Nov. 12, 1957 W. RUEGGEBERG 2,813,184

DIELECTRIC HEATING SYSTEM

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Fig. 1

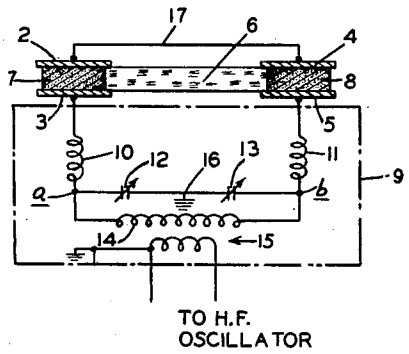
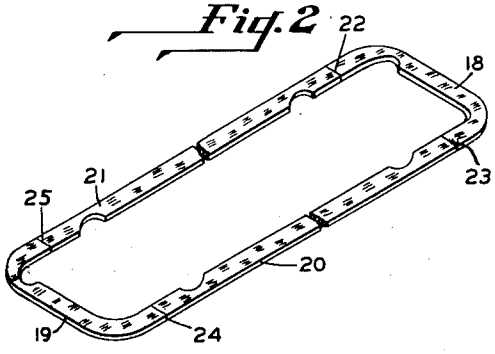


Fig. 2



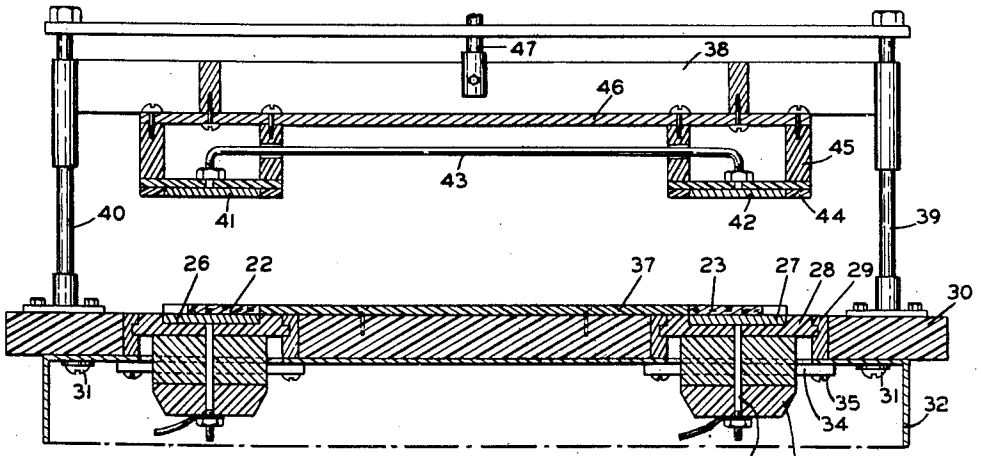


Fig. 3

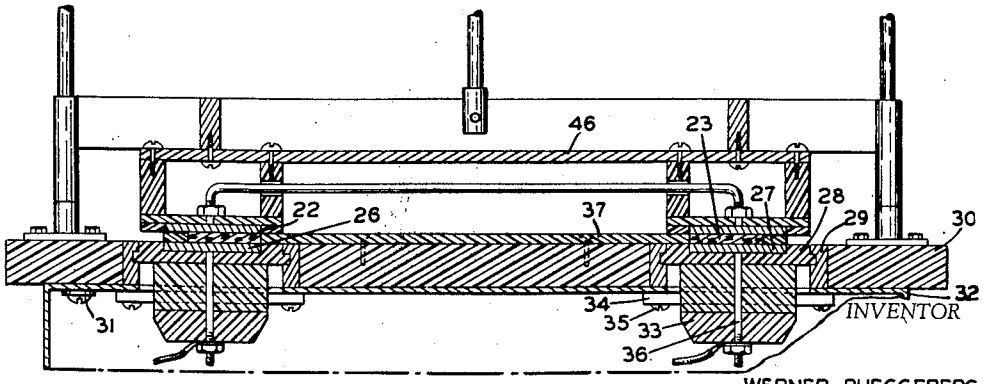


Fig. 4

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DIELECTRIC HEATING SYSTEM

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This invention relates to the art of dielectric heating. It is concerned particularly with a system for simultaneously dielectrically heating a workpiece or workpieces in a plurality of zones.

