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(54) Web winding apparatus

(57) A web winding system for winding adhesive backed web on cores mounted on wind-up spindles. The web is supported on a rotating suction drum. A knife mounted on a rotating wheel cuts the web against the supporting drum. A tab bar is mounted on the wheel adjacent to the knife, and applies a tab to the web in registration with the cut. In a second position of the wheel a tab source moves toward the tab bar and applies a tab to its surface. The knife is heated by a heater to a temperature above adhesive softening and below adhesive carbonizing to prevent adhesive to stick to or to accumulate on the knife. The web is lead to the supporting drum around a stationary gapping roller and a retractable gapping roller, mounted on an arm which is pivotable around the roller. When the knife has cut the web the arm pivots clockwise, and lengthens the distance between retractable roller and supporting drum, thus forcing the web to slide on the drum, and to form a gap between the leading cut end and the trailing cut end of the web. The gap allows for flying transfer of the web between the cores on the two wind-up spindles.

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Description

TECHNICAL FIELD

The present invention relates to a web winding apparatus. More particularly, the present invention relates to a log roll winder having a cutting system, a tab applicator, and a winding system.

BACKGROUND OF THE INVENTION

Pressure sensitive adhesive (PSA) tape, as well as other adhesive and non-adhesive tapes and webs, is often wound on log rolls, which may, for example, measure 61 cm wide (24 in) or 122 cm wide (48 in). These log rolls are later cut into many individual rolls (each 2.5 cm wide, for example) for distribution and sale. In operation, a web is typically wound onto a core until a predetermined length of web has been wound thereon to form a log roll. The web is then stopped and cut transversely, so that the log roll can be removed. A tab member, which could be a piece of paper, may then be applied along the end of the web on the log roll to facilitate grasping of the end of the web. The log roll may then be replaced by a new core, and the leading cut end of the web may be adhered to the core and the web wound therearound to begin a new log roll.

Known log roll winders of the type described above have exhibited several deficiencies relating to three distinct systems within the winder. The systems, which will be discussed further below, are the cutting system for cutting the web across its entire width, the tabbing system for applying a tab at a cut end of the web across its width, and a winding system for handling the web before, during, and after the cutting and tabbing operations.

With regard to web cutting systems, most known cutting systems require that the web handling apparatus be stopped while the web is cut. This allows the terminal cut end of the web to be secured against the log roll, and allows the leading cut end of the web to be started on the next core. However, it would be desirable to cut the web without slowing or stopping the movement of the web. This process of performing an operation without stopping the line will be referred to herein as performing the operation "on the fly" - in this case cutting on the fly.

In one web handling system attempted by the Minnesota Mining and Manufacturing Company of St. Paul, Minnesota, the assignee of the present invention, the web is threaded onto a rotating vacuum drum with the adhesive side of the web facing away from the drum. The web is cut by rotating a knife against the rotating drum while the web is disposed against the surface of the drum. The vacuum force exerted by the drum against the web holds the cut ends of the web in place to prevent wrinkling. This design permits the web to be cut and the leading cut end of the web to be transferred to a new core on the fly, without stopping the winding process. This enables the winding operation to proceed continuously, which is advantageous.

However, conventional knives typically cannot cut adhesive-coated webs against a drum during continuous winding operations without experiencing difficulties caused primarily by the adhesive. Specifically, three separate and related problems occur. First, the web and adhesive tend to stick to and wrap on the knife as the knife rotates through the cut point. Second, adhesive tends to accumulate on the knife. Third, adhesive tends to transfer through the cut in the web backing and stick to the rotating drum. These problems are undesirable, and attempts have been made to solve them.

Applying oils, greases, waxes, and lubricants to the knife, as is commonly performed with lathe slitters, has not entirely prevented the adhesive accumulation and transfer problems. Varying the knife grinding angles, dimensions, tooth type, and tooth size also has not prevented these problems, nor has changing the angle between the knife axis and the drum surface. Chilling the knife to temperatures from -45°C to 5°C (-50°F to 40°F) tends to eliminate adhesion problems, but the adhesive and web contacting the knife became stiff during the time that the knife and the web were in contact, and thus the web may be more difficult to cut.

Another proposed solution was to heat the knife, as described in a catalog by Dienes Werke of Germany. The catalog describes cutting a web at a temperature suitable for simple adhesive softening. For simple adhesive softening, the score and shear knives are heated to about 70°C (158°F), which is intended to prevent the adhesive from sticking to the knife. However, the knives disclosed in the Dienes Werke catalog are intended for longitudinal slitting, rather than transverse cutting of the web. In slitting applications, knives are continuously rolled or dragged against the adhesive coated web. By softening the adhesive next to the knife with heat, the adhesive shear strength adjacent the knife is less than in the remaining adhesive. This low strength boundary layer of adhesive next to the knife allows the material being slit to continuously wipe most of the adhesive from the knife. However, a thin layer of adhesive still remains on the knife, which is undesirable. As the temperature is raised, the adhesive becomes increasingly soft, and the adhesion problem worsens. These results suggest that further raising the temperature of the knife would further soften the adhesive and increase adhesion and adhesive transfer problems. Furthermore, the present invention does not directly relate to longitudinal slitting, but rather to transverse cutting, which is periodic rather than continuous. Moreover, the continuous self-cleaning dragging and wiping action of adjacent adhesive present with longitudinal slitting does not exist with transverse cutting. Without it, adhesive softened by heating tends to coat the knife and be pressed through the web onto the drum, which requires unacceptable cleanup.

The Dienes Werke catalog referenced above also discloses a very high temperature knife called an "element" which can be heated up to 750°C (1382°F). This high temperature carbonizes the adhesive coating and backing layer of the web. The Dienes Werke catalog discusses using the element to "separate" the material and "fuse" or seal the strands on the edge of woven material to prevent unraveling, as with cutting a typewriter ribbon. These problems, however, are distinct from those previously described and are not applicable to adhesive webs generally. It is therefore desirable to provide a cutting system that overcomes the deficiencies present in the prior art.

After the web is cut, it may be desirable to provide a tab at one or both cut ends of the web. The tab is typically a narrow strip of material, such as paper, that is applied to the PSA coated side of the web and extends across the width of the log roll. For example, in the case where a pressure sensitive adhesive tape is wound on a log roll and then slit into smaller, individual rolls, it may be desirable to provide a tab at the end of the adhesive tape so that a consumer can grasp the end of the tape. Similarly, if a non-adhesive web is used, it may be desirable to provide an adhesive tab on the end of the web that will first contact the core, to anchor the web to the core prior to winding.

Most known tabbing systems typically apply the tabs to a log roll either manually or from a magazine prior to cutting the web. Tab application is sometimes performed with the web stopped and sometimes with the web moving. Regardless, the tab is applied as a separate operation before the web is cut to terminate the log roll. Thus it is very difficult to obtain proper registration between the cut and the location of the tab, which is undesirable. It is therefore desirable to provide a tabbing system for use with a log roll winder wherein a tab may be applied to a cut end of the web while the web is moving, while avoiding the registration problems of the prior art.

Once the web has been cut, and a tab applied if one is desired, the finished log roll must be removed from the winding area, and an empty core must be positioned to receive the leading cut end of the web to begin a new log roll. In the case of a web that has been cut on the fly, the web speeds are substantial (120 m/min, for example), and the speed required to remove a full roll and replace it with an empty core is quite difficult to obtain. To obtain a timely changeover between the full log roll and an empty core, the full roll is often removed before the terminal cut end of the web is completely adhered to the log roll. However, such a procedure may not allow the log roll winder to guide the terminal cut end of the web, and thus the web may wrinkle or fold over, which is undesirable.

