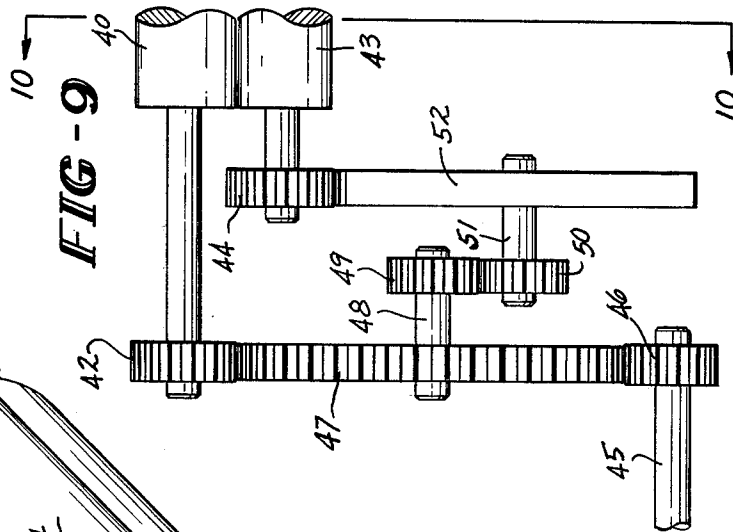
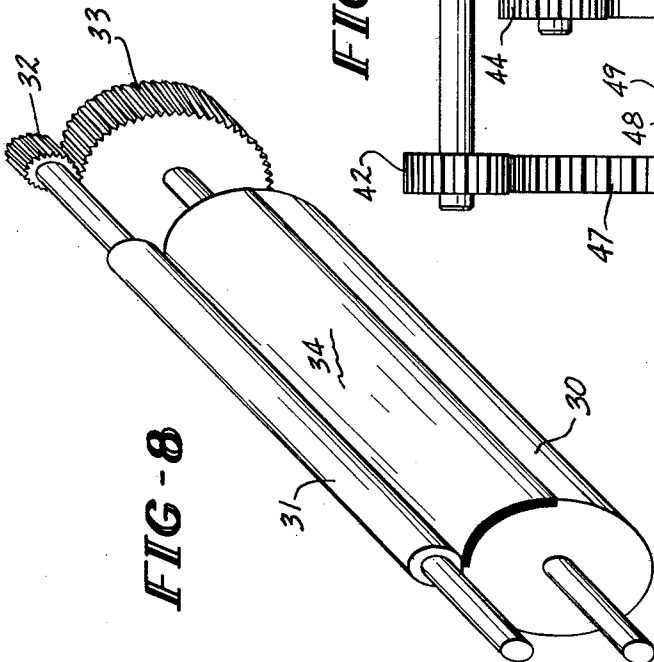


FIG - 8



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TUBE WINDER AND PROCESS

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16 Claims. (Cl. 93-81)

This invention relates to the winding of sheet material into tubular bodies which may be used to make containers such as cans or the like.

This invention more specifically relates to a method and apparatus for convolutely winding a strip of sheet material about a mandrel to form a tubular body. The strip of material is passed between a winding mandrel, having suction means or the like to grip the edge of the sheet and a nip roll. The mandrel and nip roll are driven so that the effective surface speed of the nip roll is greater than the surface speed of the mandrel during the winding of at least the first complete convolution of the strip about the mandrel. This results in the first convolution of material being looped or loosely wound about the mandrel. For the purpose of defining this invention, the effective surface speed of the nip roll is the speed at which the nip roll drives the sheet material it is in contact with. The effective surface speed of the nip roll differs from the actual surface speed of the nip roll by subtracting the surface speed lost to slippage between the nip roll and the sheet material. During the winding of convolutions subsequent to the first, the effective surface speed of the nip roll must become equal to or less than the surface speed of the sheet material the nip roll engages in order to avoid looping or wrinkling the subsequent convolutions. By the apparatus and method of this invention, a tubular body may be formed on a mandrel in which the first convolution, which is directly adjacent the mandrel, has an inside diameter slightly greater than the outside diameter of the mandrel. The first convolution of material is in effect looped about the mandrel. Subsequent convolutions are formed that are tightly compacted about the preceding convolution. The result is a tubular body that can be easily stripped from the mandrel; yet a tubular body in which the adjacent convolute layers are tightly wound adjacent each other to provide a rigid composite structure.

