Jan. 6, 1970 A. C. BERRY 3,488,242

APPARATUS FOR MAKING MULTI-PLY SHEET PRODUCT

Filed June 23, 1966

Fig. 1

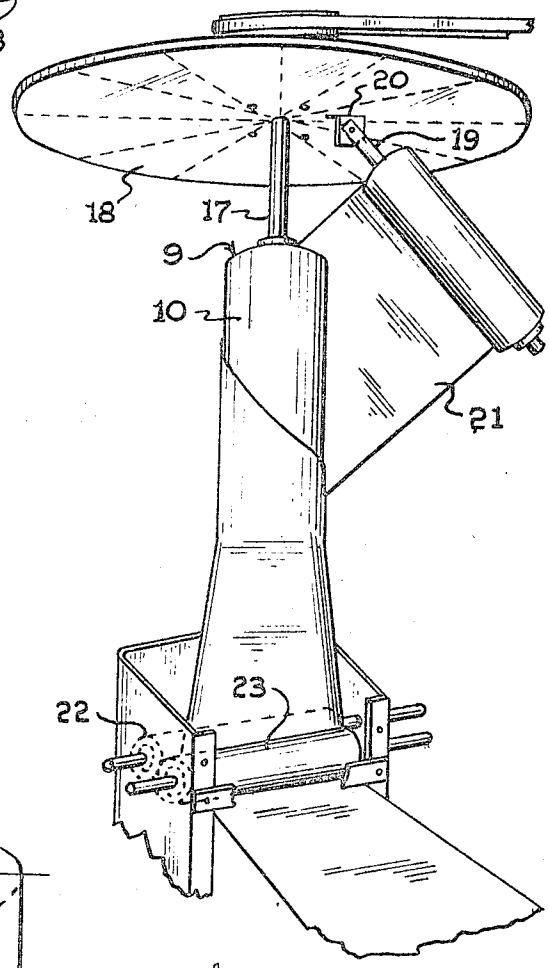


Fig. 2

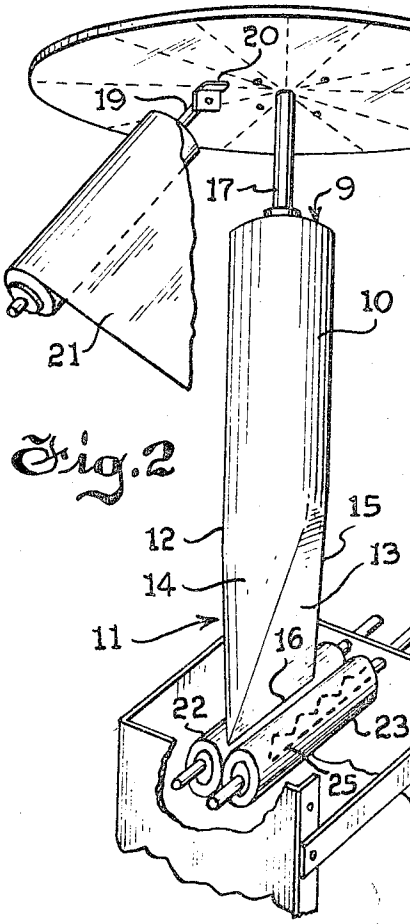


Fig. 3

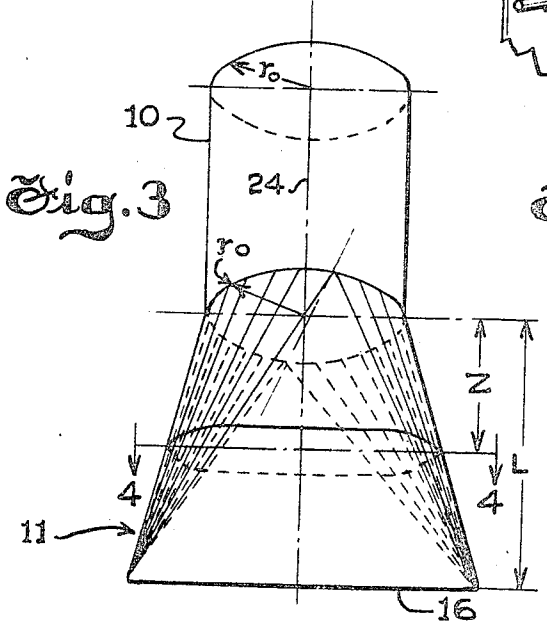
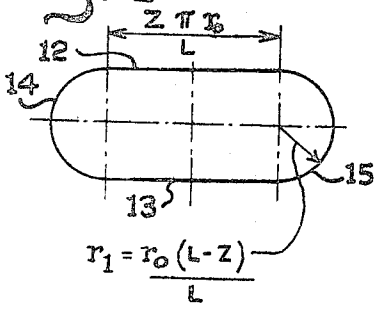


Fig. 4



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APPARATUS FOR MAKING MULTI-PLY SHEET PRODUCT

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U.S. Cl. 156—428 1 Claim

ABSTRACT OF THE DISCLOSURE

A mandrel having a cylindrical portion on which sheet material may be spirally wound as the sheet material is pulled off the free end of the mandrel which is in the form of a straight edge is disclosed. The mandrel has a transition section connecting the straight edge with the cylindrical portion. The transition section in cross section is in the form of flat sided ovals.

The invention relates to papermaking machines and more particularly to machines for making a multi-ply product of sheet material, such as paperlike material.

It has been previously proposed, for example, in Patent No. 1,515,792, to R. B. Respess, to spirally wind a web of sheet material about a central cylindrical mandrel and to pull the sheet material from the end of the mandrel between a pair of pressure rollers for flattening the web so wound into a double ply product and for bonding the plies together. A suitable adhesive may be inserted between the plies of the multi-ply product in order to cause the plies to adhere to each other. It has been found with such a process, however, that in changing the form of the web from cylindrical to flat form, the web wrinkles and distorts so that a final wrinkled two-ply product results.

It is an object of the present invention to provide an improved machine of this type and, in particular, to provide a mandrel of improved shape so that, as the wound web travels longitudinally of the mandrel, it does not wrinkle substantially and results in a correspondingly unwrinkled multi-ply product.

