April 12, 1949. J. E. YOUNG ET AL 2,467,285

HIGH-FREQUENCY GENERATING SYSTEM

Filed July 12, 1944 3 Sheets-Sheet 1

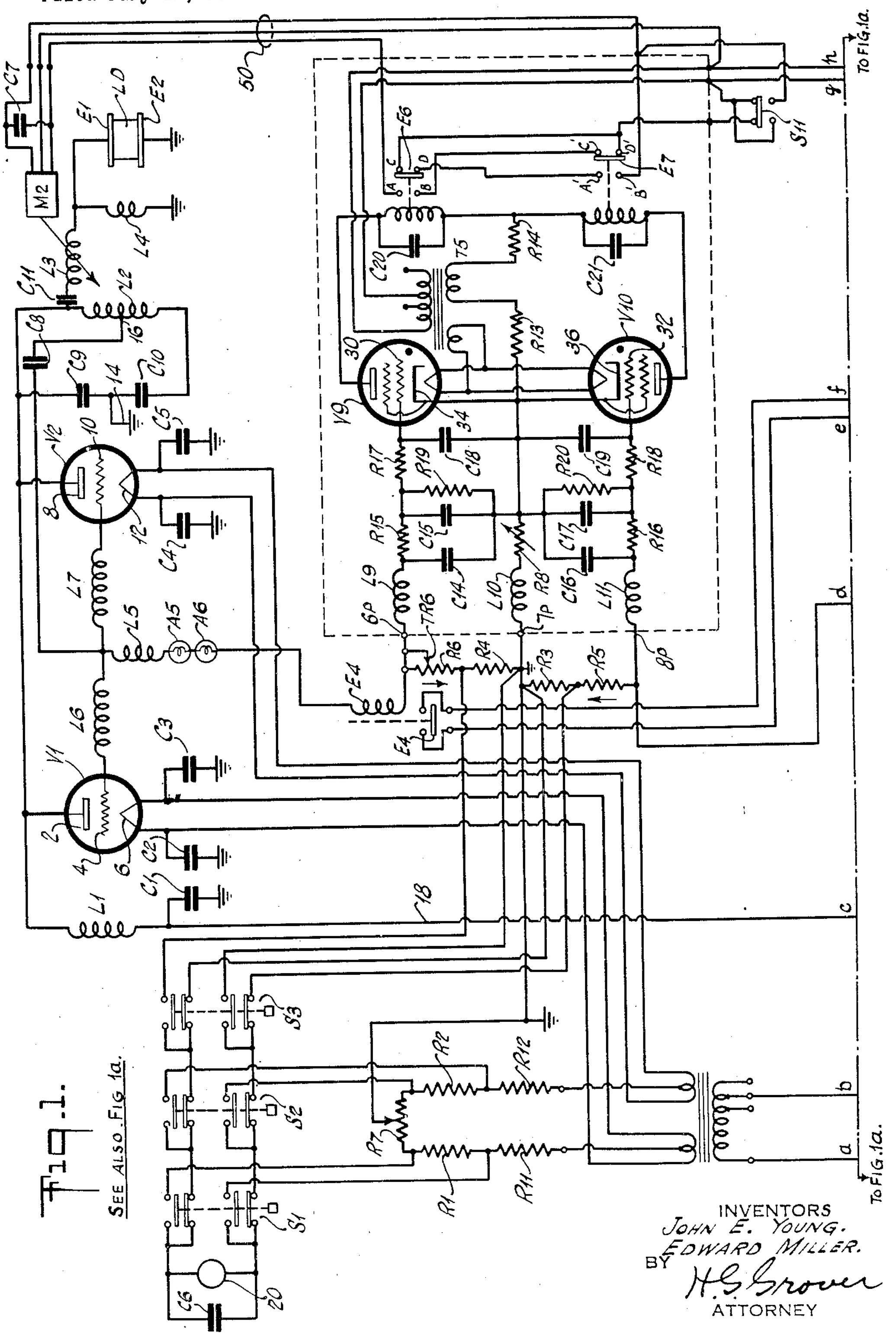

Fig. 1.

See also Fig. 1a.

