

Filed July 6, 1946

9 Sheets-Sheet 1

2,504,969

Fig. 1.

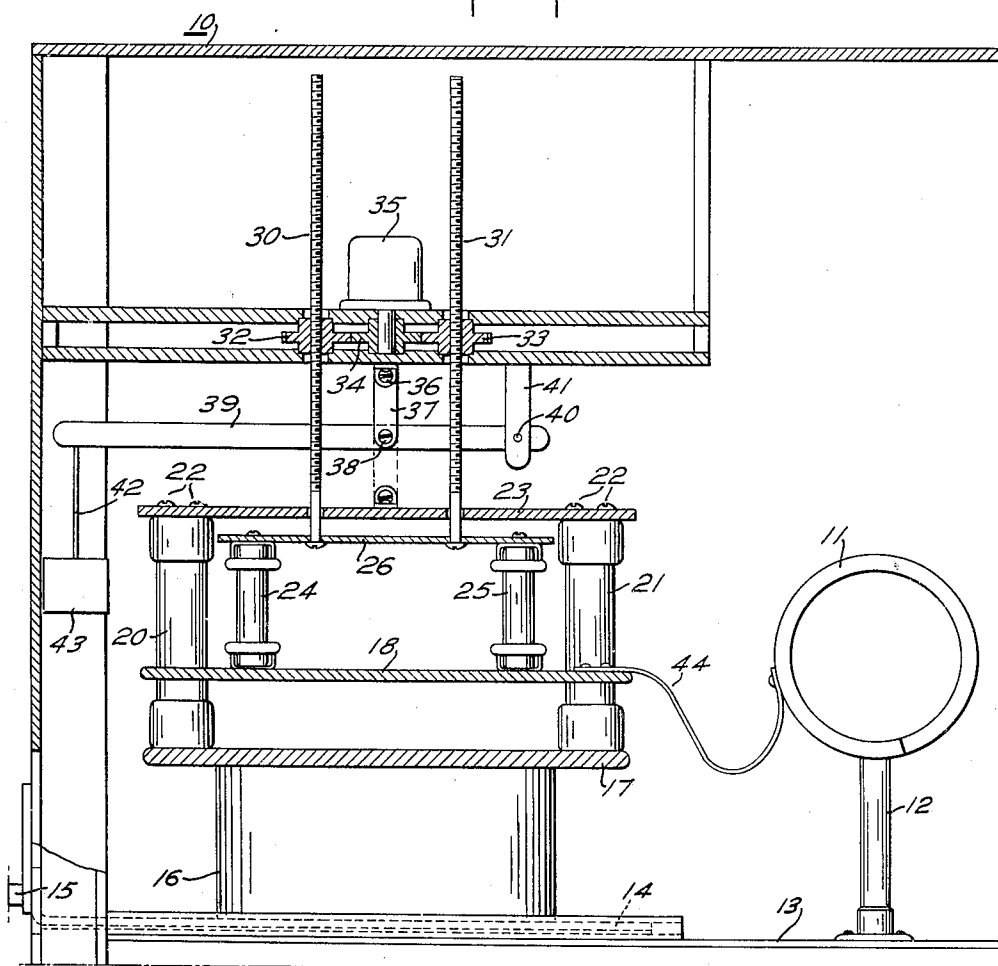
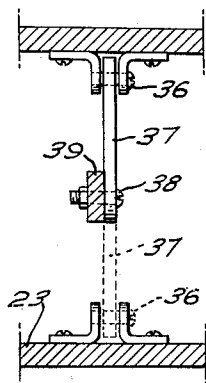


Fig. 1-A.

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April 25, 1950

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HIGH-FREQUENCY APPARATUS HAVING TWO WORK-ENGAGING
ELECTRODES AND ONE ADJUSTABLE ELECTRODE

2,504,969

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9 Sheets-Sheet 2

Fig. 2.

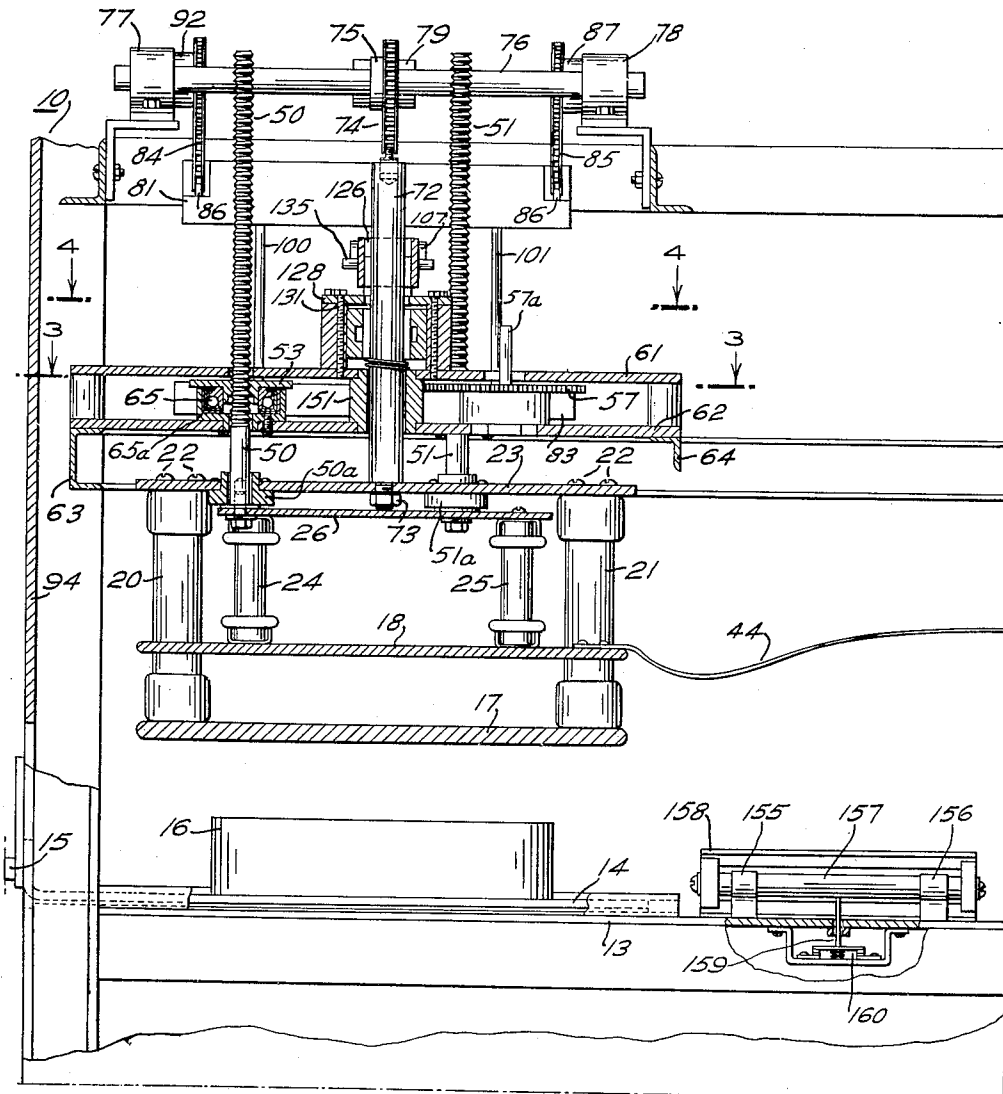
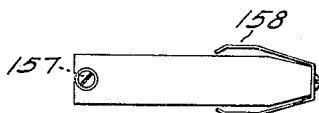


Fig. 2.A.

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9 Sheets-Sheet 3

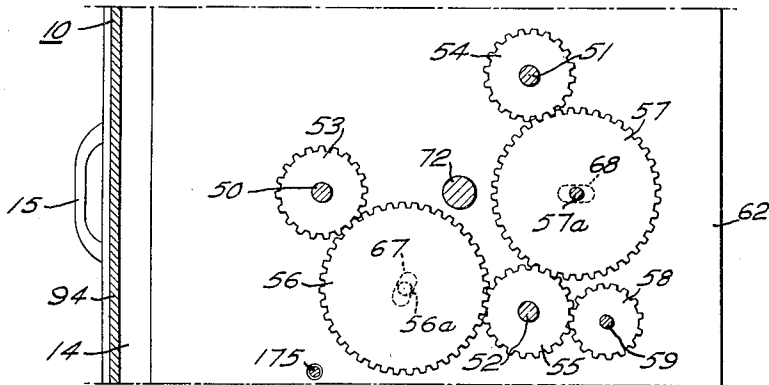


Fig. 3.

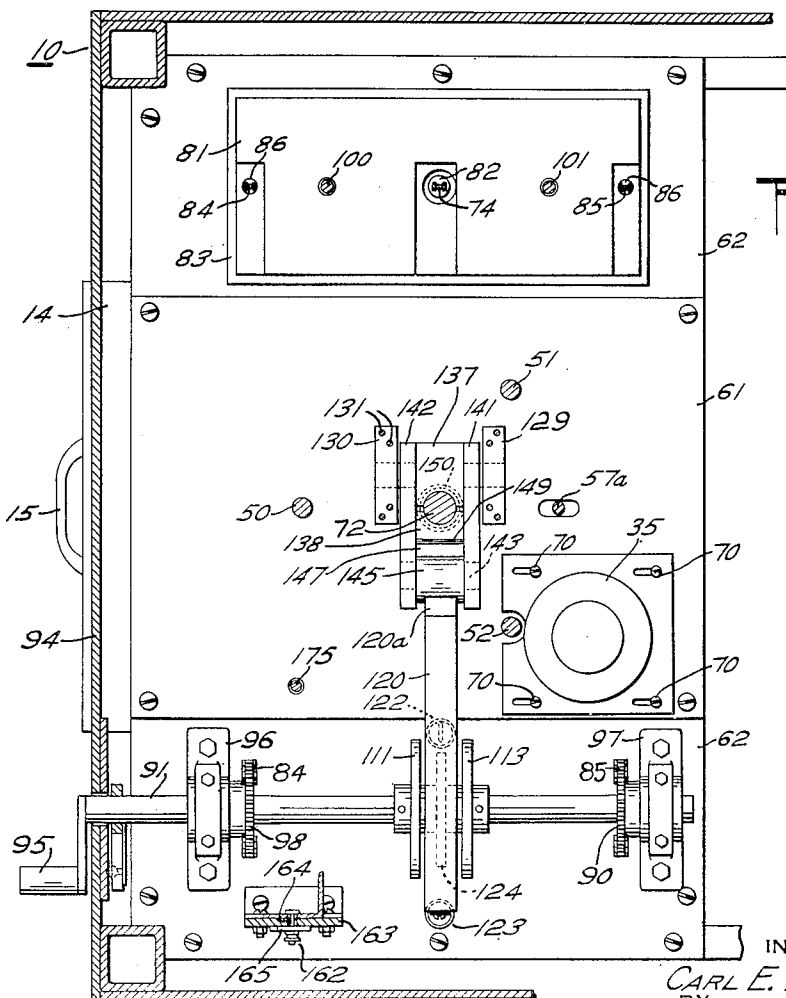


Fig. 4.

