This invention relates to a new and improved method and apparatus for drying, and particularly for processing pulp, paper and their respective end products. A principal object of the invention resides in the provision of a novel drying action, through the use and control of a high frequency electrical field in a dielectric, utilized to produce molecular frictional heat to evaporate moisture from moisture laden articles such as pulp, paper, and their allied products, more economically and with great improvement in the quality and production of the paper articles or other products so produced.

As an example, in the manufacture of paper, the wet end of the machine may be made more or less as usual for instance by the utilization of a Fourdrinier or rotary screen process, press rolls, etc.; but the large, heavy, expensive and dangerous rotary steam heated drying rolls, together with their perpetual maintenance, radiated steam heat, plumbing, awkward transportation and setting up, replacements, etc. may be either partly or completely done away with as the novel drying units of the present invention embodying the use of high frequency can be arranged to take the place of some or all of the drying rolls.

Unlike presently known paper machines, this new method of drying also provides a more versatile machine, as with this invention, the range of paper weight produced on any particular machine is limited only by its physical width or provisions on the wet end of the machine.

The advantages of the present invention over the conventional prior art drying by steam-heated rolls are many and manifest. In the first place the equipment costs far less, not only to manufacture, transport and assemble, but also to operate and maintain, there being no need for the production of steam, the use and maintenance of steam pipes or rotary equipment etc.; the space required for the equipment is far less by the use of the new and improved high frequency apparatus; the maintenance in general is considerably less, the total machine is of course much lighter in weight, more versatile, cleaner, and the operation is done in a generally dry cold state rather than in the normal hot humid wet atmosphere normally encountered in a paper mill.

In addition, the quality of paper is greatly enhanced because the high frequency field normally and naturally seeks out the heaviest concentrations of water involved as the web passes the high frequency apparatus, thus eliminating moisture streaked paper and other unevennesses across the web, resulting in a more uniform and higher grade paper. In addition, the paper is not pressed upon as in the nature of a mangle as is done by drying rolls, and thus the paper itself when finished has an open grain. The provision of this open grain allows for further processing of the paper as better sizing and applying dyes and colors thereto which is not possible with present methods of drying by the use of steam-heated rollers, it being clear that the fluids used in sizing, dyeing and other processes will be evenly received into the open fiber paper after the drying operation has been accomplished, and for this reason a more uniform processed paper is provided.

Also the percentage of moisture in the paper is a great deal more easily controlled and can be controlled much more accurately. With electricity being used to produce the drying action, the machinery can be calibrated in such a way as to indicate the exact moisture content across the web and through its thickness at any particular spot in the progress of the paper from the wet end of the machine to a final takeup roll, and a final moisture content can be accurately controlled to within a percentage or less, thus doing away with the necessity for extensive testing paper, reevaluating for differences in moisture content, streaks, etc.

There are many other advantages derived from the present invention among which may be mentioned the fact that the high frequency electric apparatus comprising the present invention is much more easily and more quickly stopped and started and is also easily controlled if it is desired to change the drying action at any point throughout the entire machine. The electrodes which produce the high frequency electric field are arranged at either side of the paper web and are easily adjusted both as to mutual spacing and spacing from the web itself so that there is almost an infinite control of the high frequency distance factor to suit the particular conditions involved in any particular run, and special new and improved apparatus is provided herein for so adjusting the electrodes. Also the entire apparatus can be quickly and easily moved from the path of the paper so as to thread the web when this becomes necessary, and other advantages will be clear to those skilled in the art.

Other objects and advantages of the invention will appear hereinafter.

Reference is to be had to the accompanying drawings, in which:

FIG. 1 is a diagrammatic view illustrating in general the setup of a paper-making machine from head box to takeup roll;

FIG. 2 is a view in side elevation illustrating a complete unit of the apparatus utilized in providing for the high frequency drying action;

FIG. 3 is a section on line 3—3 of FIG. 2;

FIG. 4 is a detail view illustrating electrode-adjustment means;

FIG. 5 is a partial plan view illustrating the electrodes in closely adjusted position, and

FIG. 6 is a view similar to FIG. 5 but illustrating the same electrodes as they appear in widely spaced condition.

Referring first to FIG. 1, this invention is illustrated as applied to a paper-making machine including a Fourdrinier wire and it is to be understood that other paper-making machines and pulp drying apparatus can also utilize the same general invention.