The invention will be described as applied to the heating of a plurality of spaced adhesive joints, for such a fabrication operation is typical of the fields in which the invention will be useful.

In the manufacture of sealing gaskets of cork composition, for instance, dielectric heating may be utilized to activate an adhesive layer disposed between the abutting edges of the end pieces and side pieces of a generally rectangular frame-shaped valve cover gasket. In such an apparatus the electrodes will be positioned above and below the workpieces over the joints, and the electric fields of force will be directed generally along lines parallel to the adhesive line. Manual manipulations involved in feeding the segments which form the gasket, effecting the desired heating, and discharging the finished pieces are minimized if at least two and preferably all four of the joints are made simultaneously. This poses the problem of obtaining uniform dielectric heating in all of the joints. There are many factors which affect such heating. For instance, variations in the thickness of the adhesive line, variations in any air gaps which may exist between workpiece and electrode, and variations in moisture content of the workpiece in different working areas adjacent to the adhesive line or therein, all directly affect the heating rate, resulting in nonuniform heating in different joints, and under aggravated conditions actually resulting in arcing between adjacent electrodes.

An object of the invention, therefore, is to provide for automatic temperature regulation in a multiple unit dielectric heating system where the fields of force from a single high-frequency energy source are applied to spaced areas of a workpiece or workpieces, avoiding objectionable variations in temperature at the various heated areas and minimizing the problem of arcing.

There is a substantial problem of radiation of high-frequency waves from commercial installations where high-frequency electrical heating is employed. Frequently, elaborate shielding is necessary to meet the requirements of the Federal Communcations Commission respecting the radiation of stray high-frequency fields, and this problem is aggravated in systems where the electrodes are movable relative to the workpiece as in gasket assembly equipment.

Accordingly, another object of the invention is to provide a dielectric heating system in which high-frequency wave radiation will be minimized inherently within the system.

An additional serious problem associated with dielectric bonding units is to minimize the hazards of accidental contact by operating personnel with an electrically charged part of the system substantially above ground potential. This frequently requires cumbersome safety guards and accessories which present a substantial maintenance problem, anything less than perfect operation being hazardous.

A further object of the invention is to provide a dielectric heating system in which the exposed parts of the unit which might be engaged by operating personnel are essentially at average ground potential.

In many dielectric heating systems it is necessary to

provide for circuit completion to ground through the electrodes. This reaches serious proportions in a multiple head dielectric bonding unit such as might be used in gasket manufacture.

An additional object of the present invention is to provide for circuit completion in a dielectric heating system without a specifically provided ground return from the electrodes.

Other objects of the invention will become apparent from consideration of the following detailed description of an embodiment of the invention which will be described in conjunction with the attached drawing, in which:

Figure 1 is a schematic diagram of a dielectric heating arrangement including a pair of bonding units;

Figure 2 is an isometric view showing a segmented, frame-shaped gasket;

Figure 3 is a diagrammatic sectional view showing the general construction of a two-unit bonding arrangement with the electrodes in "open" position; and

Figure 4 is a view similar to Figure 3 with the electrodes in "closed" position.

In the embodiment illustrated, there are two pairs of electrodes **2** and **3** and **4** and **5** between which workpiece **6** is disposed with its adhesive-coated faces **7** and **8** disposed perpendicularly to the planes of the electrodes. In gasket assembly, the workpiece **6** might be made up of an end segment and two side segments, and the coated faces **7** and **8** would be disposed at the joints where the side segments abut the end segment. Preferred practice in gasket assembly is to coat with adhesive all abutting surfaces to be joined, and thus the coated faces **7** and **8** may consist of the two adhesive-coated surfaces of the end segment and the adhesive-coated surface of each of the side segments.

