May 25, 1954 P. D. NEWHOUSE 2,679,573

CONTINUOUS DIELECTRIC HEATING MEANS

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Fig. 1.

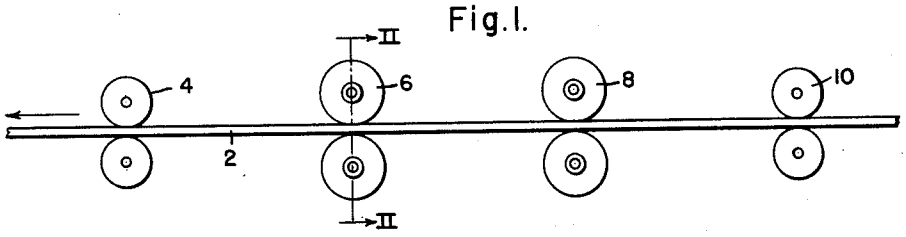


Fig. 2.

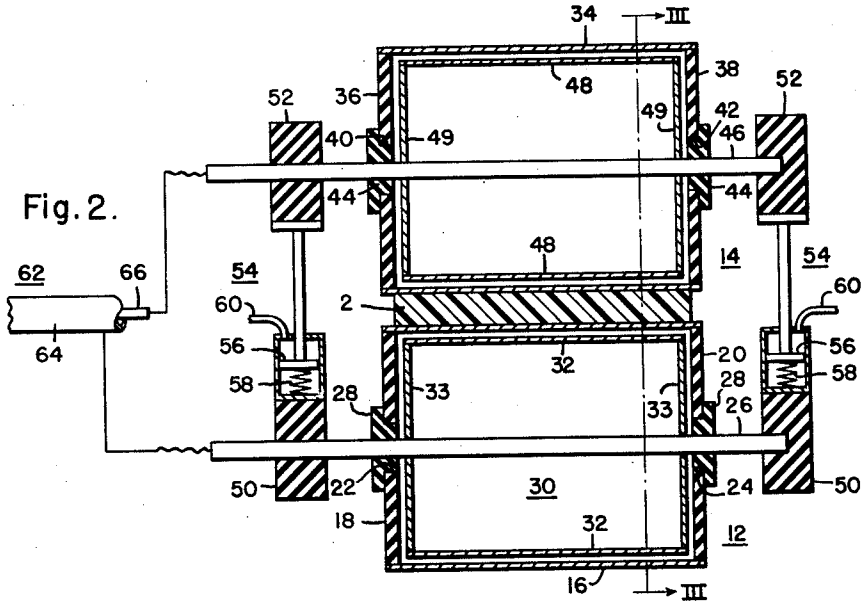
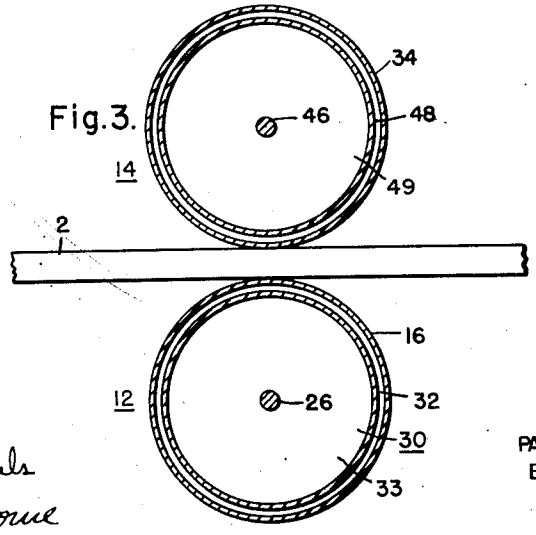


Fig. 3.



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Fig. 4.

