

June 7, 1966

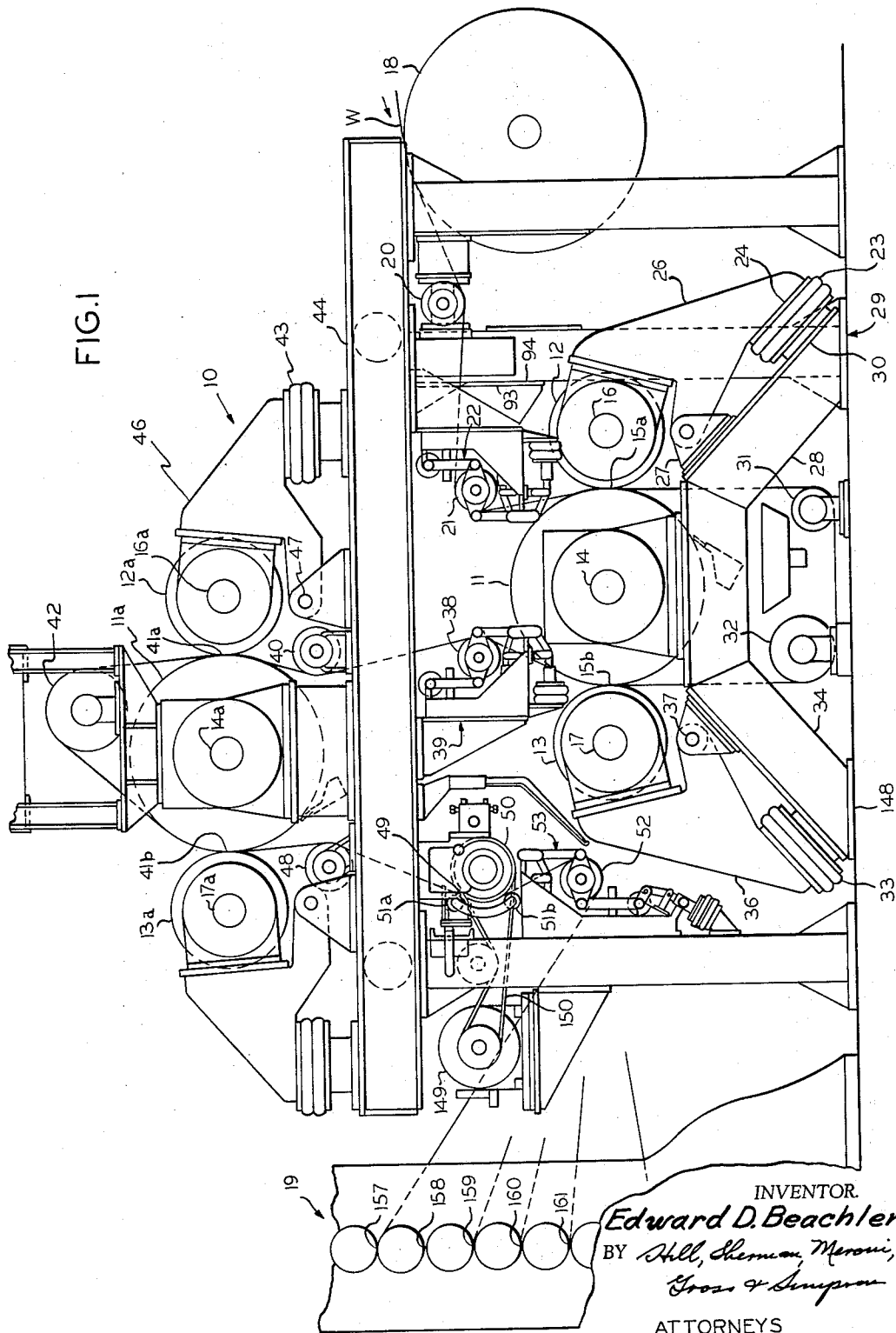
E. D. BEACHLER

3,254,593

GLOSS CALENDER DRIVE SYSTEM AND METHOD

Filed Oct. 3, 1963

4 Sheets-Sheet 1



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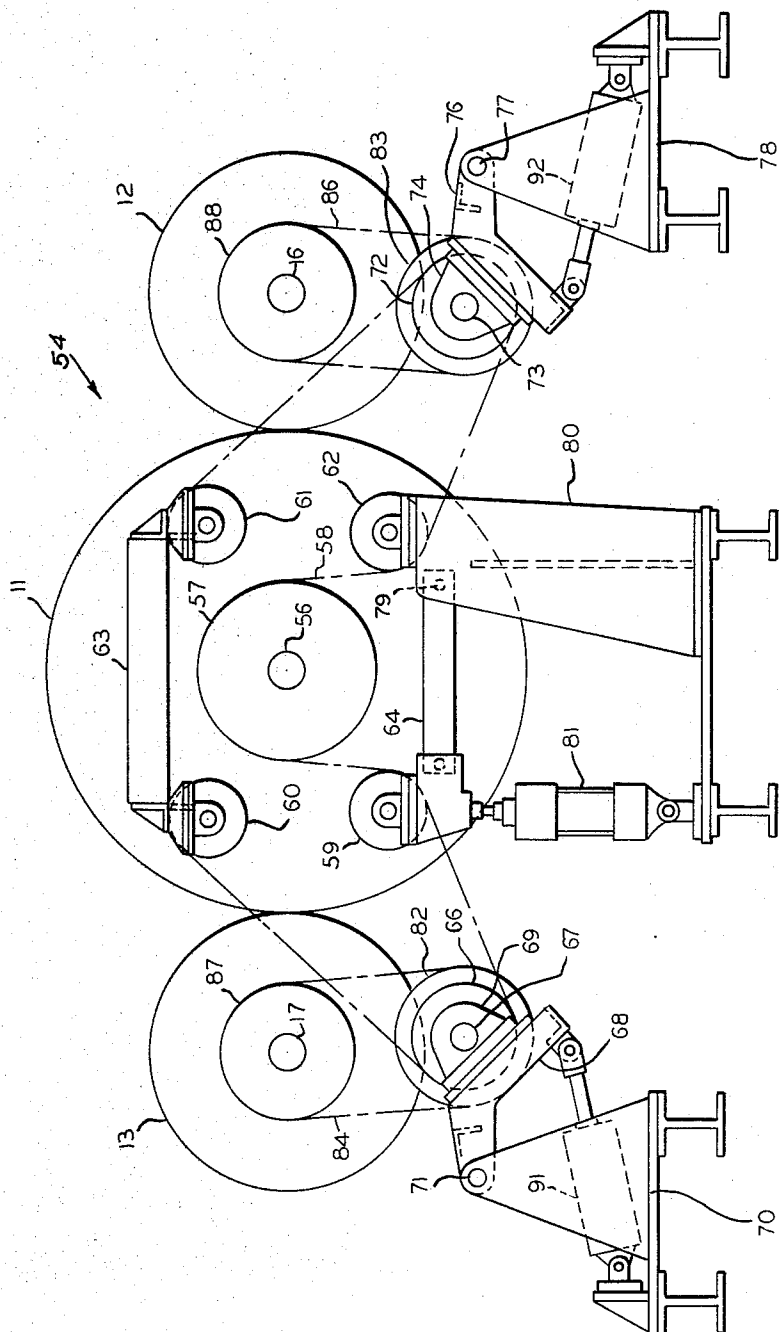
E. D. BEACHLER

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4 Sheets-Sheet 2



INVENTOR.