In FIG. 1 there is shown the usual head box 10, Fourdrinier wire 12, breast roll 14 and press rolls 16. There may be used first and second press rolls as may be desired.

The web is shown by the reference letter W and it progresses from the breast roll through the press rolls to the left in FIG. 1, passing through a series of high frequency electric drying apparatuses. These appear at the top and bottom of the web and are indicated in general as at 18 and 20. In general each drier part 18 will be alike and the same is true as to the lower drier parts 20. There may be as many of these driers as may be necessary and they may be substituted for the drying rolls of the usual paper-making machine or for any portion thereof.

The web W when in the correct moisture condition will pass through conventional breaker rolls 22, then through a further set of driers 18 and 20 if this should be found necessary, and then through a processing apparatus 24 which may be for sizing in the usual manner or for applying pig-
ments or ink and the like to the web. If the processing at the set of rolls 24 is utilized, it being noted that this can be utilized and not utilized but if the web is passed as is indicated at 26, then further drying apparatuses 18 and 20 will be required to bring the paper to the desired moisture, say for instance five or six percent, as may be predetermined. The web is then merely wound on the take-up roll 28 or passed through a set of calendaring rolls, if this is the case to be desired as at 30. Any number of calendar rolls may be utilized for the purpose involved. While the drying apparatuses 18 and 20 can be utilized in total or only in part, this will be apparent to those skilled in the art and no drying rolls have been illustrated.

In FIG. 3, the web W is again shown passing to the left, and of course it will be clear to those skilled in the art that this web can be drawn through the machine at the speed required by any means desired as for instance solely by the take-up roll or by other means.

In FIG. 3 there is shown a single unit 18 which is called the “upper” or “ground” unit and a single unit 20 which is the “charged” or “hot” unit. As illustrated, there are provided a series of electrodes 32, these electrodes being in the nature of bars which extend transversely across the machine, i.e., across the entire web. These bars are energized as desired by high frequency generators, the connections not being shown but of course these connections are through flexible leads directly onto the bars 32. Several leads are usually mounted on each bar so as to evenly distribute the load throughout the bars.

The bars 32 are mounted on insulators 34, these insulators in turn being mounted upon inverted U-shaped brackets 36 (see particularly FIG. 3).

Brackets 36 are slidable to and from each other and can utilize a connecting slide stabilizing rod 38 which will help to maintain them in this relation. In any event, however, each bracket 36 is provided with a through pin 40 extending between the legs 42, 44 of the individual brackets. Each pin is mounted in an independent inclined slot 46 in a fixed base member 48. Each bracket has its own pin 40 and its own slot 46 and looking at FIG. 2 it will be seen that the slot 46 to the far right is at a least inclination but extends to such a distance that the next slot to it which is indicated at 50, and the same is true for the succeeding slots. Obviously the pins 40 are constrained to move in these paths only and the member 48 being fixed, no other motion is possible than as guided by the respective slots.

It will be seen that for example there are shown as an illustration in this case a set of six slots and three of the slots for each one of six electrodes and there are two sets of said electrodes in the lower unit 20, also including an extra central electrode at 33.

There are two fixed members 48, one for each set of six electrodes, the slots therein being reversed. Each fixed member 48 has a cooperating sliding member 54 which is provided with the same arrangement of slots but reversed, these being indicated at 56, 58, etc. The pins or rods 40 extend through slots 56, 58, etc., each pin or rod extending through a pair of unlike slots.

The arrangement at the upper side of the web W is the same but again reversed but in this case the electrodes 60 are merely grounded to the machine although of course they could be otherwise connected with respect to high frequency generators. However there are two banks of six each of these electrodes, each being mounted on an upright U-shaped bracket 62, each bracket having a rod 64 passing through both legs of the bracket as before and having a stabilizing rod 66.

Each rod 64 extends through a fixed depending supporting member 68, there being two of these as before, each having the respective slots 70, 72, 74, 76, 78, 80, etc., as perhaps best shown in FIG. 4. These slots gradually shorten and become more erect. The two units of six electrodes are provided with a slide 82 having slots 84, 86, 88, 90, 92, 94 complementary to the slots 70, 72, etc. as before explained, and each rod 64 extends through a pair of slots and one if of slots only. Now it is noted that the slots in each member are complementary with respect to each other, there being a short more upright slot, a longer and more inclined slot, etc. to the last slot which is the most inclined to the greatest degree and is the longest, and the longest slot at one end of the slide plates are cooperatively arranged with respect to the slots of plate 82 for instance in FIG. 4 is moved to the right, the rods 64 therein are moved upwardly but of course guided by the slots in member 68. All the rods 64 move equally vertically but gradually more horizontally. Therefore this action causes the electrodes in the respective units of six described to be moved upwardly from the web to an exact uniform degree and also to be spread apart to an exact uniform degree.