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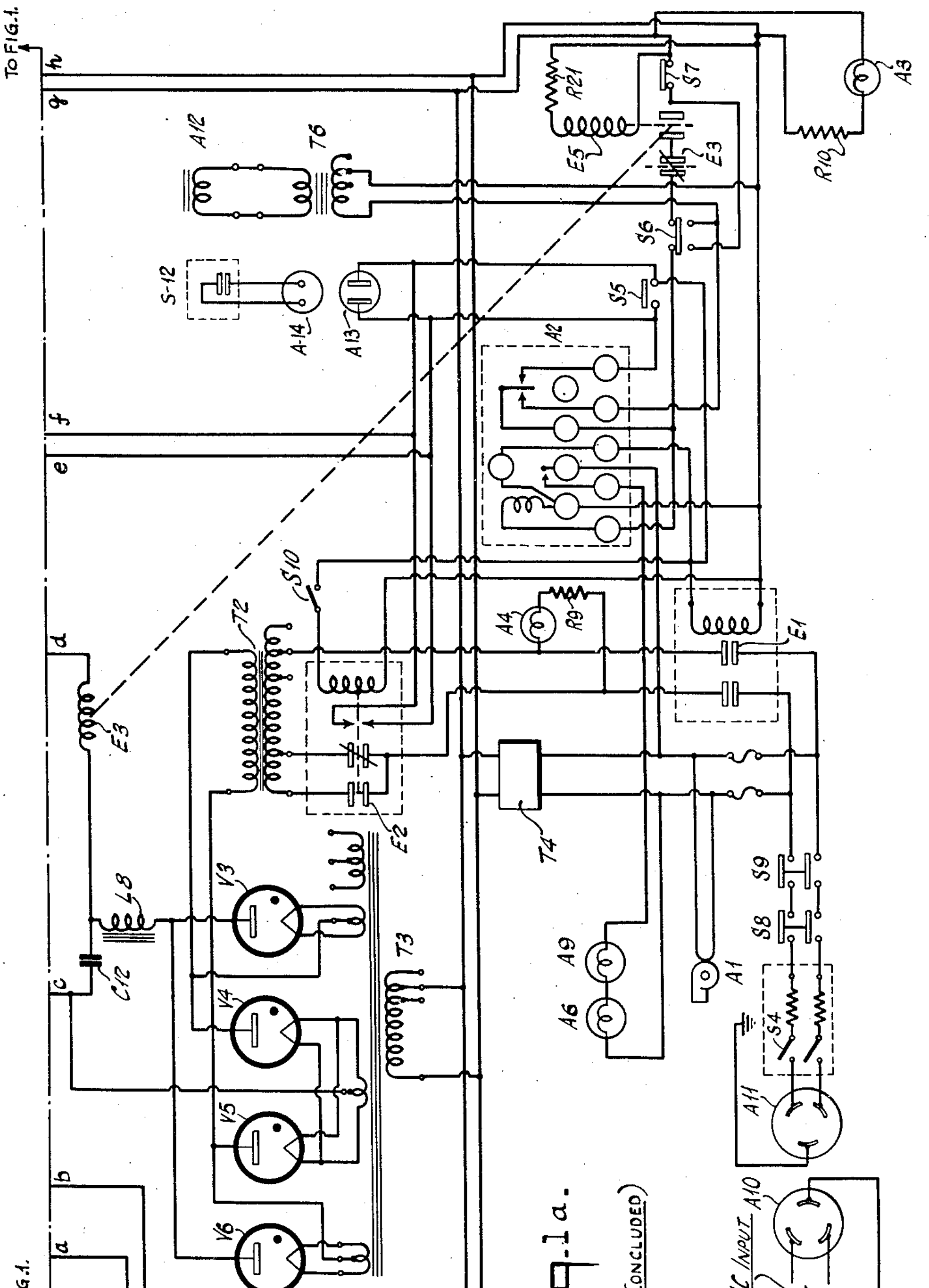

Fig. 1a.

(Fig. 1. Concluded)

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Filed July 12, 1944 3 Sheets-Sheet 3

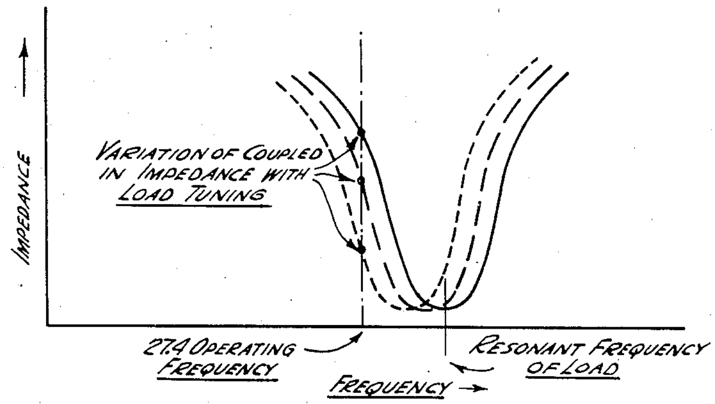

Fig. 2.

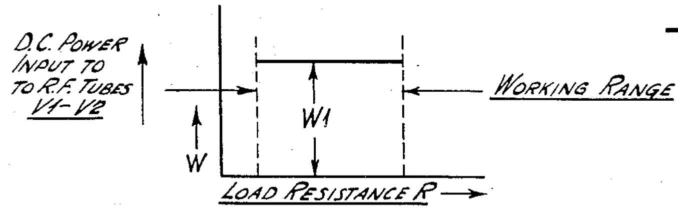

Fig. 3.

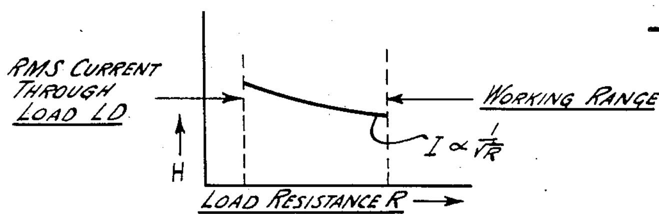

Fig. 4.