The invention consists of the novel constructions, arrangements and devices to be hereinafter described and claimed for carrying out the above stated objects, and such other objects, as will be apparent from the following description of a preferred form of the invention, illustrated with reference to the accompanying drawing, wherein:

FIG. 1 is a perspective view of a winding machine embodying the principles of the invention and shown in operation with a web of sheet material being wound about the mandrel of the machine;

FIG. 2 is another perspective view of the machine with the sheet material web being broken off and with certain parts of the machine being broken away for clarity of illustration of certain other parts of the machine;

FIG. 3 is a side elevational diagrammatic view of the mandrel of the machine; and,

FIG. 4 is a sectional view taken on line 4—4 of FIG. 3.

Like characters of reference designate like parts in the several views.

Referring now to the drawing, the illustrated machine may be seen to comprise a central mandrel **9** having a cylindrical portion **10**, and a transition section **11** formed by opposite flat portions **12** and **13** and opposite round portions **14** and **15**. The portions **12** to **15** terminate in a straight edge **16**. The mandrel **9** is held stationary and vertical by means of a downwardly disposed fixed rod **17**.

A rotatable disc **18** is disposed above the mandrel **9**, and it has the rod **17** passing through the center of the disc. A downwardly depending coreshaft **19** is fixed with respect to the disc **18** by means of a bracket **20** and carries a roll of paperlike or other sheet material **21** rotatably disposed on the coreshaft **19**.

