Abstract

Web winding apparatus has a pair of roll core supports at first and second winding stations, an accumulator upstream from the winding stations for storing web and a splicer in the web path between the winding stations and the accumulator. The splicer includes a pair of nip rolls movable toward and away from one another and means for moving the rolls. A guide guides running web from the accumulator around one of the nip rolls to a core in one of the winding stations while a web leader is retained at the other nip roll, which leader is also attached to the other roll core. The nip rolls are moved together to press the running web and leader into adhering engagement to form a splice while the accumulator stores the running web. The running web is then severed downstream from the splice and the roll core at the second winding station is accelerated up to running speed while the web stored in the accumulator is reduced in preparation for the next splice.

8 Claims, 16 Drawing Figures
Fig. 1

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Fig. 2
Fig. 6
WEB WINDING MACHINES

RELATED APPLICATION

The present application is a continuation of application Ser. No. 809,146, filed Mar. 21, 1969, now abandoned.

The present invention relates generally to improvements in web winding machines and more particularly in at least one aspect to such machines which are especially adapted for rewinding web which has been unrolled, processed and is being rerolled in preparation for storage or for further processing.

Several problems are encountered in the rewinding of web, particularly when the apparatus employed for the rewinding operation is adapted for handling web having wide variations in properties which affect the winding characteristics. Among the properties in addition to width and thickness are web material and if a laminate or composite, the material of the various parts, relative stiffness and hardness. The nature of the operation being performed on the web between unwind and rewind positions also affects the winding characteristics. The very large number of variable factors all tend when cumulatively adverse to create serious defects in rolls wound on conventional winding machines. One of these called "telescoping", being the protrusion of the core and adjacent web layers beyond the edge of outer layers of the roll, may occur either during rolling or in a defectively wound roll, during subsequent handling after the roll has been completely wound. The results of telescoping are serious in that the edge of the web is often damaged with the result that the roll must be discarded, if not in whole, then at least in part. Even if the web is salvageable, a telescoped roll must be handled with very special care, is difficult to store, and in addition renders further processing especially difficult.

Conventional winders have heretofore generally been very expensive to construct because of the very nature of the winding operation. Basically, when winding web, the roll being wound and driven from its core starts with requirements of high rotational speed and low torque. As the size of the roll increases with the progress of the winding operation, if the linear winding speed is maintained constant, the rotational speed decreases and the driving torque requirement progressively increases. Conventional winding drives have been designed with the speed capacity necessary for the start of the winding operation and the torque capacity needed at the end of the winding operation when the roll is up to full size. The combination of both high speed and high torque capabilities in a single drive has rendered such conventional drives unduly expensive.

It is accordingly an object of the present invention to provide a web winding machine having the required versatility to operate upon webs having a wide variety of properties.

A related object is to provide a web winding machine in which defects in wound rolls, particularly "telescoping", are avoided.

A further object is to provide a web winding machine having surer and more precise control of tension of the web being wound and more particularly without changing the web tension in a processing zone between an unwinding and a rewinding machine.

A further and important object of the invention is to reduce the cost of web winding machines while maintaining flexibility and accuracy of control.

A subsidiary, but often important object is to provide a web winding machine adapted for safe usage in an atmosphere containing volatile solvents such as are used in inks employed in high-speed presses.

In the achievement of the foregoing objects, a feature of the invention relates to a variable speed hydraulic drive arranged to drive the roll being wound through its core. The drive comprises a variable volume hydraulic pump, the output of which is inversely proportional to the size of the roll at any given time. According to a related feature, the diameter of the roll is continuously measured and this measurement is translated into a signal for controlling the output of the pump. A constant displacement hydraulic motor is driven by fluid from the pump, coupled to a core shaft and adapted to relatively high speed operation. The coupling of the motor to the core shaft is through a speed reduction which provides increased torque and lower speed suitable for the winding operation.

According to another feature of the invention, the present machine includes two tension control systems which may be used either together or separately during a winding operation. Between the web processing zone and the winding station, the web passes through a storage festoon including dancer rolls which are urged away from idler rolls under varying force conditions. This force, which is regulated by changes in fluid pressure, applies a tension to the web and determines the tightness of winding. According to one mode of operation of the present machine, the fluid pressure at the festoon and hence the tension of the web being rolled, is decreased at a slow rate during the progress of winding operation. Typically the difference between starting and ending tension is something on the order of 5 per cent for typical webs but this may be varied to suit the specific material being wound.

