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Dowd, Jr.

[11] **3,856,226**

[45] **Dec. 24, 1974**

[54] **METHOD AND APPARATUS FOR CORELESS SPOOL PRODUCTION**

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Related U.S. Application Data

[62] Division of Ser. No. 216,629, Jan. 10, 1972, Pat. No. 3,802,639.

[52] **U.S. Cl.** .... **242/56 R**
[51] **Int. Cl.** **B65h 17/02**
[58] **Field of Search** .... 242/56 R, 67.1 R, 67.2, 242/67.3 R

[56] **References Cited**

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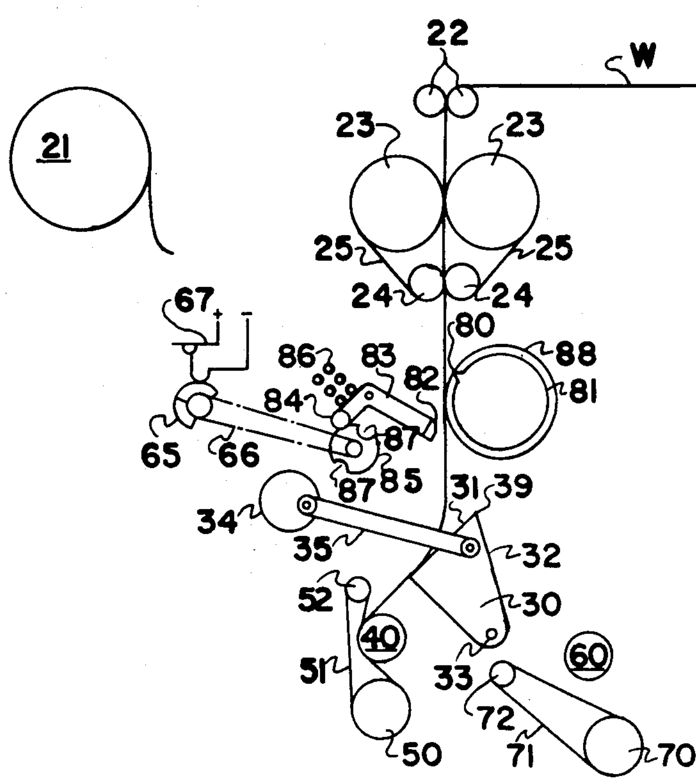
Attorney, Agent, or Firm—R. L. Schmalz; W. A. Marcontell

[57] **ABSTRACT**

Coreless spools, alternately wound on two spindle mounted mandrels from a continuous web supply of thin sheet material, are jet propulsively ejected from the mandrels by pressurized fluid conducted thereto. Loose end portions of the completed spools are rewrapped about the spool body by bridging a gap between two conveyors and two air curtains.

