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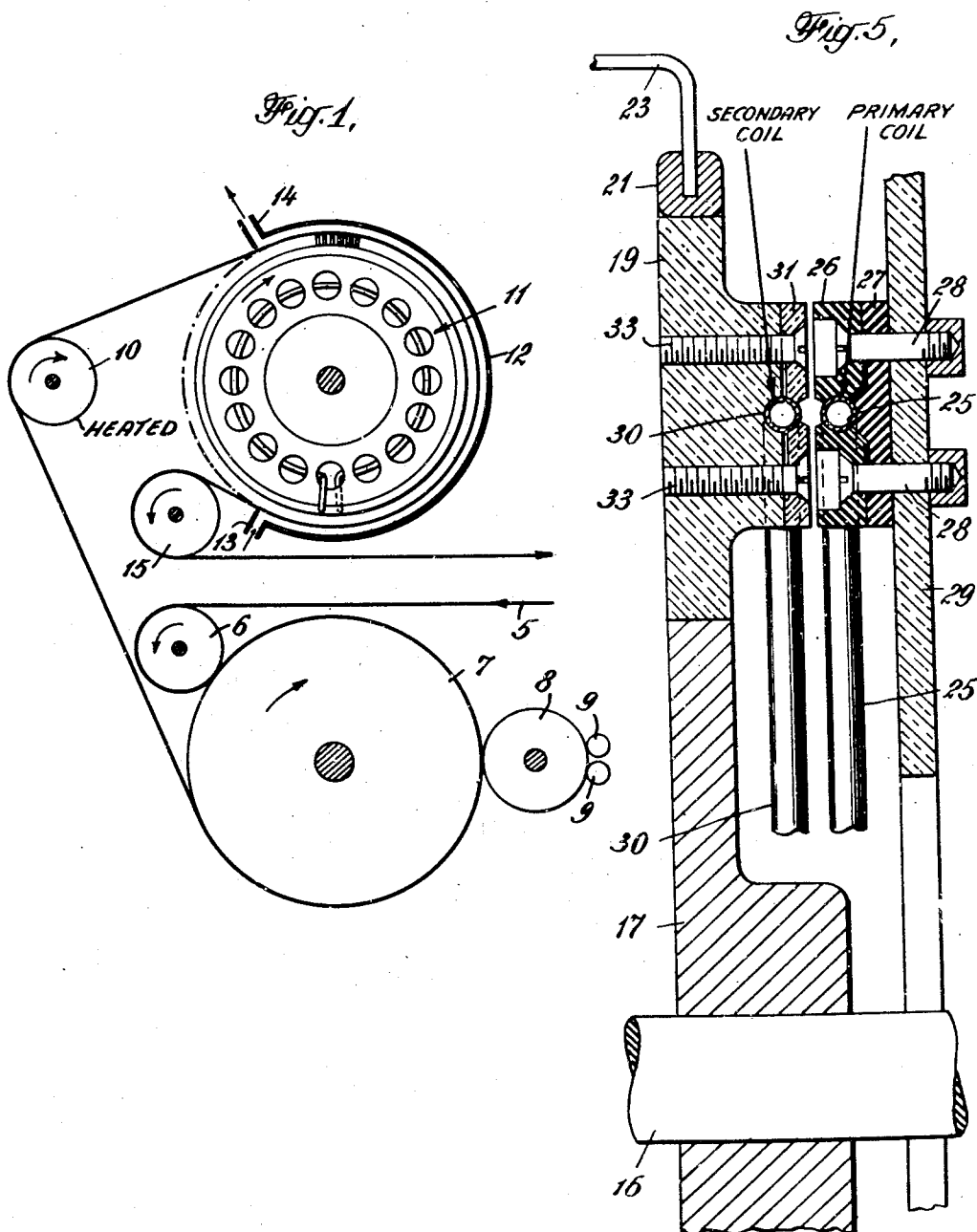
W. P. COHOE ET AL

