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R. C. SPROULL ET AL

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METHOD FOR PRODUCING A HIGH DENSITY PAPER

Filed June 19, 1952

3 Sheets-Sheet 1

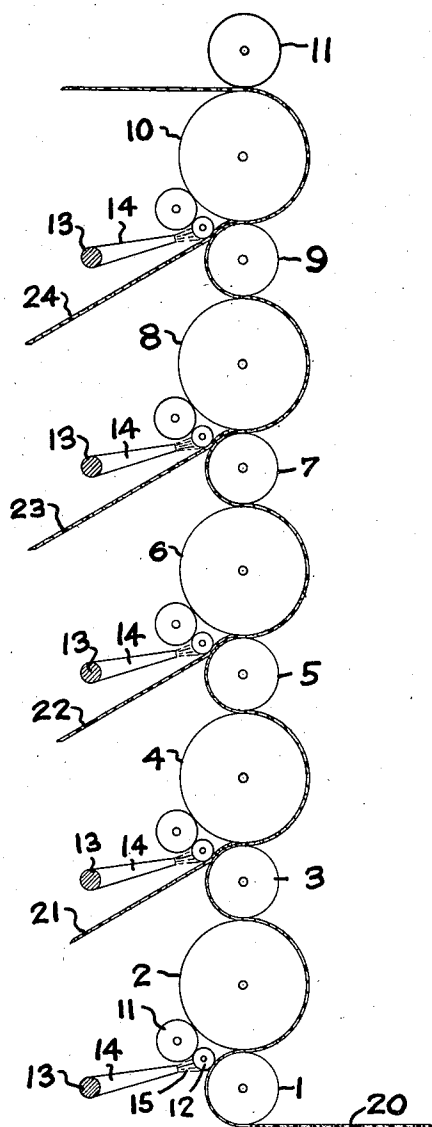


Fig. 1

INVENTORS
REAVIS C. SPROULL
DUANE L. KENAGA
BY

Carroll and Fitz
ATTORNEYS

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3 Sheets-Sheet 2

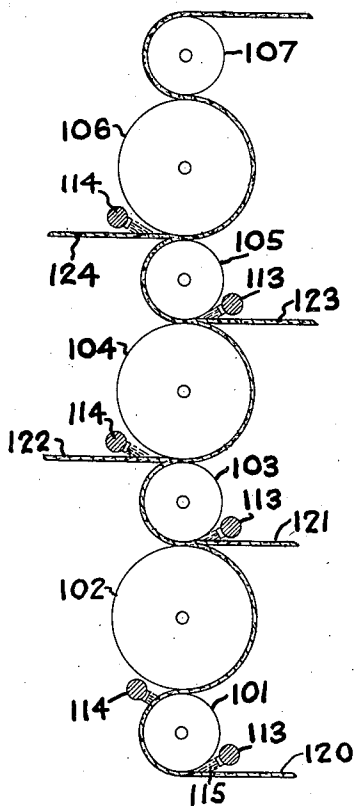


Fig. 2

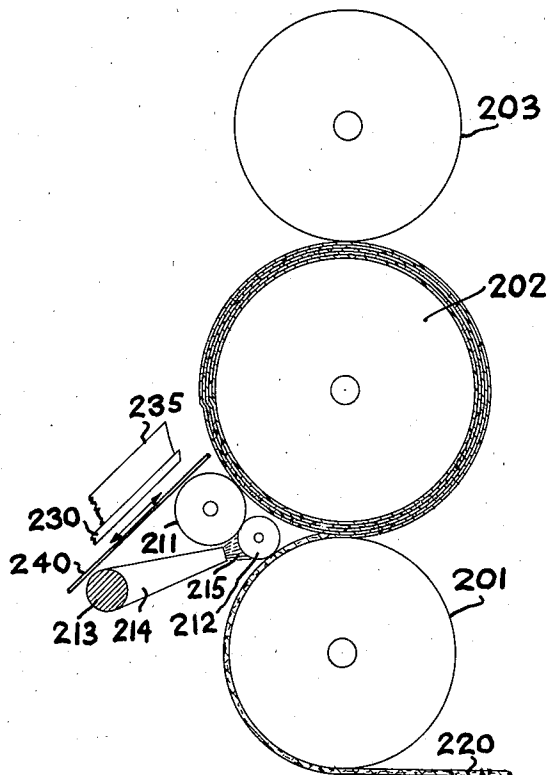


Fig. 3

INVENTORS
REAVIS C. SPROULL
DUANE L. KENAGA
BY

Connolly and Fitz
ATTORNEYS

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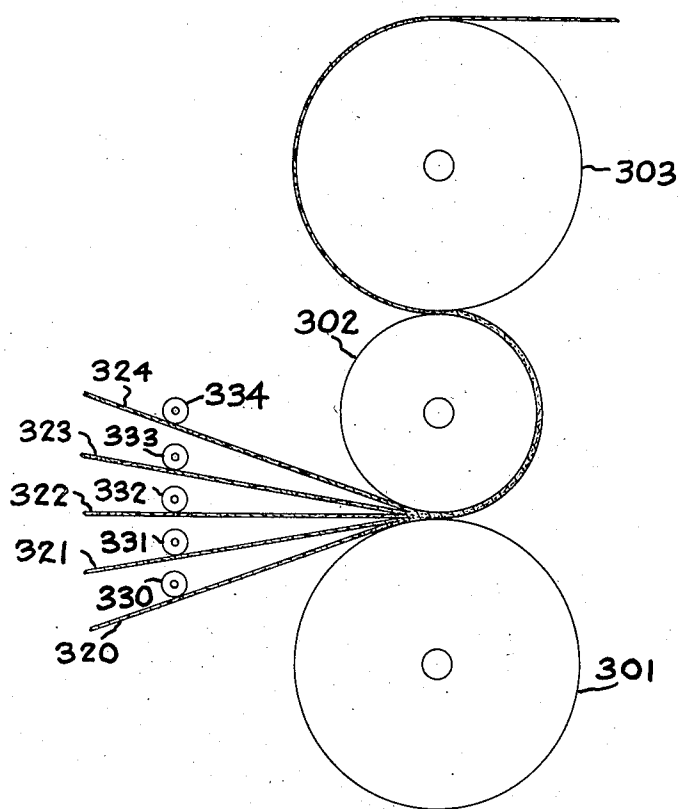


Fig 4

REAVIS
DUANE
BY
C. SPROULL
L. KENAGA
INVENTORS
Connelly and Fultz
ATTORNEYS

1

2,822,855

METHOD FOR PRODUCING A HIGH DENSITY PAPER

Reavis C. Sproull, Savannah, Ga., and Duane L. Kenaga, Midland, Mich., assignors to Sprague Electric Company, North Adams, Mass., a corporation of Massachusetts

Application June 19, 1952, Serial No. 294,312

5 Claims. (Cl. 154—2.6)

This invention relates to a high density paper and processes for forming the same. More particularly the invention relates to a method for forming a high density paper suitable for use as a dielectric in wound condensers.

Normally, paper produced for condenser dielectrics or spacers has a specific gravity of not more than about 1.0 gram per cubic centimeter. Although it is well known that the breakdown potential of a paper dielectric increases with the density of the paper, it has been considered impractical to make the paper spacers denser than about 1 gram per cubic centimeter.

In fact condenser paper as initially formed and before any calendering usually has a specific gravity of about 0.8, and even repeated calendering and/or supercalendering of such paper cannot bring the density up beyond about 1.0 gram per cubic centimeter, regardless of the moisture content of the paper during the calendering.

Among the objects of the present invention is the provision of a novel method for densifying paper by which method the density can be readily increased to 1.1 grams per cubic centimeter or higher.

