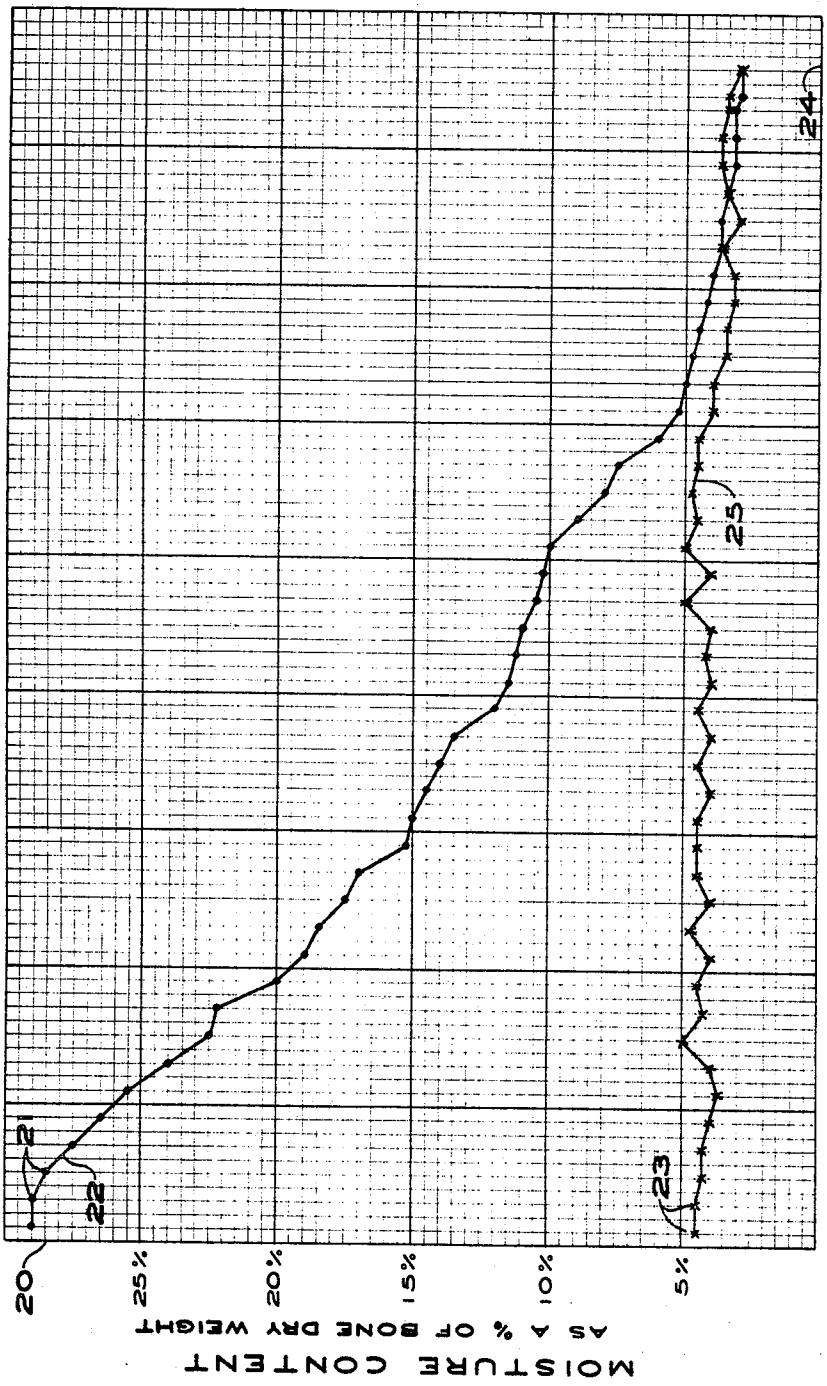
Oct. 1, 1968 J. W. MANN ETAL 3,403,450

MEANS FOR AND PROCESS OF APPROXIMATING EQUALIZATION OF THE RESIDUAL MOISTURE CONTENT WITHIN A SHEET OF VENEER AND THE LIKE

Filed April 21, 1966

2 Sheets-Sheet 1



• MOISTURE CONTENT OF AREAS IN A VENEER SHEET MEASURED BEFORE EQUALIZATION.