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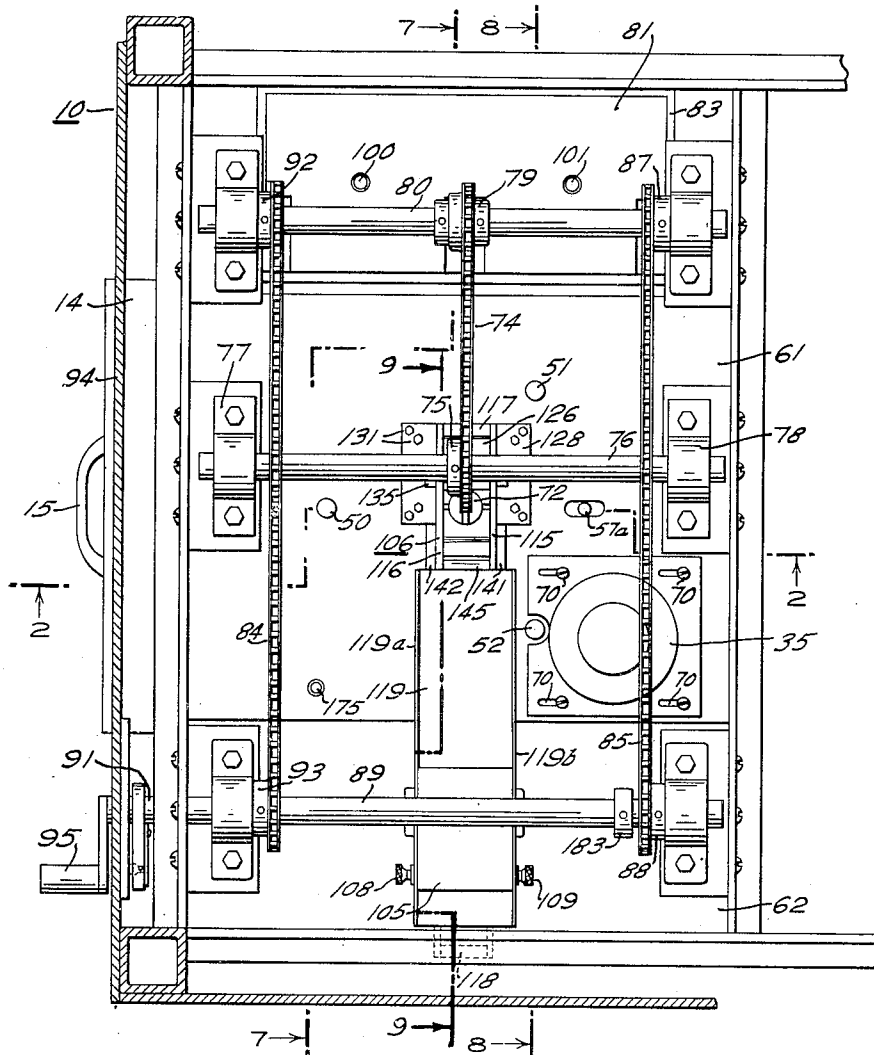


Fig. 5.

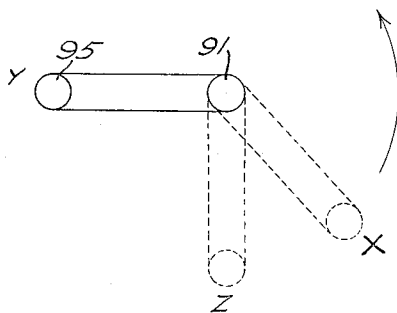


Fig. 6.

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9 Sheets-Sheet 5

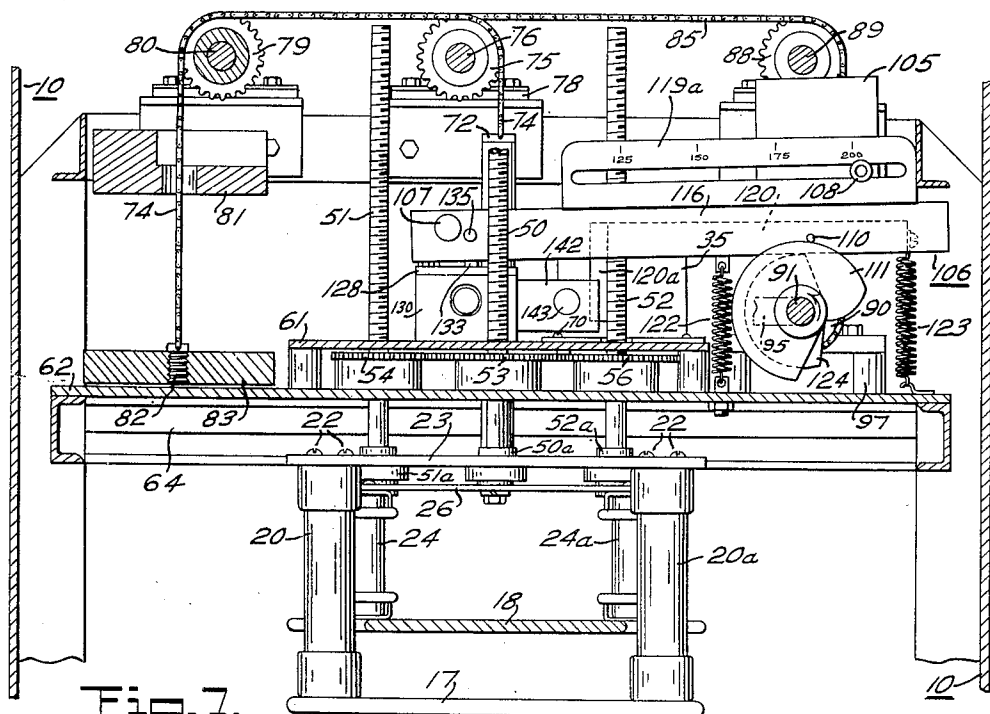


Fig. 7.

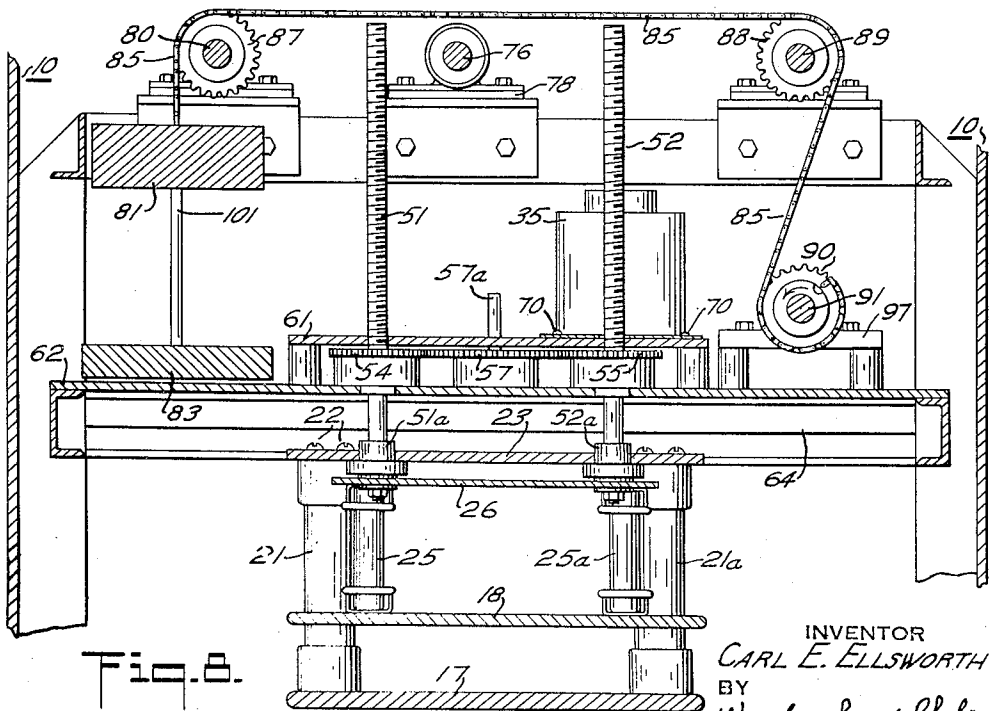


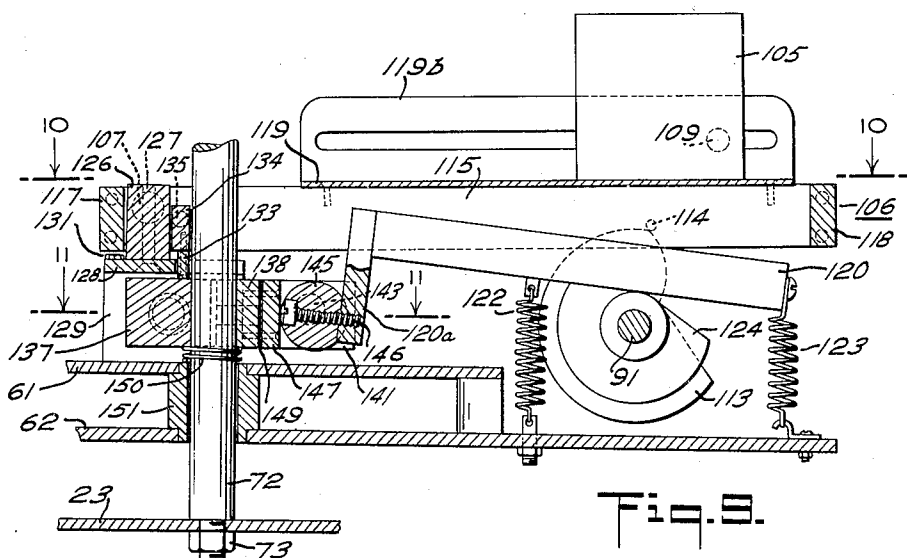
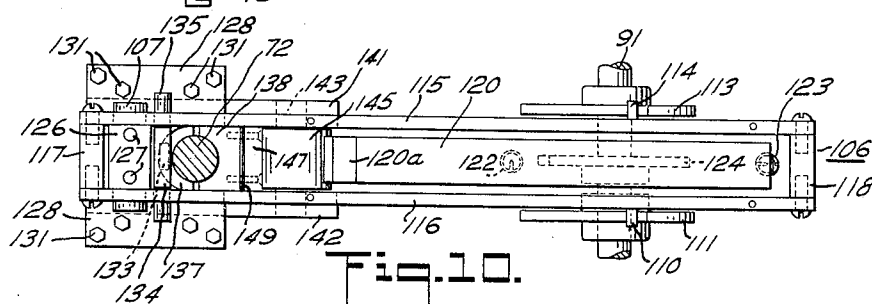
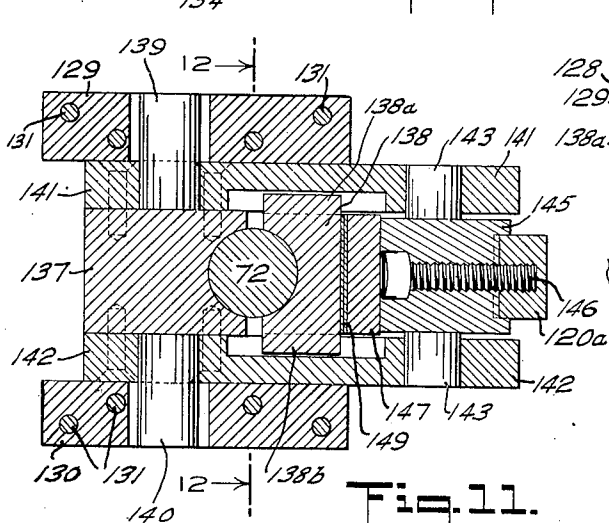
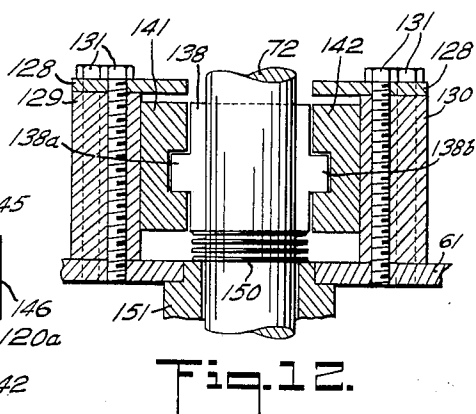
Fig. 8.