It should be noted at this point that the tubular bodies formed by the method and apparatus of this invention can be comprised of one or more convolutions. It being further understood that a tubular body having a single convolution would have to have overlapping portions which could be joined to form an integral tubular unit. Each additional convolution about the mandrel adds another layer of material to the thickness of the tubular body. A preferred embodiment useful as can bodies would comprise three to four convolutions wound about the mandrel. The sheet material from which the tubular body is formed may be comprised of relatively inexpensive kraft board. The portion of the sheet forming the first convolution and therefore the inside of the can, may include a coating or layer of barrier material. The last convolution may include a label which would surround the outside face of the tubular body. Adhesive is applied between the layers to form a composite tube.

Prior art devices are old and well known in which a sheet of material is passed between a nip roll and a mandrel and wound about the mandrel to form a tubular body. One of the difficulties encountered in the prior art, however, is that the tubular body formed in this manner may be so tightly wound about the mandrel that it is difficult to strip the finished tubular body from the mandrel. In the high speed operation of modern tube winding apparatus, it is imperative that the formed tubular

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body be readily stripped from the mandrel with a minimum of wasted time and effort.

The deficiencies of the prior art are overcome by my invention which utilizes the relatively simple but unobvious expedient of driving the nip roll at a greater effective surface speed than the mandrel, while the first convolution of the sheet material is formed about the mandrel. The result is a first layer of material looped or loosely wound about the mandrel and readily removable therefrom. Subsequent layers of material which are wound about the first layer during subsequent convolutions must be tightly compacted one against the other and not loosely wound or looped as was the first layer. This invention discloses several embodiments of apparatus which are capable of winding tubes having the desirable characteristics and effects noted above.

Various embodiments of this invention will now be described in detail with reference to the accompanying drawings in which:

FIGURE 1 shows an arrangement of a nip roll and mandrel used in this invention.

FIGURES 2, 3 and 4 show a fragmentary view of a sheet of material being fed between the nip roll and mandrel and wound on the mandrel in accordance with this invention.

FIGURE 5 shows the effect of winding the first convolution about the mandrel in accordance with this invention wherein the effective surface speed of the nip roll is only slightly greater than the surface speed of the mandrel.

FIGURES 6 and 7 show the effect of winding the first convolution at increased effective surface speeds of the mandrel.

FIGURE 8 shows another arrangement of the nip roll and mandrel wherein the diameter of the nip roll is approximately four times the diameter of the mandrel.

FIGURE 9 shows another arrangement for the nip roll and mandrel wherein the nip roll is positively driven only during the winding of the first convolution.

FIGURE 10 is an end view taken along the lines 10-10 of FIGURE 9.

Referring now to FIGURE 1 of the drawing, a mandrel 1 is shown mounted for rotation in bearings 2 and 3. Mandrel 1 is provided with a chamber 4 extending along the longitudinal center line of the mandrel. The chamber 4 is connected to a source of vacuum 5 by means of a conduit 6 and a coupling 7. Suction openings 8 extend from the surface of the mandrel and communicate with the chamber 4 to define a path of vacuum flow to the outside surface of the mandrel. A nip roll 9 is mounted adjacent the mandrel 1 by means of bearings 10 and 11. Bearings 10 and 11 are supported by piston members 12 and 13. The pistons 12 and 13 are mounted in air cylinders 14 and 15. The piston is adapted to raise and lower the nip roll relative to the mandrel in order to maintain a constant pressure between the mandrel and the nip roll. Air cylinders 14 and 15 are connected to a source of air pressure 17 through conduits 18, 19 and 20. A motor 21 drives a gear 22 mounted thereon which meshes with a gear 23 on the mandrel. Gear 23 meshes with a gear 24 on the nip roll. The ratio between the gears 23 and 24 is selected so that nip roll 9 is driven at a slightly greater surface speed than the mandrel 1. The required differential in surface speed between the mandrel 1 and the nip roll 9 cannot be stated with any degree of exactness or by a formula. The differential speed is best determined empirically during the operation of the winder since it depends on a number of variables. These variables include, among others, the smoothness of the sheet material to be wound on the mandrel, and the friction characteristics of the nip roll and of the mandrel. For example, the lower the friction between the surface of the sheet ma-

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terial and the nip roll; the greater the required difference in speed for a given pressure in the nip. This is so because with smooth sheet material the effective surface speed of the nip roll is reduced because of slippage between the roll and the sheet.