× MOISTURE CONTENT OF THE SAME AREAS MEASURED AFTER MOISTURE EQUALIZATION.

DOTS AND CROSSES ON THE SAME VERTICAL LINE REPRESENT THE SAME AREA.

Fig. 1.

INVENTORS.
JULIUS W. MANN
GEORGE F. RUSSELL
BY William R. Piper
ATTORNEY

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Filed April 21, 1966 2 Sheets-Sheet 2

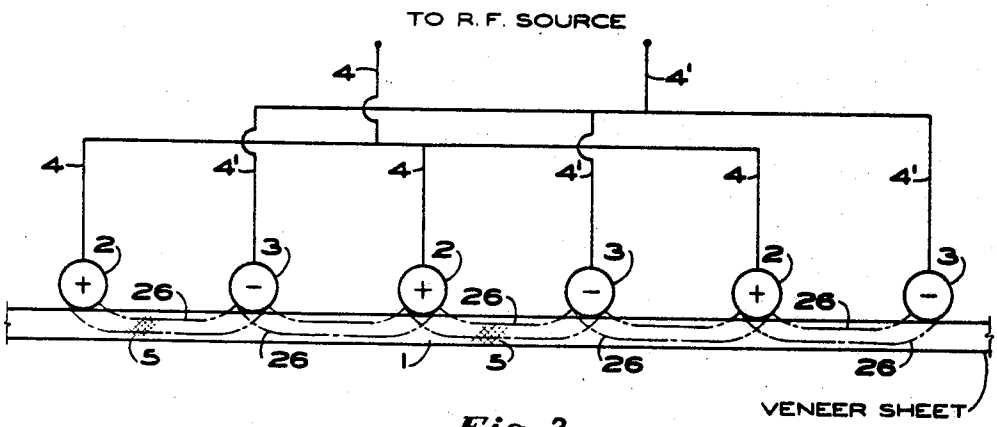

Fig. 2.

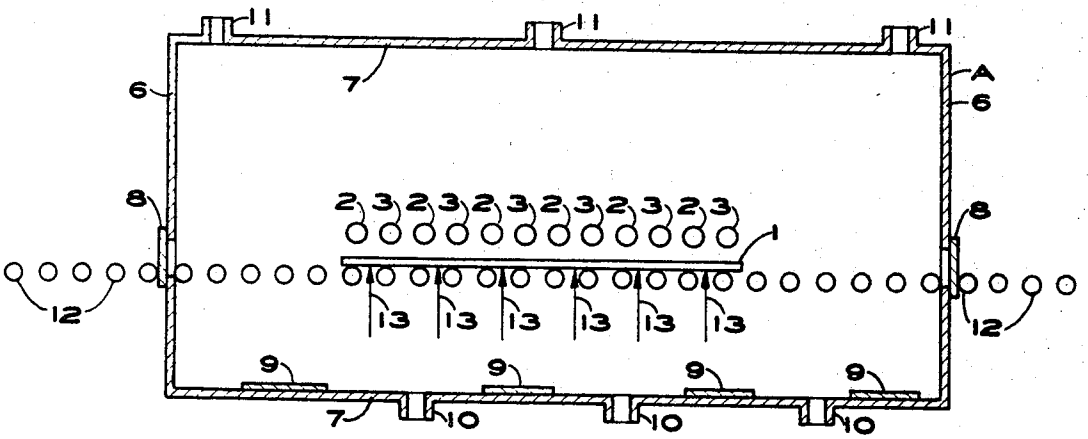

Fig. 3.

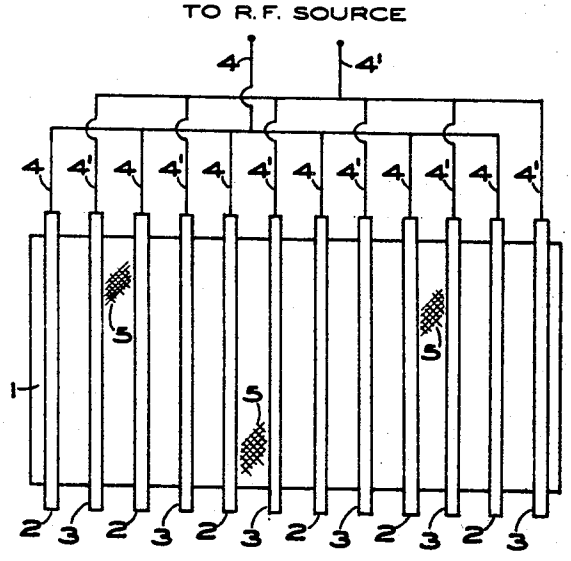

Fig. 4.