One roll winder, made by Stahlkontor Maschinenbau GmbH, attempts to overcome the foregoing problems by winding the web at a single wind-up station. The web, drum, and wind-up roll stop for the web to be cut. Following the cut, the drum and wind-up roll resume turning to wind up the tail of the web, while the incoming web remains stopped. Next, the wind-up roll is unloaded, and an empty core is loaded in its place. Finally, the winder begins winding the incoming web on the new core. While having its own utility, this winder does not cut and transfer web on the fly. If such a winder is used continuously, an accumulator apparatus is required to absorb incoming web during the time that the web is stopped for cutting and end transfer, and web speeds are limited to 70 m/min to prevent tension problems. Additionally, the Stahlkontor machine cuts the web before the web contacts the drum, leaving the web prone to wrinkling.

It is therefore desirable to provide a log roll winder apparatus that overcomes the disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

The log roll winder of the present invention includes three related systems: a web cutting system, a tabbing system, a tail gap winding system.

The cutting system of the present invention overcomes the adhesion, accumulation, and transfer problems in continuous log roll winders by cutting the web with a knife heated to temperatures above that required for softening the adhesive yet below that at which the adhesive carbonizes. For some PSA tapes, this temperature would be above approximately 149°C (300°F). In use, the web is threaded onto a rotatable drum with the adhesive side facing away from the drum. The web is carried with the drum, typically by a vacuum force exerted by the drum on the tape, and the tape is cut by rotating a knife against the drum while the web is disposed against the surface of the drum. The drum holds the cut ends to prevent wrinkling. By heating the knife to temperatures above 149°C (300°F), the web and adhesive does not stick to the knife; the adhesive does not accumulate on the knife; and the adhesive does not transfer through the cut in the web backing and deposit on the drum.

In one embodiment, a cutting and tabbing assembly both cuts the web against the rotating drum as the web rotates, and cuts and applies the tab on the web in registration with a cut end of the web. The cutting and tabbing assembly includes a wheel, a knife mounted on the wheel, and a tab bar mounted on the wheel adjacent the knife. The tab bar includes a vacuum source which holds the tab paper. The tab paper is in the form of a roll which is mounted on an unwinder adjacent the wheel.

During the winding of the web on its core, the wheel is located in the tab-receiving position and the unwinder is spaced from the wheel. After the unwinder unwinds the proper amount of tab paper, the tab paper is threaded between the knife and the unwinder. The unwinder is then moved to contact the knife and tab bar. As the tab paper contacts the knife, the knife cuts a tab from the tab paper and the tab is held on the tab bar. When the desired length of web has been wound on its core, the wheel rotates toward the web-cutting position in which the knife can cut the web. As the wheel rotates, the tab bar transports the tab to the web. When the wheel reaches the web, the tab is applied and the knife contacts and cuts the web. The tab bar applies the tab onto the web in registration with a cut end of the web. The knife and tab bar continue to rotate until reaching its beginning position, and the sequence can begin again.

The winding system of the present invention creates a gap between the cut ends of the web on the surface of the drum during the cut and transfer operation of the winder. The web is always supported during the time that the web is cut, and the leading cut end is transferred to a new core. This enables the winder to cut and transfer the web on the fly at speeds of 137.2 m/min (450 ft/min) or more. This also permits winding and cutting the web against the drum and without wrinkling the web.

The web first passes around a spreader roller, if needed, and then travels to and around the retractable idler roller before being wrapped partially around the rotating drum. The rotating drum passes the web onto a core located on one of the two wind-up spindles. When the first core has received the required length of web, the knife rotates at a surface speed equal to the surface speed of the rotating drum. The knife cuts the web as it rotates against the rotating drum and a tab is applied. As the knife cuts the web, the idler roller pivots on its pivoting arm away from the rotating drum to increase the distance between the idler roller and the drum. The idler roller pivots at a speed approximately equal to the web speed. This causes one end of the web to slide on the surface of the drum. Because the rotating drum continues to rotate at a constant speed, this creates a gap between the cut ends of the web. A vacuum is applied to the web through the rotating drum to keep the web in contact with the drum during winding. When the web slides on the drum surface by pivoting the idler roller, the vacuum controls the sliding force and maintains a constant line tension.

To transfer the winding from the first wind-up spindle to the second wind-up spindle, the first wind-up spindle is moved away from the drum surface as soon as the terminal cut end of the web is attached to the log roll. This causes the leading cut end of the web to bypass the first winding station and continue on to the core located on the second wind-up spindle. The second wind-up spindle is moved into contact with the rotating drum surface as the first wind-up spindle moves away, and the leading cut end adheres to and begins wrapping around the core on the second wind-up spindle.

During the winding portion of the operating cycle, the idler roller slowly returns toward the rotating drum. The distance between the idler roller and rotating drum decreases while the drum speed increases slightly to maintain constant line tension and to take up the extra length of web. When the desired amount of web is wound around the core on the second wind-up spindle, the knife cuts the web, the idler roller is pivoted to its gap position to slide the web on the surface of the rotating drum and create a tail gap. The first wind-up spindle is moved into contact with the drum surface as the terminal cut end of the web passes the first wind-up spindle location to cause the leading cut end of the web to wind on the first wind-up spindle. The second wind-up spindle remains in contact with the rotating drum until the terminal cut end of the web is completely wound around its core.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described with reference to the appended figures, wherein:

Figures 1A - 1H are schematic views of the cutting system, the tabbing system, and the winding system of the present invention; and

Figures 2A and 2B are schematic views of a tabbing system according to another embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The winding system 10 of the present invention, shown in Figures 1A through 1H, can be used in conjunction with most known tapes. After the web 12 is processed it is to be wound on cores 14. The present winding system 10 permits cutting, tabbing, and winding the web 12 on cores 14, and transferring the web between cores 14 on the fly. Numerous rollers 16 may be provided, only one of which is shown in the illustrated embodiment. The winding system 10 also includes a stationary gapping roller 18 around which the web 12 winds. The roller 18 can serve to spread the web 12 and eliminates wrinkles before the web 12 travels to the rotating drum 24. A tension sensor 20 is mounted on one roller 16 to measure web tension and adjust the speed of the rotating drum 24 to maintain a desired tension in the web. The web 12 then travels to a retractable primary gapping roller or idler roller 22 which is disposed downline of the roller 18. The idler roller 22 is pivotable on a radius centered at the center of the roller 18. Preferably, the idler roller 22 and the roller 18 have the same diameter, and thus the same circumference.

A rotating drum 24 is disposed downline of the idler roller 22 such that the web 12 travels in contact with a portion of the outer surface 26 of the rotating drum 24 after passing the idler roller 22. Surface 26 covered with urethane rubber or other material which supports the web 12 such that a cutting knife will penetrate the web 12 when the knife is pressed against the web 12. The drum surface 26 can be steel if the knife travel is precisely controlled to avoid knife damage. Also, the surface 26 can have a narrow groove that would engage the knife such that the edges of the groove would support the web 12 close to the cut while the cut is made in the open air space between the edges of the groove.

The web 12 can have an adhesive side, such as PSA, which faces outwardly when the web 12 is wrapped around the drum 18. This prevents the web 12 from adhering to the drum surface 20 and permits the leading end of web 12 to transfer to the cores 14 by adhesion. Adhesion transfer to the cores 14 with nonadhesive webs can be accomplished by placing adhesive directly on the cores. Alternatively, an adhesive tab can be applied to the leading cut end of the web to secure adhesion to the core. The drum 24 includes a series of holes 48 on its surface 26 which are connected to a source of vacuum 50 through the drum 24. The vacuum provides a mechanism for maintaining the web 12 in contact with the drum 24 during winding.

Two wind-up spindles 28, 30 are located adjacent the rotating drum 24 and receive the cores 14 on which the web 12 is wound to form the log rolls. The first wind-up spindle 28 is located relatively upline of the second wind-up spindle 30. Both wind-up spindles 28, 30 are movable between a first position wherein the core supported thereon is in contact with the rotating drum 24, and a second position wherein the core (or log roll) is spaced away from the rotating drum 24. In alternative embodiments, a turret can be used to hold several wind-up stations and to load and unload the wind-up spindles continuously.