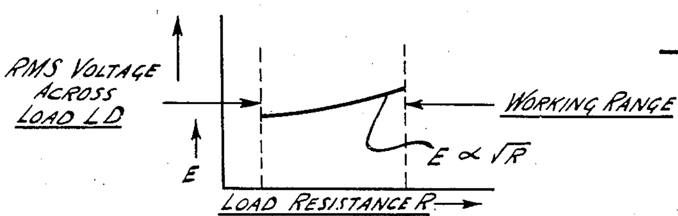

Fig. 5.

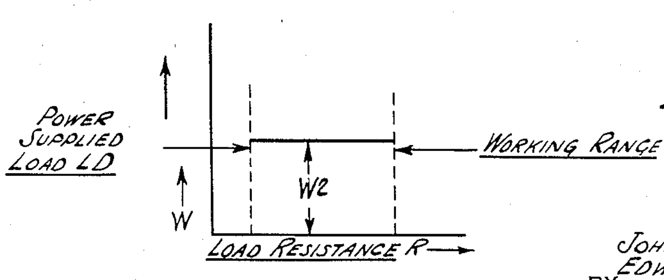

Fig. 6.

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HIGH-FREQUENCY GENERATING SYSTEM

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Application July 12, 1944, Serial No. 544,510

16 Claims. (Cl. 250—36)

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Our present invention relates to the generation of high frequency power for use, for example, in high frequency heating systems. The invention is particularly useful where large concentrations of heat are required to raise the temperature of an object or a batch of material to some predetermined level in a short time. For example, the present invention may be used for preheating uncured plastic material prior to molding.

In order to heat the load in the shortest heating period or cycle, it is desirable to subject the load to high constant power. As the load dries or otherwise changes due to the heating, it will be found that in most cases its effective capacity and resistance changes causing a change in the power used in the load. An increase in power taken by the load may cause overloading of the generator which is undesirable, whereas a decrease in load power will lengthen the heating period.

One object of our present invention is to provide an arrangement whereby despite changes in electrical characteristics of the load, the power therein is maintained substantially constant, thereby eliminating the possibility of damage to the generator caused by overloading while keeping the heating period to a minimum.

A further object of our invention is to provide apparatus wherein the power applied to a load may be set for a definite value, and wherein that applied value of power is maintained and supplied to the load despite changes in electrical characteristics of the load.

In carrying out our invention, we make use of a vacuum tube oscillation generator for which, over the working range, with constant power excitation or input, the efficiency of conversion to high frequency power is practically constant for loads connected to the oscillator. An impedance is connected in series with the load and oscillator and is automatically adjusted in such a way that, in the event the load characteristics change, the power fed to the load remains, nevertheless, substantially constant and at a set, desired value.

Further objects of our invention are to provide a high frequency oscillator whose power output may be easily controlled and set to a desired value; to provide a comparison system for a vacuum tube in which rectified grid current is compared with uni-directional plate current fed to the tube to indicate the state of operation of the apparatus, and to provide an automatic adjusting system which makes use of the comparison of direct grid and plate currents of a vacuum tube for controlling a circuit associated with the tube.

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Further objects, advantages, and features of our invention will become evident as the more detailed description thereof proceeds.

The accompanying wiring diagram, shown in Figs. 1 and 1*a* taken together, is a diagram of our improved high frequency generating system for industrial or power purposes, Fig. 2 is a graph illustrative of the characteristics of the load and generator, and Figs. 3, 4, 5 and 6 are curves graphically illustrating the operation of the system of Figs. 1 and 1*a*.

Referring to the accompanying wiring diagram, we have provided a high frequency generator comprising vacuum tubes V1, V2 operating in parallel in a Colpitts' oscillating circuit. These tubes are provided with a tank circuit TC in which oscillations of high frequency are produced, for example, oscillations having a frequency of 27.4 megacycles. Power is fed from the tank circuit TC through a variable impedance, reactor, or coupling device L3 in series with a load LD. The load LD may be any insulative object or mass of material to be heated by high frequency currents. The load LD is disposed between the metallic electrodes E1, E2, one of which is grounded. In practice the physically upper electrode is grounded.

Coil L3 and the capacity represented by the load and electrodes E1, E2 are adjusted to resonance at some frequency substantially higher than the resonant frequency of tuning of the tank circuit TC for reasons which will be more fully described later. Coil L4 is connected in shunt to the load electrodes E1, E2 in order to secure a small amount of parallel resonance, thereby relieving coil L3 of some of the current drawn by the load.

In general, the load will have capacitive and resistive components which may vary during the heating process. It is desirable to feed a constant amount of high frequency power to the load so as to make the heating period as short as practicable. The power absorbed by the load, however, will change as the characteristics of the load change, and, hence, we have provided an automatic arrangement for maintaining the power in the load substantially constant over the heating period or cycle.

