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HIGH-FREQUENCY ELECTRONIC APPARATUS
FOR HEATING DIELECTRIC MATERIALS
Filed March 31, 1945

Fig. 1.

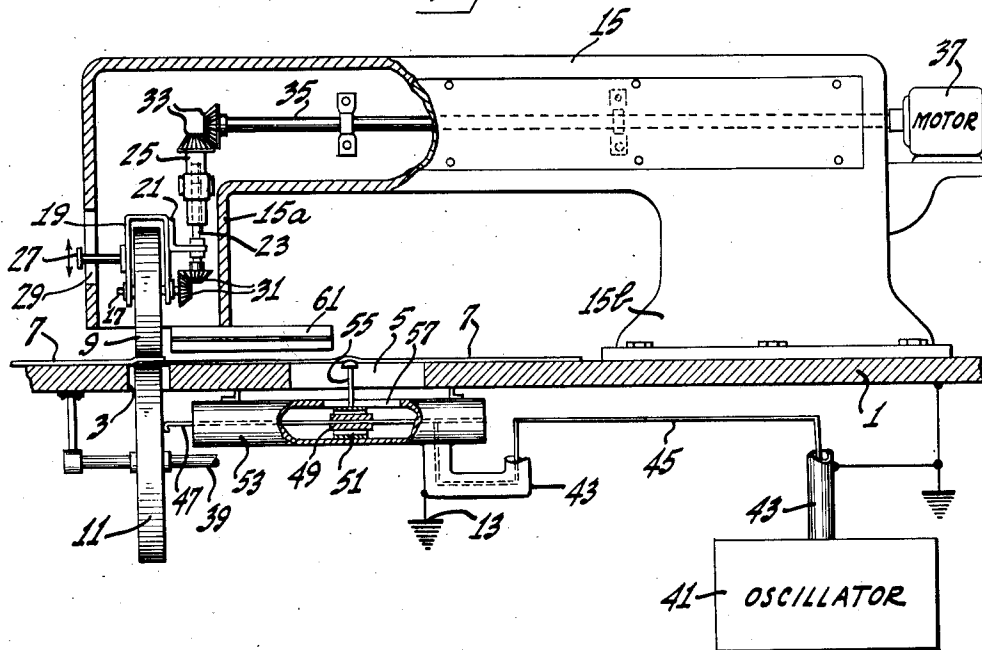


Fig. 2.

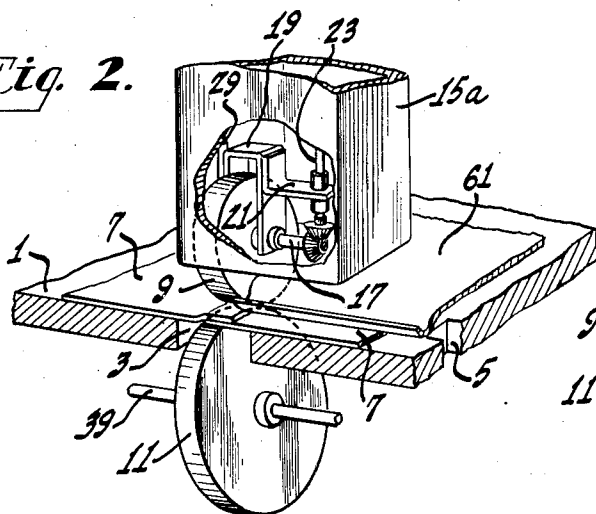
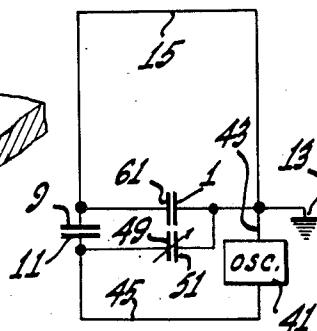


Fig. 3.



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2,468,263

HIGH-FREQUENCY ELECTRONIC APPARATUS FOR HEATING DIELECTRIC MATERIALS

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Application March 31, 1945, Serial No. 586,003

8 Claims. (Cl. 219—47)

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This invention relates to electronic heating apparatus, and more particularly to apparatus employing high frequency electric energy for heating dielectric materials by reason of dielectric losses produced therein, the present invention having particular relation to the type of apparatus disclosed and claimed in the copending application of Cyril N. Hoyler, Serial No. 539,855, filed June 12, 1944, and assigned to Radio Corporation of America.

In the aforesaid copending application there is disclosed apparatus for bonding together a plurality of superposed layers of dielectric, thermoplastic material by passing overlapping portions of the layers between two electrodes connected to a source of high frequency, electric energy. The high frequency electric field established between the electrodes serves to quickly heat the dielectric material to the plasticating or fusion temperature thereof. Pressure applied to the several layers while hot serves to unite the layers into an integral unit.