A cutting knife 32 is located upline of both wind-up spindles 28, 30 and cuts the web 12 as the web 12 rotates against the rotating drum 24. The knife 32 is mounted on a rotating wheel 34. The knife 32 cuts the web 12 against the rotating drum 24 which holds the terminal cut end 36 and the leading cut end 36' of the web 12 to prevent wrinkling. Due to the speed required for transverse cutting of the web against a rotating drum, the knife 32 should cut by pressing or stabbing through the adhesive coated web 12. Thus, the cut and transfer can be performed on the fly without stopping the winding process, such that the rolls can be wound on line and at machine speeds on a continuous basis.

A particularly advantageous feature of the present web cutting system is that a heater 35 heats the knife 32 to improve cutting. By heating the knife to temperatures above that required for softening the adhesive yet below that at which the adhesive carbonizes, the winder can cut and transfer on the fly without stopping the winding process while overcoming the adhesion, accumulation, and transfer problems previously described. For some PSA tapes, this temperature would be above 149°C (300°F). By heating the knife to these temperatures, the web and adhesive do not stick to the knife; the adhesive does not accumulate on the knife; and the adhesive does not transfer through the cut in the web backing and deposit on the drum. Additionally, the web backing cuts easier and with less force.

It is believed that the present heated cutting system achieves the desired results because one of the major adhesive components melts when the adhesive contacts the knife. This melting changes the rheology of the adhesive much more than simply softening the adhesive with slightly elevated temperature. Furthermore, the adhesive component that melts can become a lubricant next to the knife.

This cutting system can be used on continuous or noncontinuous-speed drum winders, with slit or unslit webs, and with or without adhesive-coated webs. The heated knife also can be used to cut any type of web in the air or against a backing. The cutting of nonsticky and nonorganic webs, such as glass cloth, is also improved by the heated knife.

A tabbing system is also provided for applying a tab member to one or both of the cut ends 36 and 36' of web 12. A cutting and tabbing assembly is located upline of both wind-up spindles 28, 30. After knife 32 cuts the web 12 against the rotating drum 24 as the web 12 rotates thereover, the assembly cuts a tab 60 from a roll 62 of tab paper 64 and applies the tab on the web 12 in registration with a cut end 36 of the web 12. In the illustrated embodiment, the tab is applied in registration with the terminal cut end 36 of the web, but could be applied to the leading cut end 36' of the web instead of or in addition to terminal cut end 36. The cutting and tabbing assembly 26 includes a wheel 34 which rotates as described above. A knife 32 is mounted on the wheel 34. A tab bar 52 is mounted on the wheel 34 adjacent the knife 32 and has a mechanism which holds the tab paper 60. In one embodiment, this mechanism includes a source of vacuum 66 connected to the surface 68 of the tab bar 52 through a series of openings on the surface 68. The roll of tab paper 62 is mounted on an unwinder 70 adjacent the wheel 34. Adhesive webs 12 permit the tab to be adhered to the web without adhesive on the tab, although a nonadhesive web and an adhesive tab may also be used. The unwinder 70 includes the roll 62 of tab paper 64, a backup roller 72 located near the roll 62 of tab paper 64, and a tab paper guide 74 extending from the roll 62 of tab paper 64 to and around a portion of the backup roller 72. The unwinder 70 is translatable from a first position spaced from the knife 32 to a second position adjacent and contacting the knife 32. The unwinder 70 unwinds the proper amount of tab paper 64 to form a tab 60 for application on each log roll 40 during the winding of the web 12 on cores 14.

During the winding of the web 12 on cores 14, the wheel 34 is located in the tab-receiving position and the unwinder 70 is in its first position spaced from the wheel 34. After the unwinder 70 unwinds the proper amount of tab paper 64, the tab paper 64 is threaded between the knife 32 and the unwinder 70, as shown in Figure 1A. The unwinder 70 is then moved to the second position in contact with the knife 32 and tab bar 52 while the knife 32 and tab bar 52 remain stationary, as shown in Figure 1B. As the tab paper 64 contacts the knife 32, the knife 32 cuts a tab 60 from the tab paper 64 and the vacuum 66 on the tab bar 52 holds the tab 60 against surface 68 of tab bar 52. The unwinder 70 then returns to its first position. The tab 60 is held on the tab bar 52, and when the desired length of web 12 has been wound on a core 14, the wheel 34 rotates toward the web-cutting position in which the knife 32 can cut the web 12, as shown in Figure 1C. As the wheel 34 rotates, the tab bar 52 transports the tab 28 to the web 12. As shown in Figure 1D, as the wheel 36 reaches the web 12, the tab 28 is applied and the knife 38 contacts and cuts the web 12. The tab bar 52 applies the tab 60 onto the web 12 in registration with a cut end 36, 36' of the web 12. The adhesive on the web 12 enables the tab 60 to adhere to the web 12. The knife 32 and tab bar 52 continue to rotate until reaching the position shown in Figure 1E, which is identical to that shown in Figure 1A, and the sequence can begin again. Because the drum 24 holds the cut ends 36, 36' of the web 12 to prevent wrinkling, the cut and transfer can be performed on the fly without stopping the winding process, such that the log rolls 40 can be wound on line and at machine speeds on a continuous basis.

This tabbing system precisely cuts and applies tabs along the full width of the cut end of a log roll from a full width roll of tab paper using a simple configuration that is integrated with the web cutting assembly. This system has the following advantages over precut tabs. This tabbing system can be used with continuous on-line log roll winders as well as with more conventional noncontinuous log roll winders and rewind slitters. Excellent tab placement accuracy is provided, because the same knife cuts both the tab and the web. Separate tab slitting steps are eliminated because the tabs are cut from a full width roll and individual strips of precut tabs need not be handled.

In an alternative embodiment of the cutting and tabbing assembly, shown in Figure 2, rather than cut and fix a paper tab 60 on a cut end 36, 36' of the web 12, a thermoplastic ink 80 can be applied to the web 12 to serve as the tab 82. In this embodiment, the tab bar 52 has a smooth surface 68. The sequence of operation for this embodiment is similar to that of the paper tab embodiment explained above with respect to Figure 1. When the wheel 34 is in its tab-receiving position, as shown in Figure 2A, an ink jet printer 84 applies the ink 80 to the tab bar 52 by traversing across the tab bar 52. As the wheel 34 rotates to the web cutting and tab applying position shown in Figure 2B, the tab bar 52 applies the ink 80 to the web 12 during the cutting operation. Alternatively, the ink 80 can be applied directly to the web 12 from the printer 84 if the web is stopped. The ink 80 adheres to the adhesive on the web 12, forming a nontacking surface that acts as a tab 82 on the end of the roll. The wheel 34 continues to its tab-receiving position to begin the cycle again. Because the ink jet printer 84 can start and stop as it traverses across the web 12, tab printing can be adapted to the duplex cut and wind process in which the web 12 is preslit into predetermined widths and the ink tabs 82 are printed along the total width as the web 12 is cut. The starting and stopping of the printing can be aligned easily with each cut off knife and can be easily changed as the slit web width is changed by programming the printing head of the printer 84, which applies the ink onto the tab bar 52. The tab can be applied to alternate preslit strands while not being applied to the remaining strands.

Although adhesive is not required on the web to adhere the ink, adhesive is sometimes the reason for requiring the tab as the tab is used to assist in finding the end of the web and to aid the start of unwinding. On nonadhesive webs, the tab ink or other material could be an adhesive to adhere the last wrap of the web to its roll. Also, by positioning a tab bar and tab on the other side of the knife, a tab could be applied to the leading cut end 36' to be wound against the core, and could thus adhere the first wrap of a nonadhesive web to the core. Additionally, instead of a thermoplastic ink, curable coatings can be used as the tab. The coatings could cure using light, chemical reactions, radiation, or heat. Detackifiers such as glass beads or talc also could be used.

