Feb. 11, 1947. H. REIFEL ET AL 2,415,799

AUTOMATIC MEANS FOR CONTROLLING THE POWER FED TO AN OSCILLATOR LOAD

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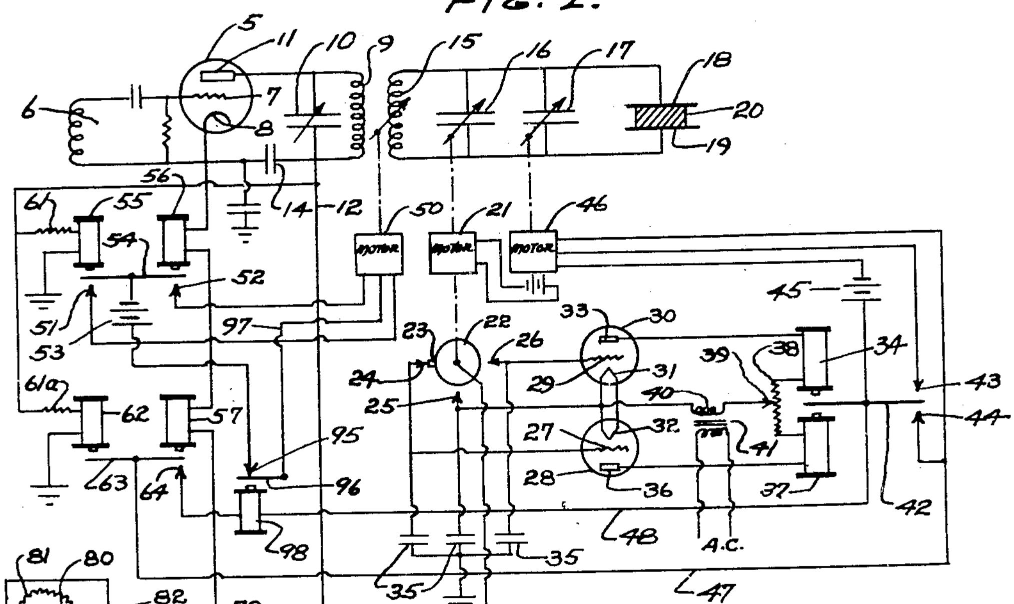
FIG. 1.



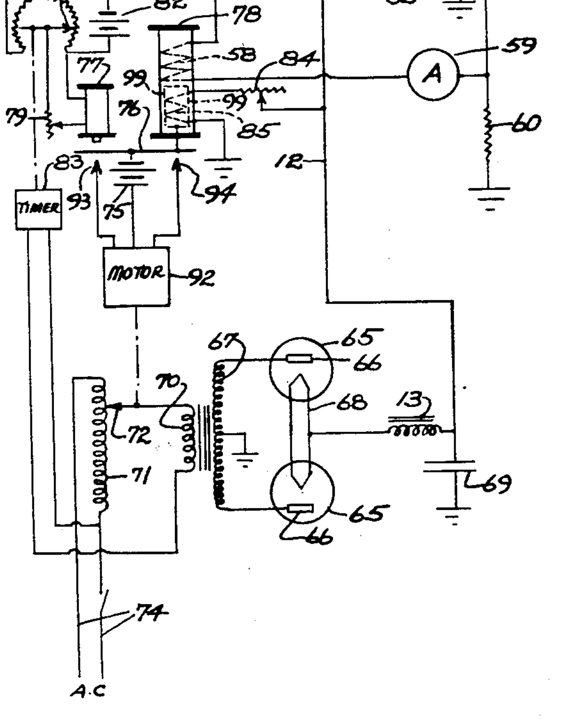
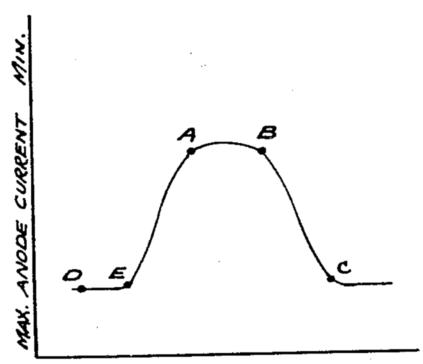


FIG. 2



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AUTOMATIC MEANS FOR CONTROLLING THE POWER FED TO AN OSCILLATOR LOAD

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18 Claims. (Cl. 250—36)

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This invention relates to radio frequency apparatus and relates more particularly to means for controlling such apparatus.

