Nov. 3, 1970 C. F. INGRAM 3,537,185

DIELECTRIC HEATING APPARATUS

Filed Oct. 21, 1968 2 Sheets-Sheet 1

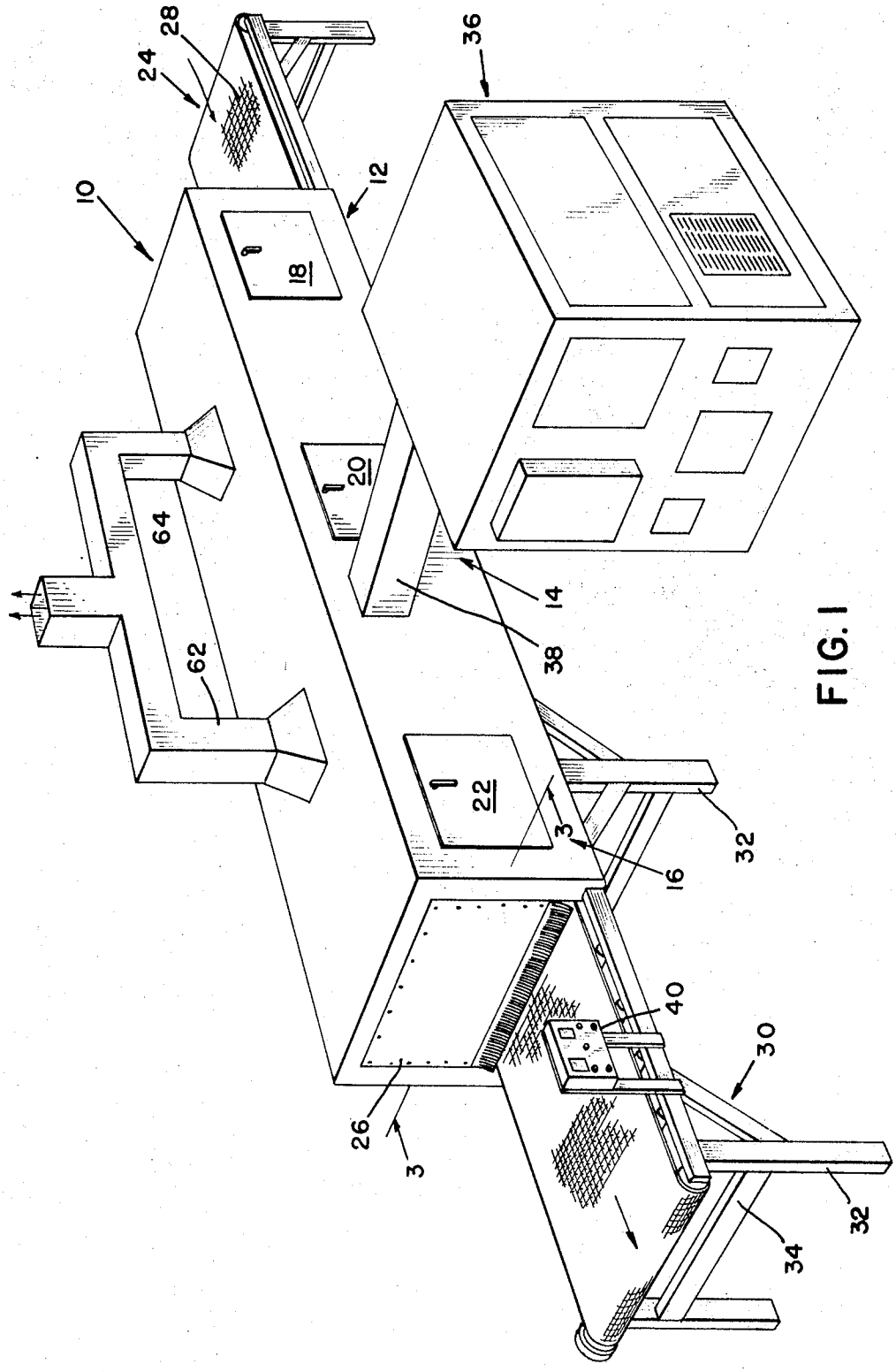


FIG. 1

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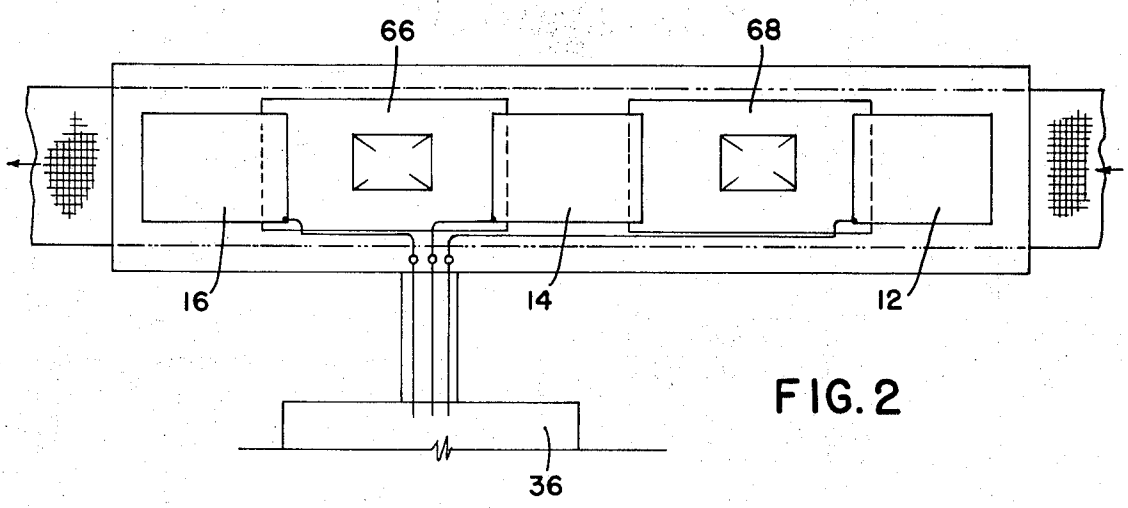


