March 13, 1951 P. B. WILSON, JR., ET AL 2,545,328

CONTROLLED HIGH-FREQUENCY SYSTEM

Filed Nov. 15, 1946

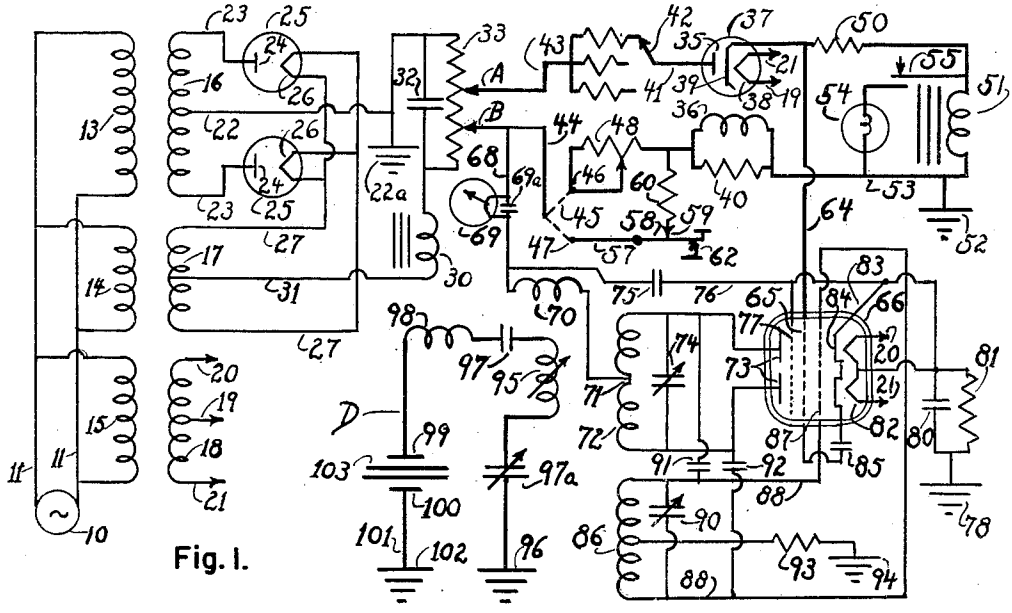


Fig. 1.

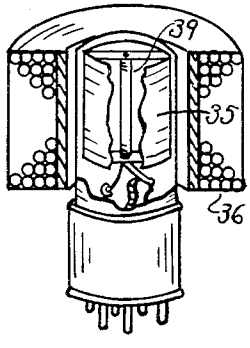


Fig. 2.

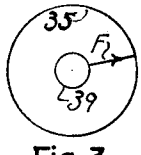


Fig. 3.

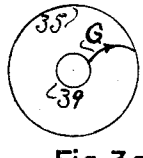


Fig. 3a.

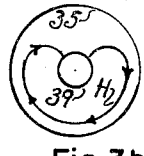


Fig. 3b.

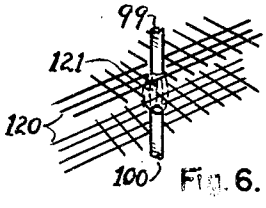


Fig. 6.

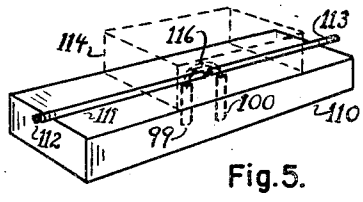


Fig. 5.

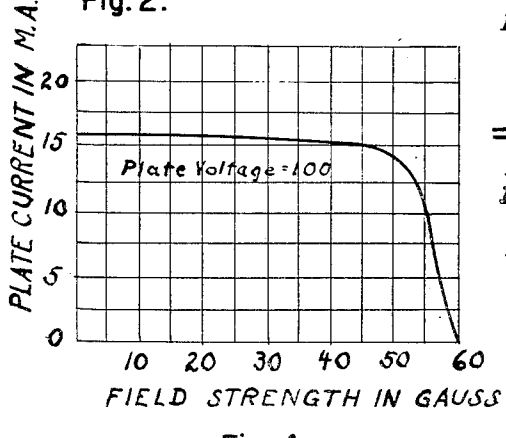


Fig. 4.