In radio frequency apparatus, such for example, as a thermionic oscillator providing a high frequency, electrostatic field between electrodes used for heating articles through dielectric hysteresis, changes in dielectric loss, electrical capacity and other changes cause the load circuit to be thrown off resonance and its impedance to vary, and cause variations in the power absorbed by the load circuit.

This invention provides means for maintaining electrical circuits in resonance, for maintaining coupled circuits at the proper impedance, and for maintaining the power applied to a load at the desired value.

An object of the invention is to tune electrical circuits automatically as they depart from resonance, to restore them to resonance.

Another object of the invention is to adjust the coupling between coupled electrical circuits automatically for maintaining the proper impedance.

Another object of the invention is to control automatically the power applied to the load circuit of an oscillator.

The invention will now be described with reference to the drawing, of which:

Fig. 1 is a circuit schematic illustrating an oscillator and a load circuit coupled thereto and embodying this invention, and

Fig. 2 is a chart illustrating a resonance curve resulting from the operation of one of the tuning controls of Fig. 1.

The thermionic oscillator tube **5** has a conventional input circuit **6** connected to its grid **7** and cathode **8**. The tank coil **9** tuned by the variable condenser **10** is connected at one end to the anode **11** of the tube **5** and at its other end to the wire **12** which is connected to the output side of the rectifier choke coil **13**. The condenser **14** between the cathode **8** and the coil **9** is the usual radio frequency bypass condenser.

The tank coil **9** is inductively coupled to the load circuit coil **15** which is arranged to be tuned by the shunt, variable condensers **16** and **17**, and which supplies radio frequency current to the electrodes **18** and **19** between which is placed an article **20** to be heated.

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The shaft of the condenser **16** is connected to the electric motor **21** so as to be continuously rotated thereby. The motor **21** also rotates the circular switch **22** having the raised contact **23** thereon. During rotation of the switch the contact strikes in sequence the contacts **24**, **25** and **26**.

The contact **24** is connected to the grid **27** of the tube **28**; the contact **26** is connected to the grid **29** of the tube **30**, and the contact **25** is connected to the interconnected cathodes **31** and **32** of the tubes **28** and **30**. The condensers **35** connect the contacts **24**, **25** and **26** to ground.

The anode **33** of the tube **30** is connected to one side of the energizing winding of the relay **34**. The anode **36** of the tube **28** is connected to one side of the winding of the relay **37**. The other side of the winding of the relay **34** is connected to one side of the potentiometer **38**, the other side of which is connected to the other side of the winding of the relay **37**. The slider **39** of the potentiometer is connected to one side of the secondary winding **40** of the transformer **41**, the other side of the winding **40** being connected to the contact **25**.

The relays **34** and **37** act on opposite sides of the armature **42** on the opposite sides of which are placed the contacts **43** and **44**. The armature **42** is connected to one side of the battery **45**, the other side of which is connected to the reversible electric motor **46**. The field winding of the motor is so connected to its armature and to the contacts **43** and **44** that when the relay armature **42** touches the contact **43**, the battery **45** rotates the motor **46** in one direction, and when the armature **42** touches the contact **44**, the battery **45** is reversely applied to the field of the motor causing it to rotate in the opposite direction.

The motor **46** is connected to the shaft of the tuning condenser **17** and rotates same for tuning the load circuit to resonance as will be described.

