

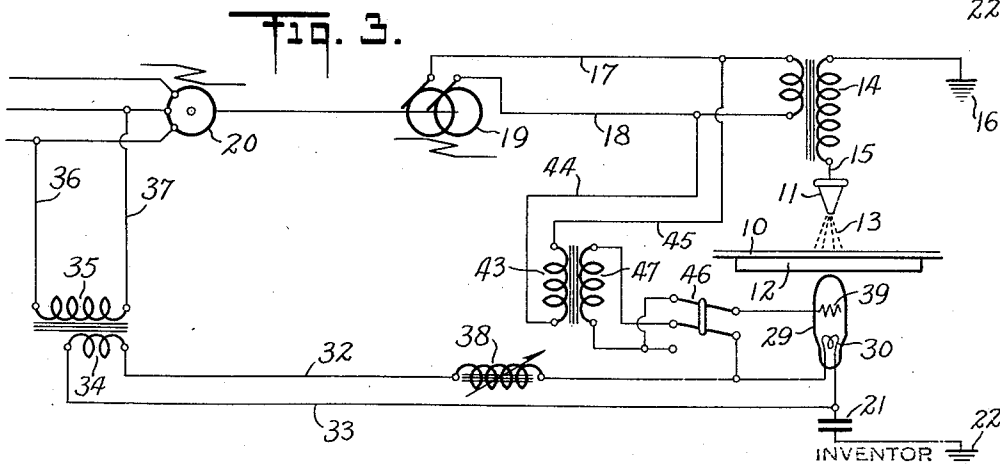
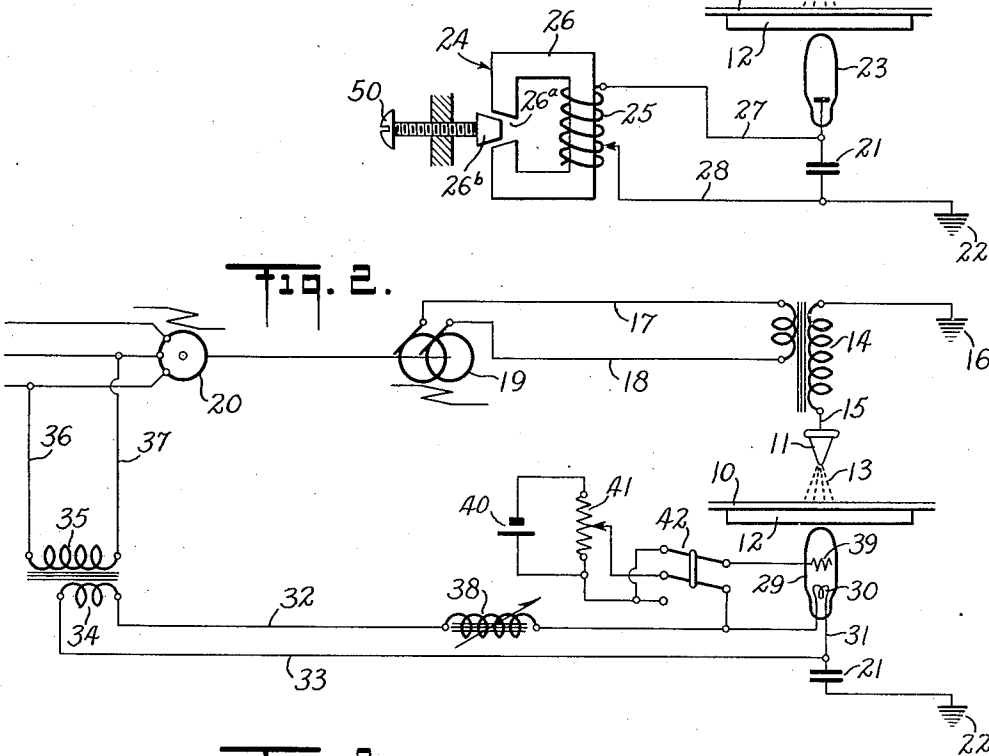
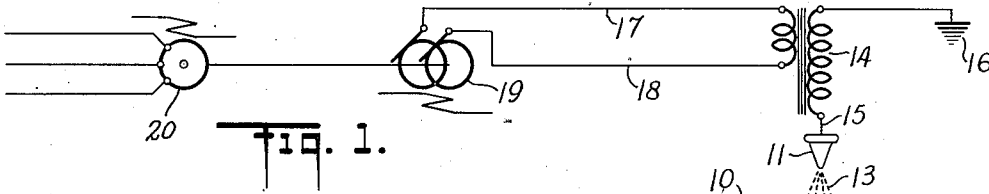
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ELECTRIC STERILIZATION

