

Sept. 19, 1961

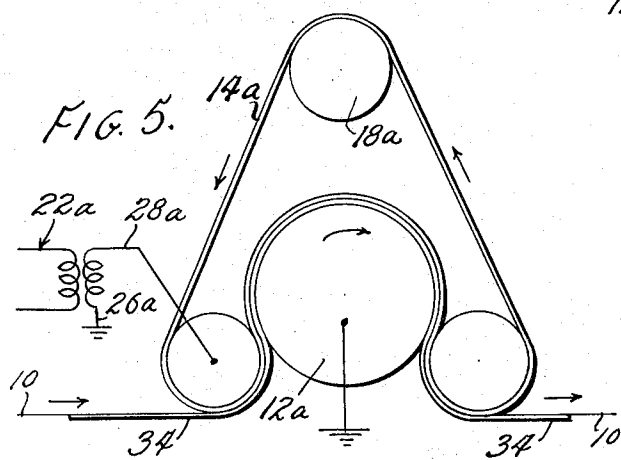
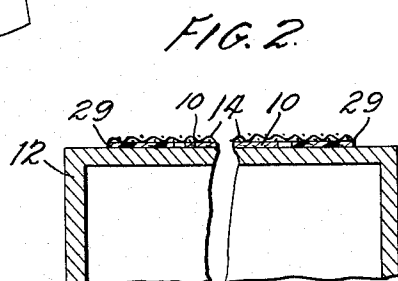
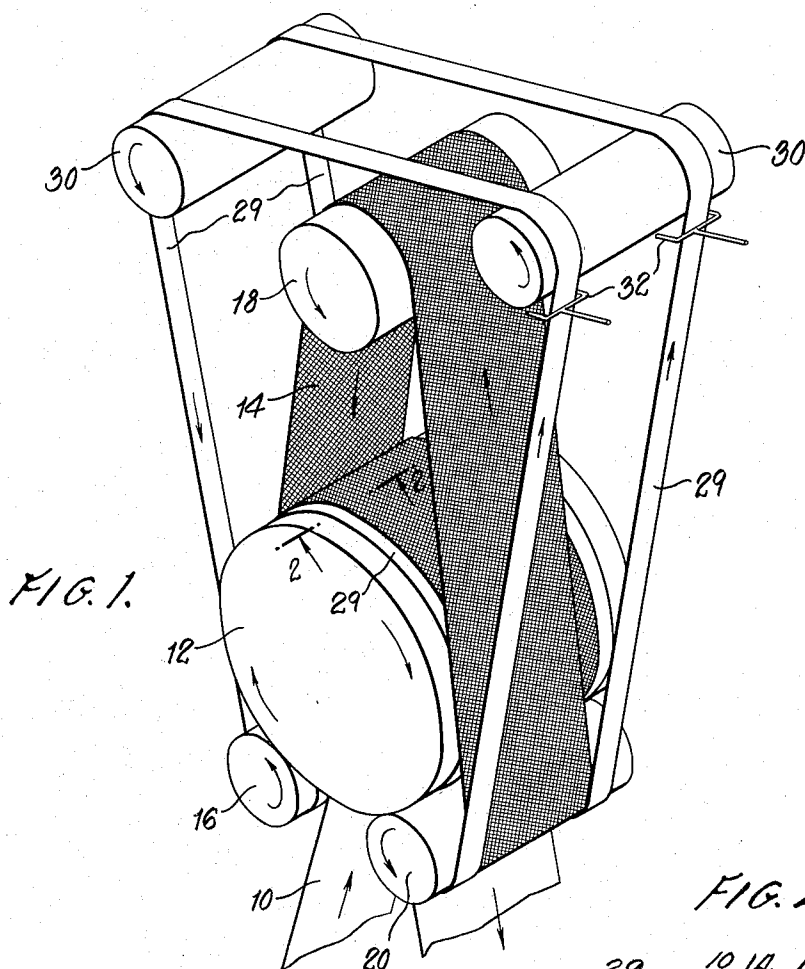
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3,000,106

APPARATUS FOR DRYING PAPER BY ELECTRICAL CONDUCTIVITY

Filed March 20, 1957

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3.

