Jan. 25, 1966 B. J. H. NELSON 3,230,867

PAPER FINISHING MECHANISM

Filed Dec. 4, 1961 4 Sheets-Sheet 1

FIG. 1

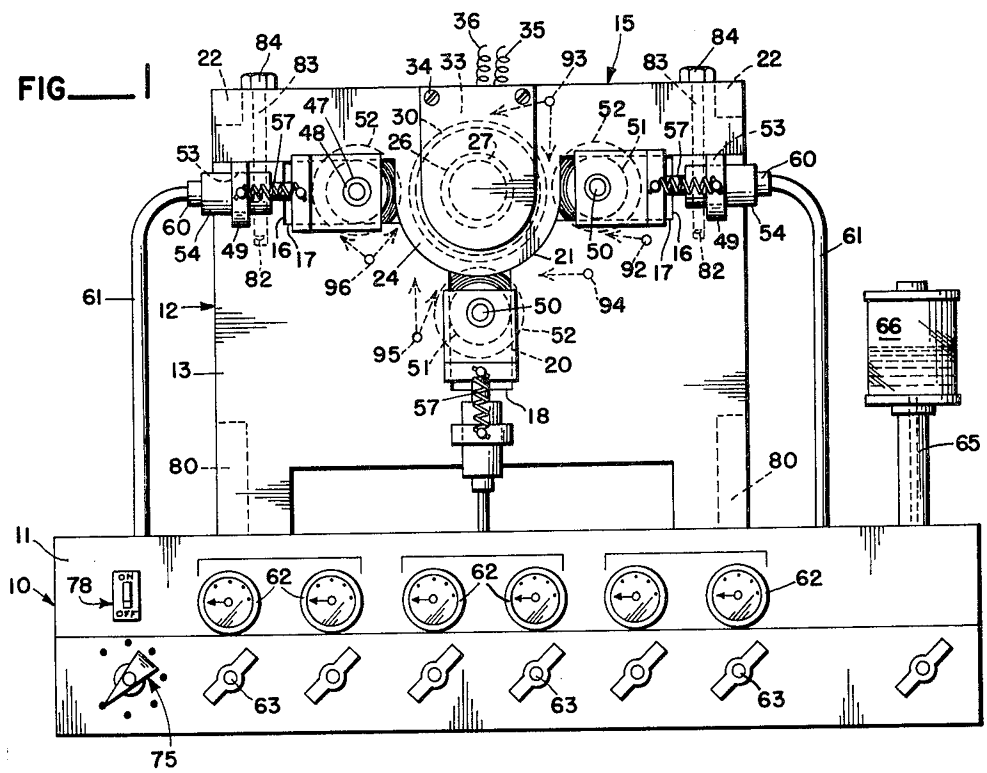


FIG. 3

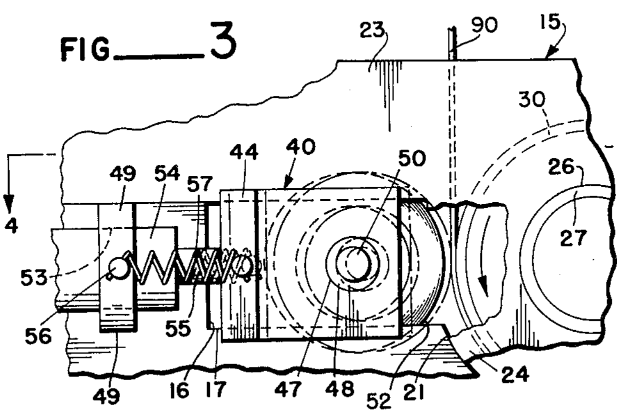
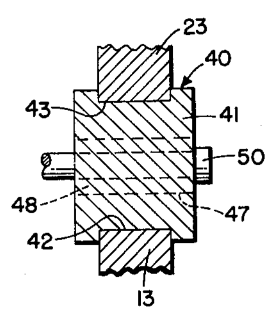


FIG. 5



INVENTOR.
BENJAMIN J. H. NELSON
BY
T W Secrest
ATTORNEY

Jan. 25, 1966 B. J. H. NELSON 3,230,867

PAPER FINISHING MECHANISM

Filed Dec. 4, 1961 4 Sheets-Sheet 2

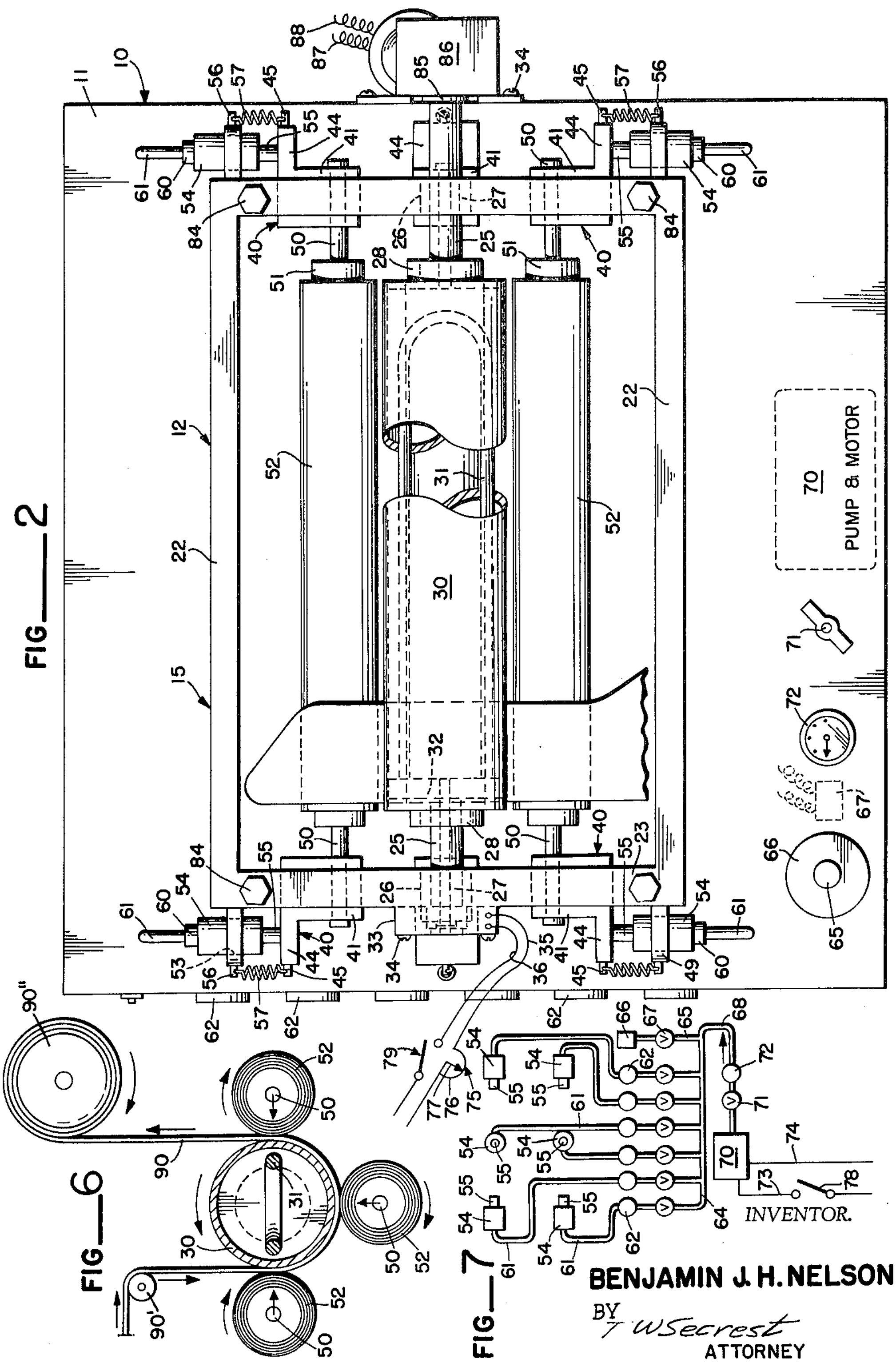


FIG. 2

FIG. 6

FIG. 7

INVENTOR.