Additional objects of the present invention are the provision of novel dielectric paper having such high density.

The above as well as further objects of the present invention will be more clearly understood from the following description of several of its exemplifications, considered together with the accompanying drawings wherein:

Fig. 1 illustrates a supercalendering apparatus and method with which the present invention can be practiced;

Fig. 2 illustrates a modified apparatus similar to that of Fig. 1;

Fig. 3 illustrates a still further modified apparatus for producing a high-density paper according to the instant invention; and

Fig. 4 illustrates another modification of the invention. The present invention can be briefly summarized by stating that when two or more layers of paper are supercalendered together at elevated temperatures and their moisture contents are adjusted so that the layers are permanently united by the supercalendering the permanently united layers form a sheet having an unexpectedly high density. This increase in density is not very striking if the supercalendering is trimmed down to the use of a single passage through only one nip.

Referring now to Fig. 1 there is here shown a supercalender having a plurality of rollers mounted in vertical alignment and through which a plurality of webs of paper are selectively threaded into superposed relationship. In the figure, the numerals 1, 3, 5, 7, 9 and 11 indicate the usual steel rolls which have smooth, polished surfaces and which are internally heated as by steam. Positioned intermediate the spaced, steam-heated steel rollers are a plurality of larger rollers 2, 4, 6, 8 and 10 of conventional pressed paper construction.

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As shown, separate webs or sheets of commercially available low-density paper are respectively threaded into the pressure nips of the apparatus at vertically staggered intervals. The lowermost web 20 is positioned to contact the lower surface of the steam heated roller 1 and is threaded thereabout into the nip between the roller 1 and the adjacent paper roller 2 and thence up through all other nips in the apparatus. Adjacent the nip between rollers 1 and 2 is positioned a moistening device shown as having rubber roller 11 which bears against and is driven by the paper roller, and which in turn frictionally contacts and drives a smaller felt roller 12 which is positioned relatively close to the nip between roller 1 and roller 2. A fluid supply pipe 13 which has a plurality of longitudinally-spaced nozzles 14 integrally connected thereto supply a continuous spray of water 15 to the surface of the felt roller 12 in order to keep it continually wet. The felt roller 12 bears upon the exposed surface of the paper web 20 immediately prior to its entering into the nip between rollers 1 and 2. The moisture so applied is largely retained in the paper during its passage into the nip, notwithstanding the evaporating induced by the high temperatures of the heated rolls for example. The moistened paper web threads through the nip between rollers 1 and 2 where it is pressed under the extremely high pressures of the apparatus while being simultaneously heated both by friction and by the steam roller 1. This action densifies and compacts the paper somewhat, but only small improvements are effected. After passage through this first nip, the paper proceeds about the periphery of the roller 2 where it may cool and dry off somewhat prior to entering the nip between the roller 2 and the adjacent steam heated roller 3. In this latter nip the paper web is repressed and reheated to further compact and densify the paper fibres a small amount. Thereafter the web 20 continues about the periphery of the steam heated roller 3 which further dries the paper matrix.

At this point a second paper web 21 is threaded along with web 20 into the nip between the roller 3 and the next adjacent paper roller 4. This second paper web is moisturized in a manner similar to that used for the web 20 immediately prior to its entering into the nip between rollers 3 and 4. In this nip the paper layers 21 and 20 are pressed together into a permanently united mass. After the pressing and heating action in the third nip, the resulting paper sheet continues about the periphery of paper roller 4 where it is dried somewhat, as before, and enters the nip between the paper roller 4 and the next adjacent steam roller 5. Here the double layered sheet is again heated and pressed under high temperatures and pressures, and thereafter passed about the periphery of the steam heated roller 5 for cooling and drying prior to being combined for passage to the next nip. This second pressing of the laminated sheet effects a considerable increase in density. The sheet is then combined with third, fourth and fifth paper webs 22, 23 and 24, respectively, to form a highly pressed five-layered sheet having a density upward of 1.1 and as high as 1.25. The exact density will depend on the amount of moisture present in the layers as they are rolled, the temperature and pressure during the rolling and the number of layers that are combined.

