Oct. 20, 1964 B. J. H. NELSON 3,153,378

METHOD OF CALENDERING

Original Filed Dec. 4, 1961 3 Sheets-Sheet 1

FIG. 1

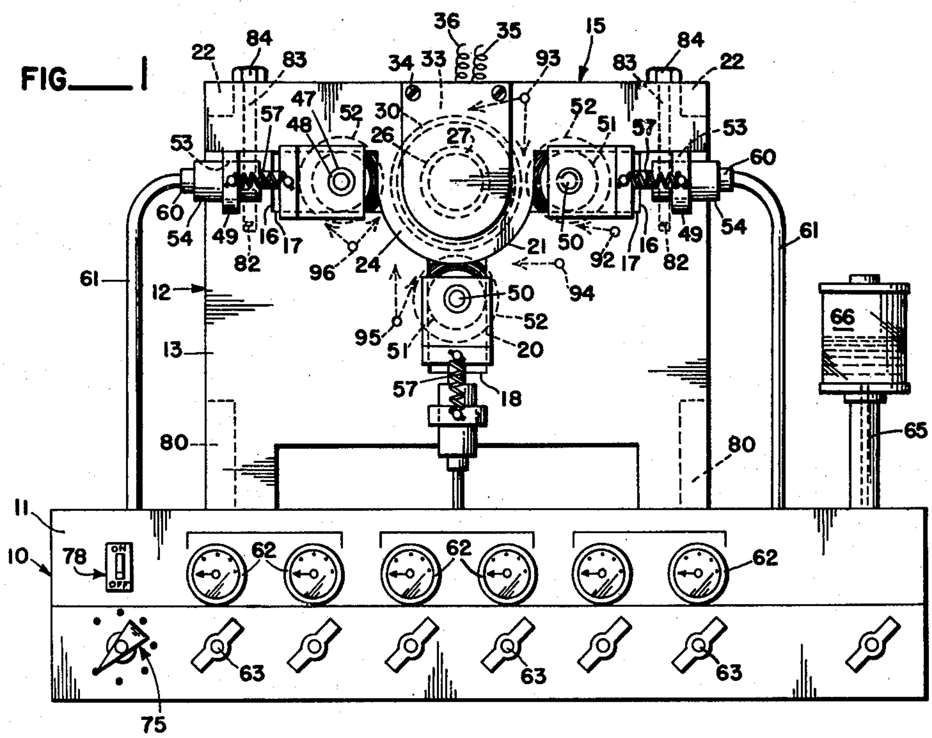


FIG. 3

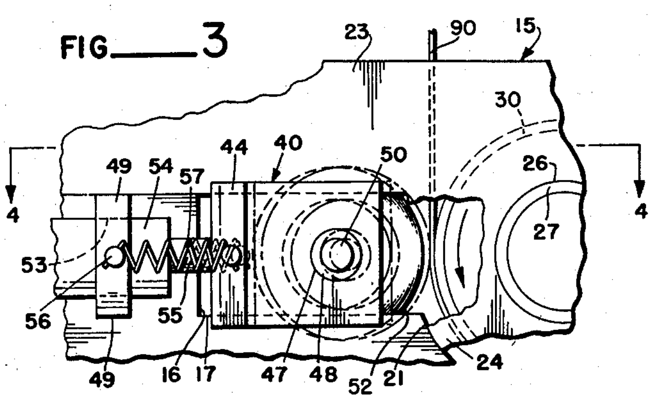
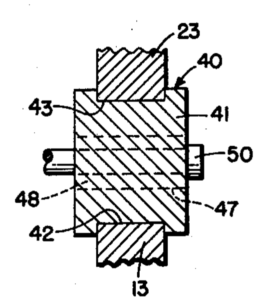


FIG. 5



INVENTOR.