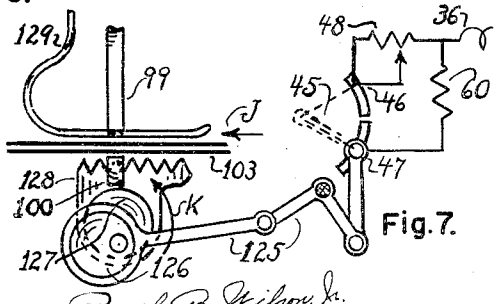


Fig. 7.

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CONTROLLED HIGH-FREQUENCY SYSTEM

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Application November 15, 1946, Serial No. 709,986

8 Claims. (Cl. 219—47)

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This invention relates to apparatus for fusing of dielectric material by means of high-frequency current.

An object of this invention is to provide in apparatus of the character described, improved means to instantaneously control a high-frequency oscillating circuit by varying the voltage potential of the screen element in a vacuum power tube used to produce oscillations, by means of a magnetically controlled vacuum diode tube.

Another object of the invention is to provide in apparatus of the character described, means to prevent overheating and arc formation in dielectric material such as shapes of plastic material, films, sheets, threads and fabric which are being treated between the output electrodes of a high frequency electrostatic field; and towards the instantaneous control of oscillation power production in electronic transmission.

Another object of the invention is to provide a durable apparatus of the character described which shall be inexpensive to manufacture and practical and efficient to a high degree in use.

When a high frequency (any value over 100 megacycles) electronic oscillator is used commercially to furnish an electrostatic field between electrodes in which field dielectric material is being treated, it is necessary to generate and deliver the maximum amount of power in the minimum time to the fluctuating electrostatic field in order to obtain the desired results and yet eliminate the danger of impairing the physical strength or appearance of the material. This is particularly necessary for materials of small cross section (materials of thickness less than ¼ inch) where heating takes place very rapidly, and where it is necessary to have an automatic means of regulating the amount of power in the electrostatic field which means will operate as rapidly as the material heats up. For materials of larger cross-section or those in which a physical change takes place which may be visually noted or measured by instruments, a manual method of controlling the electrostatic field may be more desirable. Accordingly, in the present invention means have been provided to allow for automatic or manual operation of the control means as desired.

Furthermore, where dielectric material is operated on, the margin between fusing temperature and the temperature at which disintegration commences is sometimes a small one. Even where such disintegration does not externally affect the appearance of the material, the latter may be rendered brittle, lose strength, or other

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change of quality may occur. In such cases, a control circuit is used to allow power just adequate to heat the material to a tacky condition where it may be joined together by pressure with similar material. In this manner, an absolute minimum of change to the substance of the material may be effected, so as not to appreciably change its qualities.

It has been noted that there are electrical changes which occur in all parts of an oscillating circuit as dielectric material heats up between the output electrodes in a high-frequency electrostatic field. These electrical changes are also evident in the direct current supply circuit from the rectifier to the plate feed of the power oscillator tube, and it is this change in direct current which is used for the automatic control explained in detail later, although any other change in any of the circuits of the apparatus could be used. A control tube known as a magnetically controlled diode tube is directly responsive to such change, and in turn alters the potential of a screen grid of the power oscillator tube, to vary the flow of electrons in the latter, thereby directly affecting the amount of electrical power produced at any given time by the power oscillating tube.

Other objects of this invention will in part be obvious and in part hereinafter pointed out.

The invention accordingly consists in the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the construction hereinafter described, and of which the scope of application will be indicated in the following claims.