INVENTORS.
JULIUS W. MANN
GEORGE F. RUSSELL
BY William R. Piper
ATTORNEY

United States Patent Office

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MEANS FOR AND PROCESS OF APPROXIMATING EQUALIZATION OF THE RESIDUAL MOISTURE CONTENT WITHIN A SHEET OF VENEER AND THE LIKE

Julius W. Mann and George F. Russell, both % Mann-Russell Electronics Inc., 711 St. Helens Ave., Tacoma, Wash. 98402

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10 Claims. (Cl. 34—1)

ABSTRACT OF THE DISCLOSURE

By applying radio frequency energy to wood veneers after preliminary drying and internally heating areas therein containing an excess over a desired average moisture content, more evenly equalizing the moisture content of the whole veneer and preventing escaping vapors from recondensing on the veneers by surrounding it with air of an adequate temperature.

The present invention relates to the means for and processes of approximating equalization of the residual moisture content of areas within a sheet of veneer containing undesirable excesses of moisture contents from a median deemed desirable after the normal or primary drying of green veneers in kilns employed for the purpose and applies as well, to equalization of residual moisture content in dielectrics other than veneer such as but not limited to lumber, boards, composite materials, mats of various shapes and forms including fibre sewer or conduit pipe and consists of processes, arrangements and constructions herein described and claimed.

Veneer, sliced or peeled from wood, is a dielectric and is the material from which plywood panels are made in one adaptation of its use. When veneer is peeled from logs in varying thicknesses, the resulting sheets are dried down to a desired moisture content in hot air, circulating kilns especially constructed for this purpose. A sheet of veneer, for example, of a thickness of 1/10", or 1/8" or any other desired thickness and of approximately 50" x 100" size is a single sheet which combined with others of similar size and interspaced with cross bands of core stock and innerfaces spread with adhesive is glued into a 4' x 8' plywood panel. The gluing may be accomplished either in cold press or in a so-called hot plate press which supplies heat to the sandwiches and accelerates the setting of the adhesive while under pressure. In a cold set plywood the veneer sheets in a panel may contain areas of differing moisture content if not too great from place to place without too severe a deleterious effect on the end product. A hot plate pressed panel, however, should contain veneer sheets of a relatively uniform moisture content, because, if a wet spot is passed into the press in a veneer sheet, the excess of moisture when heated may cause a pocketed envelope of vapor pressure which can expand when the pressure is released and cause a "blow" in the finished panel. Such "blows" degrade the panel and cause it to be rejected. Some good material may be salvaged but the panel is unsalable in its intended size.

In some instances, inability to dry to a uniform moisture content over the whole area of the veneer sheet forces use of an adhesive of inferior moisture resistance, rather than permitting the use of a resin adhesive which is superior in many regards to the filler types, such as mastics and blood glues. The inability of the wood to dry uniformly stems from the way in which wood grows and is peeled or sliced. Species such as Western hemlock, tend to hold moisture in pockets which in numerous instances is not correctable even by redrying in ordinary

dry kilns. In conventional re-drying, the already adequately dried areas tend to overdry resulting in shatter, and case hardening, while the wet spots oftentimes are not dried to the desired extent. Case hardening in the gluing process prevents proper absorption of the adhesive into the surface fibres thereby resulting in a poor wood to wood bond of the finished plywood panel. A desirable goal for hot plate pressed exterior grade plywood is to have the veneers dried to a uniform figure of four or five percent; in cold clamping techniques a higher average may be countenanced. In lumber or fibers this might be from 75% to 95% dry.