INVENTOR:
Edward D. Beachler

BY

Hill, Sherman, Meroni, Gross & Simpson

ATTORNEYS

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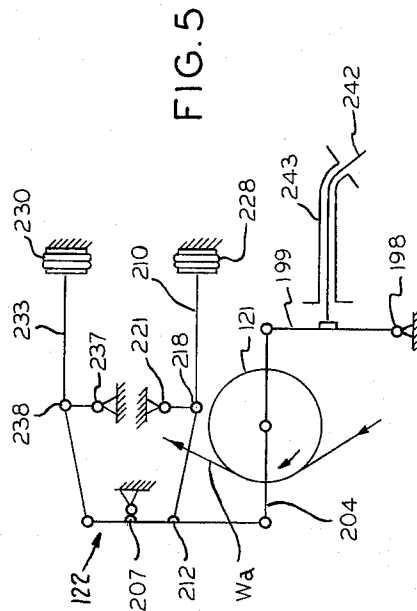
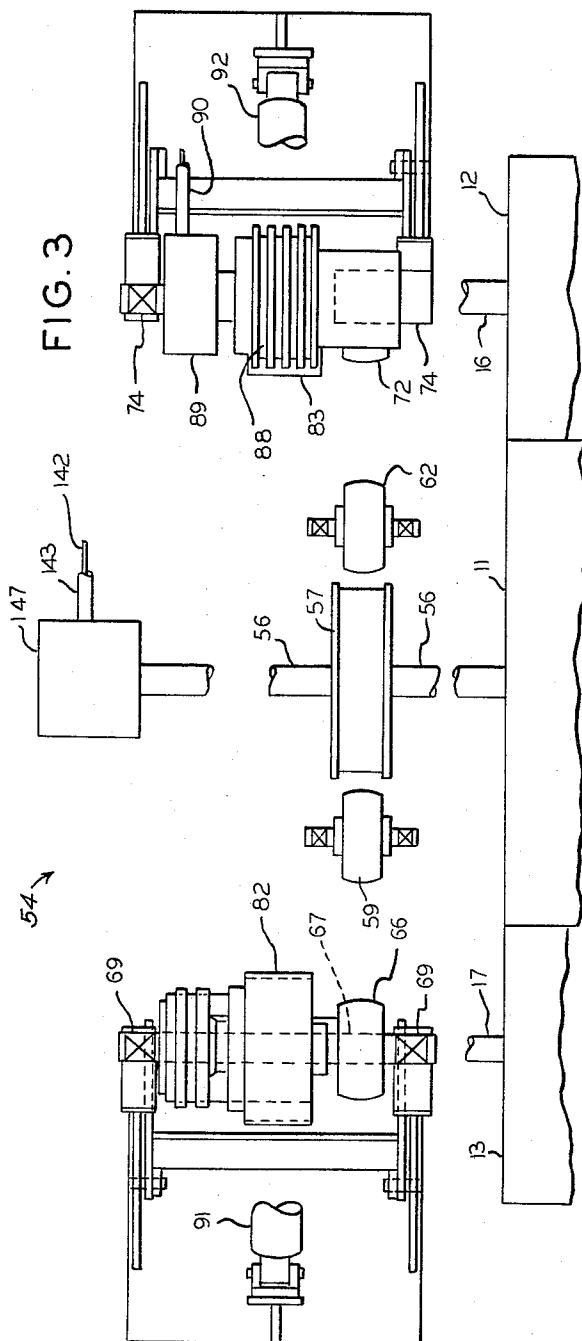
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4 Sheets-Sheet 3



INVENTOR.

Edward D. Beachler

BY

Still, Sherman, Meroni, Gross & Simpson
ATTORNEYS

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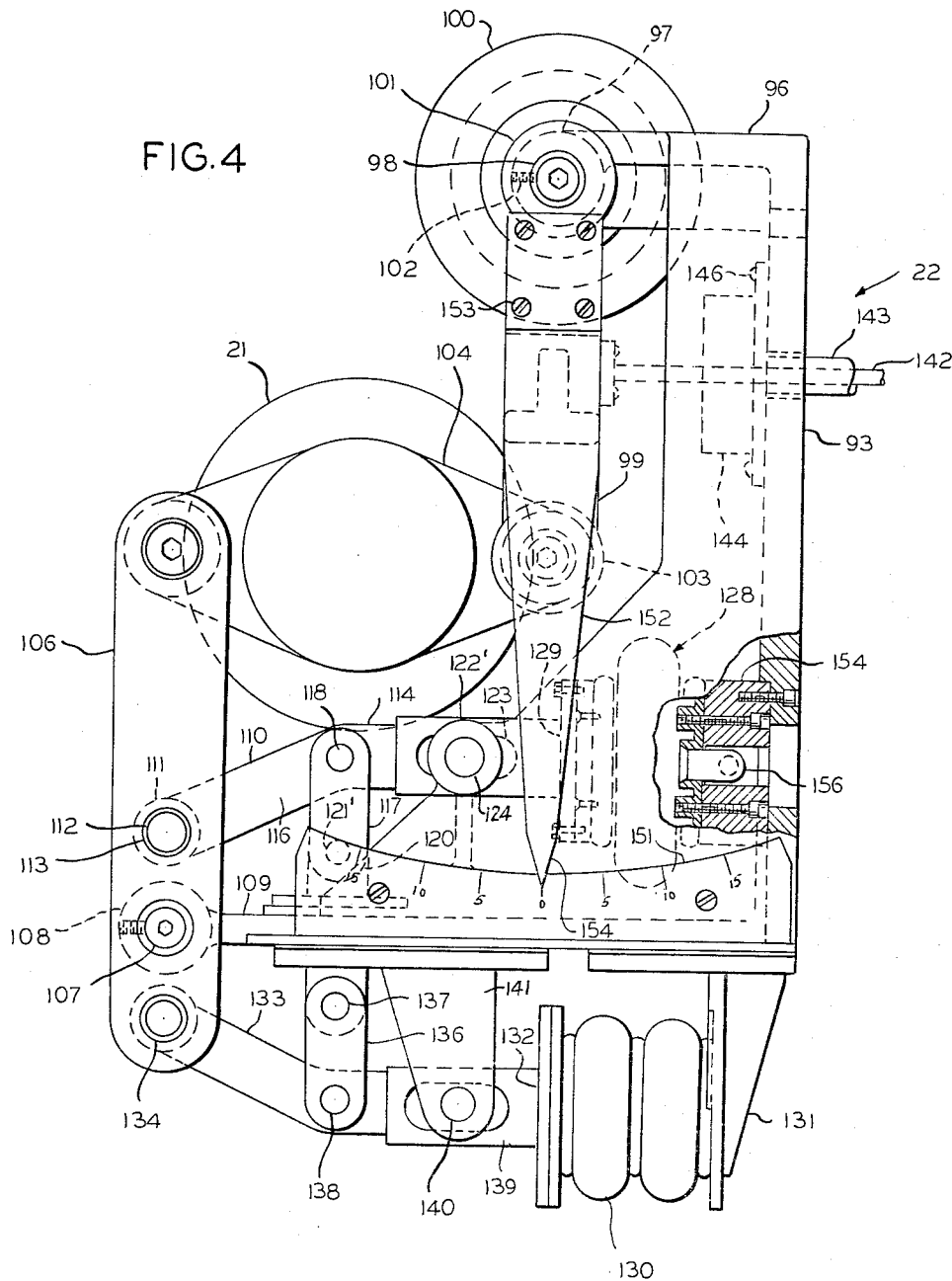
E. D. BEACHLER

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GLOSS CALENDER DRIVE SYSTEM AND METHOD

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4 Sheets-Sheet 4



INVENTOR.

