Nov. 11, 1941. LA VERNE R. PHILPOTT 2,262,044

TEMPERATURE CONTROL FOR MAGNETRON FILAMENT

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FIG. 1

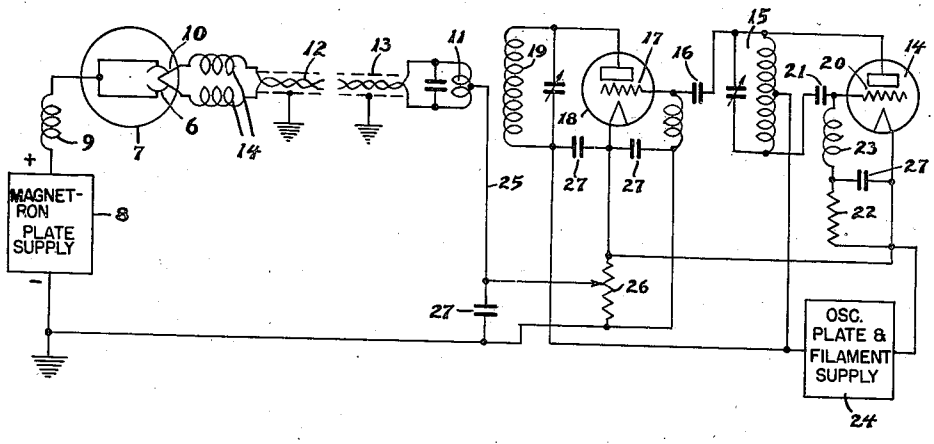
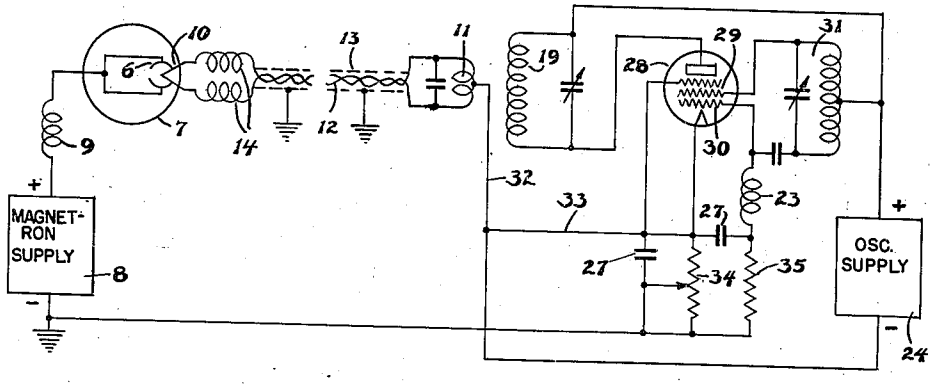