BENJAMIN J. H. NELSON

BY T. W. Secrest

ATTORNEY

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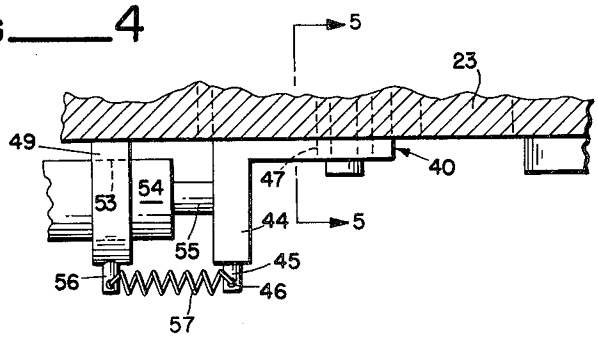
FIG. 4



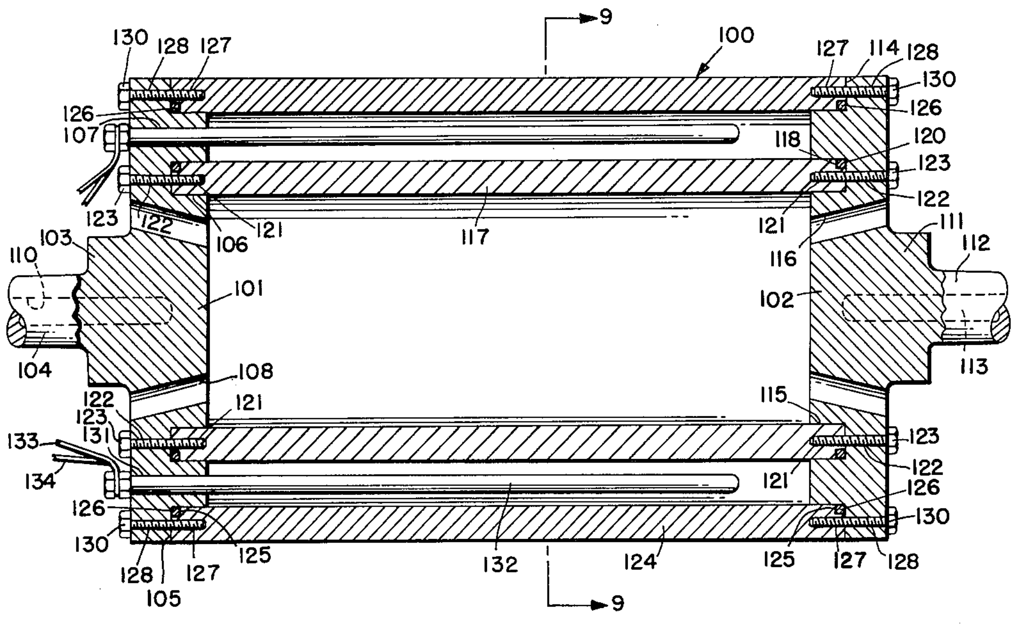


FIG. 8

INVENTOR.
BENJAMIN J. H. NELSON
BY
T W Secrest
ATTORNEY

Jan. 25, 1966 B. J. H. NELSON 3,230,867

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FIG. 9

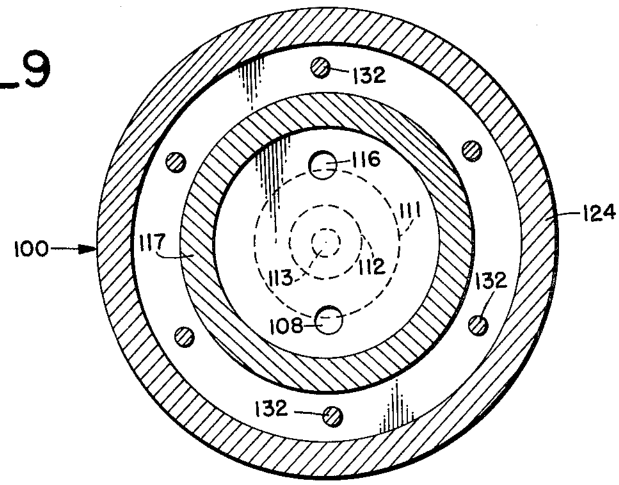
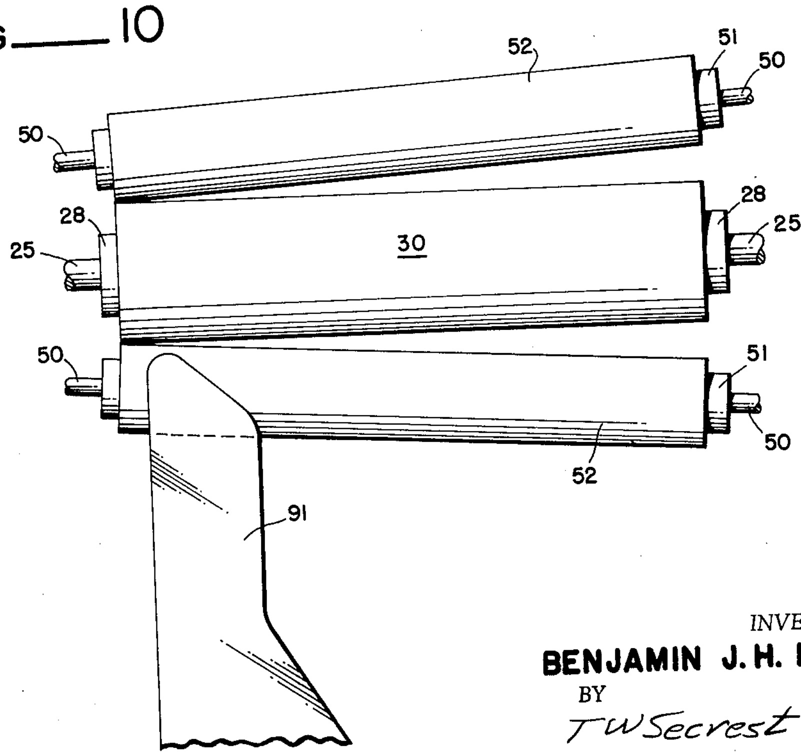


FIG. 10



INVENTOR.
BENJAMIN J. H. NELSON
BY
T W Secrest
ATTORNEY

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PAPER FINISHING MECHANISM

Benjamin J. H. Nelson, 5121 Dogwood, Everett, Wash.

Filed Dec. 4, 1961, Ser. No. 156,827
10 Claims. (Cl. 100—93)

This application is a continuation-in-part of my prior application, Serial No. 17,986, filed March 28, 1960, entitled Multi-Purpose Calender, and now abandoned.

This invention relates to a multi-purpose calender, for use in the paper making industry and, more specifically, to a calender which is capable of operating at high speeds and of imparting a high quality finish to the paper with control. The calender can be used in conjunction with the paper machine thereby making a compact unit for producing finished paper, can be used on the coating machine, or can be used independently of other machines.

Conventionally, calenders and supercalenders in the art involve what is known as "stacked rolls," the bottom one of which is driven, the pressure between the respective rolls of the stack being adjustable by means of change in the overall pressure of one roll against the next in the stack.

As known in the paper finishing art, the basic difference between a calender and a supercalender is that the calender has a complete stack of rolls of chilled iron, or some hard nonresilient material; while the supercalender has alternate resilient and hard rolls. With this difference, it is easy to see that a different set of conditions applies to each type of stack. The calender stack with chilled iron rolls has no give in the nip and retains its normal contour at normal operating pressures. The supercalender, on the other hand, having resilient rolls is governed by the law of "rolling friction." All of the best grades of off-machine coated paper and board are finished on supercalenders. Supercalenders are not generally used on-machine (i.e. with the paper machine) because of the impracticability of using soft rolls and because of the high risk of damage through breaks or imperfections. In addition, it is common practice to apply surface treatments of various kinds on mill calenders, and this can be most readily done when all steel rolls are used. Steel rolls have the disadvantage of blackening the paper if too much pressure is applied or if moisture in the paper is too high. Resilient backing rolls, on the other hand, permit more uniform polishing of low spots as well as high spots.