Since the effective surface speed of the nip roll is greater than the surface speed of the mandrel during the winding of the first convolution; the sheet material will be looped outwardly beyond the mandrel (as shown in FIG. 3) to provide a first layer of material directly adjacent the mandrel which is loose on the mandrel. During the winding of the second and subsequent convolutions (as shown in FIG. 4), there must be no looping of one layer of material on the other. It is therefore necessary that during the winding of the second and further convolutions of the sheet material about the mandrel, the effective surface speed of the nip roll must become equal to or less than the surface speed of the sheet material being wound on the mandrel. This result will occur when the correct differential speed is chosen as explained below.

The looping of the first convolution about the mandrel when the nip roll is driven faster than the mandrel can be explained in the following manner. During the winding of the first convolution, the friction between the mandrel and the sheet material is less than the friction between the sheet material and the nip roll. This is assured by coating the surface of the nip roll with rubber or other material to increase the friction. The sheet material is thus driven by the nip roll faster than by the mandrel and slips relative to the mandrel to produce the desired looping. During the winding of the second convolution, however, the sheet material instead of being pressed against the mandrel is now pressed against the first layer of sheet material that has been wound on the mandrel. (Note FIG. 3.) There is also an adhesive between the layers of sheet material which increases friction between the layers. The friction between the two layers of sheet material is therefore greater than the friction between the nip roll and the sheet material. Slipping occurs at the point of least friction; therefore increased slippage occurs between the nip roll and the sheet material. Because of the increased slippage between the nip roll and the sheet material, the effective surface speed of the nip roll becomes equal to or less than the surface speed of the sheet. The increase in wall thickness of the tube as each convolution is formed is also helpful in making the effective surface of the nip roll equal to or less than the speed of the outer surface of the tube being formed on the mandrel. Convolutions formed subsequent to the first are therefore neither looped nor wrinkled as one might expect they would be. At all times, the nip roll bears against the sheet material being wound and compresses the several layers against the mandrel as seen in FIG. 4. It is apparent that in order to carry out the invention illustrated in FIG. 1 successfully, one must carefully select the differential speed between the mandrel and the nip roll, and in so doing must take into consideration the effects of friction which occur between the nip roll and the sheet material, the mandrel and the sheet material, and between the layers of sheet material being wound on each other.

In order to make these variables more easily determinable, I have devised other embodiments of this invention described below which automatically compensate for the variables described above.

In FIG. 8, I show a modified embodiment of my invention in which the nip roll 30 has a substantially greater diameter than the mandrel 31. It should be noted at this point that the nip roll and mandrel shown in FIG. 8 can be mounted in substantially the same manner as the embodiment of FIG. 1.

A gear 32 is mounted at one end of mandrel 31 and is driven by motor means not shown. A gear 33 is mounted at one end of nip roll 30 and meshes with gear 32 of the mandrel. The ratio of gears 32, 33 is selected so that the mandrel will revolve 2, 3 or 4 times for each

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revolution of the nip roll. Thus, if a container is to be formed on the mandrel with four convolutions, the gear ratio would be 4-1. By this arrangement, the nip roll and mandrel are always in the same starting position to receive sheet material, and the suction openings on the mandrel are always in proper position to grip the sheet material fed between these elements.

In accordance with my basic concept, the nip roll is driven at a greater surface speed than the mandrel to produce a looping of the first convolution as described in detail with reference to the embodiment of FIG. 1. In order to attain the desired differential surface speeds of the mandrel and nip roll, the outside diameter of the nip roll is made slightly greater than the pitch diameter of gear 33 which drives the nip roll. The outside diameter of the mandrel is made correspondingly smaller than the pitch diameter of gear 32 which drives the mandrel.

The portion of the nip roll which bears against the first convolution of sheet material is provided with a high friction surface 34 as seen in FIG. 8. The high friction characteristic of this portion of the nip roll may be imparted to the roll by roughening this portion of the surface, by coating with rubber, or by applying a high tack coating. The rest of the surface of the nip roll which bears against the portion of the sheet material forming the subsequent convolutions is made very smooth so as to have very low friction characteristics.

By this arrangement, the nip roll will cause the first convolution of sheet material to loop outwardly of the mandrel in the manner shown in FIGS. 5-7. This occurs because there is little or no slippage between the nip roll and sheet material due to the high friction surface, and the nip roll has a greater surface speed than the mandrel. During the winding of convolutions subsequent to the first, slippage occurs between the sheet material and the nip roll because of the low friction characteristic of that portion of the nip roll. The convolutions subsequent to the first are not looped since the slippage which occurs makes the effective surface speed of the nip roll equal to or less than the surface speed of the sheet material being wound on the mandrel. The resultant tube formed on the mandrel has tightly compacted layers with the first layer loose on the mandrel and readily stripped therefrom.