Pressure sensitive adhesive (PSA) tape works well with these systems as do other adhesive-backed webs. The paper tab and the printed tab both serve to identify the end of a web roll and can be used to transmit advertising, identification, or other pertinent information about the web. In the printed tab, this information can be changed easily, on the fly, through the programmable electronics of the printer.

Immediately after the cutting and tab applying steps described in detail above, present winding apparatus includes means for providing a gap, known as a tail gap, between the terminal cut end 36 and the leading cut end 36' of the web. In the illustrated embodiment, the idler roller 22 is mounted on an arm 42 which pivots around the center of the roller 18. The idler roller 22 pivots from a first position in which winding occurs to a second position that lengthens the distance, known as the pass line, between the idler roller 22 and the rotating drum 24 to create a gap 44 between the cut ends 36 and 36' of the web 12. Immediately after the web 12 is cut the idler roller 22 pivots to lengthen the pass line, enabling the web 12 to slide on the surface 26 of the rotating drum 24 and create the gap 44 between the cut ends 36 and 36' of the web 12. The idler roller 22 is pivoted by an index mechanism 46, which can be a mechanical cam or an electrical drive such that the pivot speed is a function of the line speed.

The rotating drum 24 includes a series of holes 48 on its surface which are connected to a source of vacuum 50 through the rotating drum 24, as described previously. The vacuum 50 provides a mechanism for increasing the frictional force between the web 12 and the rotating drum 24, and for maintaining the web 12 in contact with the rotating drum 24 during winding. When the web 12 slides on the rotating drum surface 26 by pivoting the idler roller 22, the vacuum 50 controls the sliding force of the web 12 on the rotating drum 24 and to maintain a constant line tension.

The web transfer between cores mounted on the first and second wind-up spindles is provided as follows. The web 12 begins winding around and onto a core 14 that is mounted on the wind-up spindle 28 as shown in

Figure 1A. When winding on the first wind-up spindle 28, the first wind-up spindle 28 is located against the rotating drum 24, while the second wind-up spindle 30 is spaced from the rotating drum 24. As the web 12 is wound around the rotating drum 24 with the adhesive side out, the web 12 will adhere to its core 14 on the wind-up spindle 28. When the first wind-up spindle 28 has received the required length of web 12, the knife wheel 34 rotates at a surface speed equal to the surface speed of the rotating drum 24. The knife wheel 34 is rotated at a speed matched to the speed of the drum 24 by a knife drive (not shown) which is linked either mechanically or electrically to the drum 24. The knife drive is actuated when a predetermined length of web 12 has been wound. The knife wheel 34 is shifted into and out of engagement with the drum 24 to cut web 12, as described previously.

As the knife wheel 34 rotates and reaches the web 12, the cutting edge of the knife 32 contacts the web 12. The knife 32 cuts the web 12 as the web 12 rotates against the rotating drum 24, and a tab 38 is applied to the cut end of the web by a tab bar 52 which, as shown, can be located on the rotating wheel 34 adjacent the knife 32. The tab bar 52 applies a tab onto the web 12 in registration with a cut end 36 of the web 12. Alternative tab application assemblies can be used.

As the knife 32 cuts the web 12, the idler roller 22 is pivoted on its pivoting arm 42 on a radius centered at the center of the roller 18 away from the rotating drum 24 to lengthen the pass line between the idler roller 22 and the drum 24. The idler roller 22 pivots at a speed approximately equal to the web speed. This causes the web 12 to slide on the surface 26 of the drum 24. Because the rotating drum 24 continues to rotate at a constant speed, the pivoting motion of idler roller 22 creates a gap 44 between the cut ends 36 and 36' of the web 12 as shown in Figure 1D. The gap 44 is equal to the pass line length increase. Typically, this increase, and therefore the gap 44 is 15 cm (6 in).

To transfer the winding from the first wind-up spindle 28 to the second wind-up spindle 30, the first wind-up spindle 28 is moved away from the drum surface 26 as the terminal cut end 36 passes the first wind-up spindle location. This causes the leading cut end 36' of the web 12 to bypass the first wind-up spindle 28 and continue on to the second wind-up spindle 30. The core 14 mounted on the second wind-up spindle 30 is moved into contact with the rotating drum surface 26 as the first wind-up spindle 28 moves away, and the leading cut end 36' adheres to the core 14 on the second wind-up spindle 30 and begins wrapping around the core 14.

During the winding portion of the operating cycle, the idler roller 22 slowly pivots toward the rotating drum 24 and returns to its original position, as shown in Figure 1F. As the idler roller 22 moves toward this position, the pass line length between the idler roller 22 and rotating drum 24 decreases, while the speed of the drum 24 increases slightly to maintain constant line tension and to take up the extra length of web 12. The drum speed increase depends on the actual return speed and is accomplished in the drive for the drum as modified by the tension sensor signal.

When the desired amount of web 12 is wound around the core 14 on the second wind-up spindle 30, the winding is transferred from the second wind-up spindle 30 to the first wind-up spindle 28. First, the knife wheel 34 rotates to rotate the knife 32 into contact with the web 12 to cut the web 12, as shown in Figure 1G. As the knife 32 cuts the web 12, the idler roller 22 pivots away from the rotating drum 24 to lengthen the pass line between the idler roller 22 and the drum 24 by sliding the web 12 on the surface 26 of the rotating drum 24 and create a gap 44. As shown in Figure 1H, the core 14 mounted on first wind-up spindle 28 is moved into contact with the rotating drum surface 26 as the terminal cut end 36 passes the first wind-up spindle location to cause the leading cut end 36' of the web 12 to wind on the first wind-up spindle 28. The second wind-up spindle 30 remains in contact with the rotating drum 24 until the terminal cut end 36 of the web 12 is completely wound around the log roll 40. Then the second wind-up spindle 30 moves away from the rotating drum 24. As the winding begins again on the first wind-up spindle 28, the idler roller 22 slowly returns to its position of short pass line shown in Figure 1A, and the cycle begins anew.

This winding system 10 increases the time available to perform the transfer between the two wind-up spindles 28, 30 with a greatly simplified design. By creating a tail gap 44, the cut ends 36 and 36' of the web 36 are pulled away from the knife 32 after the web 12 is cut to prevent the cut ends 36 and 36' from sticking to each other or to the knife 32. Additionally, the gap 44 prevents the web 12 from contacting the core 14 prematurely, and obviates the need to strip the web 12 off of the core 14 during any part of the cut and transfer cycle as with known drum winding equipment. The cut and transfer is made on the fly at full line speed with the upstream web speed, and the rotational inertia through the roller 18 and idler roller 22 thus remains constant. This eliminates speed and inertia-related upsets from the upstream equipment.

This system can be used on continuous or noncontinuous-speed drum winders, with slit or unslit webs, and with or without adhesive-coated webs. This system also can be used where turrets or other mechanisms move the wind-up spindles into wind-up position, as where the incoming wind-up spindle is moved into contact with the drum while the gap is at that spindle location. However, the tail gap simplifies the transfer operation to a sufficient degree to obviate the need for turret mechanisms. Moreover, this winding system is simpler, less expensive, more versatile, and more reliable than known winding machines.

One winding system which can use this invention winds webs having widths of 63.5 cm (25 in) around paper or plastic cores that are 73.67 cm (29 in) long and have 7.62 cm (3 in) inner diameters. The core wall thickness can range from 0.25 to 1.02 cm (0.10 to 0.40 in), and rolls of up to 43.2 cm (17 in) in diameter can be formed with the actual size being operator selectable. As there are no thickness or material limitations on the web, glass and cotton cloth, nonwoven films, composites, and webs with high strength backings with thick adhesive can be used.