Vertical calenders using all-metal rolls may be considered to have one dimension, i.e., non-resilient metal rolls. In addition, these calenders have direct and indirect friction. A calender may be considered to gather strength by the number of incoming nips. Such a calender is not a generator of heat in itself as a paper web or fibrous web is the only resilient force in the calender. Remember, the rolls are metal rolls and non-resilient in this respect. In regard to direct friction, this type of friction occurs when the bottom king roll drives all the dead rolls in the vertical calender. Indirect friction is the crowding of the paper at the incoming nip. The crowding of the paper encourages indirect slip of the steel rolls. More particularly, a web of paper comprises small clumps of fibers in the paper. This occurs in the laying down of the fibrous mass on the wire to form the paper. It is impossible to eliminate all of these fibrous clumps in the paper. When the paper is dried to about a 5% moisture content, the fibrous lumps are still intact and remain in the paper. Now, with the fibrous lumps approaching the nip between two rolls and passing through the nip, it is seen that the clump will separate the two rolls to a greater or lesser degree. This may also be considered to be indirect friction. Actually, with a multiplicity of fibrous clumps in series, the rolls chatter as they are separated by the clumps passing between them. The separation and chatter at the nip causes one roll to vary its rotational speed with respect to the other roll. As a result, there is a slippage and a difference in the finish of the paper web at this particular area in the paper. This cannot be eliminated with steel rolls and with clumps of fiber in the paper. The result of this is that the fiber in the paper is crushed and flattened and also a higher degree of finish is imparted to the finish of the paper at this particular area.

It has been found that paper having a moisture content above about 5% carries too much heat from the drier to the paper machine. As a result, the heat produces an uneven steel roll expansion which in turn, over a period of time, will not produce a uniform finish across the paper web. In offset book and writing grade papers, the finish is critical and also the caliper uniformity is critical. From experience, it has been found that too high a moisture content in the paper going into the calender is harmful to both the finish of the paper and the uniformity of caliper.

Supercalenders have alternate metal rolls and fiber-filled rolls and may be considered to have a strength involving a single dimension plus other factors. As is recalled, the strength of a single dimension calender or a metal roll calender is determined by the number of nips. In a supercalender the strength is determined by both the number of incoming nips, the pressure on the incoming nips and the speed at which the rolls are rotating or the velocity at which the paper is passing through the rolls. In addition, there is a resilient force due to the resiliency of the fiber-filled roll. There is a direct friction factor when the bottom king roll drives all dead rolls in the vertical supercalender. There is also an indirect friction factor in that the resilient rolls change shape when the pressures are greater than the resilient roll surface. The indentation of the non-resilient roll surface to the resilient roll surface produces a nip width because of the bearing weight of the dead rolls in the vertical supercalender. The dimension change develops when the calender is turning at an operating pressure and speed. The nip becomes wider and changes to an oblique angle. The surface of the resilient roll folds or crowds the incoming nip making the oblique angle possible. At this time the severity of the non-resilient roll slip at the nip is considerable and is referred to as an indirect friction plus factor. The working movement of the resilient roll surface crowds the incoming oblique angle of the nip and produces the plus factor of indirect friction. In addition, there is a plus factor of the single dimension calender of the nips. The supercalender, as contrasted with the normal calender, is a generator of heat by way of the resilient rolls crowding the incoming nip when the weight of the metal and fiber rolls increase the pressure and also because of the speed of rotation of the rolls.

The improved calender equipment herein presented constitutes a variation from gang style calenders and supercalenders in several respects. Basically, the improved equipment includes a smooth heated master roll, heated as by electricity (because of accuracy in control of the degree of heating and relatively rapid change from a given heat input to another given heat input). However, the master roll can readily be adapted to various sources or elements that generate heat. Cooperating with and frictionally driven by the heated master roll at essentially the same peripheral speed as the heated master roll are one or more resilient subordinate rolls (e.g. cotton fiber-filled rolls). Each resilient roll is independently adjustable by selective actuation of an associated hydraulic cylinder through appropriate mechanical linkage.

The improved design provides independent adjustment and control of the degree of heat input, and the degree of pressure in each nip independent of the pressure at the other nips. In addition, each subordinate roll is frictionally driven directly by and thus at essentially the same peripheral speed as the master roll so that the pull on the paper web through the calender is more easily maintained at the optimum level.

Another operationally important factor involved in connection with the improved equipment herein presented is its ease of "threading." The paper strip being calendered is conventionally threaded through the nips by an air jet system. Since in the conventional equipment, however, the paper-strip-leading end must be turned by the jets about 180° between each nip and since the rolls must be in driven contact while being threaded, jamming of the strip while being threaded is a common occurrence. By virtue of (1) the fact that all idler rolls form a nip with and are frictionally driven by the master roll, (2) the fact that the driven rolls can be retracted during the threading operation, and (3) the fact that the leading end of the paper strip must be turned only 90° or less between the nips, the threading operation is much less subject to jamming. The safety factor achieved cannot be overemphasized since finger loss has proven to be one of the largest hazards in the paper mill. Also, the necessity for having to unjam the equipment because of faulty threading is effectively minimized.

An equally important facet is that the auxiliary or subordinate rolls break away from the master roll to permit the threading operation. There is a two-inch clearance, the purpose of which is to eliminate needless destruction to the surface of the fiber filled rolls. This is also true when the machine is in full operation and the paper web breaks. The subordinate fiber filled rolls will retract by electronic breaker light control. This breakaway system presents a new and better calender for on-the-paper machine use. It also paves the way for using resilient rolls in the multi-purpose calender on the paper machine where calender speeds are needed to match paper machine speeds while threading operations are taking place.

Dimensionally, the improved equipment set forth herein is a compact unit. This unit, when in full scale, measures four feet in height. Further, its ease of assembly and disassembly to replace a particular roll, for example, is evident. Its flexibility to provide any desired number of nips or any sequence of nip pressures is also apparent.

Another operationally important factor involved in connection with the improved equipment herein described is its ease in controlling pressure. The mechanical linkage also includes gauges that give accurate reading of hydraulic pressures used independently at each end of the subordinate rolls. Speeds and pressures are controlled automatically and manually.

Low pressures on resilient rolls do not generate heat. Therefore, induced heat is a prerequisite to be used in controlling finishes with high moistures.

The multi-purpose calender on the paper machine can make full use of the moisture in obtaining finishes required on all grades of paper. The use of high speeds reduces time exposures, with low pressures. High heat eliminates the blackening of the paper when using high moistures.

The calender operating at 2200 feet to 3000 feet per minute, with controlled pressure and controlled heat, eliminates guess work in surface finishing paper.

The test made on the multi-purpose calender with writing grades indicates a multi-purpose sheet can be manufactured. Book grades can be finished on the new calender. The Bekk readings on finecoat letterpress and offset grades at speeds of 2200 feet per minute were run on the multi-purpose calender using resilient rolls produced equal Bekk readings on both sides.

Off-machine coated grades, coated one-side labels and coated two-side offset and letterpress paper can be calendered on the coating machine all in one operation, thereby reducing the cost of manufacturing by a considerable margin. In general, the grades of paper to which the invention is addressed can be categorized as ink-receptive papers, i.e. papers sufficiently porous to retain ink after gloss finishing.

Another operationally important factor involved in connection with a multi-purpose calender is its use on the coating machine. The low height requirement of the instant calender makes it ideal for use with coating machines where turnback dryers are used. The new calender, for its size, has a marked advantage over gang style calenders in that it will produce a brighter and higher finish than gang style calenders. Finishes do not have a mottled appearance when calendered on the multi-purpose calender, of the present invention. The density of the finish, the brightness, the bulk (i.e. caliper) and the stiffness are higher when low pressures are being used.