Edward D. Beachler

BY

Hill, Sherman, Merwin, Gross & Simpson

ATTORNEYS

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3,254,593 GLOSS CALENDER DRIVE SYSTEM AND METHOD

Edward D. Beachler, Beloit, Wis., assignor to Beloit Corporation, Beloit, Wis., a corporation of Wisconsin
Filed Oct. 3, 1963, Ser. No. 313,642
4 Claims. (Cl. 100—38)

The present invention relates broadly to the production of paper and related web materials and is more particularly concerned with improved methods and means for imparting a gloss surface to paper and related web materials.

It has been customary in papermaking machines in "on machine" operation, or for treatment of the paper web after the paper has been made, in "off machine" operation, to smooth and gloss the paper web. For example, calenders and supercalenders may be employed to smooth, gloss or finish either coated or uncoated paper web.

However, a disadvantage common to conventional calendering and supercalendering devices exists as a result of the high-pressures necessary to obtain the smoothing, glossing or finishing effect desired. The above devices crush and flatten the web generally in a nip of constant thickness along its length thereby reducing the bulk or thickness of the web particularly at the thickest web locations, causing a marked variation in spot or local densities and thereby producing the well known "glossy" surface spot which refuses to take ink, printing or coatings, and the inherent resilience of the fiber constituents of the paper web employed cause fibers to rise out of the surface of the web after having been subjected to a smoothing, calendering or related or similar treatment.

An improved apparatus and method for glossing paper is shown and described in the copending patent application Serial No. 19,862, filed April 4, 1960, now Patent No. 3,124,504, issued March 10, 1964, which may be herein termed "gloss calendering" and which achieves the desired result without crushing or damaging the leveled surface of the paper web.

A gloss calendering generally embodies a first rotatable roll having a finished smooth surface, a second roll having a hard surface resiliently yieldable under pressure co-operating with the first roll to define a narrow width nip, with the temperature of the nip sufficient to heat the paper web and coalesce at least the surface of the web in contact with the finishing surface, with the nip being subjected to a uniformly applied pressure sufficient to level, smooth and blend the surface of the web, as defined in said Patent No. 3,124,504.

In "on machine" gloss calendering and where the web is not too dry, the drying action which takes place in the gloss calender nip causes sheet shrinkage and relatively severe shrinkage takes place in high moisture content web spans such as occur in a machine operation immediately ahead of and after the gloss calender nips. This web shrinkage results in increased web tension and such increased tension can generally be absorbed only by the heavier and stronger grades of paper. For lighter weights of paper such as, for example, newsprint, this increased tension normally results in sheet breaks and the many problems associated therewith.

In addition, because of the high-temperature which exists in the nip of a gloss calender, and because of the materials which form the resilient roll of the nip, a gloss calender cannot be threaded with the gloss calender nips in a closed position. The resilient material on the rolls is such that it cannot withstand the high surface temperatures of the nip unless a paper web is in the nip to serve as an insulator for the resilient material.

In a papermaking machine the gloss calendering will frequently be performed following the dryer section of the machine with some of the usual dryer drums omitted since drying occurs in the gloss calender. The dryers deliver the web at a predetermined speed related to the selected speed of operation of the paper machine. The gloss calender may include a series of gloss calendering rolls and nips with web spans in between and no web slippage can occur in the nips so that with varying web shrinkage different speeds must be maintained in each successive nip, and this speed may vary until moisture removal conditions stabilize after start-up. The present invention accommodates web shrinkage and changes in web shrinkage without substantial change in web tension and particularly permits the web to continue through the gloss calendering nips without slippage. The rolls are operated at the same surface speed at the nip in gloss calendering, or the resilient roll may be operated on the order of 1% greater surface speed.

By employment of the present invention, means are provided for overcoming the difficulties and problems of the prior art and, in addition, means are provided for utilizing gloss calendering treatment in on machine operations wherein the web constitutes lightweight material.

It is, therefore, among the objects of the present invention to provide an apparatus for successively gloss calendering paper and related web materials particularly lightweight paper webs, under all operating conditions and which can handle webs having different moisture contents.

It is another object of the present invention to provide a method and means for controlling the tension of paper and related web materials in a gloss calendering operation wherein the moisture content of the web is at a relatively high value, thereby making gloss calendering treatment feasible in on machine operations.

It is still another object of the present invention to provide means for sensing tension in the web in a gloss calender and for controlling the speed of the rolls to maintain the web tension at an acceptable level.

Yet another object of the present invention is to provide a method and means for making a gloss calendering of lightweight paper web feasible.

Another object of the present invention is to provide a method and means for threading a paper web through a gloss calender in an on machine operation.

Still another object of the present invention is to provide means for increasing the efficiency of the drying section of a papermaking machine by employing a gloss calender in an on machine operation in the production of lightweight paper products.

And yet another object of the present invention is to provide means for gloss calendering paper webs of a lighter weight than was heretofore possible in an on machine operation.

It is still a further object of the present invention to provide a gloss calender suitable for operation in a papermaking machine or a paper converter which is simple and compact in construction, efficient, and capable of high speed operation.

Many other features, advantages and additional objects will become manifest to those versed in the art from the detailed description of the invention which follows and the accompanying sheets of drawings in which a preferred embodiment of a gloss calender incorporating the principles of the present invention and arranged for on the machine operation is shown by way of illustrative example.

On the drawings:

FIGURE 1 is a partially diagrammatic view in side elevation illustrating apparatus constructed in accordance

with my invention for glossing paper web stock in an on machine operation;

FIGURE 2 is a partially diagrammatic view of a synchronous drive mechanism of the apparatus of FIGURE 1;

FIGURE 3 is a fragmentary partially diagrammatic plan view of the drive mechanism of FIGURE 2 and including central drive apparatus;

FIGURE 4 is a side elevational view of a web tension controller constructed in accordance with the principles of the present invention; and

FIGURE 5 is a diagrammatic view of the tension controller of FIGURE 4.

As shown on the drawings:

The present invention contemplates apparatus for use in on machine operation for glossing paper and related web material. Basically, a gloss calender comprises a rotatable roll having a finished smooth surface, at least one other roll having a hard surface resiliently yieldable under pressure cooperating with the first roll to define a hard, narrow width nip, means for maintaining the nip at a temperature sufficient to heat the paper web and coalesce at least the surface of the web in contact with the finishing surface and means for transversely and uniformly applying pressures at the nip sufficient to level, smooth and blend the surface of the web.

