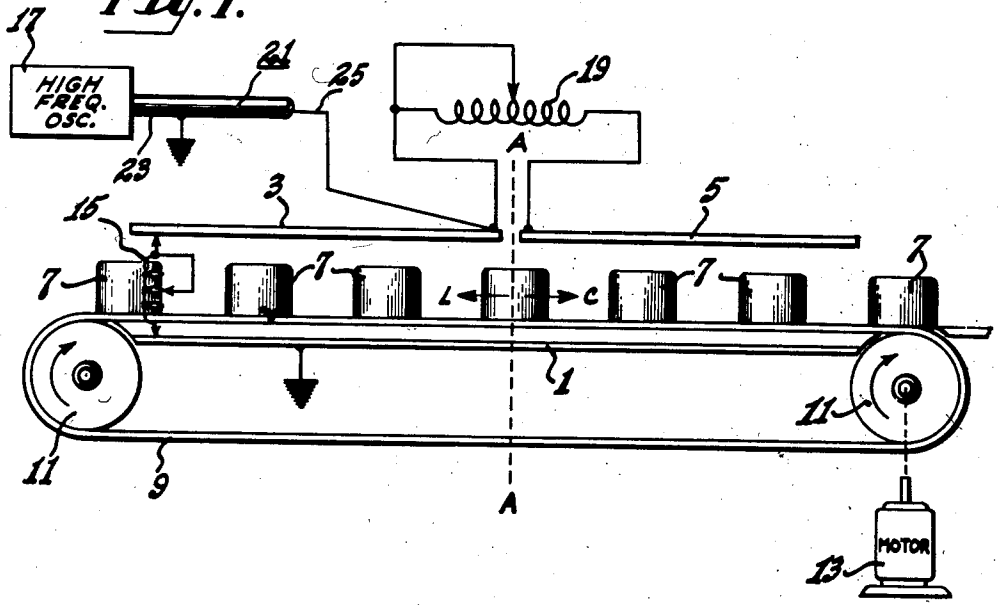
March 15, 1949. H. C. GILLESPIE 2,464,404

APPARATUS FOR HEATING DIELECTRIC MATERIALS ELECTRONICALLY

Filed Sept. 28, 1945

Fig. 1.



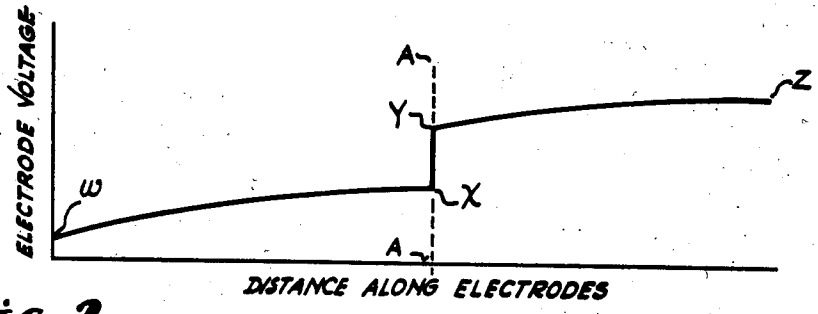


Fig. 2.

INVENTOR.
Henderson C. Gillespie
BY
ATTORNEY

Patented Mar. 15, 1949

2,464,404

UNITED STATES PATENT OFFICE

2,464,404

APPARATUS FOR HEATING DIELECTRIC MATERIALS ELECTRONICALLY

Henderson C. Gillespie, Moorestown, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application September 28, 1945, Serial No. 619,177

12 Claims. (Cl. 219—47)

1

This invention relates to apparatus for heating dielectric materials electronically, and more particularly to the heating of moisture laden dielectric articles to expel moisture therefrom, the present invention being in the nature of an improvement over that disclosed and claimed in the copending application of George W. Klingaman, Serial No. 613,508, filed August 30, 1945, and assigned to Radio Corporation of America.

In the course of manufacturing various articles of dielectric materials, it is frequently necessary to subject the articles to a washing operation during which they are, of course, rendered wet. Thus, in the course of producing rayon thread, artificial sponges, and similar articles of cellulosic materials, one or more washing operations may be encountered. It then becomes necessary to expel the moisture from such articles, since they are eventually supplied to the market or are utilized in the dry or substantially dry state.