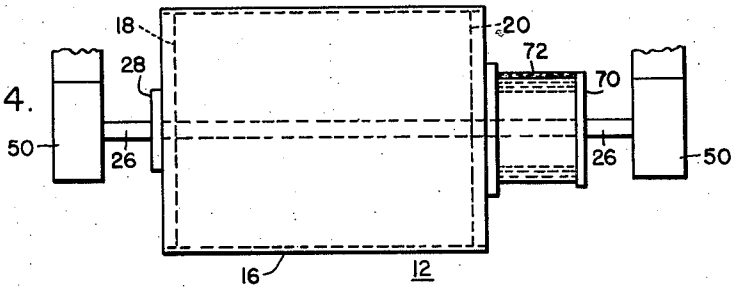


Fig.5.

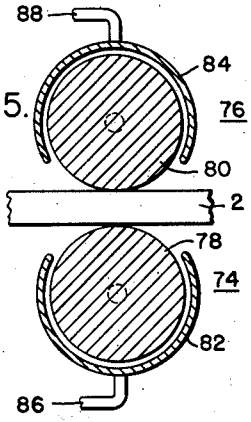


Fig.6.

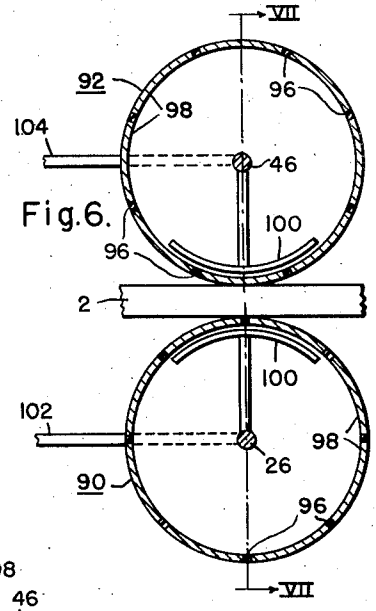
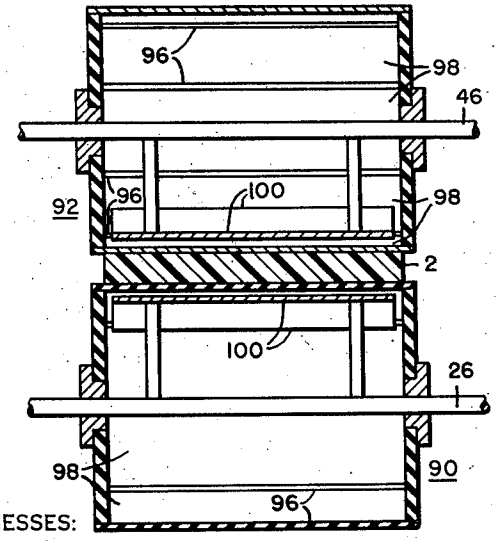


Fig.7.



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CONTINUOUS DIELECTRIC HEATING MEANS

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Application April 1, 1949, Serial No. 84,882

15 Claims. (Cl. 219—10.69)

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My invention relates more directly to dielectric heating of a type which involves one or more roller-type heating-electrodes providing an electric field through which material or work is continuously passed for dielectric heat treatment; but it is to be understood that my invention has broader application.

In conventional dielectric heating practice, work is dielectrically heated while it is between a pair of relatively-insulated heating-electrodes across which a high-frequency voltage exists. In the case of elongated work, such as sheet material, the work is usually heat-treated while it continually moves between the heating electrodes which are frequently tubular members in the form of rollers. Sometimes the rollers are under pressure. To convey electric power to such rollers, it has been customary to use insulated or uninsulated sliding or rolling contacts, brushes, or similar expedients which frequently become troublesome—especially at the high frequencies required for dielectric heat treatment.

The primary object of my invention is to provide a dielectric heating system and elements therefor of a type described comprising one or more rollers energized without the use of insulated or uninsulated sliding or rolling contacts, brushes or the like.

A further object of my invention is to provide a dielectric heating system of the aforesaid roller-type in which pressure can be applied to the roller or rollers while the roller or rollers are energized.

