Patented Apr. 11, 1950

2,503,779

UNITED STATES PATENT OFFICE

2,503,779

DEVICE FOR RADIO FREQUENCY TREATMENT OF FILAMENTARY MATERIAL

Theodore H. Story, Merchantville, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application August 13, 1947, Serial No. 768,460

4 Claims. (Cl. 219—47)

1

This invention relates to heat treating apparatus, and more particularly to apparatus employing a high frequency electric field for heating materials of high resistance, the present invention being particularly useful in connection with, although by no means limited to, the heating of rayon threads or fabrics.

In U. S. Patent No. 2,303,983, issued December 1, 1942, to George H. Brown, it has been shown how rayon threads may be heated by passing the thread past electrodes which are coupled to a radio frequency generator so that an alternating current of high frequency is caused to flow through the thread between the electrodes. The curing or drying process as practiced in accordance with the Brown patent is relatively slow. It is necessary, of course, for the thread to remain in the electric field long enough to complete the desired processing. This has required the thread to move rather slowly past the electrodes. Within limits the time of treatment can be reduced by increasing the voltage applied to the electrodes, but this increases the danger of arcing and burning.

As is well known, radio frequency heating is utilized to cure and dry the wet thread in the process of manufacture, and also to set the twist, either simultaneously with the drying process or as a separate operation. It has been discovered that as the treatment progresses and the material dries, its power factor decreases. Thus, if the voltage applied to the electrodes remains constant, the power absorbed by the material, and thus the heat generated therein, falls off rapidly as the material becomes dry. In order to maintain the power input, and thus the rate of heating, at the maximum permissible value, it is proposed, in accordance with the present invention, to increase progressively the voltage gradient between the applicator electrodes as the operation proceeds. In brief, this is accomplished by causing the material such as a filamentary thread or fabric, to pass along a path over a grid-like applicator consisting of a plurality of spaced electrodes lying side-by-side in a plane. One end of each alternate conductor is grounded, and the other end of each intermediate conductor is connected to a bus extending lengthwise of the applicator and which is connected or coupled to a suitable source of radio frequency potential. The length of the bus is such that, at the frequency of operation, a standing wave is established thereon. Thus the strength of the electric field between adjacent electrodes increases from one end of the applicator to the other. The material to be

2

treated enters the electric field at the low potential end and leaves at the high potential end.

It is, therefore, the primary object of this invention to heat continuously at a constant power input a material whose electrical characteristics tend to change during the heating process.

A further object of this invention is to provide an improved applicator characterized by an increasing electric field intensity at different positions along its length. A further, and related object, is to establish the progressively increasing field intensity by establishing a standing wave on a portion of the applicator.

In order to insure uniform heating effect the spacing between the material and the different electrodes must be maintained at a constant value. In accordance with a still further object of this invention, this is assured by constructing the electrodes in the form of cylindrical rollers, and passing the material alternately over and under adjacent rollers. The rollers are preferably covered by a thin insulating material of low heat-absorbing properties.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which

Fig. 1 is a plan view of the applicator in accordance with the present invention;

Fig. 2 is an elevation of the same structure;

Fig. 3 is a partial view of a modification of the embodiment shown in Figs. 1 and 2, and

Fig. 4 is a plan view of an alternative form embodying roller electrodes.

Referring to Fig. 1, a plurality of rod-like conductors 5 and 5a are positioned by means of any suitable insulating support, not shown, in a plane, in spaced parallel relationship so as to form an elongated rectangular grid-like applicator. One end of each alternate conductor, identified by reference numerals 5, is grounded. The opposite end of each intermediate conductor, identified by reference numerals 5a, is connected to a distribution bus 7 extending from one end of the applicator to the other adjacent the ends of the conductors to which it is connected. One end of bus 7 is grounded through a variable inductor 9 which may itself be coupled to a source of high frequency potential, such as oscillator 11, or which may be coupled thereto by a separate secondary 13.

The electrical length of distribution bus 7 is so chosen that at the operating frequency the bus 7 and the shunt impedance or impedances are tuned to resonance, and a standing wave is produced along the bus having, for example, a minimum potential at the input end determined by the value of the impedance 9 and the applied voltage, and a maximum at the far end, as shown by the curve associated with Fig. 2. Alternatively, for a given physical length of bus 7, the frequency of operation may be adjusted so as to produce the same result, as is well known. Thus the potential of the applicator electrodes connected to the bus will be determined by the standing wave pattern established on the bus. The physical length will, of course, be less than the effective electrical length due to inductance 9 and the capacity between adjacent electrodes 5 and 5a, illustrated as dotted capacitors in Fig. 2. Preferably the electrical length is of the order of a quarter wavelength at the operating frequency, since in that case the potential along the bus will increase gradually from one end to the other.

The material to be treated, which may be, for example, a plurality of filamentary threads 15 of a dielectric material, is introduced at the low potential end of the applicator. For example, the threads may be contained initially on a storage drum 17. The threads pass over an idler roller 23 and then over or under the electrodes in a plane parallel to the plane of the electrodes and in a direction perpendicular thereto, to a second idler roller 25 and then to a take-up drum 19, which may be rotated by a motor 21.

As shown more clearly in Fig. 2, idler rollers 23 and 25 are mounted so that their upper surfaces are just above the upper surface of the electrodes 5, 5a. This holds the material close to but just above the electrodes.

As the wet material comes into the field of the electrodes at the low potential end of the applicator, an alternating current is caused to flow from the "hot" electrodes 5a through the material to the grounded electrodes 5 on either side. This current causes the material to become sufficiently heated to drive off the moisture. When wet, the thread resistance is relatively low, and thus a heating current is produced with a relatively low voltage. As the material moves, it dries out, and its resistance becomes higher. But it has then advanced to a position opposite electrodes between which there is a higher potential difference. Consequently, heating current is still caused to flow. This process continues successively until the substantially dry thread passes onto the take-up drum 19.