Another important factor is the elimination of secondary calendering and double handling in the storing of the paper rolls.

Another important factor involved is the life of resilient rolls used in the multi-purpose calender. They are not abused with heavy pressures or freehand scrubbing and sanding. The compact design reduces time used in changing rolls when needed, plus the fact that the low height does not interfere with resilient roll changes. This applies wherever the new calender is installed.

An object of my invention is the provision of a calender having greater output capacity than presently employed calenders.

A further object is the provision of a calender which produces a higher quality paper than previously known and used calenders.

Another important object of this calender is that the speed of operation can be easily and closely controlled.

A still further object is the provision of a calender wherein the pressure on the calender rolls can be controlled.

Another object is the provision of a calender wherein the heat applied and the temperature of the rolls can be controlled.

A still further and important object is the provision of a calender wherein there is less wear and tear on a calender roll and consequently a longer life for the roll.

A still further object is the provision of a calender having less maintenance upkeep than previously used calenders.

Another very important object is the provision of a calender wherein it is safer to thread paper in the nip of the rolls than with previously employed calenders.

A still further and important object is the provision of a calender requiring less housing volume and overhead space than previously used calenders.

Another important object is the provision of a calender which is less expensive to manufacture and maintain than previously used calenders.

An additional object is the provision of a calender which is lighter in weight than conventional calenders and therefore requires less foundation construction than conventional calenders.

These and further important objects and advantages of my invention will be more clearly brought forth with reference to the following drawings, specification and claims.

In the drawings:

FIGURE 1 is an end elevational view of a specific embodiment of my invention in accordance with the preferred teachings thereof.

FIGURE 2 is a fragmentary plan view looking down on the calender and illustrates the central roll with the central section removed to more clearly depict the heating element in the roll.

FIGURE 3, on an enlarged scale, is a fragmentary end elevational view illustrating the means for adjusting the nip between the central roll and the auxiliary roll.

FIGURE 4, taken on line 4—4 of FIGURE 3, is a plan view looking down on the means for adjusting the nip between the central roll and the auxiliary roll.

FIGURE 5 is a fragmentary lateral cross-sectional view taken on line 5—5 of FIGURE 4 and illustrates the bearing means for maintaining the auxiliary roll in position in the calender frame.

FIGURE 6 is a schematic end elevational view illustrating the arrangement of the central calender roll and the three auxiliary rolls, and illustrates and shows the heating element in the central roll.

FIGURE 7 is a schematic diagram illustrating the hydraulic system for adjusting and controlling the pressures between each auxiliary roll and the central roll.

FIGURE 8 is a longitudinal diametrical cross-sectional view of another master roll and illustrates the details of construction of the same.

FIGURE 9, taken on line 9—9 of FIGURE 8, is a lateral cross-sectional view of the master roll; and,

FIGURE 10 is a schematic plan illustrating the separation of the auxiliary rolls from the master roll for assistance in threading the paper through the calender.

Referring to the drawings it is seen that the invention comprises a calender **10** having a base **11**. Supported on this base **11** is a roll frame **12**. This roll frame **12** comprises two end members **13** and two side members. The upper edge of each end member **13** is recessed to receive bearing blocks and a top frame member **15**. More particularly, the members **13** near their outer edges are stepped at **16**. This step runs into an inwardly directed horizontal ledge **17**. In the lower center portion of the member **13** is a slot having a bottom wall **18** and side walls **20**. Each side wall **20** connects with the adjacent ledge **17** by means of curved wall **21**. The top frame member **15** is in the configuration of a rectangular frame having longitudinal sides **22** and ends **23**. In the central portion of the end **23** is a depending curved bearing support **24**. Journalled in each of these two bearing supports **24** is a shaft **25**. This shaft **25** is not a continuous shaft but is two independent shafts. In the support **24** is a drilled passageway **26** and in this passageway is a bearing **27**. The end of each shaft **25** is journalled in said bearing **27**.

On the inner end of each of the shafts **25** is a circular hub **28**. This circular hub interfits with a hollow central roll **30**. This roll is metal. In the interior of this roll is a heating element **31** in the configuration of a U-bend. The ends of this heating element are in an electrical adapter base **32** at the left of the roll as illustrated in FIGURE 2.

On the outside left face of the frame member **23** and overlying the central part of the depending support **24** is a commutator **33**. This commutator **33** is attached to the frame member **23** by screws **34**. Leading into the commutator **33** are electrical wires **35** and **36**. The shafts **25** are hollow. The commutator **33** connects with the electrical adapter **32** through the hollow shaft **25** by suitable electrical connectors.

The top frame member **15** is supported on the upper and outer edges of the end members **13**. The lower surface of the upper member **15**, the step **16** and the ledge **17** define a guide channel for a bearing block **40**. The bearing block has a main body **41**. In the bottom surface is a groove **42** for interfitting with the ledge **17**, and in the upper surface is a groove **43** for interfitting with the lower surface of the end member **23**. On the outer edge of the block is an outwardly directed lug **44**. And, projecting out of the lug **44** is a pin **45** having a drilled passageway **46** therein.

In the body **41** is a lateral drilled passageway **47**. In this passageway is a bearing **48**.

As is seen in FIGURE 2 there are three sets of bearing blocks with two blocks in each set. Also the two blocks in each set are aligned with one block associated with one end member and the other block with the other end member.

Journalled in the bearings **48** of a set of the blocks is a shaft **50**. The central part of this shaft is of a larger cylindrical configuration **51**. Surrounding the configuration **51** is a cylindrical fibrous mat **52** of the type employed in supercalender rolls. In fact, mat **52** makes this roll a supercalender roll.

On the upper and outer surface of the end member **13** and adjacent to the step **16** is a lug **49**. In this lug is a central passageway **53**. Positioned in the passageway **53** is a hydraulic cylinder **54** having a plunger **55**.

The hydraulic cylinder **54** can be positioned in the bearing block by means of a pressure fit, a set screw or by welding.

The plunger **55** contacts the outer face of the lug **44** so as to move inwardly the bearing block **40**.

On the outer edge of the lug **49** is a pin **56**. A spring **57** connects the two pins **45** and **56** so as to pull the block **40** toward the lug **49**.

On each cylinder **54** is an adapter **60**. This adapter connects with a pipe or tube **61**. In each pipe **61** is a pressure gauge **62** and a valve **63**. The lines **61** connect with a main feeder line **64**. In each line **61** the gauge **62** is positioned between the hydraulic cylinder **54** and the main line **64**, and the valve **63** is positioned between the gauge **62** and the main line **64**. The main line **64** branches into a reservoir line **65**. This line connects with a hydraulic fluid reservoir **66**. In the line between the reservoir **66** and the main line **64** is a valve **67**.

The main line **64** also connects with a pressure line **68**. A motor and pump combination **70** connects with the pressure line. In the line **68** between the main line **64** and the pump **70** are a valve **71** and a pressure gauge **72**.

The motor and pump combination **70** are electrically actuated and controlled. There are two lead wires **73** and **74** leading to the motor **70**. In the lead **73** is a switch **78**. It is to be understood that connecting with the wiper **77** and the switch **78** is an appropriate source of electrical energy.

In the lead **35** there is a rheostat **75** having a number of resistances **76** and a wiper **77**. In the lead **36** there is a switch **79**.

In regard to details of construction of the calender it is seen that the end members are connected at their base by lower braces **80**. These members are connected at their upper edges by the top frame member **15**. The upper edges of the end members **13** are drilled and tapped as at **82**. In the end **23** is a drilled passageway **83**. The tapped hole **82** and the drilled passageway **83** are aligned. A bolt **84** is screwed into the tapped hole **82** so as to firmly position the frame members **15** on the roll frame **12**. The central roll **30** can be removed by unscrewing the bolts **84** and removing the top frame member **15**.