FIG. 2



INVENTOR
La Verne R. Philpott
BY
Ronson K. Davis
ATTORNEY

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FIG. 3

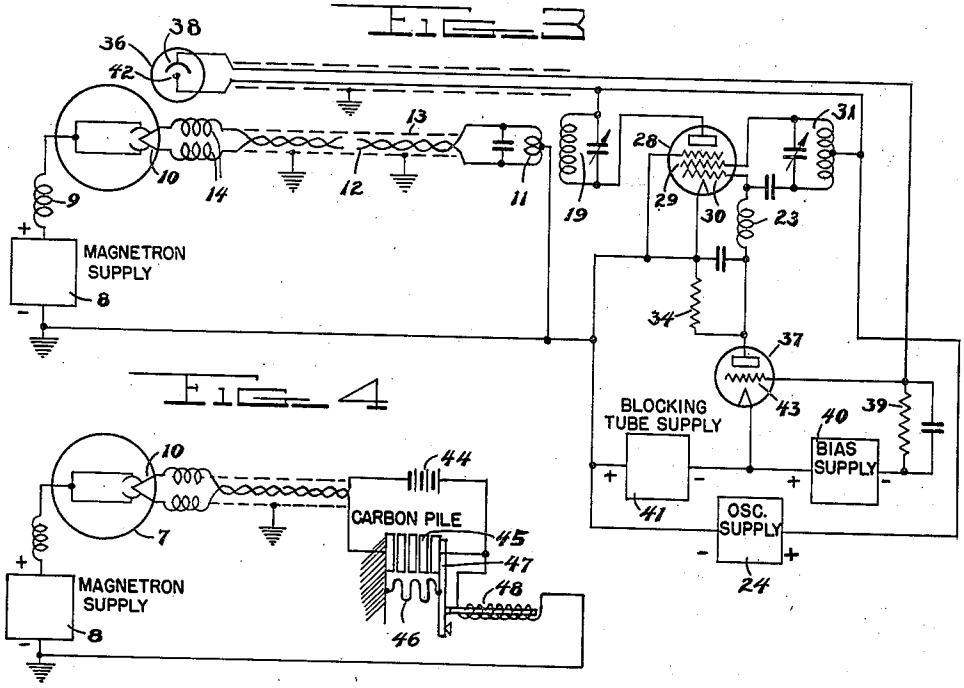
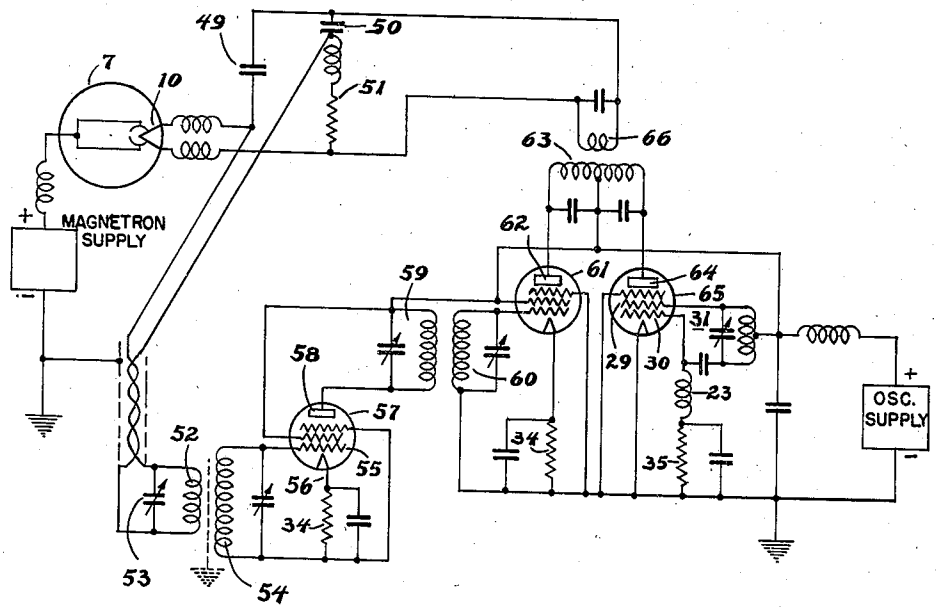


FIG. 4

FIG. 5



INVENTOR
La Verne R. Philpott
BY
Ramm & Davis
ATTORNEY

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UNITED STATES PATENT OFFICE

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TEMPERATURE CONTROL FOR MAGNETRON FILAMENT

La Verne R. Philpott, Washington, D. C.

Application March 2, 1938, Serial No. 193,546

9 Claims. (Cl. 250—27)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention relates to apparatus that functions as a thermostatic control upon the temperature of a magnetron tube filament to maintain that temperature uniform and thereby attain constancy of operation of the magnetron.

Among the several objects of this invention are:

To provide means to prevent variations of the filament current from an optimum value during operation;

To provide means to secure the optimum flow of current through a magnetron filament when for any reason that current does not have the optimum value as, for example, at the beginning of operation of the tube;

To maintain the electron emission in the magnetron within prescribed limits;

To improve generally the operation of magnetrons and increase the useful life thereof.