13 Claims, 12 Drawing Figures



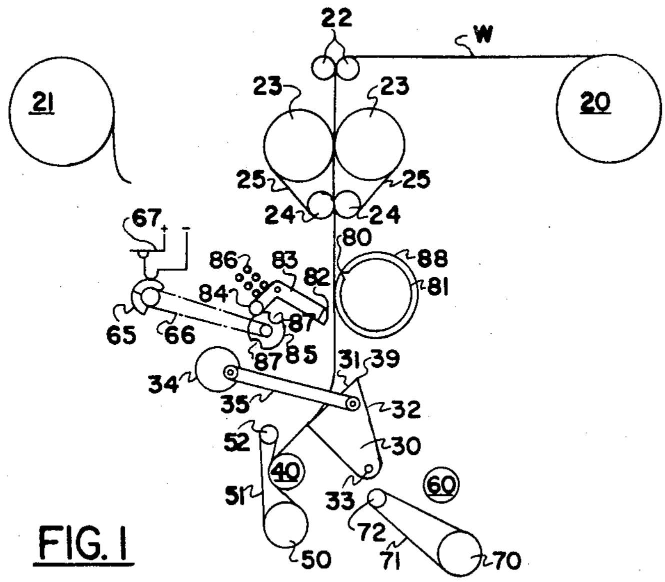


FIG. 1

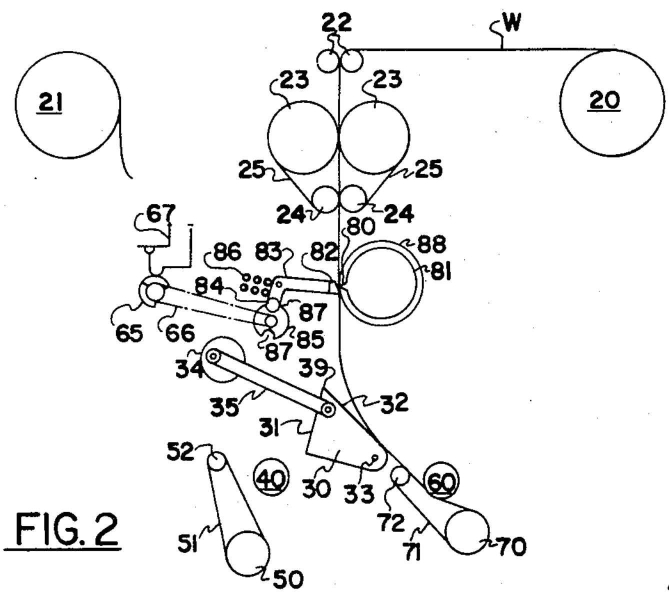


FIG. 2

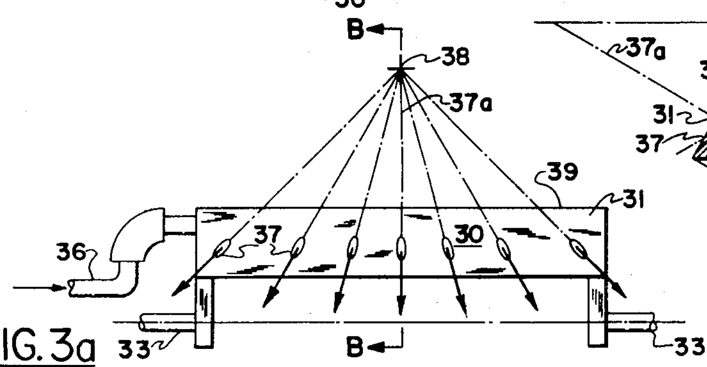


FIG. 3a

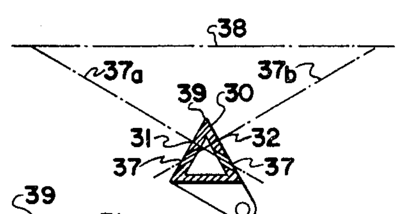


FIG. 3b

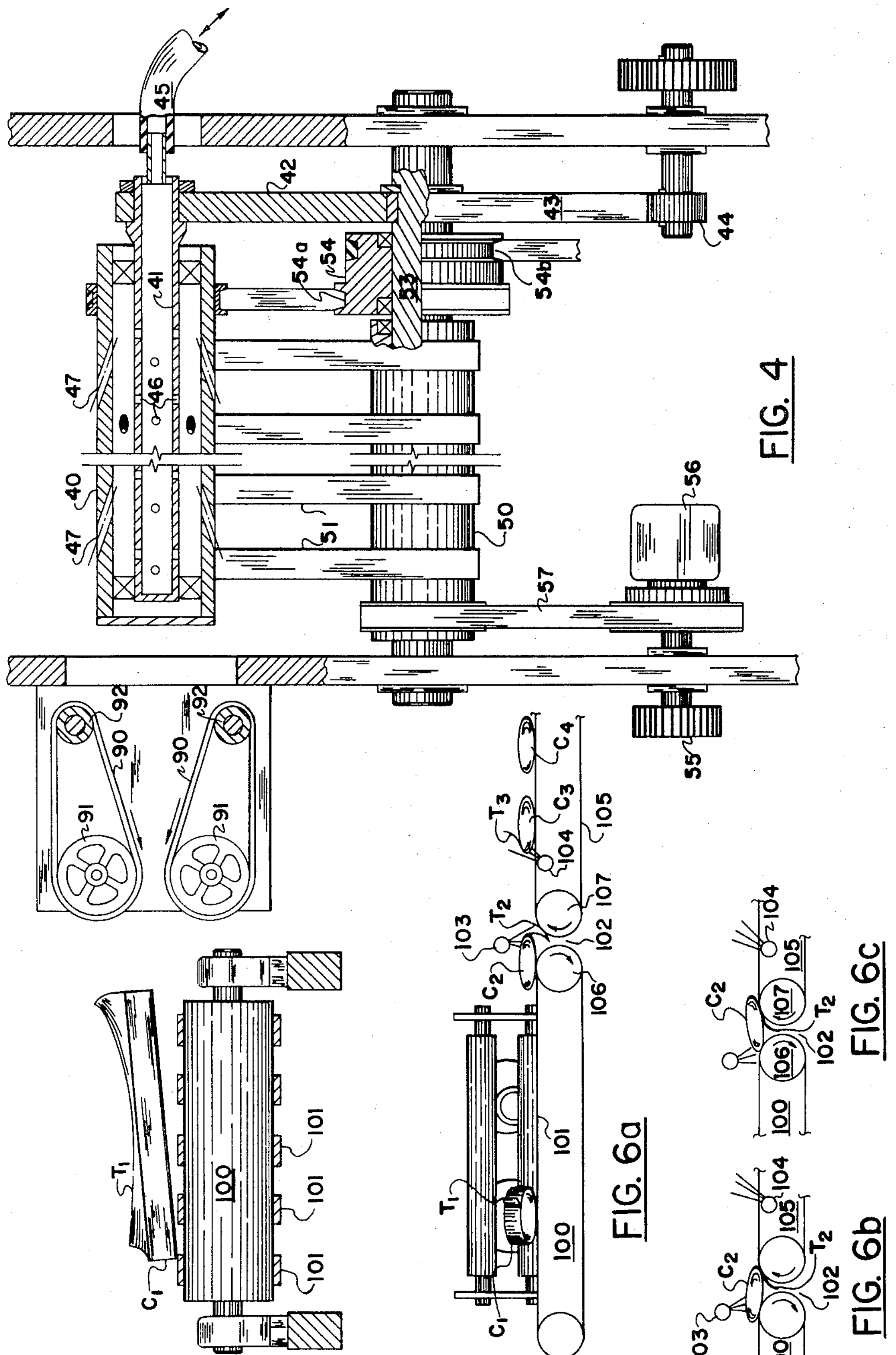


FIG. 4

FIG. 6a

FIG. 6b

FIG. 6c

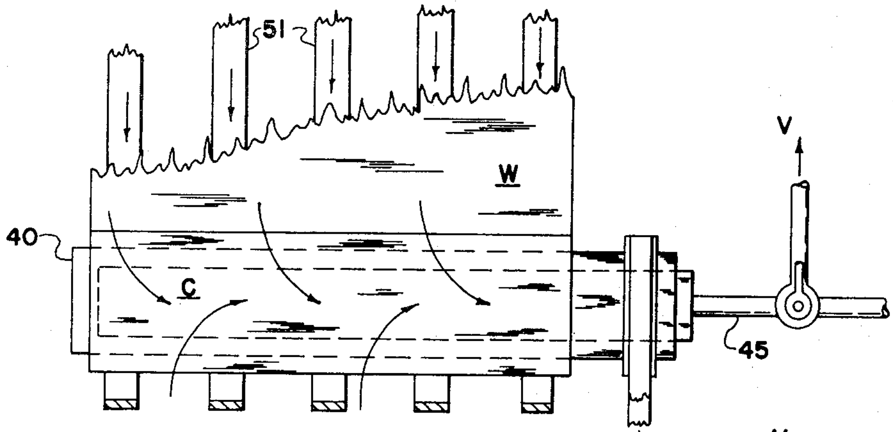


FIG. 5a

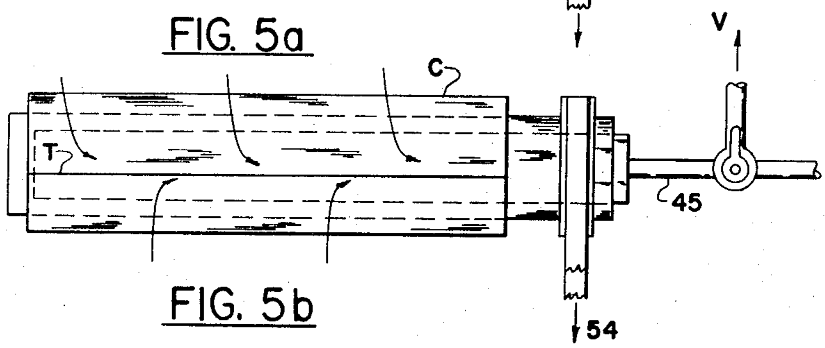


FIG. 5b

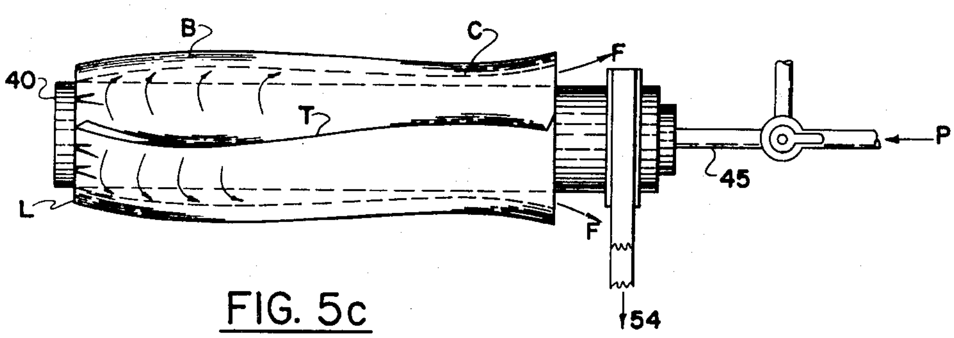


FIG. 5c

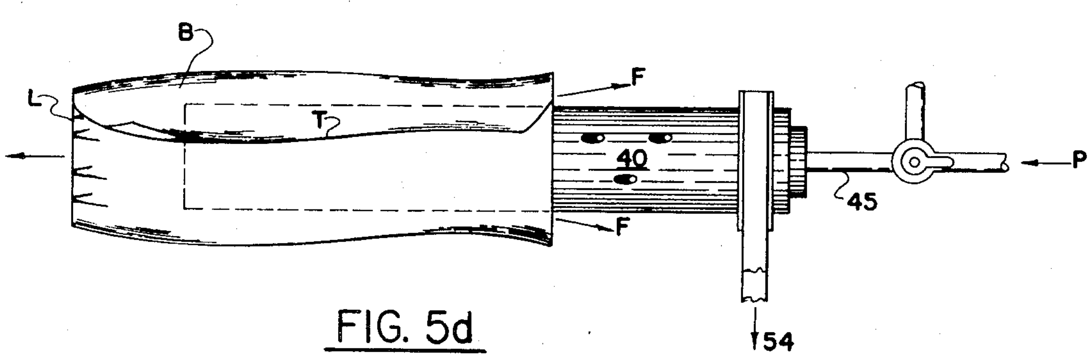


FIG. 5d

METHOD AND APPARATUS FOR CORELESS SPOOL PRODUCTION

This is a division, of application Ser. No. 216,629, filed 1/10/72 and now issued as U.S. Pat. No. 3,802,639.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the art of sheet material handling and more particularly to spool winding for the paper converting industry.

2. Description of the Prior Art

The use of spindle mounted winding mandrels for the production of coreless spools from thin sheet material such as "crepe" or "tissue" paper is a well established practice in the art.

To assist the starting wrap and spool removal, alternate communication of the mandrel surface with vacuum and pressure fluid sources has been taught by E. A. Link in U.S. Pat. No. 2,575,631.

Although such fluid assistance for starting and finishing a spool winding cycle as taught by Link is of value, manual removal of the finished spool is still necessary. Accordingly, if greater production rates from such spool winding devices are to be realized, such manual functions in the operation must be eliminated.