From this specific description of the invention it is seen that there is a central heated roll **30** and three auxiliary rolls **52**. Referring to FIGURE 2 it is seen that the right end of the shaft **25** of the central roll **30** connects with an output shaft **85** of a motor **86**. This motor drives the roll **30**. The motor connects with an appropriate source of electrical power by means of wires **87** and **88**. The central roll is of metal and may be heated to an appropriate temperature of 250–500° F.

The pressure between the central roll and the auxiliary can be readily varied. Also, the pressure between one auxiliary roll and the central roll can be different than the pressure between another auxiliary roll and the central roll.

Referring to FIGURE 6 it is seen that paper **90** is threaded between the three auxiliary rolls **52** and the central roll **30**. As seen in this figure the central roll

30 rotates in a counterclockwise direction while the three auxiliary rolls rotate in a clockwise direction, while the web of paper 90 is fed into and out of the calender in the manner indicated by the arrow designations shown in conjunction with the paper web 90 in FIG. 6, it being of course understood that for this purpose the paper web 90 has associated therewith suitable web feeding means which are conventional per se, such as an infeed guide roll 90' and an outfeed power driven take-up roll 90''.

In FIGURE 10, with reference to the threading of paper in the machine, it is seen that with my particular calender 15 it is possible to move the fiber rolls 52 with respect to the main metal roll 30. This is possible because of the bearing structure. As a result the fiber rolls are at an angle with respect to the master roll. With the fiber rolls being spaced apart from the master roll it is possible to thread the paper 90 in the calender. To assist the threading of the paper 90, the paper is slit so as to have a thin leading edge 91. The leading edge 91 goes between the roll 52 and the roll 30. With the paper firmly in place in the calender, the leading edge 91 broadens out so that the paper becomes the full desired width.

To also assist in the threading of paper in the calender, there are provided jet air ducts. It is seen that, under the right-hand fiber roll 52, there is a jet air duct 92. This air duct is underneath and to the right of this particular fiber roll and directs a stream of air somewhat tangentially to the left so as to direct the paper coming off the roll in a leftward direction. Positioned above and to the right of the metal roll 30 is an air duct 93. This air duct 93 is substantially over the nip between the right-hand fiber roll 52 and the metal roll 30. It directs the air in two directions: a downward direction toward the nip and a left hand and downward direction over the top of the metal roll 30. Underneath the left-hand fiber roll 52 is an air duct 94. This air duct 94 is also to the left of the nip between the metal roll 30 and the lower fiber roll 52. The air duct 94 directs air in a leftward direction and toward the nip between the metal roll 30 and the lower fiber roll 52. To the left and somewhat below the center of the lower fiber roll 52 there is an air duct 95. This duct directs a jet stream of air upwardly and to the right and substantially tangentially to the surface of the roll 52 so as to direct the paper on the roll toward the metal roll 30. Also, the duct 95 directs air upwardly toward the nip between the metal roll 30 and the left-hand fiber roll 52. Underneath the left-hand fiber roll 52 is an air duct 96. This air duct directs air upwardly and to the right toward the metal roll 30 so as to force paper toward the metal roll 30. Also, the air duct 96 directs air in an upward and left-hand direction and substantially tangentially to the left fiber roll 52. This stream of air tends to force the paper coming from the fiber roll 52 in an upward direction.

As previously stated, in the conventional calender and super-calender, a number of workmen have lost and lose fingers in the threading of paper between the rolls. In threading the paper the workman stands back and grabs a wad of paper and throws this wad of paper in the opening. If he does not let go of the wad of paper in sufficient time, he may get his finger caught and then have one or more fingers crushed. It is seen that, with my machine, there is provided a relatively simple and safe manner of threading paper between the rolls. In fact, it is difficult to see how a person could lose a finger in the threading of my calender.

In FIGURE 8 there is illustrated another master metal roll 100. This roll comprises a first hub 101 and a second hub 102. The exposed face of the hub has a shoulder 103 and which shoulder 103 tapers down to a shaft or axle 104. In the inner or hidden face of the hub 101 there is a peripheral recess 105. This recess is in the outer edge of the hub. In the more central portion of the hub 101 there is a circular recess 106. Between the outer recess 105 and the circular groove 106 there is drilled in the hub a plurality of holes or openings 107. In the hub 101 are a plurality of vent holes 108. These vent holes 108 are between the shoulder 103 and the circular groove 106. Also, drilled in the axle 104 and the shoulder 103 is a recess 110.

In the hub 102, and on the exposed face, there is a shoulder 111. The shoulder 111 is reduced to an axle 112. In the axle 112 and the shoulder 111 there is a drilled recess 113. In the inner or hidden face and at the outer periphery there is a recess 114. This recess 114 corresponds to the circular recess 105 in the hub 101. Also, there is a circular recess 115 in the hub 102. The recess 115 corresponds to the recess 106 in the hub 101. There are vent holes 116 in the hub 102. These vent holes are between the shoulder 111 and the circular recess 115.

In the circular recesses 106 and 115 there is positioned a cylinder 117. The cylinder 117 has the outer wall recessed at 118 so as to receive in an assembled position a gasket 120 or an O-ring 120. In the end walls of the cylinder 117 are a number of drilled tapped passageways 121. In the hubs 101 and 102 are a number of drilled holes 122. The drilled holes 122 are aligned with the tapped holes 121. As is readily appreciated, bolt 123 can be inserted through the holes 122 and screwed into the tapped holes 121. In this manner the hubs 101 and 102 are positioned with respect to the cylinder 117.

In the circular recess 105 there is positioned a metal cylinder 124. It is seen that this cylinder 124 is larger in diameter than the cylinder 117. The inner-outer edge of the cylinder 124 is recessed at 125. The roll 100 in assembled position has an O-ring 126 in this recess 125. The ends of the cylinder 124 have a plurality of tapped holes 127. The hubs 101 and 102 have a plurality of drilled passageways 128. It is to be understood that the tapped holes 127 and the drilled passageways 128 are in alignment. A bolt 130 projects through the hole 128 and is screwed into the tapped hole 127. It is to be realized that by tightening the bolt 130 the hubs 101 and 102 are drawn closer together and the O-ring 126 is squeezed so as to function as a gasket.

In the hub 101, and positioned between the holes 122 and 128 there are a plurality of drilled holes 131. Inserted in these holes is an electric heating element 132. On the outside of the hub 101 there is attached electric lead ends 133 and 134. In the toroidal space between the hubs 101 and 102 and the cylinders 117 and 124 there may be a compound which can withstand relatively high temperature without decomposing, having a low coefficient of expansion and which is a liquid at the higher temperatures, and is perfectly a liquid at room temperature. One such compound is tetraiodotetrasilane. The reason for a liquid in the toroidal space is that better results are achieved by having a liquid in contact with the cylinder 124 instead of depending upon convection from a gas and radiation.

The vent holes 108 allow the pre-passage of air in the central part of the metal roll 100. A beneficial result of this is that there is not created undue pressure due to the expansion of heated gas inside of the roll.

It is noted that the shafts 104 and 112 have drilled holes 110 and 113. This is so that the cooling liquid may be pumped into the drilled holes and thereby cool down the hubs. A longer life is realized by this.

Having described my invention I will now present some examples illustrating the use of my calender and the product realized therefrom. These examples are by way of illustration only and are not to be taken as limitations on the invention.

Example I

The paper was a 45 pound raw stock having a 15 pound coating, i.e., latex and clay, to make a 60 pound paper.

	Invention calender	Conventional calender
Nips	6	7
Temperature, ° F	309	<200
Speed of paper, feet per minute	2,200	1,072–1,200
Pressure, pounds per lineal inch	792	5,500
Smoothness (glare, Bekk reading)	44	43–44
Appearance	(1)	(2)

1 White paper. 2 Like wax paper.

In my calender, in order to realize six (6) nips, it was necessary to pass the paper through the calender two times. The results of this example show that a better quality paper, e.g., a white appearance as contrasted with a wax paper appearance, is realized at approximately twice the output speed viz, 2200 f.p.m. as contrasted with 1072–1200 f.p.m., with my calender than with the conventional calender.