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FREQUENCY IN PHASES HAVING TWO WORK-ENG
ELECTRODES AND ONE ADJUSTABLE ELECTRODE

9 Sheets-Sheet 6



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2,504,969

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9 Sheets-Sheet 7

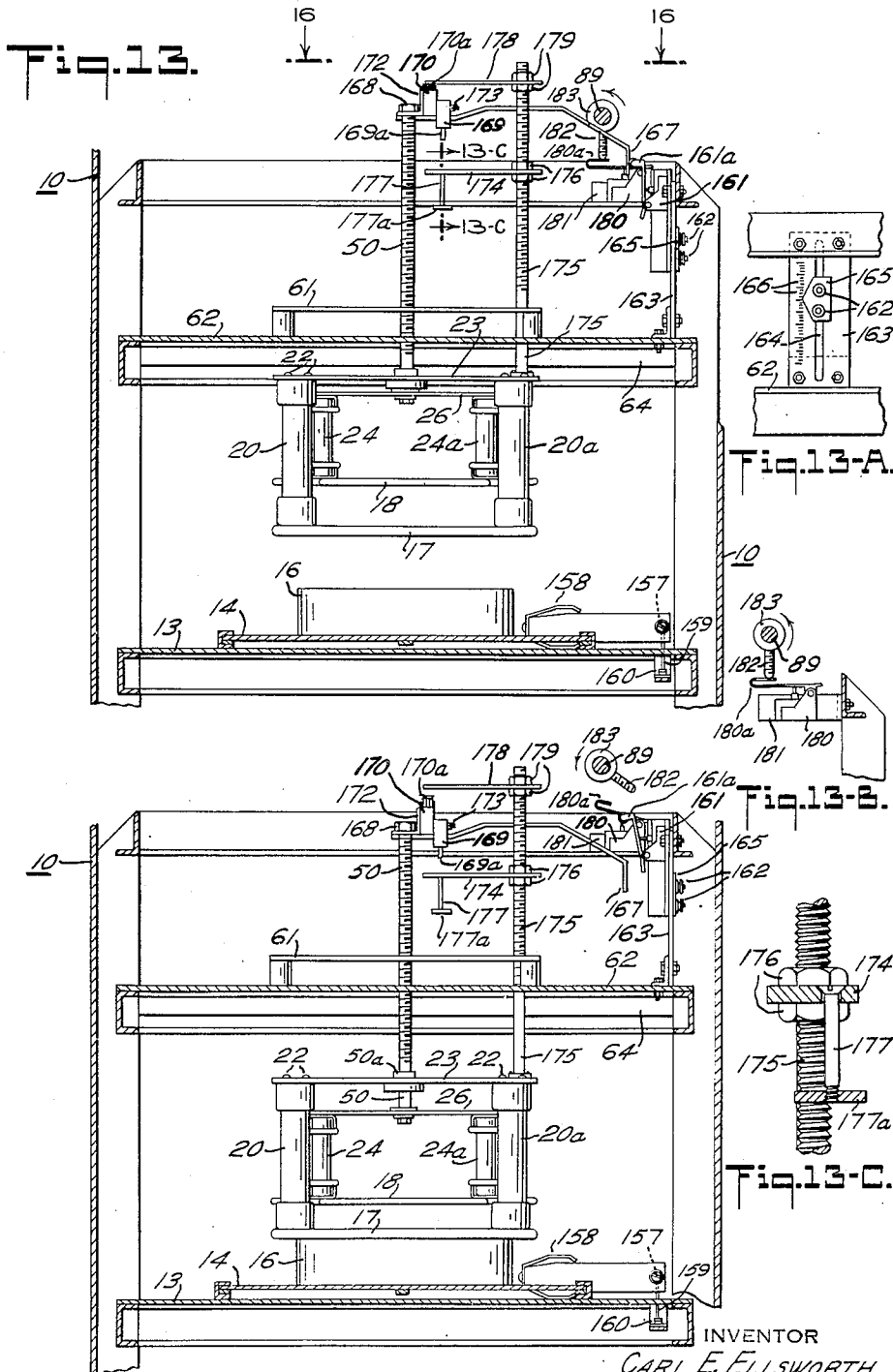


Fig. 14.

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HIGH-FREQUENCY APPARATUS HAVING TWO WORK-ENGAGING
ELECTRODES AND ONE ADJUSTABLE ELECTRODE

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9 Sheets-Sheet 8

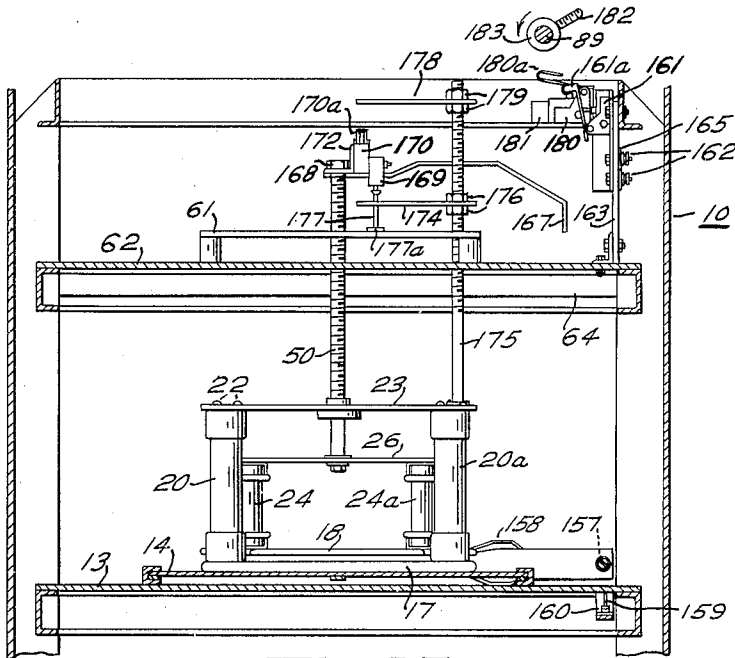


Fig. 15.

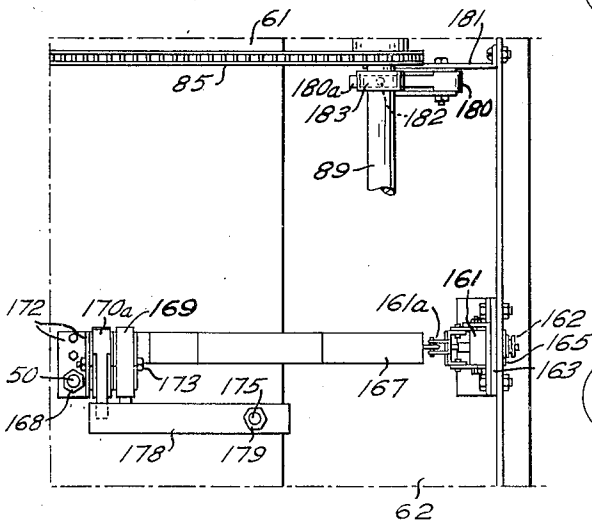


Fig. 16.

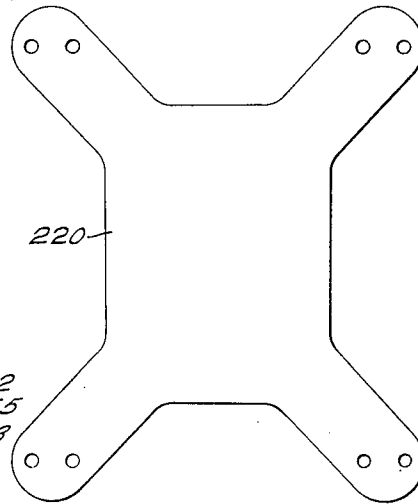


Fig. 17.

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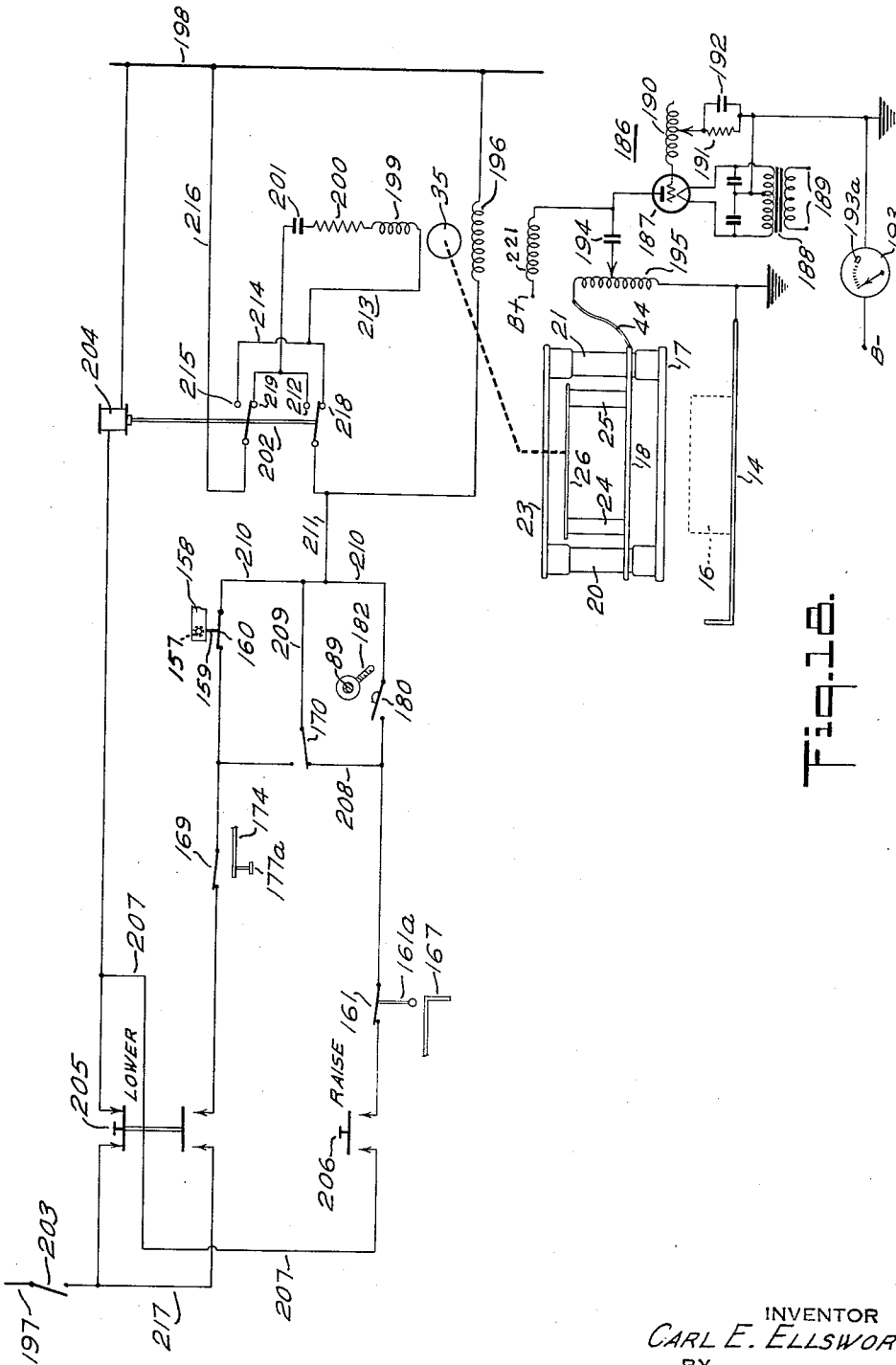


Fig. 1a.