A specific object of my invention is to provide a novel and improved roller-type heating-electrode to which energy can be supplied by means of a member out of contact with the roller portion of the heating-electrode.

Further objects, features and innovations of my invention will be discernible from the following description of several embodiments thereof. The description is to be taken in conjunction with the accompanying schematic drawings which are limited to such parts and details as are necessary for an understanding of the principles underlying my invention. In the drawings:

Figure 1 is a side elevational view of a dielectric heating system embodying my invention;

Fig. 2 is a vertical sectional view substantially along the line II—II of Fig. 1, axially through a set of heating-electrodes embodying features of my invention;

Fig. 3 is a sectional view on the line III—III of Fig. 2;

Fig. 4 is an elevational view of part of a modified form of a roller-type heating-electrode;

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Fig. 5 is a vertical sectional view through a modified form of heating-electrodes embodying my invention;

Fig. 6 is a vertical sectional view of still another embodiment of my invention; and

Fig. 7 is a partial sectional view along the lines VII—VII of Fig. 6.

Fig. 1 generally illustrates a dielectric system embodying my invention. Elongated work or material 2 moves between as many sets or pairs of roller-means as a particular application may require. Four such sets of roller-means 4, 6, 8 and 10 are shown in Fig. 1. The set of roller-means 4 may pull the material through the work line in the direction of the arrow shown in Fig. 1, and as many other sets of roller-means may be used as drive or feed rollers as desired. Sometimes drag units are also desired for controlling the tension in the material, and the set of roller-means 10 may be of this type. The intermediate sets of roller-means 6 and 8 are constructed in accordance with my invention so as to provide an electric field for heating the work 2 as it passes between these sets of roller-means. Since each set may be alike, it is apparent that my invention should be understood from a description of a single set.

Accordingly, the set 6 of roller-means comprises a pair of heating-electrodes, each being indicated in its entirety by the reference numeral 12 or 14. The lower heating-electrode 12 comprises an outer hollow, round tubular member or roller 16 preferably of copper. Spaced bases 18 and 20 of insulating material are inside the tubular member. In this particular instance, the bases are in the form of disks and are located at the ends of the tubular member 16. Base-ends 18 and 20 have central holes 22 and 24, respectively, so as to loosely receive a rod or shaft 26 preferably of copper. A shaft 26 rotatably carries the tubular member 16 through bearings 38 secured to the base-ends 18 and 20. The shaft 26 is relatively stationary with respect to the tubular member 16 and is adequately insulated therefrom by the insulating bases 18 and 20. Secured to the shaft 26 in good electrical contact therewith is a hollow metal inner cylinder 30 comprising a tube 32 closed by ends 33. This cylinder is preferably of copper and the tube 32 is inside of and concentric with the tubular member or roller 16, but spaced at all points therefrom so as to provide a capacitive coupling thereto.

The heating-electrode 14 is constructed in the same manner as the heating-electrode 12. It comprises an outer hollow, round tubular mem-

ber or roller 34, base-ends 36 and 38 having central holes 40 and 42, bearings 44, a stationary shaft 46 passing through the bearings, and a conducting cylindrical structure inside the tubular member 34. This conducting structure comprises a tube 48 concentric with the tubular member 34 and ends 49 secured to the shaft 46 by any suitable means which includes a conductive connection.

The ends of the shafts 26 and 46 are carried in parallel relation by any suitable supporting means. As shown in Fig. 2, such supporting means comprises fixed supports 50 of insulating material for the shaft 26 and insulating supports 52 for the shaft 46. The supports 52 carry the shaft 46 in any suitable manner that permits the shaft 46 to be pressed or forced toward the other shaft 26. To this end, the supports 50 and 52 on each side of the heating-electrodes 12 and 14 are mechanically interconnected through any suitable pressure-exerting means, such as for example, a pneumatically-operated interconnection 54 between the supports. The pneumatic connection comprises a piston 56. A spring 58 acts on one side of the piston and gas pressure applied through pipes 60 acts on the other side of the piston 56.