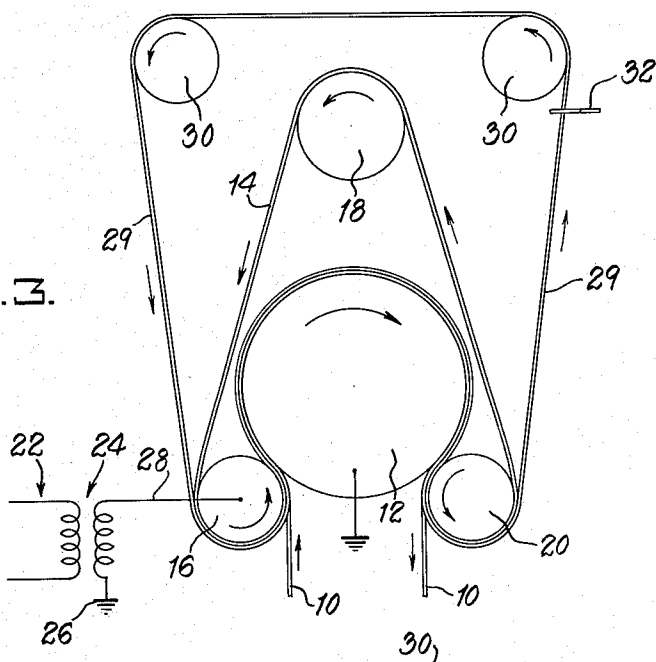
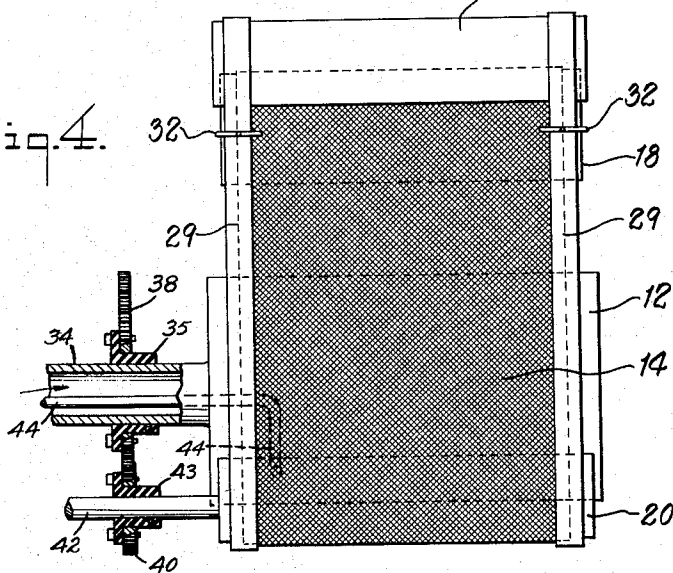


Fig. 4.



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APPARATUS FOR DRYING PAPER BY
ELECTRICAL CONDUCTIVITY

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Filed Mar. 20, 1957, Ser. No. 647,240

11 Claims. (Cl. 34—1)

This invention relates to the drying of paper, and more particularly to the evaporation of moisture carried in the paper web through the conversion into heat of electrical energy furnished from a source through a circuit which includes the web itself.

In many ways electrical heating of a paper web by conductivity is superior to the use of steam. It selectively evaporates water most rapidly in the wettest areas. This tends to reduce wet spots, making the water content across the sheet more uniform. Use of electrical conductivity drying in that stage of the web development at which the paper begins to shrink will, because of the more uniform drying obtained, produce more uniform shrinking, and thereby reduce cockling. Electrical conductivity drying can be used with advantage after the last steam dryer to produce a more uniform moisture profile across the sheet.

It is well known that the last 30 percent of the dryers of a paper making machine are very inefficient, because of the very low heat transfer rates. In this section of the machine a large number of dryers is required for the relatively small amount of water evaporated. This makes the equipment cost high in relation to the drying accomplished by a unit. The low efficiency of the drying equipment is accentuated by the great heat loss by radiation which occurs per pound of water evaporated. In contrast, the conductive dryer converts the electrical energy to heat right in the paper web itself, so that the efficiency is very high.

For the reasons indicated, conductive electrical heating may be used with great advantage in place of a part or all of the steam heated drying rolls, and/or ahead of the press section. Where felts are used, electrical conductive heating can be used to dry the felts along with the paper, or to dry the felts by themselves in their inactive runs. Either procedure increases the drainage rate.