Web winding speeds of up to 120 m/min (400 ft/min) have been attained. The system can cycle by removing a full log on a core and loading a new core in 8 seconds and can wind with center winding or surface winding with center assist. Center winding and center assisted winding refer to the rotational movement of the wind-up spindles being independently provided by those spindles, as opposed to by contact of the log roll with the drum 24. Thus, in surface winding the wind-up roll remains in contact with the drum 24 during the entire wind-up process, and in center winding the wind-up roll contacts the drum only during the first and last wraps with the wind-up torque being supplied through only the center of the wind-up roll at other times.

This winding system 10 provides a gap without causing web tension upsets from changes in roll inertia due to starting and stopping the line. Because the rotational inertia of the rotating drum 24 remains constant throughout the gap generation, there is no inertial change to impart web tension upsets to the web 12. This is accomplished simply by the geometry of the system 10. Roll inertia problems can be overcome by other systems. For example, a precision drive could be used on each roller affected by rotational speed changes to power the roller at the precise speed profile required to match the web speed at that roller and prevent roll inertia from upsetting web tension. Also, rollers could be replaced by slider or floatation bars on which the web freely slides to avoid upset web tension.

Numerous characteristics, advantages, and embodiments of the invention have been described in detail in the foregoing description with reference to the accompanying drawings. However, the disclosure is illustrative only and the invention is not intended to be limited to the precise embodiments illustrated. Various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention.

Claims

1. A web winding system (10) for winding a web (12) on cores (14) mounted on respective first and second wind-up spindles and for transferring the web between the cores on the fly, comprising:

(a) a first roller (18) around which the web winds;
(b) a rotating drum (24) located downline of the first roller such that the web travels in contact with a portion of the surface (26) of the rotating drum;
(c) a retractable idler roller (22) located between the first roller and the rotating drum around which the web winds, wherein the idler roller is movable toward and away from the rotating drum;
(d) rotatable means (32) for cutting the web;
(e) means for moving the idler roller away from the rotating drum immediately after the web is cut to lengthen the distance between the idler roller and the rotating drum to enable the web to slide on the surface of the rotating drum, thereby creating a gap between the cut ends of the web; and
(f) means for transferring the web from a core mounted on the first wind-up spindle (28) to a core mounted on the second wind-up spindle (30).

2. The web winding system (10) of claim 1 for winding an adhesive-backed web on cores mounted on respective first and second wind-up spindles, for cutting the web and applying a tab on the web in registration with a cut end of the web, and for transferring the web between the cores on the fly, wherein the rotatable means for cutting the web comprises a rotatable knife (32) for cutting the web to produce a leading cut end and a terminal cut end of the web; and wherein the web winding system further comprises:

(g) a tabbing system for applying a tab on the web in registration with a cut end of the web, comprising:

(i) a tab bar (68) mounted adjacent the knife,
(ii) a tab source (70),
(iii) means for moving the tab source from a first position spaced from the knife and tab bar to a second position adjacent the knife and tab bar to enable the tab bar to receive the tab (60) while the knife and tab bar are in the second position, and
(iv) means for rotating the knife and tab bar from the second position to a web-cutting position to enable the knife to cut the web while the tab bar applies the tab onto the web in registration with a cut end (36) of the web.

3. The winding system (10) of either of claims 1 or 2, further comprising.

a first wind-up spindle (28) on which a core (14) is mountable, wherein the first wind-up spindle is movable between a first position in which a core mounted on the spindle is in contact with the rotating drum (24) and a second position spaced from the rotating drum; and a second wind-up spindle (30) on which a core (14) is mountable, wherein the second wind-up spindle is located downweb of the first wind-up spindle and is movable between a first position in which a core mounted on the spindle is in contact with the rotating drum (24) and a second position spaced away from the rotating drum.

4. The winding system (10) of either of claims 1 or 2, wherein the means for transferring the web from a core (14) mounted on the first wind-up spindle (28) to a core (14) mounted on the second wind-up spindle (30) comprises means for moving the first wind-up spindle from the first position to the second position as the gap (44) passes the first wind-up spindle location, means for moving the second wind-up spindle from the second position to the first position as the first wind-up spindle moves away, and means for winding the leading cut end (36') around the core mounted on the second wind-up spindle.

5. The winding system (10) of claim 4, further comprising means for transferring the web (12) from a core (14) mounted on the second wind-up spindle (30) to a core (14) mounted on the first wind-up spindle (28) comprising means for moving the first wind-up spindle from the second position to the first position as the gap (44) passes the first wind-up spindle location to enable the leading end of the web to wind on a core mounted on the first wind-up spindle, means for maintaining the second wind-up spindle in the first position until the terminal cut end (36) of the web is wound around the second wind-up spindle, and means for moving the second wind-up spindle from the first position to the second position.

6. The winding system (10) of either of claims 1 or 2, wherein the idler roller (22) is pivotable and further comprising means for pivoting the idler roller toward the rotating drum (24) to decrease the distance between the idler roller and rotating drum while the speed of the drum increases to maintain constant line tension and to take up the extra length of web (12) during winding of the web.

7. The winding system (10) of either of claims 1 or 2, wherein the rotating drum (24) comprises a vacuum applied to the web through the rotating drum wherein the web slides on the rotating drum surface (26) when the idler roller (22) is pivoted, and the vacuum controls the sliding force of the web on the rotating drum to maintain a constant line tension in the web.

8. The web winding system (10) of claim 2, wherein the tab source (77) is a tab paper unwinder on which a roll (62) of tab paper (64) is mounted, wherein the tab bar (68) comprises means for holding the tab paper, and wherein the means for moving the unwinder from a first position to a second position enables the knife (32) to cut a tab (60) from the tab paper roll.

9. The web winding system (10) of claim 2, wherein the tab source (70) comprises an ink jet printer (84) that applies ink to the tab bar.

10. The web winding system of claim 2, wherein the knife (32) comprises means for cutting the web, and means for preventing the adhesive on the web from sticking to the knife and for preventing the adhesive from accumulating on the knife.

11. The web winding system of claim 10, wherein the cutting means comprises a cutting blade, and the sticking and accumulating preventing means comprises means for heating the blade to temperatures above the temperature at which the adhesive softens and below the temperature and which the adhesive carbonizes.

12. The web winding system of claim 11, wherein the heating means is adopted to heat the cutting blade to temperatures between 149°C and 232°C (300°F and 450°F).

13. The web winding system of claim 12, wherein the sticking and accumulating preventing means further comprises means for preventing the adhesive from transferring through the cut in the web and depositing on the drum.

14. The web winding system of claim 13, wherein the transferring preventing means and the sticking and accumulating preventing means comprise means for heating the cutting blade to temperatures above that required for softening the adhesive and below that at which the adhesive carbonizes.

15. A winding system (10) for winding a web (12) of adhesive-backed material on a core (14), comprising:

(a) at least one roller (18) around which the web winds;
(b) a rotatable drum (24) disposed downline of the roller such that the web travels in contact with a portion of the surface (26) of the drum;
(c) a wind-up spindle (28) on which the core is mounted; and
(d) a rotatable knife (32) that cuts the web against the drum, wherein said knife includes means for heating the knife to temperatures above the temperature at which the adhesive softens and below the temperature at which the adhesive carbonizes.

16. The winding system of claim 15, further comprising.

(e) means for applying a tab to the web in registration with a cut end of the web.

17. The winding system of claim 16, wherein the drum comprises a vacuum applied to the web through the drum to maintain the web in contact with the drum during winding.