An end of each of the shafts 26 and 46 of the heating-electrodes 12 and 14 extends beyond a pair of the supports 50 and 52. To these protruding ends, high-frequency power may be connected as shown in Fig. 2. The means for supplying high-frequency energy to the shafts consists of a transmission line 62 having conductors 64 and 66 which can be supplied with high-frequency energy by any suitable tube-oscillator generator (not shown).

Assuming that there is high-frequency energy on the transmission line 62, the power flows from the shafts 26 and 46 to the two metallic tubes 32 and 48. A high-frequency voltage will exist across them. Because of the capacitive coupling between the roller 34 and tube 48 and between the roller 16 and tube 32, a somewhat lower high-frequency voltage will also exist between the facing surface-portions of the rollers; by facing surface-portions, meaning those parts of the rollers that face each other and provide a concentrated electric field in the space between the rollers that heats the work 2 moving between the rollers. As the work 2 moves, the rollers 16 and 34 roll around the shafts 26 and 46, respectively, so that their facing surface-portions are constantly changing.

The shafts 26 and 46 and the tubes 32 and 48 can be said to be stationary with respect to the rotating tubular members or rollers 16 and 34; but it is to be understood that I do not use the word "stationary" as necessarily synonymous with "fixed" because the pressure-exerting means, (comprising the mechanical interconnection 54 between the shafts 26 and 46) if used, provides a limited amount of relative movement between the shafts. Moreover, they can be adjustably supported, if desired.

Ordinarily, the space inside a roller, such as the space between the hollow cylindrical roller 16 and the cylindrical tube 32 is gaseous and can be air so that the nested cylinders need not be air-tight. However, the nested cylinders can be made liquid-tight or gas-tight so as to be able to hold a dielectric liquid or a gas other than air.

In the embodiment shown in Figs. 2 and 3, the hollow tubular members or rollers 16 and 34 of the heating-electrodes 12 and 14 are of the idling type, being rotated by the moving material. However, they can be driving rollers if desired and can be driven in any suitable manner. Fig. 4 shows a simple expedient that may be used to convert one or both of the idling rollers to driving rollers, but other expedients can obviously be used. In Fig. 4, an end-base 20 for the roller 16 is provided with a drum 70 around which may be wrapped an insulating driving belt 72. The drum is insulated from the tubular member or roller 16 by the insulating end-base 20.

Instead of transferring electrical energy to the rollers of the heating-electrodes from inside the rollers, the energy can be transferred to them from the outside. Consequently, the rollers can be made solid, if desired, and capable of exerting a higher pressure on the material or work being heat treated. An embodiment of this kind is shown in Fig. 5 where heating-electrodes 74 and 76 comprise insulatedly and rotatably-supported, solid metal rollers 78 and 80, respectively. Curved parti-cylindrical conducting members 82 and 84 are concentrically around portions of the outside of the rollers 78 and 80, respectively, being spaced therefrom for capacitive coupling. By attaching conductors 86 and 88 of a high-frequency transmission line to these stationary curved members 82 and 84, high-frequency energy is capacitively transferred to the rollers 78 and 80; and a highly concentrated electric field is provided between the facing surface-portions of the rollers between which the work moves. Each member 82 or 84 terminates at any desired distance from the work, and can be made of more than one segment.

In applications where rollers of large diameters are required, it might be objectionable to have a large part of the heating-electrodes electrically energized for many different reasons, such as for example, excessive capacitance or excessive electrical radiation, etc. For applications of this kind, the embodiment shown in Figs. 6 and 7 is recommended. In this embodiment, the heating-electrodes comprise hollow outer tubular members or rollers 90 and 92 that are insulatedly rotatably supported while pressed together in any suitable manner, such as for example, by the construction shown in Figs. 2 and 3. Each roller is segmented, being made up of similar segments or strips of metal separated by narrow segments or strips of insulation. More specifically, each roller comprises a plurality of circumferentially-spaced axially-extending insulating portions 96. Alternating with these insulating portions are similarly arranged conducting sections 98. Accordingly, each conducting section 98 is insulated from all the other conducting sections of the tubular members 90 and 92 by the insulating portions 96. In the preferred embodiment, the axial sides of the segments are parallel to the axis of the roller.