The electrodes 60 at the right-hand side of the apparatus in FIG. 2 move up to the right as the six electrodes 60 at the left-hand apparatus above the web W move upward to the left, and the reverse action takes place with respect to the hot electrodes 52. The six electrodes 32 at the right-hand side move down to the right, the six electrodes 32 at the left-hand side move down to the left and in unison spacing from the web and in uniform but gradually increasing spacing from each other. The central electrode 33 has a vertical guiding slot 96 and it can only move up and down.

The action is shown in dotted lines at the right-hand side of FIG. 2 and the relative spacing of the electrodes is shown in a comparison of FIGS. 5 and 6 wherein it will be noted that the respective supporting members, slide plates, etc. are offset in the various sets so that they will not interfere with each other in the operation thereof, but the effective lengths of the rods are the same inasmuch as those to the right in FIG. 6 for instance will extend past the edge of the web W.

The electrodes 52 are maintained in staggered relation with respect to the electrodes 60 because the current of course flows from electrode to electrode, thus traversing the web on the bias and providing a much greater sectional area for the drying action than if the current were to flow merely vertically. In any event it will be seen that the various electrodes are evenly and simultaneously adjusted both to and from the web and relative to each other providing for the maximum adjustment of effectiveness of the high frequency current as it passes through the web W. These adjustments will of course be made simply for achieving optimum conditions for the particular point at which the drying is done, the size and grade of paper, the degree of moisture desired to be extracted, etc.

It is also pointed out that it is a very easy matter to gear the plates 54 together to cause them to operate simultaneously as for instance by use of chains and a hand-crank or an electric motor, and the same is true as to the plates at 74 for the upper set of electrodes. In turn such chain or gearing can be interconnected to move all of the eight sets of six electrodes each simultaneously.

Furthermore the entire setup including the supporting beams 100 can easily be mounted to be retracted as units from the paper web to provide for threading the same. In the assembly of the drying device, it is a simple matter to provide for extra lengths of electrodes simply by attaching fillers or spacer bars as at 102 as by threaded studs 104 or the like, so that any width of machine is easily taken care of.

Due to the small size of the novel drying apparatus compared to the old heated roll system, it is feasible to completely enclose the machine and apply blowers to evacuate the air causing a partial vacuum and at the same time exhausting the vapors. This greatly speeds the drying process since the water is vaporized at a lower temperature and the vapors are dispersed.

It will be seen that the objects of the invention have been carried out and that this invention provides for a
5 great multiplicity of advantages over conventional drying methods and apparatus and particularly over the old steam-heated drying roll operations, in the paper or pulp industry. Almost any thickness of porous paper can be manufactured so that paper filters can be made directly through, and this in addition to the fact that all pressing and mechanical squeezing operations can be completely avoided. A much higher quality of paper is produced, no testing being required, the initial investment is much less than with the drying rolls of the prior art, the upkeep is minimized, and the cost of operation is held to a minimum far less than that of the prior art of paper drying.

The circuit for producing high frequency currents and the phenomena of heating through the use of high frequency currents are well known and it is not believed that further description is necessary.

Having thus described my invention and the advantages thereof, I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:

1. In the method of drying paper the step comprising subjecting a wet paper sheet to a high frequency field sufficient to cause certain of the moisture in the sheet to be vaporized, by passing the sheet in wet form past and between a pair of sets of electrodes which are connected to a high frequency source in the absence of crushing, sizing, or calendering, then applying materials in fluid form to the paper web being passed through the same, further drying the paper web to a predetermined degree of moisture by further subjecting the now processed web to a further high frequency electric field by again passing the sheet past and between a pair of sets of electrodes which are connected to a high frequency source, the field being applied relative to the electrode mounting means in the same manner as described above.