Electrical conductivity heating is not basically new. According to the prior practice, however, a pair of opposed feed rolls have been used as electrodes for transmitting electrical energy through the body of the paper web. In such a structure the only contact available for electrical transmission and subsequent heating is found in the very limited zone at the nip of the rolls—only a small fraction of an inch in length. The short contact thus made available necessitates the use of a high voltage between the electrodes to force enough energy into and through the sheet. This high voltage constitutes an important safety hazard. It also precludes the effective utilization of the equipment upon high speed webs.

The primary object of the present invention is to make available a safer and more effective form of electrical conductive heating apparatus by greatly extending the contact of the electrodes with the traveling web in the direction of web travel. To this end, it is an important feature that electrodes are provided which run continuously in engagement with opposite faces of the web throughout an extended portion of the web path. With an arrangement of this kind the voltage can be reduced to a safe figure, and still a greatly increased amount of electrical energy can be put into the web per unit length.

It is a further object of the invention to provide a safeguard against short-circuiting the electrodes, either through contact of the marginal portions of the electrodes with one another or otherwise.

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Other objects and advantages will hereinafter appear. In the drawing forming part of this specification,

FIG. 1 is a perspective view of illustrative drying mechanism which represents a practical and advantageous embodiment of the invention;

FIG. 2 is a fragmentary sectional view on a larger scale than FIG. 1, the section being taken on the line 2—2 of FIG. 1, looking in the direction of the arrows, and the structure of FIG. 2 being shown broken away intermediate its ends for compactness of illustration;

FIG. 3 is a view in side elevation of the illustrative mechanism;

FIG. 4 is a view in end elevation of the same mechanism; and

FIG. 5 is a view similar to FIG. 3 but showing a carrying felt belt associated with the paper web arranged to carry the web to, around and away from the drying unit.

In FIGS. 1 to 4, only that portion of a paper making machine is illustrated with which the present invention is immediately concerned. For illustrative purposes, the structure shown may be assumed to follow the steam heated dryer rolls of a conventional machine, or to replace one or more of such rolls.

The paper 10 is fed part-way around a conductive roll 12, being pressed and guided against the roll by a conductive feed belt 14. The belt 14 is desirably formed of copper screening, like a Fourdrinier wire, because the copper screening combines flexibility with a high degree of conductivity, and is vapor permeable so that vapors may escape from between the roll and belt as fast as they are formed. Alternatively, at times it is of advantage to reduce vaporization of moisture until higher temperatures have been reached in order to take advantage of the lower electrical resistance at higher moisture contents of the paper. Under these conditions the belt may advantageously be made impermeable and it may then be formed of flexible steel or of electrical conducting rubber. The roller 12 and the belt 14 constitute opposed electrodes which are narrowly and uniformly spaced from one another, being separated by the substantially even thickness of the moist paper web 10 throughout a very substantial arc of the roll 12 (substantially above 180° as shown). The belt 14 runs upon three rolls 16, 18 and 20, one or more of which is conductive.

As shown, alternating current is furnished from a primary circuit 22 through a transformer 24, which would ordinarily be a step-down transformer. The secondary winding of the transformer 24 has one end connected to ground through a conductor 26, and the other end connected to the conductive roller 16 through a conductor 28. If desired, the transformer secondary may also be directly wired to the rolls 18 and 20. The rolls 16, 18 and 20 are carefully insulated from ground, but the roll 12 is connected to ground in order to provide a return path to the conductor 26.

The paper web varies in width, depending on shrinkage which occurs before it enters the nip of the roll 12 and the belt 14. Since it is necessary that the paper be dried along its edges, the conductive belt 14 must be of a width somewhat greater than that of the paper web. It is an important feature of the invention that provision is made for spacing the overhanging margins of the belt 14 from the roller 12. For this purpose provision is made of a pair of non-conducting belts 29, arranged to run alongside the paper in the plane thereof and between the roll 12 and the conductive belt 14. Desirably, the non-conductive belts are made of non-absorbent material, such as rubber or a synthetic polymer. The belts 29 run upon guide rolls 30 as well as the rolls 12, 16 and 20, being driven by the roll 12 at the speed of the paper web. Suitable guiding means, such as forks 32, are adjustably

mounted and serve to adjust the disposition of the belts 29 axially of the roll 12.