Each heating-electrode also comprises a stationary curved plate 100 close to the portion of a roller that faces the work to be heat treated and the other roller. This plate 100 is a longitudinal part of a cylinder and has an axis which is preferably concentric with, or parallel to, a conducting section of the roller. Circumferentially, however, the plate is slightly wider than the circumferential width of a single conducting section 98, but it can be of more or less width.

The stationary plates 100 of the heating-electrodes 90 and 92 are connected in any suitable manner to conductors 102 and 104 of a high-frequency transmission line. These connections

may include the stationary shafts around which the rollers 90 and 92 rotate, in a manner similar to the embodiment previously described in connection with Figs. 2 and 3.

It is desirable to so angularly displace the rollers 90 and 92 of the heating electrodes 86 and 88 that their insulating segments 96 do not come exactly opposite to each other as they rotate past the space in which the work moves. In this way, a more uniform electric field between the rollers is obtained because no two insulating segments 96 on different rollers ever come exactly opposite to each other. Fig. 6 indicates a proper arrangement, and to maintain this arrangement it is desirable to synchronize the rotation of the rollers.

In the embodiment described in Figs. 6 and 7, it is evident that only the facing conducting segments or sections 98 of the roller heating-electrodes 90 and 92 will be strongly electrically energized, since significant capacitive coupling to the other sections 98 is limited by the circumferential extent of the plates 100. If electrification of additional or a greater number of conducting sections 98 is desired, as many conducting jumpers as desired may be used electrically interconnecting them.

While I have described my invention in many forms, which I now prefer, it is obvious that the principles of my invention may be widely applied in different forms and modifications. For example, another form is disclosed and claimed broadly in my application Serial No. 84,881, filed concurrently herewith, now Patent No. 2,644,073.

I claim as my invention:

1. Dielectric heating means of a type described comprising, in combination, heating-electrodes comprising a pair of rotatable rollers, supporting means insulatedly supporting each of said rollers from ground for the passage of work therebetween, power-applying means for applying a high-frequency voltage across said heating-electrodes to provide an electric field therebetween for heating said work, each of said rollers having an outer metallic surface-portion at which said field is concentrated, said power-applying means comprising a metallic member for each of said rollers, each of said metallic members being elongated in a direction axially of said rollers and positioned within its respective roller, and supporting means supporting said metallic members insulating spaced from said metallic surface-portions in stationary energy-feeding capacitive coupling relation thereto.

2. Dielectric heating means of a type described, comprising, in combination, a pair of relatively-insulated spaced heating-electrodes, a first of said heating-electrodes comprising a roller in the form of a hollow tubular member having a metallic surface-portion adapted to face the second of said heating-electrodes, supporting means insulatingly and rotatably supporting said roller, said supporting means comprising bases for said tubular member, bearing means associated with said bases and a stationary shaft carried in said bearing means, a metallic member inside said roller and secured to said shaft so that said metallic member is stationary with respect to said roller, said metallic member being elongated axially of the roller and spaced from but in energy-feeding capacitive coupling relation to said surface-portion when the latter faces said second heating-electrode, and means comprising a conductor associated with said shaft for connecting a source of high-frequency energy across said metallic member and said second heating-electrode.

3. An invention including that of claim 2 but characterized further by metallic member being a tube.

4. An invention including that of claim 3 but further characterized by said roller of said first heating-electrode comprising a plurality of insulated sections.