FIG. 2

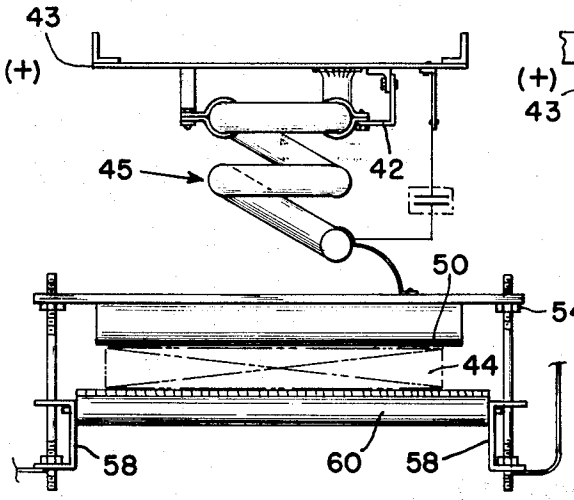


FIG. 3

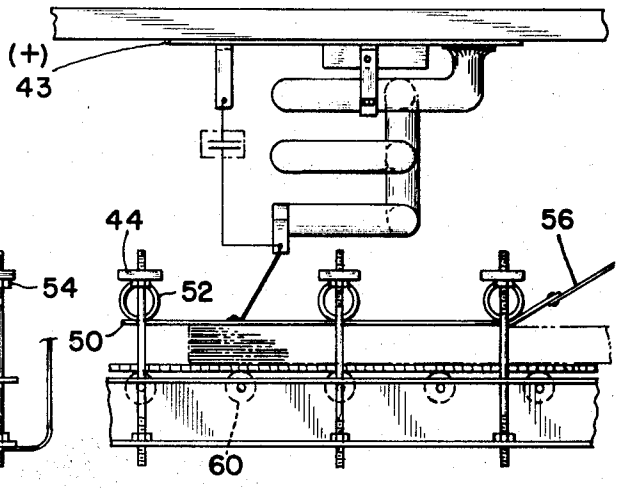


FIG. 4

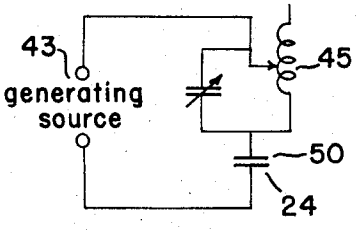


FIG. 5

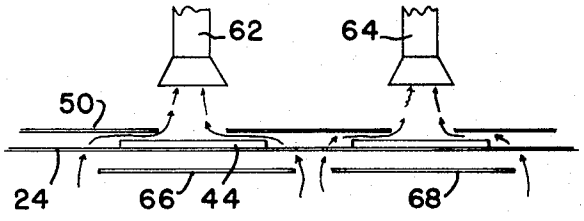


FIG. 6

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3,537,185

DIELECTRIC HEATING APPARATUS

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U.S. Cl. 34—1 10 Claims

ABSTRACT OF THE DISCLOSURE

A dielectric heating apparatus for drying veneer and related wood articles having three separately controlled drying stages, a movable, mesh, conductive conveyor used as one of the heating electrodes and an exhaust system utilizing baffles to direct air flow across the surface of the articles to be dried, the mesh conveyor being driven by a plurality of interconnecting, conveyor engaging gears and each of the heating stages being adjustable for a predetermined power output by the provision of a network having a variable coil and capacitor to control the power circuit.

BACKGROUND, BRIEF SUMMARY AND OBJECTIVES OF THE INVENTION

In recent years, dielectric heating has, for the most part, surpassed gas or electric oven heating where a rapid and uniform distribution of heat throughout the mass of a generally nonconductive material is desired. It is possible by means of a dielectric heater or dryer in which a moisture containing material has been inserted between a pair of electrodes energized by a high frequency voltage to remove substantially all the moisture from the material within a matter of minutes.

Dielectric heating requires a generating apparatus capable of setting up an electric field that will oscillate at a high frequency between condenser plates or electrodes. Wood for example, when placed in a strong electric field oscillating at a very high frequency, will be heated quickly throughout to a temperature above the boiling point of water. Such heating devices and techniques are illustrated and described in U.S. Pats. Nos. 2,590,562; 2,546,004; and 2,464,404.

During the heating process, considerable quantities of water vapor may be liberated depending upon the amount of moisture in the material and the characteristics of that material. This released water vapor is initially above its dew point, and unless it is rapidly removed from the dryer or unless heat is continually applied to the vapor, it will fall below its dew point and be condensed on surrounding surfaces. This condensation will vitiate the drying effects, since the moisture is partially re-introduced into the substance from which it was previously extracted.

