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DIELECTRIC HEATING DEVICE AND RF CONTROL COILS THEREFOR

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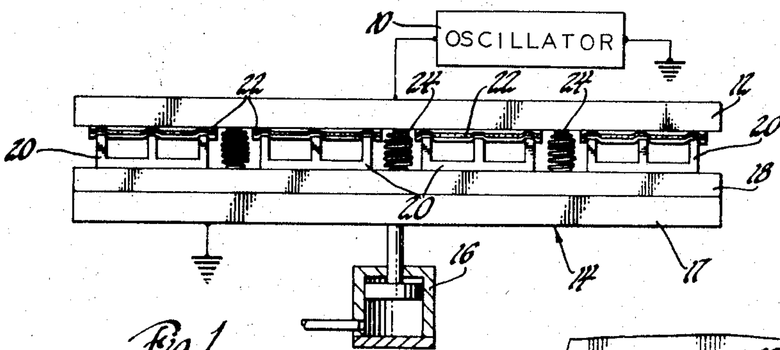

Fig. 1

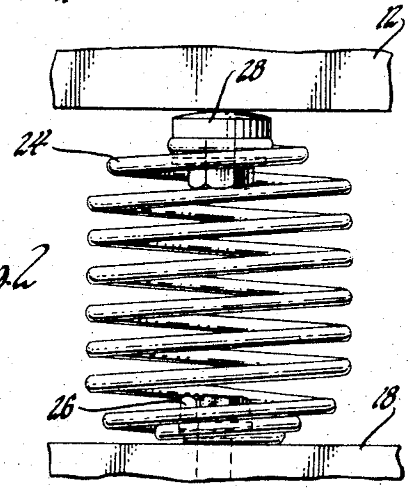

Fig. 2

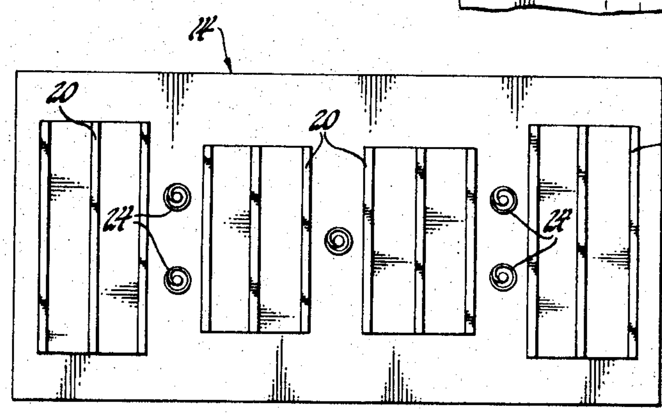

Fig. 3

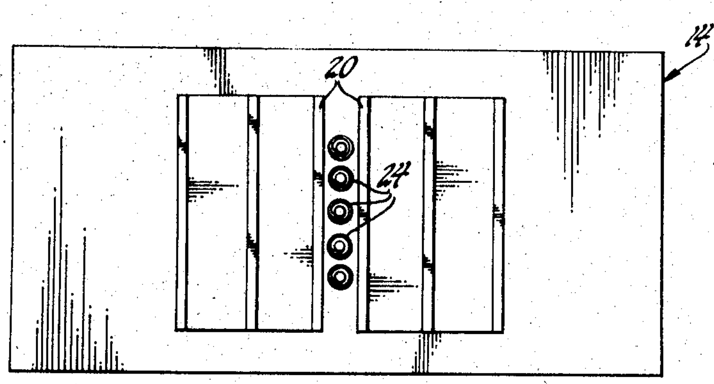

Fig. 4

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DIELECTRIC HEATING DEVICE AND RF CONTROL COILS THEREFOR

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ABSTRACT OF THE DISCLOSURE

In a dielectric embossing apparatus containing several embossing dies, RF tuning coils between the dies are releasably connected across the electrodes to minimize an uneven voltage distribution.

This invention relates to dielectric heating apparatus and particularly to impedance modifying means for minimizing uneven voltage distribution along the high voltage electrode.

In certain applications of dielectric embossing, for example, the embossing of automobile trim material, a large embossing press, say 40 by 80 inches, contains a plurality of embossing dies so that several separate trim items may be processed simultaneously. The trim material typically comprises a sandwich of a backing sheet, a polyvinyl chloride facing sheet, and intermediate filler material. Such trim materials require very accurate control of the heat applied thereto since if the temperature becomes too high, blistering of the polyvinyl chloride will occur and if the temperature is too low, satisfactory adhesion between the several layers of material is not obtained. It has been found that in such large dielectric embossing presses, it is common for both conditions to obtain at the same time, i.e., blistering will occur in one portion of the press and poor adhesion will occur in another portion. This is attributed to an uneven heating of the trim sandwich. In presses of this type, radio frequency electrical energy is applied across the electrodes and the frequency is such that the size of the electrode is approximately one-eighth wave length, thereby creating a standing wave on the high voltage electrode, with the maximum voltage theoretically occurring at the center of the electrode, although in practice, due to imperfect loading of the press, the high voltage node may shift from the center somewhat. In any event, the edges and particularly, the corners of the electrode have a voltage substantially less than the maximum, typically 16 to 22% less. Since the temperature generated in any specific portion of the press is a function of the voltage at that point, the temperatures will vary by as much as 35° F. However, the trim material has a permissable heating range of only 12½° F., which means that the voltage range across the embossing dies must be held within a 4% variation from maximum.