The electrodes **3** and **5** are coupled to a high-frequency alternating current source as noted in Figure 1. This source may be a 200-watt, 65-megacycle high-frequency generator of conventional design and construction. An impedance matching network is provided within a grounded shielding case **9**. It includes inductances **10** and **11** and variable capacitances **12** and **13** connected to electrodes **3** and **5** and coil **14** of transformer **15** fed by the high-frequency generator, with a ground connection **16** between capacitances **12** and **13** at essentially the electrical center of the circuit. Electrodes **2** and **4** are electrically connected by lead **17** and are capacitively coupled to electrodes **3** and **5**, respectively, with the load **6** constituting a dielectric therebetween. While separate electrodes **2** and **4** have been illustrated, it will be clear that since they are electrically connected, a single electrode which is complementary to both electrodes **3** and **5** may be employed, if structurally more convenient. As will be noted from examination of Figure 1, a bridge type circuit results and high-frequency current from the generator is forced around a loop starting at *a*, for instance, through the workpiece **6** and its adhesive line **7**, through lead **17** and again through workpiece **6** but now at its adhesive line **8**, and then ending at *b*. The voltages at *a* and *b* are 180° out of phase with respect to point or connection **16** which is at ground potential. The electrodes **2** and **4** are not grounded but are what may be termed "floating secondary electrode means," with the electrodes **3** and **5** coupled to the source of high-frequency alternating voltage constituting what may be termed "primary electrodes."

It will be clear from the foregoing that electrodes **2** and **4** and lead **17**, which in actual commercial construction may constitute the movable electrodes of the machine disposed above the assembly table, as will be described more fully in conjunction with Figures 3 and 4, will have an average potential equal to potential at point **16** or ground. The voltage drop within the load or workpiece

6 from electrode 3 to electrode 2, for example, may be from 2500 volts to essentially 0 volt. The same would be true of the voltage drop within the workpiece from electrode 5 to electrode 4, assuming the impedance of the workpiece at adhesive lines 7 and 8 and adjacent thereto to be equal.

However, with the system of this invention, self-balancing of temperatures at the two adhesive lines or joints is obtained because of the series configuration of the electrode circuit and the variable impedance characteristics of each joint with respect to temperature. A marked decrease in impedance results when the temperature of the adhesive and the cork composition increases. Thus any increase in the temperature at one adhesive joint which is not equal to the temperature increase at the other joint results in a substantial difference in impedance between the respective pairs of electrodes 2—3 and 4—5. Assuming, for instance, that the adhesive joint 7 between electrodes 2 and 3 heats faster than the adhesive joint 8 between electrodes 4 and 5 because of differences in adhesive line thickness, for example, its heating rate automatically will be reduced through lower applied stress, since the majority of the voltage from point *a* to point *b* will be absorbed at adhesive line 8 because of its higher impedance. The majority of the applied voltage thus will be absorbed by the two joints in such manner that the temperature of neither joint at any time will exceed greatly that which exists in the other.

In the diagram of Figure 1, the adhesive joints 7 and 8 have the same surface area. In some segmented gaskets the adhesive joints to be formed may be of nonuniform surface area; and, in such event, the division of voltage between the two may be adjusted by the variable capacitances 12 and 13 to match the nonuniform impedances at the joints and, in operation, the system will be self-compensating for any deviations in heating rates in the manner discussed above.

The apparatus shown in Figures 3 and 4 may be used in the assembly of the segmented frame-shaped gasket shown in Figure 2. The gasket is made up of end pieces 18 and 19 and side pieces 20 and 21. All of the adhesive-bonded joints 22, 23, 24, and 25 may be activated simultaneously with a dielectric heating unit having two separate sources of high-frequency power, or two of the joints may be activated in one operation and the other two in a subsequent operation. Figures 3 and 4 show equipment for simultaneously forming two of the joints.