In this connection, relatively constant plate voltage and, accordingly, input power is fed to the oscillator tubes V1, V2. The efficiency of conversion by these tubes, of the input excitation or power, to high frequency power is practically constant for loads within the working range of the system. The tubes can be set to deliver a definite amount of power in the load, as will be described in detail later, and this amount of power so fed will be maintained relatively constant even though, for example, the load impedance drops or changes. For in that event, the impedance L3 in series with the load is automatically varied by reversible motor M2 in such a direction as to maintain constant the power in the load. Although a change in L3 may cause a small change in frequency of the oscillations generated, of the order of a few percent, this change is of no practical significance.

The motor M2 is operated in one direction or another in response to a comparison of the unidirectional rectified grid current and the unidirectional plate current fed to the tubes.

The rectified grid current, it will be noted, is maintained substantially constant by the use of resistors A5, A6, which may be in the form of incandescent lamps and which serve to maintain substantially constant grid current at any value determined by the setting of auxiliary resistor R6. This grid current is compared with the plate current flowing through resistor R5 and the differential voltage resulting from a comparison of the currents or voltages in the resistors R5 and R6 causes the motor M2 to be operated in such a direction as to bring the plate current back to its proper value as determined by the grid current setting. The D. C. plate current, it is to be noted, is a measure of the high frequency power output of tubes V1, V2.

The compared currents or voltages are used to operate a pair of thyratron tubes V9, V10 which operate the reversing switches E6 and E7, controlling the direction of rotation of motor M2.

To go into greater detail, the high frequency generator comprises vacuum tubes V1, V2 effectively connected in parallel. Tube V1 is provided with an anode or plate 2, a grid 4, and a cathode 6. Tube V2 is provided with a plate 8, a grid or control electrode 10, and a cathode or filament 12.

The tank circuit TC includes condensers C9 and C10 which may be of the sulphur dielectric type. A point 14 intermediate of condensers C9, C10 is grounded. Coil L2 connected across the tank condensers is of such value as to resonate with the tank condensers at a desired frequency of operation, for example, 27.4 megacycles. An intermediate point 16 on coil L2 is connected to the grids of the high frequency tubes V1, V2 through bypassing condenser C8. Although the grids of the tubes are effectively connected in parallel, coils L6, L7 are provided for insuring that the grids and plates are 180° apart at the desired operating frequency.

As before indicated, the load circuit L3, L4, LD is directly coupled to the oscillator tank circuit TC for power transfer. Grid excitation is controlled by varying the magnitude of R. F. voltage of the proper phase fed from the tank circuit TC to the grid of the tube. Since the magnitude of the voltage across the tank coil decreases from a point of maximum grid voltage at the grid end of the coil L2 to zero at some point along the coil, tapping in at some point between these two limits will vary the grid voltage drive from zero to the value of voltage existing across capacitor C10.

Metering is accomplished by the use of a single meter 20 and three push-buttons. When operating normally, the meter reads total plate current for both tubes V1 and V2 in percent of rated load current. By pressing push-button S1, S2, or S3, the meter 20 will read cathode current in tube V1, cathode current in tube V2, and total grid current respectively.

High voltage plate excitation is derived from the mercury vapor rectifier tubes V3, V4, V5, V6 and applied through lead 18 and choke L1 to the parallel-connected plates 2 and 8. The rectifier tubes are of the RCA 8008 type and operate in a single phase, full wave bridge rectifier circuit. Condenser C1 is a bypassing condenser and serves to insure the absence of high frequency power from the rectifying circuit.

The plate circuit return to the cathodes includes resistors R5 and R7, the latter of which is provided with a variable tap, as indicated, so as to balance the current flow through the tubes V1, V2 to equal values.

One purpose of the automatic control system involving variable reactor L3, motor M2, and thyratron V9, V10 is to have continual unattended control of the tuning elements in the loading circuit so that the average power supplied to the load LD is at maximum throughout the entire heating period or cycle. The loading system is a series tuned circuit comprising inductance L3 and the load LD together with the stray capacity between the electrodes E1 and E2. In this series circuit, the material LD to be heated forms the dielectric for the capacitive element, and the continuously variable rotary coil L3 forms the inductive element. The degree of loading depends upon how close to resonance this series circuit is tuned. In normal operation, L3 and the load are adjusted so as to be capacitive and operate off resonance, as indicated illustratively in Fig. 2. A switch S11, manually operated, is provided to run motor M2 back to adjust L3 and the load to the capacitive side of resonance, which operation will be found necessary when going from a high to a low reactive load. An indication for the necessity of operating S11 is given by the kicking out of overload relay E3 in the R. F. plate circuit of tubes V1 and V2, or failure of the automatic control to adjust the loading to the predetermined setting.

The series inductive element L3 is driven by motor M2 and the direction of rotation of the motor will determine whether the inductance of L3 will increase or decrease. Control of direction of rotation is supplied by the automatic control circuit which includes actuating switches E6 and E7 which control the direction of rotation of motor M2 and thyratrons V9 and V10 which control the switches.

Thyratrons V9 and V10, in turn, are controlled by the difference in voltage across resistance R6, through which rectified grid current flows, and the voltage drop across resistance R5 through which the D. C. plate current for tubes V1 and V2 flows. The difference in voltage is made effective across resistance R8 where they are compared or combined, as will be explained in greater detail later. The value of R5 is fixed so that the voltage drop across it will depend upon the current flowing.