According to a related feature of the invention, the fluid pressure and hence the tension applied to the web in the festoon remains constant from the start to the finish of the winding operation. However, additional tension essentially "in series" with the festoon tension is applied to the web by a pair of nip rolls which are used not only for forming a splice, but also for applying a drag to the web just ahead of the winding station. Not only does this feature simplify the control of dancer pressure, but it also eliminates variations in web tension in a web processing zone ahead of the festoon. In some cases, the process being carried on is particularly sensitive to changes in web tension and the quality of the process is adversely affected by such changes.

The foregoing objects, features, and numerous advantages of the present invention will be more fully understood from a detailed description of an illustrative embodiment taken in connection with the accompanying drawings in which:

FIG. 1 is a view in right side elevation of a winding machine according to the invention;
FIGS. 2 and 3 are views in front and rear elevation respectively of the machine of FIG. 1;
FIG. 4 is a schematic view in perspective of mechanical connections between a dancer yoke and a speed control device depicted with frame portions of the machine eliminated for clarity;
FIG. 5 is a schematic detail view in perspective illustrating machine connections for varying fluid pressure to the dancer yoke in accordance with roll size;

FIG. 6 is a view in left side elevation of the machine of FIGS. 1 to 3 inclusive;

FIG. 7 is a simplified view of a combination of an unwind stand and a rewinder according to the present invention together with a generalized interposed processing zone illustrative of a typical installation;

FIGS. 8 to 11 are progressive views showing the formation of a splice and the movement of web during the formation of the splice and at the start of a winding operation;

FIG. 12 is a fragmentary detail view in right side elevation showing the mounting of a movable idler roll;

FIG. 13 is a fragmentary detail view in left side elevation showing actuators for splice forming nip rollers;

FIG. 14 is a schematic diagram of electrical connections of the machine;

FIG. 15 is a schematic diagram of pneumatic connections of the machine; and

FIG. 16 is a schematic diagram of hydraulic connections of the machine.

Turning now to the drawings particularly FIGS. 1, 2, and 3 it will be seen that the illustrative machine comprises a frame including vertical upright plates 20 and 22 maintained in parallel relationship by appropriate horizontal stretchers one of which is seen at 24. The machine includes two winding stations, an upper and a lower one at which are positioned winding drives indicated generally at 26 and 28 respectively. The two drives 26 and 28 are identical in construction and are automatically brought into operation by appropriate control devices which will later be described in detail.

At the rear of the machine, there is a dancer assembly indicated generally at 30 for performing the dual functions of controlling web tension and of providing storage for a quantity of web in motion to permit stoppage of the web at a point near the winding stations while web is delivered uninterruptedly and absorbed by the festoon. The web may thus be stopped or slowed when a roll has been completely wound so that a splice may be formed and winding shifted from one winding station to the other. While the web is stopped or moving very slowly, the splice is formed between the running web and a leader secured to an empty core at the alternate winding station after the formation of the splice and cutting of the web to the full roll, winding is resumed at the alternate station. During stoppage for formation of the splice and while the core is being accelerated, web being fed to the winder is accumulated in the festoon 30. As the winding speed increases after the formation of the splice the quantity of web in the festoon is reduced to provide available storage for a subsequent reduction in winding speed.

Upon entry into the winder the web passes first to the dancer assembly 30 which is similar in the general layout of dancer and idler rollers to that described in U.S. Letters Patent No. 3,414,205 granted Dec. 3, 1968 upon application of Richard A. Butler, Jr. et al. The dancer assembly 30 comprises a yoke 32 mounted for vertical movement and carrying six dancer rollers numbered in order of contact with the web 34, 36, 38, 40, 42, and 44. For storing web, the yoke 32 is urged upwardly by a pair of air actuated pistons 46 each contained in a cylinder 48 and having a rod 50 as shown schematically in FIG. 12, one of the like cylinders being depicted in FIGS. 1 and 4 together with its connections to the yoke 32. The present machine includes two like cylinders 48 so as to provide the necessary forces for a normally expected range of web winding operations with readily available air pressure without incurring the expense of very large cylinders which tend to be limited in production and hence relatively costly. Web stored in the dancer assembly 30 alternates between one of the dancer rollers 34, 36, 38, 40, 42 and 44 and an idler roller 52, 54, 56, 58, 60, 62 and 64. Thus the path of the web in the dancer assembly, as the web comes in beneath the idler roller 52 is alternately in engagement with idler and dancer rollers as follows: 52, 34, 36, 56, 38, 58, 40, 60, 62, 42, 44 and 64. From the idler roller 64, the web is trained over a pair of overhead idler rollers 66 and 68 and down to a slitter indicated generally at 70 and later to be described in some detail. From the slitter 70 the web passes over idler rollers 72 and 74 and through a splicer assembly indicated generally at 76 to either the upper or the lower winding station.

