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FIG. 3.

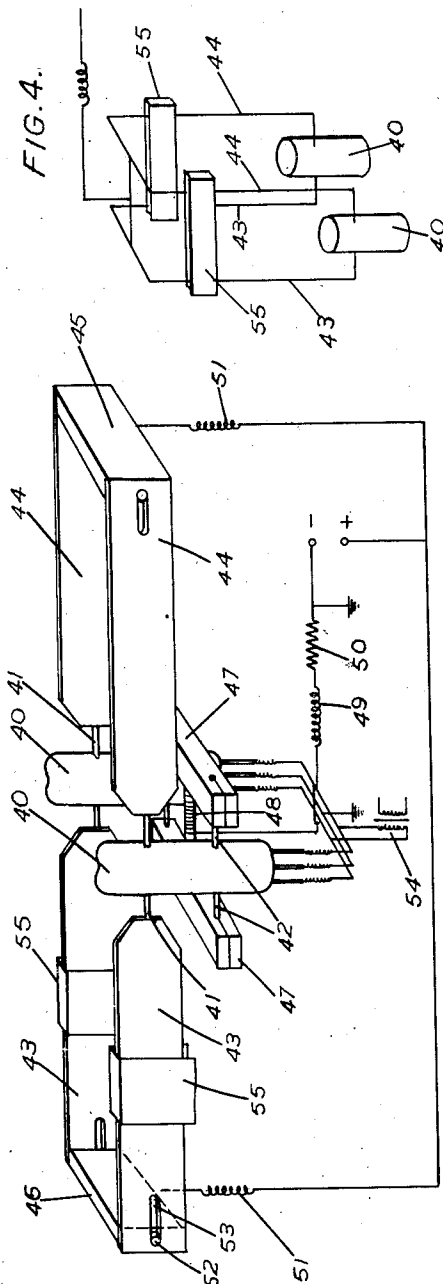
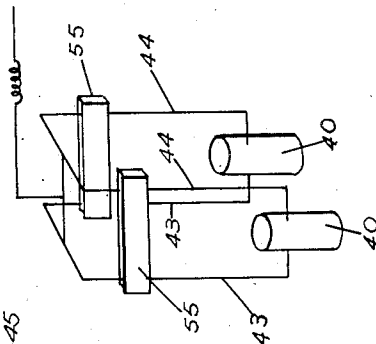


FIG. 4.



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MEANS FOR FEEDING HIGH-FREQUENCY
ELECTRIC CURRENTS TO THE ELECTRODES OF DIELECTRIC HEATING APPARATUS

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4 Claims. (Cl. 219—47)

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This invention relates to the production of heat by means of electric fields alternating at high frequency in dielectric material by making use of electrodes between or adjacent to which the material is placed and between which a high potential difference is maintained. The invention deals particularly with the means for feeding high frequency electric currents from an oscillator to the electrodes in a manner particularly suitable for very high frequencies, for instance 200 megacycles per second and upwards.

In this improved arrangement we utilise an oscillator having an output circuit (tank circuit) in the form of a resonant line which structurally is wholly or in part a rigid bar or tube and we make coupling with this circuit by means of two rigid rings surrounding the bar or tube without making contact with it. These rings are not necessarily complete rings (although in general cases this will be found an advantageous form) and in the following description the word "ring" in this connection is to be interpreted with this proviso and in the light of the functions to be performed by the part to which the word is applied. These rings, which make capacity coupling with the output circuit, are spaced apart appropriately on an insulating carrier and each have a projecting part which makes direct coupling with one of the electrodes. There is provision for relative movement between the rings and the line. This movement may be effected by moving the carrier along the line but in most instances it is advantageous to fix the carrier and move the oscillator relative to it. In either case the position of the coupling rings on the resonant line is varied and in this way the load on the oscillator is adjusted according to the requirements of each case, that is to say according to the nature and dimensions of the material to be heated, or according to the rate of increase of temperature which is desired.

Examples of apparatus embodying the invention will be described with reference to the accompanying drawings.

Figure 1 is a partly diagrammatic drawing in perspective of part of a machine for joining together sheets of thermoplastic material.