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ELECTRIC STERILIZATION

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This invention relates to electric sterilization and more particularly to a method and apparatus for controlling the high frequency high voltage corona discharge in electric sterilizing apparatus.

5 One of the objects of this invention is to provide a simple, practical and effective method and apparatus for electrically sterilizing food products and the like by corona discharge of appropriate voltage wave shape. Another object is to provide a method and apparatus of the above-mentioned nature in which the wave shape of the alternating high potential and hence of the sterilizing corona discharge produced by it may be controlled, varied or altered in a practical, depend-
10 able and efficient manner to suit various conditions met with in practice and to meet certain desirable or variable considerations according to the character of the material undergoing sterilization. Another object is to provide a method and apparatus of the above-mentioned character for dependably regulating or controlling or determining the intensity of corona discharge in the treatment zone. Another object is to provide a method and apparatus of the above-mentioned character in which, in the corona discharge treatment zone sparking may be dependably and efficiently negated or minimized and thus the character of the corona discharge and of its action improved. Another object is generally to improve the action and operation of the corona discharge in the treatment zone in electric sterilizing apparatus of this character.

Another object is to provide a simple, inexpensive and dependable apparatus for carrying out such objects as those noted above. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing in which are shown several of the various possible embodiments of the mechanical and electrical features of my invention,

50 Figure 1 is a diagrammatic representation of the electrical circuit arrangements and certain of the mechanical parts of an electric sterilizing apparatus, showing one form or embodiment of my control method and apparatus;

Figure 2 is a similar representation of another form, and

Figure 3 is a similar representation of another possible embodiment.

Similar reference characters refer to similar parts throughout the several views in the drawing.

As conducive to a clearer understanding of certain features of my invention, it may be here pointed out that my invention is concerned principally with electrical sterilizing apparatus of the type and character such as disclosed in Patents Numbers 1,959,390, 1,960,173, 1,960,174 and 1,975,805, issued to Franklin S. Smith, to which reference may be had for disclosures of suitable mechanical and electrical apparatus and of the manner in which they operate, as by the achievement of a corona discharge in the treatment zone, in achieving electrical sterilization or the destruction of insect life, in its various forms, in food and other products; it is therefore believed unnecessary to show and describe herein in detail the various mechanical and electrical and structural features of an apparatus in which my invention may be adapted or carried out and it is believed sufficient to show diagrammatically, as is later described herein, the principal or major features of such apparatus and with which my invention coacts and is combined for achieving such objects as are hereinabove noted.

Accordingly, and turning first to Figure 1, I have there diagrammatically shown an electrical sterilizing apparatus comprising a carrier 10, illustratively in the form of an endless belt, for transporting the material or products, illustratively packaged cereals, or the like, into the treatment zone which in turn comprises an electrode structure diagrammatically indicated at 11 spaced above the belt 10 and a suitable means, such as a solid dielectric plate member 12 illustratively of Pyrex glass or the like, and between which a corona discharge, diagrammatically indicated at 13, is produced in a manner as is described in the above-mentioned patents.

In the production of the aforesaid corona discharge, there is impressed upon the electrode structure 11 a suitable high potential, illustratively on the order of 150,000 volts, and preferably alternating and of relatively high frequency, a frequency illustratively on the order of 720 cycles per second. This may be produced in any suitable manner, as is also described in the aforesaid patents, and may be achieved by way of a step-up transformer 14 one terminal of whose high voltage winding is connected by conductors 55

15 to the electrode structure 11 and the other terminal of which is grounded as at 16. The low potential winding of the transformer is connected by conductors 17 and 18 to an alternator 19 preferably of relatively low voltage, such as 220 volts and illustratively of 720 cycles frequency. The alternator 19 may be driven in any suitable way as, for example, by an electric motor 20 which may be supplied with energy from any suitable source such as a commercial power supply and the motor and the latter may be, for example, 220 volts, 3 phase and 60 cycle.