Dielectric heating has been successfully applied to the textile, plastics, and rubber industries as well as to some specific applications in the wood industry to cure and dry glue lines and similar problems. A heretofore undeveloped application in the wood industry lies in the drying of veneer which is manufactured in sheets or in a continuous web by a veneer slicer or lathe. The veneer is in a saturated condition subsequent to manufacture due to long cooking process which serves to elevate the temperature of the moisture within the interstices of wood fiber and make the fiber more susceptible to cutting. After veneer has been produced in final form, it is then necessary to remove this moisture, this operation being effectively accomplished by use of a high frequency drying apparatus such as that presented herein. While reference is made herein primarily to the drying of veneer, it is to be understood that the apparatus disclosed can be utilized with equal advantage to dry other wood forms and products wherein these materials contain an undesirable high moisture content.

One characteristic of radio frequency heating is that heat is produced at a greater rate in the more conductive materials than in the less conductive materials. Thus a moist substance which may be nonconductive in a dry state is more susceptible to electrical conduction when wet and thus will become hotter when subjected to radio frequency heating at a given voltage than would the same substance absence the moisture at that same voltage. Accordingly, unless specific adjustments are made throughout the chamber of a dielectric heater, the object to be dried will be dried less effectively as moisture is continually removed so long as the same voltage is applied to the electrodes located on each surface of the drying article. It has been found advantageous to provide a plurality of heating stages wherein adjustments in the control network for voltage regulation are included. This will permit development of heat most efficiently in each stage of the heater to correspond with the varying moisture content of the drying article.