In the manufacture of rayon thread or yarn, for example, it has been proposed heretofore to dry the so-called wet rayon "cakes" or "packages" by subjecting them to the influence of a high frequency electric field. Rayon and many other dielectric materials which are capable of absorbing moisture have the characteristic that the power factors thereof vary as a function of the moisture content. Thus, as the rayon cakes or packages are dried, the power factor thereof changes and, for a given voltage which is applied to the work, a point is reached sooner or later where it becomes very difficult to put enough power into the work to continue the drying process at an adequate rate.

In the above identified copending application of Klingaman, there is disclosed a novel electrode system for heating dielectric articles of the character under consideration in a manner to apply greater voltage to the articles at a certain point in the heating cycle. The Klingaman arrangement involves the use of a heating unit comprised essentially of an inductor constituted by a pair of elongated, opposed electrodes spaced from each other to receive therebetween the articles to be heated and having an inductor connected thereacross in proximity to the inlet end thereof. To tune the circuit, there is provided a variable capacitor which is connected across the other end of the aforementioned electrodes. At a point intermediate the ends of the inductor electrodes, a second inductor is connected across the electrodes. With this arrangement, the voltage across the electrode portions between the inlet end thereof and the point at which the last

2

mentioned inductor is connected thereto will vary at a relatively low rate sufficient to expel most of the moisture from the wet articles. By the time the articles have been advanced to the point where the last mentioned inductor is connected across the electrodes, the articles will have had a considerable part of the moisture expelled therefrom and the power factor thereof will have changed considerably, so that the effectiveness of the field must be increased from that point on. In the arrangement proposed by Klingaman, the voltage from the last mentioned point on to the outlet end of the electrodes will increase at a much higher rate, and therefore more power will be applied to the work for a unit distance along which the work is advanced. By the time the work will have reached the outlet end of the electrodes, it will have attained a minimum moisture content and will have become as dry as may be desired.

While the system proposed by Klingaman affords very satisfactory results, it has the disadvantage that the total power drawn from the generator is increased by reason of the fact that the tuning capacitor is added to the inductor electrode unit. Thus, the efficiency of Klingaman's system is not as great as might be attained.

The primary object of my present invention is to provide an improved apparatus for heating dielectric articles the power factors of which change appreciably during the heating process, which apparatus will not be subject to the aforementioned limitation of the Klingaman system.

More particularly, it is an object of my present invention to provide an improved apparatus for heating wet dielectric articles which will effectively carry out the drying operation in a highly efficient manner.

Another object of my present invention is to provide, in heating apparatus of the type set forth above, an efficient and flexible electrode tuning arrangement where a variable voltage along the length of the electrodes is required.

It is also an object of my present invention to provide improved heating apparatus as aforesaid in which the heating of dielectric articles may be effected rapidly and in great quantities, which will draw a minimum of power from the generator, and which is highly efficient in use.

In accordance with my present invention, I sectionalize the long electrodes such as are used in conjunction with a conveyor belt in a dielectric heating application of the type set forth above, and connect the sections in such a manner as to provide both the capacitive and the inductive

tuning elements needed in the load circuit. One way of accomplishing this, for example, is to split one of the electrodes into two parts each of which has a length which is less than one-quarter wave length at the operating frequency and to serially connect these two electrode parts by a suitable impedance element, such as a variable inductor. Further, in accordance with my invention, I connect an inductor across one of the electrode sections, preferably at the end where the wet articles are introduced. This inductor is of such value that it makes an inductance out of this particular electrode section at the operating frequency. The other electrode section may be left open at both ends whereby it constitutes a capacitive section. By suitable choice of constants, resonance can be obtained between the inductive and the capacitive sections of the electrodes without the necessity of providing an additional tuning capacitor as in the Klingaman system. The inductor which connects the two electrode sections is also useful in adjusting the resonant frequency of the combination and is effective in obtaining an increased voltage rise along the electrodes at the point where, in the course of travel of the work along the electrodes, it is found necessary to increase the voltage. With a system of this sort, the total load circuit kva. are not increased, as in the case of the Klingaman system, since no capacitive reactance is added to the essentially capacitive load.