The load circuit coil **15** has a rotary shaft rotatable by the electric motor **50**. The field winding of the motor **50** is connected to the contacts **51** and **52** and to the battery **53** whereby when the relay armature **54** to which the battery **53** is connected, touches the contact **51**, the field winding of the motor **50** is connected to the armature thereof so that the motor armature rotates in one direction, and when the relay armature **54** touches the contact **52**, the armature of the motor **50** rotates in the opposite direction. Rotation of the shaft of the coil 15 in one direction by the motor 50 increases the coupling between the coils 9 and 15, and rotation of the coil shaft in the opposite direction decreases the coupling.

The winding of the relay 57 is a current coil through which the space current of the tube 5 passes, it being connected in series with the cathode 8 of the tube 5, the coil 58, the ammeter 59, the resistor 60 and ground. The winding of the relay 62 is a voltage coil and is connected through the resistor 61*a* to the high voltage direct current lead 12 and to ground, thus being shunted across the rectified voltage supply.

The relays 57 and 62 act oppositely upon the relay armature 63 which is connected by the wire 47 to the contact 44. The contact 64 for the relay armature 63 is connected by the wire 48 and the relay 98 to the relay armature 42.

The relays 57 and 62 are adjusted to hold the armature 63 away from the contact 64 except when the impedance of the tank circuit is abnormally high, at which time the relay 62 will attract the armature 63 causing it to touch the contact 64 and start the motor 46 for tuning the condenser 17 as will be described.

The position of the relay armature 54 is controlled by the relays 55 and 56. The winding of the relay 58 is connected as previously described, in series with the cathode 8 of the tube 5 whereby the space current of the tube flows through it.

The winding of the relay 55 is connected in series with ground and the resistor 61, and to the direct current lead 12.

The relay 56 thus is a current responsive relay and the relay 55 a voltage responsive relay. The relays 55 and 56 respond to impedance changes in the tank circuit and act oppositely upon the relay armature 54 for adjusting the coupling between the coils 9 and 15 as will be described.

The relay armature 54 is connected in series with the battery 53, the relay contact 94, the relay armature 96 and the wire 97 to the motor 50. The relay 98 and its armature 96 and contact 95 are provided for preventing the relays 55 and 56 from acting to adjust the coupling when the relays 57 and 62 are acting to adjust the condenser 17.

The push-pull rectifier tubes 65 have their anodes 66 connected to the secondary 67 of the power transformer, the center point of the secondary 67 being connected to ground.

The cathodes 68 of the tubes 65 are connected together and to the input side of the rectifier choke coil 13. The filter condenser 69 is connected to the output side of the choke coil 13 and to ground.

The primary 70 of the power supply transformer has one end connected to the contact 71 of the "Variac" auto-transformer 72, and has its other end connected in series with the timer 83 and to one of the alternating current supply leads 74 which also are connected to the auto-transformer 72.

The contact 71 is movable along the winding of the auto-transformer 72 by the motor 92, the field winding of which is connected to the contacts 93 and 94 and to the motor armature and the battery 75 whereby when the relay armature 76 to which the battery 75 also is connected, touches the contact 93, the field winding is so energized that the motor 92 rotates in one direction, and when the armature 76 touches the contact 94, the field winding of the motor 92 is so energized that the motor rotates in the opposite direction. Rotation of the motor 92 in one direction adjusts the contact 71 along the auto-transformer 72 to provide increased voltage to the primary 70 of the power transformer, and rotation of the motor in the other direction adjusts the contact 71 to provide decreased voltage to the transformer primary.

The relay armature 76 is actuated by the relays 77 and 78 which act in opposition. The winding of the relay 77 is connected through the variable resistor 79 to the slider 80 of the potentiometer 81 which is connected across the battery 82. The slider 80 is arranged to be set manually for providing desired power in the load circuit, and is connected to the conventional timer 83 for adjusting the period the timer holds closed the energizing circuit of the transformer primary 70.

The relay 78 is a power operated relay responding to power in watts. The previously described coil 58 is wound on the core of the relay 78 in inductive relation to the coil 85 thereof. The coil 85 is wound on the movable form 99 which is attached to the relay armature 76 for moving same. The coil 85 is connected at one end to ground and at the other end through the variable resistor 84 to the high voltage direct current supply lead 12.