Commercial apparatus of this type has been constructed in a form similar to conventional sewing machines and has included (1) a grounded metallic bedplate for supporting the work, (2) a head or frame supported by the bedplate, (3) a pair of roller electrodes, one mounted below the bedplate and extending through an opening therein, and the other carried by the aforesaid head in alignment with the first mentioned roller for cooperation therewith, and (4) a high frequency oscillation generator having a grounded output terminal and a second terminal the potential of which varies with respect to ground. The electrode roller mounted below the bedplate is connected to the last mentioned terminal of the generator while the other roller is connected to ground through the machine head.

In order to accommodate workpieces of substantial width, it is necessary to make the machine head fairly long between the point where it supports the upper electrode roller and its point of connection to the bedplate. The length of the head is then large compared to the wave length at the operating frequency of the generator and, due to the high impedance afforded thereby, there is set up in the head a standing wave of voltage which not only results in instability and erratic operation, but also some degree of danger to the operator.

The primary object of my present invention is to provide an improved electronic heating apparatus of the type set forth above which will not

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be subject to the aforementioned disadvantage of similar prior art apparatus.

More particularly, it is an object of my present invention to provide an improved electronic heating apparatus for heating dielectric materials which will accommodate workpieces of all widths within the limits of the apparatus and which will, at the same time, be entirely stable and uniform in operation, as well as safe for the operator to use.

Another object of my present invention is to provide an improvement in apparatus of the type set forth, which can be readily applied to existing electronic heating and/or bonding machines with great ease, thereby rendering such machines free from the objection pointed out heretofore.

It is also an object of my present invention to provide an improved apparatus as aforesaid which is economical in cost and highly efficient in use.

In accordance with my present invention, I provide an electro-conductive plate of substantial area around or in close proximity to the upper electrode roller (that is, the one intended to be at ground potential) and dispose this plate in close proximity also to the grounded bedplate. Thus, the plate which I add to the apparatus cooperates with the bedplate to form, at the operating frequency, a low impedance capacitor in shunt relation with the machine head between the associated electrode roller and ground. This permits the current to pass off and hence eliminates the standing wave which normally results along the head, with attendant safety and improved, uniform, stable operation regardless of the width of the material presented to the machine.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, 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 of one embodiment thereof, when read in connection with the accompanying drawing, in which

Figure 1 is a front elevation, partly in section, of one form of electronic heating apparatus according to my present invention,

Figure 2 is a fragmentary, perspective view showing certain details of construction, and

Figure 3 is a wiring diagram of the output circuit of the oscillation generator according to my present invention.

Referring more particularly to the drawing, wherein similar reference characters designate corresponding parts throughout, there is shown

an electronic heating machine for heating dielectric materials, the machine including a metallic bedplate 1 provided with an opening 3 and a slot 5. The bedplate 1 serves to support a workpiece 7 shown in the drawing as a pair of thermoplastic layers of dielectric material arranged in overlapping relation along adjacent marginal portions at which they are to be bonded together between a pair of cooperating rollers 9 and 11. The bedplate 1 is maintained at ground potential by connection to any suitable ground point 13.

Secured to the grounded bedplate 1 in electro-conductive relation therewith is a hollow head 15, also of electro-conductive material, the head 15 terminating in a downwardly extending arm 15a which is spaced from the bedplate 1 and in which the roller 9 is mounted for vertical adjustment. For the latter purpose, the roller 9 is secured to a shaft 17 which is rotatably carried by a yoke 19. Secured to the yoke 19 is a bracket 21 which carries a vertical shaft 23 slidable vertically in and splined to a hollow shaft 25 within the arm 15a. The yoke 19 also carries a post 27 which extends through a vertical slot 29 in one side of the arm 15a. By manipulating the post 27 manually within the slot 29, the assembly comprising the roller 9, the yoke 19, the bracket 21, the shaft 23 and a pair of bevel gears 31 which couple the shafts 17 and 23 to each other may be raised or lowered as a unit relative to the bedplate 1 and the roller 11. When the rollers 9 and 11 are separated, the workpiece 7 may be inserted therebetween, after which the roller 9 is lowered onto the work.

The shaft 25 is coupled by a pair of bevel gears 33 to a shaft 35 within the head 15. A motor 37 carried by the head 15 drives the shaft 35 which, in turn, delivers power to the shafts 25, 23 and 17 for driving the upper roller 9. The lower roller 11, which is rotatably supported on a shaft 39 below the bedplate 1 in electrically insulated relation thereto and which extends through the opening 3 into cooperative relation with the roller 9, may also be driven by suitable coupling means (not shown) from the motor 37. Thus, as the rollers 9 and 11 rotate while engaging the workpiece 7, they advance the workpiece between them.