The invention, together with additional objects and advantages thereof, will be better understood by reference to the accompanying drawing, in which

Figure 1 is a diagrammatic view of one form of heating apparatus according to my present invention, and

Figure 2 is a curve showing the voltage distribution along the electrodes of Fig. 1.

Referring more particularly to the drawing, there is shown an elongated, conductive member 1 which may be connected to ground and which constitutes a first electrode disposed in one plane, and two additional electrodes 3 and 5 spaced from each other and disposed in a common plane above the electrode 1. Thus, there are provided two electrode sections 1, 3 and 1, 5 between the respective pairs of electrodes of which the dielectric articles 7 (such as wet rayon cakes or the like) are received in energy transfer relation with respect thereto. Each of the electrode sections 1, 3 and 1, 5 has a length which is less than one-quarter wave length at the operating frequency. The articles 7 are advanced by an endless belt 9 of canvas or the like which is trained around the pulleys 11, one of which may be driven by a motor 13.

Connected across the electrodes 1 and 3 in proximity to the electrode section 1, 3 is a variable inductor 15 which is preferably made adjustable along the length of the electrode section 1, 3, but not necessarily so. By connecting the inductor 15 across the section 1, 3, this section becomes essentially an inductive section L. The electrode section 1, 5 is open at both ends and, since the electrode 5 is capacitively related to the electrode 1, the section 1, 5 constitutes a capacitive section C. The inductive section L and the capacitive section C may be tuned to resonance at the operating frequency of a high frequency oscillation generator 17 (such as a vacuum tube oscillator operating at radio frequency) without the use of any additional capacitors. The electrodes 3 and 5 are serially connected at their proximate ends by a suitable impedance element, such as a variable inductor 19. The inductor 19 is also useful in adjusting the resonant frequency of the combination. Connection between the generator 17 and the electrode system is preferably made by means of a concentric transmission line 21 the outer conductor 23 of which is preferably connected to ground and the inner conductor 25 of which may be connected to the junction of the electrode 3 and the inductor 19.

The fresh, moisture laden articles 7 are introduced into the heating apparatus at the left hand end of the inductive section L and are advanced successively first through the section L between its electrodes 1 and 3 and then through the section C between its electrodes 1 and 5. The voltage distribution along the inductive electrode section L from the entrance end thereof to the exit end thereof is represented by the curve W—X of Figure 2, while the voltage distribution along the capacitive electrode section C from the point A—A to the exit end thereof is shown by the curve Y—Z of Figure 2. From the entrance end of the inductive section L to the exit end thereof the wet articles 7 are gradually dried until, at the point A—A, sufficient moisture has been expelled therefrom to make further heating difficult at the voltage X by reason of the decreased power factor of the partly dried articles. However, the inductor 19 causes the voltage to rise sharply at the point A—A from the value X to the value Y, so that, from the point A—A on, a much higher voltage is applied to the work and therefore more power can be put into the partly dried articles 7 until, at the exit end of the electrode system, the articles 7 have reached the desired state of dryness.

It will be apparent, from the foregoing description, that a minimum amount of power is drawn from the generator 17 since no additional tuning elements are required in the heating circuit other than the electrode sections L and C. It will also be apparent that the present invention, although described with special reference to the drying of moisture laden, dielectric articles, is broadly applicable to the general heating of dielectric articles (whether wet or dry) the power factors of which change materially during the heating operation. It may also be pointed out that, with an arrangement such as described above, it has been possible to obtain a desired voltage distribution along the electrode system with none of the articles 7 or other material in progress through the electrode system. Under this no-load condition, practically no power is drawn from the generator until the material to be heated enters the heater. If the articles 7 or the like are then fed in through the successive electrode sections L and C, as above described, the amount of power delivered by the generator will automatically increase proportionally to the amount of work between the electrodes, until the electrode system is full, when full power will be delivered. During this process, the desired electrode voltages are maintained.

Although I have shown and described but a single embodiment of my invention, it will undoubtedly be apparent to those skilled in the art that many variations thereof are possible. For example, instead of making the electrode 1 of a single, elongated, conductive member, it may be made of two, separate members one associated with the electrode 3 and one with the electrode 5 and each of said separate members grounded similarly to the electrode 1. Also, in place of the

inductor 19, any other suitable impedance element, such as a capacitor or resistor, or any suitable combination of inductors, capacitors and/or resistors, may be employed, depending upon the constants of the system and the voltage distribution that may be desired. Various other changes will, no doubt, readily suggest themselves to those skilled in the art. Hence, I do not intend to be limited merely to the precise arrangement disclosed herein.