Example II

The paper was a 45 pound raw stock having a 15 pound coating, i.e., latex and clay to make a 60 pound paper.

	Invention calender	Conventional calender
Nips	3	7
Temperature, ° F	380	<200
Speed of paper, feet per minute	2,200	800
Pressure, pounds per lineal inch	540	5,500
Smoothness	45	(1) 44
Appearance	(2)	(3)

1 Blackened. 2 White. 3 Like wax paper.

The results of this example show that a better quality paper, e.g., a white appearance as contrasted with a wax paper appearance is realized at approximately two and one-half to three times the output, viz, 2200 f.p.m. as contrasted with 800 f.p.m., with my calender than with the conventional calender. Also, the product of the conventional calender is of an undesirable nature as the appearance is blackened, i.e., the fibers of the paper have been crushed. As contrasted with this the fibers in the product of the calender are not crushed. Also, it is possible to realize these advantages with three nips instead of a larger number of nips as employed on a conventional calender.

Example III

This paper was a 45 pound raw stock having a 15 pound coating, i.e., latex and clay to make a 60 pound paper. This paper was run through my calender under four different sets of conditions. These sets were:

	1	2	3	4
Nips	6	6	3	6
Temperature, ° F	250	300	380	380
Speed of paper, feet per minute	525	1,050	2,250	2,250
Pressure, pounds per lineal inch	1,110	900	555	1,110
Bulk	800	260	260	300
Glare	45	45	45	48.5
Roll hardness	84	84	84	84
Varnish	(1)	(1)	(1)	(1)

1 Satisfactory.

In order to pass the paper through the six nips it was necessary to run the paper through the machine two times. The bulk of the paper was checked by a micrometer, and the thickness of the paper is in ten thousandths of an inch. With the conventional supercalender there is a 6 to 8 point loss in bulk (i.e. caliper) while with my calender there is only about a 2.5 point loss in bulk (i.e. caliper). It is pointed out that a variation in the speed from 525 f.p.m. to 2250 f.p.m.; a variation in temperature from 250° F. to 380° F.; a variation in lineal pressure from 555 pounds per lineal inch to 1110 pounds per lineal inch; and a variation in bulk from 260 to 800 do not appreciably affect the glare and the varnish on the paper. All of the papers from these four runs were of satisfactory commercial quality. From this, it is seen that it is possible to manufacture on my calender a satisfactory commercial paper with a wide range of operating conditions.

Example IV

The paper was a 45 pound raw stock having a 15 pound coating, i.e., latex and clay, to make a 60 pound paper.

	Invention calender		Conventional calender
Nips	3	6	7
Temperature, ° F	350	350	110–120
Speed of paper, feet per minute	1,000	1,000	800
Pressure, pounds per lineal inch	180	180	1,500–3,000
Moisture, percent:			
Initial	6	10	4–5
Final	5	6	
Appearance	(1)	(1)	(2)

1 White paper. 2 Like wax paper.

With the invention calender there was employed a label grade of paper having a high clay content or a high filler content. With one pass through the invention calender the paper passed through three nips. With two passes through the calender the paper passed through six nips. The temperature of the invention calender was set at approximately 350° F.; the speed of the paper was approximately 1000 feet per minute; the pressure was 180 pounds per lineal inch and the moisture content for the three-nip paper was at approximately 6 percent initial moisture and 5 percent final moisture. For the six-nip paper the initial moisture content was approximately 10 percent and the final moisture content was approximately 6 percent. In contrast with this the conventional calender may employ seven nips; have an operating temperature of approximately 110°–120° F.; a speed of approximately 800 feet per minute; a pressure of approximately 1500 to 3000 pounds per lineal inch; and, a moisture content in the range of 4 to 5 percent. It is seen that the invention calender has fewer nips, a higher operating temperature, a higher speed of the paper passing through the calender, a lower pressure in pounds per lineal inch and a higher moisture content. It is my opinion that this high moisture content along with the higher temperature makes it possible to operate at a lower pressure and to achieve a finer finish than can be achieved with the conventional calender.

Example V

A reproduction or copier paper capable of being used for xerography work was finished.

	Invention calender		Conventional calender
Nips	3	3	7
Temperature, ° F	350	350	(1) 80
Speed of paper, feet per minute	1,000	2,200	350
Pressure, pounds per lineal inch	180	180	(2)
Moisture, percent	8–10	8–10	4–4½

1 Chilled calender. 2 Not known.

It is seen that in this example the invention calender employs three nips while the conventional calender employs seven nips. In addition, the temperature of the invention calender is approximately 350° F. as compared with about 80° F. for the conventional calender. The speed at which the paper may pass through the invention calender can be as high as 2200 feet per minute as compared with 350 feet per minute for the conventional calender. The pressure in pounds per lineal inch for the inventional calender is about 180. Unfortunately, the pressure for the conventional calender is not known. Finally, the moisture content of the paper entering the invention calender may range from approximately 8 to 10 percent while for the conventional calender it may range from approximately 4–4½ percent. The paper manufactured on the invention calender has a somewhat better appearance and is more satisfactory for reproduction work than paper manufactured on the conventional calender.

Example VI

In this example, I mounted a cloth on the cotton filled rolls or the fiber filled rolls and moistened it. In effect, the water was wicked onto the mounted cloth. The paper was passed through the three nips and steam formed on the metal roll. The metal roll was operated at a temperature of approximately 450° F.; a paper speed of approximately 1000 feet per minute; and, a pressure of approximately 180 pounds per lineal inch. It may be assumed that the steam functioned as a lubricant on the metal surface and, also, as a softener for the surface of the sized sheet. The result was a stiffer sheet than produced by the conventional calender and, also a brighter sheet with a heavier caliper. The fibers were not crushed as with the conventional calender. This lack of the crushing of the fibers in conjunction with the heavier caliper makes it possible to use less fiber weight than with the conventional calender and, therefore, have a saving in the fiber content of the paper. Naturally, the paper is less costly from the fiber-content standpoint. Further, the super-label paper manufactured by this method had less glare and a better varnish than the label paper manufactured by the conventional calender.

Example VII

The paper was a 45 pound raw stock having a 15 pound coating, i.e., latex and clay, to make a 60 pound paper.

	Invention calender	Conventional calender
Nips	3	7
Temperature, ° F	500	110–120
Speed of paper, feet per minute	2,200	800
Pressure, pounds per lineal inch	180	1,500–3,000
Moisture, percent:		
Initial	15	4–5
Final	8	

In this example there was used one-side-coated label paper. This paper was passed through three nips in the invention calender as compared to seven nips for the conventional calender. The temperature in the invention calender as approximately 500° F. as compared with the conventional calender temperature 110°–120° F., viz, approximately four times the conventional calender temperature. The speed of the paper passing through the invention calender was 2200 feet per minute as compared with 800 feet per minute for the conventional calender, approximately three times the speed of paper in the conventional calender. The pressure in pounds per lineal inch is approximately 180 as compared with the conventional calender of about 1500 to 3000 pounds per lineal inch. Further, the moisture content initially was considerably higher being in the range of about 15 percent as compared with the conventional calender range of about 4 to 5 percent.

From the above description of my calender and the examples it is seen that it is possible to have both a high bulk and a good finish. As contrasted with this the bulk and finish factors are usually at cross purposes, i.e., in order to realize good finish it is necessary to have a poor bulk quality. A contributing factor to good finish while simultaneously realizing good bulk may be the higher temperature of operation of my calender as contrasted with the operating temperature of the conventional calender. Another advantage of my calender is that it is possible to realize a good finish without applying too much pressure. Therefore, there is only a small possibility of crushing the fibers and of blackening the paper. As contrasted with this in the use of a conventional calender there is a continual struggle to give a good finish without crushing the fibers and blackening the paper. The difference in the blackening of the two calenders may be explained by the difference in the pressure of the rolls. With my calender there is a small pressure of about 500 to 1100 pounds per lineal inch which with the conventional calender having a large number of rolls the pressure may reach about 5500 pounds per lineal inch.