BENJAMIN J. H. NELSON

BY Mathis & Graybeal

ATTORNEYS

METHOD OF CALENDERING

Original Filed Dec. 4, 1961 3 Sheets-Sheet 2

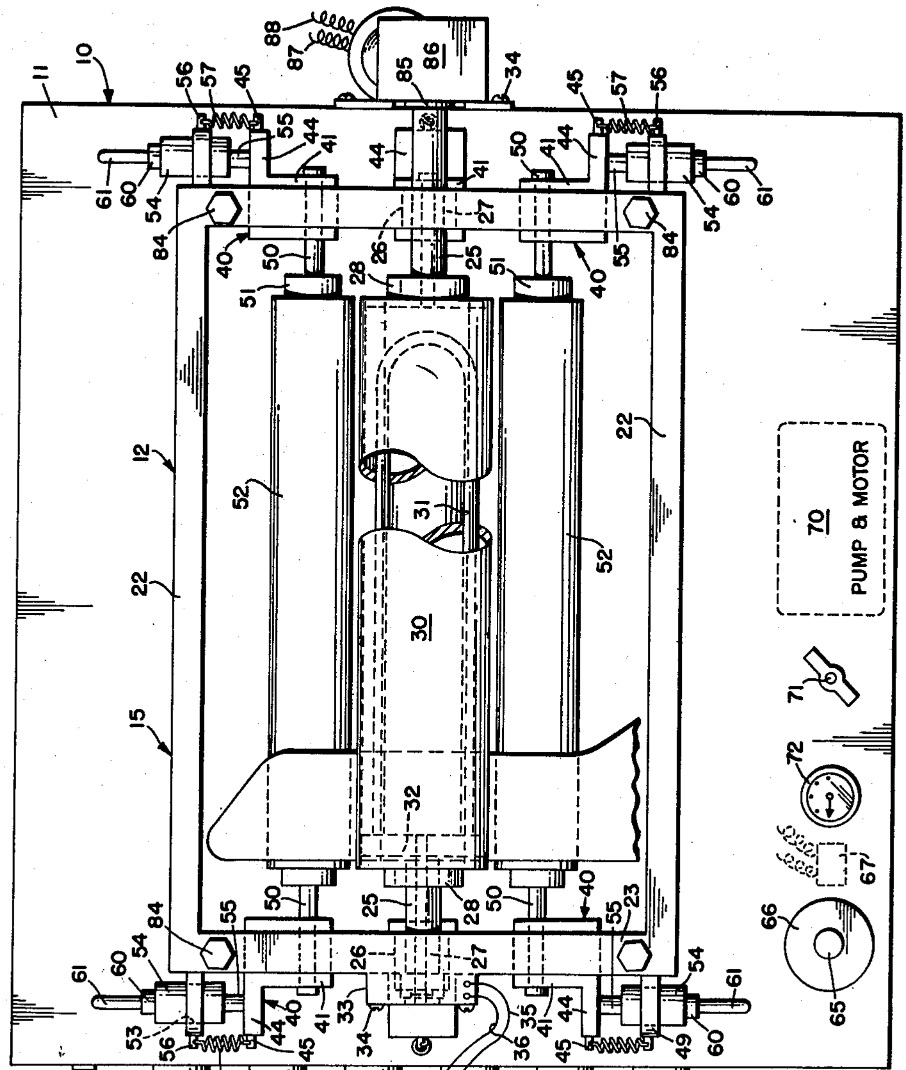


FIG. 2

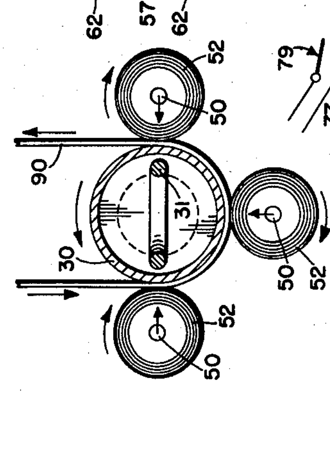


FIG. 6

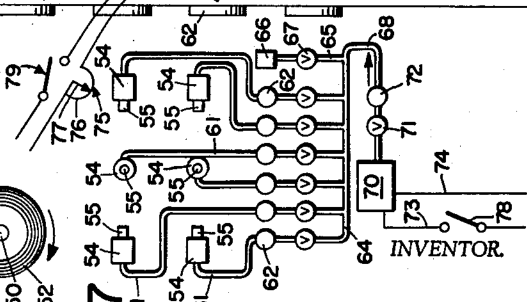


FIG. 7

INVENTOR.