The coil 58 is seen to be a current responsive coil, and the coil 85 to be a voltage responsive coil.

If the amount of power supplied to the oscillator 5 is less than the predetermined value, the relay armature 76 will be moved by the relay 77 against the contact 94 causing the motor 92 to increase the voltage to the primary 70 of the power transformer. Then when the power supplied to the oscillator reaches the selected value, the armature 76 will move away from the contact 94 and stop the motor 92. If the power supplied to the oscillator is excessive, the relay 78 will act to move the armature 76 against the contact 93 causing the motor 92 to rotate in the opposite direction for decreasing the voltage supplied to the transformer primary 70 until the relay 78 acts to move the relay armature 76 from the contact 93 and stops the motor 92.

The slider 80 preferably adjusts the energization of the relay 77, and timer 83 so that the product of time and power is a constant. For one article to be heated a relatively short heating time and a relatively large power may be desired while for another article a relatively long heating time and a relatively small power may be desired. The resistor 79 can be adjusted for regulating the power without adjusting the time if this is desired.

The timer and the slider 80 could be separately adjusted manually as in accordance with correspondingly calibrated dials.

In operation, with no load coupled to the oscillator, the oscillator tank circuit is tuned to the operating frequency which, for example, may be 20 megacycles, by adjusting the circuit to resonance by the condenser 10. Resonance is indicated by the lowest reading on the ammeter 59 at which time the voltage drop across the resistor 60 will be a minimum.

The rotor of the condenser 16 is continuously rotated by the motor 21 as in conventional wobblers. The motor 21 also rotates the switch 22 which alternately applies through the contact 23 and the contacts 24 and 26, the voltage developed across the resistor 60 to the grids 27 and 29 of the tubes 28 and 30. This voltage will appear as one value at the grid 27 and as another value at the grid 29 if the load circuit is not in tune with the oscillator tank circuit. The reason for this may be understood with reference to Fig.

2 which is a resonance curve with the capacities of the condenser during one complete rotation of the rotor thereof as ordinates, and the voltage drops across the resistor as abcissae.

When the load and tank circuits are in tune, the variations in the capacity of the condenser 16 will maintain the voltage across the resistor 60 at substantially the same value as shown between the points A and B of Fig. 2. If the load circuit is above resonance, the voltages will vary between those shown by the points B and C of Fig. 2, point B giving a lower voltage than point C. This will result in the grid bias on one of the grids 27 or 29 being higher than that on the other. This will unbalance the anode currents of the tubes 28 and 30 causing the relay 34 to become more strongly energized than the relay 37 and the relay armature 42 to move against the contact 44 causing the motor 46 to rotate in one direction to adjust the condenser 17 to tune the load circuit to resonance with the tank circuit. This tuning will cause the points on the curve of Fig. 2 to approach the points A and B and when the peak is reached, the anode currents of the tubes 28 and 30 will again be equal and the armature 42 will move away from the contact 44 and the motor 46 will stop.

When the load circuit is tuned below resonance, the voltage across the resistor 60 will vary between the values shown by the points A and E on the curve of Fig. 2. This will cause different voltages at the grids of the tubes 28 and 30 and their plate currents to be unbalanced in the other direction, resulting in the relay 37 becoming more strongly energized than the relay 34; causing the armature 42 to move against the contact 43 and causing the motor 46 to rotate in the other direction to retune the circuits to resonance.

If when starting up, the condenser 16 should have a capacity at the extreme end of the resonance curve as at the point D on the curve of Fig. 2, then it will be impossible for the means described in the foregoing to bring the circuits in resonance since the required voltages differing in value, would not appear across the resistor 60. Instead the voltage would remain constant as illustrated at points D and E on the curve of Fig. 2. When this condition exists, the relays 34 and 37 will not act to start the motor 46. This can be corrected by properly setting the condenser 16 at the start-up or can automatically be taken care of by the operation of the relays 57 and 62 as will now be described.