In on the machine operation, however, wherein the web is gloss calendered while having a relatively high moisture content, shrinkage of the web may cause breakage, and such breakage is particularly prevalent in the case of lightweight web. However, in accordance with the principles of the present invention, means are provided for maintaining the tension of the web below a predetermined value, thereby permitting successful gloss calendering in on machine operation for webs of lighter weight than was heretofore feasible.

As appears in FIGURE 1, apparatus constructed in accordance with the principles of the present invention may be employed for finishing one side or both sides of coated or uncoated paper web and related web materials.

In the arrangement shown in FIGURE 1, the gloss calender apparatus is indicated generally by the reference numeral 10 and may take the form of rolls 11 and 11a having a highly polished finishing surface. Cooperating with roll 11 to define a pair of hard and narrow width nips are a pair of hard surfaced but resilient pressure rolls 12 and 13. Likewise, similarly constructed pressure rolls 12a and 13a cooperate with finishing rolls 11a to define another pair of hard and narrow width nips.

The finishing rolls 11 and 11a may be constructed to provide the surface temperature required to plasticize at least the fibers in the surface of the web in the nips. For this purpose, at least the surface of the rolls are suitably heated such as a suitable source of heat medium being introduced into chambers within the finishing rolls 11 and 11a through respective conduits 14 and 14a. The pressure rolls 12 and 12a and 13 and 13a may preferably comprise a metal core and a resilient cover such as rubber of the required hardness for applying the pressure necessary to level, blend and smooth the plastic fibers in at least the surface of the web material while in the nip to thereby obtain the desired surface finish or gloss. The metal finishing rolls 11 and 11a, which have a highly polished surface, define the aforesaid narrow-width hard nips with the resiliently surfaced pressure rolls 12, 12a, 13 and 13a, which preferably have a high hardness, less than 30 P. and J. ($\frac{1}{8}$ inch ball). The finishing surface of the rolls 11 and 11a may be plated, as with chrome or nickel.

For particular applications and in order to obtain a smooth level surface having excellent ink receptivity and printability properties, while avoiding the high specular gloss comparable to that obtained by the cast coating methods achieved with the chrome plated or highly polished finishing surfaces, a smooth finished roll may be substituted for the highly polished rolls 11 and 11a. Also,

the web may be immediately removed from the finishing nip without the necessity of maintaining the web in extended contact with the finishing rolls and without damage to the finish of the web or to other desirable characteristics of the web.

Employment of a hard surface resilient roll permits concentration of total pressure loading on a relatively narrow nip, in the direction of travel of the web, and excellent results have been obtained when the nip is of a cross-sectional width less than one inch and preferably about $\frac{1}{2}$ inch. The development of high unit pressures in the narrow nip is desirable only below the crushing point of the web. It will be appreciated, of course, that continued use of the nip will tend to cause the resilient or hard rubber surface rolls 12, 12a, 13 and 13a to soften slightly due to the temperature conditions existing at the nip and due to the effects of working engagement with the web during the operation. Thus, to maintain the backing rolls at the desired hardness level and thereby the nip web within the desired limits, means may be employed, if desired, to cool the resilient pressure rolls. For this purpose, a cooling agent may be maintained in the interior of each of the pressure rolls introduced respectively by conduits 16, 17, 16a and 17a or cooling rolls (not shown), may be run in continual contact with the resilient rolls.

Generally, the temperature at the nip is maintained above the boiling point of water and no known upper temperature limits exist other than the decomposition of the particular web undergoing treatment and the other materials involved. Thus, any paper web or related web material may be employed in the practice of the present invention. Satisfactory finishing results have been obtained for various web material with the finishing surface of the finishing roll heated to a temperature within the range of from about 240° F. to about 550° F. Experience has indicated that the transversely and uniformly distributed high intensity unit pressure at the nip is preferably within the range of from about 200 pounds per square inch to about 2400 pounds per square inch, depending primarily upon the particular paper web involved.

Thus, in the nip, the high pressure and the high surface temperature of the finishing roll induce a condition of temporary plasticity in at least surface fibers of the web stock and permanently level the majority of surface fibers while in the plastic state thereby permitting the high pressure to coalesce the plastic fibers and thus providing a surface which is closed or sealed to an extent unobtainable by other means, while at the same time the resilience of the hardened surface pressure rolls permits sufficient yielding thereof in the nip to reduce minor web thickness in equalities without materially reducing the bulk and opacity of the web.

Satisfactory finishing results are obtained at any practical operating speeds and, therefore, finishing operating speeds are limited only by the operational speeds of the paper machine itself or the web supply means and of the nip rolls. It will be appreciated that finishing temperatures are generally directly related to operating speeds.

The gloss calendering apparatus illustrated in FIGURE 1 is arranged for on machine operation and may receive a web from a dryer roll 18 and may then deliver the glossy treated web to a conventional calender stack indicated generally at 19 for further treatment or may deliver the web directly to a winding reel (not shown). In the illustrated arrangement of FIGURE 1, the gloss calendering apparatus is situated between the last dryer roll and the calender stack, but it will be understood that the gloss calendering apparatus may be positioned at any suitable location in the dryer section and, when so employed, is preferably located in a position where the base web paper is introduced into the first finishing nip with a moisture content generally less than 50% and preferably less than 35%. For most grades of paper the web at this moisture

level is sufficiently integral to undergo a finishing treatment since the relative volume of water and fiber in the compressed condition is adaptable to such treatment. Thus, the choice of the most suitable location in the dryer section of the apparatus depends primarily upon the moisture content of the base web paper and the grade and weight of the web to undergo the finishing treatment.

Experience has indicated that the finishing gloss calendering apparatus may be advantageously employed not only as a substitute for other smoothing presses but also for portions of the dryer section. It is to be noted that from an efficiency standpoint this substitution is highly desirable when it is considered that one gloss calender having two nips has a drying capacity approximately equivalent to that of two and one-half sixty inch diameter dryers. In any event, the gloss calendering apparatus may be situated at any location in the papermaking machine where the particular paper web is of a moisture content of from 0 to about 50%, preferably less than 35%.

Thus, in operation, the untreated web W, traveling in the direction indicated by the arrow and having a relatively high moisture content, leaves the dryer roll 18 to be introduced into the gloss calendering apparatus 10.

After leaving the dryer roll 18, the web W passes under a guide paper roll 20 which is wormed to prevent wrinkles and to ensure a flat and smooth sheet in the first nip defined by the finishing roll 11 and the first backing roll 12. After the web leaves the roll 20 and before it enters the first nip it wraps around a roll 21 which is also wormed for wrinkle prevention and which forms a part of a web tension controller 22, which will be described in detail hereinafter.