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UNITED STATES PATENT OFFICE

2,504,969

HIGH-FREQUENCY APPARATUS HAVING
TWO WORK-ENGAGING ELECTRODES
AND ONE ADJUSTABLE ELECTRODECarl E. Ellsworth, Louisville, Ky., assignor to The
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tion of Delaware

Application July 6, 1946, Serial No. 681,664

20 Claims. (Cl. 219—47)

1

This invention relates to high-frequency treating systems for dielectric materials and has for an object the provision of means not only of applying pressure to the load or to the dielectric material undergoing treatment but also for regulating the amount of electrical power or energy applied to or absorbed by said material.

It has heretofore been recognized that dielectric materials change their characteristics with increasing temperature. The power factor and dielectric constant of many materials increase as the temperature rises. In accordance with the disclosure of a co-pending application, filed May 31, 1946, Serial Number 673,296, of W. L. Atwood, and assigned to the same assignee as the present invention, the dielectric material undergoing treatment may be disposed between two electrodes for application of pressure thereto, while a third electrode may be adjusted in a manner to produce a predetermined application of power to the material. While the system or arrangement of said Atwood application is believed to represent an improvement in the art, the present invention is a further improvement as regards both simplification of structure and flexibility of operation.

In carrying out the present invention in one form thereof, there may be applied to the dielectric material to be heated a uniform pressure of a predetermined magnitude which will be maintained constant during the heating of said material. The pressure-applying mechanism is separate from the mechanism for varying the tuning, or position of a control electrode, by means of which the voltage applied to the dielectric material may be changed. For some conditions of operation, the pressure-applying means may be rendered ineffective and the dielectric material may be heated in the absence of pressure or with an air space between it and one of the two electrodes between which the high-frequency energy is applied.

The present invention includes additional features of arrangement and constructional combinations and subcombinations, a detailed description of which, together with other objects and advantages of the invention, may be best set forth in the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a fractional sectional view of one form of apparatus embodying the invention;

Fig. 1—A is a fractional side view, partly in section, illustrating the manner in which the

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pressure-applying lever of Fig. 1 may be made effective or ineffective;

Fig. 2 is a fractional sectional view, taken on the line 2—2 of Fig. 5, of another apparatus embodying the invention;

Fig. 2—A is an end view of a shorting bar which under some conditions of operation may be inserted between two of the electrodes;

Fig. 3 is a fractional sectional view, taken on the line 3—3 of Fig. 2, with certain parts omitted;

Fig. 4 is a fractional sectional view taken on the line 4—4 of Fig. 2;

Fig. 5 is a plan view including parts shown in Fig. 2;

Fig. 6 is a side elevation of the operating handle of Fig. 5;

Fig. 7 is a fractional sectional view taken on the line 7—7 of Fig. 5;

Fig. 8 is a fractional sectional view taken on the line 8—8 of Fig. 5;

Fig. 9 is a sectional view of the clamping mechanism for the pressure-applying electrode taken on the line 9—9 of Fig. 5;

Fig. 10 is a fractional sectional elevation taken in plan on the line 10—10 of Fig. 9, with the member 119 omitted;

Fig. 11 is a sectional view on enlarged scale taken in plan on the line 11—11 of Fig. 9;

Fig. 12 is a sectional view taken in elevation on the line 12—12 of Fig. 11;

Fig. 13 is a side elevation, partly in section, illustrating the parts in certain positions with respect to associated limit switches;

Fig. 13—A is a fractional side elevation of one adjustable limit switch of Fig. 13;

Fig. 13—B is a detailed view illustrative of the manner of operation of another of the limit switches of Fig. 13;

Fig. 13—C is a sectional view on enlarged scale taken on the line 13c—13c of Fig. 13;

Figs. 14 and 15 are similar to Fig. 13 but the parts are illustrated in different positions for a better understanding of the operation of the several limit switches;

Fig. 16 is a fractional plan view taken on the line 16—16 of Fig. 13, illustrating the location of four of the limit switches;

Fig. 17 is a plan view of a modified form of a pressure electrode; and

Fig. 18 is a wiring diagram which schematically illustrates both the high-frequency oscillator and the manner in which the limit switches and other control devices are utilized in the operation of the invention as a whole.

Referring to the drawings, a simplified form

of the invention has been illustrated in Figs. 1 and 1—A, the apparatus as a whole being enclosed in a housing or cabinet 10. The power supply, the high-frequency generating equipment, and the like are preferably included in separate compartments in the cabinet while the output or oscillator coil 11, one end of which is connected to ground i. e. to the shelf or dividing wall 13 of the enclosing cabinet, may be mounted on pedestal-type insulators 12 supported from a dividing wall 13 in the compartment containing a normally stationary electrode illustrated in the form of a slidable tray 14. By means of handles 15, the tray electrode 14 may be removed for easy insertion or withdrawal of dielectric material to be heated, which, as illustrated, may be a preform 16. In typical applications of the invention, the preform 16 to be heated to a predetermined temperature, generally one at which the preform 16, formed of a thermoplastic or thermo-setting dielectric material, may be readily shaped in a press or mold to form the final product. High-frequency heating for applications of this character have been found to be very useful. In some cases, it is desirable to conduct the heating operations with both electrodes 14 and 17 between which the preform 16 is located contacting the preform, or while the preform 16 is under pressure. Accordingly, the second electrode 17 may be adjusted or moved to engage the preform 16 and also to apply the desired pressure. Above electrode 17 is a third electrode 18 adjustable to control the potential or voltage difference between the electrodes 14 and 17.

As shown, the electrode 17 is carried by or suspended from a plurality of insulators, preferably one at each corner thereof, two of them, the insulators 20 and 21, being shown in Fig. 1. At their upper ends they are secured, as by screws 22, to an upper plate 23. The electrode 17 is secured to the lower ends of the insulators by means of screws countersunk into the electrode. Similarly, the electrode 18 is supported by insulators 24 and 25, which at their upper ends are attached to a plate 26 which is movable independently of plate 23 and electrode 17 attached thereto. (With electrode 17 out of contact with load 16, the plate 23 rests on top of the screws in the plate 26.) Thus, the assemblies 17—23 and 18—26 may be supported from a pair of threaded rods 30 and 31 which threadedly engage axial holes through gears 32 and 33 which are both driven by a gear 34 secured to the shaft of a motor 35. By energizing the motor 35 for rotation in the proper direction, the threaded rods 30 and 31 are moved downward simultaneously to lower the electrodes 17 and 18. When the electrode 17 strikes the dielectric material or preform 16, the position shown in Fig. 1, its downward movement is of course arrested but continued rotation of the motor 35 in the same direction effects further lowering of the electrode 18 so that it moves nearer to the electrode 17. The corners of the electrode 18 are cut away so as to clear the insulators 20 and 21 and the two insulators not shown in Fig. 1, so that, if desired, the electrode 18 may be lowered substantially into contact with the electrode 17.

Normally, as soon as the electrode 17 engages the preform 16, the motor 35 will be deenergized. If the preform 16 is then to be heated while pressure is applied thereto, a pin or screw 36 will be removed to release a link 37 secured by pivot pin 38 to a lever 39 which is itself attached at one end by a pivot pin 40 to a bracket 41. The link

37 is rotated to the dotted-line position illustrated in Figs. 1 and 1—A where the screw 36 may then serve to connect the link to the plate 23. At the free end of the lever 39, there is attached thereto, as by a rod 42, a weight 43 of a predetermined size which, through the described lever system, applies to the electrode 17 a pressure of predetermined desired magnitude which in turn is transmitted to the preform 16. For preforms thinner than the one shown in Fig. 1, the link 37 may have to be longer than shown. Accordingly longer links or shorter links may be substituted for the link 37 to; accommodate loads of any desired thickness.

The oscillator or high-frequency generator is then energized for application to the preform 16 of high-frequency energy, the circuit being completed by way of a flexible connection 44 and the grounded tray-electrode 14. The preform 16 and the electrodes 14 and 17 form a capacitor in the output circuit. There is formed between the electrodes 17 and 18 a second capacitor in series therewith in the output circuit. Accordingly, the total voltage across the capacitors divides between them inversely as the ratio of their capacitances. Therefore, as the electrode 18 is brought nearer the electrode 17 to increase the capacitance between them, the voltage across that capacitor will decrease. This will result in an increase in the the voltage applied to the capacitor including the preform 16. Conversely, as the electrode 18 is moved farther away from the electrode 17, the voltage applied to the preform 16 will decrease. It will therefore be seen that an operator, by suitable energization of the motor 35 may maintain at any desired value within the limits of the high-frequency generator the out-put therefrom or the intensity of the application of high-frequency energy to the load or preform 16. If desired, the electrical energy delivered to or absorbed by the load comprising the preform 16 may be automatically maintained at a constant value notwithstanding changes in its power factor and dielectric constant, or any predetermined heating rate may be maintained therein by suitably adjusting the position of the electrode 18 with respect to the electrode 17. By utilizing a single motor, the control system may be made relatively simple and the apparatus as a whole may be relatively compact.

In the preferred form of the invention shown in Figs. 2—18, inclusive, parts corresponding with those of Fig. 1 have been identified by the same reference characters. It will be observed that the upper electrode or adjustable capacitor plate 18 is carried by insulators 24, 25 and 24a, 25a (Figs. 7 and 8) which are in turn secured to the upper plate 26. This plate 26 has secured to it three threaded rods 50, 51, and 52 (Fig. 3) which, respectively, threadedly engage axial holes through gears 53, 54, and 55. The rods 50—52 respectively extend through bushings 50a—52a provided in plate 23. An idler gear 56 interconnects the gears 53 and 55, while an idler gear 57 interconnects the gears 54 and 55. The gear train as a whole is driven by a driving gear 58 secured to the shaft 59 of the driving motor 35 (Figs. 4, 5 and 8). The gear train is supported between two plates 61 and 62 (Fig. 2) supported on cross members or beams 63 and 64, which form a part of the framework of the cabinet 10. Excluding gear 58, each gear hub is preferably pressed into an anti-friction bearing, such as a ball bearing 65, illustrated in section in Fig. 2, which is, in turn, pressed into a housing 65a,

said housing being secured to plate 62 as by screws. The bearing housings for the idler gears 56 and 57 may be adjusted for proper gear mesh, the plate 62 (Fig. 3) having elongated slots 67 and 68 for this purpose. The mesh of gear 53 with gear 55 is also adjustable by moving the motor assembly as a whole, suitable slots and locking screws 70 being provided as best shown in Figs. 4 and 5, said slots being long enough to provide adjustment for gears of smaller or larger sizes to obtain slower or faster electrode speeds as may be required. The use of the three threaded rods 50—52 provides a geometrically stable support for the subassembly including the plate 26, the associated insulators, and the upper electrode or capacitor plate 18. The shaft 57a of gear 57, Figs. 2, 4, 5, and 8, extends above the motor plate 61 as a convenient means of manually turning the gear train during testing or for adjustment of limit switches.