In the drawings:

Fig. 1 illustrates means for utilizing the IR drop resulting from the passage of the magnetron anode current through a resistor to control the filament current supply;

Fig. 2 is in general similar to Fig. 1 but a single tube, having a dual function, replaces two tubes in the current supply in Fig. 1;

Fig. 3 depicts the use of a photoelectric cell energized by light from the filament to produce a current that is applied to control the magnetron filament supply;

Fig. 4 illustrates how the effective value of a variable resistance in series with the filament is changed by the anode-cathode current of the magnetron;

Fig. 5 shows schematically the use of a resistance-capacitance bridge whereof the filament of the magnetron is one arm, which bridge is balanced when the filament has the correct temperature, and unbalance of the bridge acts to cause a change in the filament current that will restore the balance.

It is to be understood that the present invention may be utilized to control the operation of a magnetron oscillator either within prescribed limits or in an arbitrary manner according to certain desired conditions of operation. The conventional circuits such as the coils for producing the magnetic field in a magnetron oscillatory circuit have been omitted from the drawings for the purpose of simplification. It is very essential that close control be exercised over the temperature of the filament in a magnetron oscillator, since as the anode voltage thereof is raised from zero, with initially normal current flowing through the filament, no oscillations are generated until the anode voltage reaches almost the final point and at that time the filament temperature rises suddenly, often to the point of destroying the filament. The present invention provides means for automatically reducing the filament current before damage is done by the above mentioned sudden and inordinate rise of the filament temperature.

Referring to Fig. 1, the anode 6 of magnetron oscillator tube 7 is supplied from a suitable source 8 through high frequency choke 9. The cathode 10 of tube 7 is heated by current from transformer secondary 11 through leads 12 enclosed in grounded shielding 13 through high frequency chokes 14. The filament current is derived from an oscillator unit comprising a tube 14 suitably connected to the oscillatory network 15 whereof the output is transmitted through coupling condenser 16 to the grid 17 of tube 18 having an output circuit that includes the tuned transformer primary 19 coupled to transformer secondary 11. Grid 20 of tube 14 is coupled to an oscillator tank circuit 15 by condenser 21 and is biased by resistor 22 through choke 23. The plate and filament supply for tube 14 is derived from the unit 24. The anode-cathode circuit of magnetron 7 includes the conductor 25 connected to a center tap of secondary 11 and a portion of resistor 26 that serves as a biasing resistor for grid 17 of tube 18. The usual by-pass condensers 27 are provided where desired. It is apparent that, the magnetron supply 8 having been connected into the magnetron circuit, when the oscillator unit is set into operation current will be supplied from the oscillator 14 through condenser 16 and tube 18 to transformer primary 19, whereby current to heat the cathode 10 will be induced in transformer secondary 11. When the operating conditions of magnetron 7 have been reached current will flow from the cathode 10 through secondary 11 and conductor 25 to resistor 26 and in the portion of that resistor included in the anode-cathode circuit of magnetron 7 there will be produced an IR drop proportional to the anode-cathode current of the magnetron and this drop will be impressed upon grid 17 of tube 18, thereby reducing the output of tube 18 and diminishing the current supplied to filament 10. Proper adjustment of that portion of resistor 26 included in the magnetron circuit will result in reduction of the filament current to proper value when the returned current is flowing through the magnetron.

The embodiment of my invention shown in Fig.

2 is essentially similar to that illustrated in Fig. 1, with the difference that a dual purpose tube is utilized to replace the tubes 14 and 18 of Fig. 1. Here the tube 28 serves both as the master oscillator and as the transferring tube. The grid 29 functions as the anode and the grid 30 functions as the control grid for producing oscillations in the network 31 and these oscillations are simultaneously impressed upon the electron stream through tube 28, and the output is connected to transformer secondary 11 by the tuned primary circuit 19. The anode-cathode current from magnetron 7 passes through conductors 32 and 33 to resistor 34 and the potential drop resulting therefrom is applied to the grid 30 to control the output of the tube. Resistor 35 has the same biasing function as does resistor 22 in Fig. 1.