After leaving the roll 21 the web is introduced to the first nip of the gloss calender apparatus, such nip being indicated by the reference numeral 15a and being defined by the finishing roll 11 and the first pressure roll 12. Means are provided for varying the pressure applied by roll 12 and may take the form of a pneumatically operated air chamber arrangement 23. An end 24 of the chamber 23 may be connected to a movable link 26 which is pivotally connected to an arm 27 rigidly connected to a member 28 of the main frame of the gloss calendering apparatus as indicated generally at 29. An opposite end 30 of the chamber 23 may also be connected in fixed assembly to the member 28 and as pressure in the chamber 23 is increased, the chamber expands to pivot roll 12 to exert a greater pressure against the finishing roll 11. Conversely, when pressure is decreased in the chamber, the chamber contracts and less pressure is exerted by the roll 12 on the roll 11. If the pressure in the chamber 23 is sufficiently reduced, roll 12 may move a relatively substantial distance from roll 11 to effectively no longer define a nip therebetween.

It will be appreciated that any conventional means may be employed to vary pressure of the roll 12 on the finishing roll 11, depending upon the glossing arrangement adopted. However, the illustrated embodiment provides simple and effective means to vary the pressure necessary in the nip to provide a level, smooth and desired surface on the web material.

After leaving the hard, narrow-width nip defined by rolls 11 and 12, the fibers in at least the finished surface of the web are permanently leveled and coalesced and the web may now be fed around a paper guide roll 31 and a wormed guide roll 32 for introduction of the web into a similar hard, narrow-width nip defined by the finishing roll 11 and the pressure roll 13, as indicated at reference numeral 15b. The side of the web in contact with the finishing roll 11 in the nip 15a and which is subjected therein to a glossing treatment receives a second finishing treatment in the nip 15b.

Similar means are provided for varying the pressure of the roll 13 against the finishing roll 11 and may comprise a pneumatically operated air chamber 33 connected

at one end to a member 34 of the main frame 29 and connected at its opposite end to a movable link 36 pivotally mounted on the member 34 by means of an arm 37. Other suitable means may be employed to effect variation in pressure or complete separation of the roll 13 relative to the roll 11.

After leaving nip 15b, the web W is trained over a roll 38 of another tension controller 39 and additionally over a wormed paper guide roll 40 to be introduced into a nip indicated by reference numeral 41a defined by the finishing roll 11a and the pressure roll 12a. Finishing roll 11a and pressure roll 12a may be similar in construction and operation to finishing roll 11 and pressure roll 12 respectively.

The unfinished side of the web W is subjected to a first glossing treatment in the nip 41a after which the web is wound around a wormed guide roll 42 to be introduced into another nip 41b defined by the finishing roll 11b and the backing roll 13a.

Similar means are provided for varying the pressure of rolls 12a and 12b against the finishing roll 11a and may comprise an air chamber 43 connected to a member 44 of the main frame 29 and to a movable link as at 46 mounted for pivotal movement on an arm 47. By increasing the air pressure in diaphragm 43 the nip pressure of the nip 41a can be increased, and conversely, by decreasing the pressure of diaphragm 43 the nip pressure can be correspondingly reduced, or the roll 12a can be moved away from a nip defining relationship with the finishing roll 11a.

After leaving the nip 41b the web passes over a paper roll 48 and is introduced to another nip 49 defined by a suction roll 50 and a pair of pressure rolls 51a and 51b the purpose of nip 49 will be described hereinafter, and the web is then trained over a tension controller roll 52 of a tension controller 53 from which, in the illustrated embodiment of the invention, the web is introduced to the vertical calender stack 19. It will be understood that if a conventional calendering treatment is not desirable the web may be wound directly on a conventional reel (not shown) and if calendering is desirable, the web may be introduced into any one of several nips defined by the stack to give the web material a variable calendering treatment.

In accordance with the principles of the present invention, it is desirable to controllably preset the speed of the pressure rolls relative to the speed of the finishing rolls, and for that reason a suitable synchronous drive mechanism may be operatively interconnected between each of the finishing rolls and their respective pressure rolls for driving the pressure rolls from the finishing rolls. One such suitable synchronous drive mechanism is illustrated in FIGURES 2 and 3 and is indicated generally by the reference numeral 54. The synchronous drive mechanism interconnecting finishing roll 11 and pressure rolls 12 and 13 is illustrated and described, but it will be understood that a similar drive mechanism may be used to synchronize the relative speeds of finishing roll 11a and pressure rolls 12a and 13a.

As illustrated, the finishing roll 11 is mounted on a shaft 56 journaled for rotation by means (not shown) connected to the main frame 29. A drive pulley 57 is mounted for corotation on the shaft 56 and is wrapped by a flexible force transmitting means 58 which may be preferably an endless belt. The belt 58 wraps a plurality of idler pulleys 59, 60, 61 and 62 which are journaled on members 63 and 64 which are connected to the main frame 29 by suitable means (not shown).

Situated operatively intermediate pulleys 59 and 60 is pulley 66 mounted on a shaft 67 which is mounted for rotation on a movable link 68 by means of a journal member 69. The movable link 68 is additionally pivotally mounted on a member 70 by means of a shaft 71, the member 70 being connected by suitable means (not shown) to the main frame 29.

A pulley 72 similar to pulley 66 is mounted inter-

mediate pulleys 61 and 62 and is similarly mounted on a shaft 72 journaled as at 74 to a movable link 76 pivotally mounted by means of a shaft 77 on a member 78 connected in fixed assembly by suitable means (not shown) to the main frame 29.

In order to maintain proper tension on the belt 58, the frame member 64 is pivotally mounted on a pin 79 connected to a frame member 80 and an air cylinder 81 may be connected to the distal end of the member 64 and to the frame for raising or lowering pulley 59 and thereby varying the tension in the belt 58.

Another pair of pulleys 82 and 83 are mounted for corotation on shafts 67 and 73 respectively, and are spaced axially from pulleys 66 and 72. Pulleys 82 and 83 are multi-grooved to receive respectively groups of multi-V belts 84 and 86 which extend upwardly to wrap respectively around complementarily grooved pulleys 87 and 88 which are mounted for corotation with pressure rolls 13 and 12 on shafts 17 and 16 respectively.

As best seen in FIGURE 3, wherein the extension of the shaft 17 over the shaft 67 has been deleted for purposes of clarity, pulleys 87 and 88 are variable pitch pulleys wherein the spacing between the grooves can be varied to vary the pitch diameter of the pulley and thereby vary the speeds of shafts 16 and 17 which are driven respectively by shafts 73 and 67. The variable pitch pulleys 87 and 88 may be of the type manufactured by Allis-Chalmers and may comprise respectively an actuating member 89 which may be actuated by a handle or control member 90. It will be understood, however, that other means may be employed to accommodate slight variance in relative speed between the shafts 67 and 73, which are driven by the finishing drum 11, and the shafts 16 and 17 which mount the pressure rolls 12 and 13.

Suitable means may be employed to maintain proper tension in the multi-V belts 84 and 86 and for this purpose the distal or free ends of movable links 68 and 76 may receive one end of pressurized fluid operated cylinders 91 and 92 respectively which are pivotally mounted at their opposite ends to members 70 and 78 of the main frame 29.

Cylinders 91 and 92 may preferably be of the type wherein an increase in fluid pressure will cause retraction of the cylinder for increasing tension in the multi-V belt.