The second or intermediate electrode 17 and its sub-assembly, including the insulators 20, 20a, 21 and 21a, and the plate 23, are secured (Fig. 2) to a vertically extending lift rod or post 72 by means of a nut 73 which clamps the plate 23 against a shoulder of rod 72. The lift rod 72 at its upper end is connected to a chain 74 carried on a sprocket 75, Figs. 2, 5 and 7, which in turn is supported by a shaft 76 rotatably mounted by journals 77 and 78. The chain 74 extends (Figs. 5 and 7) over a sprocket 79, rotatably mounted with respect to a supporting shaft 80, and thence downwardly through a central opening in a counterweight 81. Its lower end is secured to a threaded stud 82 of a second counterweight 83. The counterweights 81 and 83 cooperate, in a manner that will later be described in detail, to control the direction of the force applied and thus the direction of movement of the assembly including the plate 23 and the electrode 17. The upper counterweight 81 has secured to it a pair of chains 84 and 85 (Fig. 5), which are shown in Fig. 2 as attached to threaded studs 86. The chain 85 extends over a sprocket 87 carried by the shaft 80, over a sprocket 88 carried by a shaft 89, and downwardly around a sprocket 90, one end being attached thereto by a screw extending through the down-turned link on the end of the chain 85, Fig. 8. The sprocket 90 is secured to an operating shaft 91.

Similarly, the other chain 84 extends from the other side or end of the counterweight 81 (Fig. 5) over sprockets 92 and 93, respectively carried by shafts 80 and 89, and thence downwardly to a sprocket 98 (Fig. 4), corresponding with the sprocket 90 (Fig. 8), which of course is also secured to the operating shaft 91. The operating shaft 91 (Figs. 4, 5, 7, and 8) is located directly beneath the shaft 89 and one end thereof extends outwardly through a wall 94 of the housing or cabinet 10. A crank 95 (Figs. 4 and 5) is secured to the end of the shaft 91 for actuation externally of the housing 10. The counterweight 81 is thus moved under the control of the crank 95. As best shown in Fig. 4, the crank shaft 91 is journaled in bearings 96 and 97. It will also be seen in Figs. 2 and 4 that the counterweights 81 and 83 are guided in their movement by rods 100 and 101. The rod 101 has been omitted in Fig. 7 in order not to be confused with the chain 74 which is directly in front of it. The counterweight 83 partially balances the weight of the assembly including the electrode 17. This partial bias limits the force with which 17 falls when 81 is suddenly raised. It also decreases the load which

the operator of the crank 95 must handle. It also decreases the load which the motor 35 must handle when moving both electrode assemblies. Movement of the counterweight 81 by means of the crank 95 thus may serve to control the movement of the assembly which includes the pressure-applying electrode 17 and its associated counterweight 83.

More specifically, the parts are illustrated (in Figs. 2, 3, 4, 5, 7 and 8) in positions corresponding with electrodes 17 and 18 at their maximum heights, and the crank located in its "Y" position as viewed in Fig. 6. The crank 95 will have been moved in a counterclockwise direction from the "X" position to the normal operating, or "Y" position. The shaft 91 (Fig. 8) will have been rotated in a counterclockwise direction. Since corresponding ends of the chains 84 and 85 (Figs. 4, 5 and 7) are bolted or otherwise secured to the sprockets 90 and 98, it will be seen that that rotation thereof will lift the counterweight 81 to its illustrated position. Since the assembly, including the pressure electrode 17, is heavier than the counterweight 83, the assembly including the electrode 17 will tend to descend. It may not descend because bushings 50a—52a of plate 23 are resting on plate 26. However, if the motor 35 is now energized in a direction to lower the assembly including the electrode 18, the assembly including the electrode 17 which is shown resting on plate 26 will also descend. Of course, as soon as the electrode 17 rests upon the top of the dielectric material or preform 16, its movement is arrested and its associated counterweight 83 likewise comes to rest. Continued operation of the motor 35 in the same direction will continue to lower the assembly including the electrode 18, but will have no effect upon the assembly including the electrode 17, because the rods 50, 51, and 52 slide freely through the bushings 50a—52a in plate 23. The parts are so proportioned that in rotating the crank from its "X" position to its illustrated "Y" position, the counterweight 81 will be raised to a height which will allow the electrode 17 to be lowered until it comes to rest upon a load of any height (within the limits of the design) that may be placed upon the tray electrode 14, or until the bushings 50a—52a in its supporting plate 23 come to rest on plate 26. By this arrangement, heat may be generated in thin loads while subjected to pressure as well as to thick loads or loads having a height equal to the maximum spacing provided between electrodes 14 and 17.

Continued rotation of the crank 95 from its "Y" to its "Z" position (Fig. 6) will of course continue to elevate the counterweight 81, but such continued movement of the counterweight has no further effect upon the apparatus. However, such rotation to the "Z" position applies to the electrode 17 and to the dielectric material or preform 16 a pressure of a known and predetermined magnitude. This is accomplished by means of a weight 105 (Figs. 5, 7 and 9) slidably mounted on a lever 106 pivoted by a relatively heavy pin 107 to the frame, the lever having an operative connection with the mechanism now to be described, for applying the desired pressure to the electrode 17. It will be observed that the weight 105 (Figs. 5, 7 and 9) may, by loosening the clamping nuts 108 and 109, be moved to any desired position along the lever 106. Up-turned sides 119a and 119b of horizontal member 119, connected to lever 106, retain the weight in a desired path of travel and also provide a con-

venient place for location of a scale, such as shown in Fig. 7. They are also slotted to form guides for the threaded studs which carry the clamping nuts 108 and 109. If the weight is moved toward the pivot pin 107, the effective lever arm is shortened and the pressure applied to the electrode 17 is correspondingly decreased. As shown in Fig. 7, the weight is located in a position to develop a pressure somewhat greater than 200 pounds on the electrode 17.

In Fig. 7, the lever 106 is shown with an outwardly extending pin 110 resting upon the surface of a cam 111. The cam 111 is secured to the shaft 91 (Figs. 4 and 10) and on the opposite side of the lever 106, as shown in Fig. 10, a second cam 112 identical with cam 111 is provided and which is shown engaging a second pin 114 extending outwardly from the other side of the lever 106. Fig. 10 also illustrates the manner in which the lever 106 is constructed. It is formed by two side members 115 and 116 interconnected by spacers 117, 118, and suitable fastening screws. The two sides are connected together by a cross member 119 (Figs. 5 and 9) which also carries the sides 119a and 119b for the support of the weight 105. By spacing the side members 115 and 116, a clamp-operating lever or member 120 may be disposed in nesting relation between them. The member 120 is pulled by springs 122 and 123 against the surface of a cam 124 disposed intermediate the cams 111 and 113. In Fig. 7, it will be seen that cam 124 is holding the lever or arm 120 in an elevated position against the bias of the springs 122 and 123. A nut and threaded stud is provided for adjustment of the tension of spring 122. Since these springs are located on opposite sides of the shaft 91, the cam 124, when in the position shown in Fig. 7, acts as a true fulcrum, thus permitting spring 122 to be adjusted relative to spring 123 to obtain a vertical alignment of the axis and clamping face of each of clamping members 137 and 138 with the axis of rod 72. Such alignment is necessary if 72 is to slide freely through 137 and 138 when in their unclamped positions.

Referring now to Figs. 9 and 10, it will be observed that the pivot pin 107 extends through the two sides 115 and 116 of the lever 106 and through a stationary block 126 held by screws 127, the heads of which may be countersunk into a cross member 128 extending between a pair of blocks 129 and 130. The blocks or supporting members 129 and 130 (Fig. 11) are fastened as by bolts 131 (Fig. 10) to the motor-supporting plate 61 (Fig. 9). The cross member of plate 128 is provided with an enlarged opening or recess through which extends the rod 72 as well as a thrust member 133 secured in a member 134 which is pivoted between the sides 115 and 116 by means of a pivot pin 135. When the lever 106 is rotated in a clockwise direction around its pivot pin 107, as viewed in Fig. 9, the thrust member 133 engages the upper face of a clamping member 137. The clamp also includes a second clamping member 138. As best shown in the enlarged sectional view of Figs. 11 and 12, there are attached to the clamping member 137 two side pieces 141 and 142, as by screws. These members extend laterally of the rod 72 and provide pivotal support for the ends 143 of an eccentric cam 145 which is rotated by movement of the lever 120. This lever (Fig. 9) has a down-turned end 120a which is secured to the cam 145 as by a screw 146. The face of the cam 145 engages the co-

operating face of a member 147 secured to the clamping member 138 as by screws (Fig. 10) with shims 149 disposed between them. Upon rotation of the lever 120 from its position in Fig. 7 to the position in Fig. 9, the eccentric cam 145 is rotated in a clockwise direction. It presses directly against member 147 to move the clamping member 138 toward the rod 72. The clamping member 138 (Fig. 12) is provided with side projections 138a and 138b which are received by guiding channels or grooves in the respective side pieces 141 and 142. While the cam 145 presses the clamping member 138 toward the rod 72, the other clamping member 137 will be moved toward the rod 72 by the reactive force of the cam which is transmitted through the pivotal ends 143 to the yoke comprising the side pieces 141 and 142. These are secured to the clamping member 137 and move it into clamping engagement with the rod 72. Thus, a very effective clamp is provided which fixes the clamping member 137 to the rod 72. The extent of movement of the member 137 is limited by projections 139 and 140 which extend into enlarged openings (Fig. 11) of the blocks 129 and 130.

As the crank 95 (Fig. 6) is rotated from position "Y" toward position "Z," the shaft 91 is rotated in a counterclockwise direction as viewed in Figs. 6-9. The cam 124 first releases the lever 120 which, by the action of the springs 122 and 123, is rotated in a clockwise direction to the position shown in Fig. 9. During its rotation, it sets the clamp to lock the clamping members 137 and 138 to the rod 72 in the manner above described. It will be observed (Fig. 9) that a coil spring 150 encircles the rod 72, one end bearing against a spacer 151 while the opposite end bears against the clamping members 137 and 138. The coil spring 150 is strong enough to support the weight of the clamping mechanism and to maintain it above, and in spaced relation with, the motor-supporting plate 61. Continued counterclockwise rotation of the crank 95 rotates the cam 113 (Fig. 9) in a counterclockwise direction to release the weight-actuated lever 106 for rotation of the latter in a clockwise direction about its stationary pivot pin 107. Since the clamps 137, 138 have been rigidly, though frictionally, connected to the rod 72, the thrust member 133 as actuated by the lever 106 presses downwardly on the clamping member 137 to apply through the rod 72 the resultant pressure developed by the weight 105 and the lever 106. This pressure, of substantial and predetermined magnitude, is transmitted from the rod 72 through the plate 23 and the insulators 20, 20a, and 21, 21a (Fig. 2, 7 and 8) to apply the pressure to the electrode 17, which, it will be remembered, has previously been operated into engagement with the preform 16 (Fig. 2). The crank 95 then occupies its "Z" position and the apparatus is now in condition for the application of high-frequency electrical energy to the preform while the preform is under the aforesaid applied pressure, which may be from below 125 pounds to above 200 pounds. By changing the size of the weight 105, any desired pressure within a wide range may be selected.