5. Dielectric heating means of a type described, comprising, in combination, a pair of relatively-insulated spaced heating-electrodes, a first of said heating-electrodes comprising a roller in the form of a hollow tubular member having a metallic surface-portion adapted to face the second of said heating-electrodes, said first heating-electrode comprising a shaft insulatingly and rotatably carrying said roller, and a stationary metal member inside of and fixedly spaced from the inside surface of said roller and capacitively coupled to said surface-portion, and means for connecting a source of high-frequency across said metal member and said second heating-electrode.

6. Dielectric heating means of a type described, comprising, in combination, a pair of relatively-insulated rollers, each roller being in the form of a hollow tubular member having a metallic surface-portion adapted to face the other of said rollers, a stationary means insulatingly and rotatably carrying said rollers, a stationary metal member inside of and fixedly spaced from the inside surface of each of said rollers and capacitively coupled to the surface-portion thereof, and means for connecting a source of high-frequency across said stationary metal members.

7. A dielectric heating-electrode of a type described comprising a hollow-roller having a conducting portion, a shaft which is relatively stationary with respect to said roller, structural means between said shaft and roller constructed and arranged so that said shaft is insulated from but rotatably carries said roller, a curved metallic member inside said roller adapted to be capacitively coupled to said conducting portion, said metallic member being relatively stationary with respect to said roller, and a high-frequency connection to the metallic member.

8. A dielectric heating-electrode of a type described, comprising, a hollow cylindrical member having an outer surface member and a pair of spaced insulating bases, a shaft extending through one of said bases, said shaft being stationary and rotatably carrying said cylindrical member, an inner metallic curved member inside said cylindrical member, said curved member being attached to said shaft, and an energizing conductor secured to said shaft.

9. Dielectric heating means of a type described comprising, in combination, a pair of heating-electrodes, each of said heating-electrodes comprising a rotatable tubular member, the tubular members being spaced to provide a space therebetween in which work can be dielectrically heat treated, at least one of said tubular members comprising a plurality of successive insulating and conducting segments, and means for supplying high-frequency energy to said heating-electrodes, with the last said means comprising a curved member inside said one tubular member, said curved member being of limited circumferential length and spaced from but facing a conduction segment when the latter segment is facing said space.

10. Dielectric heating means of a type described

comprising, in combination, a pair of heating-electrodes, each of said heating-electrodes comprising a rotatable tubular member, the tubular members being spaced to provide a space therebetween in which work can be dielectrically heat treated, each of said tubular members comprising a plurality of circumferentially-spaced insulating portions extending lengthwise thereof, and conduction sections between the insulating portions, means for rotating said tubular members, and means for applying a high-frequency voltage to the conduction sections at said space without applying such voltage to conduction sections away from said space.

11. An invention including that of claim 10 but further characterized by said tubular members being arranged so that their insulation portions do not lie in the same angular relation, opposite each other, when the last said insulating portions are in said space.

12. Dielectric heating means comprising a tubular member comprising a plurality of circumferentially-spaced insulating portions extending lengthwise thereof and conduction sections between said insulating portions, and means for electrically energizing a limited number of sections, the said number being less than the total number of said sections.

13. Dielectric heating means comprising a tubular member comprising a plurality of successive insulating and conducting segments, a stationary shaft, means for insulatedly and rotatably mounting said tubular member on said shaft, and means positioned within but spaced from said tubular member for electrically energizing a number of said conducting segments during rotation of said tubular member.

14. Dielectric heating means of a type described comprising a heating-electrode comprising a tubular member, said tubular member comprising a plurality of circumferentially spaced insulating portions and conducting sections between said insulating portions, and a coupling member positioned within and capacitively coupled to said tubular member for supplying high-frequency energy to a predetermined number of said conduction sections.

15. A dielectric heating-electrode comprising, a hollow rotatable tubular member comprising a plurality of circumferentially-spaced insulating portions and a plurality of conducting sections between the insulating portions, and a stationary metallic conducting member inside said tubular member, spaced therefrom, said conducting member spanning less than all of said conduction sections.

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