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METHOD AND APPARATUS FOR DRYING SHEET MATERIALS

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2 Sheets-Sheet 1



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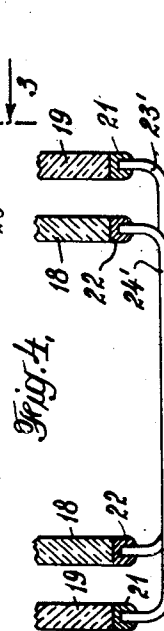
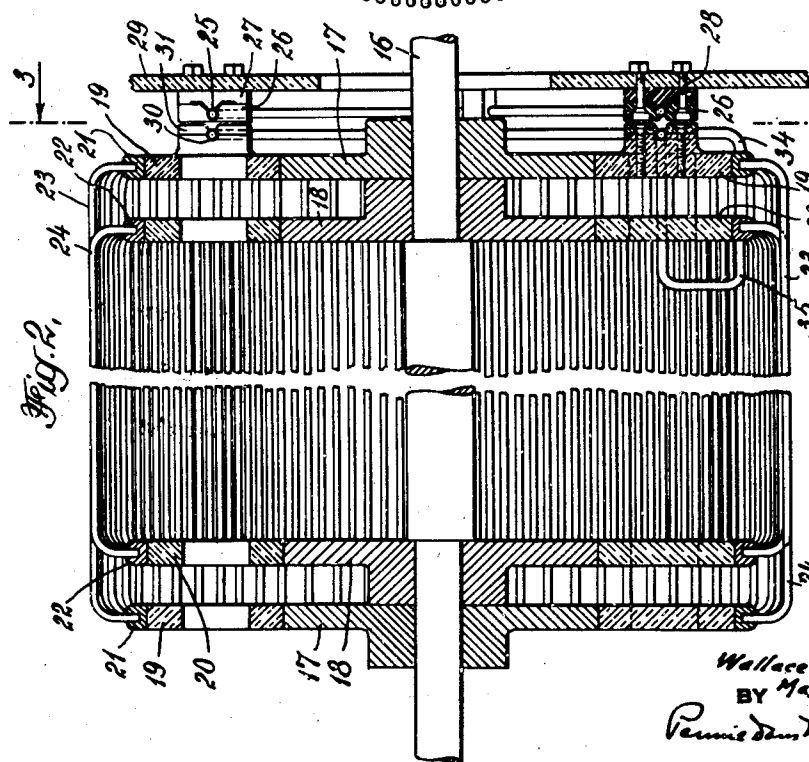
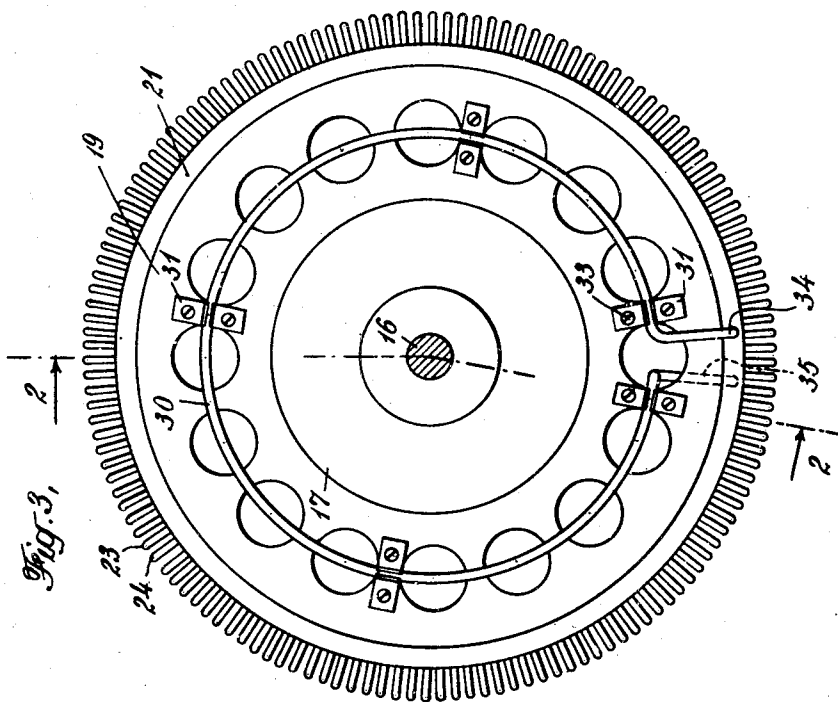
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METHOD AND APPARATUS FOR DRYING SHEET MATERIALS

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2 Sheets-Sheet 2



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METHOD AND APPARATUS FOR DRYING
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This invention relates to the drying of sheets, webs and films and more particularly to a method of and apparatus for utilizing electric fields produced by high frequency currents to effect a transient increase in the temperature of a moving body whereby moisture and volatile constituents are removed therefrom or chemical and physical changes promoted.