The machine comprises a work-table 1, slotted at 2 to receive a disc 3 of insulating material mounted on a shaft 4. The method of mounting the disc 3 and its construction is more clearly shown in Figure 2 which is a part cross section in a vertical plane passing through the shaft 4. The disc 3 is formed with metal rims 5 and 6 which act as two electrodes between which is

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maintained a high frequency alternating potential by means which will be hereinafter described. Suitable means for rotating the disc 3 and for pressing the sheets of plastic material against its upper edge, are described in co-pending application for U. S. patent, Serial No. 702,220, and United Kingdom application No. 30418/45. The work-table 1 is carried on four supports 7, which are shown partly cut away to disclose other parts of the machine. To these supports are joined rigid cross members 8 on which a platform 9 of insulating material is slidably mounted. The platform 9 is movable backwards and forwards in the direction indicated by the arrows on its upper surface. This platform carries a high frequency oscillator. The output circuit (tank circuit) of the oscillator is a U-shaped resonant line which consists of a tube divided into two parts 11 and 12 which are joined by a hollow terminator 13. The anodes 14 of two oscillator valves fit into the free ends of the tubular parts 11 and 12. These valves are of type ACT.19 manufactured by the General Electric Company, having an anode dissipation of 200 watts and a transconductance of 5500 umhos. Two valves in a push-pull circuit are rated to deliver 500 watts at frequencies up to 100 mc./s. with forced air cooling at a rate of 25 C. F. M. The filament leads 32 of the valves (shown dotted where they pass through the tubular parts 11 and 12) are connected to a suitable low tension supply (not shown). The filament circuit includes a phase adjusting reactance to maintain oscillations. The grid circuit for the two valves is a U-shaped resonant line 14 connected to the valves by grid leads 15 and supported on an insulator 16 carried on the platform 9. The resonant line 14 is connected at its centre through a grid choke 17 and resistor 18 to earth. The H. T. anode supply is connected through a lead 29 and an anode choke 19 to a terminal 20 mounted on the centre of the terminator 13. The tubular parts 11 and 12, the terminator 13 and the anodes 14 are all supported on insulators 21 mounted on the platform 9. The anodes 14 are formed with air ducts 22. A supply of air under pressure is fed through a pipe 30 to the terminator 13 and the escapes through the ducts 22.

Two horizontal members are rigidly mounted on the supports 7. Only one of these is shown under reference 23. These members carry a cross piece 24. Around each of the tubular parts 11 and 12 is a metal ring 25 supported by a block 26 of polythene which is itself rigidly mounted on the cross piece 24. The inside diameter of the

rings 25 is greater than the outside diameter of the tubular parts 11 and 12 and the supporting means for the rings 25 which includes the polythene block 26, the cross piece 24 and the horizontal members 23 are so constructed that when the platform 9 moves horizontally between the four supports 7 in the direction indicated by the arrows, a uniform spacing between the inside surfaces of the rings 25 and the outside surfaces of the tubular parts 11 and 12 is maintained. Two spring contacts 27 are mounted on the rings 25 and bear against the metal rims 5 and 6 of the disc 3.

The tubular parts 11 and 12 and the terminator 13 form a U-shaped resonant line. By applying a suitable H. T. supply to the lead 23 and low tension supply to the valve filaments, a standing wave of voltage is set up on each side of the line, falling from a maximum at the anodes 14 of the two valves to approximately zero at the centre of the terminator 13, the effective length of each side of the line being a quarter wave-length. Accordingly, by varying the position of the capacity coupling provided by the two rings 25 along the part of the resonant line consisting of the tubular parts 11 and 12, the value of the potential difference picked up by the rings 25 and applied to the electrodes, formed by the rims 5 and 6 of the disc 3, is adjusted, this value being decreased as the distance between the rings 25 and the anodes 14 increases. This adjustment is effected by sliding the platform 9 backwards and forwards in the direction of the arrows drawn on its upper surface. The external connections, namely the H. T. lead 29, the filament leads 32, the grid lead 18 and the air pipe 30 are all flexible to allow for this movement of the platform 9. The output resonant line may consist of a tube bent in the form of a U, similar to the grid resonant line, in which case the H. T. supply will be connected to the centre of the U and the terminator 13 will not be necessary.

Figure 3 is a diagrammatic drawing of an alternative form of oscillator which may be used in a machine of the kind described with reference to Figures 1 and 2. This construction includes two valves 40 each having two projecting anode terminals 41 and two projecting grid terminals 42. These valves are type 8012, manufactured by R. C. A. Inc., Camden, New Jersey, U. S. A. and have a convection cooled glass envelope, an anode dissipation of 40 watts and an amplification factor of 23. The two valves in a push-pull circuit are rated to deliver 60 watts at 500 mc./s. The anode terminals 41 are connected to metal bars 43 and 44 which are joined by metal terminators 45 and 46 to form two U-shaped anode resonant lines. The bars are of 1" x 1/8" strip metal. The grid terminals are connected by metal bars 47 forming two grid resonant lines. The centres of these bars are connected by a choke 48 which is connected to earth through a choke 49 and resistor 50 and to the negative terminal of the H. T. supply. The positive terminal of the H. T. supply is connected through anode chokes 51 to the centre points of the terminators 45. Provision is made for adjusting the terminators 45 with respect to the bars 43, the terminators being supported by studs 52 sliding in slots 53. Filament current is supplied to the valves 40 through a transformer 54.