In the present invention, a tubular conductive, preferably copper coil is fixed in series with the upper electrode and in parallel with a variable vacuum-typed capacitor so that the inductive and capacitive components of the resonant circuit may be varied as desired to enable the voltage across the heating electrodes to be more readily adjusted in accordance with the voltage required for heating the work at the desired rate. This variation is subject to the type of material to be dried, the size of that material, and to the moisture content of that material within each stage of the unit.

The present dielectric dryer comprises broadly a chamber or housing within which is located first, second, and third drying stages or areas in a predetermined, spaced-apart relationship. An upper electrode is separately placed in each chamber and is variable in distance above the conveyor. The lower electrode is comprised of a conductive, continuous web conveyor formed from a metallic grid which is particularly adaptable to being driven by gears whose cogs intermesh with perforations in the grid. A conventional radio frequency generator, well known in the art, is used though separate control devices of a conventional nature are preferably included to provide a potential variation in applied power within each stage of the dryer if such is needed. An exhaust system is incorporated so that high velocity air flow is induced within the dryer to remove the water vapor released from the drying substance upon the application of heat. Critically positioned baffles below the conveyor between each of the drying stages direct air flow upwardly through the conveyor and across the surface of the object to be dried in a most effective manner so that all removed vapor is evacuated.

From the previous generalization concerning the present invention, it can be seen that a primary object of this development is to provide an electric heating system for the drying of veneer and related materials while these materials are being moved on a conveyor, the energy being introduced at a controlled rate at different drying stages along the path of travel of the material.

A further object of the present invention is to provide a dielectric dryer of the type described comprising a plurality of drying stages through which the materials to be heated and dried are successively passed, all electrodes within the stages being energized from a single high frequency power source.

Another object of the present invention is to provide a dielectric dryer of the type described for heating and drying moving moist materials along a predetermined path of travel and through pairs of heating electrodes being connected to a common source of high frequency

power that permit the voltage across each set of heating electrodes to be individually adjusted or controlled.

Yet another object of the present invention is to provide a drying apparatus of the type described, the lower electrode of each drying stage being comprised of a conductive, metallic, grid conveyor which continuously moves material to be dried through the housing and the drying stages, the conveyor being particularly adapted to driving movement by engageable gears extending from a motor driven shaft.

Yet another further object of the present invention is to provide a dielectric dryer of the type described having a vapor exhaust system suitable to remove water vapor rapidly from the chamber which has been released from the drying material, the removal being assisted by the positioning of baffle plates between the drying stages in a manner which will allow air flow substantially parallel to the surface of the objects being dried.

Other objects and advantages of the dielectric dryer disclosed herein will become more readily apparent from the following detailed description taken in conjunction with the accompany drawings in which like characters of reference designate corresponding parts throughout several views.

FIGURE DESCRIPTION

FIG. 1 is a perspective view of the dielectric drying apparatus disclosed herein showing the housing and three spaced-apart drying chambers through which passes the conveyor and from which extend the exhaust ports of the drying system.

FIG. 2 is a schematic, sectional and plan view of the dielectric dryer of FIG. 1.

FIG. 3 is an end elevational, isolated and sectional view of a helical, conductive, tubular coil provided with an adjustable clamp which is connected to the upper electrode of a drying stage and across which is positioned a variable capacitor, the coil and capacitor providing means by which the voltage across the material to be dried may be changed to compensate for the moisture contained in that material.

FIG. 4 is a side elevational, sectional, and isolated view of the tubular coil, upper electrode and conveyor of the dielectric dryer shown in FIG. 1 and FIG. 2.

FIG. 5 is a circuit diagram of the preferred form of the present invention.

FIG. 6 is a schematic, side elevational view of the dielectric dryer showing the location of the baffle plates.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and particularly to FIG. **1**, the dielectric dryer of the present invention comprises a housing shown generally as **10** preferably forming a completely enclosing cabinet within which is housed a first, second and third drying stage generally indicated as **12**, **14** and **16**, the structure of which will be more particularly described subsequently. The housing may be formed of sheet metal or other suitable material and is preferably provided with removable doors **18**, **20** and **22** on each of the respective drying stages for accessibility within. A conveyor shown generally as **24** provides continuous movement of articles positioned thereon through the housing opening within the three drying stages and outwardly from the exit **26** of the housing. The conveyor **24** is more particularly formed of a conductive metallic web or grid **28** through which air may circulate and which also may be used in the present invention as the lower electrode for each of the various drying stages. Suitable supporting structure shown generally as **30** maintains the conveyor and housing a convenient working distance above the floor, that structure particularly including legs **32** and connecting members **34** in the manner best shown in FIG. 1.