While the invention will be described in detail with reference to the drying of printed impressions on a traveling web, it may be utilized for other purposes, as for example the drying of films of ink of varying composition applied as printed impressions or otherwise. The invention is likewise applicable to the removal of moisture from paper and fabrics and to the drying of coating and finishing compositions applied to paper and fabrics and generally to the removal of vaporizable constituents of films of various kinds, the polymerization of heat setting resins and oxidation of drying oils.

The use of an electric field to generate heat within various bodies has been suggested heretofore, and proposals have been made with respect to the application of the principles involved. In particular, the general subject matter has been disclosed in an application Ser. No. 527,122, filed March 18, 1944, by Wallace P. Cohoe and Mitchell Wilson. That application describes the utilization of electric fields between a rotating electrode system in which the electrodes are embedded in dielectric material so that the surfaces of the electrode which are in contact with the material being treated are flush or substantially flush with the surface of the dielectric material. In the application mentioned, the electrodes are connected alternately to the ground and to a source of high frequency energy by means of a pickup coil.

It is the object of the present invention to afford a simple, practicable and commercially applicable method and apparatus whereby sheets, webs, films and the like may be subjected effectively to an electric field for the purpose of heating and thereby removing volatile constituents such as water and organic solvents.

A further object of the invention is the provision of a more efficient system of utilizing high frequency currents, avoiding losses and otherwise securing more advantageous utilization of the energy consumed in the operation.

Other objects and advantages of the invention will be apparent as it is better understood by reference to the following specification and the accompanying drawing, in which

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Fig. 1 is a diagrammatic representation of an application of the invention in the drying of printed impressions on a web;

Fig. 2 is a longitudinal section through a rotatable structure which supports the electrodes, said section being taken on line 2—2 of Fig. 3;

Fig. 3 is an end elevation taken on line 3—3 of Fig. 2;

Fig. 4 is a detail in section of the outer periphery of the rotatable structure showing a slightly different arrangement of the electrodes; and

Fig. 5 is an enlarged sectional view illustrating certain of the details of the structure.

In order to secure the maximum available heating effect in a sheet, web or film, as it is passed through an electric field unaccompanied by corona discharge, it is desirable to employ a multiplicity of electrodes so formed and spaced with respect to each other as to provide a minimum of dead space due to electrode surface and a maximum of field space between the electrodes. In other words, the area of the surface of the electrodes should be reduced to the minimum compatible with requisite strength and other conditions. A minimum efficient gap between the electrodes affords a maximum current utilization. Moreover, in order to secure parallelism between the axis of the web and the electric field, the sheet, web or film should be momentarily in actual contact with the electrodes while it is subjected to the electric field generated between them by the high frequency current impressed thereon. By causing the sheet, web, or film to actually contact the electrode, the region of greatest intensity of the electric field which normally would be in a direct path between the respective pairs of electrodes is caused to deviate and to pass through the sheet, web, or film so that the maximum drying effect is obtained.

We have discovered that the desired result can be obtained in a much more efficient manner by employing electrodes of circular cross-section to minimize the voltage gradient at the surfaces thereof and an air dielectric between the electrodes. By employing the air dielectric, heating loss which is inevitable in solid insulation is eliminated, the air gap being free from such heating loss. Thus the most suitable solid dielectric has a dielectric constant of 4.2, so that each pair of electrodes would have to conduct 4.2 times the current that it would have to conduct with air insulation. This reduction of 4.2 times in radio frequency currents causes a reduction of resistance heating losses in the circuit by 4.2 squared or 17.6 times, which is a very substantial advance-

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tage. Moreover, the capacity of the electrode system is reduced by a factor of at least 4.2 to 1, thereby permitting the field to be resonated to a higher frequency. Radio frequency conduction losses in the circular electrode rods are drastically reduced.