It has been suggested in the prior art that for applications requiring relatively coarse temperature control, e.g., laminating wood, uneven voltages may be held to within 5 or 6% variation by inductors or tuning stubs across the electrodes along the edges thereof, each inductor to tune a portion of the electrodes into resonance with the power source. There, however, the prior art was dealing with electrodes 13 feet long and 6 inches wide where several

standing waves with incident voltage variations were occurring along the length with only minor variations occurring across the narrow conductor width. In applying that teaching, however, to electrodes of large width, this expedient of placing inductors along the electrode edges would aggravate the uneven voltage distribution rather than ameliorate it.

It is therefore an object of this invention to provide improved dielectric heating apparatus and more particularly dielectric embossing apparatus.

It is a further object of this invention to provide dielectric heating apparatus with means for controlling the range of heating occurring therein.

It is another object of this invention to provide dielectric heating apparatus with means for controlling the voltage variations across the electrodes.

It is a further object of the invention to provide an impedance adjusting means across the electrodes of the dielectric heating apparatus.

Yet another object of this invention is to provide an inductor suitable to be placed across the electrodes of the dielectric embossing press and remote from the electrode edges.

The invention is carried out by providing inductors across the electrodes of the dielectric embossing press, the inductors being judiciously located between the dies to minimize voltage variations.

The invention is further carried out by providing means to alter the localized load impedance between the electrodes and accordingly to alter the pattern of voltage distribution on the high voltage electrode. More specifically, the means comprises coil springs secured to one electrode remote from the edges thereof and biased toward the other electrode. The springs serve as inductors.

The invention is also carried out by providing inductors suitable for connecting across electrodes of a dielectric embossing press comprising coil springs coated with a highly conductive metal and including means for releasably contacting an electrode surface.

The above and other advantages will be made more apparent from the following specification taken in conjunction with the accompanying drawings wherein like reference numerals refer to like parts and wherein:

FIGURE 1 is a cross-sectional schematic view of a dielectric embossing apparatus with tuning inductors according to the invention;

FIGURE 2 is a detailed drawing of the tuning inductor according to the invention;

FIGURE 3 is a plan view of the lower electrode including the embossing dies of the apparatus in FIGURE 1; and

FIGURE 4 is a plan view of the lower electrode of an embossing press according to the invention, which press has a different die arrangement than that of FIGURE 1.

FIGURE 1 illustrates a dielectric embossing press including a high frequency oscillator 10 connected between ground and an upper electrode **12**. A lower electrode **14** is electrically grounded and is mounted on a fluid motor **16** so as to be vertically movable between open and closed position. The electrode **14** includes a lower platen **17**. A loading tray **18** rests on platen **17** and forms a part of the lower electrode **14** and four separate embossing dies **20** are secured to the loading tray **18** and also form a part of the lower electrode. Sandwiches of trim material

22 are supported by the embossing dies 20 so that when the fluid motor 16 places the press in closed position, the trim sandwiches 22 are squeezed against the lower or inner surface of electrode 12. A plurality of coil springs or inductors 24 are secured to the loading tray 18 and are located in the spaces between the dies 20 and remote from the electrode edges. The upper portion of the inductors 24 contact the lower surface of electrode 12 when the press is in closed position and are disengaged from electrode 12 when the press is open so that the load tray 18 may be withdrawn for removing the embossed trim sandwiches and loading new trim material.

The inductors 24 are best shown in FIGURE 2 wherein it is seen that the inductors comprise a coil spring having several central turns of uniform diameter and on each end, two turns of progressively smaller diameters, the terminal turn on each end being small enough to form an eyelet for receiving a threaded fastener. The lower end of inductor 24 is secured to the loading tray 18 by a bolt 26 while the upper end has a contact button 28 secured thereto, which button releasably makes contact with the upper electrode 12.

A plan view of the lower electrode 14 is illustrated in FIGURE 3 wherein the relationship between the dies 20 and the inductors 24 is apparent, the inductors being remotely located from the periphery of the electrode 14 and being located in the spaces between the dies 20.

As stated above, the purpose of the inductors is to minimize the voltage variations on the upper electrode 12. Without the inductors the high frequency electrical energy applied to the upper electrode forms a standing wave along the surface of the upper electrode 12 and considering only the inner surface of the electrode 12, which faces the embossing dies, the standing wave produces a node of maximum voltage at the geometrical center of the electrode under ideal conditions and the voltage decreases toward the electrode periphery. The equal potential lines surrounding the node are generally dog bone shaped, extending longitudinally along the major axis of the electrode. Without the inductors, the voltage at locations corresponding to the extreme outer corners of the outer dies 20 approach values of 9% below the maximum voltage at the die area, which is more than double the amount of variation permissible to achieve acceptable dielectric embossing results. To obtain a satisfactory bond between the layers of the trim sandwich, it is essential that the voltage variation in the die area of the electrode be no more than 4%. When the voltage variation exceeds this amount, poor bonding occurs in the low voltage areas or blistering occurs in the high voltage areas, or both.