At the time of operation of the clamping mechanism, it will be observed that it is spaced above the motor-supporting plate 61 by means of a compression spring 150 which is strong

enough to support the weight of the clamping mechanism 137—138. However, after operation of the clamping mechanism to clamp the rod 72, the application of pressure from the weight 105 through the thrust member 133 overpowers the spring 150 and permits the rod 72 and the sub-assembly including plate 23 and electrode 17 to move downwardly. Of course, no immediate movement occurs, inasmuch as the electrode 17 has already been moved into engagement with the work, other than that required for application of the pressure on the work or preform 16. If the preform 16 is hard and unyielding, there will be no movement of the electrode 17. However, as its temperature rises and as it is softened, the electrode assembly 17—23 will move downwardly by a predetermined amount depending upon the movement permitted by the spring 150 disposed between the bushing 151 and the clamping mechanism 137—138. In a preferred application of the invention this movement was of the order of one-eighth of an inch. Accordingly, the clamping mechanism will not unduly deform and compress the load or preform 16, but it will apply a predetermined pressure to it and it will maintain that pressure so long as the preform maintains its original shape and in the event of softening or expansion of preform 16.

By now energizing the motor 35 for rotation in one direction or the other, the upper electrode or capacitor plate 18 may be moved in either direction to control the voltage applied between the electrodes 14 and 17, and in that manner to control the rate of heating of the preform 16.

At the end of the heating operation, the crank 95 will be rotated from its position "Z" in a clockwise direction. As it is moved toward its "Y" position, the cams 111 and 113 (Fig. 10), acting against the pins 110 and 114, return the lever 193 and the weight 105 to the positions shown in Fig. 9. Thereafter, the cam 124 rotates the clamping lever 120 from the position shown in Fig. 9 to the position shown in Fig. 7, the "Y" position of the crank 95. In other words, the clamping mechanism is operated in the reverse sequence to unclamp the rod 72. Any downward movement that may have been produced on the clamp and rod 72 by the applied pressure was opposed by a coil spring 150. Upon unclamping of the rod 72, the coil spring 150 will be effective to return the clamping members 137 and 138 to their original positions, the thrust member 133 having been previously elevated by lever 106 to provide for the return movement of the clamping mechanism.

The clockwise rotation of the crank 95 and the shaft 91 from its "Z" position to its "Y" position will also be effective to lower the weight 81 by an amount which has no effect upon the apparatus. Continued clockwise rotation of the crank 95 and the shaft 91 from the "Y" position toward the "X" position will be effective to transfer the weight of member 81 from the chains 84 and 95 (Fig. 5) to the weight 83. Since the cooperating counterweights 81 and 83 are heavier than the subassembly including the electrode 17, the latter will rise as long as the crank is lowering the weight 81, and, in turn, weight 83, the limit being when the electrode 17 strikes the electrode 18, which condition may occur at any point between the "Y" and "X" position of the crank, depending upon the location of electrode 18. Additional rotation of the crank toward the "X" position after the electrode 17 strikes the elec-

trode 18 is merely effective to add slack to the chains 84 and 85.

From the foregoing, it will be seen that any desired pressure may be applied by the electrode 17 to work disposed between it and the cooperating electrode 14. This has been accomplished without providing a direct drive to the assembly including the electrode 17. This feature is of considerable value since it makes it relatively impossible for anyone to injure the mechanism, by causing excessive pressure to be applied by the electrode 17, which might and probably would occur if it were necessary to provide a direct drive.

Another feature is that the pressure can be applied to a load of any height within the limits of the design, but once applied to a given load, is effective over a very small distance (approximately $\frac{1}{8}$ "'). This feature makes it impossible for the initial pressure to cause the electrode 17 to "mash" a load that becomes soft when heated.

With the parts again in the positions illustrated in Fig. 2, it now will be assumed that it is desired to operate the mechanism without utilizing the pressure-applying feature. It will be observed from the right-hand portion of Fig. 2 that there is held by clips 155 and 156 a handle 157 of a shorting bar 158. While in the clips 155 and 156, the handle 157 is effective through a rod 159 to maintain closed a switch 160. A side view of the shorting bar 158 removed from the clips is shown in Fig. 2—A. It will be seen that it comprises a U-shaped member, the respective legs of which normally extend outwardly from each other. They are resilient and preferably of a copper alloy. The frame of the shorting bar is of insulating material such as hardwood.

The handle 157 is grasped and the shorting bar 158 thrust between the electrodes 17 and 18. The outwardly extending arms will be depressed and, because of the wiping action incident to their insertion between plates 17 and 18, good electrical contact will be made with the electrodes. Accordingly, the circuit including the flexible conductor 44 extends from the oscillator to the electrode 18, through the shorting bar 158 and to the electrode 17. The capacitor formed by electrodes or plates 17 and 18 is thereby removed from the circuit. If the motor 35 (Fig. 8) be now energized, the threaded rods 50, 51, and 52 may be rotated in a direction to lower the subassembly including the electrode 18. The assembly including the electrode 17 will then follow the descent of the assembly including the electrode 18 in manner already described. By suitably controlling the energization of the motor 35, the electrode 17 may be adjusted to any desired position with respect to the dielectric material such as the preform 16.

Besides providing for movement of the assembly including the electrode 17 by shifting the effective and relative positions of the counterweights 81 and 83, limit switches are provided in a control system for the motor 35 to prevent the development of undue strain on any of the parts. In accordance with the invention, the limit switches are automatically effective to control the permissible movement of the upper electrode or capacitor plate 18 between predetermined limits, both of which limits may be varied by amounts within the permissible range of movement of the assembly including the intermediate electrode 17.

To prevent obscurement of parts already described, these limit switches have in general been

omitted from Figs. 1-12 but they have been illustrated in Figs. 13-16, in which figures other parts of the apparatus already described have been omitted the better to show the location, function, and operation of the limit switches forming the important components of the position-controlling system.

The manner in which the several limit switches cooperate together will be described in connection with Fig. 18 after a brief description of the limit switches in terms of the functions they perform.

Referring now to Fig. 13, a limit switch 161 adjustably secured, as by clamping nuts 162, to an upright member 163 supported from the plate 62, determines the maximum height to which the motor may raise the capacitor assembly including the electrode 18 and the supporting plate 26. As shown in Fig. 13A, the upright 163 is provided with an elongated slot 164 through which threaded studs extend from the case or housing of the limit switch 161. Beneath their associated clamping nuts 162 is an index plate 165 which cooperates with a scale 166 which permits a setting of the limit switch 161 to predetermine the height to which the capacitor electrode 18 may be raised, the maximum setting corresponding with the maximum height to which the apparatus is designed to operate.

The actuator 167, which coacts with a roller-carrying arm 161a of the limit switch 161, is supported from an angle 172 carried by the upper end of the threaded rod 50, which it will be recalled is driven by the motor 35. The upper end of the rod 50 is provided with a tapped hole which receives a cap screw 168 to clamp the angle 172 against the upper face of the threaded rod 50. The angle 172 provides for the mounting of two additional limit switches 169 and 170.

In Fig. 14, the electrode 17 and the capacitor plate or electrode 18 are shown in positions much lower than in Fig. 13. Accordingly, the actuator 167 is below the actuating arm 161a of the limit switch 161. When the motor rotates the threaded rod 50 to raise it, the actuator 167 moves against the roller of arm 161a to open the limit switch 161 thereby to deenergize the motor.

The limit switch 169 has its housing secured to that of the limit switch 170, and the two together are secured to an upright of angle 172 by one or more bolts 173 (Fig. 16). Accordingly, these limit switches 169 and 170 move up and down with the threaded rod 50 and with the actuator 167. The limit switch 169 prevents the motor 35 from driving the capacitor plate 18 into engagement with the electrode 17. Thus, if the rod 50 be rotated in a direction to lower the plate 18, it will be observed the actuator 169a (Fig. 13) will be moved toward a stationary arm 174 carried by a rod 175 which is secured to the plate 23 forming a part of the movable assembly which includes electrode 17. The arm 174 is factory-adjusted on the rod 175 by means of clamping nuts 176. The preferred arrangement is such that as the capacitor plate 18 approaches to about $\frac{1}{8}$ -inch of the electrode 17, the limit switch 169 opens the motor circuit to prevent further lowering thereof.

It will be remembered that the electrode assembly 17-23 may also be moved to any position within its range of movement. Of course, as it is lowered (Fig. 14), the arm 174 is also lowered. From the end of arm 174 there is suspended an auxiliary member 177 which consists of a screw having the head portion countersunk in the arm 174, the hole therethrough providing

adequate clearance for free movement of the member 177. As best shown in Fig. 13-C, the end of member 177 has secured thereto a small plate 177a, as by threaded engagement. As the electrode 17 is lowered to the position shown in Fig. 15, the plate 177a of member 177 engages the motor-supporting plate 61. Though the movement of member 177 be arrested, the electrode 17 may be further lowered. However, if the capacitor electrode 18 is also lowered as by proper energization of the motor 35, the resultant lowering of the threaded rod 50 (Fig. 15) will move the limit switch 169 into engagement with the auxiliary member 177 thereby to open the motor circuit and prevent further lowering of capacitor plate 18.

By reason of the foregoing provisions great flexibility of operation is provided and there is avoided any danger of operation of the motor to lower the threaded rods to positions below their threaded engagement with their cooperating supporting members carried by the respective gears 53, 54, and 55.

The limit switch 170 is a single-pole double-throw switch. Its actuator 170a cooperates with an arm 178 secured to the rod 175 by means of clamping nuts 179, provided for factory adjustment thereof. One of the functions of the switch 170 is to limit the upward movement of the plate 26 with respect to the plate 23. For example, when the plate 26 is moved upwardly from its position as shown in Fig. 14 to the position shown in Fig. 13, the limit switch 170 and its actuator 170a approach the arm 178 for actuation of the limit switch 170 from one of its positions to the other. These will be hereinafter referred to as the actuated position and the unactuated position.

A fourth limit switch 180 is supported from the frame by a bracket 181 (Fig. 16) so disposed that actuating member 180a of the switch is in a position to be engaged by an actuator 182 secured to a collar 183 carried by and secured to the shaft 29. The shaft 29 is, as above described, driven through the chains 34 and 35 upon rotation of the crank 95 (Figs. 5 and 6). The actuator 182 is arranged to engage the actuating member 180a of the limit switch 180 (Fig. 13) when the crank 95 (Fig. 6) is in its "Y" position. With the crank 95 in its other positions, the limit switch 180 will be open. By reason of these provisions, and with the crank in the "Y" position (Fig. 13), a circuit may be completed through the limit switch 180 for raising the capacitor plate 18 even though the plate 26 is in engagement with the upper plate 23. In other words, the motor is then effective to raise both subassemblies which include electrode 17 and capacitor plate 18.

With the above understanding of the location of the respective limit switches and the functions performed by each, reference may now be had to Figs. 13-16 and 18 for a description of the operation as a whole. In Fig. 18, a high-frequency generator or oscillator 186 has been illustrated as including a vacuum tube 187, the cathode of which is heated by connection to the secondary winding of a transformer 188 the primary winding of which is connected to a suitable source of supply 189. There are included in the grid circuit a grid coil 190, a grid-leak resistor 191, and a capacitor 192 in shunt therewith. The anode of the vacuum tube 187 is connected by way of a radio-frequency choke 221 to the positive terminal B+ of a direct-current

source of supply, the negative terminal marked B— being connected to ground. A suitable measuring instrument 193 is connected in the plate or anode circuit to measure the magnitude of the current. A part of the scale of the instrument or ammeter 193 may be distinctively marked, as at 193a, for flow of current of magnitude corresponding with a normal full load output for the generator or vacuum tube 187. The output circuit includes a blocking capacitor 194, the output inductor 195 (corresponding with coil 11 of Fig. 1) and the capacitor formed by the plates 17 and 18, as well as a second capacitor in series therewith and formed by the plates or electrodes 14 and 17. The frequency of the oscillations produced by the generator 186 will be determined by the values of the inductance of the inductor 195 and the capacitance in parallel therewith. While the frequency is not critical, it will generally be selected as something above 1,000,000 cycles per second and in general will be of the order of from one to thirty megacycles per second and above. The particular frequency range desired will be selected in accordance with principles well understood by those skilled in the art.