One of the important considerations of the present invention resides in the provision of means for controlling the tension of the web in the machine. In on the machine gloss calendering operations, wherein the web material is introduced to the gloss calender while having a relatively high moisture content, the heated nips in the gloss calender tend to shrink the web, particularly that portion of the web just preceding a heated nip.

As illustrated in FIGURE 1, a web tension controller is situated on the machine 10 just preceding nips 15a and 41a, namely, tension controllers 22 and 39. Another tension controller 53 is situated on the machine just preceding introduction of the web into the calender stack 19. The tension controllers illustrated in FIGURE 1 are identical functionally and quite similar structurally.

One embodiment of a tension controller, namely, tension controller 22 in FIGURE 1, is illustrated structurally and diagrammatically in FIGURES 4 and 5 respectively and comprises a back plate 93 adapted to be connected to a frame member 94 (FIGURE 1) of the main frame 29. An over-hanging flange 96 extends inwardly from the top of the back plate 93 and forms at the end thereof a journal portion 97 rotatively receiving a shaft 98. Depending downwardly from the shaft 98 is a linking arm 99 having a journal portion 100 mounted on the shaft 98 for corotation therewith by means of a hub portion 101 secured to the shaft 98 by a pin 102. The lower portion 103 of the linking arm 99 forms a pivotal connection for a mounting bracket 104 which rotatively mounts the wormed tension controller roll 21.

An opposite end of the mounting bracket 104 is connected for pivotal movement on an arm 106 which is also

pivotally connected to a shaft 107 mounted for rotation in a stationary journal member 108 formed by a plate 109 of the tension controller 22.

Also connected for pivotal movement to the arm 106 intermediate the connection thereof with the mounting bracket 104 and the shaft 107 is a force transmitting member 110 having a journal member formed at one end thereof as at 111 for receiving a shaft 112 which is also journaled in a bore 113 formed in the arm 106. The force transmitting member 110 comprises a horizontally extending portion 114 and a downwardly inclined portion 116. At the junction of said portions the member 110 is pivotally connected to a linking member 117 by means of a pin 118, an opposite end of the linking member being pivotally connected to a flange 120 by means of a pin 121', the flange 120 being connected in fixed assembly to the plate 109 of the tension controller 22.

Formed in an enlarged portion 122' of the member 110 is an elongated horizontally extending slot 123 which receives a shaft 124 immovably attached to the plate 109 by means of a journal member 126 securely affixed to an upstanding leg support 127.

For reasons to be discussed in detail hereinafter, a flexible, resiliently extensible pressurized air chamber or air spring indicated generally at reference numeral 123 is fixedly connected to one end 129 of the member 110 and the back plate 93 of the tension controller 22. Similarly, another air spring 130 interconnects a flange member 131 depending downwardly from and fixedly connected to the plate 109 and 132 of a second force transmitting member 133 which is pivotally connected to the arm 106 on a side of the shaft 107 opposite the bore 113. The second force transmitting member 133 is similar to but inversely arranged with respect to member 110 and the pivotal connection between the member 133 and the arm 106 may be provided by a pin as at 134. Member 133 is similarly pivotally connected to the plate 109 by means of a link 136 mounted for pivotal movement by means of pins 137 and 138. Further, a slotted portion 139 slidably receives a shaft 140 immovably connected to the plate 109, by means of a downwardly depending bracket 141 connected in fixed assembly to the plate 109 by any suitable means, such as a welded joint (not shown).

FIGURE 5 illustrates diagrammatically the function and operation of a typical web tension controller constructed in accordance with the principles of the present invention wherein structural elements similar in function to those illustrated in FIGURE 4 have been given reference numerals which are similar but raised by the number 100. It will be understood that the configuration of the three tension controllers 22, 39 and 53 varies slightly one to the other, but the fundamental function and operation thereof is identical. Therefore, in FIGURE 5, a tension controller indicated generally by the reference numeral 122 includes a wormed tension controller roll 121 mounted for rotation on a mounting bracket 204 and around a portion of which is wrapped a web *W*a traveling in the direction of the arrows, for example, between the dryer roll 18 and the nip 15a as illustrated in FIGURE 1. Various components of the tension controller have fixed positions relative to a stationary main frame, for example, air springs 228 and 230, and pins or shafts 198, 221, 237 and 207. The roll 121 is on a "floating pivot," as well as pins or shafts 218, 238 and 212.

Air spring 228 is pneumatically "loaded" or pressurized to a predetermined level and thereby axially expanded to assume a predetermined configuration. Air spring 230 is a "counterbalance" member and is also pressurized to a predetermined value whereby the force transmitting members 233 and 219 are moved to a "normal" or stabilized position thereby maintaining the roll 121, through various pivotal linkages, in a normal or "zero" position.

In operation, the tension controller roll 121 will move, essentially in a plane parallel to the horizontal plane de-

finied by the bracket 204, in response to force transmitted thereto by the web *Wa* in a direction normal to the axis of rotation of the roll 121. For example, if the tension in the web *Wa* should increase due to shrinkage thereof, roll 121 would be urged rightwardly as viewed in FIGURE 5, thereby causing translatory movement of the forced transmitting member 210 to act against the air spring 228 to compress air spring 228, and further causing translatory movement of the member 233 to further expand the counterbalancing spring 230. Rightward movement of the roll 121 would continue until the increased pressure in the air spring 228 exactly compensated for the additional force applied to the roll 121 by the web *Wa*. Conversely, a reduction in tension of the web *Wa* would cause a slightly leftward movement to the roll 121, assuming, of course, that the normal or "zero" position of the roll 121 was established when a slight rightwardly directed force was imposed thereon, corresponding to a tension in the web *Wa*.

As illustrated, in FIGURE 5, horizontal movement of the roll 121 imparts corresponding pivotal movement to the linking arm 199 about the pin 198 and fixedly connected to the linking arm 199 and movable therewith is a flexible force transmitting rod or cable 242 housed within a flexible covering member 243 and movably attached at one end to the main frame of the tension controller 122. As will be described in detail hereinafter, the cable 242 may be used as a control actuator for controlling the speed of the finishing roll associated therewith in response to movement of the tension controller roll 121 which is, in turn, responsive to tension in the web *Wa*.

A corresponding reference numeral 142 leads to the flexible cable or rod which attaches to the linking arm 199 and which is relatively movably housed within the cover 143 attached to the back plate 93 by means of a connector assembly 144. The assembly 144 may be fixedly attached to the back plate 93 by any suitable means, for example, a plurality of fastening screws as at 146.

Referring again to FIGURE 3, the shaft 56 which mounts the finishing roll 11 may be driven by any variable speed driving mechanism, such as a prime mover coupled with a multi-speed transmission V-belt drive or other suitable variable speed drive units and indicated generally by the reference numeral 147. The flexible cable or rod 142 which is connected to and movable with the linking arm 99 is operatively connected to the variable speed drive unit 147 for controlling the drive unit to vary the speed of the shaft 56 in response to movement of an associated tension controller. In connection with the cable 142, it will be understood that other control actuating devices may be substituted therefore, and any suitable means may be utilized for translating movement of the tension control roller to a change in speed of the finishing roll associated therewith. For example, one of a number of known simple electrical resistance assemblies could be used to cooperate with the tension controllers to translate movement of the tension controller rolls into correspondingly varying electrical current for controlling the speed of a variable speed drive unit as disclosed, for example, in Hornbostel U.S. Patent No. 2,514,240. Further, pneumatic controls could be used for translating movement of the tension controller rolls responsive to tension in the web wrapped therearound into a change in speed of a variable speed drive unit.