From the above it will be appreciated that there is provided a very simple technique by which a plurality of individual paper layers are rolled into a compacted unitary sheet of highly densified paper. Furthermore, by reason of the superposition of the layers, flaws that may be present in these layers are not likely to be aligned and the resulting sheet has exceedingly few electrically weak spots.

The moisture content of the paper at the nips should be such that the layers become integrally united by the

rolling. The moisture content of the paper webs or layers may vary widely, but preferably is maintained within a range of from 15 and 55 percent, based on the dry weight of the paper. The moisture can be applied to either surface of either layer being rolled, and if desired can also be supplied to two or more of these surfaces simultaneously. For multiple moistening additional roller type applicators or sprays can be used. It is important however that the moisture application be made close to the nip so that too much time does not elapse before the moistened paper is rolled. A time delay of about one second can be tolerated.

If desired, the system of threading the separate web layers into the calendering rolls may be inverted with respect to that illustrated, i. e., the entire unit may be upended with roll 1 constituting the upper roll and roll 11 the lowermost roll. With this latter arrangement the initial web 20 would be threaded into the apparatus adjacent its upper end and would proceed progressively down the stack in a manner similar to that in which it moved up the stack. This form of operation will assure the application of the greatest pressure to the thicker, five layered sheet at the bottom of the stack due to the additional weight of the stacked rolls.

In either case each paper layer is subjected to a process of densification, although in sets of two or more. Each layer also receives at least two treatments and some layers, such as layer 20, receive many repetitions of the treatment. The final composite web is a single homogeneous sheet wherein the several constituent layers are separately undetectable. It cannot be peeled apart and does not separate even after the most rough handling over an extended period of time.

The number of webs combined into a single sheet is not controlling, and the number herein illustrated may be either increased or decreased as desired. It may be stated, however, that the greater the thickness per pressing, the greater the resulting densification. In the above example when the original webs 20 through 24 inclusive are conventional kraft tissue capacitor type 0.62 mils thick with a specific gravity of 0.73, the web paper may be conditioned to any desired moisture content, as for example to 10% moisture based on dry weight, before it is subjected to the process of the present invention. The resulting unified compacted sheet, after processing, has a specific gravity of about 1.25 and corresponds to an individual layer thickness of about 0.37 mils for each original web. The five layered compacted sheet is no thicker than the combined thicknesses of only three of the original webs and has a much higher dielectric constant. As a consequence, the paper provides a much improved dielectric material which may be incorporated into a wound paper capacitor, i. e., between two foil electrodes with a substantial reduction in the size of the capacitor and an increased electrical rating, both as to capacitance and overload voltages. In addition, only one pair of rugged dielectric sheets need be handled in the manufacture of the capacitor rather than a plurality of fragile sets of sheets.

Fig. 2 illustrates a modified example of a simplified apparatus for producing the paper of the invention. In this form of the invention the calendering stack is composed of seven cylinders; four steam-heated, stainless steel rolls 101, 103, 105 and 107, alternating with three paper rolls 102, 104 and 106 of a larger diameter. A moisturizing conduit or pipe 114, similar to the pipes and nipples 13 and 14 of Fig. 1, is positioned adjacent the nip between each steel roll and its next vertically adjacent paper roll, and is adapted to distribute a fine mist or fog spray along the length of the cylinders. A second group of conduits 113 are respectively positioned beneath the steel rolls 101, 103 and 105 at points diametrically opposite the conduits 114. A plurality of low-density paper webs (composed of such commercially available papers as kraft tissue and the like) are threaded into the calender-

ing stack at successive nips between the steel and paper rolls.