A pair of nipped calender rolls **22** and **23** are disposed below the mandrel **9** with the straight edge **16** immediately above the nip between the rolls **22** and **23**. The nip of the rolls **22** and **23** extends parallel to the straight edge **16** and lies on the longitudinal center **24** of the mandrel **9**.

In operation, as illustrated in FIG. 1, the disc **18** and thereby the roll **21** are rotated about the longitudinal center **24** of the mandrel **9**, and the web **21** is wound onto the cylindrical portion **10** of the mandrel. The web **21** slides downwardly along the surface of the mandrel and, in particular, on the portions **12** to **15**, down to the straight edge **16**, and the web passes from the straight edge **16** to and between the calender rolls **22** and **23** and from thence to a suitable takeup roll or reel (not shown). The web **21** is helically wound on the cylindrical portion **10** and while on the portion **10** is of course in cylindrical shape; and the cylindrical of sheet material is flattened as the web travels downwardly over the portions **12** to **15** to the straight edge **16** and through the nip between the rolls **22** and **23**. The rolls **22** and **23** are driven by any suitable means (not shown) so as to pull the spirally wound web **21** off the free end of the mandrel **9** defined by the straight edge **16**.

Preferably the web **21** has some thermoplastic fibers within it or else has thermoplastic adhesive within it and at least one of the rolls **22** and **23** is heated, as by an internal electric heater **25**, so that as the web passes between the rolls **22** and **23**, the two plies formed from the flattened web cylinder are thereby caused to adhere to each other to form a unitary two-ply sheet material product. Preferably also, the sheet material web **21** in its original roll form has longitudinally extending, substantially aligned, synthetic filaments or has aligned, staple fibers within it; and, due to these filaments or fibers, the sheet material web **21** is very strong in the longitudinal direction. Since the web **21** is wound spirally on the mandrel **9**, and since its cylindrical form is flattened as the web passes between the calender rolls **22** and **23**, one ply of the composite material extends at 45° with respect to the longitudinal dimension of the final composite web, and the other ply also extends at 45° to the web but at 90° with respect to the other ply. Thus strength is imparted to the composite sheet material product primarily in two directions extending at 90° with respect to each other and both extending at 45° with respect to the longitudinal dimension of the composite sheet material product.

It is very desirable that the web **21**, as it passes downwardly on the mandrel **9** and along the transition section **11** to the straight edge **16**, remain in unwrinkled condition, otherwise the wrinkles are calendered into the composite laminated final product and the final product is not smooth. I have discovered that if the transition section **11** of the mandrel **9** is made so that, in cross section, the side portions **12** and **13** are flat and the rounded end portions **14** and **15** are circular, considering the mandrel **9** in cross section between the cylindrical portion **11** and the straight edge **16**, substantial web wrinkling does not occur. Also, the perimeter of each cross section of the transition section **11**, from the cylindrical portion **10** to the straight edge **16**, shall preferably be the same and equal to the circumference of the cylindrical portion **10**.

Referring to the diagrammatic illustration of the mandrel shown in FIG. 3 and to the cross section of the mandrel shown diagrammatically in FIG. 4, which is taken through the transition section **11** between the cylindrical portion **10** and the straight edge **16** on any plane spaced a distance Z from the lower end of the cylindrical por-

tion **10** and disposed at right angles to the longitudinal center line **24** of the mandrel, it will be apparent that the perimeter of such a cross section, if it is to be equal to the circumference of the cylindrical portion **10**, shall be equal to $2\pi r_0$ where r_0 is the radius of the cylindrical portion **10**. If this relationship is to hold along the straight edge **16**, the length of the straight edge must, therefore, be equal to πr_0 which is one-half the circumference of the cylindrical portion **10**. I have found that the perimeters of the various cross sections through the transition section **11** will also be equal to $2\pi r_0$ (the circumference of the cylindrical portion **10**) if

$$r_1 \text{ equals } \frac{r_0(L-Z)}{L}$$

and if the length of each of the flat portions **12** and **13** in cross section equals $Z\pi r_0/L$, where L is the distance between the lower end of the cylindrical portion **10** and the straight edge **16**, Z is the distance from the lower end of the cylindrical portion **10** to the plane of the particular cross section being considered and r_1 is the radius of curvature of the end portions **14** and **15** in cross section.