After ordinary kiln drying, some species of veneer sheets can retain residual trapped moisture in pockets, either sap or heartwood. The position of such pockets is unpredictable, and the wet areas vary widely from small spots to streaks running the entire length of the sheet, or they may be the size of a dollar or the size of a dinner plate. In a veneer sheet intended to contain 6% moisture (i.e. 94% dry) as measured in percentage of the bone dry or air dry weight the average may be near 6% but areas or spots may be as high as 25%. It is these high moisture areas which cause great trouble in hot plate gluing, and are at the root of most "blows."

In a typical and not uncommon example of a 52" x 103" veneer sheet 1/8" thick taken from a conventional veneer dryer and on which some forty or fifty moisture content readings were taken at spaced points over the entire surface it was found to have a median average of approximately 8%. In a typical dried sheet, ten of these areas may have acceptable moisture contents of under 6%; ten may have readings of over 20% and the rest may fall between the upper and lower limits. Such a sheet, obviously is unsuitable for plywood production in a hot plate press. After redrying in a regular kiln most points fall to within near reasonable limits but several, more often than not, remain too high for use in a hot plate press. Many sheets sampled have shown a near proper average of moisture content but single areas have reached up to 15 or 20%. It is with veneer of this type with which this invention is most concerned, since the invention makes possible for the first time recovery of such unevenly dried sheets for plywood production, makes possible saving the raw material in them by returning such sheets to the assembly line after equalizing the moisture content of the sheet and eliminating the trapped moisture pockets in the veneer. The invention, therefore, is new, not previously having been employed in the plywood or lumber or fiber industry, has commercial value, saves otherwise wasted raw material and is economical. The invention does not encompass drying the entire veneer sheet from green to dry for this is a function of a generally satisfactory air circulating dryer in use in all plywood plants in the Pacific Northwest, but is described and claimed as a method of equalizing unevenly distributed residual moisture content in sheets of veneer or wood after primary drying to a selected moisture content goal as an acceptable condition for gluing.

In the production of laminated wood beams, purlins, arches and the like building materials, use is made of pieces of wood or ribbons glued face to face to a desired depth or cross section and length. In some beams many separate pieces of wood are laminated into one contiguous beam. A typical laminated beam might be 6" wide x 18" in depth and 40' long or 8" x 22" x 60' long or almost any variation of size. Ten laminates of 2" x 6" lumber would make up the cross section of the first size beam, but several pieces would be required to make up each layer in its length. If the moisture content of the component pieces vary widely and the faces are glued up into a solid laminated beam, undesirable locked-in stresses will

result in the finished beam over a long period of time when equilibrium moisture balance is reached. In a laminate of many components the averaging is such that unusual characteristics in the beam may be unobservable. In beam lamination, as in the gluing of veneer where the use of more water proof adhesives is possible the more uniform the moisture content. Here also, the case hardening effect caused by rapid or violent external heating is deleterious to the results of later gluing processes. Post dryer equalization while requiring more energy input in large timber than in sheets of veneer is effective for the purposes above described.

In ordinary drying of fibre pipe, uneveness of moisture distribution as between areas of the product particularly the ends can result in imperfect impregnation or later processing, the rejection of a finished length of pipe or the degrading of the output. Other dielectric products, including felts, cloth, paper or paperboard are subject to uneveness in primary drying which can be corrected by the processes of this invention. We have illustrated the radio frequency moisture equalization of veneer as only one example.

Other objects and advantages will appear as the specification continues. The novel features of the invention will be set forth in the appended claims.

Drawings

For a better understanding of our invention, reference should be made to the accompanying drawings, forming part of this specification, in which:

FIGURE 1 is a chart depicting by each dot a moisture content reading before equalization; and by each cross the same spot after equalization by the process claimed in this invention; dots and crosses in a common vertical plane, one below the other, depict the moisture content of a specific area of the veneer tested before and after the application on this process.

FIGURE 2 is a schematic cross section in part of an acceptable type of electrode configuration which may be used to apply the high frequency field of force to the veneer during its R.F. treatment, although other configurations may be used.

FIGURE 3 is the outline of a cabinet for containing the high temperature ambient air surrounding the veneer and with R.F. electrodes therein for treatment of sheets of veneer for equalization of moisture content.