As will be seen from an inspection of the figure, the lowermost web 120 is threaded around the steel roll 101 prior to passing through the nip between the steel roll and the adjacent paper roll 102. Before contacting the steam-heated steel roll 101 the upper surface of the web is wetted by the spray from the conduit 113. The underside of web 20 is also wetted by means of the conduit 114 which directs a water vapor across the width of the web immediately before it enters the nip between rolls 101 and 102. This spray is also adjusted, as are all of the other sprays, to deliver water vapor at the desired rate. The provision of the initial spray unit 113 prevents the steam heated roll 101 from drying the web 120 to such an extent that subsequent wetting and pressing would produce cracks and creases in it.

Four additional webs are subsequently threaded into the calendering stack to merge with the initial one in forming a compacted composite sheet. Two of these additional webs 121 and 122 enter the stack at the nips between the second and third steam-heated rolls and the respective lower paper rolls 102 and 104. A further two webs are threaded into the stack at the nips between the steam-heated rolls 103 and 105 and the next vertically adjacent paper rolls 104 and 106, respectively. Immediately before entering the stack, each additional web is moisturized by water vapor from one of the spray units 113 or 114. The final composite sheet of five webs is threaded between the paper roll 106 and steel roll 107 where it receives a final pressing operation. The process conditions of temperature and pressure are the same as in the Fig. 1 construction.

It will thus be seen that this form of the invention provides a structure whereby an initial web of porous, low-density paper is sequentially combined with similar webs on its separate surfaces under repeated moisturizing, heating and pressing operations to produce a final compacted, dense sheet in which the initial web forms the central layer. This sheet is comparable to that produced in the Fig. 1 structure.

The spray units 113 and 114 could be replaced by the felt rolls of the Fig. 1 construction; and further, the paper webs may be threaded into the calender stack in inverse order, i. e., from the top down.

A still further modified form of the invention is illustrated in Fig. 3. This form of apparatus for producing the densified paper of the invention is exceedingly simple and consists of a three cylinder calendar stack in addition to a single moisturizing unit, such as that of Fig. 1, and a cutting unit. As shown, the calendering unit contains two steam-heated stainless steel (or equivalent) rolls 201, 203 with an interposed paper roll 202 mounted in vertical alignment. The cylinders of this form of the invention, particularly the central paper roll 202, are constructed to be larger in circumference than those previously described for a purpose hereinafter apparent.

A single web 220 of conventional low-density paper is threaded about the periphery of the roll 201 into the nip between it and the adjacent paper roll 202, and thence about the surface of the paper roll through the nip between it and the upper steam-heated roll 203. The web is thereafter permitted to lap or wind up upon the surface of the paper roll for as many turns as desired.

A single moisturizing or web wetting unit is positioned adjacent the nip between rolls 201 and 202 and consists of a long conduit 213 and spaced nipples 214 for directing a water spray upon the surface of a small felt roll 212 which frictionally contacts the web surface 220. An idler rubber roll 211 is resiliently urged by conventional means (not shown) against the adjacent peripheries of the felt roll 212 and paper roll 202 and is adapted to be driven by the paper roll, to in turn frictionally rotate the felt roll 212 at a relatively high speed in the direction of

movement of the web 220 to provide the requisite moisture therefor.

It will thus be seen that each succeeding layer of paper is subjected to moisturizing, heating, pressing and repressing as it winds about the paper roll 202. It will also be apparent that the initial layer is subjected to as many reprocessings as there are additional layers wound upon the paper cylinder. This results in a highly compacted and homogeneous paper matrix about the periphery of the paper roll which corresponds to the final compacted sheets produced in the previously described apparatus. After the web is wound upon the roll 202 for the desired number of turns, it is removed by slitting the compacted web along the length of the roll.

One convenient technique for removing the compacted web from cylinder 202 is illustrated diagrammatically in the figure, although many diverse structures for producing the same result will be apparent to those skilled in the art. As shown in the figure, the removing unit includes a reciprocating knife 230 and an associated suction unit 235.