In the accompanying drawing, in which is shown various possible illustrative embodiments of this invention:

Fig. 1 is the wiring diagram in conventionalized form of the apparatus embodying the invention, including a rectifier circuit, a high-frequency oscillator circuit, an output circuit; and an accompanying control circuit;

Fig. 2 is a cut-away view through the magnetically controlled diode tube used in the control circuit;

Figs. 3, 3*a* and 3*b* indicate in diagrammatic form the action of the magnetic field upon the electron flow of the diode tube;

Fig. 4 is a graph indicating a typical characteristic curve of the diode tube for one value of plate voltage only, showing the relation between magnetic field strength and the effective current which the latter allows to pass through the diode tube;

Fig. 5 indicates the positioning of the output electrodes adjacent to each other, so as to create the proper magnetic field for butt joining dielectric material;

Fig. 6 indicates the positioning of the output electrodes opposite one another, so as to create the proper magnetic field for fusing together dielectric material contiguous to and in contact with other similar material; and

Fig. 7 is a diagrammatic view illustrating the synchronous control of the electrical circuit in combination with a mechanical movement, such as the one which operates the feed mechanism for continuous plastic film being operated on.

Referring now to Fig. 1, there is shown therein a source 10 of low voltage commercial current such as 110 volt, A. C., 60 cycle current, to feed current to a rectifier circuit. The current feeds through leads 11 to the primary transformer coils 13, 14 and 15 connected in parallel. The transformer coils 13, 14, 15 couple with a high voltage secondary coil 16, and filament coils 17 and 18 respectively. Connected to the center tap of the filament coil 18 is a wire 19, and extending from the ends of said filament coil are wires 20 and 21. The center tap of coil 16 is connected by wire 22 to ground as at 22a. At the ends of coil 16 are wires 23 leading to the plates 24 of a pair of rectifying vacuum tubes 25. The filaments 26 of said rectifying tubes are connected in parallel with each other, and to the ends of coil 17 by wires 27. A filter choke coil 30 is connected at one end by wire 31 to the center tap of coil 17, and at its other end in series with a filter condenser 32 which in turn is grounded as at 22a. Connected in parallel across the condenser 32 is a bleeder resistance 33. The circuit heretofore described serves to cause a pulsating direct current through the filter choke 30, filter condenser 32 and bleeder resistance 33. This circuit is a customary type of rectifying circuit.

From the bleeder resistance 33, taps A and B are brought out. Tap A is connected in the manner hereinafter disclosed, to the plate 35 of the diode 37. Diode 37 further comprises a filament 38 and a cathode 39. The filament 38 is connected to the wires 21 and 19. The magnetic coil 36 of the diode surrounds the tube. Connected across said magnetic coil in parallel is a resistance 40. Plate 35 of the diode 37 is connected by wire 41 to a selector switch 42. Said selector switch includes a plurality of resistances connected to the tap A by wire 43. The potential of plate 35 may be varied by adjusting the selector switch 42. The cathode 39 is connected to a current limiting resistance 50, which in turn is connected in series to an automatic relay 51 and thence to ground as at 52. Connected in parallel across the automatic relay 51 is a pilot light 54 controlled by a switch 55 which is normally open but closes under the influence of said relay when the latter is energized, thereby passing current through the pilot light and allowing the latter to become illuminated.

Tap B is connected through wire 44 to a switch arm 45 adapted to engage either of the contacts 46 or 47 depending on the position of said switch arm. When the switch arm 45 engages contact 46, a circuit is set for automatic control as will appear hereinafter, and when said switch arm is moved to contact 47, the circuit is set for manual control, as will appear hereinafter. Contact 46 is connected to limiting resistor 48, which in turn is connected in series with the magnetic coil 36. The purpose of the resistance 40 is to obtain the correct voltage drop required for correct coil operation. Contact 47 is connected through wire 57 to a switch key 58. The key is normally in engagement with a contact 59 connected through a current limiting resistor 60 to a point between the coil 36 and the resistor 48. Any suitable spring 62 may normally keep the key 58 in engagement with contact 59. When the key is depressed however, it moves away from said contact to break the circuit through resistor 60.

Tapped off between cathode 39 and resistance 50 is a wire 64 which leads to a screen element 65 of a power oscillating vacuum tube 66, and it is this screen element 65 which controls the oscillating circuit to be described hereinafter. The power tube 66 is shown here as containing two complete sets of units mounted in one envelope. The two complete sets of units are in push-pull relationship as shown in the drawing.

The afore-noted circuit fed from tap B may be termed a control circuit and its operation will be explained hereafter.