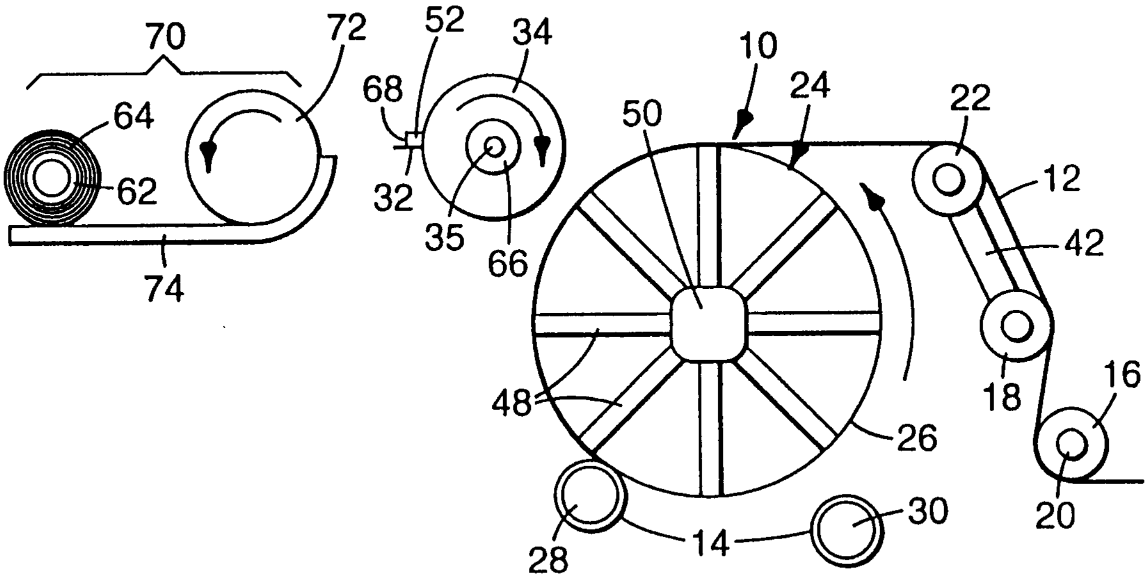
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Fig. 1A

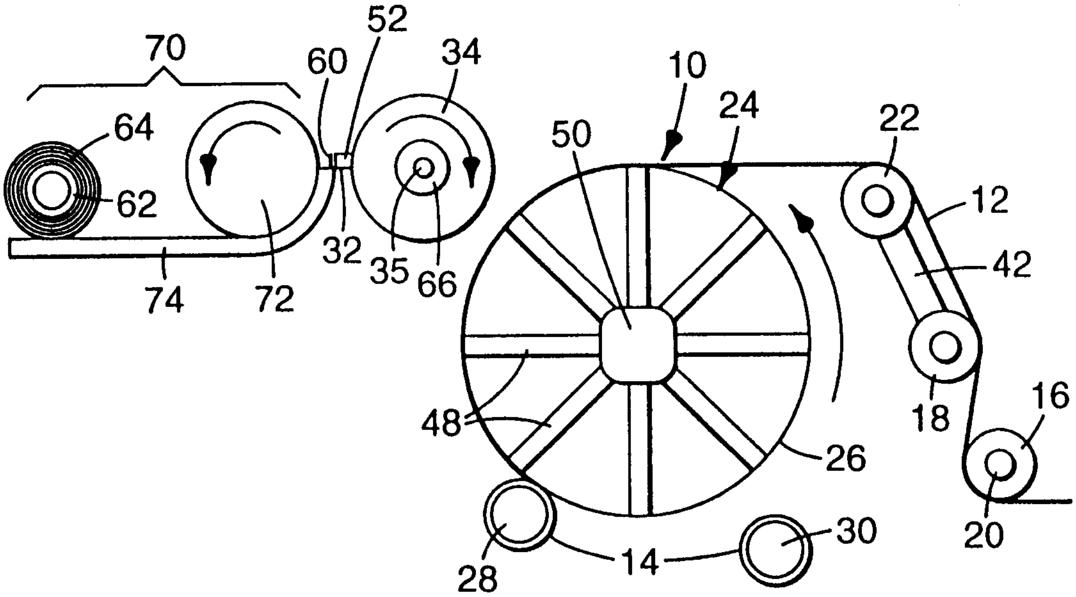
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Fig. 1B