The D. C. grid current is maintained constant through R6 which is variable. In order to maintain the D. C. grid current constant, a grid bias resistor comprising one or more incandescent bulbs or lamps A5 and A6 is provided. These bulbs have a variable resistance characteristic whereby the resistance increases rapidly as the bulbs draw current.

As loading on the oscillator is increased, the high frequency drive increases which causes the grids to draw more current. This rectified current flowing through the lamps A5 and A6 increases their resistance, resulting in an increase of negative grid bias, thus tending to reduce the D. C. grid current. If the loading decreases, the rectified grid current decreases, resulting in a rapid drop in grid bias. This condition causes the grid to draw more current.

The net result is, that as the loading is either increased or decreased, the limits between which the D. C. grid current varies have been reduced considerably. The average D. C. current will then be approximately constant. Therefore, the voltage developed across resistance R6 will depend upon its resistance setting as fixed by adjustment of tap TR6.

Since the ratio of D. C. plate current to D. C. grid current is constant, here, approximately 4:1, adjustment of R6 by TR6 will automatically adjust the plate current, thereby enabling setting and control of the power output of tubes VI, V2 to any desired value within, of course, the operating range of the system.

Resistance R4, in series with R6, is a meter resistance of 1 or 2 ohms, the voltage drop across which indicates the grid current flow when impressed across meter 20 when switch S3 is closed. Similarly R3 is a low metering resistance, the voltage drop across which represents the total D. C. plate current flow for tubes V1 and V2.

The voltage drop across resistance R6 is fed through radio frequency filtering choke L9 and a resistive-capacitive filter comprising resistors R15 and R19 and condensers C14 and C15, through a high resistance R17 to the control grid 30 of the thyratron tube V9. Condenser C18 in shunt with the grid and cathode of tube V9 is also a bypassing condenser. A portion of the voltage drop across resistance R6, that is, the voltage from point 6P to grounded point 7P representing the voltage drop produced by the rectified grid current flow, is developed across the variable return resistor R8 in series with a radio frequency choke L10.

In a similar way, the voltage drop across resistance R5 produced by the D. C. plate current flow in tubes V1 and V2 is fed to the grid 32 of thyratron tube V10 and also impressed across the common cathode return resistor R8. In this connection, it will be noted that inductance L11 serves as a radio frequency choke coil, and condenser C16 and C17 together with resistors R16 and R20 serves as a radio frequency filter, resistances R16 and R20 also acting as voltage dropping resistors as do also R15 and R19. R18 is similar to R17 and they serve to keep the grid current of tubes V9 and V10 down to a safe value. Condenser C19 is a bypassing condenser.

Cathode 34 of tube V9 and the cathode 36 of tube V10 are connected directly together and are returned to ground through common variable resistor R8. It will be noted, therefore, that if for some reason a large voltage drop is developed across resistance R5, a portion of it will appear across resistance R8. This resulting voltage drop across resistance R8 will tend to place a positive potential on the grid 30 of tube V9. Similarly, if an abnormally large voltage is developed across resistor R6, this voltage drop will be manifest by a voltage drop in resistor R8 which will tend to overcome the voltage drop in resistor R5 and impress a positive voltage on the grid 32 in the tube V10 with respect to the cathode 36 of tube V10.

The plates of tube V9 and V10 are supplied with alternating voltages derived from the secondary of transformer T5 which is connected between the cathode of the tubes and the anodes through radio frequency damping or filtering resistors R13 and R14. In the plate circuit of tube V9 is the solenoid-operated switch E6 and in the plate circuit of tube V10 is the solenoid-operated switch E7.

When the generator is in operating condition, that is, with all voltages applied except D. C. plate voltage, the thyratrons V9 and V10 will fire since there is no bias on the thyratrons. This will cause plate current to flow in V9 and V10, energizing relays E6 and E7 and closing contacts A—B and A′—B′. Relays E6 and E7 control the direction of rotation of the reversible motor M2, since they control the relative phases of currents applied through leads 50 to the reversible induction motor M2. Condenser C7 is a phasing condenser for motor M2.

It can be seen from the diagram that in order for the motor to rotate, contacts A—B on E6 and contacts C′—D′ on E7 must be closed at the same time for one direction of rotation and, likewise, contacts C—D on E6 and A′—B′ on E7 must be closed at the same time for rotation in the opposite direction. Therefore, if V9 and V10 both fire at the same time or both fail to fire, the motor will not rotate. There must be only one tube firing at a time for the system to operate, i. e., to cause rotation of motor M2.

When D. C. voltage is applied to the anodes of V1 and V2 in the R. F. circuit, plate current will flow through R5 and grid current will flow through R6. Since the ratio of D. C. plate current to D. C. grid current is approximately 4:1, resistors R6 and R5 can be so proportioned that the voltage drop across them will be equal. Under this condition, both tubes V9 and V10 will cease firing since they will be biased beyond cut-off and both grids will be negative and at the same potential. Contacts A—B and A′—B′ on E6 and E7 respectively will close, and no motor rotation will occur.