FIGURE 4 is a schematic top plan view of a sheet of plywood and high frequency electrodes and illustrates one example of how different portions of the plywood can retain varying percentages of residual trapped moisture in pockets.

While we have shown a chart illustrating the results accomplished by our invention and also means of applying a field of force to veneer as well as a container in which one adaptation of the process of the invention may be accomplished, various modifications and changes may be made without departing from the spirit and scope of our invention, as set forth in the claims particularly in the type of high frequency electrode used and the container with its appurtenances for receiving the plywood.

Detailed description

In FIGURE 1, the vertical axis **20** of the chart designated as representing differing percentages of moisture content expressed as a percentage of the bone dry weight of a veneer sheet which has already been primarily dried in a typical hot air circulating continuous veneer dryer commonly used in plywood plants in the Pacific Northwest of the United States. Each dot **21** of the forty-four dots contained in the figure represents a separate area **5** on the face of a sheet of veneer **1**, see FIGURE 4, measured by a conventional moisture detector. It will be noted that areas will vary in moisture content; some running up to over 25%; others to just below 4% which latter area could for purposes of perfection be called a desired goal. If all of the dots **21** in FIGURE 1 were on or about the four to six percent area of the chart, no need would arise to equalize the sheet by the herein described invention. The dots **21** are connected by a graph line **22** from one to another and are arranged in the order of a steady decline. In the sheet of veneer **1**, however, the dot at the left may be in the center of the sheet and its nearest neighbor at one edge, etc., see FIGURE 4. The graph line **22** is a mere statistical assistance in viewing the end result. Directly beneath each dot **21** on most of the chart, of FIGURE 1, but slightly above a few dots **21** at the right side are crosses **23** which represent the moisture content of the areas represented by the dots **21**, after the processes of this invention have been carried out. The bottom or horizontal axis **24**, therefore, merely uses space to separate a designation of differing areas in the veneer sheet.

In the veneer represented on the chart of FIGURE 1, a four minute test was made in an ambient air temperature of 260° to 290° F. During the first two minutes, a high frequency field of force was applied to the veneer over its whole area, the field having an intensity equivalent to impressing 1000 B.t.u.'s per minute to the whole area of a 52" x 103" veneer sheet. The lower line of crosses **23** are also connected by lines so that an average can be made visually by the resulting lower graph line **25**. The treatment left no areas with moisture contents of over 5%, while all but thirteen of the forty-four dots **21** started above that value. Four crosses, however, see the right hand end of the graph line **25**, in FIGURE 1, started below their ending moisture content, the treatment having an equalizing effect as described. From a desired goal, therefore, the treatment does not appear to dry further those areas having attained the desired goal of dryness, but primarily to concentrate the effectiveness of the treatment on the wetter areas.

FIGURE 2 is a diagrammatic representation of the cross section of a sheet of veneer **1**, adjacent to and below an electrode configuration of which a plurality of positively charged electrode elements **2** and a plurality of instantaneously oppositely charged negative electrode elements **3** spaced apart and alternately placed are attached to lead elements **4** and **4'** intended for attachment to a radio frequency generator or source of high frequency alternating current, shown in the figure, "To R.F. Source." The field of force established between the elements **2** and **3** and indicated by the dot-dash lines **26**, will strike through the veneer **1**, heating it. Cross hatched sections **5**, shown in FIGURES 2 and 4, may be areas in the veneer having an excessive concentration of moisture compared to the other areas of the sheet **1**. The field of force between adjacent positive and negative electrodes **2** and **3** that bound an area of excessive concentration of moisture will concentrate in this area in proportion to its relative power factor and/or conductivity thus selectively concentrating heat therein. If a single ender generator were employed one or the other of the elements **2** and **3** would be charged and its pair grounded, and one of the leads **4** and **4'** attached to a source of high frequency and its alternate grounded.