The yoke 32 comprises a pair of spaced apart side plates vertically sidable on guide columns 89 and urged upwardly by the force of the pistons 46. As best shown in FIGS. 1, 3 and 4, each of the side plates comprising the yoke 32 is connected to a roller chain loop 82 trained over idler sprockets 84, 86, and 88 rotatably mounted on the machine frame and over a large active sprocket 90 keyed to a shaft 92 journaled in the machine frame. There are also mounted on the shaft 92 beside the pair of sprockets 90, one for each of the chains 82, a pair of smaller sprockets 94 each keyed to the shaft and over each of which is trained a looped roller chain 96 each connected to one of the piston rods 50. When pressurized air is supplied to the cylinders 48 so as to cause downward motion of the rods 50, the shaft 92 is urged in a counterclockwise direction and the yoke 32 upwardly to place the web in the festoon under tension. The relative sizes of the sprockets 90 and 94 are so chosen that they enable the stroke of the pistons 46 to match the travel of the yoke 32. During the total travel of the yoke 32 from its lowermost to its uppermost position, the shaft 92 and the sprockets 90 turn slightly less than a complete revolution.

The turning of the shaft 92 is employed for regulating the output of a pump, shown schematically at 98 in FIG. 16, through a mechanism now to be described. For this purpose, as best seen in FIG. 4, there is keyed to the outboard end of the shaft 92, a pinion 100 meshing with a gear 102 keyed to a stub shaft 104 which is journaled in the frame. A cam 106 is also keyed to the shaft 104 and the periphery of the cam is engaged by a follower roll 108 mounted near one end of a lever 10 pivoted near its center at 112 upon the machine frame. Connected to the end of the lever 110 opposite the follower roll 108 is a cable 114 which is coupled to the delivery volume control of the pump 98. The cam 106 is so shaped that as the storage capacity of the dancer assembly 30 diminishes with the rise of the yoke 32, the lever 110 is pivoted in a counterclockwise direction as seen in FIG. 4 pulling the cable 114 upwardly and increasing the delivery of the pump 98 to increase the winding speed and cause the yoke 32 to descend thereby increasing the storage capacity of the festoon 30. Conversely, if the yoke 32 is near the lower extreme of its travel, the contact of the follower roll 108 with the contour of the cam 106 causes the lever 110 to swing in a
counter-clockwise direction allowing the cable 114 to slacken downwardly and thereby decreasing the delivery rate of the pump 98 and the web winding speed so that the yoke 32 rises.

As shown in FIGS. 1 and 5, there is provided in the present winding machine apparatus for continuously measuring the size of the roll being wound for two different purposes. The first of these, according to a mode of operation of the machine, is to regulate the tension in the web in accordance with the size of the roll at any given moment. The second purpose is to permit the automatic termination of the winding operation at one winding station and the initiation of a winding operation at the alternate winding station when the roll being wound has reached a predetermined size. For these purposes there is provided at each winding station an arcuate arm 116 affixed to a shaft 118 and carrying at its distal end a roller 120 which is maintained in contact with the outside of the roll being wound. The shaft 118 which is journaled in the machine frame also carries a second arm 122 to the distal end of which is connected a spring loaded chain 124 trained over a sprocket 126 affixed to one end of a control shaft 128 which is also journaled in the frame. The shaft 128 has affixed to it cams 130 and 132, the peripheries of which are engaged by follower rolls respectively associated with a control valve 134 and a switch 136. The contour of the cam 130 is such that as the roll being wound increases in size, the output pressure of the valve 134 decreases. The cam 132 is formed to allow the switch 136 to close when a predetermined web roll size has been reached.

Both winding drives 26 and 28 are alike and accordingly the following description will be equally applicable to both. Each drive 26 and 28 comprises a hydraulic motor designated as 138 and 139 respectively as best seen in FIGS. 1 and 2. A cogged belt 140 passes over a driving pulley 142 of each motor 138 and 139 and also over an intermediate driven pulley 144 mounted on a common shaft with an intermediate driving pulley 146. A second cogged belt 148 passes over the pulley 146 and also over a large driven pulley 150 keyed to the cutboard end of stub winding shaft 152. At its inboard end, the shaft 152 also has keyed to it a chuck 154 by which it is coupled to a core shaft 156 which grips the interior of the web roll core for imparting rotary motion to the roll. The combination of belts 140 and 148 and the pulleys 142, 144, 146 and 150 which these belts engage provide a speed reduction between the pulley 142 of the core shaft 156, of approximately six to one with a resultant increase in torque. Both the motors 138 and 139 are driven from the same pump 98 through appropriate control circuitry later to be described.