This is the condition of equilibrium in which the voltage drop across R6 is equal to that across R5. The grids 30 and 32 will be at the same negative potential with respect to their cathodes 34, 36 and biased sufficiently negative to produce plate current cut-off.

Suppose now it is desired to increase loading. The value of R6 is increased, causing the voltage drop across R6 to increase. This also increases the drop across R8 making its right hand terminal relatively more negative. As a result, the grid 30 of tube V9 is now biased more negative with respect to its cathode 34 than that of grid 32 with respect to cathode 36 of tube V10, or V10 grid is now positive with respect to V9 grid, and V10 cathode. Consequently, V10 will fire, closing relay E7 and causing the motor to rotate in such a direction so as to tune the load circuit closer to resonance by increasing the inductance of L3. As series resonance is approached, the radio frequency tubes V1 and V2 will draw higher plate current, which will result in an increased voltage drop across R5. This voltage drop will increase to a point at which it will be equal to the drop across R6. At this point, the grid 32 of V10 will be at the same negative potential as that of the grid 30 of V9 and this potential will cause the plate current of V10 to cut off, de-energizing E7 and stopping motor rotation.

A similar analysis will hold true if it is desired to decrease loading. In the same way, if the characteristics of the load change, thereby changing the oscillator plate current, the balance between the voltage drops across R5 and R6 will be destroyed, and the control relays will operate the motor to rotate the inductor in the proper direction to restore equilibrium, and consequently to restore the loading to normal.

The setting of the sensitivity control R8 will determine how much voltage difference must exist between the grids of V9 and V10 before they fire their respective tubes.

Power supply for the system may be, for example, of 230 volts, 60-cycle input applied through polarized plugs A10 and A11. The power is fed through switch S4 and interlock switches S8, S9 which may be door-interlocks on the apparatus as set up. With switches S8, S9 closed, the filament transformer T4 is energized. Transformer T4 may also include an automatic filament voltage regulator to maintain constant voltage on the filaments of the various tubes of the apparatus. Simultaneously with the operation of the filament, blower A1 is energized which blows cooling air across the grid and plate seals of high frequency tubes V1 and V2.

A time delay relay E5 is provided which prevents closing of the plate voltage contactor E1 until the filaments have been on for at least 30 seconds. This enables the filaments to reach proper operating temperature before the application of high voltage.

A manually operated switch S10 is provided so that the secondary of the plate voltage transformer T2 may be operated at two values of voltage. Thus, when the left-hand contacts on contactor E2 are closed, the voltage across the secondary of transformer T2 is relatively high; whereas, when the right-hand contacts of V2 are closed and the left-hand contacts open, a higher voltage appears across the secondary for operation of the rectifiers V3, V4, V5, V6.

A D. C. plate current overload relay E3 is provided for overload protection and is in series with the rectifier-to-ground connection.

A D. C. under-current relay E4 is provided as shown connected in the grid circuit of tubes V1, V2. Under certain conditions of loading, adjustment, or due to failure of some circuit component, the grid excitation may fall below normal, resulting in excessive plate dissipation of tubes V1 and V2. Under this condition rapid deterioration and burning out of the tubes may occur. This is prevented by operation of the under-current relay E4 which opens the contacts of E4, thereby removing plate excitation voltage. Opening of E4 has the same effect, it will be noted, as opening S5.

An electric automatic reset timer A2 is provided which is set into operation by start button S5. The apparatus in rectangle A2 may be so arranged as to open the cage interlock switch S7 after a definite time of operation has elapsed. That is to say, by setting A2 for a definite time duty interval or cycle, the apparatus is automatically shut off after the elapse of the interval. A manually operated "power-off" button S6 is also provided.

In operation it will be understood that the load will be placed on the lower electrode E2 and that the upper electrode may be universally mounted on an end of a goose neck, and the upper electrode pulled down to touch or to be suitably spaced from the load. A safety cage may be provided which may be pulled down over the electrodes and load. The cage may be provided with a latch operated by solenoid A12 in turn

energized by the secondary of transformer T6. After the cage is closed, a clock provided in apparatus A2 may be set to the time required to properly heat the particular size of material or load being heated. Then the start button S5 is pressed which energizes the generator, as described, causing radio frequency currents to be supplied to the material LD. At the end of the preset time interval, the generator is automatically de-energized by the apparatus within the apparatus A2 and the safety cage latch is released by A12 permitting the cage to automatically open, which action may also be arranged to automatically lift the upper electrode E1 from the work or load LD.

Infra-red lamps may be provided adjacent the electrodes E1, E2 for the purpose of heating the electrodes during the radio frequency heating operation in order to prevent the dissipation of heat to the otherwise cold electrodes.

Figs. 3 to 6 inclusive are illustrative of the operation of the system. Although the curves of Figs. 3 to 6 are theoretical, in practice the apparatus will follow them very closely.