Tap B also feeds the plate circuit of the high-frequency oscillator circuit, through wire 68, thence to meter 69 shunted by condenser 69a, and thence in series with a radio frequency choke 70. Said choke is connected to the center tap 71 of a resonant frequency inductor 72. The ends of the inductor 72 are connected to the plate 73 of the tube 66. Connected in parallel across the inductor 72 is a variable condenser 74. Between meter 69 and choke 70 is connected by-pass condenser 75 leading to cathode 84, which is connected internally through blocking capacitor 85 to the screen grid 65. Wire 76 which connects condenser 75 and cathode 84 also connects to suppressor grid 77, to the center of filament 82, and in series to cathode grid bias resistor 81 which is by-passed by capacitor 80. The latter are connected to ground as at 78. The filaments 82 are connected by wires 20 and 21 to the ends of secondary coil 18.

An additional resonant frequency coil 86 is inductively connected to coil 72. Coil 86 is connected by wires 88 to control grid 87. A variable capacitor 90 in parallel with coil 86 serves to tune the control grid. Feed back condensers 91 and 92 are connected between coil 72 and coil 86. The center of coil 86 through resistance 93 is grounded at 94.

This is a customary type of high-frequency oscillator circuit, and its operation will be understood by one skilled in the art.

The oscillating circuit is coupled to an output circuit D by means of a coupling coil 95 which is adjustable to vary the degree of coupling with the resonant frequency coil 72. One end of coil 95 is connected to variable condenser 97a and thence to ground at 96. The other end of coil 95 is connected in series to a tuned transmission line represented by condenser 97 and inductance 98, which in turn is connected to an output electrode 99. A complementary output electrode 100 is connected by wire 101 to ground as at 102. Dielectric work or material 103 may be mounted between the electrodes 99 and 100. In lieu of output electrodes, a transmission antennae may be installed.

To understand the operation of the automatic and control features of the circuit, it is first necessary to examine the operation of the magnetically controlled diode 37. Referring to Fig. 2, the diode plate is indicated at 35, cathode at 39, and magnetic control (induction) coil at 36. The action of the magnetic field formed by the induc-

tion coil can best be explained by reference to diagrammatic Figs. 3, 3*a* and 3*b*. Fig. 3 illustrates the operation of the tube when no magnetic field is induced by coil **36**. In such case, the electrons will follow a straight path F from cathode **39** to plate **35**, and current will flow through the diode. In Fig. 3*a* there is illustrated the condition when a magnetic field is created by the induction coil which causes the electron path to be deflected from a straight line to a curved path G, but where current continues to flow through the diode, although its magnitude will be less. In Fig. 3*b* there is illustrated the condition where the magnetic field strength increases to a point where such magnetic field strength is great enough to completely deflect the electron path so that the electrons return to the cathode and do not reach the plate, as indicated by path H, thus resulting in complete cutoff of current passing through the diode.

This is further illustrated in the graph shown in Fig. 4, where the current allowed to pass through the diode tube is an amount dependant upon the magnetic field strength and plate voltage of said tube, and as field strength increases the current passing through the diode rapidly decreases to zero. This is the characteristic of diode tube **37** which is used to control the power oscillating tube **66**. Adequate maximum field strength can readily be obtained under various values of voltage and amperage by varying the size of wires and the number of turns of the induction coil **36**. Effective action can thus be obtained for various values of voltage and amperage and for any change thereof.

The complete functioning of the apparatus will now be entered into. For normal high-frequency operation switch **45** is placed on contact **46** for automatic control, with dielectric material in position between output field electrodes **99** and **100**.

As the material becomes heated through the molecular friction induced by the rapidly alternating electrical field, there is an impedance change which causes a potential increase across electrodes **99** and **100**, and through the interaction of the component parts of the various circuits heretofore mentioned, the voltage potential of the direct current plate feed B rises. The diode control circuit is connected with plate feed circuit B, and there will be a rise in potential of the control circuit including induction coil **36**, with a consequent increase of magnetic field strength induced by the coil. The amount of current passed through induction coil **36** may be varied to suit output power requirements by variable resistor **48**, so as to arrive at a magnetic field strength which will allow cutoff of the electron flow in the diode whenever the voltage potential in the direct current feed B rises beyond a predetermined operating point.