SUMMARY OF THE INVENTION

An objective of the present invention, therefore, is to provide a method and apparatus for rapid and positive ejection of a completed spool from the winding mandrel.

Another object of the invention is to teach a material flow strategy to a plurality of winding mandrels.

Another object of the invention is to teach a method and apparatus for rewrapping loose ends of ejected spools.

These and other objects of the invention may be accomplished by driving the web flow path into an oscillating deflector for chuting the web to one of a plurality of winding mandrels.

The leading edge of the web is drawn into a converging nip between the receiving mandrel and surface friction drive belts therefor. A vacuum bias applied to the surface of the mandrel serves to adhere the web leading edge thereto until the first full wrap is complete and assists with tight, smooth layering for wraps applied thereafter.

When the desired length of web designated to form a spool has passed, the web is transversely severed above the deflector which indexes to the next chute position for directing the new leading edge into the next winding apparatus.

Meanwhile, tail winding of the previous spool is completed.

Sequentially thereafter, the spool wrapped mandrel disengages from the surface drive belts for acceleration to a greater rotational velocity. The mandrel surface vacuum is then replaced with a pressurized fluid flow which expands the spool from the mandrel surface in such a manner as to either impulsively or reactively propel the spool over the mandrel end and onto a receiving conveyor. This receiving conveyor delivers the spool across an air curtain which presses any free end portions against the conveyor surface plane to be carried into a gap between the delivery end of the receiving conveyor and the receiving end of a delivery conveyor. The gap dimensions, however, are insufficient to accommodate the main spool body which bridges the gap in transfer from said receiving to said delivery conveyor. The transition causes the free end portion to be drawn from the gap and under the spool main portion.

A subsequent air curtain may be used to blow any remaining free end portion of the spool up and over said main body portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of the present invention showing the spool winding operation on one of two mandrels.

FIG. **2** is a schematic representation of the present invention showing the spool winding operation on the other of the two mandrels with the cutting mechanism engaged.

FIG. **3*a*** is a side elevation of the deflector apparatus.

FIG. **3*b*** is an end elevational of the deflector apparatus.