We have moreover discovered that certain advantages may be obtained by a balanced arrangement whereby at all times one set of electrodes is at the same potential as the other set of electrodes with respect to the ground, but the two sets of electrodes are always of opposite polarity. This arrangement provides a minimum of electrical radiation which would interfere with normal radio communications and would also represent a dissipation of useful energy. Furthermore, the voltage stress on the insulating supports is so distributed with respect to ground that only one-half of the entire electrode voltage is imposed on each insulating support and the total dielectric heating losses in the insulating supports is halved. Balanced connections provide a better impedance match to the high frequency generator. The induced eddy current losses in the supporting and adjacent metal parts of the apparatus are greatly reduced.

It is desirable to preheat the sheet, web or film before it enters the field in order to avoid absorption by the sheet, web or film of heat generated in the field without accomplishing the purpose for which the field is applied. Preheating to temperatures from 175° to 200° F. will not only save much of the energy consumed in maintaining the electric field but will also cut the drying time in half even though the boiling point of the vaporizable constituent may be as high as 400° F. or higher.

To understand this phenomenon, it is necessary to realize that the heat capacity of a web of paper is relatively enormous. If a web carrying, for example, a printed film of ink is subjected momentarily to the electric field, the temperature of the film tends to rise sharply, but in the meantime heat flows rapidly to the paper and the maximum desired temperature is not attained in the film. A long interval is thus required to evaporate the volatile constituent of the ink. In other words, the lineal speed of the web must be reduced in order to attain the desired result. If, however, the paper is preheated even to relatively low temperatures, the temperature gradient between the paper and the ink film is reduced. Hence faster drying is possible because the available high temperature heat is concentrated in the ink film. Obviously energy is saved because less of the heat produced by the electric field is drawn off to the paper.

We shall describe the details of the invention as applied in drying a printed paper web in a printing press. This, however, is merely for the purpose of illustration. The same procedure may be applied in the treatment of coated paper, fabrics printed or coated and to films generally which include a volatilizable constituent or one which is hardened or otherwise modified by the application of heat. Many of the materials employed in printing inks and pastes and coating compositions are subject to heating in the electric field, and any such materials may be utilized for the practice of the invention. An ink, for example, may consist of any suitable resin dissolved in an organic solvent to afford a varnish and pigmented with any of the materials which are commonly used in ink formulations.

Referring to Fig. 1 of the drawing, 5 indicates

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a paper web which is fed to a printing mechanism of any suitable type. This is illustrated conventionally by a roller 6 which delivers the web to a packing cylinder 7. A printed impression is applied to the web from a plate cylinder 8 which is inked by inking rolls 9. The details of the printing mechanism form no part of the present invention and may be modified in accordance with the customary practice.

From the packing cylinder 7 the web 5 passes over a roller 10 which is supplied with heat in any suitable manner as for example by introducing steam to raise the temperature of the web to the desired point, for example from 175° to 200° F. The web so heated passes to the apparatus 11 where it is subjected to the electric field between electrodes supplied with high frequency alternating current from a suitable source such as an oscillator. The details of the heating apparatus are described hereinafter.

As the result of the heating effect by the electric field, solvent vapors are separated from the ink film. To facilitate removal of the vapors, a portion of the apparatus 11 is enclosed by a hood 12. Air or any other suitable medium, preferably heated to a temperature which is above the dew point of the highest boiling solvent employed and well above the web temperature, is introduced through an inlet 13 and escapes through an outlet 14 after passing in a direction counter to the direction of travel of the web. The web then passes over a cooling roller 15 which may be supplied with water or other cooling medium. The web may be withdrawn from the press or subjected to second side printing and subsequent drying in apparatus similar to that already described, as may be desired.

It is to be understood that the several cylinders and rollers are driven from any suitable source of power through the usual mechanism provided for that purpose (not shown). The details of the driving mechanism form no part of the present invention and are well understood in the art. Preferably the apparatus 11 is driven at a peripheral speed slightly in excess of the linear speed of the web as it is delivered thereto in order to prevent any slack in the feed. This involves a slight slippage of the web with reference to the apparatus 11 which is desirable because it ensures more uniform and complete action of the electrostatic field in the heating of the film.