Referring to Fig. 3, it will be noted that over the working range the direct current power input to the plate circuits of radio frequency tubes V1 and V2 is substantially constant. Fig. 6 shows the power input or power supplied to the load LD. Here again it will be noted that over the working range the power supplied to the load is substantially constant and of a value W2, which is somewhat less than the input power W1, since, of course, the efficiency of conversion from D. C. to A. C. power is not perfect.

The root mean square current through the load LD is given in Fig. 4 and over the working range it will be noted that this current is inversely proportional to the square root of the load resistance. The root mean square voltage across the load or across electrodes E1, E2 is illustrated in Fig. 5 from which it will appear that this voltage is proportional to the square root of the load resistance.

We claim:

1. In combination, an electron discharge device oscillation generator having a grid circuit and a plate circuit, a source of D. C. power connected to the plate circuit of the device, a resistive circuit connected to the grid circuit of the device for controlling and adjusting the input D. C. plate power fed to the generator to a desired value, a high frequency load coupled to said generator and whose electrical characteristics change when supplied with power over a period of time, and electronic means coupled to said resistive circuit and responsive to a change in D. C. plate current to said electron discharge device generator for automatically adjusting the coupling to the load in such a way as to bring the direct current input power to said generator back to its adjusted value, to thereby supply the same average power to said load despite the change in electrical characteristics of said load.

2. In combination, a generator of alternating currents having a grid circuit and a plate circuit, a load coupled to said generator, means for maintaining constant the D. C. grid current of said generator, and a comparator circuit coupled to said generator and arranged to compare said D. C. grid current and D. C. plate current and responsive to a change in the D. C. plate current of said generator for automatically adjusting the coupling of said load to said generator so

as to maintain the power supplied to the load substantially constant.

3. In combination, a generator having a tuned output circuit, a load to be heated, an adjustable reactor coupling said load to said tuned circuit, said reactor having such value that it together with said load comprises a tuned circuit whose resonance frequency is to one side of the frequency of operation of said generator, and a comparator circuit arranged to compare the grid D. C. current and the plate D. C. current and to provide an output whenever said plate D. C. current changes due to a change in said load, and a motor coupled to the output of said comparator circuit and linked to said reactor for automatically adjusting the effective value of said reactor so as to control the power supplied to said load.

4. A high frequency power supply system including a high frequency generator comprising a vacuum tube having cathode, grid, and plate electrodes, and a tuned circuit connected to the electrodes of said tube for controlling the frequency of operation of the generator, a resistance connected between said grid and cathode electrodes, a resistance connected between the anode and cathode, a load coupled to said tuned circuit, means for supplying D. C. grid and D. C. plate currents through said respective resistances, circuit elements for maintaining the D. C. current constant through one of said resistances, and an electron discharge device system arranged to compare said D. C. grid and D. C. plate currents and responsive to a change in D. C. current through the other resistance due to a change in loading for varying the power supplied by said generator to said load so as to maintain constant the power delivered to said load without interrupting the operation of said generator.

5. In combination, a high frequency generator comprising a vacuum tube having anode, cathode, and grid electrodes, a tuned circuit connected to said electrodes for controlling the frequency of power generated, a load circuit coupled to said tuned circuit, a resistance connected between the grid and cathode electrodes, another resistance connected between the anode and cathode of said tube generator, and circuits comparing the D. C. currents flowing through said resistances and responsive to a change in the difference between said D. C. currents due to a change in loading for automatically adjusting the coupling to said load to maintain constant the power supplied to said load.

6. A high frequency generator in which the grid-cathode current is automatically regulated over a range of loading conditions, comprising a vacuum tube having a cathode, a grid, and an output circuit, connections for causing said tube to oscillate and supply high frequency current from said output circuit to a load device, a resistance circuit located externally of said vacuum tube connected between said grid and cathode, said circuit having a rising resistance-current characteristic and serving to maintain the rectified grid current flow substantially constant.

7. A high frequency generator in which the grid-cathode current is automatically regulated over a range of loading conditions, comprising a vacuum tube having anode, cathode, and grid electrodes, a tuned circuit connected to said anode and cathode electrodes, a load coupled to said tuned circuit, and an incandescent lamp and a variable resistance both located externally

of said vacuum tube and connected in series between said grid and cathode, said incandescent lamp serving to maintain the grid current flow substantially constant, and said variable resistance serving to enable adjustment of the power output of said generator to said load.

8. A high frequency generator in which the grid-cathode current is automatically regulated over a range of loading conditions, comprising a vacuum tube having anode, cathode and grid electrodes, a tuned circuit coupled to said electrodes, a load device coupled to said tuned circuit, connections for causing said tube to oscillate and supply high frequency oscillations to said load device, and a grid bias resistor in the form of an incandescent lamp or lamps located externally of said vacuum tube and connected between said grid and cathode for limiting the rectified grid current flow in the grid-cathode circuit between certain limits, said incandescent lamp or lamps having variable resistance characteristics and changing the bias on said grid in response to a change in loading conditions.