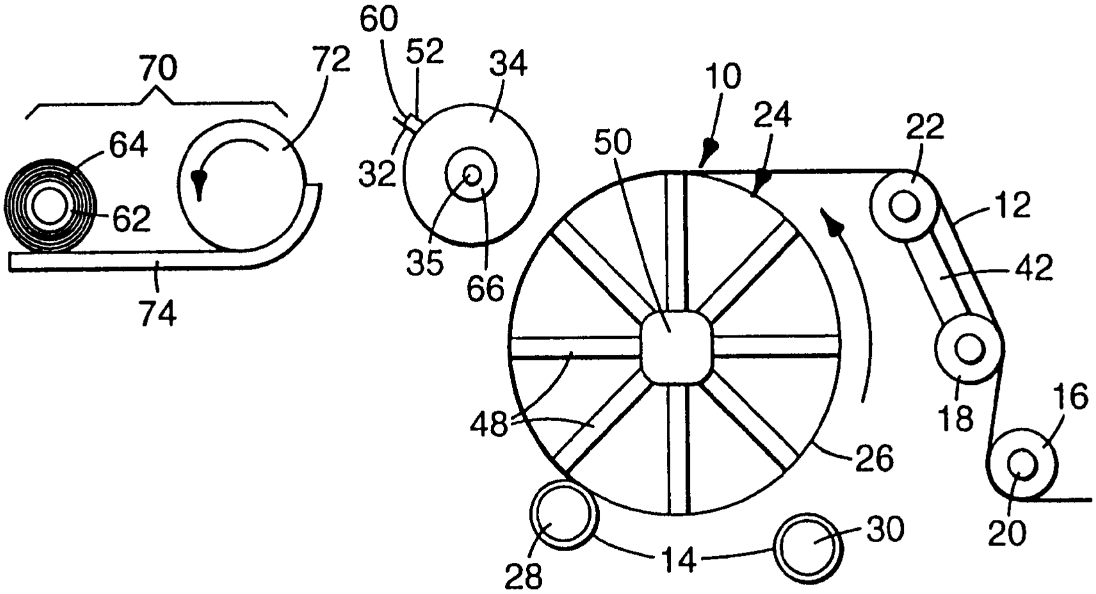

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Fig. 1C

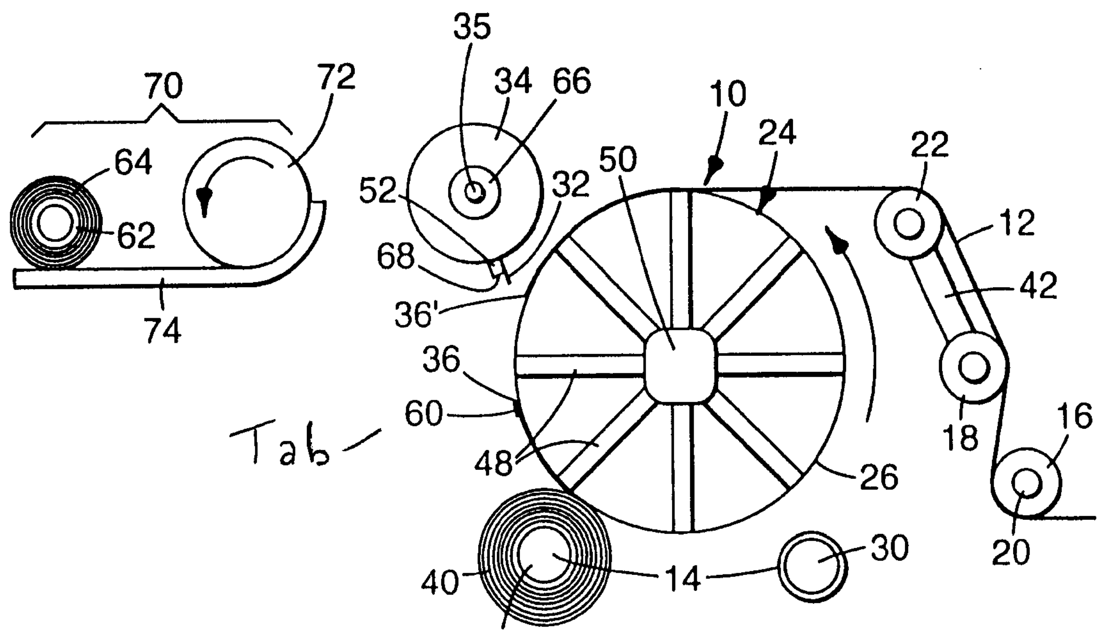

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Fig. 1D

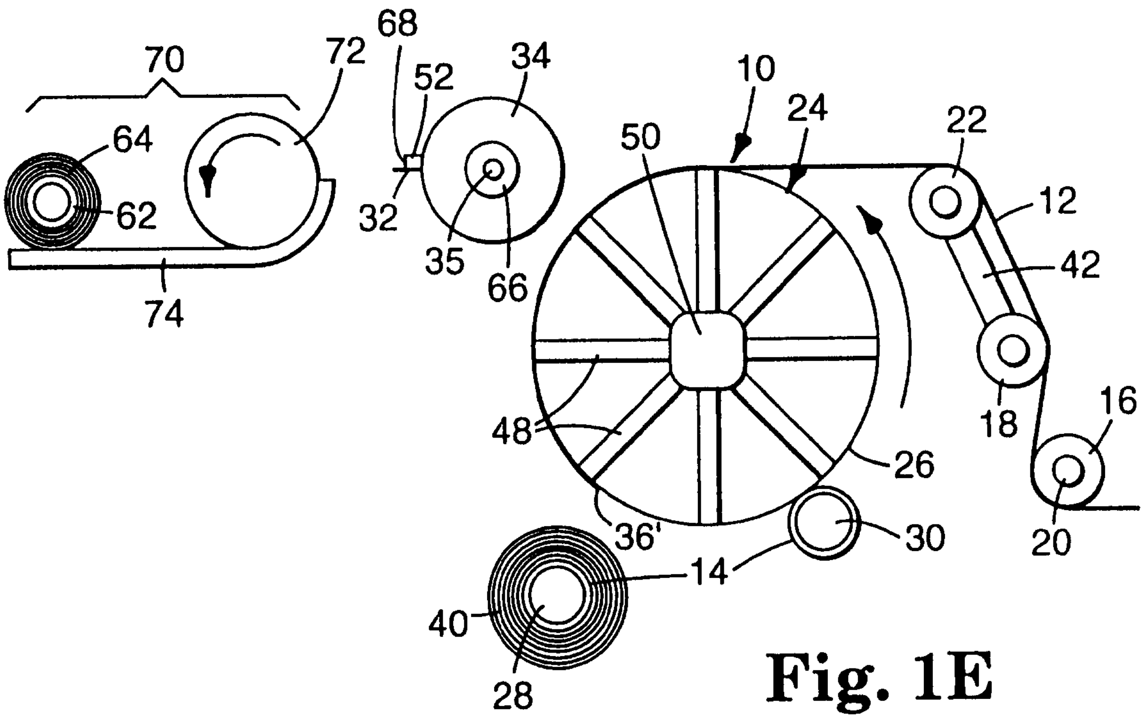
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Fig. 1E

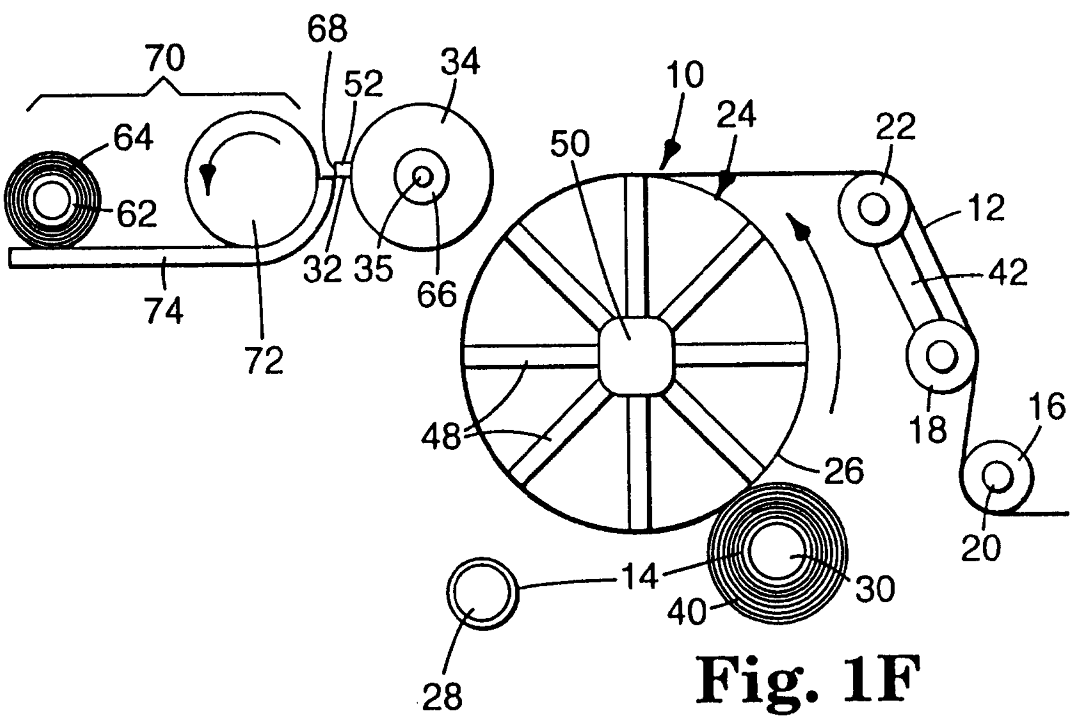
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Fig. 1F

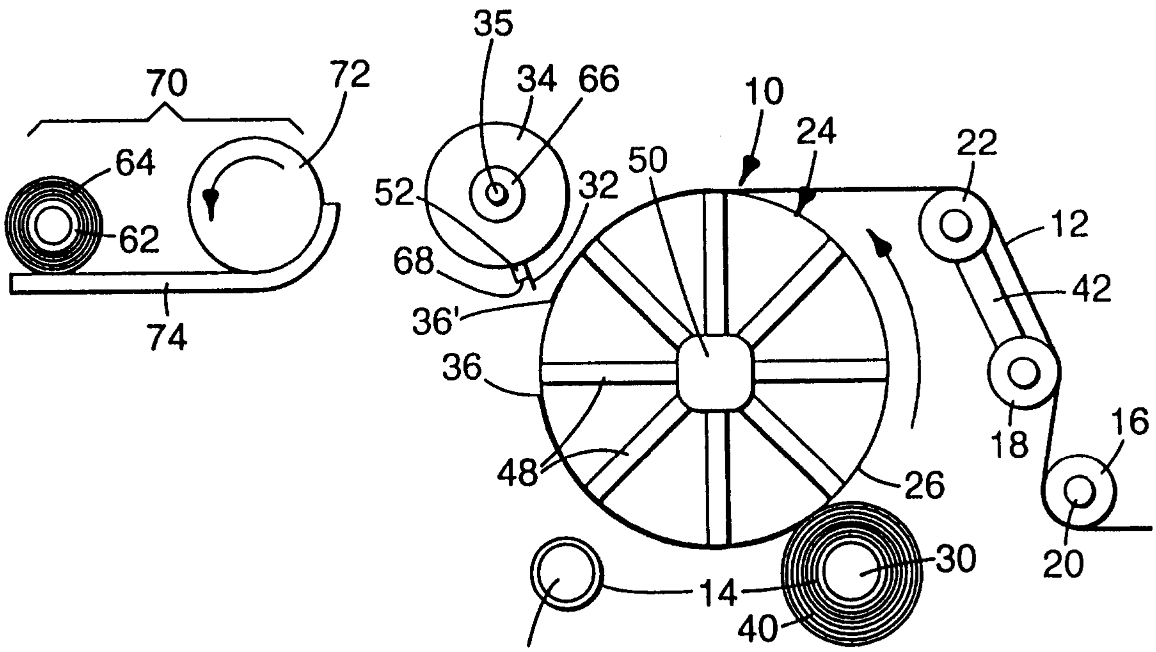
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Fig. 1G