If when starting up the capacity of the condenser 16 is at the point D on the curve of Fig. 2, the impedance of the tank circuit will be abnormally high and the voltage responsive relay 62 will become more strongly energized than the current responsive relay 57 and will cause the armature 63 to touch the contact 64 thus starting as previously described, the motor 46 which will adjust the condenser 17 to tune the load circuit until the points A and B on the resonance curve of Fig. 2 are approached. At and between these points the impedance of the tank circuit will drop and the relays 57 and 62 will act to restore the armature 63 to its neutral position, stopping the motor 46 and restoring control to the relays 34 and 37.

The relay 98 is energized when the peak finding circuit described in the foregoing is energized by the relay armature 63 touching the contact 64, and opens the circuit including the battery 53 and the relay armature 54 described in the foregoing, for preventing the coupling adjustments now to be described from operating when the peak finder circuit is operating.

When the proper impedance between the load circuit and the tank circuit exists, the relays 55 and 56 exert the same pull on the armature 54 which therefore remains in neutral position. If the impedance is too high the relay 55 responding to voltage will exert a stronger pull on the armature 54 than the current responsive relay, and the armature 54 will move against the contact 52 causing, when the peak finding circuit is deenergized and the armature 96 touches the contact 95, the motor 50 to rotate in a direction for increasing the coupling between the coils 9 and 15. If the impedance is too low, the current responsive relay 56 will exert the stronger pull causing the armature 54 to move against the contact 51 and causing the motor 50 to rotate in the opposite direction for decreasing the coupling.

It is usual in electrostatic heating, to time the heating periods by conventional timers. This invention adds to such a timer, controls for maintaining the desired power throughout the heating periods, automatically, regardless of conditions which change the heating load.

Thus, if for any reason, the power drawn by the system of Fig. 1 tends to fall below the selected value for the particular article being heated, the relay armature 76 will, as previously described, strike the contact 94 causing the motor 92 to rotate in the direction to increase the voltage supplied to the power transformer, thus increasing the power and the heat intensity. If the power is too high for any reason, the armature 76 will strike the contact 93 causing the motor 92 to rotate in the opposite direction for decreasing the power. When the power is at the selected value the relays 77 and 78 will exert the same pull on the armature 76 which will be restored to its neutral position and will stop the motor 92.

Conditions which could result in the needs for the adjustment of tuning, coupling and power described in the foregoing, may be changes in the electrical capacity of an article being heated as caused by the evaporation of moisture therefrom or by compression between electrodes, or differences in the dielectric or other characteristics of different supposedly similar articles being treated in succession in quantity production.

While the invention has been described in connection with electrostatic heating, the features of the invention can of course be applied to other forms of radio frequency apparatus.

The automatic tuning, peak finding, coupling and power control features while described as cooperating in a completely automatic system, can be used separately for improving other systems.

While not illustrated, the frequency of the oscillator tube 5 preferably would be maintained constant by conventional quartz crystal apparatus.

While one embodiment of the invention has been described for the purpose of illustration, it should be understood that the invention is not limited to the exact apparatus and arrangement of apparatus illustrated, as modifications thereof may be suggested by those skilled in the art without departure from the essence of the invention.

What is claimed is:

1. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode, and an anode, an input circuit connected to said grid and

cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, means including a resistor for restablishing direct current flow between said cathode and anode, a load circuit coupled to said output circuit, means for tuning said load circuit, and means including means responsive to voltage variations across said resistor for adjusting said means for tuning said load circuit until said load circuit is tuned to resonance.

2. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and an anode, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, means for establishing direct current flow between said cathode and anode, a load circuit coupled to said output circuit, means for tuning said load circuit, and means including means responsive to variations in said current flow for adjusting said means for tuning said load circuit until said load circuit is tuned to resonance.

3. Radio frequency apparatus comprising a thermionic tube having a grid, cathode and ancde, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, means for establishing direct current flow between said cathode and anode, a load circuit coupled to said output circuit, continuously operated means for increasing and decreasing the frequency to which said load circuit is tuned, and means including means actuated by said continuously operated means and including means responsive to variations in said current flow for tuning said load circuit to resonance independently of said continuously operated means.

4. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and an anode, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, means including a resistor for establishing direct current flow between said cathode and anode, a load circuit coupled to said output circuit, continuously operated means for increasing and decreasing the frequency to which said load circuit is tuned, and means including means actuated by said continuously operated means and including means responsive to voltage variations across said resistor for tuning said load circuit to resonance independently of the tuning by said continuously operated means.

5. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and an anode, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, a load circuit coupled to said output circuit, means for establishing direct current flow between said cathode and anode, a first motor driven means for tuning said load circuit, a second motor driven means for tuning said load circuit, and means including means actuated by said first motor means and including means responsive to variations in said current flow for causing said second motor driven means to vary the frequency to which load circuit is tuned in one direction when said current flow is reduced by the tuning of said first motor driven means, and for causing said second motor driven means to vary the frequency to which said load circuit is tuned in the opposite direction when said current flow is increased by the tuning by said first motor driven means.

6. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and an anode, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, a load circuit coupled to said output circuit, means for establishing direct current flow between said cathode and anode, a first motor driven means for increasing and decreasing the frequency to which said load circuit is tuned, a second motor driven means for tuning said load circuit, means including oppositely operating relay means for controlling the direction of rotation of said second motor means, said second motor means acting to vary the frequency to which said load circuit is tuned in opposite directions for opposite directions of rotation, and means including means responsive to variations in said current flow and including a switch actuated by said first motor means for supplying increased energizing current to one of said relay means when said frequency is increased by said first motor driven means for causing said means including said relay means to rotate said second motor means in one direction, and for supplying increased energizing current to the other of said relay means when said frequency is decreased by said first motor means for causing said means including said relay means to rotate said second motor means in the opposite direction.

7. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and anode, an input circuit connected to said grid and cathode, an output circuit connected to said grid and anode, means for tuning one of said circuits to resonance, a load circuit coupled to said output circuit, means for establishing direct current flow between said cathode and anode, a first motor driven means for tuning said load circuit, a second motor driven means for tuning said load circuit, means including relay means for controlling the direction of rotation of said second motor means, said second motor driven means acting to vary the frequency to which said load circuit is tuned in opposite directions for opposite directions of rotation, a pair of control tubes each having a control electrode and an anode, said relay means being so connected to said anodes of said control tubes that the currents thereof act oppositely to cause said relay means to adjust said second motor means to rotate in one direction when the anode current of one of said control tubes is greater than that of the other control tube, and to adjust said second motor means to rotate in the opposite direction when the anode current of said other control tube is greater than that of said one tube, means responsive to said direct current flow providing a voltage conformable thereto, and means including a switch operated by said first motor means for applying said voltage to one of said control electrodes when the frequency to which said load circuit is tuned is increased by said first motor driven means, and for applying said voltage to the other of said control electrodes when the frequency to which said load circuit is tuned is decreased by said first motor driven means.

8. Radio frequency apparatus according to claim 5 in which means including means responsive to impedance changes in said output circuit cause said second motor means to rotate in one direction for impedance increases and to rotate in the opposite direction for impedance decreases.

9. Radio frequency apparatus according to

claim 6 in which means including means responsive to impedance changes in said output circuit cause said second motor means to rotate in one direction for impedance increases and to rotate in the opposite direction for impedance decreases.

10. Radio frequency apparatus according to claim 7 in which means including means responsive to impedance changes in said output circuit cause said second motor means to rotate in one direction for impedance increases and to rotate in the opposite direction for impedance decreases.

11. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and an anode, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, a load circuit inductively coupled to said output circuit, means for establishing direct current flow between said cathode and anode, means for tuning said load circuit, means including means responsive to variations in said current flow for adjusting said means for tuning said load circuit until said load circuit is tuned to resonance, and means including means responsive to changes in the impedance of said output circuit for increasing the coupling between said output and load circuits for impedance changes in one direction and for decreasing the coupling for impedance changes in the opposite direction.

12. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and an anode, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, a load circuit inductively coupled to said output circuit, means for establishing direct current flow between said cathode and anode, continuously operated means for increasing and decreasing the frequency to which said load circuit is tuned, means including means actuated by said continuously operated means and including means responsive to variations in said current flow for tuning said load circuit to resonance independently of the tuning of said continuously operated means, and means including means responsive to changes in the impedance of said output circuit for increasing the coupling between said output and load circuits for impedance changes in one direction and for decreasing the coupling for impedance changes in the opposite direction.

13. Radio frequency apparatus comprising a thermionic tube having a cathode and an anode, an output circuit connected to said cathode and anode, means for establishing direct current flow between said cathode and anode, said means including a rectifier and means for supplying high voltage alternating current thereto, and means including means resposive to variations in said current flow and including means responsive to the rectified voltage from said rectifier for adjusting said alternating current supply means for maintaining constant power in said output circuit.

14. Radio frequency apparatus comprising a thermionic tube having a cathode and an anode, an output circuit connected to said cathode and anode, a load circuit coupled to said output circuit, means for establishing direct current flow between said cathode and anode, said means including a rectifier and means for supplying high voltage alternating current thereto, and means including a relay having a winding responsive to the voltage of the current supplied by said rectifier and having another winding responsive to said current flow for adjusting said alternating current supply means for maintaining constant power in said load circuit.

15. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and an anode, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, a load circuit inductively coupled to said output circuit, means for establishing direct current flow between said cathode and anode, said last mentioned means including a rectifier and means for supplying high voltage alternating current thereto, continuously operated means for increasing and decreasing the frequency to which said load circuit is tuned, means including means actuated by said continuously operated means and including means responsive to variations in said current flow for tuning said load circuit to resonance independently of the tuning of said continuously operated means, and means including a relay having a winding responsive to the voltage of the current supplied by said rectifier and having another winding responsive to said current flow for adjusting said alternating current means for maintaining constant power in said load circuit.

16. Radio frequency apparatus comprising a thermionic tube having a grid, a cathode and an anode, an input circuit connected to said grid and cathode, an output circuit connected to said cathode and anode, means for tuning one of said circuits to resonance, a load circuit inductively coupled to said output circuit, means for establishing direct current flow between said cathode and anode, said last mentioned means including a rectifier and including means for supplying alternating current thereto, continuously operated means for increasing and decreasing the frequency to which said load circuit is tuned, means including means actuated by said continuously operated means and including means responsive to variations in said current flow for tuning said load circuit to resonance independently of the tuning of said continuously operated means, means including means responsive to changes in the impedance of said output circuit for increasing the coupling between said output and load circuits for impedance changes in one direction and for decreasing the coupling for impedance changes in the opposite direction, and means including relay means having a winding responsive to the voltage of the current supplied by said rectifier and having another winding responsive to said current flow for adjusting said alternating current supply means for maintaining constant power in said load circuit.

17. Radio frequency apparatus comprising a load circuit, power supply means for energizing said circuit, a timer, means including a relay controlled by said timer for adjusting said power supply means, a relay responsive to power in watts in said circuit, and means including said relays for maintaining a desired constant wattage in said circuit.

18. Radio frequency apparatus comprising a thermionic tube having a cathode and an anode with an output circuit connected thereto, means for tuning said output circuit, a load circuit coupled to said output circuit, means including power supply means for establishing direct current flow between said cathode and anode, means

for tuning said load circuit, continuously operated means for periodically increasing and decreasing the frequency to which said load circuit is tuned, means including means actuated by said continuously operated means and including means responsive to variations in said current flow for adjusting said means for tuning said load circuit for maintaining same tuned to resonance with said output circuit, means including means responsive to impedance changes in said output circuit for adjusting the coupling between said circuits, a timer, a relay controlled by said timer, a relay responsive to the power in watts in said output circuit, and means including said relays for adjusting said power supply means for maintaining a desired constant wattage in said load circuit.

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