At the completion of a roll winding operation the web is spliced to a leader such as that shown at 162 in FIGS. 8 through 11 and then cut between the leader and the full roll. In these FIGS. there is depicted the end of the winding operation for a roll at the lower winding station and the start of winding at the upper station. A web 164 is shown in FIG. 8 being drawn downwardly toward the lower winding station and in FIG. 9 being cut as the web is being spliced to the leader 162. For forming the splice, the leader 162, which is securely anchored to a core mounted on the upper core shaft 156, is provided with adhesive strips 166 and 168 typically in the form of double faced adhesive tape. The splice is formed by pressure from a pair of nip rollers consisting of a lower and an upper one 170 and 172 respectively. The rollers 170 and 172 are moved into splicing engagement with the web by air cylinders 174 and 176 respectively as shown in FIG. 13. The nip rollers 170 and 172 are hollow, rubber-covered, perforated and connected to a vacuum source for holding the leader in readiness for the splicing operation as shown in FIG. 8 in which the free end of the leader 162 is supported by vacuum on the upper nip roller 172. Also associated with the nip rollers are knives 178 and 180 mounted on pivoted arms and moveable into engagement with the web running to the lower and upper rewind stations respectively. The knife blades 178 extends across the web running from the roller 170 to the lower winding station and is mounted on arms 182 while the knife which is arranged to engage the web running upwardly from the roller 172 is similarly mounted on arms 184 as shown in FIG. 11. A brush 186 is pivotable to either of two positions to back the web for cutting by the appropriate knife. The splicing operation is initiated by actuating the nip roller which is supporting the leading end of the leader toward the running web passing over the other nip roller when the roll being wound has reached an appropriate diameter. Thus, as seen in FIGS. 8 and 9, the roller 172 which is supporting the leader 162 is pressed downwardly toward the web 164 at a point where the web is passing over the nip roller 170. As the adhesive band 166 is secured to the web 164, the knife 178 is actuated to cut the web 164 between the nip rollers 170 and the lower winding station. The web 164 ahead of the nip rollers 170 and 172 to the left as seen in FIG. 9, is under tension from the festoon 30. The result of the tension is that the leader 162 is thereby drawn through the nip between the rollers 170 and 172 and to the left toward the festoon as indicated by an arrow in FIG. 10. This is in effect a reverse or unwinding motion of the web which is no longer being pulled in the winding direction after having been severed by the knife 178 as seen in FIG. 9. The effect of the reverse motion of the web 164 and the leader 162 is to splice both bands of adhesive 166 and 168 to the web 164. After the leader 162 has been drawn a sufficient distance in the reverse direction to splice both adhesive bands to the web 164, rotary motion is imparted to the new core and the splice is thereby drawn toward the upper winding station as shown in FIG. 11. This view is largely schematic in nature since it shows the nip rollers 170 and 172 spread apart and a leader 188 is shown ready on the lower nip roller 170 for the next splice which occurs only after the web roll at the upper unwind station has been wound to its full size. In practice, as will be seen, the nip rollers 170 and 172 may remain closed upon the running web for an appreciable period of time to provide additional web tension for winding a tight core. As will later be explained, the leader 188 can be applied to the nip roller 170 at a later time so long as it is ready for the formation of the next splice.

It is thus seen from the foregoing that the splice is formed in the present machine in a novel manner to assure reliability of splice formation. When the adhesive band 166 is pressed into engagement with the running web 164 as shown in FIG. 9, the running web is either moving very slowly or stopped as will later be explained. The tension on the web 164 originating in the festoon 30 which is to the left of the nip rolls 170 and
draws the splice backwardly or in an unwinding direction between the nip rolls for a first pass which presses both adhesive bands 166 and 168 into secure contact with the web 164. When the rotary motion is imparted to the upper core shaft 156 so that the web 164 begins to move in a winding direction, both adhesive bands 168 and 166 are again pressed against the web 164 by a second pass between the nip rolls 170 and 172 as seen in FIG. 10 with the result that a secure and reliable splice is formed between the leader 162 and the web 164.