2. Apparatus for drying paper comprising a pair of sets of mutually spaced electrodes, each set containing a plurality of electrodes, said sets being arranged in spaced relation, means supporting the electrodes in said sets, means to travel a moist web between the sets of electrodes, a high frequency circuit connected to the electrodes providing a high frequency field between the sets, the field in general following a plurality of paths through the wet web, and means to vary the spacing of the sets and speed of travel of the web and the spacing of the electrodes within each set, said electrode supporting means including a member for each set, each member having a plurality of separate slots therein at gradually increasing degrees of inclination to the path of the web, each electrode mounting element for each electrode, an element being located in each slot, and the last-named means including means in each set to move the electrode mounting elements along the slots and thereby toward and away from the web.

3. Apparatus for drying paper comprising a pair of sets of mutually spaced electrodes, said sets being arranged in spaced relation, means supporting the electrodes in said sets, means to travel a moist web between the sets of electrodes, a high frequency circuit connected to the electrodes providing for a plurality of paths for a high frequency field to pass through the wet web, means to vary the spacing of the sets and speed of travel of the web and the spacing of the electrodes within each set, said electrode supporting means including a member for each set, each member having a plurality of separate slots therein at gradually increasing degrees of inclination to the path of the web, each electrode mounting element for each electrode, an element being located in each slot, and the last-named means including means in each set to move the electrode mounting elements along the slots and thereby toward and away from the web.

4. The apparatus of claim 3 wherein the last-named means includes a plate in each set to move the electrode mounting element along the slots and thereby toward and away from the web path, the plates having a series of inclined slots therein complementary to the slots in the electrode supporting members, the electrode mounting elements also being located in the slots in the plate.

5. The apparatus of claim 3 including means to move the plate relative to the electrode supporting member.

6. Apparatus for drying a traveling web comprising a plurality of sets of electrodes, said electrodes being generally parallel and spaced and extending generally transversely of the path of the web, the electrodes comprising a plurality of sets of electrodes at each side of the web path, a high frequency circuit connected to said electrodes for passing a high frequency field through the web, and means for adjusting the electrodes similarly in sets with respect to each other and with respect to the web path to thus move same toward and from the path of travel of the web while maintaining even spacing of the electrodes within the sets and even spacing of the electrodes in each set with respect to the path of the web.

7. The apparatus recited in claim 6 wherein said means comprises an electrode mounting member for each set, a series of spaced individual slots in each electrode mounting member, said slots lying at different and gradual degrees of inclination relative to the plane of the web path, the slots extending in opposite directions from the web path in the respective pairs of sets at opposite sides of the web path, and an actuating adjustment plate for each member, each plate containing a series of inclined separate slots complementary to but reversed with respect to the slots in the electrode mounting member with which it is associated, and means to move the adjustment plates relative to the electrode mounting members to move the electrodes to a spread condition from a more closely adjacent condition thereof, all of the electrodes being adjustable from a minimum spacing to a maximum spread spacing in a plane parallel to the plane of the web path and the electrodes at opposite sides of the web path being uniformly adjusted toward and away from the web path.

8. The apparatus recited in claim 6 wherein said means comprises an electrode mounting member for each set, a series of spaced individual slots in each electrode mounting member, said slots lying at different and gradual degrees of inclination relative to the plane of the web path, the slots extending in opposite directions from the web path in the respective pairs of sets at opposite sides of the web path, and an actuating adjustment plate for each member, each plate containing a series of inclined separate slots complementary to but reversed with respect to the slots in the electrode mounting member with which it is associated, and means to move the adjustment plates relative to the electrode mounting members to move the electrodes to a spread condition from a more closely adjacent condition thereof, all of the electrodes being adjustable from a minimum spacing to a maximum spread spacing in a plane parallel to the plane of the web path and the electrodes at opposite sides of the web path being uniformly adjusted toward and away from the web path, means for simultaneously moving all of said plates so that all of the electrodes are adjusted at the same time.

References Cited by the Examiner

UNITED STATES PATENTS

2,344,686 3/1944 Fenselow 34—18
2,409,431 10/1946 Hess 34—18
2,473,251 6/1949 Hsu 219—10.61
2,512,311 6/1950 Davis 34—1
2,562,911 8/1951 Hare 219—10.61
2,630,119 3/1953 Grnd 219—10.43
2,842,383 2/1958 Mich 34—1

FREDERICK L. MATTESON, Jr., Primary Examiner.
NORMAN YUDKOFF, WILLIAM F. O’DEA, Examiners.
F. E. DRUMMOND, D. A. TAMURRO, Assistant Examiners.