The apparatus 11 is illustrated in more detail in Figs. 2-5. It comprises a shaft 16 adapted to be driven as hereinbefore described and carrying supporting members 17 and 18, preferably of ceramic material to the periphery of which rings 19 and 20, likewise of ceramic material are firmly secured. To the outer peripheries of the rings 19 and 20, metallic conducting rings 21 and 22 are secured. The conducting rings 21 and 22 with the supporting structure are duplicated at the opposite end of the shaft 16 and thus afford supports for a plurality of metallic electrodes 23 and 24, preferably spanning the outer rings and the inner rings respectively. The electrodes 23 and 24 are of circular cross-section and are bent at their ends to engage and find support in the rings.

In an alternative arrangement as shown in Fig. 4, the electrodes 23' and 24', instead of spanning the outer and inner rings respectively, each engage an inner and an outer ring, being thus arranged in staggered relation. In either case, the electrodes 23 and 24 or 23' and 24' are closely

spaced about the periphery as more clearly indicated in Fig. 3, and thus afford the elements of a cylindrical surface over which the web or sheet travels as the apparatus rotates. As already indicated, the circular electrodes are so spaced as to afford a substantially no loss air gap between them to ensure the maximum effectiveness of the high frequency current supplied.

The current is supplied to a coil 25 supported in insulating brackets 26 and 27 secured by bolts 28 to a fixed member 29, preferably of ceramic material which surrounds the shaft 16. Suitable connections are provided to deliver current to the coil 25 from a source such as an oscillator (not shown).

A similar coil 30 is supported by insulating brackets 31 secured by bolts 32 to the ring 19 of the rotating apparatus. The coil 30 rotates with respect to the coil 25 and is so positioned with respect thereto that it has high frequency alternating current of substantially the same potential with respect to ground induced into every part thereof. The coil 30 is connected by leads 34 and 35 respectively to the outer and inner rings 21 and 22 so that the electrodes 23 and 24 are energized by high frequency alternating voltages of opposite polarity and equal magnitude with respect to ground. Between each alternating pair of electrodes about the periphery of the apparatus there is set up an alternating electric field which causes heating of the sheet, web, or film which is subjected to the field as the sheet, web, or film travels about and in contact with the electrodes 23 and 24.

In the operation of the apparatus as described, the web 5 passes continuously about the apparatus 11, which rotates preferably at a slightly higher peripheral speed than the lineal speed of the web. As the web passes about the apparatus 11, it is in actual contact with the electrodes during the period while the electric field is effective to produce heating of the ink film, and advances successively in paths substantially parallel to the normal planes of greatest intensity of the electric fields. The temperature of the ink film rises rapidly, with the result that vaporizable constituents are separated and are carried away preferably by the flow of air or other gas introduced to the hood 12. As the result of initial heating of the web, very little of the heat generated in the film escapes thereto, thus ensuring concentration of the heat produced by the electric field for effective use. Rapid operation is thus possible, that is to say the linear speed of the web may be maintained at the maximum speed at which drying can be effected by the application of the electric field.

In the drying of cloth, for instance, as distinguished from the drying of the film applied thereto, there would be a system wherein the body of the web contains material which is active with respect to the field, i. e., water. In that case, the web itself would be heated necessarily by the effect of the electric field. Preheating would, however, supplement the action of the electric field and speed up the drying operation. The method and apparatus as described afford a rapid and satisfactory procedure for the drying of films of various kinds, affording the maximum possible advantage of the heating effect of the electric field, particularly in avoiding losses due to the interposition of solid dielectric material between the electrodes and the utilization of balanced connections between the electrodes. The practical application of the invention avoids

many of the disadvantages of heating methods employing open flames or large steam drums and permits particularly more rapid drying than can be effected by other means.

Various changes may be made in the details of the apparatus and in the method as described without departing from the invention or sacrificing the advantages thereof.

We claim:

1. An apparatus for heating sheet material comprising a rotatable insulating support, two pairs of metallic conducting rings mounted on the periphery of the support at the ends thereof, a plurality of electrodes disposed in parallel spaced relation about the periphery of the support and connected alternately to the opposite rings of each pair, the surfaces of the electrodes being exposed entirely to the surrounding atmosphere, and means for supplying high frequency alternating current to the electrodes.