FIGURE 3 is a diagrammatic sketch of a container A, shown in cross section and within which one of the processes of our invention may be carried out. Sidewalls **6** and top and bottom walls **7** surround an area containing the electrode configuration composed of the elements **2** and **3** also shown in FIGURE 2. Entrance and exit doors **8** may be provided to keep the temperatures elevated within the container A when heaters indicated schematically at **9** are operating to supply heat to the air taken in through bottom vents **10** and discharged through upper vents **11**. Carrier rolls or other driven or driving means **12** provide carriage for the veneer sheet **1** into, at and/or out of the heating area. Lifting fingers **13** indicated by vertical arrows in FIGURE 3, may provide for solid contacting of the electrode elements **2** and **3** by the veneer **1** if desired, the lifting fingers being activated by suitable means, not shown. Doors **8** and elevating fingers **13** may

be operatively interconnected for simplicity of action so that the lifting fingers **13** will move the veneer **1** into contact with the electrodes **2** and **3** only after the doors **8** are closed. Any convenient timing device for controlling the cycling of the doors **8**, lifting fingers **13** and electrodes **2** and **3** may be employed but are not shown.

In the course of our experience with high frequency dielectric heating, we have found that the high frequency field of force is selective, seeking out where to apply itself by testing areas capable of receiving the greatest energy from the field, whether on the surface or in the interior of the material treated. In a single sheet of dielectric material such as the sheet **1** of wood veneer, the field seeks out those areas where moisture might make it more conductive, where its power factor is greater than an adjacent area. Such areas are apt to be inside the material. Where great differences in moisture content exist, the selective effect is increased, where small differences exist, the selective effect is less, etc. In this manner application of a high frequency alternating current field of force to the veneer sheet **1** in its entirety will accomplish the purpose of the invention, namely to seek out and apply energy to those areas **5** in FIGURES 2 and 4, possessing the greatest concentrations of moisture and therefore the greatest capability of receiving it. This may be done in either a continuous process or in a "batch type" operation. In a continuous process the sheet may pass progressively through an area of R.F. exposure and be completely encompassed at different stages as it progresses past a point or area, or in a batch treatment as shown in FIGURE 3 where the entire sheet may be exposed to the R.F. field effect applied at one time to its entire area. We have illustrated the "batch type" process in FIGURE 3, but want the invention to be broad enough to also apply to a continuous process.

The invention of moisture equalization by R.F. application, however, is more than merely exposing the sheet to an R.F. field, since it alone is less effective in this regard than when used in combination with exposure of the veneer sheet **1** to an ambient surrounding temperature as in the housing A of over 212° F. We have preference for exposure of the veneer sheet **1** simultaneously to a high temperature atmosphere surrounding it and an R.F. treatment. The application of external heat before, during and/or after application of the R.F. energy will produce emminently satisfactory results in some areas. We have found that veneer sheets **1** when treated simultaneously with R.F. in high ambient surroundings above a temperature which will prevent moisture recondensation therein and retained in a subsequent high ambient temperature after the R.F. is turned off produces excellent moisture equalizing results. Contrarywise no appreciable benefit appears to be gained by high ambient preheating before application of the R.F. field. The charring temperature of veneer is well over 325° F. and no harm is found to result to the wood if exposed to ambient temperatures in a range between 212° F. and 325° F. and during the R.F. exposure, but less effective is the equalization of the moisture in the wood as the ambient temperature is lowered toward and below 212° F., and more deleterious case hardening to the surfaces of the wood in the already dry areas will occur as ambient temperatures exceed 325° F.

Faster cycles of treatment are possible if the temperature of the ambient surrounding air exceeds 212° F. and a preferred range falls over 230° F. As the temperature is raised above 212° F. the air has greater affinity for the moisture vapor forced out of the wood by the R.F. heating and certainty exists that recondensation of vapors cannot take place in the surrounding medium, whether air or other gasses.

Methods of applying the high frequency energy to the veneer sheet may vary widely. Electrodes of a type generally described in the U.S. Patent No. 2,625,969, issued Jan. 20, 1953, to Julius W. Mann, and used as a patch gluer utilizing high frequency electricity, while not of a compatible size or dimension to treat a sheet of veneer 52" x 103", can be sized so as to be employed, utilizing the principle of applying the high frequency field from one surface face of the veneer only. Electrodes described in the U.S. Patent No. 2,599,930 (FIGURE 3), issued June 10, 1952, to Julius W. Mann on glue-setting platens, might be employed if convenient to a moving sheet of veneer curved or in a flat plane. The illustration of FIGURE 2 as to R.F. electrodes on one face of a dielectric sheet in our U.S. Patent No. 2,678,897, issued May 18, 1954, on split pole parallel bonding, if extended alternately to cover the size of the veneer sheet, would serve adequately as a means of applying the high frequency field, or electrodes of the type described in our U.S. Patent No. 2,870,808, issued Jan. 27, 1959, to a continuously operated radio frequency adhesive setter for the edge bonding of materials would, when enlarged properly, might be adaptable to the use of the herein described invention. The specific electrode means shown in FIGURES 2 and 3 for applying the energy of the high frequency field of force to veneer to accomplish this invention should not limit the scope of the invention since many alternates can be used.