As set forth in the aforesaid patents the high potential or discharge circuit is completed by suitable means forming a condenser, the condenser being of such electrical characteristics with respect to the other parts in the circuit that the condenser can stand at total or maximum voltage of the high voltage discharge circuit without complete breakdown and hence so that, all as described in the aforesaid patents, the treatment zone between the electrode structure and the conveyor or belt comprises a corona discharge of many fine streamers and through which corona discharge the material or products to be treated are passed. In Figure 1 this condenser is diagrammatically indicated at 21 but it is to be understood that in practice it will usually take a form or forms of which those described in the aforesaid patents are illustrative.

As shown in Figure 1, one side or plate of this condenser 21 is grounded as at 22 thereby, with the ground 16, completing the high potential circuit.

Interposed between the lower end of the treatment zone 13 and the condenser 21 I provide a suitable construction of gaseous conduction means such as those described in Smith Patent 1,930,174 or Smith Patent 1,965,609 or Smith Patent 1,975,805, and such a gaseous conduction arrangement I have diagrammatically indicated in Figure 1 at 23, and its coactions in the circuit and with the apparatus thus far described are as set forth in the said patents and with results as therein described.

However, and in accordance with my invention I provide a reactor of suitable characteristics and arrange it in parallel with the condenser 21. As later explained, the reactor may be an air core reactor or an iron cored reactor with an air gap in the magnetic circuit so that the iron is not saturated, thus to achieve practically constant reactance throughout each cycle, but for present purposes it will suffice to note that the reactor generally indicated at 24 has a suitable winding 25 about its iron core 26, the latter being provided with an air gap 26^a which, however, may be closed by the core portion 26^b mounted in any suitable manner, as by a hand operated screw 50. Suitable conductors 27 and 28 connect winding 25, the latter preferably adjustable as indicated, in parallel to the condenser 21.

Assuming first that the air gap 26^a is completely or sufficiently closed, the permeability of the iron of the core 26, illustratively transformer core iron, varies and depends on the flux density in the iron and hence it depends upon the instantaneous current passing through the winding 25, that winding forming a parallel circuit with the condenser 21, in the high frequency high potential circuit. The inductive reactance of the winding 25 accordingly varies throughout and within each cycle of the high frequency high potential current flowing in the treatment cir-

cuit. Consequently, the total impedance of the above-mentioned parallel circuit varies. The more nearly that the inductive reactance of the winding 25 and the capacity reactance of the condenser 21 approach equality, the greater is the impedance of the parallel circuit and hence of the high potential treatment circuit; conversely the greater the departure in value between these two reactances, the less is the impedance of the parallel circuit.

By this arrangement the wave shape of the corona current may be controlled or adjusted to give the desired intensity of corona discharge 13 with minimum of sparking therein. For example, the reactor unit may be given such electrical characteristics with respect to those of the condenser 21, that the reactor is in resonance or nearly in resonance with the condenser at the fundamental frequency of the high frequency generator, but out of resonance for all the higher harmonics including the third, fifth, seventh, etc. Hence, the fundamental frequency current component may be effectively suppressed and the harmonic current components exaggerated. The resultant corona current wave shape is a steep current wave. This wave shape is found to achieve improved sterilization particularly with certain kinds of products or materials to be sterilized.

On the other hand, and as by adjusting the reactor, a condition of, or approaching, resonance in the parallel circuit may be produced for any one of the harmonic current components, for example the third, thereby producing a current wave shape more nearly sine wave and giving a form of current wave which has advantages in the electrical treatment of other materials or products.

In either case, also, I am enabled to achieve the production of the desired intensity of corona discharge with substantial reduction or minimizing of sparking in the treatment zone, in a simple and easily controlled way and with superior results than have heretofore been possible, it being noted that the sparking that sometimes takes place in the corona discharge zone is undesirable, tends to shunt energy away from corona production, and otherwise has detrimental and undesirable effects; by my arrangement, I am enabled materially to minimize this sparking with its disadvantages and at the same time to achieve the desired intensity of corona discharge.