The operation of the machine will be better understood from a description of the electrical schematic diagram, FIG. 14, which includes a transformer indicated at 200 whose primary winding is connected to the power line and whose secondary is connected to main machine lines 202 and 204, the connections between the secondary of the transformer 200 and the main line 204 being made through a fuse 206. For setting the machine in operation, there is a main on-switch 208 of the momentary contact type. The main switch 208 is in series with a normally closed electrical interlock switch 210 which is opened when an access door is opened and also with a normally-closed main off-switch 212. When the switch 208 is momentarily closed a motor controller solenoid 214 is energized and causes a pair of normally open holding contacts 216 to close and also causes the closure of a pair of normally open contacts (not shown) for switching on a motor 218 which drives the pump 98 as shown schematically in FIG. 16. At the same time a signal light 220 is lit to indicate that the pump 98 is in operation. After the pump 98 has been started and in preparation for the formation of a splice, a splicing cycle on-switch 222, of the momentary contact type is closed to energize circuits prior to the triggering of a splice. The switch 222 is in series with a normally closed off-switch 224 interposed between the one switch and auxiliary line 226 connected to the main line 204 through the contacts 216 when the controller solenoid 214 is energized, the contacts 216 serving as holding contacts for the solenoid 214. When the switch 222 is momentarily closed, a motor controller solenoid 228 is energized closing normally open holding contacts 230 and another pair of contacts not shown which provides power to a vacuum pump motor for supplying vacuum to the nip rolls for holding a leader 162 or 188 upon the appropriate nip roll in preparation for the formation of a splice. When the solenoid 228 is energized and the contacts 230 closed, a signal light 232 is lit to indicate the availability of vacuum at the nip rolls and the readiness of the splicing apparatus of the machine.

A splicing cycle is started by momentary closure of a push button switch 234 or alternatively by closure of the switch 136 also depicted in FIG. 5. Momentary closure of either the switch 136 or the switch 234 causes a relay solenoid 1CR to be energized from the auxiliary line 226, through the normally closed switch 224 and the closed contacts 226A and 230. When energized, normally open contacts 1CR-A closes to latch the coil 1CR in energized condition and to continue energization of the time delay relay coils TD-1, TD-3 and TD-4. Each of the time delay relays TD-1, TD-3 and TD-4 has contacts for controlling subsequent operation of the machine in sequence. Time delay relay TD-1 is provided with two pairs of normally open contacts TD1-A and TD1-B which are closed following a prede-termined time interval after relay coil TD1 is energized by the momentary closure of either the switch 136 or the switch 234. Switches 242 and 243 are coupled to a valve which determines whether vacuum is supplied to the upper or lower nip roll 170 or 172. As shown in FIG. 14, the machine is prepared for splicing to a leader from the lower winding station since the switches 242 and 243 are arranged to energize solenoids 238 and 240 respectively in order to actuate the lower nip roll 170 and the upper knife 180 in proper sequence. When the contacts TD4-A closes, a time delay relay solenoid TD2 is energized in order to reset the circuits at the termination of the splice operation. For this purpose there is associated with the time delay relay TD2 a single pair of normally closed contacts TD2-A which opens after a predetermined time interval following the energization of the time delay relay TD4. When the contact TD2-A opens, the motor control solenoid 228 is de-energized and the holding contacts 230 open thereby de-energizing relay solenoids 1CR, TD1, TD3, and TD4. The de-energization of the solenoid 1CR causes the opening of the contact 1CR-A thereby interrupting power to solenoids 236, 238, 239, and 240.

The time delay relay TD4 also includes a pair of normally closed contacts TD4-B in series with a relay coil 2CR having a single pair of normally closed contacts 2CR-A for terminating the throttling of the output of the pump 98 as will be seen. When the relay contacts TD1-A close, one or the other of a pair of valve operating solenoids 236 and 238 is energized. Similarly, when the time delay relay contact TD4-A close, one or the other of a pair of valve operating solenoids 239 and 240 is energized. For determining which of the pairs of solenoids will be energized upon closure of a relay contacts TD1-A and TD4-A, there is provided a pair of switches 242 and 243 coupled mechanically to a valve for controlling vacuum to the nip rollers 170 and 172. When the switches 242 and 243 are in the condition shown in FIG. 14, the solenoids 238 and 240 are energized on closure of the contacts TD1-A and TD4-A respectively. When the solenoid 238 is energized, the spool of a two way valve is shifted to cause the lower nip roll to be raised. Similarly, when the solenoid 240 is energized, a valve spool is shifted to cause the upper knife to be actuated at the proper time sequence.

For electrically controlling the connection of the hydraulic motors 138 and 139 to the pump, there are provided push-button switches 244 and 246 respectively. The switch 244 is in series with a relay coil 3CR having a single pair of normally open contacts 3CR-A serving as holding contacts. The contacts 3CR-A are in parallel with the switch 244 and in series with a pilot light 248. The closure of contacts 3CR-A latches coil 3CR in energized condition, turns on the pilot light 248 and energizes a relay coil 5CR, which is provided with a single pair of normally open contacts 5CR-A in series with a throttle control solenoid 250.