As mentioned heretofore, threading of the web through a gloss calender machine in an on the machine arrangement has been a difficult operation. This difficulty is primarily brought about because of the heated surface of the finishing rolls which prevents contact thereby by the rubber-covered backing rolls until a web is introduced into the nip defined between the two rolls to protect or insulate the rubber cover of the pressure rolls from the heated finishing roll.

One aspect of the present invention resides in a method and apparatus for simplifying the threading operation of a gloss calender machine arranged for on the machine operation. Referring to FIGURE 1, the two gloss calenders comprised respectively of finishing roll 11 and pressure rolls 12 and 13 and finishing roll 11a and pressure rolls 12a and 13a must be threaded with nips 15a, 41a, 41b and 15b in an open position and therefore provision must be made for a positive hold on the tail of the web which is cut at the dryer roll 18.

The tail is fed through the gloss calenders by a conventional rope system, but for operational and other technical reasons it is not possible to extend this rope system beyond the vertical calender stack 19. Since the nip at which the web or sheet enters the calender stack 19 may vary with certain operating conditions, a rope system extending beyond the calender stack would have to be made adjustable, which is both complicated and impractical.

After the tail has been fed through the nip 41b, it is introduced into the nip 49 defined by the suction roll 50 and pressure rolls 51a and 51b. Use of a suction roll 50, and the nip 49 defined thereby, prevents the web or sheet from slipping back through nips 41b, 41a, 15b and 15a while they are maintained in their opened position. The suction roll 50 is also useful to avoid sheet flutter in the vertical sheet run between nip 41b and the tension controller 53.

After the tail has been fed through the nip 41b and nip 49, it is dropped into a broke chute below a bottom member 148 of the main frame 29 and essentially vertically below the tension controller 53.

Prior to the actual threading operation, the surface or peripheral speed of the last dryer roll which precedes the gloss calender machine, roll 18 in FIGURE 1, is determined and the surface speed of the suction roll 50 is matched therewith. Thereafter, the surface speeds of finishing rolls 11 and 11a are also matched to correspond with the surface speed of dryer roll 18. After the tail has been fed through the gloss calenders, through the suction roll nip 49 and into the broke chute (not shown) the backing roll drives are engaged, for example, by means of cylinder 81 increasing the tension of belt 58 to drive backing rolls 12 and 13. By means of the variable speed pulleys, for example, pulley 88, the backing rolls are set at a speed which is approximately 1% faster than the peripheral speed of the finishing rolls.

With the full width sheet across the last dryer roll preceding the gloss calender apparatus and with the pressure rolls 51a and 51b forced against the suction roll 50, which may be driven by a motor 149 through a belt 150, the tail may be widened at the dryer roll 18. Thus, the sheet or web material is widened through nips 15a, 15b, 41a, 41b and through the nip 49 defined by the suction roll 50 and the pressure roll 51a and 51b. The widening of the web may be accomplished by traversing a conventional tail cutting device (not shown) at the last dryer roll 18.

Referring again to FIGURE 4, an indicator scale having numerical indicia marked thereon may be supported on the plate 109 below the linking arm 99. A center point of the scale is indicated by the number "0" and equally spaced gradients are marked progressively on either side of the "0." The purpose of the scale is to provide visual indication of a normal or centered position of the roll 21, which, correspondingly, would indicate a "zero" tension thereon. In order to indicate the position of the roll 21 relative to the scale 151, an indicator arm 152 is connected by means of fastener 153 to the linking arm 99. The indicator arm 152 essentially overlies and is a continuation of the linking arm 99 and the lower portion thereof is tapered as at 154 for providing a precise indication of the relative position of the roll 21.

As soon as the full width sheet is threaded through all of the nips of the gloss calender apparatus, the tension

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controllers are adjusted so that the tension rolls thereof are balanced in the center or 0° position.

In order for the tension controllers 22, 39 and 53 to be adjusted to their center position, the air springs thereof must be properly inflated and for this reason a suitable air spring collar or adapter as illustrated in FIGURE 4 may be connected to the air springs and may comprise suitable means for increasing the fluid pressure within the chamber, such as an openable and closable pneumatic coupling 156.

Once the tension controllers are adjusted in a 0° position and a stable condition is reached, the air diaphragm 43 is inflated to move the backing roll 12a to close the nip 41a. Proper nip pressure is attained by increased pressure in the diaphragm 43 until the requisite nip pressure is attained. The nip 41a is the first nip to be closed inasmuch as it is most nearly at the midway point in the path of web travel between the dryer roll 18 and the suction roll 50.

Tension controller 39, which senses the tension of the web between nips 41a and 15b and which controls the speed of the finishing roll 11a and its associated pressure rolls 12a and 13a, is again adjusted to its 0° position, by adjusting the speed of the preceding dryer section, since it is deviated from its center position due to changes in the tension of the web due to the closing of the nip 41a.

As soon as the tension controller 39 has reached a stable position, the nip 15b is closed and adjusted followed by the closing of the nips 41b and 15a successively. The tension controllers 22 and 39 are again adjusted and stabilized by varying the pressure in the air springs thereof so as to obtain the desired sheet tension in the web material.

During the preceding threading procedure a full width sheet has been running down into the broke chute (not shown) following the suction roll 50. When a stable operating gloss calender has been attained, a tail is cut ahead of the suction roll 50 and fed into the desired nip of the vertical calender stack 19, the several nips thereof being indicated in FIGURE 1 by reference numerals 157-161. From the vertical calender stack 19, this tail is then fed to a winding reel (not shown) and the tension controller 53 is adjusted at its 0° position. When a stable operating condition has been reached the sheet is gradually widened by traversing the conventional tail cutting device (not shown) at the suction roll 50 when the full width sheet is finally obtained through the vertical calender stack 19 and onto the winding reel, tension controller 53 is given a final adjustment for obtaining the desired sheet tension. After this final adjustment, the tension controllers 22, 39 and 53 will control the speeds of the various apparatus to maintain the proper sheet tension.

The greatest shrinkage in the web occurs immediately preceding the nips, and for this reason it will be understood that tension controller 22 controls the speed of finishing roll 11 and its associated pressure rolls 12 and 13, tension controller 39 controls the speed of finishing roll 11a and if associated pressure rolls 12a and 13a and tension controller 53 controls the speed of the king roll of the vertical calender stack 19 through suitable driving mechanism similar to the driving unit 147 illustrated in FIGURE 3.

It is, of course, apparent that other suitable tension responsive means may be employed within the concept of the present invention to sense the tension of the web and to control the speeds of the various rolls. In addition, means other than those illustrated may be suitable for increasing the pressures of the nips defined by the finishing rolls and their associated pressure rolls, and also for moving the pressure rolls away from the finishing rolls during a threading operation.