For supplying electrical energy to the rollers 9 and 11, there is provided a suitable, high frequency oscillation generator 41, such as a vacuum tube oscillator operating at radio frequency. One terminal of the oscillator 41 is connected to the ground point 13 by the outer conductor 43 of a concentric transmission line. The other terminal of the oscillator 41 is connected to the lower roller 11 by means of the inner conductor 45 of the aforesaid transmission line and a brush or wiper 47. A tuning capacitor comprising a metallic cylinder 49 carried by the conductor 45 and a metallic sleeve 51 which surrounds the cylinder 49 in spaced relation thereto and which is slidably mounted in a metallic tube 53 conductively supported by the bedplate 1 and through which the bedplate 1 may be connected to the ground point 13, if desired, serves to tune the circuit. The capacitance of the capacitor 49, 51 may be varied manually to tune the circuit for loads of different thicknesses between the roller electrodes 9 and 11 by means of a post 55 secured to the capacitor sleeve 51 and extending through a slot 57 in alignment with the slot 5. Energy supplied to the electrodes 9 and 11 establishes a radio frequency electric field therebetween and, since the overlapping portions of the workpiece 7 are

immersed in this field, the field produces dielectric losses therein to heat the overlapping workpiece portions to the plasticating temperature. Bonding of the two layers may then be effected with the aid of pressure applied to the work by the rollers 9 and 11 or by other suitable means in a manner more fully set forth in the above identified, copending, Hoyler application.

Where the workpiece 7 is quite wide, it is apparent that the head 15 must be made quite long between its arm 15a and its arm or base 15b where it is connected to the bedplate 1 if the machine is to accommodate the work. In such case, the length of the electrical path through the head 15 becomes large compared to the wave length at the operating frequency of the oscillator 41. Since this path has a high impedance at the operating frequency, a standing wave is set up in the head 15 which varies in voltage between the ground point 13 and the roller electrode 9. Thus, the roller 9, instead of being at ground potential, is actually at some other potential. This not only results in unstable operation of the machine, but also creates a somewhat dangerous condition for the operator.

To eliminate the standing wave, I mount on the lower end of the arm 15a an electro-conductive plate 61. The plate 61 should have a substantial area and may be mounted either to one side of the roller 9 in close proximity thereto, as shown in the drawing, or it may be arranged to straddle the roller 9. In any case, it is mounted close to the grounded bedplate 1 and cooperates therewith to provide a low impedance path between the roller 9 and the ground point 13 through which the high frequency current can readily return to ground. This low impedance path, it will be noted, is arranged in shunt relation with the head 15. In this way, the standing wave in the head 15 and its attendant disadvantages are entirely eliminated.

Although I have shown and described but one embodiment of my invention, it will undoubtedly be apparent to those skilled in the art that other modifications and forms thereof are possible. I therefore desire that my invention shall not be limited except insofar as is made necessary by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In electronic heating apparatus for heating a dielectric workpiece, the combination of a pair of spaced, cooperating electrodes, a source of high frequency electric energy having a pair of output members one of which is maintained at a reference potential and the other at a potential which varies with respect to said reference potential, means coupling said electrodes each to a separate one of said output members, said coupling means having a length which is long compared to the wave length at said high frequency, said coupling means being so terminated at said electrodes that there tends to be set up in the path between that one of said electrodes which is coupled to said reference potential output member and said last named output member a standing voltage wave which would cause said last named electrode to have a voltage thereon other than at said reference potential, and low impedance means connecting said last named electrode to a point at said reference potential for providing a low impedance path between said last named electrode and said point whereby to eliminate said standing wave.

2. The invention set forth in claim 1 wherein

said low impedance means comprises a reactive element.

3. The invention set forth in claim 1 wherein said low impedance means comprises a capacitor.

4. In electronic heating apparatus for heating a dielectric workpiece, the combination of a pair of spaced electrodes adapted to receive said workpiece therebetween, a source of high frequency electric energy having a pair of output members one of which is maintained at ground potential and the other at a potential which varies with respect to ground potential, means coupling said electrodes each to a separate one of said output members, said coupling means having a length which is long compared to the wave length at said high frequency, said coupling means being so terminated at said electrodes that there tends to be set up in the path between that one of said electrodes which is coupled to said grounded output member and ground a standing wave of voltage at said frequency which would cause said last named electrode to have a voltage thereon other than at ground potential, and a low impedance capacitor connected between said last named electrode and ground in shunt with that portion of said path in which said standing wave tends to exist whereby to eliminate said standing wave and bring the voltage on said last named electrode to ground potential.