Methods of applying or generating the high ambient air temperatures which should surround the veneer during its R.F. exposure also vary widely and can be supplied in varying ways. A box or container closed to encompass both the R.F. electrodes and the veneer sheet **1** while under treatment can be supplied with steam pipes, electrical resistance or any convenient and effective source for heating the air surrounding the veneer. Oddly, infrared heating directed to the surfaces of the veneer sheet **1** does not appear to add to the effectiveness of equalization treatment, and in some cases has a surface charring effect. In a batch operation where one sheet at a time is treated, an opening must be provided for entrance and exit of the veneer. This opening and closing of a door to the container or housing permits a changing air supply, within the housing but such a change in air also may be supplied by air circulation means, as well. In developing the most effective air heating means for accomplishing the purposes of this invention, several were found equally competitive. The means of furnishing and/or maintaining the high temperature air surrounding the veneer sheet **1** during the process of this invention are so varied that no limitation to its scope should be dependent on any one such specific means.

The treatment of the sheets of veneer having pocketed moisture in certain areas after ordinary drying may be handled directly from the offbearing table of the dryer to a progressive means such as a conveyor, not shown, to carry a sheet into its area of treatment. The conveyor may move continuously or intermittently, not shown, but carries the sheet into an area disposed on, above or below the carriers for housing a compatible radio frequency electrode configuration connected to a source of high frequency alternating current. The energy source used in some of our tests of these processes consisted of a Mann-Russell single standing wave radio circuit electronic generator, Patent No. 2,506,158, issued May 2, 1950, and capable of a continuous output rating of 70,000 B.t.u.'s per hour of R.F. energy into the work load. While this generator type is designated as a double ender type—a single ender type may be used with effectiveness.

In single ender generators, however, current usage usually requires a loose coupled output circuit and this results in inconsistency of output into the work load compared to Patent No. 2,506,158, on a single standing wave Mann-Russell generator's ability to transfer to the work load predictable amounts of R.F. energy. The invention is not restricted to the use of one or another type of generator as the source of radio frequency energy, or the so-called high frequency alternating current field of

force and limitations of its scope should not from such a factor be imposed on the breadth of the invention.

The veneer sheet after R.F. treatment can be passed to a post conditioning stage in another chamber containing high ambient temperature air alone, if compatible with production processes. An alternate means of post heating may be to treat with R.F. and high outside temperature for a given time then cut off the R.F. and leave the sheet in the same chamber at high surrounding air temperature for a specified time.

The temperature surrounding the veneer sheet **1**, may be any temperature from a room temperature of 70 degrees up to 212 degrees Farenheit. Some veneers and other dielectric products that are to be dried may not need a surrounding temperature of 212 degrees Farenheit as their minimum ambient temperature. The door **8** may be omitted or left open and a continuous web of dielectric material may be treated by R.F. heating. The electrodes **2** and **3** may be below a moving web for continuous treatment rather than be placed above as shown in the drawings.

We claim:

1. In a process of equalizing unevenly distributed residual moisture in dielectric materials after primary drying: the step of simultaneously subjecting the said materials to the heating effect of a high frequency alternating current field of force in a surrounding ambient temperature of more than 212° F.

2. In a process of equalizing unevenly distributed residual moisture in dielectric materials: the step of subjecting the said materials to the heating effect of a high frequency alternating current field of force and coincident therewith surrounding the materials in an ambient atmosphere of over 212° F.