The switch 246 is in series with a relay coil 4CR which is energized when the switch is momentarily closed. Closure of the switch 246 and energization of the coil 4CR causes contacts 4CR-A to close and thereby to latch the coil 4CR in energized condition, also causing a pilot light 252 to be turned on and a relay coil 6CR to be energized. The coil 6CR has a single pair of normally open contacts 6CR-A in parallel with the contacts 3CR-A. A double pole normally closed switch
having a pair of contacts interposed between the relay contacts 3CR-A and the relay coil 3CR and a second pair of contacts interposed between the relay contacts 4CR-A and the coil 4CR serves as a stop switch for stopping both motors 138 and 139 in case of emergency.

A pair of normally open contacts TD1-B closed by the time delay relay TD1 serves to make possible the energization of upper and lower motor solenoids 266 and 268 as will later appear. The choice of which of the hydraulic motors 138 or 139 is energized is determined by a circuit including latching relay coils LR1 and LR2 provided respectively with pairs of contacts LR1-A and LR1-B and LR2-A and LR2-B. As shown in FIG. 14, the contacts LR1 A and LR2-A are closed and LR1-B and LR2-B are open. The construction of the relay gangs of the latching relays is such that each time a coil is pulsed, the then open contacts close and the closed contacts open. For pulsing coils LR1 and LR2 there are provided coupled normally open switches 262 and 264 in series across the line with the coils LR1 and LR2 respectively.

While the switches 262 and 264 are open, contacts of the time delay relay TD3 and TD4 are employed for maintaining the energization of the coils LR1 and LR2. Thus contacts TD3-A are in series with coil LR1 and contacts TD4-A are in series with coil LR2.

A circuit for energizing upper and lower motor solenoids 266 and 268 respectively includes the contacts of the latching relays LR1 and LR2. In series with a pair of normally closed switches 270 and 272, a branch including the upper motor solenoid 266 includes the latching relay, LR1-A and LR2-A together with normally open relay contact 3CR-B. Another branch includes the lower motor solenoid 268, the latching relay contacts LR1-B and LR2-B together with relay contact 4CR-B. The switches 270 and 272 are coupled to devices which measure the size of the roll being wound in order to interrupt the winding operation in the event that the roll is wound to excessive size. This is done by opening the switch 270 and 272 in response to the measurement.

In parallel with the solenoid 266 there is a solenoid 274 for actuating the valve to control the tension regulating circuit for the upper unwind station. There is a similar solenoid 276 in parallel with solenoid 268 for the tension control at the lower unwind station. In order to permit inching or jogging of the upper motor 138 there is a double pole momentary contact switch 278 which, when closed, causes the solenoids 266 and 274 and a solenoid 282 to be energized. Similarly, for the motor 139 at the lower unwind station there is a switch 280 which, when closed, energizes the solenoids 268, 276 and 282.

The pneumatic connections of the machine are shown in FIG. 15 and include a main line 290 in which there is provided a filter 292 and a lubricator 294. After the lubricator 294 there are provided branch circuits, each controlled by a pressure regulator indicated at 296, 298, 300 and 302. The pressure regulator 296 adjusts the air pressure to the dancer cylinders 48 while the pressure regulator 298 is employed to adjust loading of the cylinders 48. The regulator 300 controls the pressure to the nip roller actuating cylinders 174 and 176. Finally, the regulator 302 controls the pressure of a throttle control cylinder 304 and of a jog control cylinder 306. The output of the regulator 296 is connected to the control valve 134 which is shown in FIG. 5 and associated with the upper winding station and a like control valve 310. The function of the valves 134 and 310 is to change the air pressure supplied to the cylinders 48 to regulate the tension on the web which varies in accordance with the size of the roll being wound. Connected to the control valve 134 is a solenoid actuated valve including the solenoid 252 and a spool 312 which blocks the output of the valve 134 from a shuttle valve 314 unless the solenoid is energized. When the solenoid 252 is energized, communication is established through the lower portion of the spool 312 between the control valve 134 and the valve 314. Similarly when the solenoid 254 is energized a spool 316 rises as seen in FIG. 15 and thereby establishes communication between the control valve 310 and the shuttle valve 314. In practice, only one of the solenoids 252 and 254 is energized at any given time. The shuttle valve is provided with a ball which moves in response to the greater pressure applied to it so that it blocks off the lower pressure input. Thus, when the solenoid 252 is energized, the lower chambers of the cylinders 48 are in communication with the control valve 134 through the valve 314. When the solenoid 252 is de-energized and the solenoid 254 energized, it is the output of the control valve 310 which communicates through the valve spool 316 and the valve 314 with the lower chambers of the cylinders 48.