5. In electronic apparatus for heating a dielectric workpiece, the combination of an electro-conductive bedplate adapted to support said workpiece, said bedplate being maintained at ground potential, a pair of spaced electrodes associated with said bedplate in spaced relation to each other for receiving said workpiece therebetween, a source of high frequency electric energy having a pair of output members one of which is also maintained at ground potential and the other of which is maintained at a potential which varies with respect to ground potential, means coupling said electrodes each to a separate one of said output members, said coupling means having a length which is long compared to the wave length at said high frequency, said coupling means being so terminated at said electrodes that there tends to be set up in the path between that one of said electrodes which is coupled to said grounded output member and ground a standing wave of voltage at said frequency which would cause said last named electrode to have a voltage thereon other than at ground potential, and an electro-conductive plate mounted in close proximity to said last named electrode and in closely spaced relation to said bedplate, said plate and bedplate cooperating to provide a low impedance capacitor in shunt with that portion of said path in which said standing wave tends to exist for eliminating said standing wave and bringing the voltage on said last named electrode to ground potential.

6. In electrical apparatus for heating a dielectric workpiece, the combination of an electro-conductive bedplate adapted to support said workpiece and having an opening therein, said bedplate being maintained at ground potential, a pair of electro-conductive rollers arranged for peripheral cooperation and constituting electrodes adapted to receive said workpiece therebetween, one of said rollers being disposed on one side of said bedplate and the other on the opposite side thereof, said other roller extending through said opening into cooperative relation with said first mentioned roller, a source of

high frequency electric energy having a pair of output members one of which is also maintained at ground potential and the other of which is maintained at a potential which varies with respect to ground potential, means coupling said first mentioned roller to said grounded output member and said other roller to said other output member, said coupling means having a path length between said grounded output member and said first mentioned roller which is long compared to the wave length at said high frequency, said coupling means being so terminated at said electrodes that there tends to be set up in said path length a standing wave of voltage at said frequency which would cause said first mentioned roller to have a voltage thereon other than at ground potential, and an electro-conductive plate mounted in close proximity to said first mentioned roller and in closely spaced relation to said bedplate, said plate and bedplate cooperating to provide a low impedance capacitor in shunt with said path length for eliminating said standing wave and bringing the voltage on said first mentioned roller to ground potential.

7. In electrical apparatus for heating a dielectric workpiece, the combination of an electro-conductive bedplate adapted to support said workpiece and having an opening therein, said bedplate being maintained at ground potential, a pair of electro-conductive rollers arranged for peripheral cooperation and constituting electrodes adapted to receive said workpiece therebetween, an elongated, electro-conductive head carried by said bedplate on one side thereof and extending to a point over said opening, one of said rollers being rotatably carried by said head in alignment with said opening, means rotatably mounting the other of said rollers on the opposite side of said bedplate, said other roller extending through said opening into cooperative relation with said first mentioned roller, a source of high frequency electric energy having a pair of output members one of which is also maintained at ground potential and the other of which is maintained at a potential which varies with respect to ground potential, means coupling said other roller to said other output member, said head serving to connect said first mentioned roller to ground but having a length between its connection to said grounded bedplate and said first mentioned roller which is long compared to the wave length at said high frequency, said head having such an impedance at said high frequency that there tends to be set up in said head a standing wave of voltage at said frequency which would cause said first mentioned roller to have a voltage thereon other than at ground potential, and an electro-conductive plate carried by said head in close proximity to said first mentioned roller and in closely spaced relation to said bedplate, said plate and bedplate cooperating to provide a low impedance capacitor between said first mentioned roller and said bedplate in shunt relation with said head for eliminating said standing wave and bringing the voltage on said first mentioned roller to ground potential.

8. In electronic heating apparatus for heating a dielectric workpiece, the combination of a pair of spaced, cooperating electrodes, a source of high frequency electric energy having a pair of output members one of which is maintained at a reference potential and the other at a potential which varies with respect to said reference potential, means coupling said electrodes each to a

separate one of said output members, said coupling means including in the portion thereof which couples said reference potential output member and that one of said electrodes which is coupled to said last named output member a member which is long compared to the wave length at said high frequency and which has a relatively high impedance at said high frequency whereby there tends to be set up along said high impedance member a standing voltage wave which would cause said last named electrode to have a voltage thereon other than at said reference potential, and low impedance means connecting said last named electrode to a point at said reference potential for providing a low impedance path between said last named electrode and said point whereby to eliminate said standing wave.

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