This operation results in a very rapid decrease of the current allowed to flow through the diode. As the current passing through the diode and wire **64** provides correct operating potential with respect to the ground for the screen **65** of the power oscillating tube **66**—when the current allowed to pass through the diode decreases there is a resultant diminution of the potential of screen **65**, and in accordance with the characteristics of the power tube, the flow of electrons is inhibited. The power developed by the tube decreases in proportion to the drop in potential of the screen, and is thus in turn proportional to the amount of current passing through the diode, which in turn is proportional to the change in potential of circuit "B."

During normal operation, adequate current flows through the diode and thence through automatic relay **51** to close the circuit connected to pilot light **54** (by energizing coil **51**). The light will therefore remain lit during normal operation of the diode. However, as the current passed by the diode decreases to some predetermined point, the automatic relay switch will open, and the pilot light will go out. This affords a means of determining approximate approaching cut-off conditions in the diode with resulting suppression of power in the power oscillating tube.

All the control elements of the diode and screen members are electronic, and the only loss of time in actual operation is caused by the transit time of the electrons in diode tube **37** and power tube **66**, the loss of time in the electrical interconnections, and the loss of time involved in the buildup of the magnetic field of induction coil **36**. Transit time is equivalent to the speed of light, as is the electrical interconnection time due to short leads. Induction field buildup time is minute due to direct current being used, and because a small increase in voltage is adequate to operate cut-off of the diode. The combination times of the factors heretofore mentioned is of the order of one micro-second (one millionth of a second). This gives an extremely fast reaction time sufficient to reflect without appreciable lag changing conditions in material being heated, to prevent dielectric strength collapse, arcing and damage.

As the oscillating circuit is always working, although the power developed by it varies with the impedance of the dielectric material **103**, the circuit is adaptable to changing conditions of any nature between electrodes **99** and **100**. The circuit is limited only by the power of the oscillating apparatus to heat varying dielectric materials as determined by the rate of oscillations of the apparatus, the dielectric loss of the material, and the capacity of the component parts.

When power is cut down, it will remain so as long as the dielectric material and its condition remain unchanged. However, when the dielectric strength of the material between electrodes **99** and **100** is restored due to the motion of the material, external cooling or any other cause, the voltage of circuit "B" falls with a consequent diminution of voltage across the terminals of induction coil **36**. In turn, this allows a restoration of current flow through the diode, which allows the potential of the screen to return to its normal value, permitting normal full operation of the power oscillating tube.

As an illustration of the operation of the safety circuit in controlling oscillating power output, refer to Fig. 5. This figure shows output electrodes **99** and **100** set side by side in block **110** which is grooved at its upper side as at **111**, to carry opposing nylon threads **112** and **113** which are to be heat fused together at their butt ends (thereby eliminating knots such as has been heretofore customary in repairing broken warp threads of looms with consequent slubs, defective weaves, etc.). Holding the threads in place is a hinged (dotted) top member **114** which is grooved at its underside complementary to groove **111**. The lines of force of the electrostatic field may be represented by dotted lines **116**, running approximately parallel to the axis of the threads, and perpendicularly across the intersection to be heated. The heat of friction of the nylon mole-

cules caused by the rapid reversals of the electrostatic field will cause the thread to heat, become plastic, and tend to flow together and unite at the joint, under the pressure of top member 114. As this action takes place, the control circuit cuts down the amount of power developed by the power oscillating tube so as to prevent arcing with consequent disruption of the thread particles. Simultaneously pilot light 54 will go out, indicating the cutting down of current passed by the diode, and the existence of a fused condition at the butt joint between the threads. The entire apparatus may then be shut off, the threads will cool together and fuse together in the shape of the groove surrounding them, and the resultant weld will be as strong or stronger than the thread.