BENJAMIN J. H. NELSON

BY Mathis & Graybeal

ATTORNEYS

METHOD OF CALENDERING

Original Filed Dec. 4, 1961 3 Sheets-Sheet 3

FIG. 4

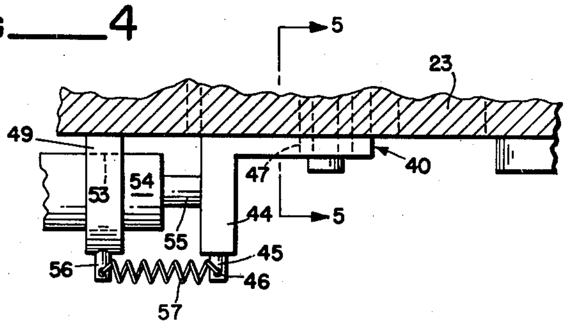


FIG. 8

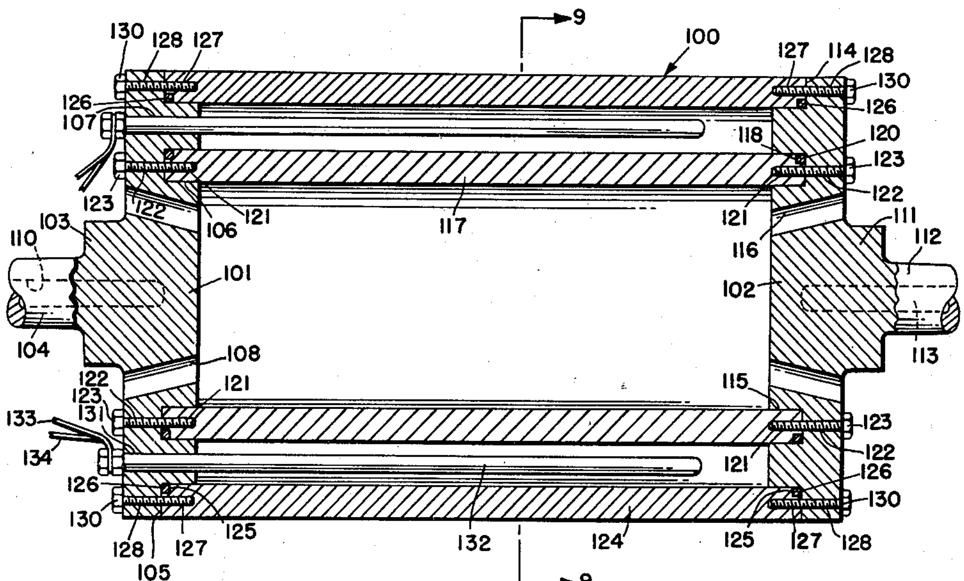
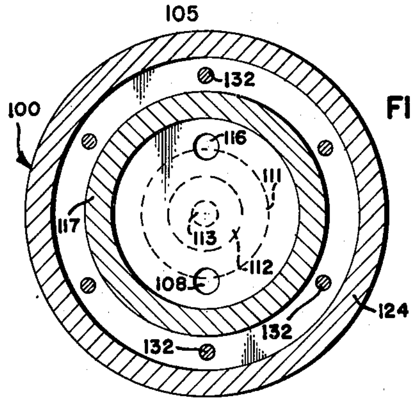


FIG. 9



INVENTOR.
BENJAMIN J. H. NELSON
BY Mathis & Graybeal
ATTORNEYS

3,153,378
METHOD OF CALENDERING

Benjamin J. H. Nelson, 5121 Dogwood, Everett, Wash.
Original application Dec. 4, 1961, Ser. No. 156,827. Divided and this application Oct. 7, 1963, Ser. No. 314,229
6 Claims. (Cl. 100—38)

This application is a division of my co-pending application Serial No. 156,827, filed December 4, 1961, and entitled Paper Finishing Mechanism and Method, which 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.

The present invention relates to gloss calendering, and more particularly to a method of calendering ink receptive papers having a substantial moisture content, to provide a high gloss on a surface thereof without blackening of the surface and without loss of caliper.

As used herein, the term "ink-receptive papers" means papers sufficiently porous to retain ink after gloss finishing.

Generally speaking, the calendering technique provided by the present invention comprises nipping a web of paper having a substantial moisture content between a smooth metal master roll and at least one resilient auxiliary roll frictionally driven by the master roll at essentially the same peripheral speed as the master roll, maintaining a nip pressure of from about 180 to about 1100 pounds per lineal inch, maintaining the master roll at a temperature of at least 250° F., and driving the master roll at a peripheral speed of at least about 525 feet per minute.

In known conventional methods of calendering ink-receptive papers, it has been necessary to reduce the moisture content of the paper down to approximately 4–5% prior to the actual calendering. In contrast, a paper web to be calendered by the process of the present invention may have a moisture content up to about 15%. This results in a significant saving in the manufacturing costs of the paper, as the removal of water from the paper web is a costly operation. In the calendering process of the present invention, at least most of the moisture content of the paper is vaporized solely by contact of the web with the heated master roll.

In conventional calenders and supercalenders, each type of which involves a vertical stack of rolls, the nip pressure may reach 3000 pounds per lineal inch of roll. Nip pressures of this magnitude may result in a crushing of the fibers and a consequent blackening of the surface. Also, with the higher pressures the fibers are squeezed together so as to become more dense. In contrast, in the calendering technique of the present invention the nip pressure is maintained at about 180 to about 1100 pounds per lineal inch. I have found that with the lower pressures there is less crushing of the fibers, and a better finish is produced. Also, since less crushing is experienced there is less fiber per unit volume of the finished paper. As will be appreciated, this means a reduction in the cost of fiber per unit volume of paper produced, resulting in an additional saving in the total manufacturing cost of the paper.

According to the present invention, the paper web can be calendered at the rate of at least about 525 feet per minute to about 2250 feet per minute, when using the presently available equipment for handling the calendered web of paper after it leaves the calendering machine.

These and other 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.