The overall length of the applicator, from input end to output end, is made sufficiently long that the material is dried to the desired state in the time required for it to cover the distance. The linear speed of the thread may be adjusted readily to control the total effective heating period.

Where the electric field heating method as described above is employed with materials which are saturated with water, a modification of the arrangement described above may be employed to advantage. In such a case it is desirable to have a relatively high initial heating rate to bring the material, and the absorbed moisture, rapidly up to the boiling point, and thereafter to reduce the heating rate to a safe value. As drying progresses, the intensity of the field is then increased again as in the preceding illustration. This may be accomplished, as shown in Fig. 3, which is a partial view of the apparatus shown in Figs. 1 and 2. Inductor 9 is positioned a distance on from the incoming end of the applicator, so that the point of voltage minimum occurs at the point where the boiling temperature is reached. A standing wave representing somewhat less than 90 electrical degrees, or a quarter wavelength, is established at the short incoming end of bus 7. The longer outgoing end will, as in the preceding case, have a standing wave of greater maximum amplitude, as shown by the curve associated with Fig. 3.

When operated at high speeds, the threads 15 may have a tendency to vibrate and come into contact with the electrodes, or to move too far from the electrodes to effect a uniform energy transfer thereto. In order to overcome this the modification illustrated in Fig. 4 may be employed. In this case the electrodes of the applicator all take the form of rollers journalled in electrically conducting supporting members 27, 29. Supporting member 27 is grounded, while member 29 is the equivalent of bus 7, and is tuned by inductor 9 so that a standing wave is produced thereon, as shown by the associated curve.

The rollers are all identical, but are placed in the support in alternately reversed fashion, so that one roller is effectively grounded and the next one effectively connected to supporting member 29. Rollers 31, for example, consist of an inner conductor 33 making electrical connection with supporting member 27 and extending most of the way laterally across the applicator, supported in an insulating sheath 34. A short pin 35 embedded in the insulating sheath 34 provides a bearing for the other end of the roller. Roller 31a is identical, except that it is inserted in the carrier in reversed position so that the inner conductor 33 is connected electrically to member 29.

The filamentary material then passes over one and under the next roller, from one end of the applicator to the other. The tortuous path of the material thus holds it constantly in contact with the insulating sheaths, and accurate and constant spacing is maintained between the electrodes and the material.

Instead of treating a plurality of separate filamentary threads, a woven fabric may similarly be treated. The treatment may be for simple drying, or for polymerization of a resin as is well known. Various modifications of the roller construction will occur to those skilled in the art. The actual construction will depend upon the thickness of the insulation desired and the rigidity of the material employed. Other means of insulating one end of each electrode may be employed, such as an insulating bushing mounted on the supporting member. It is therefore intended that the invention shall not be limited to the specific embodiments illustrated except insofar as is made necessary by the prior art and the spirit of the appended claims.

What I claim is:

1. An applicator for high frequency treatment of filamentary dielectric material and the like, comprising a plurality of substantially parallel spaced conductors in a single row lying in a common plane, means connecting alternate conductors to ground, an electrical distribution bus extending along the ends of said conductors on one side of said row, means connecting intermediate conductors to spaced points along said distribution bus whereby adjacent conductors are oppositely polarized in operation to establish electro-

static fields therebetween along said row, the electrical length of said bus having such a relation to the frequency of operation that a standing wave is produced along its length whereby the potential of said intermediate conductors is determined by the standing wave pattern established on said bus, and means establishing a path for work to be treated along the row of conductors and through said fields.

2. An applicator for applying a radio frequency electric field to filamentary dielectric material comprising a single row of spaced parallel conductors lying in a plane in side-by-side relation, means connecting adjacent ends of alternate conductors to ground, an electrical distribution bus extending along the opposite ends of said conductors, means connecting the opposite ends of intermediate conductors to spaced points along said distribution bus, and means providing electrical coupling for said bus with a source of high frequency energy, and said bus having a length such that a standing quarter wave is produced on said bus at said frequency, the potential along said bus varying from a minimum at one end to a maximum at the other end of said bus, whereby the potential of said intermediate conductors increases successively from one end of said applicator to the other with respect to ground and said alternate conductors.

3. An applicator for applying a radio frequency electric field to moisture-laden dielectric material comprising a plurality of spaced substantially parallel conductors in a single row lying in a plane in side-by-side relation; means connecting adjacent ends of alternate conductors to ground, an electrical distribution bus extending along the

opposite ends of said conductors, means connecting the opposite ends of intermediate conductors to spaced points along said distribution bus, and means providing electrical coupling for one end of said bus with a source of high frequency energy having a predetermined operating frequency, the electrical length of said bus being of the order of a quarter wavelength at said frequency, and said coupling means including a reactance element connected between said one end of said bus and ground for tuning said bus; whereby the potential of said intermediate conductors successively more remote from said one end of said bus increases from a minimum to a maximum value.

4. A device of the character described in claim 1 which includes an inductor connected between said bus and ground at a point intermediate the ends thereof, for establishing thereon a standing wave pattern having a higher potential at the ends of said bus than at a point intermediate the ends.

THEODORE H. STORY.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,288,269	Crandell	June 30, 1942
2,303,983	Brown	Dec. 1, 1942
2,308,043	Bierwirth	Jan. 12, 1943
2,308,204	Parry	Jan. 12, 1943
2,321,131	Crandell	June 8, 1943
2,433,067	Russell	Dec. 23, 1947