The unit comprises electrodes 26 and 27, each of which is received within an insulating holder 28 which may be made of polytetrafluoroethylene or other electrical insulating material possessing the requisite dielectric properties. The holder 28 is received within a metal frame 29 disposed within a work table 30 which may be made of reinforced phenolic resin or other insulating material. Screws 31 secure a metal impedance matching network case 32 to the table 30, and a clamping arrangement 33—34 with screws 35 which pass through the case 32 and into the electrode holder frame 29 holds each of the electrode assemblies in fixed position. A lead-connecting screw 36 extends from each electrode, and through these screws connection is made between the electrodes 26 and 27 and the impedance matching network system. A guiding frame 37 of polytetrafluoroethylene or other suitable insulating material may be fastened to table 30 to aid in aligning the pieces to be joined.

The upper electrode system comprises a carrier 38 mounted on slides 39 and 40 fixed to table 30. The carrier 38 is thus arranged for vertical reciprocation from the "open" or elevated position of Figure 3, in which position the pieces to be joined may be inserted in their proper relationship for heat activation, to the "closed" position of Figure 4. There are shown two electrodes 41 and 42 which are complementary to lower electrodes 26 and 27 and which are adapted to overlie the joints 22 and 23, for instance, of gasket segments 18, 20, and 21. The two electrodes are electrically connected by a conductor 43 which corresponds to the connection 17 of Figure 1. Electrodes 41 and 42 are mounted in polytetrafluoroethylene holders 44 or similar material, and the holders are in turn secured to insulating frame members 45 attached to a plate 46 secured to carrier 38. A carrier reciprocating member 47 is attached to carrier 38 and may be mechanically, hydraulically, or otherwise actuated to impart the desired vertical reciprocatory movements to the carrier.

The floating secondary electrode and its associated reciprocating mechanism are always at an average potential which is equal to ground potential and thus these exposed parts of the machine, above the operating table, are not "hot" and may be engaged by operating personnel without danger. This also minimizes the problem of radiation of high-frequency fields. This radiation problem is also reduced by virtue of the 180° phase shift between heating electrodes.

By having the electrode system in series configuration and in push-pull relationship with the high-frequency source through the impedance matching network, the desired division of applied energy to the two joints is obtained and self-balancing of temperature elevation in both joints consistently is assured. The system has a reduced sensitivity to air gaps which may exist between workpiece and electrode, to differences in adhesive thickness, and to the other variable factors which are frequently encountered in dielectric heating in multiple areas with a single high-frequency source. Arcing tendencies through the workpiece are also reduced to a point where they are of negligible importance. The complicated circuit completion arrangements to ground are not needed, for as a matter of fact no specific "ground" return is necessary or provided. The exposed electrode or electrodes will be at average ground potential; and this, together with the 180° phase shift between the heating electrodes, will minimize undesirable radiation.

I claim:

In a multiple-unit dielectric heating device, the combination of two primary electrodes, floating secondary electrode means capacitively coupled to said primary electrodes, said electrodes and said electrode means being arranged for the reception therebetween of material to be dielectrically heated in separate spaced areas, an impedance matching bridge circuit comprising a variable reactance disposed in each of two of the arms of said bridge, an inductance and the capacitance between one of said primary electrodes and said floating secondary electrode means disposed in each of the other two arms of said bridge, a ground connection at essentially the electrical center between said reactances, and means inductively coupling to said bridge across the arms thereof a source of alternating high-frequency electrical voltage to drive said bridge, whereby the voltages applied to said primary electrodes are maintained 180° out of phase with respect to ground as a result of the circuitry of said bridge and said floating secondary electrode means is maintained essentially at average ground potential.

References Cited in the file of this patent

UNITED STATES PATENTS

2,109,323	Smith	Feb. 22, 1938
2,298,038	Crandell	Oct. 6, 1942
2,309,303	Crandell	Jan. 26, 1943
2,333,412	Crandell	Nov. 2, 1943
2,474,420	Himmel	June 28, 1949
2,519,193	MacDermaid	Aug. 15, 1950
2,542,702	Prow	Feb. 20, 1951
2,546,004	Kinn	Mar. 20, 1951
2,551,757	Mittelmann	May 8, 1951
2,583,128	Stevenson et al.	Jan. 22, 1952
2,660,660	Von Hauteville	Nov. 24, 1953
2,662,162	Blok	Dec. 8, 1953