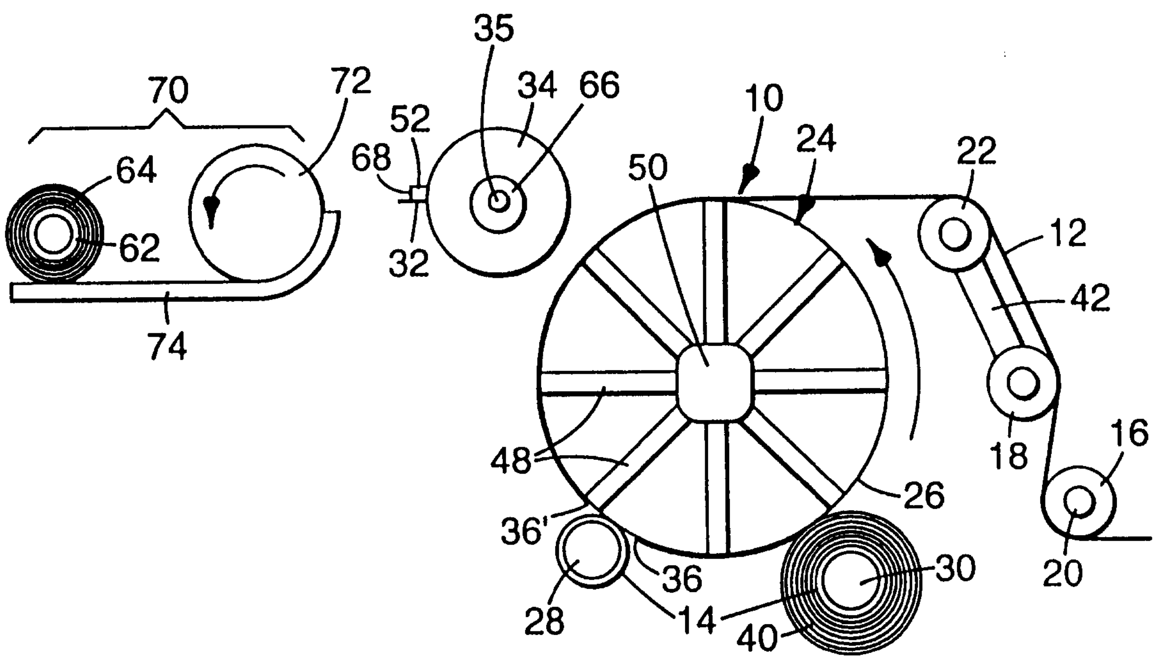
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Fig. 1H

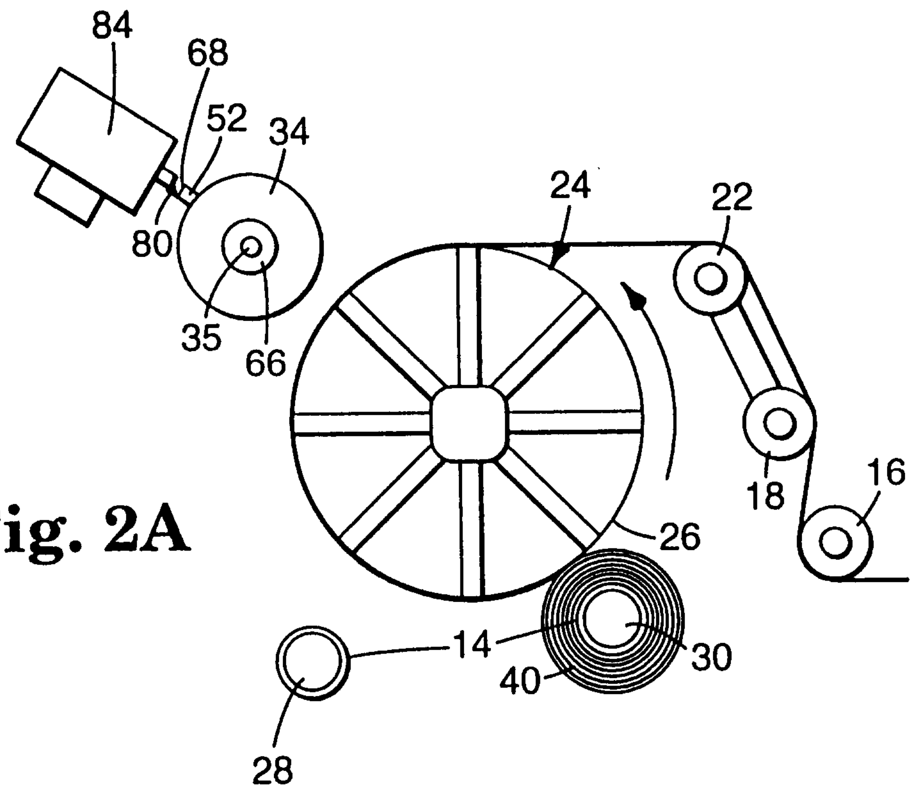
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Fig. 2A

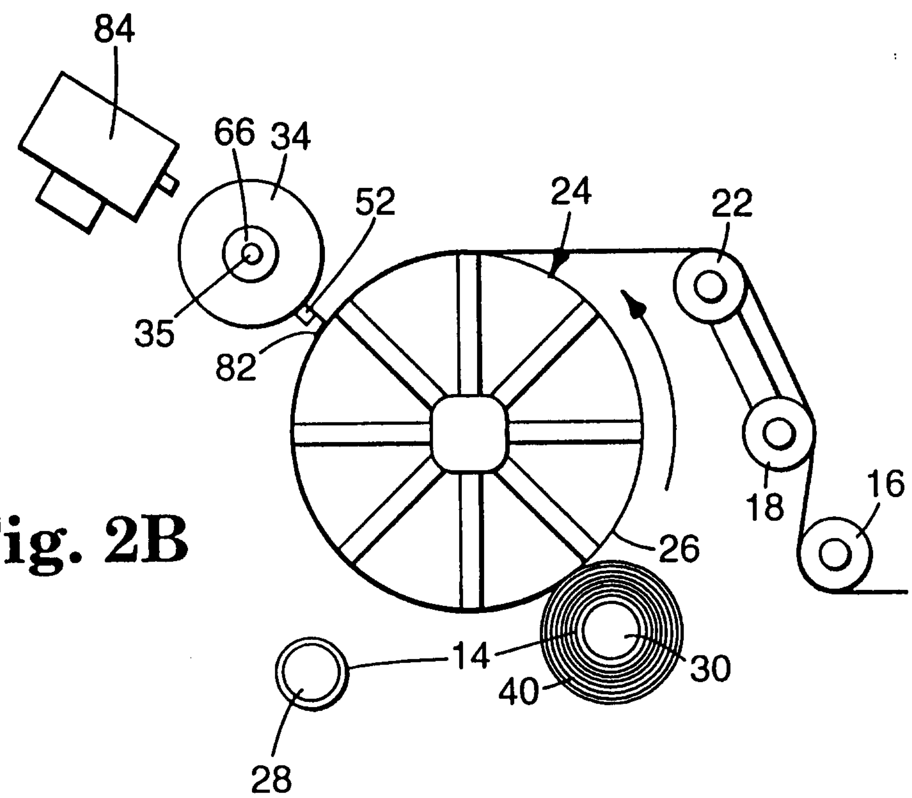
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Fig. 2B