9. In combination, a vacuum tube having an anode, a cathode, and a grid, an output circuit connected between said anode and cathode, a resistor connected between said anode and cathode, another resistor connected between the grid and cathode and having a predetermined temperature coefficient of resistance, the value of said last resistor changing to change the bias on said grid in response to a change in current on said grid, whereby said last resistor serves to maintain substantially constant the direct current flow between said grid and cathode, a reversible motor, circuits coupled to said resistors and responsive to the difference in voltage drops across said resistors for driving said reversible motor in one direction or in an opposite direction, a variable electrical element electrically coupled to a pair of electrodes of said tube, and means mechanically coupling said element to said motor, whereby the operation of said motor varies the value of said electrical element in such direction as to maintain constant the D. C. input power fed to said tube.

10. In a high frequency heating system, a vacuum tube having anode, cathode, and grid electrodes, a tuned circuit tuned to a desired operating frequency coupled to said electrodes, an incandescent lamp or lamps and a variable resistance connected between said grid and cathode for setting and maintaining the rectified grid current at a desired substantially constant value, a resistance connected between the anode and cathode of said device, a common resistor across which voltage drops, derived from the grid and plate circuit resistors are impressed, a pair of thyratron tubes responsive to voltage set-up across the common resistor, solenoid-operated switches connected to the output terminals of said thyratron tubes operated by current flow through said thyratron tubes, a reversible motor operated by action of said switches, a load, and a variable coupling device linked to and operated by said motor for variably coupling said load to said tuned circuit.

11. In combination, a vacuum tube high frequency generator having a grid circuit, a plate circuit and a tuned tank circuit, a resistive circuit operating to maintain substantially constant grid direct current flow connected between the grid and cathode of the tube, a load coupled to said tank circuit, circuits to utilize the resultant voltage drop derived from combining voltage

drops produced by the grid direct current flow and the plate direct current flow to vary the coupling between said tank circuit and said load, the coupling being adjusted in such direction as to maintain substantially constant the direct current flow in the plate circuit of said vacuum tube generator for maintaining constant the power delivered to said load.

12. In combination, an electron discharge device oscillation generator, a resistance and a source of plate potential connected in series between the plate and cathode terminals of said generator, an adjustable resistance connected in the grid circuit of the generator for adjusting the plate circuit input power to a desired value, a device in the grid circuit for maintaining the rectified grid current flow therein substantially constant and at its adjusted value, a common resistor across which are impressed potentials derived from D. C. current flow in the grid and plate circuits of said generator, a pair of grid-controlled glow discharge tubes having said common resistor in the grid-cathode return circuits thereof, a load, a coupling device for coupling said load to said generator, a reversible motor for varying the coupling of said coupling device, and instrumentalities responsive to the flow of current in the plate circuits of said grid-controlled glow tubes for causing said motor to rotate in one direction or another when one of said glow tubes is extinguished and the other firing.

13. In a high frequency heating system, an oscillation generator for heating a load whose electrical characteristics are adapted to change as it is heated over a period of time, said generator including a vacuum tube having a grid, a cathode and a plate, individual impedances in the grid-cathode and plate-cathode circuits of said vacuum tube generator, a pair of gas tubes each having a cathode, a grid and a plate, a common cathode circuit for said gas tubes including a common resistor, one of said impedances being also included in the grid-cathode circuit of one gas tube while the other of said impedances is also included in the grid-cathode circuit of the other gas tube, a pair of magnetic switches respectively controlled by the plate circuits of said gas tubes, a motor and a source of potential therefor connected to said switches, the operation of said switches determining the direction of rotation of said motor, a variable element connected between said vacuum tube generator and said load and controlled by said motor for changing the amount of power fed to said load, the voltage drop developed across said impedances determining in part at least the voltage drop developed across said common resistor, the character of the voltage drop developed across said common resistor determining which one of said gas tubes fires, whereby the firing of only one of said gas tubes will cause the operation of its associated switch and the movement of said motor in a direction to maintain constant power output from said generator.

14. The combination, in an electronic oscillation generator, including an electric discharge device provided with a control grid, of a grid current stabilizing circuit including a grid bias resistance for said discharge device having such temperature coefficient of resistance and having such current carrying characteristics as to be heated by a change in the grid current caused by a change in power output of the generator in such sense as to change the bias on the control grid in a direction to reduce the change in grid current.

15. The method of regulating the grid current in the discharge device of an oscillation generator caused by changes in load conditions, which comprises utilizing any change in the grid current to automatically vary the grid bias of the discharge device in such sense and magnitude as to restore the grid current to a substantially constant value.

16. In a high frequency heating system wherein an electron discharge device generator delivers power to a load through a variable reactor, said generator having grid, cathode and plate electrodes, the method of maintaining constant the power supplied to said load by said generator despite changes in the electrical characteristics of said load during operation of said generator, which comprises maintaining constant the magnitude of the flow of direct current in the grid circuit, comparing the magnitude of the direct current in the plate circuit with the direct current in the grid circuit for a predetermined amount of power delivered to said load, and utilizing any changes in the difference between said two direct currents caused by a change in the load to automatically adjust said variable reactor in such sense and degree as to cause a constant amount of power to be delivered to said load.

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