FIG. **4** is an elevational detail of the mandrel, mandrel drive, ejected spool braking mechanism, and the receiving conveyor station shown in partial section.

FIG. **5*a*** is a detail of the mandrel and drive mechanism during the spool winding process.

FIG. **5*b*** shows the next sequential step from FIG. **5*a*** in preparation of a wound spool for ejection.

FIG. **5*c*** shows the pressurized expansion of a spool immediately antecedent to ejection.

FIG. **5*d*** shows the initial ejective movement of a spool from the mandrel.

FIG. **6*a*** schematically shows the spool receiving and delivery conveyors for rewinding loose end portions thereof.

FIGS. **6*b*** and **6*c*** sequentially show a spool bridging the gap between the two conveyor sections to illustrate a critical portion of the rewrapping process.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring initially to the schematic of FIG. **1**, a continuous web W of paper, foil or other thin sheet material of indefinite length is drawn from the active supply roll **20** and turned over one of bars **22** into the nip of the web pulling section.

This pulling section comprises pulling drums **23** which are driven cylinders having a traction belt **25** wrapped partially thereabout. For greater area distribution of the pulling section nip pressure, the portion of the belts **25** in actual contact with the web W is increased by turning the belts over idler rolls **24**.

Since the web W path through the pulling section is vertical, supply rolls **20** and **21** may be positioned on either side thereof. Accordingly when the web material from one roll is exhausted, supply from a reserve roll **21** may be started immediately with minimum time loss.

Upon emerging from the pulling section nip, web W is passed between cooperative cutting elements **80** and **82** held at the open position and deflected by the left face **31** of deflector **30** into the nip between winding mandrel **40** and winding belts **51**.

Deflector **30**, as further shown in FIGS. **3*a*** and **3*b*** is an elongated, hollow triangular body that is offset positioned from the axis of journals **33**. Position control of the deflector is provided by means of an eccentric **34** driven connecting rod **35**. Such position control comprises a small angle oscillatory movement of the deflector apex **39** from the position shown in FIG. **1** on the right side of the web path to the position shown in FIG. **2** on the left side of the web path.

Since, in many cases, the web W product comprises extremely thin material such as "crepe" or "tissue" paper, means are provided by the deflector **30** to prevent undesirable wrinkling and folding of the web as it turns from the straight line path out of the pulling section. Such means provided by the present invention comprises a plurality of low velocity air jets **37** emanating from the deflector body at a shallow angle from the plane of the deflector face **31**. Moreover the axes **37*a*** and jets **37** are respectively disposed in a radial array of planes emanating from axis **38** which is transverse of the web path W and remote from the deflector apex ridge **39**. This radial or fan-like array of axes **37*a*** provides a subtle but effective transverse and longitudinal smoothing of the web plane as it enters the nips between mandrel **40** and winding belts **51**.

Air supply to deflector **30** hollow interior is conventionally provided through a flexible conduit **36** from a suitable pressurized source. Of course, the jets **37** are provided on both faces **31** and **32** of the deflector **30**.

At this point in the machine cycle, mandrel **40** is internally evacuated causing an atmospheric draft radially inward through perforations **47** (FIG. **4**) in the outer mandrel wall as will be described in greater detail relative to FIGS. **4** and **5**.

As the nips between mendrel **40** and belts **51** press or wipe the web W into intimate contact with the mandrel **40** outer surface, the atmospheric pressure differential across the web thickness adheres the leading edge thereof to the mandrel surface for completion of the first full wrap after emerging from the nip between the mandrel and the belts **51**. Thereafter, successive wraps of a continuous web length are wound thereon to complete a coreless spool.

Rotational force is provided to the mandrel **40** by surface friction drive from the belts **51** which, in turn, are driven by one of the turning rolls **50** and **52**.

The length of web W wound upon the mandrel may be determined by any of several well known techniques including a gear mechanism or a timer. Although the details of a suitable drive mechanism for the web cutting mechanism shown are not illustrated, it should be understood that many such mechanisms are known to the prior art. Depending on the degree of precision desired for the cut length of web W, the rotational position of drum **81** may or may not be positively coordinated with the rotational position of cam **85**. If the web W cut length may fluctuate within a tolerance defined by the circumferential arc of knife edge **80**, the continuously rotating drum **81** may be free of any coordinating mechanism with cam **85**. The particular technique selected for description herewith, however, is to cyclically coordinate, by means of chain drives, for example, the angular position of rotating knife drum **81** with that of cam detents **87**. By making the speed of traction belts **25** independently variable of the cutting unit rotational speed, the desired length of web W to form a spool may be determined by the web W velocity.