I claim as my invention:

1. Electrical heating apparatus for heating dielectric articles comprising an alternating current circuit having a section which is inductive and a section which is capacitive at a predetermined operating frequency, each of said sections including a pair of conductive members which are spaced from each other to receive said articles therebetween in energy transfer relation with respect thereto, impedance means serially connecting said sections, and power input means for coupling said circuit through said inductive section substantially at the connection therewith of said impedance means to a source of alternating current at said operating frequency.

2. Electrical heating apparatus for heating dielectric articles comprising an alternating current circuit having a section which is inductive and a section which is capacitive at a predetermined operating frequency, each of said sections including a pair of conductive members which are spaced from each other to receive said articles therebetween in energy transfer relation with respect thereto, one of said conductive members being common to each of said pairs, an inductor serially connecting the two other conductive members of said pairs, and power input means for coupling said circuit to a source of alternating current at said operating frequency, said power input means providing coupling with the common one of said conductive members and with the inductive section substantially at the junction with said inductor.

3. Electrical heating apparatus for heating dielectric articles comprising a circuit tuned to resonance at a predetermined operating frequency, said circuit including a pair of elongated sections arranged substantially in end to end relation and each including a pair of conductive members which are spaced from each other to receive said articles therebetween in energy transfer relation with respect thereto, a first inductor connected across the pair of members of one of said sections whereby to constitute said one section an inductive section at said operating frequency, the other of said sections being open at its ends and constituting a capacitive section at said operating frequency, a second inductor serially connecting said sections, and power input means for coupling said circuit to a source of alternating current at said operating frequency, said last named means providing an input connection with one conductive member of each section and another input connection with the inductive section substantially at the connection therewith of said second inductor.

4. Electrical heating apparatus according to claim 3 wherein said first inductor is connected across the conductive members of said one section in proximity to that end thereof which is remote from said other section.

5. Electrical heating apparatus according to claim 3 wherein said first inductor is adjustable along the length of said one section.

6. Electrical heating apparatus according to claim 3 wherein said inductors are both variable.

7. Electrical heating apparatus according to claim 3 wherein one of said conductive members is common to each of said sections.

8. Electrical heating apparatus employing alternating current for heating dielectric articles which comprises a circuit tuned to resonance at a predetermined operating frequency, said circuit including a first and elongated conductive member, second and third conductive members spaced from said first member to receive said articles therebetween in energy transfer relation with respect thereto, said third conductive member being also spaced from said second conductive member, a first inductor connected across said first and second members, a second inductor serially connecting said second and third members, and power input means for coupling said circuit to a source of alternating current at said operating frequency, said last named means providing a power input connection to said first conductive member and to said second conductive member substantially at the junction therewith of said second inductor.

9. Electrical heating apparatus according to claim 8 wherein said first named, elongated, conductive member is disposed in one plane, and wherein said second and third conductive members are disposed in a common, second plane spaced from said first plane.

10. Electrical heating apparatus according to claim 1 characterized in that said sections are disposed successively along a certain path, and characterized further by the addition of conveyor means disposed along said path between the conductive members of each of said sections for receiving thereon the articles to be heated and for advancing said articles successively through said sections.

11. Electrical heating apparatus according to claim 1 characterized in that said sections are disposed successively along a certain path, and characterized further by the addition of conveyor means disposed along said path between the conductive members of each of said sections for receiving thereon the articles to be heated and for advancing said articles successively first through said inductive section and then through said capacitive section.

12. Electrical heating apparatus according to claim 8 wherein said means for coupling said tuned circuit to said source comprises a concentric transmission line of which the inner conductor is connected to said circuit at said junction of said second conductive member and said second inductor.

HENDERSON C. GILLESPIE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,972,050	Davis	Aug. 28, 1934
2,042,145	Darrah	May 26, 1936
2,231,457	Stephen	Feb. 11, 1941
2,308,043	Bierwirth	Jan. 12, 1943

FOREIGN PATENTS

Number	Country	Date
375,587	Great Britain	June 30, 1932