From the regulator 298, there is a connection through a check valve 318, connected in parallel with a restriction 320, with the upper chambers of the cylinders 48. The regulator 298 is always adjusted to a pressure greater than that of the regulator 296 and the force supplied by the rod 50 to the yoke 32 is dependent upon the difference between the pressure of the regulator 298 and the output of the control valve 134 or 310, whichever is active. It will also be realized that the cam corresponding to the cam 132 in FIG. 5 may be considerably varied in shape and also that the control valves 134 and 310 may be bypassed altogether. The line establishing communication between the check valve 318 and the restrictions 320 with the upper chambers of the cylinders 48 is provided with a pressure relief valve 322.

The output of the regulator 300 is connected to a pair of valves respectively comprising spools 324 and 326 and actuated by solenoids 236 and 238. While the solenoids 256 and 238 are de-energized, air under pressure is admitted to the upper chamber of both cylinders 176 and 174. The result is that the piston is retracted in the cylinder 176 and projected outwardly in the cylinder 174. When the solenoid 236 is energized the connections are reversed and air under pressure is supplied to the lower chamber of the cylinder 176 and exhausted from the upper chamber through the lower portion of the spool 324 to atmosphere. Similarly when the solenoid 338 is energized connections are reversed so that the lower chamber of the cylinder 174 is in communication with air under pressure and the upper chamber is exhausted. Motion of each piston is associated with the cylinder 176 or 174 causes travel of the related nip roller into splice forming position. Thus, when the solenoid 236 is energized, the roll 172 is moved downwardly into splicing position. Similarly, when the solenoid 238 is energized, the roll 170 is moved upwardly into splicing position.

For controlling motion of the knives 178 and 180, there are provided air cylinders actuated through
valves including spools 328 and 330 actuated respectively by solenoids 240 and 239. When the solenoids 239 and 240 are deenergized the spools are in the position of FIG. 15 and the cylinders 332 and 334 have their upper chambers in communication with the regulator 300. Under such conditions a piston 336 slidable in the cylinder 332 and a piston 338 slidable in the cylinder 334 are both depressed. When the solenoid 240 is energized, the spool 328 rises and communication is established between the regulator 300 and the lower chamber of the cylinder 332 forcing the piston 336 upwardly and venting the upper chamber to atmosphere through the lower portion of the spool 328. The effect is to actuate the upper knife 180 to web cutting position. Similarly when the solenoid 239 is energized the spool 330 rises as seen in FIG. 15 with the result that the output of the regulator 300 is communicated through the lower portion of the spool 330 with the lower chamber of the cylinder 334 and the upper chamber is exhausted through the spool. The result of the rise of the piston 338 is to impart a web cutting motion to the lower knife 178.

The output of the regulator 302 is in communication with to the throttle control cylinder 304 through a valve including a spool 340 actuated by the solenoid 250. The output of the regulator 302 is also connected to the jog control cylinder 306 through a valve including a spool 342 actuated by the solenoid 282. Under the conditions depicted in FIG. 15, when both solenoids 250 and 282 are de-energized, the upper chambers of the cylinders 304 and 306 communicate with the regulator 302 through the upper portion of the spools 340 and 342 respectively. When the solenoid 250 is energized, the connections are reversed and the lower chamber of the cylinder 304 is in communication with the regulator 302 through the lower portion of the spool 340 while the upper chamber is vented to atmosphere through the spool. When the solenoid 282 is energized, the connections to the cylinder 306 are also reversed so that they are under pressure from the regulator 302 introduced into the lower chamber whereas the upper chamber is vented to atmosphere, both through the lower portion of the spool 342.

The hydraulic connections of the machine are shown in FIG. 16 in which the pump 98 is seen having its inlet connected to a sump 350 through a line having a shut-off valve 352. The outlet of the pump 98 is through a check valve 354 connected in parallel with a restriction 356 to a main machine line 358 which has its pressure controlled by a regulator 360. From the line 358, the pressurized hydraulic fluid is conducted to the motors 138 and 139 through check valves 362 and 364 respectively. Between the inlet and the outlet of the motor 138 there is a back flow circuit comprising a check valve 366 in series with a restriction 368. Around the motor 139 there is a similar circuit comprising a check valve 370 in series with a restriction 372. At the outlet of the motor 138 there is an overload relief valve 374 and a similar valve 376 is at the outlet of motor 139. The actuation of either motor 138 or 139 is controlled by a three-way valve including a spool 378 shown in a central position which causes both motors to be idle. When the solenoid 248 is energized the spool 378 is shifted to the right as seen in FIG. 16 and the result is that the outlet of the motor 138 is returned to the sump through the left portion of the spool 378 and a check valve 380. At such times, the outlet of the motor 139 is subjected to the pressure of the main machine line 358 also through the left portion of the spool 378. When the solenoid 250 is energized, connections are reversed and the outlet of the motor 138 is subjected to a full line pressure through the right portion of the valve spool 378 while the motor 139 is exhausted through the same portion of the valve 378 and the check valve 380.