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 14. 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 25 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 co-fits with a hollow central roll 30. This roll may be of metal. In the interior of this roll is a heating element 31 in a 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 co-fitting with the ledge 17, and in the upper surface is a groove 43 for co-fitting 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 auxiliary rolls may be of metal or may be fiber filled, depending on the surface to be imparted to the paper.

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.

In FIGURE 1 the elements 92, 93, 94, 95 are air-jet forming means used to assist in the threading of the paper web into the calendering machine. The preferred threading technique, and the apparatus for its practice, form the subject matter of and are claimed in my pending application Serial No. 292,804, filed July 1, 1963, entitled Calender and Method of Threading Same, and also a division of my aforementioned application Serial No. 156,827.

In FIGURE 8 there is illustrated another master or 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 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 cycinder 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 passageway 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	Less than 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	White paper	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 sped, 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	Less than 200.
Speed of paper, feet per minute	2,200	800.
Pressure, pounds per lineal inch	540	5,500.
Smoothness	45	44 (blackened).
Appearance	White	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	Satisfactory.	Satisfactory.	Satisfactory.	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 thousandths of an inch. With the conventional supercalender there is a 6 to 8 point loss in bulk while with my calender there is only about a 2.5 point loss in bulk. 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	White paper	White paper	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 of 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	Not known
Moisture, Percent	8–10	8–10	4–4½

[1] Chilled calender.

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. was 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 calander, 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 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 auxilairy rolls there is 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 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.

What is claimed is:

1. A method for gloss calendering a web of ink-receptive paper having a substantial moisture content, said method comprising nipping the paper between a heated, positively driven smooth metal master roll and at least one resilient auxiliary roll frictionally driven by said master roll at essentially the same peripheral speed as the master roll, maintaining a nip pressure of from about 180 to about 1100 pounds per lineal inch, maintaining the master roll at a temperature of at least 250° F., and driving the master roll at a peripheral speed of at least about 525 feet per minute so as to vaporize at least most of the moisture content of the paper solely by contact with the said heated master roll without charring of the paper.

2. The method of calendering a web of porous, ink-receptive paper having a substantial moisture content to provide a high gloss on a surface thereof without blackening and without substantial loss of caliper, said method comprising; nipping a web of the paper between a smooth metal master roll and a smaller, resilient auxiliary roll, positively driving said master roll and frictionally driving said auxiliary roll by contact with the master roll so that the web speed and the peripheral speed of each roll are all substantially equal, maintaining the web movement at a speed of at least about 525 feet per minute, maintaining the nip at an effective glossing pressure of less than about 1100 pounds per lineal inch, and heating the metal roll to heat the moisture containing paper in the nip to a temperature of at least about 250° F.

3. The method of claim 2, wherein the paper web being calendered is raw paper stock with a latex and clay coating.

4. A method for calendering a web of pervious paper stock, said method comprising passing the paper between the nips of a smooth metal central roll and a plurality of resilient rolls, positioned around the central roll and being frictionally driven by the central roll at essentially the same peripheral speed as the central roll, maintaining the web speed at a velocity of up to 2250 feet per minute with a pressure between the nips in the range of 180-1100 pounds per lineal inch, said paper having the same surface facing the central roll while being calendered, said resilient rolls being spaced apart to allow the paper to be exposed to the surrounding atmosphere, and heating said central roll so as to heat the paper in the nips to a temperature in the range of about 250-500° F.

5. A method for calendering a web of pervious paper stock with a moisture content up to about 15% by weight, said method comprising passing the paper between the nips of a smooth metal central roll and a plurality of resilient rolls positioned around the central roll and being frictionally driven by the central roll at essentially the same peripheral speed as the central roll, maintaining the web speed at a velocity of up to 2250 feet per minute with a pressure between the nips in the range of 180-1110

pounds per lineal inch, said paper having the same surface facing the central roll while being calendered, said resilient rolls being spaced apart to allow the paper to be exposed to the surrounding atmosphere, and heating said central roll so as to heat the paper in the nips to a temperature in the range of about 250-500° F.

6. The method of gloss calendering a non-laminant paper web having a substantial moisture content up to about 15% by weight and uniformly producing a non-crushed, high gloss and non-waxy appearance in the calendered paper, said method comprising:

(*a*) nipping the paper between a smooth metal roll and a resilient roll at a substantially uniform pressure of about 180-1100 pounds per lineal inch;

(*b*) maintaining said resilient roll at essentially the same peripheral speed as that of the metal roll;

(*c*) heating the metal roll to a substantially uniform surface temperature of about 250-500° F.; and

(*d*) moving the paper web through the nip at a speed of about 525-2250 feet per minute.

References Cited in the file of this patent

UNITED STATES PATENTS

1,291,626 Parks ---------------- Jan. 14, 1919
2,518,806 Muench -------------- Aug. 15, 1950