When the desired length of web W has passed cam **85** is rotated so that one of the detents **87** thereon aligns with the bell crank **83** follower **84**. Spring **86** provides the bias to urge the follower **84** into continuing contact with the surface of cam **85**.

When the follower **84** drops into a detent **87**, the bell crank **83** rotates the few degrees necessary to bring the anvil **82** into cutting position. When the rotating drum **81** mounted knife edge **80**, traveling at a greater surface speed than the web W, reaches complimentary alignment with the anvil **82**, the web W is sheared therebetween.

To prevent the leading edge of web W following a cut from momentarily adhering to the anvil **82**, drum **81** is sheathed with a resilient foam material **88**, the circumferential surface thereof radially projecting slightly beyond the edge of knife **80**. At the moment of cut, the portion of the foam immediately behind the blade **80** presses the web leading edge against the upper surface of anvil **82** for a frictional grip on said leading edge to pull it off the anvil **82**.

The remaining rotating surface elements of sheath **88** sustain touching contact with the web W as it passes thereby lending a positive control assist to the web path.

The rotational speed of cam **85** also provides a convenient timing reference for coordinating the cyclic activity of the deflector **30**, mandrels **40** and **60**, the several drive mechanisms and solenoid actuated fluid control valves as to be subsequently described. Accordingly, a multiple lobe cam shaft **65** is driven by a timing chain **66** from the drive shaft for cam **85** to selectively make and break electrical contacts **67** for each electrically actuated control mechanism appropriate for the functions hereinafter described.

After completely winding the tail of a cut length of web W, winding belts **51** and roller **52** are rotated about the axis of roller **50** to disengage the belts **51** from the wound spool of web W about mandrel **40**. If desired, the machine may be designed so that mandrel **40** is displaced in an opposite direction away from the winding belts **51** for complete disengagement therebetween. At this point, the coreless spool of web W wrapped about mandrel **40** is ejected therefrom in a manner to be subsequently described in detail.

Meanwhile, deflector **30** has been rotated by eccentric **34** mounted connecting rod **35** from the position shown in FIG. **1** to that of FIG. **2** to chute the new leading edge of web W into the nip between winding mandrel **60** and belts **71**. The following events pursuant to winding another coreless spool of web material are the same as previously described relative to mandrel **40**.

When the web spool C_1 (FIG. **6*a***) ejects from the end of mandrel **40**, the speed thereof is first retarded by a breaking section comprising converging belts **90** driven by drums **91** over idlers **98** (FIG. **4**). Here the spool is flattened to an oval and controllably placed on a receiving conveyor section **100** comprising a multiplicity of spaced belts **101**.

Upon emerging from the braking section (FIG. **6*a***), the tails T of the spools C are uncontrolled and are likely to be lifted free and partially unwound from the spool body. To neatly rewrap the tails T onto the spool body C, the receiving and delivery conveyor sections **100** and **105**, respectively, are provided with air curtains from upper and lower manifolds **103** and **104** extending transversely across respective conveyor sections. If the tail has come free from the spool body underside as shown by T_2 in FIG. 6*a*, the tail T_2 is blown by the air curtain from upper manifold **103** into the crevice **102** between the downstream end of receiving conveyor **100** and the upstream end of delivery conveyor **105.** Since the radii of turning drums **106** and **107** are critically sized, as is the width of crevice **102,** the spool body C does not follow the tail T into the crevice but is merely passed tangentially between the drums **106** and **107** across the crevice as illustrated by FIGS. 6*b* and 6*c*. Consequently, the free tail T_2 is wrapped under the spool body C_2.

In the extreme case, where a free tail T yet remains behind a spool C after bridging the crevice **102,** the air curtain from lower manifold **104** blows same up and around to the top side of the spool C as shown in FIG. 6a relative to spool C_3 and tail T_3.

Accordingly, after passing the aforedescribed tail control section, the tails of such spools lay entirely in juxtaposition with the body and in immediate condition for final packaging.

Turning next to the internal details of the winding mandrels and the mechanics of coreless spool ejection, reference if first made to FIG. 4 where the mandrel **40** is shown as a closed, hollow cylinder rotationally mounted on a hollow spindle **41.**

One end of the spindle **41** is rigidly secured to a swing arm **42** journaled about a bearing shaft **53.** Conduit **45** is connected, alternatively, to positive and negative (vacuum) fluid pressure sources. Fluid communication between conduit **45** and apertures **47** through the shell of mandrel **40** is allowed via apertures **46** through the shell of spindle **41.**

Integral with the wing arm **42** but opposite of the shaft **53** axis from the spindle **41** is a cam follower portion **43.** The cam **44,** in cooperation with the follower portion **43,** is functionally effective to swing the mandrel **40** from the winding position of FIG. 1 to the ejection position of FIG. 2.