In FIG. 7, there is shown a typical application of a winder according to the present invention indicated generally at 390, including a festoon indicated at 392 receiving web from a processing zone 394 which may be a printing press or a converting machine. The web is fed to the processing zone 394 from a supply apparatus such as that disclosed in the above-identified Butler et al. patent. The unwinding apparatus indicated generally at 396 includes a running web roll 398 and a ready web roll 400. The web is unwinding from the roll 398 through a festoon indicated at 402 and through the processing zone 394. After passing through the zone 394, web is directed through the festoon 392 of the winder 390 and is reeled at the lower station on a roll 404. When the roll 404 has reached its predetermined diameter, the web is spliced to a leader from the upper unwind station including a hydraulic driving motor 406 and the web is then severed from the roll 404 as the winding operation continues at the upper unwind station.

When the roll 398 is depleted, the leading end of the roll 400 is spliced to the running web and the web continues to pass uninterrupted through the festoon 402 in the processing zone 394 to the winder 390. The festoon 404 senses the input tension to the zone 394 and the festoon 392 controls the tension during the winding operation at the winder 390.

The illustrated combination of unwind and rewind apparatus thus furnishes web uninterrupted, continuously controls unwinding and rewinding tension and finally renews the web uninterruptedly after processing.

Having thus disclosed our invention, what we claim is new and desire to secure by letters patent of the United States is:

We claim:
1. Web winding apparatus comprising
A. means for supporting a roll core at a first winding station,
B. means for supporting a roll core at a second winding station,
C. means upstream from the winding stations for storing a quantity of web,
D. splicing means disposed in the web path between the winding station and the storage means, said splicing means including
1. a pair of nip rolls movable relatively between a first position wherein the nip rolls have a gap between them and a second position wherein the nip rolls contact one another to form a nip,
2. means for moving the rolls between said two positions,
3. means for guiding running web from the storage means around one of the nip rolls to a core at one of the winding stations,
4. means for retaining an end of a web leader at the second nip roll, means for attaching the leader to the other roll core,
5. means for moving the nip rolls to their second position so as to press the running web and leader end into adhering engagement to form a splice, while the storage means stores the running web,

6. means for severing the running web downstream from the splice, and

E. means for accelerating the core at the second winding station up to running web speed while the quantity of web stored by the storage means is reduced in preparation for the next splice cycle so that the web can proceed uninterruptedly through the storage means to the first or second winding station.

2. Web winding apparatus as defined in claim 1 wherein the storage means include means for pulling the running web in a direction opposite the direction of web movement immediately after the nip rolls are moved to their second position so that the splice makes one pass through the nip in a direction opposite the direction of normal running web movement and then makes a second pass through the nip in the direction of running web movement when the roll at the second winding station is accelerated.

3. Web winding apparatus as defined in claim 2 and further including adhesive applied to the exposed face of said leader and to facilitate bonding the leader to the running web.

4. Web winding apparatus as defined in claim 1 wherein the severing means comprise

1. a pair of knives pivotally mounted adjacent the pair of nip rolls, each knife being swingable from a position wherein its blade is spaced from the path of web trained around the associated roll to a second position wherein the knife blade intercepts the path of web trained around the associated roll, and

2. means for swinging the knives selectively between said two positions, and

B. further including

1. a knife backup swingable between two positions, in one of which positions the backup is disposed opposite the knife blade associated with one nip roll and the other of which positions the backup is disposed opposite the knife blade associated with the other nip roll, and

2. means for swinging the knife backup between its two positions.

5. Web winding apparatus as defined in claim 1 and further including means for controlling the rate at which the amount of web stored by the storage means is reduced following completion of the splice.

6. Web winding apparatus as defined in claim 5 and further including means for initiating a splice cycle when the running web reaches a predetermined maximum size.

7. Web winding apparatus as defined in claim 2 and further including

A. first adhesive means affixed to the exposed face of the leader near its said end, and

B. second adhesive means affixed to the exposed face of the leader at a point spaced along the leader from the first adhesive means, both said adhesive means being positioned so that both pass through the nip on each said pass of the splice through the nip.

8. Web winding apparatus as defined in claim 2 and further including means for controlling the rotational speed of the running web roll in accordance with the amount of web stored by the storage means.

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