The knife 230, which is preferably carried on guides, is moved against roll 202 and cuts the paper along its entire width. Suction is simultaneously or subsequently applied via unit 235 which is brought into contact with the cut paper adjacent the cut. This operation may be performed while the web continues to feed about the periphery of the paper roll, and due to its continued movement, the slit edge of the compacted web is peeled off of the drum 202 and carried away from the roll surface. The knife need not cut entirely through the paper inasmuch as the suction will readily break a small unsevered thickness. If desired, a guide or deflecting plate 240 may be positioned over the moisturizing unit to prevent the compacted strip being withdrawn from becoming entangled therewith.

If desired, an additional moisturization unit, such as a second felt roll or a direct spray unit, may be employed to wet the upper side of the web 202 as it emerges from the nip between rolls 201 and 202. Alternatively, such unit may be positioned in front of the nip between rolls 202 and 203 to wet the web surface prior to the second pressing.

The paper produced by the apparatus of Fig. 3 appears to be no different than those produced under the same conditions in the apparatus of Figs. 1 and 2.

Fig. 4 illustrates a still further modified structure for producing the densified paper. In this form of the invention the same type of unit is used as in the Fig. 3 construction with the exception that the steam-heated rolls are formed to be larger than the paper roll. The calendering unit comprises two heated steel rolls 301 and 303 between which are interposed a smaller paper roll 302. A plurality of low-density paper webs 320 to 324 inclusive are simultaneously fed into the nip between rolls 301 and 302 after being individually moisturized by means of the separate felt idler rolls 330 to 334 inclusive. The moisturizing rolls may be supplied with a continuous stream of water via an internal coaxial conduit (not shown) in the roll support shaft as is conventional practice in many cooling and lubricating systems. As indicated above the rolls 330 to 334 inclusive are positioned as close to the nip as possible; and if desired, may be so

positioned as to contact the upper surface of one web as well as the lower surface of an adjacent web. The separate webs are heated and pressed in the nip between rolls 301 and 302 and then again in the nip between rolls 302 and 303. The resulting densified paper has qualities and characteristics comparable to those indicated previously for paper produced on the other apparatus.

The advantages of the invention do not appear to be obtainable unless the supercalendering is effected with rolls heated to at least about 100° C. However, best results are obtained at temperatures approaching 230° C. Regular supercalendering pressures are all that is needed. By way of example nip pressures of about 800 pounds per linear inch of paper width with rolls having diameters of 12 and 14 inches respectively is very satisfactory.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope hereof, it is to be understood that the invention is not limited to the specific embodiments hereof except as defined in the appended claims.

What is claimed is:

1. A method for producing a paper dielectric having a density of at least about 1.1 grams per cubic centimeter, said method comprising supplying a paper having a density of not more than 1 gram per cubic centimeter and supercalendering a plurality of layers of such paper together in a supercalender having rolls heated to at least about 100° C. while moistening said layers, as they enter the nips, to a moisture content of at least 10% based on the dry weight of the paper, to cause the rolling to dry and permanently unite the layers into a single sheet.

2. The combination of claim 1 in which the layers are separate webs of paper simultaneously fed to the supercalendering.

3. The combination of claim 1 in which the layers are portions of a single web of paper that is wrapped around a supercalender roll and rolled up to provide the desired number of laminated layers.

4. The combination of claim 1 in which the nip pressure is about 800 pounds per linear inch, the supplied paper is not more than about 0.62 mils thick, and the moistening is carried out to a moisture content of from 15 to 55 percent based on the dry paper weight.

5. A method for producing a dielectric having a density in excess of 1.0 and consisting essentially of paper which comprises the steps of supplying a plurality of layers of low density kraft paper, supercalendering the layers together in a supercalender at a temperature of about 230° C., said layers being moistened with at least 10% water, based on the dry weight of the paper, immediately prior to entering into the nip of said supercalender.

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