The following mathematical equations may be utilized to prove that the perimeter (designated as P) of any cross section taken through the transition section **11** of the mandrel **9**, below the cylindrical portion **10**, is equal to the circumference of the cylindrical portion which is $2\pi r_0$, if the radius r_1 equals

$$\frac{r_0(L-Z)}{L}$$

and if the length of each of the flat sides **12** and **13**, as seen in cross section, equals $Z\pi r_0/L$:

$$P=2\frac{Z\pi r_0}{L}+2\left[\frac{\pi r_0(L-Z)}{L}\right] \quad (1)$$

$$P=\frac{2\pi r_0}{L}(Z+L-Z) \quad (2)$$

$$P=2\pi r_0=\text{Circumference of cylindrical portion 10} \quad (3)$$

Utilizing Equation 1 it will be apparent that if Z equals zero for the cross section at the lower end of the cylindrical portion **10**, the first term of Equation 1 is zero and the second term of Equation 1 equals $2\pi r_0$, satisfying the one end condition for the transition section **11** of the mandrel. For the other end condition, when Z equals L at the straight edge **16**, the second term of Equation 1 is zero and the perimeter P equals $2\pi r_0$, thus satisfying the other end condition. For each intermediate cross section of the transition section **11** of the mandrel **9** comprising the portions **12** to **15**, both terms of Equation 1 have finite values and add up to $2\pi r_0$.

In view of the fact that the perimeter of the mandrel **9**, considering it in cross section from one end to the other, is the same, and in view of the fact that the portions **14** and **15** are circular and the portions **12** and **13** are flat, there is no substantial wrinkling of the web **21** due to web distortion as the web travels down the mandrel **9** in producing bias cross laid product. Therefore, the web **21**, as it is wound onto the mandrel **9**, travels at a substantially constant linear speed; and the amount of

overlap or the amount of space between successive turns of the spirally wound web **21** may be quite accurately controlled.

It is contemplated that, for best results, the dimension L is preferably substantially greater than multiples of the radius r_0, in view of the fact that there is some slight stretching of the material **21** in portions as it travels along the transition section **11**, which stretching is, however, decreased as the dimension L is increased with respect to the radius r_0. Material of the type above mentioned, for example, allows a 2½ percent stretch within its elastic limit (measured on the 45° bias direction of the material); and it can be shown mathematically that if the dimension L is equal to or greater than $4r_0$, the amount of stretch of the material **21** as it passes over the transition section **11** is substantially less than the 2½ percent stretch capabilities of the material **21**. Therefore, I prefer that the dimension L shall be equal to or greater than $4r_0$.

I wish it to be understood that the invention is not to be limited to the specific constructions, arrangements and devices shown and described, as it will be apparent to those skilled in the art that changes may be made without departing from the principles of the invention.

What is claimed is:

1. In apparatus for making a multi-ply sheet product, a mandrel having a cylindrical portion on which sheet material may be spirally wound as the sheet material is pulled off a free end of the mandrel, said free end being in the form of a straight edge and said mandrel having a transition section connecting said straight edge with said cylindrical portion, said transition section in cross section from said cylindrical portion to said straight edge being in the form of a continuous series of flat sided ovals; the flat sides of the oval of each cross section of said transition section having a length of $Z\pi r_0/L$ and the ends of said oval being circular and having a radius of

$$\frac{r_0(L-Z)}{L}$$

where L is the length of the transition section from said cylindrical portion to said straight edge, Z is the distance from said cylindrical portion to the particular cross sectional plane in said transition section being considered, r_0 is the radius of said cylindrical portion, and the dimension L is not less than $4r_0$.

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