The roll 12 may advantageously be steam heated in order to avoid the dissipation of electrically generated heat through the roll. To this end, heating steam may be supplied to the interior of the imperforate roll 12 through a hollow end of the drive shaft 34, and condensate may be discharged under pressure by any conventional means, for example, a condensate collecting pipe 44.

The belt 14 is caused to run in unison, or substantially in unison, with the surface of the roll 12 and with the paper web 10 by an suitable means. The belt 14 may be driven by the roll 12 through the paper web 10 so long as no objectionable amount of creep is permitted to occur. Another suitable arrangement may be that shown in FIGURE 4, in which the roll 12 and the roll 20 are connected for operation at identical peripheral speeds through gears 38 and 40. The gears 38 and 40 may be composed of insulating material, or they may be insulated in any suitable manner from their shafts 34 and 42, as by insulating collars 35 and 43.

The advantages inherent in the invention are susceptible of mathematical demonstration.

Let it be assumed that under the prior practice, with a narrow conductive area (in the machine direction) provided, the moist paper opposes a resistance R to a high voltage E , so that a current I is caused to flow according to Ohm's law:

$$E=IR \quad (1)$$

The energy input per unit time under this arrangement would then be determined from the equation:

$$W=IE=\frac{E^2}{R} \quad (2)$$

Now assume that through multiplication of the conductive area by n the resistance is divided by n , and that the voltage is arbitrarily divided by m . In the resulting equation

$$W_1=\frac{E_1^2}{R_1} \quad (3)$$

$$E_1=\frac{E}{m}$$

$$R_1=\frac{R}{n}$$

and

$$\frac{W_1}{W}=\frac{E_1^2 R}{E^2 R_1}$$

Then

$$\frac{W_1}{W}=\frac{n}{m^2} \quad (4)$$

If we assume that, because of the increased area of effective transmission, n is 36, and that m is arbitrarily made equal to 6, Equation 4 becomes

$$\frac{W_1}{W}=1$$

Thus with one-sixth the original voltage, and a thirty-six-fold increase of conductive area, the original energy input (same total rate of evaporation) would be maintained. This is one practical way of utilizing the improvement.

It is not requisite, however, that the energy input be limited to the original level. Had n been made equal to thirty-six and m to three, the energy input would have been increased fourfold, and a single unit, according to the invention, would be equal in heating power to four units under the prior arrangement.

Actually the single unit according to the invention would produce better than a fourfold increase of evaporation because the paper and its contained moisture would

not have an opportunity to cool in passing from roll to roll.

It has been mentioned that according to the conductivity heating practice of the prior art, the web is brought to a more uniform moisture content in the cross direction than can be achieved by other means. With the present invention this same advantage is realized, but the further advantage is also realized that the web is brought to a substantially more even moisture content in the direction of web travel.

Under the prior art arrangement, the energy could only be distributed at any chosen instant throughout an area having an extremely short dimension in the direction of web travel. Under the invention, the energy can be distributed variably according to wetness throughout an area of very considerable extent in the direction of web travel.

The invention is not limited to the utilization of alternating current, but can be used with direct current if desired. Alternating current is preferred, however, because its use avoids the development of objectionable electrolytic effects such as decomposition of water in the web, and the possible electro-deposition of the material of one electrode on the other electrode.

In FIGURE 5 a felt web carrying belt 34 is shown as conducting the web 10 to and from electrodes 12a and 14a. The felt belt 34 travels between the electrodes with the paper and is broader than the belt electrodes 14a. The current flows through the paper web and the felt belt 34 in series in passing between the electrodes 12a and 14a. The felt belt is wide enough to prevent direct contact of the electrodes with one another, even when the paper web is not present. The belts 29, guide rolls 30 and guides 32, of FIGURES 1 to 4 are omitted in the FIGURE 5 construction, being unnecessary. In all other respects the construction of FIGURE 5 is the same as that of FIGURES 1 to 4. Corresponding reference characters have been applied to corresponding parts in FIGURE 5 with the subscript "a" added in in each instance, and no further detailed description will be given.

While preferred embodiments of the invention have been illustrated and described in detail, it is to be understood that changes may be made therein and the invention embodied in other structures. It is not therefore the intention to limit the patent to the specific constructions illustrated, but to cover the invention broadly in whatever form its principles may be utilized.