As above indicated, however, the reactor may be of a type such that its reactance is practically constant throughout each cycle of current, and this I may achieve by using an air core reactor or by withdrawing the core portion 26^b of Figure 1 to make the air gap 26^a sufficiently effective in the magnetic circuit of the winding 25 so that the iron of the core 26 operates below the saturation point, giving the reactor a reactance practically constant throughout each cycle. With the reactor thus having substantial constancy of inductive reactance, the inductive reactance thereof and the capacitative reactance of the condenser 21 are so proportioned that a condition of resonance exists at or near the fundamental frequency of the current effective in the sterilizing or discharge circuit. The resultant current wave shape is a steep current wave, for the harmonics flow through the condenser with ease.

Or by adjusting the reactor, a condition of, or approaching, resonance in the parallel circuit may be produced for any one of the harmonic components of the current, for example, the third

harmonic, thereby producing a current wave shape that is more nearly sine wave.

Turning now to Figure 2, the above described sterilizing apparatus as disclosed in, for example, the above-mentioned patents, may have included in the discharge circuit, instead of the gaseous conduction tube 23 of Figure 1 herein, an electronic tube (or tubes) 29, preferably evacuated and having a suitable electron emitting cathode which may and preferably does take the form of a heated cathode illustratively in the form of the filament 30. By way of conductor 31, the cathode 30 is connected to one side of the condenser 21, the other side being grounded as above described, the electronic conduction path formed by the electrons emitted from the cathode 30 being thus included in the high potential or discharge circuit.

The cathode 30 may be heated from any suitable source of heat energy and illustratively may be connected by conductors 32, 33 to the secondary winding 34 of a suitable step-down transformer whose primary winding 35 is connected by conductors 36, 37 to one phase of the alternating current line supplying energy to the motor 20.

Any suitable means may be employed for controlling the above-mentioned electronic path: for example, I may include in the conductor 32 a suitable current controlling or varying device illustratively in the form of a variable reactor 38, whereby the energy that heats the cathode 30 may be varied or controlled at will and likewise the heating and hence the electron emission of the cathode 30 varied or controlled as desired.

By varying the electron emission, as by appropriately adjusting or setting the device 38, the conductivity or impedance of the electronic conduction path in the tube 29 is correspondingly altered or varied and thereby the intensity of the corona discharge in the treatment zone, as indicated at 13, may be controlled or varied as desired and to the desired nicety or precision. Thereby the energy in the high frequency high potential circuit available for corona production may be definitely limited by making available in the tube 29 a conduction path whose current-carrying capacity or conductivity or impedance is a function of the electron emission.

Furthermore, the conductivity of the tube 29 is unidirectional and that characteristic brings about the feature of causing the positive corona discharge in the treatment zone to be materially greater than the negative corona discharge, more corona energy being dissipated during the positive than during the negative part of each cycle of the high frequency of the high potential treatment circuit.

Furthermore, the tube 29, when thus functioning, acts also to prevent spreading of the corona discharge along the belt 10 and achieves an easily controllable concentration of the discharge.

Still referring to Figure 2 I may, if desired, achieve additional features and advantages of control by embodying in the tube 29 a control electrode or grid 39 connected to a suitable biasing or control source of potential; the latter may comprise a source such as a direct current source, for example a battery 40, that impresses upon the control electrode or grid 39 a constant potential with respect to the cathode 30. The magnitude of this potential may be controlled in any suitable manner as by a potentiometer resistance 41 and a reversing switch 42 may be connected into the circuit arrangement in the manner shown in

Figure 2 whereby the battery may be so related to the grid 39 and the cathode 30 as to make the former either positive or negative in potential with respect to the latter, depending upon the adjustment required in operating the sterilizing apparatus.

In this arrangement the reactor 38, the potentiometer 41, and the reversing switch 42 may be employed individually or in coaction in combination with each other, as may be desired. For example, if it is desired, the potential applied to control electrode 39 may be removed by simply leaving the reversing switch 42 open, or control electrode 39 may be connected directly to cathode 30.