In the manufacture of label and letter-press papers with conventional equipment, the paper is run through a regular calender and then run through a supercalender. It is possible to realize the same results by processing the paper in my calender. In other words, it is possible to accomplish the same results with my one calender as is now accomplished by two calenders.

Another contrasting feature of the paper product is in the folding ability. With the conventional calender the fibers are crushed and the folding ability is lessened because the fiber's structure has been damaged. As contrasted with this the folding ability of my paper product is much superior as the structure of the fibers has not been damaged.

Also, with my calender the porosity of the fibrous product is not decreased as with a conventional calender. As a result it is possible to use more filler and less fiber with my calender. Because filler is not as expensive as fiber, it is possible to manufacture a lower priced product.

With my calender it is possible to have good temperature control at speeds up to 10,000 feet per minute. This is because of the external heating of the central metal roll. However, in the conventional calender there is not this good temperature control as the heat is generated by the rolls and is not externally supplied.

From my experience in the paper manufacturing industry and working on Fourdrinier machines and calenders and the finishing of paper, I consider that some of the major factors in the manufacture of paper are the temperature of the calender, the moisture content in the paper, the pressure of the calender rolls and the speed in which the paper passes through the calender. In regard to temperature, the conventional process for manufacturing paper employs calender rolls which are not heated. The temperature of the calender rolls is determined by the friction of the calender rolls as they contact the paper. The normally employed temperature has been less than 200° F. and in the range of 110°–120° F. As contrasted with this, my master roll is a heated roll and may achieve a temperature of approximately 500° F. Some of the beneficial results of this higher temperature are that this temperature vaporizes the moisture inside the sheet. Also, the sheet becomes more pliable and easier to work by the calender rolls. In regard to the moisture, the conventional process has been to use paper having a moisture content of approximately 4–5%. Now, as is well-known in the manufacture of paper, the fibers are held in water and are laid down on a wire. A large percentage of the water drains through the wire and the fibers are on this continuously moving wire to form somewhat of a sheet of fibers. Then, the sheet of fibers is transferred to a continuous felt and passed through the dryer. As is readily appreciated, the removal of the water in this sheet of fibers on the felt is a tremendous operation. The removal of one percent of the water in the paper by a drying apparatus is costly and requires additional floor space and expensive equipment. As contrasted with this, paper entering my machine may have a moisture content of up to 15 percent. This is approximately three times the moisture content of paper which enters the conventional stacked roll calender. Therefore, it is possible with my machine to cut down on the size of the drying equipment for the paper sheet or to run the paper sheet at a higher velocity through the drying equipment so as to allow the sheet to have the 15 percent moisture. Now, the moisture in the paper, in conjunction with the relatively high temperature on the master roll, produces the beneficial effect from the pressure standpoint. At the incoming nip to the master roll and the auxiliary rolls, the moisture is heated and expands. Some of the moisture may become a vapor or the moisture may remain a liquid. In effect, this expansion of the moisture creates a counter pressure to the pressure being applied by the calender rolls. The counter pressure is in the sheet and keeps the sheet from collapsing. Actually, the expanded moisture in the sheet is substantially trapped in the sheet and cannot escape at the nip. In effect, it may be considered that the moisture in both the vapor form and in the liquid form functions as a solid and I refer to it as a gas-solid. This gas-solid prevents crushing of the paper by the calender rolls. At the nip center point of the master rolls and the auxiliary rolls there is a build-up of the compression and the nip of the rolls functions as a gate. To repeat, in the incoming nip, the moisture is trapped in the paper and cannot escape. Once the paper is passed the nip center line, the moisture is allowed to escape or to be exhausted with the release of moisture vapor. This results in a reduction of the amount of moisture in the paper. In regard to the pressure at the nip of the rolls, I have found that a lower pressure is beneficial to the results of the paper product. With the conventional stacked-roll, vertical calender pressure may reach 3000 pounds per lineal inch of roll. With this high pressure there is a crushing of the fibers of the paper and a consequent blackening of these fibers with the crushing. Also, with the higher pressure the fibers are squeezed together so as to become more dense. As contrasted with this, I found that with a lower pressure, such as may be used with my calender, there is less crushing of the fibers and a better finish. Also, with less crushing there is a higher caliper of the paper which means that there may be less fiber per unit volume of paper. Naturally, with less fiber per unit volume there is a lower cost of fiber per unit volume and, therefore, a lower cost of the final paper product as compared with the conventional stacked-roll vertical calender. Finally, in regard to the speed of operation of the calender, it is possible with my calender to realize a high output speed of approximately 2200 feet per minute. I believe that it is possible to achieve a higher output speed than 2200 feet per minute; however, I have not been able to test this as, at the present time, I do not have a machine capable of feeding paper to my calender at a velocity higher than 2200 feet per minute, and I do not have a machine for winding paper at a velocity higher than 2200 feet per minute. I firmly believe that, under proper conditions, paper can pass through my calender at a velocity of up to 10,000 feet per minute. However, it will be necessary to provide feeding apparatus and also winding apparatus for such velocity.

Although I have described my invention as having a central roll having three auxiliary rolls, it is to be realized that in certain instances it may be desirable to have a central roll and only one or two auxiliary rolls or a central roll and more than three auxiliary rolls. The number of rolls is not as important as the ability to control the temperature of the central roll at a higher than the conventionally used calender; the ability to exert pressure between the rolls without stacking one roll on another roll and the ability to control said pressure; and, the ability to operate said machine at much higher temperature than presently used.

Having presented my invention, I claim:

1. A calender for finishing paper, said calender comprising a frame having a first member and a second member, said first member having two spaced-apart centrally positioned upwardly directed first slots, a journal in each of the first slots and a first roll carried by said journals, said first member having two sets of spaced-apart recesses

on its upper surface, each of said recesses being at approximately a right angle to the upwardly directed first slots, said second member adapted to interfit with the first member and having a smooth metal central roll in operating position with the first roll, said second member in combination with the two sets of spaced-apart recesses defining second and third sets of spaced-apart slots, a journal in each of the slots and second and third rolls carried by the journals in the second and third sets of spaced-apart slots, means attaching to each of the journals for spacing the same with respect to the central roll, a centrally positioned control panel for controlling said means for moving the journals, means for heating said central roll, and a motor in driving relationship with said central roll, the said first and second members being readily assembled to form said frame.

2. A calender for gloss finishing porous, ink-receptive paper, said calender comprising a frame having a first member and a second member, said first member having two sets of spaced-apart recesses in its upper surface, each set of recesses being substantially opposed to the other, said second member being adapted to fit with the first member and have a smooth metal central roll, said second member in combination with the two sets of spaced-apart recesses defining substantially opposed sets of spaced-apart slots, resilient rolls carried by the journals in the spaced-apart slots, means attaching to each of the journals for spacing the same with respect to the central roll, a centrally positioned control panel for controlling said means for spacing the journals, means for heating said central roll, and a motor in driving relationship with said central roll, the said resilient rolls being frictionally driven by the central roll at essentially the same peripheral speed as the central roll.

3. A calender for finishing paper, said calender comprising a frame having a first member and a second member, said first member having two spaced-apart centrally positioned upwardly directed slots, a journal in each of the first slots and a first resilient roll carried by said journals, said first member having two spaced-apart recesses on its upper surfaces, each of said recesses being at approximately a right angle to the first slot, said second member adapted to interfit with the first member and having a central roll in operating position with the first resilient roll, said second member in combination with the two sets of spaced-apart recesses defining second and third sets of spaced-apart slots, a journal in each of the slots and a roll carried by the journals in the second and third sets of spaced-apart slots, a hydraulic cylinder attaching to each of the journals for spacing the same with respect to the central roll, a centrally positioned control panel for controlling the hydraulic cylinders, means for heating said central roll, and a motor in driving relationship with said central roll, the said first and second members being readily assembled to form said frame.