The high frequency generating equipment is housed within a partially isolated package **36** and is of a conventional manufacture commonly used in high frequency glue-drying devices. For the drying of veneer and other wood

materials of a relatively small thickness containing varying quantities of moisture, it has been found most advantageous to utilize a generator of approximate 70 kilowatts operating at a frequency of 3.9 megacycles, this capacity and frequency providing the most successful results particularly when the power in each drying stage is to be independently controlled and varied for the most advantageous moisture evacuation. Conductors extending inwardly of the generator package **36** are covered by a duct **38** to insure safety in and about the machine during its operation. The control panel **40** is preferably mounted along the supporting structure of the machine and includes suitable controls for initiating the generating facilities of the machine as well as monitoring the power output, operating voltage and current of the machine.

That characteristic of radio frequency heating of producing heat at a greater rate in more conductive materials than in less conductive materials makes necessary and desirable the provision of adjustable means for varying the value of the oscillator circuit components to insure a maximum power being developed across the drying material. These components may be capacitors, coils and/or resistors arranged in any number of combinations or networks such as shown in U.S. Pat. No. 2,546,004, and interposed between the power supply line and the heating electrodes to enable adjustment of the voltage thereacross. For example, in FIG. 3 the power source permits the value of a tubular coil **45** to be varied so as to change the circuit oscillating frequency according to the load represented by the veneer or other moist material **44** placed therein. As the wood becomes drier because of heating that has occurred, for example, in the first heating stage, the oscillator circuit's frequency changes because of the capacitive change between the electrodes and requires compensation through other circuit components. The inclusion of the variable coil provides a suitable compensating component to accomplish this adjustment.

The drying of wood within the described apparatus is accomplished in three stages wherein the moist wood moves within the housing **10** and into heating stage number one **12** which is subjected to a predetermined amount of radio frequency power. From the first drying stage **12**, the wood moves along the conveyor **24**, to the second drying stage **14** where the radio frequency power is adjusted upwardly for greater drying capacity. The third heating stage **16** provides additional and greater radio frequency power so that a final drying step is accomplished. The ararngement of the heating stages is most desirable in order to prevent splits or checks in the wood drying when subjected to an initial large pulse of radio power since the intense heat generated accompanied by the liberated steam from the interstices of the wood will often explode the wood cells. Controlled drying is best accomplished by the provision of additional drying stages wherein, for example, the wood temperature is brought up almost to the steam level in the first heating stage, exactly to the steam level in the second stage and held for a longer duration at the steam level in the third heating stage. The cooling areas located between the heating or drying stages help stabilize and adjust the wooden materials being dried to the intense heat.

Movement of the materials to be dried through the housing **10** of the machine varies with the particular materials used and the moisture content thereof though a movement of forty feet in an approximately thirty minute time cycle through all stages of the machine has proven most satisfactory for hardwoods such as oak, pecan, rosewood and the like. Conveyor speed control may be accomplished by a placement of a variable drive (not shown) on the conveyor drive mechanism in a conventional manner.

A desirable drive feature for the conveyor has been achieved by the use of a drive shaft to which is affixed a plurality of gears that will intermesh with the openings in the metallic grid conveyor utilized as the lower electrode

in each of the various drying stages. Thus sometime troublesome and expensive pulleys, belt or drive gears have been eliminated by a simple device that is extremely effective in setting an exact speed for the conveyor.

The upper electrode **50** may be positioned as shown in FIGS. 3 and 4 by means of tubular insulators **52** and posts **54** which serve to provide an even distribution of pressure against the electrode **50** and urge it downwardly against the upper surface of the object to be dried. The upper electrode is adjustable by the provision of conventional threaded screws **54** or the like and is preferable equipped with a cranking mechanism so that all adjustments may be made simultaneously to insure a level movement of the plate. The electrode **50** may be electrically connected to the power source **43** by a conductor **56** which is located as shown in FIG. 2.