I claim:

1. Drying apparatus for web material comprising, in combination, a pair of evenly spaced traveling conductive electrodes bearing forcibly and evenly against one another through the web material to be dried throughout an extensive range of travel, a source of electrical potential, conductive means connecting opposite sides of said source to the respective electrodes, and protective means of high electrical resistance interposed between the electrodes and beyond the lateral bounds of the web material for preventing short circuiting contact of the electrodes beyond the lateral bounds of the web material.

2. Paper drying apparatus for paper making machines comprising, in combination, a pair of similarly curved, evenly spaced, traveling conductive electrodes arranged to bear forcibly and evenly against one another through the paper web to be dried throughout an extensive range of arcuate travel of the web, said electrodes being of substantially the same curvature and being curved in the same direction, a source of electrical potential, and conductive means connecting the opposite sides of said source to the respective electrodes, and protective means of high electrical resistance interposed between the electrodes and beyond the lateral bounds of the web material for preventing short circuiting contact of the electrodes beyond the lateral bounds of the web material.

3. Drying apparatus for drying fibrous web material moisture withdrawing, carrying belt of felt for the web,

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moisture with drawing, carrying belt of felt for the web, a source of electrical energy, a conductive roll on which the web material and the carrying belt travel, a traveling conductive belt trained to overlie the web material and the carrying belt on the conductive roll in conformity with the curvature thereof throughout a substantial arc of travel, so that the conductive belt and the roll may serve as electrodes of extensive area spaced evenly from one another by the carrying belt and the web material, and circuit means connecting the source of electrical energy, the roll and the conductive belt in series circuit, with the moist web material itself and the carrying belt transmitting the current in series between the roll and belt electrodes and constituting the sole conductive means for connecting the roll and the conductive belt electrically to one another, the carrying belt being at least as wide as the conductive belt and serving to prevent short circuiting contact of the conductive belt with the roll.

4. Drying apparatus for web material comprising, in combination, a source of electrical energy, a conductive roll on which the web material travels, a traveling conductive belt trained to overlie the web material on the roll in conformity with the curvature thereof throughout a substantial arc of travel, so that the belt and the roll may serve as electrodes of extensive area spaced evenly from one another by the web material, circuit means connecting the source of electrical energy, the roll and the belt in series circuit, with the moist web material itself constituting the sole conductive means for connecting the roll and belt electrically to one another, the belt being wide enough to extend beyond the opposite side boundaries of the web material to assure the conductive drying of the web out to its edges, and endless belts of insulating material disposed to run between the conductive belt margins and the roll adjacent to the opposite edges of the web material for preventing short circuiting contact of the conductive belt with the roll.

5. Drying apparatus as set forth in claim 4 in which the insulating belts are composed of rubber.

6. Drying apparatus as set forth in claim 4 in which provision is made of laterally adjustable guides for the respective insulating belts.

7. Electrical resistance drying apparatus for evaporating moisture from web material by the conversion of electrical energy into heat in, and in contact with, the

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web itself, comprising, in combination, a source of electrical energy suitable for supplying such energy at a low voltage but at a sufficiently rapid rate to effect practical evaporation, an imperforate roll having a continuously conductive surface on which the web material travels, a traveling conductive belt trained to overlie the web material on the roll in conformity to the curvature thereof throughout an arc of travel substantially in excess of 180°, means for driving the belt and roll substantially in unison with the web material, said belt and roll serving throughout their web contacting areas as opposite electrodes of extensive area spaced evenly from one another only by the thickness of the web material, and circuit means connecting the source of electrical energy, the roll and the belt in series circuit, with the moist web material itself constituting the sole conductive means for connecting the roll and belt electrically to one another.

8. Drying apparatus as set forth in claim 7 wherein the imperforate roll is steam tight, and further including means for supplying heating steam to the imperforate roll and means to remove condensate therefrom, in order to avoid the dissipation of electrically generated heat through the roll.

9. Drying apparatus as set forth in claim 7 in which the belt is of impervious construction.

10. Drying apparatus as set forth in claim 7 in which the belt is of a vapor-pervious construction so that the vapor may escape from between the belt and the roll as fast as it is formed.

11. Drying apparatus as set forth in claim 7 in which the belt is composed of copper screening.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,000,106

September 19, 1961

Arthur Christgau

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 74, after "material" insert -- by evaporation comprising, in combination, an absorbent, --.

Signed and sealed this 6th day of March 1962.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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