As a further illustration refer to Fig. 6. This figure shows output electrodes 99 and 100 set opposite one another with two layers of dielectric fabric 120 such as nylon stocking fabric, in position between the electrodes so that the two layers may be seamed together. The stocking layers are moved along a straight line by an intermittent cam shoe motion as in an ordinary sewing machine, such as is hereafter exemplified in Fig. 7. As the layers of dielectric fabric come momentarily to rest, the influence of the dielectric field represented by dotted lines 121 causes the nylon threads to become soft so that they may be pressed and fused together. When the cam shoe moves the fabric layers to the next succeeding position, the previously heated threads cool and harden together under the pressure of the sewing machine foot member, forming a fused member or weld. The same process is repeated at every point where the cam motion allows the fabric layers to halt momentarily between the electrodes, thus creating a series of tack welds which seam the layers of fabric together. The seamed points are small, neat, and the stocking material is not puckered as with thread sewing. As only enough heat is allowed so as to develop a condition where adjacent material may become softened so as to be pressed together, there is no excess of heat leading to disintegration of the material with consequent brittleness.

Where this same time of tack welding is used for dielectric material such as the plastic film used for shower curtains, umbrellas, etc., the further advantage exists, that the material is not punctured as in needle machine sewing, thereby eliminating a prolific source of troublous tearing of the completed product.

On such work (i. e., involving woven threads and film) the action of the control circuit prevents overheating and burning of the material at such time as the operator is starting or stopping the sewing machine during individual operations. An extremely high-frequency oscillator of the order of 200 megacycles is required to heat individual threads or portions of film in the brief period of time they are motionless between electrodes, and the control circuit is capable of such extremely rapid control also, together with the precision to prevent overheating of the small sectional areas involved, and the prevention of arcing.

Referring now to operation of the power oscillating tube with manual control, using switch 45 set at contact 47, the circuit is so designed as to operate only when key 58 is manually depressed. For this type of operation, a fixed proportion of the direct plate current used in circuit "B" is allowed to pass to induction coil 36 by means of the limiting resistance 60 and key 58. Said key 58 is normally closed so that the circuit is completed, and adequate current is permitted to pass at all times to induce sufficient magnetic field from coil 36 to completely inhibit the flow of electrons in diode 37. In turn, through wire 64 this gives such a low potential to the screen 65 of the power oscillating tube as to prevent oscillations. However when the key 58 is manually depressed the circuit is opened, no current flows through induction coil 36, no magnetic field is induced, the electron flow through the diode is not interrupted, current flows through the latter, and by means of wire 64 the screen potential of the power oscillating tube rises to its correct operating value—permitting oscillation to take place, and consequent transfer of energy to the output circuit. Thus when the key 58 is depressed, dielectric heating may take place.

Upon release of key 58 it resumes a position whereby the circuit again closes, and oscillations are again inhibited.

During such time as the operator is holding down the key, he can watch the work for visible indications afforded by the heating processes, or can watch meters connected in appropriate circuits which will indicate empirical points at which adequate heating has been reached. When he releases key 58, oscillations will stop, and he can remove or otherwise adjust the work with no possibility of effect or danger to himself from the existence of high-frequency potential between electrodes 99 and 100 between which the work is located.

As an example of the combined use of resistor 48 to allow current to pass through the diode, and resistor 60 to cut off the current through the diode, in Fig. 7 is re-drawn in detail the synchronous control of the electrical circuit in combination with the mechanical movement of plastic contiguous sheets to be operated on, which may be exemplified as follows:

Let 129 be a sewing machine foot, 128 a sewing machine drive shoe, 127 be the cam which moves the drive shoe, and 103 the contiguous dielectric plastic sheets which are being tacked together. On the same drive spindle as cam 127, is another cam 126 offset in advance of cam 127—which cam 126 through lever motion 125 actuates the mechanical control switch 45 to make it fully automatic in action and synchronized with the drive shoe 128.

With the spindle rotating, assume the drive shoe at a point in its motion contacting the sheets and moving them as indicated by arrow J, which position is shown in the diagram. At this point cam 126 has carried the lever motion to the extremity of its movement so as to carry control switch 45 to its extreme bottom point 47. At this point current passes through resistance 60 in such magnitude as to develop enough field strength in magnetic control coil 36 as to completely inhibit current passing through the diode, which thereby shuts off oscillations and prevents a welding potential being set up between the output electrodes 99 and 100. As the drive spindle continues to turn in the direction indicated by the circular arrow K, the drive shoe moves the dielectric plastic a distance controlled by the eccentricity of the cam 127. At the same time cam 126 is moving the lever motion so that switch 45 moves along a circular path as indicated.