Turning now to Figure 3, I have there shown diagrammatically an arrangement like that above described in connection with Figure 2, excepting that the potential for biasing the control electrode 39 is an alternating current potential preferably of the same frequency as that of the high potential discharge circuit. That may be obtained by means of a transformer whose primary winding 43 is connected by conductors 44 and 45 to the output of the high frequency alternator 19 which supplies energy to the high frequency step-up transformer in the discharge circuit, and whose secondary winding 47 has its terminals connected respectively to the control electrode 39 and to the cathode 30, with a reversing switch 46 interposed therein.

The potential of the control grid 39 thus varies in substantial synchronism with the high frequency alternating current energy effective in the discharge circuit, the reversing switch 46 permitting selection at will as to when the control electrode or grid 39 is at a negative potential or a positive potential with respect to the cathode 30, again depending upon the adjustment required in operating the apparatus.

The tubes 29 of Figures 2 and 3 may, it will be understood, be given any suitable shape or configuration and the electrodes made to correspond, as may be further desired; illustrative forms or shapes of these tubes, as was the case with tube 23 of Figure 1, are shown in, for example, Patents Nos. 1,960,174, 1,965,609 and 1,975,805, above-mentioned.

With the arrangements of Figures 2 and 3, also, the wave shape may be varied or controlled at will. For example, in the arrangement of Figure 3, if a steep wave shape is required, the switch 46 is so positioned that the high frequency biasing potential is impressed between the control electrode 39 and the cathode 30 that the former is at a positive potential with respect to the latter at the time that the electrode structure 11 is at positive potential with respect to the ground; hence the tube 29 becomes very highly conducting when the electrode structure is at high instantaneous positive potential with respect to ground. The current flow through the discharge circuit rises and falls very rapidly, approximately as the square of the voltage, during the positive half cycle; this is due to the fact that both the control electrode 39 and the electrode structure 11 rise to their respective maximum potentials in a positive direction and fall away therefrom, at the same time or synchronously, resulting in a wave shape of current in the corona discharge circuit that is very steep.

To achieve a flat wave shape, the reversing switch 46 is actuated and as a result the potential of the control electrode rises to a maximum in the negative direction and falls away therefrom

at the same time that the potential of the electrode structure 11 rises to a maximum in a positive direction and falls away therefrom.

In the arrangement of Figure 2, the reversing switch 42 permits a change or variation in the wave shape to be achieved according as the control electrode is positively or negatively biased.

Thus, it will be seen that there has been provided in this invention a method and apparatus in which the various objects hereinbefore set forth, together with many practical advantages are successfully achieved.

As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawing, is to be interpreted as illustrative and not in a limiting sense.

I claim:—

1. In an electrical sterilizing apparatus having a source of high alternating potential to which is connected a corona discharge producing treatment circuit that comprises electrode means, means for presenting a product to be sterilized adjacent said electrode means and impedance means in series with the space in which said product is supported for limiting the breakdown of said space to a corona discharge, the combination therewith of means for controlling the wave shape of the corona discharge current, said controlling means comprising impedance means the impedance of which changes throughout each half cycle of the potential effective in said treatment circuit.

2. An apparatus as claimed in claim 1 in which the first-mentioned impedance means is a condenser and in which the second-mentioned impedance means is an iron cored inductance connected in parallel with said condenser.

3. An apparatus as claimed in claim 1 in which the first-mentioned impedance means is a condenser and in which the second-mentioned impedance means is an iron cored inductance connected in parallel with said condenser, said condenser and said inductance being substantially in resonance at or near the fundamental frequency.

4. An apparatus as claimed in claim 1 in which the first-mentioned impedance means is a condenser and in which the second-mentioned impedance means is an iron cored inductance connected in parallel with said condenser, said condenser and said inductance being in resonance at a frequency corresponding to, or approximating that of, one of the harmonics.

5. An apparatus as claimed in claim 1 in which said impedance means comprises also an electronic conduction device, and means for controlling the conductivity of said device at will.

6. An apparatus as claimed in claim 1 in which said impedance means includes also an electronic conduction device with a control electrode, and means for applying a biasing potential to said control electrode.

7. An apparatus as claimed in claim 1 in which said impedance means includes also an electronic conduction device with a control electrode, and means for selectively biasing said control electrode either positively or negatively with respect to the cathode of said device.