The lower electrode which is formed from the metallic conveyor **24** contains supporting structure such as channels **58** and the like so that the entire machine structure may be grounded by a suitable connection. Additionally, free-spinning rollers **60** support the belt at spaced-apart locations to maintain the belt in a substantially horizontal position and parallel to the upper electrode **50**. The passage of wood or related materials into the drying stages between the upper electrode **50** and the conveyor belt **24** thus places the load between the electrodes for the application of radio frequency power.

The exhaust system includes exhaust ports **62** and **64** of which are shown best in FIG. 1, these ports communicating with the housing **10** at a location between each of the drying stages as explained below. Baffle plates **66** and **68** are located at a level lower than the conveyor but positioned therebeneath so as to extend from one side of a drying stage to a side of an adjacent drying stage as shown in FIG. 6. Positioning of the baffle plates **66** and **68** in this manner causes induced air flow upward into the exhaust ports **62** and **64** in the direction illustrated by the arrows in FIG. 6 whereby the majority of the surface of the article to be dried is exposed to a parallel flow of air which rapidly removes water vapor liberated from the wood during the heating operation.

While there has been described a novel dielectric dryer for the drying of veneer and related wood materials, it is to be fully understood that many modifications and variations may be made in the construction of the machine and its components such as the conveyor, the electrodes and the exhaust system without departing from the real spirit and purpose of this invention. Such modifications of parts and alternatives as well as the use of mechanical equivalents to those herein illustrated and described are contemplated.

I claim:

1. A dielectric dryer for removing the moisture from moist objects such as veneer and the like comprising: a housing; first, second and third drying stages spaced within said housing; an upper electrode located in each of said drying stages; adjustable means for positioning said upper electrode; conveyor means extending throughout said housing and said drying stages advancing the moist objects to be dried therethrough, said conveyor means including a conducting, continuous web forming a common lower electrode beneath each of said upper electrodes and spaced from said upper electrodes so that the moist objects to be dried may pass therebetween; means driving said conveyor means; radio frequency generating means connected between said upper electrodes and said web generating heat within the moist objects to remove moisture therefrom; circuit tuning means positioned between said generating means and said upper electrodes; and exhaust means communicating with said housing to evacuate said moisture therefrom.

2. A dielectric dryer as claimed in claim **1**, said circuit tuning means including a tubular, helical and adjustable coil positioned upwardly of each of said electrodes and connected thereto ad a variable capacitor connected in parallel across said coil, said coil and said capacitor creating a resonant circuit of predetermined frequency.

3. A dielectric dryer as claimed in claim **2** said coil having a slidable clamp operable therewith for varying the frequency of said resonant circuit upon movement thereof and said capacitor being of a vacuum type construction.

4. A dielectric dryer as claimed in claim **1**, said conveyor means further comprising conductive supporting means maintaining said web and connected to said generator.

5. A dielectric dryer as claimed in claim **1**, further comprising driving gears rotatably driven by said conveyor driver means and engageable with said wire mesh conductive belt to drive continuously said belt through said housing and drying stages.

6. A dielectric dryer as claimed in claim **1**, wherein the moist objects to be dried are heated to a temperature of approximately 212° F. in the first drying stage, 220° F. in the second drying stage, and 225° F. in the third drying stage.

7. A. dielectric dryer as claimed in claim **3**, said conveyor means including conductive supporting means maintaining said web and connected to said generator, driving gears rotable by said conveyor driving means and engageable with said conductive web to drive continuously said belt through said housing and drying stages.

8. A dielectric dryer as claimed in claim **7** wherein the moist objects are heated to a temperature of approximately 212° F. in the first drying stage, 212° F. in the second drying stage, and 212° F. in the third drying stage.

9. A dielectric dryer as claimed in claim **8**, said exhaust means including exhaust ports within said housing, air flow inducing means associated with said ports and air flow baffle plates positioned within said housing.

10. A dielectric dryer as claimed in claim **9**, said baffle plate positioned between said drying stages and beneath said conductive web so that induced air flow is directed along the surface of objects to be dried, upwardly therefrom and out said exhaust ports.

References Cited

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CHARLES SUKALO, Primary Examiner

U.S. Cl. X.R.

219—10.55