The motor 35 includes a field winding 196 arranged to be energized from supply lines 197 and 198. A second field winding 199, with a series resistor 200 and a series capacitor 201, is connected to a reversing switch 202, which determines the direction of current flow through the field winding 199 for rotation of the motor 35 in one direction or the other. Upon closure of a line switch 203, it will be observed the operating coil 204 of the reversing switch 202 is energized through a circuit which may be traced from supply line 197, line switch 203, the normally closed contacts of a "lower" push-button switch 205, the operating coil 204, and to the other supply line 198. The reversing switch 202 is thereby operated to complete connections of the field winding 199 preparatory to flow of current therethrough in a direction for rotation of the motor 35 to elevate or raise the inner subassembly including the plates 18 and 26. This circuit may be completed by depressing the "raise" push-button switch 206. This circuit may be traced from the supply line 197, the line switch 203, the normally closed contacts of switch 205, conductor 207, the "raise" switch 206, limit switch 161, conductor 208, limit switch 170 in its unactuated position, conductors 209—211, contact 212 of reversing switch 202, capacitor 201, resistor 200, field winding 199, conductors 213 and 214, contact 215, and by conductor 216 to the supply line 198. The subassembly 18—26 will then be raised until either the limit switch 161 or the limit switch 170 is operated.

Regardless of where the outer electrode assembly 17—23 may be, as soon as the plate 26 approaches the plate 23 the limit switch 170 will be operated from its unactuated to its actuated position to deenergize the motor 35.

If the subassembly 17—23 is thereafter raised, as by operation of the crank 95, it is to be understood the limit switch 170 will be returned to the illustrated unactuated position of Fig. 18, thereby rendering the "raise" circuit effective to energize the motor 35 further to elevate the subassembly 18—26.

If it be assumed that the subassemblies are in the positions shown in Fig. 15 and that the crank 95 is located in its "Y" position, the actuator 182 will have closed the limit switch 180 and will have by-passed the limit switch 170 so far as the

"raise" circuit is concerned. Hence, the motor 35 will then be effective not only to raise the subassembly 18—26, but after engagement by the plate 26 of the bushings 50a—52a in the plate 23, the outer subassembly 17—23 will also be raised. The limit switch 180 is closed or made effective only when the crank is in the "Y" position, since the electrode 17 is clamped when the crank is turned toward the "Z" position. This provides additional flexibility since the electrode 17 and the capacitor plate 18 may both be raised without requiring operation of the crank 95 to shift the counterweights for gravity elevation of the outer subassembly 17—23.

As has already been explained, if the crank 95 is moved from its "Y" position, in either direction, the limit switch 180 is opened and the described alternative operation may not take place until the crank 95 is returned to its "Y" position.

With the motor 35 energized through the limit switch 180, upward movement of both assemblies continues until the actuator 167 engages the roller on the arm 161a to open the limit switch 161, which of course deenergizes the motor 35. Thus, the limit switch 161 determines the absolute height of the subassembly 18—26 and this may be adjusted as by varying the position of the limit switch 161, as has already been explained in connection with Figs. 13 and 13—A.

Again assuming the parts are in the positions illustrated in Fig. 18, with line switch 203 closed and the coil of reversing switch 202 energized, then if the "lower" push-button switch 205 is depressed its normally closed contacts will be opened to deenergize the coil 204 of the reversing switch 202 which thereupon operates to its illustrated position to reverse the direction of flow of current through the field winding 199. The push-button switch 205 also closes its normally open contacts to complete an energizing circuit for the field winding 199 which may be traced from the supply line 197 by line switch 203, conductor 217, the now closed contacts of switch 205, limit switch 169 and 160, conductors 210 and 211, the contact 218 of the reversing switch 202, conductors 214 and 213, field winding 199, resistor 200, capacitor 201, contact 219, and by conductor 216 to the other supply line 198. The motor 35 thereupon rotates in a direction to lower the subassembly including the capacitor plate 18. As the plate or electrode 18 approaches the plate electrode 17, the limit switch 169 will be opened. Accordingly, the motor 35 may never be energized to lower the capacitor plate 18 far enough to engage or apply pressure to electrode 17. The minimum space which will be maintained between the two plates 17 and 18 is determined at the factory by fixing the position of the actuator 174 on the rod 175 (Fig. 13). Since the position of the plate electrode 17 may be anything between its upper and lower limits, it is to be understood that the limit switch 169 is operated not as a function of absolute height but as a function of the approach of plates 17 and 18 toward each other, that is, the relative distance between them.

If it is desired to utilize only the electrode 17 without making use of the separate capacitor provided by the plate 18, the shorting bar 158 is grasped by its handle 157 and inserted between the electrode 17 and the capacitor plate 18. This insertion may be made only when there is maximum separation between them, as when plate 23 is caused to rest on plate 26 by turning the

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crank 95 to its "Y" position, and after operation of the limit switch 170 to its actuated position. With the shorting bar 153 in position, its flexible U-shaped form frictionally engages the two plates and, because of the resilience or elastic character of the shorting bar 153, permits some relative movement as will be hereinafter explained. By lifting the handle 157 (Fig. 2) from its supporting clips 155 and 156, the by-pass switch 160 (Fig. 18) moves to open the circuit which was above traced through it. An inspection of the wiring diagram of Fig. 18 shows that the opening of the switch 160 transfers the control of the motor 35 to the limit switch 170. Specifically, the lowering circuit may not be completed unless the limit switch 170 is in its actuated position. But this requirement has been met, since it has already been stated that the shorting bar 153 may not be inserted between plates 17 and 18 unless they are spaced apart enough to insure operation of the limit switch 170 to its actuated position.

By depressing the push-button switch 205, a lowering circuit may be completed through the limit switch 170 and the motor 35 will continue simultaneously to lower both subassemblies until the plate electrode 17 engages the preform 16. When this occurs, the motor will move the plate 18 downwardly to compress the U-shaped shorting bar 153. A slight movement thereof will be adequate for operation of the limit switch 175 to its illustrated unactuated position, thereby to deenergize the motor 35.

Again assuming the parts are in the positions as illustrated in Fig. 13 but with the shorting bar in place between the plates 17 and 18, the "raise" push-button switch 205 will be ineffective because the limit switch 161 will be open. If after the lowering of the subassemblies it is desired to raise them again, the limit switch 161 will have been closed. However, the "raise" circuit will not be completed through the switch 170 which is in its actuated position, but will be completed through the limit switch 160, which was closed when the crank 95 was turned to its "Y" position for operation with the shorting bar. It should here be observed that the crank 95 is turned primarily to shift the counterweights or clamp the electrode and apply pressure. Any limit switches actuated in the process energize or deenergize the "raise" or "lower" circuits because the load, electrodes, and crank are so located that it is safe or unsafe for energization of the motor in one direction or the other.

Again returning to the simultaneous lowering of the subassemblies, after the electrode 17 has engaged the preform 16 and the motor 35 has been deenergized, the crank 95 may be rotated to its "Z" position for operation of the clamping mechanism and the application of the weight 85 and its arm 93 to apply a predetermined pressure through the electrode 17 to the preform 16.

The many variations in the operation, which have been explained in detail, provide a high-frequency heating apparatus of great versatility and one in which a large number of heating problems may be successfully solved and carried out with a minimum of time required for adjustments of the apparatus.

While a preferred form of the invention has been illustrated, it is to be understood that many variations may be made therein without departing from the scope of the appended claims. The control circuits may be either of the manually controlled type or they may include motor-con-

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trolling relays for automatically varying the position of the capacitor plate 18 to maintain substantially constant the anode current of the oscillator or vacuum tube 187. One such relay may be included in the circuit common to the ammeter 193, with "lower" contacts thereof substituted for switch 205 and arranged to be closed when the anode current is below the desired value and with the "raise" contacts thereof substituted for the switch 206 and arranged to be closed by the relay when the anode current is above the predetermined value. Besides changes of this character, various elements such as the tray-electrode 14 may take various forms and the electrode 17 and the capacitor plate 18 may also have any desired configuration such as illustrated by the plate 220 of Fig. 17 where, it will be observed, the central portion is made relatively small with arms extending outwardly from the corners thereof for securement to the supporting insulators. The advantage of an electrode 220 of the type illustrated is that the central portion thereof may be made of substantially the same area as that of the preforms or other shapes of dielectric materials to be heated, and thus reduce the capacitance between the various electrodes.

Summarizing the foregoing operations, when the crank 95 (Figs. 6 and 7) is in the "X" position the weights 81 and 83 are effective to raise the assembly including electrode 17. That assembly will rise until electrode 17 strikes electrode 18, thus bringing it to standstill. In Figs. 2, 7 and 8 both electrode assemblies are in their uppermost positions. But as already explained for the preferred operation, the electrode 17 will normally be raised only an amount to clear the preform 16 or other work to be heated. Accordingly, the limit switch 161 will be set (Figs. 13 and 13-A) to predetermine the upper position of the assembly including electrode 18. Thus, assuming the parts in the positions shown in Fig. 14, with the crank 95 in its "Z" position for application of pressure to electrode 17 and preform 16, high-frequency energy will be applied until the preform has been heated the requisite amount. Meanwhile, under manual, semi-automatic, or fully automatic control, the motor will be positioning the electrode 18 to maintain a desired potential difference on the load or preform 16. At the end of the heating operations, the crank will be rotated from its "Z" position to its "Y" position to release the clamping mechanism and to return the weight-applying mechanism to the position shown in Fig. 7. As this is done, the weight 81 will be lowered from its uppermost position towards the weight 83. The weight 83, for the position of the electrode 17 in Fig. 14, will be well above its position as shown in Fig. 7. Thus the extent of rotation of crank 95 required to lower weight 81 onto weight 83 depends upon the position of the electrode assembly 17-23. The weights may engage for any position of the crank between its "Y" and "X" positions and thus their combined weight will raise the assembly including electrode 17 for removal of the heated preform 16.

Since it is possible for the motor to have lowered electrode or plate 18 close to the plate 17, it will be seen the shifting of the counterweights alone may not in every case insure adequate elevation of electrode 17 to clear the preforms. To avoid this possibility the "raise" button 205 should be closed before manual operation of the crank 95. This is a simple operation for the operator and it may also be carried out by a relay which opens

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the lowering circuit and which is arranged to bypass the "raise" push-button switch upon deenergization of the oscillator, the limit switch 161 in either case serving to open the raise circuit as electrode 17 reaches its predetermined position.

After the weight 81 has been lowered onto the weight 83, continued rotation of the crank 95 towards its "X" position produces slack in the connecting chains but that is all that occurs after the elevation of electrode 17 into engagement with the plate or electrode 18.

It is again emphasized that while the crank is in its weight-applying "Z" position, the switch 180 is open so that the switch 170 is effective to prevent elevation of plate 26 into engagement with the plate 23. However, with the crank in its "Y" position, the switch 180 is closed and the motor 35 may then be energized to raise in unison the assemblies including electrodes 17 and 18. Of course when limit switch 161 opens, the motor 35 is deenergized.