According to this invention, the voltage pattern is modified by placing localized inductive loads across the inner surface of the electrodes. Such inductive loads have the effect of lowering the voltage in their general vicinity. Thus, if inductors were placed near the electrode periphery as has been suggested by the prior art, the already low voltages along the periphery will be lowered even further thereby aggravating the problem. Rather, it is necessary to place the inductors at locations remote from the electrode periphery in the ranges of normally high voltage. Then the high voltages will be reduced to lessen the amount of voltage variation.

A specific example of a dielectric embossing structure according to this invention is illustrated in FIGURE 4 which discloses an electrode 14 and a single pair of dies 20 symmetrically located about the center. Five inductors are located along the transverse central axis of the electrode midway between the dies 20 and symmetrically located with respect to the center of electrode 14. For a specific installation, the electrode 14 was 40 by 80 inches and the dies were 18 by 29 inches spaced 4½ inches apart. The central inductor was placed at the center of the electrode and the other inductors were placed 3 inches apart on centers. The inductors comprise coil springs as illustrated in FIGURE 2 comprising ten turns and have a diameter of 2 inches and a length of 2.25 inches when not compressed. The coil is comprised of 0.1285 diameter stainless steel stock plated with 0.0005 inch of silver and a silver contact button 28 was used. The coil has a Q of 344 at 20 megacycles and an inductance of 1.187 microhenries. The oscillator frequency was 20 megacycles which is not a resonant frequency for the dielectric embossing press, resonant frequencies being considered undesirable because of instability problems and consequent difficulty in controlling the operating parameters. With this arrangement, the voltage variation in the die area does not exceed the critical value of 4% below the maximum voltage.

It will thus be seen that this invention provides a means for controlling the temperature variations in dielectric heating devices and more particularly in dielectric embossing presses where the very critical temperature range is essential to satisfactory performance and that the invention will further provide a specific inductor suitable for releasably interconnecting the inner surface of dielectric heating electrodes. The specific form of the coil spring which forms the inductor 24 requires that the two turns on each end be of progressively smaller diameter than the central turns providing openings at the top and bottom of the inductor to permit the escape of the magnetic field thereby reducing the amount of inductive heating which would occur in a cylindrical coil.

The preferred embodiment of the invention described herein is for purposes of illustration and the scope of the invention is intended to be limited only by the following claims:

It is claimed:

1. In dielectric embossing apparatus, the combination comprising a pair of electrodes; a high frequency electrical source connected across the electrodes; one of the electrodes comprising, in part, a plurality of embossing dies each for embossing a separate article; and a plurality of inductors connected across the electrodes and located between the dies.

2. In dielectric embossing apparatus as described in claim 1 wherein the electrodes are movable apart and the inductors are secured to one electrode and resiliently biased toward the other electrode to releasably contact said other electrode.

3. In dielectric heating apparatus for treating a plurality of separate articles, the combination comprising a pair of electrodes spaced to receive the plurality of articles therebetween, a high frequency power supply connected to one of the electrodes, the other electrode being grounded, and a plurality of inductors across the electrodes and disposd between the articles.

4. In heating apparatus, in combination, a pair of spaced electrodes, a high frequency electrical energy source connected to the outer surface of one of the electrodes for normally creating a standing wave over the electrode surface having maximum voltage near the center of the inside surface of the one electrode and substantially lower voltages at other points on the said inside surface, the other electrode being grounded, and means for mitigating the uneven voltage distribution comprising a plurality of reactive elements across the electrodes and remote from the electrode edges.

5. In dielectric heating apparatus, the combination comprising a pair of spaced electrodes, a high frequency electrical power supply connected across the electrodes, means for displacing the electrodes toward and away from each other for moving them to closed and open position respectively, a plurality of laterally spaced dies incorporated in an electrode and at least one inductor secured to one electrode between a pair of adjacent dies and resiliently engaging the other electrode in closed position and disengaged from the other electrode in open position.

6. In dielectric heating apparatus as described in claim

5 wherein the inductor is a coil spring coated with a highly conductive metal.

References Cited

UNITED STATES PATENTS

1,231,875	7/1917	Gifford ----------	336—231 X
1,810,499	6/1931	Romp ----------	174—126.2 X
1,904,241	4/1933	Kammerer --------	174—126.2
2,892,915	6/1959	Gard et al. ------	219—10.75 X
2,948,929	8/1960	Stallard --------	219—10.53 X
3,053,960	9/1962	Spieles ------------	219—10.53

FOREIGN PATENTS

1,151,084	8/1957	France.

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