4. A calender for finishing paper, said calender comprising a frame having a first member and a second member, said first member having two spaced-apart centrally positioned upwardly directed first slots, a journal in each of the first slots and a first resilient roll carried by said journals, said first member having two sets of spaced-apart recesses on its upper surfaces, each of said recesses being at approximately a right angle to the first slot, said second member adapted to interfit with the first member and having a central roll in operating position with the first resilient roll, said second member in combination with the two sets of spaced-apart recesses defining second and third sets of spaced-apart slots, a journal in each of the slots and second and third resilient rolls carried by the journals in the second and third sets of spaced-apart slots, a hydraulic cylinder attaching to each of the journals for spacing the same with respect to the central roll, a centrally positioned control panel for controlling the hydraulic cylinders, means for heating said central roll, and a motor in driving relationship with

said central roll, the said first and second members being readily assembled to form said frame.

5. A calender for finishing paper, said calender comprising a frame having a first member and a second member, said first member having two spaced-apart centrally positioned upwardly directed first slots, a journal in each of the first slots and a first roll carried by said journals, said first member having two sets of spaced-apart recesses on its upper surface, each of said recesses being at approximately a right angle to the upwardly directed first slots, said second member adapted to interfit with the first member and having a central roll in operating position with the first roll, said second member in combination with the two sets of spaced-apart recesses defining second and third sets of spaced-apart slots, a journal in each of the slots and second and third rolls carried by the journals in the second and third sets of spaced-apart slots, means attaching to each of the journals for spacing the same with respect to the central roll, a centrally positioned control panel for controlling said means for moving the journals, said central roll having a tubular metal outer shell and a hollow interior, a heating element in said interior, and a motor in driving relationship with said central roll, the said first and second members being readily assembled to form said frame.

6. A calender for finishing paper, said calender comprising a frame having a first member and a second member, said first member having two spaced-apart centrally positioned upwardly directed first slots, a journal in each of the first slots and a first roll carried by said journals, said first member having two sets of spaced-apart recesses on its upper surface, each of said recesses being at approximately a right angle to the upwardly directed first slots, said second member adapted to interfit with the first member and having a central roll in operating position with the first roll, said second member in combination with the two sets of spaced-apart recesses defining second and third sets of spaced-apart slots, a journal in each of the slots and second and third rolls carried by the journals in the second and third sets of spaced-apart slots, means attaching to each of the journals for spacing the same with respect to the central roll, a centrally positioned control panel for controlling said means for moving the journals, said central roll having a tubular metal outer shell and a hollow interior, in the interior there being an inner wall spaced apart from the outer shell to define a heating cavity, heating means in said cavity, a liquid in said cavity for transferring heat from the heating means to the outer shell, and a motor in driving relationship with said central roll, the said first and second members being readily assembled to form said frame.

7. A calender for gloss-finishing one surface of a continuous web of porous, ink-receptive paper, said calender comprising:

(a) a frame;
(b) a smooth metal master roll journalled for rotation about a fixed axis on said frame;
(c) means rotatably driving said master roll;
(d) means uniformly heating the surface of said master roll;
(e) at least one resilient auxiliary roll journalled on said frame for free rotation about a movable axis;
(f) selectively controllable pressurized fluid means for moving said auxiliary roll into and away from nipping engagement with said master roll, the resilient auxiliary roll when so engaged being frictionally driven solely by and at substantially the same peripheral speed as said master roll; and
(g) means for continuously feeding the paper web through space and then directly into and through the nip between said master roll and said auxiliary roll in a manner so that the first contact of the paper web with the said master roll and the said auxiliary roll is at the nip therebetween.

8. A calender for gloss-finishing one surface of a continuous web of porous, ink-receptive paper, said calender comprising:

(a) a frame;
(b) a smooth metal master roll journalled for rotation about a fixed axis on said frame;
(c) means rotatably driving said master roll;
(d) means uniformly heating the surface of said master roll;
(e) a plurality of resilient auxiliary rolls each journalled on said frame for free rotation about independently movable axes;
(f) selectively controllable pressurized fluid means for independently moving said auxiliary rolls into and away from nipping engagement with said master roll, the resilient auxiliary rolls when so engaged being frictionally driven solely by and at substantially the same peripheral speed as said master roll; and
(g) means for continuously feeding the paper web through space and substantially directly into the nip between the first one of said auxiliary rolls and said master roll so that the first contact of the paper web with the said master roll is at the nip therebetween, then through the nips between said master roll and said auxiliary rolls, and finally directly out from the nip between the last auxiliary roll and said master roll, away from contact with said last auxiliary roll and said master roll.

9. A calender for gloss-finishing one surface of a continuous web of porous, ink-receptive paper, said calender comprising:

(a) a frame;
(b) a smooth metal master roll journalled for rotation about a fixed axis on said frame;
(c) means rotatably driving said master roll;
(d) means uniformly heating the surface of said master roll;
(e) first and second resilient auxiliary rolls arranged around the master roll substantially diametrically opposite from each other and journalled on said frame for free rotation about independently movable axes;
(f) selectively controllable pressurized fluid means for moving said auxiliary rolls into and away from nipping engagement with said master roll, the resilient auxiliary rolls when so engaged being frictionally driven solely by and at substantially the same peripheral speed as said master roll; and
(g) paper web feeding and guiding means, including and associated with said master roll and said auxiliary rolls, by which the paper web is fed through space directly into the nip between said first auxiliary roll and the heated master roll so that the first contact of the paper web with the said master roll and the said first auxiliary roll is at the nip therebetween, then substantially reversing the direction of travel of the web, and then feeding the web through the nip between said second auxiliary roll and said heated master roll.

10. A calender for gloss-finishing one surface of a continuous web of porous, ink-receptive paper, said calender comprising:

(a) a frame;
(b) a smooth metal master roll journalled for rotation about a fixed axis on said frame;
(c) means rotatably driving said master roll;
(d) means uniformly heating the surface of said master roll;
(e) first and second resilient auxiliary rolls arranged around the said master roll substantially diametrically opposite from each other and each journalled on said frame for free rotation about independently movable axes;
(f) selectively controllable pressurized fluid means for independently moving said auxiliary rolls into and away from nipping engagement with said master roll,

the resilient auxiliary rolls when so engaged being frictionally driven solely by and at substantially the same peripheral speed as said master roll; and

(g) paper web feeding and guiding means, including and associated with said master roll and said auxiliary rolls, by which the paper web is fed downwardly, directly into and through the nip between said master roll and one of said auxiliary rolls in a manner so that the first contact of the paper web with the said master roll and the said one auxiliary roll is at the nip therebetween, the web then being fed upwardly through and directly out from the nip between said master roll and the other of said auxiliary rolls.

References Cited by the Examiner

UNITED STATES PATENTS

222,081	11/1879	Schlatter et al.	100—162
555,385	2/1896	Linton	100—162
639,974	12/1899	Harley et al.	100—162
838,616	12/1906	Goldman	100—162 X
862,105	7/1907	Reagan	100—40
1,054,721	3/1913	Simon	68—244
1,145,630	7/1915	Taft	100—40
1,720,716	7/1929	Blombery	117—155
1,780,375	11/1930	Bradley	117—155
2,011,748	8/1935	Boyd	100—93 X
2,404,946	7/1946	Clem	100—168 X
2,518,806	8/1950	Muench	162—206 X
2,917,781	12/1959	Petry	18—26
2,985,100	5/1961	Hornbostel	100—163

References Cited by the Applicant

UNITED STATES PATENTS

1,575,539	3/1926	Butterworth.
1,739,572	12/1929	Bidwell.
2,515,648	6/1950	Hornbostel.
2,850,952	9/1958	Hornbostel.

WALTER A. SCHEEL, *Primary Examiner.*

ABRAHAM A. STONE, CHARLES A. WILLMUTH, LOUIS O. MAASSEL, *Examiners.*