A preferred embodiment of my invention is illustrated in FIGS. 9 and 10.

The arrangement and support of the nip roll and mandrel in the embodiment of FIGS. 9 and 10 is the same as that illustrated in FIG. 1. The drive mechanism of the nip roll and mandrel, however, has been modified to produce the desired looping and compacting of the formed tube in a novel and highly desirable manner. In the arrangement shown in FIGS. 9 and 10, the nip roll is positively driven only during the winding of the first convolution of the tube. During the winding of convolutions subsequent to the first, the nip roll is rotated only by frictional engagement with the being formed tube. By a proper selection of gear ratios, the nip roll is positively driven at a greater effective surface speed during the forming of the first convolution of the tube. During the winding of subsequent convolutions on the mandrel, the surface speed of the nip roll automatically becomes equal to the surface speed of the being formed tubing.

Referring now to FIG. 9, a mandrel 40 is driven by gear 42 secured thereto at one end. Nip roll 43 is driven by gear 44 secured thereto at one end. A drive shaft 45 is connected to a drive motor not shown. Gear 46 on shaft 45 drives a large gear 47 which in turn drives gear 42 and mandrel 40. Gear 47 is keyed to shaft 48 which has another gear 49 keyed to its other end. Gear 49 in turn meshes with and drives gear 50 mounted on shaft 51. Mounted on the opposite end of shaft 51 is a large gear 52 which drives gear 44 and nip roll 43. In order to drive nip roll 43 at a greater surface speed than mandrel 40, the gear ratios are arranged in the following manner. Gears 42, 46, and 49 have the same pitch diameter. Large

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gears 47 and 52 also have the same pitch diameter which may be approximately four times the diameter of gears 42, 44, 46 and 49, if four convolutions are to form the tubular body. Gear 50 has a pitch diameter smaller than gears 42, 44, 46 and 49 to drive the nip roll at a greater speed. Large gear 52 has teeth which mesh with gear 44 on only $\frac{1}{4}$ of its surface as seen in FIG. 9. Thus, gear 52 only drives the nip roll through one revolution to form the first convolution of the tubular body. After the first convolution is formed, the nip roll gear 44 disengages from large gear 52 and the nip roll is driven only by frictional engagement with the being formed tube on the mandrel. The nip roll 43 is thus free to rotate at exactly the same speed as the being formed tube.

In summary then, nip roll 43 is driven at a greater surface speed than mandrel 40 for one complete revolution by the engagement of gear 44 with large drive gear 52. After the first revolution, gears 44 and 52 disengage and the nip roll 43 is driven only by frictional engagement with the being formed tube on the mandrel. Since the speed of the nip roll is greater than the speed of the mandrel during the first revolution, a sheet fed between the nip roll and mandrel will loop about the mandrel in the manner illustrated in FIGS. 5-7. During the forming of convolutions subsequent to the first, the nip roll is not positively driven and rotates only because of frictional engagement with the being formed tube. The nip roll functions during the winding of the subsequent convolutions only to compress the layers of the tube together. There is no further looping of the subsequent convolutions.

It should be understood that in forming tubes having 4 layers of material and requiring four complete rotations of the mandrel, the ratio of gears 47 to 42 will be approximately 4 to 1. If only three convolutions are desired, this ratio will be approximately 3 to 1, and so forth.

While this invention has been described in detail with reference to the preferred embodiments illustrated in the accompanying drawings; variations and modifications are contemplated which are within the spirit and scope of the appended claims.

What is claimed is:

1. A method of forming tubular bodies from sheet material comprising the steps of inserting a sheet into the nip between a winding mandrel and a nip roll, releasably securing an edge of said sheet to the mandrel for a predetermined interval of time, and rotating the nip roll at a greater effective surface speed than the mandrel during the winding of the first convolution of material about the mandrel so that the first convolution is looped slightly about the mandrel and readily removable therefrom.

2. A method of forming convolute tubular bodies from sheet material comprising the steps of providing a rotatable mandrel and nip roll, inserting the sheet material into the nip between the mandrel and nip roll, releasably securing an edge of said material to said mandrel for at least a portion of the time required for the mandrel to make one complete revolution, and feeding said sheet around said mandrel at a greater surface speed than the surface speed of the mandrel, so that the sheet is looped about the mandrel to facilitate removal of the tubular body formed about the mandrel.

3. The method of claim 1 further including the step of adjusting the pressure between the mandrel and nip roll as the tube is formed.