3. The herein described process of taking dielectric materials containing areas with a substantial excess of moisture content compared with a desired goal after the primary drying process is completed for approximating a relatively uniform distribution of its remaining moisture content near to a desired goal average and without materially changing the said desired goal average: which consists in the step of subjecting the said material to exposure to the selective heating effect of an alternating current high frequency field of force while the said material being so exposed is surrounded by air the ambient temperature of which exceeds 212° F.

4. In a process of equalizing unevenly distributed residual moisture in dielectric materials after primary drying: the step of subjecting the said materials to the internal heating effect of a high frequency alternating current field of force and applying a proportionately greater quantity of the high frequency alternating current field of force to areas in the dielectric materials having a higher than average residual moisture content; whereby a greater amount of moisture in these areas will be vaporized than in the remainder of the dielectric materials with the result that the remaining moisture in the materials will be substantially more evenly distributed throughout the materials.

5. The process as set forth in claim **4**: and in which a simultaneous step is effected of surrounding the dielectric materials with an ambient temperature of more than 212° F. and less than 325° F. to receive any water vapor forced from the said materials and preventing the recondensation of this water vapor onto the surfaces of the materials.

6. A process of equalizing unevenly distributed residual moisture in dielectric materials comprising: the step of subjecting the materials to the internal heating effect of a high frequency alternating current field of force and supplying a proportionately greater quantity of the high frequency alternating current field of force to areas in the dielectric materials having a higher than average residual moisture content; whereby a greater amount of moisture in these areas will be vaporized than from the remainder of the dielectric materials with the result that the total moisture in the materials will be substantially more evenly distributed throughout the materials; and the simultaneous step of surrounding the dielectric materials with air of a temperature sufficiently elevated to receive any moisture vapor forced from the higher than average moisture content areas in the materials and thus preventing the immediate recondensation of such moisture vapor onto the surfaces of the materials.

7. The herein described process moisture equalization of a dielectric material containing areas with a substantial excess of moisture content and other areas with less of a moisture content compared with a desired average moisture content goal after the primary drying process for approximating a relatively more uniform distribution of the remaining moisture content and without materially changing the said desired goal average of moisture content; which consists in subjecting the said material to exposure to the selective heating effect of an alternating current high frequency field of force for changing the excess moisture into a vapor some of the vapor moving to the areas in the material with less moisture content and some escaping from the material into the surrounding air; and maintaining the temperature of the air surrounding the material at a point high enough for preventing any recondensation of the evaporated moisture back onto the material; whereby there will be less total residual moisture in the material but a more even distribution average thereof throughout the material.

8. In a process of equalizing a residual nonuniformly distributed moisture content of a dielectric such as a wood veneer having already been dried by any means to a generally acceptable average moisture content for further processing; the steps of

(a) subjecting the material to the simultaneous effects of a surrounding air at a temperature exceeding 212° F., but below 300° F., and

(b) the internal heating effects of a high frequency alternating current field of force applied to the material.

9. The herein described process of treating wood for substantially equalizing a nonuniformly distributed internal moisture content of such wood which contains after primary drying, spots or areas, the moisture content of which spots or areas exceeds a desired average moisture content for the wood; consisting of

(a) exposing the wood to the selective and internal heating effects of a high frequency alternating current field of force to internally heat primarily the spots or areas of excessive or over-average moisture content in the wood while

(b) the wood is surrounded by air the temperature of which is sufficiently high to prevent moisture vapor emitted from the wood through action of the field recondensing immediately on the surface of the wood.

10. In an apparatus for approximating equalization of unevenly distributed moisture content area in a dielectric material comprising:

(a) a housing for receiving dielectric material;

(b) means for heating the air within said housing to temperatures approximating 212° F. or more and at least in the immediate area of the materials being moisture equalized;

(c) an electrode configuration disposed within said housing;

(d) means for effecting an alternating current high frequency field of force to be resident upon said electrode configuration; and

(e) means for conveying the dielectric material so as to be acted upon by said electrode configuration for exposure to the internal heating effects of said field of force resident upon said electrode configuration for partially evaporating moisture in those areas of the material which exceed the average moisture con-

tent of the material to such an extent that these areas will approach the average residual moisture content of the whole dielectric material desired therein.

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JOHN J. CAMBY, *Acting Primary Examiner.*