The "rings" for effecting capacity coupling between one of the anode lines and the electrodes are in this construction in the form of stirrups 55. These stirrups are supported by means (not

shown), similar to those described with reference to Figure 1, in such a way that a uniform spacing is maintained between them and the bars 43. The stirrups make capacity coupling with only one of the two anode resonant lines but by modifying the position of the anode lines so that bars 43 and 44 lie parallel to each other as shown diagrammatically in Figure 4 and increasing the length of the stirrups 55, coupling can be made to both anode resonant lines as shown. This circuit is capable of oscillating at frequencies up to 500 mc./s. the output being of the order of 60 watts.

Where it is preferable to keep the oscillator stationary, the adjustment may be attained by mounting the support for the two rings on a carrier similar to the member 24 in Figure 1 but which can be moved horizontally through the desired range in a direction parallel with the run of the line. In this case a modified form of electrode would be used having a surface large enough, in the direction in which the spring contact members mounted on the rings move, to maintain contact with the spring contact members throughout the range of their movement.

If the two electrodes are not side by side but in some other disposition, for instance in the same plane, the spring blades may be skewed or one ring may be arranged in advance of the other on the carrier in order that simultaneous contacts can be made between blades and electrodes.

We declare that what we claim is:

1. In apparatus for producing heat in a dielectric material by passing said material through an electric field adjacent to or between two rotating electrodes between which a high frequency alternating potential is maintained by an oscillator, a variable coupling between said oscillator and said electrodes which is adjustable to vary the potential difference between said electrodes comprising an output tank circuit for said oscillator in the form of a resonant line which structurally includes two parallel rigid conducting members, two fixed coupling members each at least partially surrounding one of said conducting members without making contact therewith, a contact member on each of said coupling members which makes rubbing contact with one of said rotating electrodes and means for moving said oscillator and said line together in a direction parallel with the longitudinal axes of said rigid conducting members thereby effecting the required adjustment.

2. In apparatus for producing heat in a dielectric material by passing said material through an electric field adjacent to or between two rotating electrodes between which a high frequency alternating potential is maintained by a vacuum tube oscillator comprising at least two oscillator tubes, a variable coupling between said oscillator and said electrodes which is adjustable to vary the potential difference between said electrodes comprising an output tank circuit for said oscillator in the form of a resonant line which structurally includes two parallel rigid conducting members each connected at one end to the anode of one of said tubes and connected together at their other ends by a metal member, two fixed coupling members each at least partially surrounding one of said conducting members without making contact therewith, a contact member on each of said coupling members which makes rubbing contact with one of said rotating electrodes and means for moving said oscillator and said line together in a direction parallel with the longitudinal axes of said rigid

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conducting members thereby effecting the required adjustment.

3. In apparatus for producing heat in a dielectric material by passing said material through an electric field adjacent to or between two rotating electrodes between which a high frequency alternating potential is maintained by a vacuum tube oscillator comprising at least two oscillator tubes, a variable coupling between said oscillator and said electrodes which is adjustable to vary the potential difference between said electrodes comprising an output tank circuit for said oscillator in the form of a resonant line which structurally includes two parallel tubular rigid conducting members each connected at one end to the anode of one of said tubes and connected together at their other end by a metal member, two fixed coupling rings each surrounding one of said conducting members without making contact therewith, a contact member on each of said coupling rings which makes rubbing contact with one of said rotating electrodes and means for moving said oscillator and said line together in a direction parallel with the longitudinal axes of said rigid conducting members thereby effecting the required adjustment.

4. In apparatus for producing heat in a dielectric material by passing said material through an electric field adjacent to or between two rotating electrodes between which a high frequency alternating potential is maintained by a vacuum tube oscillator with a U-shaped output tank circuit in the form of a resonant line with the ends of the arms of the U each connected to the anode of one of the oscillating tubes and each of length equal approximately to one quarter wave length, standing waves of voltage being generated

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in each arm of the U varying from a maximum at the tube anode to a minimum at the centre of the U, a variable coupling between said oscillator and said electrodes which is adjustable to vary the potential difference between said electrodes comprising two fixed coupling members each at least partially surrounding one of the arms of said U-shaped line, a contact member on each of said coupling members which makes rubbing contact with one of said rotating electrodes and means for moving said oscillator and said resonant line in a direction parallel with the longitudinal axis of said arms of said U-shaped line thereby effecting the required adjustment.

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PETER JONES.

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