In the case of winding belt unit **50, 51** and **52,** drum **50** enjoys a fixed axis about shaft **53** but idler drum **51** oscillates between winding and ejection positions. Winding unit **70, 71** and **72,** on the other hand enjoys fixed axes for both drums **70** and **72.** This distinction, however, is a mere designers choice and is not critical to the invention. Nevertheless, for power transmission convenience, drums **50** and **70** should be mounted on fixed axes and driven through a suitable, variable speed transmission **56.** In the FIG. 4 embodiment, power is delivered from the input gear **55,** through the transmission **56** and to the drum **50** via belt **57.**

Experience with the present invention has found the variable speed transmission **56** extremely useful due to subtle distinctions in winding characteristics between different web materials. Even color differences between two, otherwise identical, webs of paper will require different winding speeds.

Although the web W winding drive is delivered by belts **52,** mandrel **40** is also independently driven from a suitable, selectively engageable source, not shown, which delivers power to a transfer reduction sheave **54,** also mounted on shaft **53,** via an input **54*b*** and and output **54*a***.

As indicated above, the shell of mandrel **40** is perforated by a multiplicity of apertures **47** drilled therethrough at an angle of approximately 20° with and in radial planes of the mandrel axis.

The exact number, angle, and distribution pattern of apertures **47** optimum for a given core diameter and weight of particular wound web material are all variable parameters that are dependent upon the pressure and delivery characteristics of a working fluid source and upon the mechanical characteristics of the particular web material.

In a particular example, however, with a 2.75 inch OD and 20½ inch long mandrel provided with 36, 3/32 inch diameter apertures **47,** drilled at a 20° degree angle with the mandrel axis in radial planes, and uniformly distributed around the mandrel circumference in eight symetrically offset rows, spools wound from 20 inch wide and 120 inch long webs of 0.002 caliper crepe paper were quickly and neatly ejected without axial or telescopic expansion with an 18 psi source of air pressure.

As described above relative to the winding operation, conduit **45** is connected to the vacuum source for the mandrel to receive the leading edge of the web W. This vacuum connection is continued throughout the winding process, FIG. 5*a*, and immediately after the wrapped mandrel has disengaged from the winding belts **51.** When such disengagement is complete, power is delivered to the mandrel independent drive train **54** to rotationally accelerate the mandrel and wound spool C, the effect of which is to complete the tail wrap and draw the trailing edge T thereof next to the spool surface C as illustrated by FIG. 5*b*. Since the web is permeable, in the case of "crepe" or "tissue" paper, the slight pressure differential attraction remaining through a multiplicity of wraps is sufficient to adhere the tail T against the cylindrical surface.

With the independent mandrel drive still engaged, conduit **45** is switched from the vacuum source to a pressure source causing an air blast from mandrel apertures **47** to expand and distort the cylindrical configuraton of spool C to that exageratedly shown in FIG. 5*c*.

High speed photographs have shown that under the aforedescribed conditions, the wound spool assumes a bulb shape at the discharge end of the mandrel as evidence that the leading axial end L of the spool C is retaining a close circumferential proximity to the mandrel surface and the air discharged from the apertures **47** is forming a pressure chamber within the region B. This circumstance dictates a fluid flow bias in the reverse direction F (relative to the air discharge direction from apertures **47** and the consequent movement of spool C). Consequently, spool C is, at least partially, reactively propelled from the mandrel **40** by the fluid mass discharge in the direction F as shown by FIG. 5*d* just as any jet powered vehicle.

Although detailed theoretical and laboratory analysis may reveal that the cylinder C is also propelled impulsively to some degree, for the purpose of this disclosure and the claims appended hereto, the phenomena, whether impulsive, reactive or a combination of the two, will be characterized as "reactive propulsion."

It is to be understood that the foregoing description is of a preferred embodiment and that the invention is not to be limited by descriptions of incidentally disclosed machine elements and power transmission arrangement. Therefore, changes may be made in the described preferred embodiment without departing from the scope of the invention defined in the following claims.

I claim:

1. An apparatus for winding coreless spools of thin web material from a substantially continuous supply thereof, said apparatus comprising:

supply means for dispensing an indefinite length of thin web material having substantially uniform width along a material flow path having a substantially fixed portion thereof;

cyclically positionable deflector means for directing said web along one of at least two distribution flow paths;

cutting means disposed between said supply means and said deflector means for severing said web across the width thereof at substantially uniform length intervals;

substantially cylindrical, axially rotatable mandrel means proximately disposed at the terminal end of each distribution flow path for receiving said uniform lengths of web directed thereto by said deflector means, each of said web lengths being wound about said mandrel with a plurality of wraps to form a spool; and,

fluid ejection means for removing said spool from the proximity of said mandrel comprising pressurized fluid supply means and a plurality of fluid discharge apertures disposed about the wrapping surface of said mandrel, said apertures being in communication with said fluid supply means and disposed at an angle to the mandrel axis whereby the discharge of pressurized fluid from said apertures expands said spool from substantial surface contact therewith and propels said spool over one axial end of said mandrel.