When the drive shoe under the action of cam 127 drops down and ceases to move the plastic 103, the switch reaches the dividing sector be-

tween position 47 and position 46. As the spindle continues to turn, the drive shoe 128 is no longer in contact with sheets 103 which are motionless, and the drive shoe moves back to the starting position below the line of travel of the sheets 103, and not in contact with them. Simultaneously cam 126 through lever motion 125 moves switch 45 to its uppermost position 46. At this point current is allowed to pass through resistance 48 which limits the magnetic field passing through control coil 36 as previously described, thereby permitting the flow of current through the diode and permitting an increase in the potential of screen 65 as required for oscillation, which in turn produces a welding potential between the output electrodes and forms a weld in the plastic sheets.

As the spindle continues to turn, cam motion 126 pulls down switch 45 to position 47 before drive shoe 128 again rises to engage and move the plastic sheets, current is thus inhibited, and welding cannot take place while the plastic sheets are being moved.

As a result of the complete control of the power developed by a high-frequency oscillator using a screen in the power oscillating tube whose potential is varied by a control circuit actuated by a magnetically controlled diode tube, the following advantages result:

(1) The power developed by a high-frequency oscillator—
- (a) May be varied independently of mechanical circuit changes or changes of circuit constants.
- (b) May be instantaneously varied (periods of one microsecond of time).
- (c) May be synchronized with mechanical or other motion.
- (d) May be synchronized with any machine operation, yet may be controlled so as to prevent overheating and arcing during such periods as power oscillation is permitted.
- (e) May be varied from full power to no power without keying transients, and without affecting frequency of emitted wave.

(2) The electrostatic field strength developed between output electrodes of a high-frequency oscillator—
- (a) Will instantaneously vary directly as the dielectric strength of the material being operated on; so as to prevent overheating, arcing, puncturing, burning, distortion or other undesirable change for all sizes and types of dielectric material.
- (b) May be adjusted to attain the greatest possible power commensurate with the frequency being used and the dielectric loss of the material; with the control circuit automatically varying the power to lower amounts as required by slower speeds of operation, decreases of thickness of material, etc.
- (c) May be adjusted to conform to the minimum dielectric strength of the material being operated on, and thereafter may be left in fixed adjustment to eliminate controls and skill in the operation of this type of apparatus; thereby making same usable by all.
- (d) May be made self-limiting so as to protect operating personnel against heating or short circuit effects induced by accidental contact with output electrodes.
- (e) Will instantaneously vary directly as the dielectric strength varies of different types of material passing between output electrodes; such as when material being operated on is dielectric cloth such as nylon threads and air spaces in the woven cloth construction; the dielectric material will be operated on, yet the current will not arc across the air gaps with resultant damage to adjoining dielectric material.
- (f) Will instantaneously vary in accordance with the cross-section of the material being operated on.
- (g) Will instantaneously vary in accordance with the rate of speed of the dielectric material passing between the output electrodes.
- (h) May be adjusted to develop a fixed amount of power adequate for a desired purpose, yet limited in amount should change in circuit constants tend to induce the development of an increased amount of power.

It will thus be seen that there is provided a device in which the several objects of this invention are achieved, and which is well adapted to meet the conditions of practical use.

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

Having thus described our invention, we claim as new and desire to secure by Letters Patent:

1. In combination, a rectifier circuit, including a bleeder resistance, a control circuit tapped from said bleeder resistance, said control circuit including a diode tube provided with a cathode and a magnetic coil, an oscillating circuit tapped from said bleeder resistance and including a vacuum power tube provided with a screen element, and conductor means connecting said cathode with said screen element, and an output circuit including a pair of electrodes coupled to said oscillating circuit, a relay in series with said magnetic coil and said cathode, an electric signal, means to connect said signal in parallel across said relay, including a contact controlled by said relay.