4. The method of claim 1 including the step of automatically reducing the effective surface speed of the nip roll so that it is equal to or less than the surface speed of the being formed tube as convolutions subsequent to the first are formed on the mandrel.

5. A method of winding tubular bodies about a mandrel comprising the steps of inserting the edge of a sheet into the nip between a mandrel and a nip roll, releasably securing the edge of the sheet to the mandrel, turning the nip roll at a greater effective surface speed than the mandrel

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during the winding of the first convolution of material about the mandrel so that the first convolution loops about the mandrel, and automatically adjusting the surface speed of the nip roll so that it becomes substantially equal to the surface speed of the being wound sheet as subsequent convolutions are formed.

6. The method of claim 5 further including the step of adjusting the nip pressure between the mandrel and nip roll.

7. A method of winding and compacting a convolute tubular body on a mandrel comprising the steps of advancing a sheet of stock between a rotatable nip roll and mandrel, releasably securing the leading edge of the sheet to the mandrel, rotating said nip roll at a surface speed greater than the surface speed of the mandrel so that the convolute tubular body developed has an internal diameter larger than the exterior diameter of said mandrel with overlapped layers of material tightly compacted in face-to-face contact.

8. The method of claim 7 including the step of increasing the speed of said nip roll relative to the speed of the mandrel so as to increase the diameter of the tube body relative to the diameter of the first roll.

9. The method of claim 8 wherein the leading edge of the sheet is releasably secured to the mandrel for an interval corresponding to the time required to wind at least one convolution about the mandrel.

10. Apparatus for forming sheet material into tubular bodies comprising a rotatably mounted mandrel, a rotatably mounted nip roll adjacent said mandrel, said mandrel having openings extending to the outer surface thereof through which suction can be applied to grip the leading edge of said sheet material, means connecting said openings to a vacuum source, means operative to adjust the nip pressure between the mandrel and nip roll, and drive means for rotating said nip roll at a greater effective surface speed than said mandrel during the winding of said first convolution of sheet material about said mandrel.

11. The apparatus of claim 10 in which said nip roll has a diameter which is substantially greater than the diameter of said mandrel so that a single rotation of the nip roll is effective to form a tubular body on the mandrel having a plurality of convolutions.

12. The apparatus of claim 11 in which the portion of the surface of the nip roll which engages the sheet material forming the first convolution about the mandrel has high friction characteristics and the remainder of the surface of said nip roll is smooth and has low friction characteristics.

13. Apparatus for forming sheet material into tubular bodies including a mandrel and a nip roll mounted for relative rotation, drive means, means for releasably securing a leading edge of said sheet material to said mandrel, first gear means connecting said drive means to said mandrel, second gear means connecting said drive means to said nip roll, said second gear means including an intermediate gear having teeth along only a portion of its periphery, said intermediate gear being operative to drive said nip roll through a single rotation at a greater surface speed than the surface speed of said mandrel and thereafter disengage from the nip roll so that the nip roll rotates freely during the winding of convolutions of material subsequent to the first about the mandrel.

14. Apparatus for forming sheet material into tubular bodies including a mandrel and a nip roll mounted for relative rotation, means on said mandrel to releasably grip a leading edge of said sheet material, a first gear mounted on one end of said mandrel, a second gear mounted on the corresponding end of said nip roll, drive means, first intermediate gear means connecting said drive means to said first gear, second intermediate gear means connecting said drive means to said second gear, said second intermediate gear means including a large gear having teeth on only a portion of its surface, said large gear being adapted to drive said nip roll while engaging

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said second gear at a greater effective surface speed than said mandrel and to thereafter disengage from said second gear so that the nip roll rotates freely as the tubular body is formed on said mandrel.

15. A method of winding sheet material into a tubular body about a mandrel comprising the steps of, releasably securing one edge of said sheet to said mandrel, rotating the mandrel, and feeding the sheet material around the mandrel at a greater effective speed than the speed at which the mandrel is rotating so that the sheet material loops slightly about the mandrel during the winding of the first convolution about the mandrel.

16. A method of forming tubular bodies by convolutely winding a strip of sheet material about a mandrel comprising the steps of, feeding a blank of sheet material toward the mandrel at a given linear speed, releasably se-

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curing the leading edge of said blank to said mandrel and rotating the mandrel at a surface speed which is less than the speed at which the blank is fed around said mandrel so that the first convolution of sheet material formed around the mandrel is slightly looped to facilitate the removal of the tubular body from the mandrel.

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