Since the normal and preferred operation will generally be with the plate 23 but a few inches above its position in Fig. 14 (and lower than in Fig. 13) it will be understood that when the assembly 17-23 is raised by the counterweights it will come to rest with the electrode 17 against 18. Hence the limit switch 169 will be open and the motor may not then be energized in a direction to lower the assemblies 17-23 and 18-26. This avoids overloading the motor and undue strain on the parts. However as soon as the crank 95 is moved towards and/or to the "Y" position the counterweight 81 is lifted from the counterweight 83 and the unbalanced weight will then cause assembly 17-23 to descend. Its initial movement opens limit switch 169 thus permitting energization of the motor 35 in a direction to lower assembly 18-26.

It may be further pointed out that with the shorting bar 158 in position between plate electrodes 17 and 18, the crank 95 is kept in its "Y" position. The motor 35 may then raise and lower the assembly 18-26. The assembly 17-23, being heavier than the counterweight 83, tends to move downwardly and the motor in moving the plate 26 against the bushings 50a-52a of plate 23 raises it, the motor acting only against the unbalance weight as between assembly 17-23 and the counterweight 83.

With the foregoing detailed explanation in mind, it will be readily understood that further modifications in structure and in operation may be made without departing from the scope of the appended claims.

What is claimed is:

1. A high-frequency heating system comprising a high-frequency generator including a resonant circuit, a pair of electrodes forming a capacitor in series in said circuit, means including a counterweight for moving one electrode toward or away from the other electrode for accommodation of dielectric objects to be disposed therebetween for heating, a capacitor plate spaced from one of said electrodes to form a second capacitor in series in said resonant circuit, means including a motor for varying the position of said plate with respect to said one electrode to select a desired proportion of the total available radio-frequency voltage to be applied to said objects by said electrodes, two limit switches respectively connected in circuit with said motor, one of them being effective to deenergize the motor when said plate approaches within a predetermined distance of said one electrode and the other of which is

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effective to deenergize said motor when said plate is raised a predetermined distance above said one electrode, a flexible shorting bar for disposition between said plate and said one electrode for electrically connecting said plate and said electrode together, and means including said second-named limit switch for deenergizing said motor upon engagement of an object to be heated by said one electrode and after a slight initial movement of said plate toward said one electrode.

2. A high-frequency heating apparatus comprising a relatively stationary electrode for supporting dielectric objects to be heated, a second electrode, means including a lever and a weight for pressing said second electrode against said work with a predetermined pressure, means mounting said weight for slidable movement along said lever to control the magnitude of said applied pressure, a capacitor plate disposed above said movable electrode, means for adjusting the position of said capacitor plate for controlling the heating of said object during said application of pressure thereto, clamping means disposed between said lever and said second electrode, and means for engaging and disengaging said clamping means for removal of and for the application of pressure to said second electrode.

3. The combination set forth in claim 2 in which said clamping means has a means extending from it and into mechanical engagement with said second electrode, and means for operating said clamping means to interconnect said lever and said second electrode for application thereto of said pressure by said lever.

4. A high-frequency heating apparatus comprising a relatively stationary electrode, a movable electrode, insulating means connected at one end to said movable electrode, a plate joined to the opposite end of said insulating means, a rod extending upwardly from said plate, a clamping mechanism associated with said rod, means for operating said clamping mechanism into and out of clamping engagement with said rod, and pressure-applying means effective after clamping of said rod by said mechanism for applying through said rod and to said movable electrode a pressure of predetermined magnitude.

5. A high-frequency heating apparatus comprising a relatively stationary electrode, a movable electrode, an upwardly extending rod for supporting said movable electrode, a double lever arrangement disposed in operative relation with said rod, a cam for controlling the position of one of said levers, a second cam for controlling the position of the other of said levers, a clamping mechanism operable by movement of one of said levers into clamping engagement with said rod, a weight adjustably mounted on the other of said levers for pressing it against its associated cam, and means operable by movement of said last-named cam to release said last-mentioned lever for applying the pressure developed by said weight to said clamping mechanism and thence to said rod and said movable electrode thereby to develop upon objects placed between said movable and stationary electrodes a pressure of predetermined magnitude.

6. A high-frequency apparatus comprising a relatively stationary electrode, a movable electrode for engaging dielectric objects disposed between it and said stationary electrode, a rod extending upwardly from said movable electrode, a clamping mechanism surrounding said rod, means supporting said mechanism in floating relation with respect to said rod, a lever extending

outwardly from said clamping mechanism for operating said mechanism into and out of clamping engagement with said rod, a cam for moving said lever in one direction, and a pair of springs for moving said lever in the opposite direction, said springs being respectively located on opposite sides of said cam for applying forces to said lever on opposite sides of said cam of magnitude to hold said lever at a predetermined angle with respect to said clamping mechanism to prevent binding with said rod when said mechanism is out of its clamping position.

7. The combination set forth in claim 6 in which a second lever extends outwardly from said rod, said second lever having a projection extending downwardly toward said clamping mechanism, a relatively heavy weight adjustably secured to said second lever, and a cam normally supporting said second lever and said weight but operable after clamping engagement of said rod by said mechanism for applying the pressure developed by said weight on said second lever to said clamping mechanism and through said rod to said movable electrode and the dielectric object disposed therebeneath.

8. A high-frequency heating apparatus comprising a relatively stationary electrode, a movable electrode, means including a counterweight for moving said movable electrode in one direction, a capacitor plate disposed above said movable electrode, means including a motor for adjusting the position of said capacitor plate with respect to said movable electrode, and means for electrically interconnecting said capacitor plate and said movable electrode for movement thereof in unison in either direction.

9. The combination set forth in claim 8 in which said interconnecting means is flexible, and means operable upon movement of said plate toward said movable electrode for stopping said motor means.

10. A high-frequency heating apparatus comprising a relatively stationary electrode, a movable electrode disposed thereabove, means including a rod for adjustably supporting said movable electrode, a counterweight connected to said rod to apply an upward force thereto but having insufficient weight to lift said movable electrode, a second weight, adjustable means supporting said second weight above said counterweight, and manually operable means for lowering said second weight onto said counterweight to raise said movable electrode and operable to lift said weight from said counterweight for lowering of said movable electrode.

11. A high-frequency heating apparatus comprising a relatively stationary electrode, a movable electrode disposed thereabove, means including a rod for adjustably supporting said movable electrode, a counterweight connected to said rod to apply a lifting force thereto but having insufficient weight to lift said movable electrode, a second weight adjustably supported above said counterweight, manually operable means for lowering said second weight onto said counterweight to raise said movable electrode and operable to lift said second weight from said counterweight for lowering of said movable electrode, means associated with said rod for applying a predetermined downward pressure thereto, and means operable under the control of said manual means for rendering said pressure-applying means effective or ineffective, as may be desired.

12. A high-frequency heating apparatus com-

prising a stationary electrode and a movable electrode between which may be disposed dielectric material to be subjected to high-frequency heating, means including a rod for adjusting the position of said movable electrode with respect to said stationary electrode, clamping mechanism disposed around said rod and comprising a clamping member on either side thereof, a cam for moving said members in opposite directions into and out of clamping engagement with said rod, a lever connected to said cam and extending outwardly therefrom, a second cam normally supporting said lever in a predetermined position, springs disposed on opposite sides of said second cam for biasing said lever for movement to a clamping position, a third cam concentrically mounted with said second cam, a second lever supported by said third cam in predetermined position, a relatively heavy weight adjustable lengthwise of said second lever, means for pivotally mounting said second lever adjacent to said rod, said second lever having means movable into engagement with said clamping mechanism after release of said second lever by said third cam, and means for rotating said second and third cams, first to release said first lever for rendering said clamping mechanism effective and thereafter for releasing said second lever for applying the weight developed on said second lever to said rod and thence to said movable electrode and the dielectrical material disposed therebeneath.

13. A high-frequency heating apparatus comprising a stationary electrode, a movable electrode for engaging dielectric objects disposed between it and said stationary electrode, rotatable means movable through predetermined positions for controlling movement of said movable electrode toward and away from a dielectric object to be heated, a capacitor plate disposed above said electrode and forming a capacitor therewith, motor means for moving said capacitor plate relative to said movable electrode, a limit switch for stopping said motor when said capacitor plate is a predetermined distance from said movable electrode, and a by-pass switch operable when said rotatable means is in a predetermined position for rendering ineffective said limit switch for further energization of said motor simultaneously to raise said capacitor plate and said movable electrode.

14. The combination set forth in claim 13 in which there is provided a flexible shorting bar which may be placed between said plate and said movable electrode electrically to interconnect them, mounting means for said shorting bar including a normally open switch which is maintained closed when said shorting bar is in place in said mounting means, a second limit switch operable from one position to another upon separation of said plate and said movable electrode by a predetermined amount, said predetermined separation being required for insertion of said shorting bar between said plate and said movable electrode, said switch of said mounting means in its closed position rendering ineffective said second limit switch to open a lowering circuit for said motor, said lowering circuit including said second limit switch for deenergizing said motor upon movement of said plate toward said movable electrode and against the bias of said flexible shorting bar.

15. A high-frequency heating apparatus comprising a relatively stationary electrode, a movable electrode, structure movable with the mov-

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able electrode, means for effecting application of pressure by the movable electrode on objects disposed between the electrodes for heating including a weight and a first member engageable thereby and releasably clamped to said structure, and a second member operable in one sense to effect clamping engagement between said structure and said first member and to release said weight and in another sense to lift the weight and to unclamp said structure.

16. A high-frequency heating apparatus comprising electrodes between which dielectric objects may be disposed for heating, means including structure mechanically connected to one of said electrodes for varying the spacing between them to accommodate objects of different dimensions, a weight, and releasable clamping means interposed between said weight and said structure for application, with any required spacing of the electrodes, of a predetermined pressure to the object engaged by said electrodes for heating.

17. A high-frequency heating system comprising a relatively stationary electrode, a first movable electrode, means for biasing said movable electrode to engage an object in contact with the stationary electrode, a second movable electrode, means insulating said electrodes one from the other, driving means operable within predetermined limits to vary the distance of said second electrode from said first movable electrode and to move said second electrode beyond one of the limits to move said first movable electrode away from said stationary electrode, and means for supplying high-frequency electrical energy to said stationary electrode and said second movable electrode.

18. A high-frequency heating system comprising a lower relatively stationary electrode, an upper movable electrode biased to engage an object in contact with the stationary electrode for heating said object, structure above and movable with said movable electrode, a second movable electrode insulated from said upper movable electrode, means for supplying high-frequency electrical energy to said stationary electrode and said second movable electrode and means for moving said second movable electrode in either direction between said structure and said upper movable electrode to vary the voltage difference between said stationary electrode and said upper movable electrode and effective upon continued upward movement to engage said structure and to raise said upper movable electrode.

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19. A high frequency heating apparatus comprising a relatively stationary electrode, a movable electrode, means for relatively moving said electrodes into engagement with work disposed therebetween, a rod for supporting one of said electrodes, a clamping mechanism operable into clamping engagement with said rod, pressure-applying means effective after engagement of said rod by said clamping mechanism for relatively moving one electrode with respect to the other and for applying pressure on the work disposed between said electrodes, and a stationary stop normally spaced from but engageable by said clamping mechanism for limiting the extent of said relative movement of said electrodes during application of said pressure, thereby to limit the extent of compression of said work by reason of the pressure applied thereto.

20. The combination set forth in claim 4 in which a spring normally supports said clamping mechanism a predetermined distance above a stationary member, said spring being strong enough to support said clamping mechanism but upon operation of said pressure applying means permitting movement of said rod and plate through a predetermined distance, thereby to limit the extent of movement of said plate during which said pressure is applied to said load.

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