In certain finishing operations, it may not be necessary or desirable to subject the web to the gloss calendering operation, and at such time the nips 15a, 15b, 41a and 41b may be maintained in an open position to effectively by-

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pass the gloss calendering apparatus. Likewise, the vertical calender stack 19 can also be effectively by-passed by the web to be wound directly on a winding reel, under certain conditions.

The temperature of the covering material on the pressure rolls 12, 13, 12a and 13a is preferably maintained as low as possible and a suitable means may be provided to effect such temperature reduction, for example, internal water cooling or an external cold air blast. It is often preferable where internal water cooling is used to cool the edge portions of the pressure rolls which extend beyond the width of the sheet by a cold air blast in order to protect the uninsulated rubber covering of the rolls from the heat radiated by the finishing rolls. These outward edges may also be tapered outwardly so as to prevent contact thereof with the finishing rolls.

Accordingly, there has been provided gloss calendering apparatus suitable for finishing lightweight paper web in an on machine arrangement whereby the tension of the web due to shrinkage is maintained at a satisfactory level by individually varying the speeds of the finishing rolls and their associated pressure rolls in response to web tension. Further, a synchronous drive mechanism is provided for driving the pressure rolls from their corresponding finishing rolls in order to provide proper surface speed relationships between the finishing rolls and their respective pressure rolls. Maintenance of proper speed relationship between the finishing rolls and their associated pressure rolls is particularly important at the time of closing the nips subsequent to the threading operation.

In addition to providing for pressure rolls movable away from the finishing rolls, the threading operation is improved by the provision of the suction roll 50 and its associated pressure rolls 51a and 51b which prevent the sheet from slipping back through the gloss calender operation when the nips are in an open position.

Although various modifications might be suggested by those versed in the art, I wish to embody within the scope of the patent warranted hereon all such modifications as come within the scope of my contribution to the art.

I claim as my invention:

1. In a paper machine for finishing paper and related web materials,
 - first and second gloss calenders each having a hard, heated, polished finishing roll and at least one pressure roll having a relatively resilient surface to define a hard, narrow-width nip,
 - said gloss calenders being arranged in successive in-line arrangement on the machine,
 - means for supplying a traveling web having a relatively high moisture content to a nip in said first gloss calender,
 - means for receiving said web from said second gloss calender,
 - first and second variable speed drive means for driving said first and said second gloss calenders respectively, and
 - first and second speed control means connected respectively to said drive means and engageable with said web and movably responsive to the tension in said web for controlling the speed of said gloss calenders in response to web tension,
 - said first control means being responsive to web tension at the on-running side of said first gloss calender to control the speed thereof for maintaining the on-running tension of the web at a predetermined level, and said second control means being responsive to web tension at the on-running side of said second gloss calender to control the speed thereof for maintaining the on-running tension of the web at a predetermined level.
2. In a paper machine for finishing paper and related web materials,

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first and second gloss calenders each having a hard, heated, polished finishing roll and a pair of pressure rolls having a relatively resilient surface with a hardness of less than 30 P. and J. ($\frac{1}{8}$ inch ball) defining with said finishing roll a pair of hard nips 5
 having a width of from about one inch to about one-half inch and spaced angularly about said finishing roll for heating and pressing the web to induce a condition of plasticity in at least the surface fibers of the web and to level and to coalesce said surface 10
 fibers,

said gloss calenders being situated successively in on line arrangement on said machine, individual variable speed drive means for each of said finishing rolls, 15

means for driving said pressure rolls from their respective finishing roll, means for slightly varying the relative speed between said pressure rolls and their respective finishing rolls, means for varying the pressure of said pressure rolls 20
 against said finishing rolls and for moving said pressure rolls away from nip-defining relation with their respective finishing roll,

a dryer roll for supplying a traveling web having a moisture content of less than 50% to the first nip of said first gloss calender, 25

first tension control means situated between said dryer roll and said first gloss calender,

said first control means having a wormed roll engageable with the web and movable in response to changes in web tension and having means connected to said roll and to the variable speed drive of said first gloss calender for controlling the speed of said first gloss calender to maintain a substantially constant tension of the web at the on-running of said first gloss calender, 35

a wormed roll for receiving the web from the first nip of said first gloss calender and for introducing the web to the second nip thereof,

second tension control means situated between said first and said second calenders, 40

said second control means having a wormed roll engageable with the web and movable in response to changes in web tension and having means connected to said wormed roll and to the variable speed drive of the second gloss calender for controlling the speed of said second gloss calender to maintain a substantially constant tension of the web at the on-running side of said second gloss calender, 50

a wormed roll for receiving the web from the first nip of said second gloss calender and for introducing the web to the second nip thereof,

rotatable receiving means for receiving the traveling web from said second gloss calender, 55

variable speed drive means for said receiving means, third tension control means situated between said second gloss calender and said receiving means,

said third control means having a wormed roll engageable with the web and movable in response to changes in web tension and having means connected to said wormed roll and to the variable speed drive of said receiving means for controlling the speed of said receiving means to maintain a substantially constant tension of the web between said second gloss calender and said receiving means, and 60

a suction roll and pressure rolls in nip-defining relation between said second gloss calender and said third tension control means to prevent back slippage and flutter of the web. 70

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3. In the method of finishing paper web and related web materials, the steps comprising,

supplying a traveling sheet of web material having a moisture content of less than 50%,

introducing the sheet to a first gloss calender to heat and press at least the surface fibers of one side of the sheet to induce a condition of plasticity therein to level and to coalesce said fibers,

sensing and maintaining the tension of the sheet at the on-running side of said first gloss calender to a predetermined value,

removing said sheet from said first gloss calender, introducing the sheet to a second gloss calender to heat and press at least the surface fibers of the other side of the sheet to induce a condition of plasticity therein to level and to coalesce said fibers,

sensing and maintaining the tension of the sheet at the on-running said of said second gloss calender to a predetermined value, and

removing the sheet from said second gloss calender.

4. In a paper machine for finishing paper and related web materials including means for supplying a travelling web having a moisture content of less than 50% and means for receiving the web,

first and second gloss calenders each comprising a hard, heated, polished finishing roll and at least one pressure roll having a relatively resilient surface and being in nip-defining relation with said finishing roll to receive the web and to induce a condition of plasticity in surface fibers of the web to level and to coalesce said surface fibers,

said gloss calenders being arranged successively in on-line arrangement on the machine between said supply means and said receiving means,

first and second variable speed drive means for independently driving said first and second gloss calenders, and

first and second tension control means connected respectively to said first and second drive means for controlling the speed of said respective drive means,

said first tension control means being engageable with said web at a first point between said supply means and said first gloss calender for controlling the speed of said first gloss calender as a function of the tension of the web at said first point and said second tension control means being engageable with said web at a second point between said first and second gloss calenders for controlling the speed of said second gloss calender as a function of the tension of the web at said second point.

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WALTER A. SCHEEL, *Primary Examiner.*

LOUIS G. MAASSEL, *Examiner.*