2. In combination, a rectifier circuit, including a bleeder resistance, a control circuit tapped from said bleeder resistance, said control circuit including a diode tube provided with a cathode and a magnetic coil, an oscillating circuit tapped from said bleeder resistance and including a vacuum power tube provided with a screen element, and conductor means connecting said cathode with said screen element, an output circuit including a pair of electrodes coupled to said oscillating circuit, and a normally closed manually operated switch interposed in series with the magnetic coil of said control circuit.

3. In combination, a high frequency oscillator circuit including a vacuum power tube having a screen element, means for automatically controlling the voltage potential of the screen element of said tube for varying the power output of said circuit, a power circuit coupled with said oscillator circuit and including a pair of electrodes, means to feed dielectric material between said electrodes, said feeding means comprising a shoe, means to drive said shoe in reciprocating motion, and means for intermittently engaging said shoe with said dielectric material to advance said material in one direction and means controlled by said feeding means to regulate the operation of said control means, said control means including a control circuit, a diode tube in said circuit having a cathode connected to the screen element of the power tube.

4. In combination, a high frequency oscillator circuit including a vacuum power tube having a screen element, means for automatically controlling the voltage potential of the screen element of said tube for varying the power output of said circuit, a power circuit coupled with said oscillator circuit and including a pair of electrodes, means to feed dielectric material between said electrodes and means controlled by said feeding means to regulate the operation of said control means, said control means including a control circuit, a diode tube in said circuit having a cathode connected to the screen element of the power tube, said regulating means including a switch interposed in said control circuit

and means for alternately opening and closing said switch.

5. In combination, a high frequency oscillator, a load circuit coupled to said oscillator to induce a current in said load circuit, said load circuit including dielectric material to be electrically treated by the current flowing through said load circuit, said dielectric material being subject to changing electrical characteristics while being treated and thereby varying the current in said load circuit, substantially instantaneously operative means including a diode tube having a cathode and an anode, and a magnetic coil, said magnetic coil including means to control the space current flowing through said tube, to limit the increase of said load current, and means to control said magnetic coil in response to variations in current through said dielectric material, whereby to prevent overheating and arc formation in said material.

6. In combination, a D. C. voltage supply source, a high frequency oscillator circuit powered by said D. C. voltage supply source, substantially instantaneously responsive means controlled by voltage variations in said voltage supply source for automatically controlling the power output of said oscillator circuit, said means including a diode having a cathode and an anode and a magnetic coil, said magnetic coil having a part of its magnetic field passive, between said cathode and anode, and means interconnecting said magnetic coil and said voltage supply source to vary the field strength of said magnetic coil in response to variations in said voltage supply, and a power control circuit, including a pair of electrodes, coupled to said oscillator circuit.

7. In combination, a D. C. voltage supply source, a high frequency oscillator circuit powered by said D. C. voltage supply source, substantially instantaneously responsive means controlled by voltage variations in said voltage supply source for automatically controlling the power output of said oscillator circuit, said means including a diode having a cathode and an anode and a magnetic coil, said magnetic coil having a part of its magnetic field passive, between said cathode and anode, and means interconnecting said magnetic coil and said voltage supply source to vary the field strength of said magnetic coil in response to variations in said voltage supply, and a power control circuit, including a pair of electrodes, coupled to said oscillator circuit, and means to feed dielectric material between said electrodes, said feeding means comprising a shoe, means to drive said shoe in reciprocating motion,

and means for intermittently engaging said shoe with said dielectric material to advance said material in one direction only.

8. In combination, a D. C. voltage supply source, a high frequency oscillator circuit powered by said D. C. voltage supply source, substantially instantaneously responsive means controlled by voltage variations in said voltage supply source for automatically controlling the power output of said oscillator circuit, said means including a diode having a cathode and an anode and a magnetic coil, said magnetic coil having a part of its magnetic field passive, between said cathode and anode, and means interconnecting said magnetic coil and said voltage supply source to vary the field strength of said magnetic coil in response to variations in said voltage supply, and a power control circuit, including a pair of electrodes, coupled to said oscillator circuit, and means to feed dielectric material between said electrodes, said feeding means comprising a shoe, means to drive said shoe in reciprocating motion, and means for intermittently engaging said shoe with said dielectric material to advance said material in one direction only, and mechanically operated switching means including said first means and controlled by said feeding means to control the power output of said oscillator circuit.

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