8. An apparatus as claimed in claim 1 in which said impedance means includes also an electronic conduction device with a control electrode, and means for applying to said control electrode an

alternating potential derived from said source of high alternating potential.

9. An apparatus as claimed in claim 1 in which said impedance means includes also an electronic conduction device with a control electrode, and means for applying to said control electrode an alternating potential derived from said source of high alternating potential, together with means for controlling said biasing alternating potential with respect to the potential effective in said treatment circuit and hence effective upon the cathode of said device so that during half cycles, said control electrode may be biased with respect to the potential of said cathode either positively or negatively as desired.

10. An apparatus as claimed in claim 1 in which the second-mentioned impedance means includes a thermionic valve, and means for controlling the conductivity of the electronic conduction path therein.

11. An apparatus as claimed in claim 1 in which said control impedance means comprises a circuit having therein an inductance and capacity related to each other so as to be resonant at a certain frequency.

12. In electrical treating apparatus of the type wherein a high potential is impressed across a pair of electrode structures so as to produce a corona-like disruptive type of gaseous discharge between said electrode structures to effectively treat a product within a treatment zone, means to supply a pulsating potential gradient within the treatment zone including a source of high potential and means for controlling the wave-shape of the gaseous discharge, said last-named means comprising impedance means the effective impedance of which changes as the value of the potential of said high potential source varies.

13. In electrical treating apparatus of the type wherein a high potential is impressed across a pair of electrode structures so as to produce a corona-like disruptive type of discharge between said electrode structures to effectively treat a product within a treatment zone, the combination of, means to supply a pulsating potential gradient within the treatment zone including a source of high potential and means for controlling the wave-shape of the discharge which effects treatment of the product, and means to cause relative movement between the product and the paths of the individual discharges, said means for controlling the wave-shape of the discharges comprising impedance means the effective impedance of which changes as the value of the potential of said high potential source varies.

14. In electrical treating apparatus of the type wherein a high potential is impressed across a pair of electrode structures so as to produce a corona-like disruptive type of gaseous discharge between said electrode structures to effectively treat a product within a treatment zone, the combination of, electrode means defining a treatment zone between a pair of electrode structures, a source of pulsating high potential connected across said electrodes so as to produce a potential gradient within said treatment zone which periodically rises from zero along a predetermined curve until the potential gradient within the treatment zone is great enough to cause a gaseous discharge, and means to control the gaseous discharge which follows each rise in potential gradient, said last-named means including a grid and electrical biasing means for controlling the relative potential of said grid.

15. In electrical treating apparatus of the type wherein a high potential is impressed across a pair of electrode structures so as to produce a corona-like disruptive type of gaseous discharge
5 between said electrode structures to effectively treat a product within a treatment zone, the combination of, electrode means defining a treatment zone between a pair of electrode structures, a source of pulsating high potential connected
10 across said electrodes so as to produce a potential gradient within said treatment zone which periodically rises from zero along a predetermined curve until the potential gradient within the treatment zone is great enough to cause a gaseous
15 discharge, and means to control the gaseous discharge which follows each rise in potential gradient including a grid and means to bias said grid to a potential proportional to the high potential output of said high potential source.
20 16. In electrical treating apparatus of the type wherein a high potential is impressed across a pair of electrode structures so as to produce a corona-like disruptive type of gaseous discharge between said electrode structures to effectively
25 treat a product within a treatment zone, the

combination of, electrode means defining a treatment zone between a pair of electrode structures, a source of high alternating potential connected across said electrodes so as to produce a potential gradient within said treatment zone which
5 periodically rises from zero along a predetermined curve until the potential gradient within the treatment zone is great enough to cause a gaseous discharge, and means to control each individual discharge including a variable impedance which may be adjusted to be resonant to
10 various frequencies.

17. In the art of treating materials by means of a corona-like disruptive type of discharge which results from producing a fluctuating high
15 potential gradient within a treatment zone by impressing a high potential across a pair of electrode structures, the steps of, producing an electrical stress within the treatment zone having a predetermined maximum value and impressing
20 a control potential upon the means producing said electrical stress so as to cause the value of said electrical stress to vary along a predetermined wave-shape.

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