2. Apparatus as defined by claim 1 wherein said deflector means comprises:

fluid distribution manifold means;

substantially smooth web deflection surfaces respective to each distribution flow path; and,

apertures in said deflection surfaces and in fluid communication with said manifold means for discharging a fluid at an acute flow angle with said deflector surfaces between said surfaces and said web.

3. Apparatus as defined by claim 2 wherein axes of apertures respective to a deflection surface form said acute angle therewith and emanate from a common point so that the fluid discharge direction therefrom is substantially parallel with the direction of said web flow path at the center thereof and substantially transverse of said web flow path at the lateral edges thereof.

4. Apparatus as described by claim 1 wherein said mandrel means is rotationally driven by surface friction drive means.

5. Apparatus as described in claim 1 wherein said mandrel apertures are also selectively communicated with vacuum source means to start and continue the winding of said web lengths about said mandrel.

6. Apparatus as described in claim 5 wherein said mandrel is rotationally driven by surface friction applied first drive means.

7. Apparatus as described by claim 6 wherein said mandrel is also rotationally driven by second drive means, said mandrel being driven by said first drive means at a first rotational speed for winding said spool and driven by said second drive means at a second, greater rotational speed for ejecting said spool.

8. Apparatus as described by claim 7 wherein said communication of said mandrel apertures with said vacuum source is coordinated with engagement of said first drive means and communication of said mandrel apertures with said pressurized fluid supply means is coordinated with disengagement of said first drive means and engagement of said second drive means.

9. An apparatus for producing coreless spools of thin sheet material from a substantially continuous supply thereof, said apparatus comprising:

supply means for dispensing an indefinite length of thin sheet material having substantially uniform width;

axially rotatable mandrel means for receiving said material and winding same thereabout to form coreless spools of said material;

cutting means disposed between said supply means and said mandrel means for severing said web across the width thereof at substantially uniform length intervals;

reaction propulsion stripping means including pressurized fluid supply means for axially ejecting said coreless spools from the proximity of said mandrel means;

first planar conveyance means for receiving said ejected coreless spools and translating same away from a receiving station thereof;

second planar conveyance means disposed at the delivery end of said first conveyance means for receiving said spools and continuing said translation in substantially the same plane;

gap means between said first and second conveyance means of such width as to receive at least one ply of said sheet material but to be bridged by said spools in transition from said first to said second conveyance means;

first fluid curtain means directing fluid flow against said translation plane from one side thereof into said gap means to fluid dynamically urge free end portions of said spools into said gap means; and,

second fluid curtain means directing fluid flow against said translation plane from the other side thereof on the second conveyance means side of said gap to fluid dynamically urge remaining free end portions of said spools away from said plane and around said spools.

10. Apparatus as described by claim 9 wherein said second conveyance means comprises a plurality of transversely spaced conveyance belts and the fluid flow of said second fluid curtain means is directed through the spaces between said conveyance belts against said translation plane.

11. Apparatus as described by claim 10 wherein said first and second fluid curtain means comprises elongated fluid manifold means transversely disposed across respective conveyance means, said manifold means having fluid outlet means disposed along the length thereof.

12. Apparatus as described by claim 9 further comprising velocity retarding means disposed between said mandrel means and said first conveyance means for receiving said ejected spools from said mandrel means, reducing the velocity thereof and depositing same with said first conveyance means.

13. A process for producing coreless spools of thin sheet material from a substantially continuous supply thereof, said process comprising the steps of:

supplying a substantially continuous web of thin sheet material to axially rotatable mandrel means for winding same thereabout to form coreless spools of said material;

cutting said continuous web of material across the width thereof at substantially uniform length intervals;

stripping said coreless spools from said mandrel means by reactively propelling same over one end of said mandrel;

depositing said spools on first planar conveyance means;

transfering said spools across a gap from said first conveyance means to second planar conveyance means;

directing a first fluid flow stream against the conveyance plane of said first conveyance means from one side thereof to fluid dynamically urge free end portions of said spools into said gap; and,

directing a second fluid flow stream against the conveyance plane of said second conveyance means from the other side thereof to fluid dynamically urge remaining free end portions of said spools away from said plane and around said spools.

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