2. The method of drying a sheet which comprises establishing a plurality of parallel, spaced electric fields, unaccompanied by corona discharge, by connecting alternate parallel, spaced electrodes, in succession, to the opposite poles of a source of high frequency, alternating current which are at the same potential with respect to ground, maintaining the sheet in peripheral contact with the corresponding sides of said electrodes causing the region of greatest intensity of said electric fields to deviate from its normal path directly between said electrodes and to pass through said sheet, and causing relative movement between said sheet and said electrodes while the region of greatest intensity of said electric field is passing through said sheet.

3. The method of drying a sheet which comprises establishing a plurality of substantially parallel, spaced electric fields, unaccompanied by corona discharge, by connecting alternate, parallel, spaced electrodes, in succession, to the opposite poles of a source of high frequency, alternating current which are at the same potential with respect to ground, moving said electrodes in a continuous path, and advancing the sheet relative to said electrodes over and in peripheral contact with them at a rate different from that at which the electrodes are moving, whereby the region of greatest intensity of said electric field is caused to deviate from its normal path directly between said electrodes and to pass through said sheet.

4. The method of drying a sheet as set forth in claim 3 in which the continuous path is arcuate.

5. The method of drying a sheet as set forth in claim 4 in which the sheet is supported solely by the electrodes while it is passing in peripheral contact with them.

6. The method of drying a relatively thin film deposited on one surface of a relatively thicker sheet which comprises establishing a plurality of spaced electric fields, unaccompanied by corona discharge, by connecting alternate, parallel, spaced electrodes, in succession, to the opposite poles of a source of high frequency, alternating current which are at the same potential with respect to ground, maintaining the sheet in peripheral contact with the corresponding sides of said electrodes causing the region of greatest intensity of said electric fields to deviate from its normal path directly between said electrodes and to pass through said sheet and film, and causing relative movement between said sheet and said electrodes while the region of greatest intensity

of said electric fields is passing through said sheet and film.

7. The method of drying a relatively thin film deposited on one surface of a relatively thicker sheet as in claim 6 in which the electric fields are moved in a continuous path.

8. The method of drying a relatively thin film deposited on one surface of a relatively thicker sheet as in claim 6 in which the sheet is advanced successively in paths substantially parallel to the normal planes of greatest intensity of the electric fields.

9. The method of drying a relatively thin film deposited on one surface of a relatively thicker sheet as in claim 6 in which the sheet is pre-heated to a temperature insufficient to effect appreciable drying of the thin film.

10. The method of drying a relatively thin film deposited on one surface of a relatively thicker sheet as in claim 9 in which the electric fields are moved in a continuous arcuate path.

11. The method of drying a relatively thin film deposited on one surface of a relatively thicker sheet as in claim 10 in which the sheet is supported solely by the electrodes while it is passing in peripheral contact with them.

12. An apparatus for heating sheet material comprising a rotatable insulating support, two pairs of metallic conducting rings mounted on the periphery of the support adjacent the ends thereof, a plurality of electrodes disposed in parallel, spaced relation about the periphery of the support and connected alternately to the opposite rings of each pair of metallic rings, means for inducing a high frequency, alternating current into said electrodes including a coil secured to the insulating support and connected at opposite ends to alternate electrodes, and a fixed coil connected to a source of high frequency alternating current, successive electrodes thereby receiving charges of opposite polarity but of equal potential with respect to ground, whereby said electrodes become part of a balanced electric circuit.

13. An apparatus for heating sheet material

comprising a rotatable insulating support, two pairs of metallic conducting rings mounted on the periphery of the support adjacent the ends thereof, a plurality of electrodes disposed in parallel, spaced relation about the periphery of the support and connected to the opposite rings of each pair of metallic rings, a coil to which high frequency alternating current is to be supplied, a second coil so positioned with respect to said first coil as to have high frequency alternating current of substantially the same potential with respect to ground induced into all parts thereof, means for moving one of said coils relative to the other, and means for electrically connecting one ring of one of said pairs of metallic rings to one end of said second coil, and means for connecting the other ring of said one of said pairs of rings to the other end of said second coil, whereby when current is supplied to said first coil all of said electrodes will be of the same potential with respect to ground and alternate electrodes will be of opposite polarity.

14. An apparatus for heating sheet material as set forth in claim 13 in which the surfaces of the electrodes are exposed substantially entirely to the surrounding atmosphere.

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