The apparatus disclosed in Fig. 3 is very similar to that in Fig. 2 and the same reference characters have been applied to corresponding parts. However, it has been found that in some cases undesirable results follow from changing the anode-cathode potential of the magnetron tube, as in the forms of my invention above described. The embodiment of Fig. 3 effects regulation independently of that potential. Here a photoelectric cell 36 is disposed to be energized or excited by light from the filament 10, the current output of the cell being proportional to the intensity of that light, as is well-known. A blocking tube 37 has its anode connected between biasing resistor 34 and grid 30 of tube 28, thus including the resistor 34 in the anode-cathode circuit of the tube 37. The current flows from cathode 38 of photocell 36 through resistor 39 thence through bias supply 40, blocking tube supply 41 and oscillator supply 24 back to anode 42 of photocell 36. As the temperature of the filament 10 increases the output of photocell 36 rises and thereby produces an increased potential difference across resistance 39 to the high potential end of which grid 43 of blocking tube 37 is connected, and thus greater current flow from the photocell 36 results in increased current through blocking tube 37 and increased potential drop across resistor 34 which swings grid 30 of tube 28 more negative and cuts down the current supply to filament 10.

In Fig. 4 the current for filament 10 is derived from a suitable source 44 in series with the filament and also in series with a carbon pile resistor 45. A spring 46 acts upon member 47 to press the elements of resistor 45 together and maintain the resistance thereof at a minimum. The anode-cathode current from magnetron 7 passes through a solenoid 48 acting upon member 47 in opposition to spring 46 to increase the resistance of carbon pile 45. It is apparent that the resistance in the filament circuit of magnetron 7 will be increased as the anode-cathode current of the magnetron rises and thus the filament current is held to a value within the desired operating conditions. This modification also, as in Fig. 3, provides control of the filament temperature without variation of the anode-cathode potential of the magnetron.

In Fig. 5 the filament 10 of magnetron 7 is one arm of a resistance-capacitance bridge having a capacitance 49 in one arm, capacitance 50 in another arm and the resistance 51 in still another arm. Connected across the bridge in the well-known manner is a coil 52 in parallel with a variable capacitance 53, the coil 52 being coupled to coil 54 that is connected between grid 55 and cathode 56 of a tube 57 whereof the anode 58 is connected to a tank circuit 59 coupled to tuned input 60 of a tube 61. The anode 62 of tube 61 is connected to one terminal of a center-tapped transformer primary 63. Anode 64 of oscillator 65 is connected to the other terminal of primary 63 which is coupled to secondary 66 that supplies current to filament 10 of magnetron 7. The values of the elements making up the bridge in the circuit of filament 10 are so chosen that when the filament is at the proper temperature the bridge is balanced and no current flows through coil 52. However, when the temperature of filament 10 is too low the bridge becomes unbalanced and the input into tube 57 from coil 52 is such that tube 61 is caused to pass current in such phase that it is additive in primary 63 with the output from oscillator 65, thereby increasing the current flowing through filament 10 and raising the temperature thereof but, on the other hand, if the temperature of filament 10 is too high the unbalance of the bridge phases the output of 61 to buck the output of tube 65 and so reduce the current supplied to the filament.

The invention herein described and claimed may be used and/or manufactured by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising a transformer secondary coil in series with said cathode, a vacuum tube having a cathode, a grid and an anode, a tuned output circuit connecting the cathode and the anode of said vacuum tube including a transformer primary coil coupled with said secondary, a circuit operatively connecting the grid and the cathode of said vacuum tube including a grid biasing resistor, a circuit connecting the anode of the magnetron to the midpoint of said secondary and including at least a portion of said resistor whereby to reduce the output of said vacuum tube proportionately to the current between the anode and the cathode of said magnetron, a vacuum tube oscillator network, and means operatively connecting the output of said oscillator to the grid of said vacuum tube.

2. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising a transformer secondary coil in series with said cathode, a vacuum tube oscillator network, means to transfer energy from said oscillator to said secondary including a tuned transformer primary, means operatively connecting the anode of said magnetron to the midpoint of said secondary including a resistance so connected and related to the aforesaid energy transfer means that the potential drop due to the passage of anode current from said magnetron through said resistance diminishes the transfer of energy to said secondary in proportion to said potential drop.

3. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising a transformer secondary coil in series with said cathode, a vacuum tube oscillator network, means to transfer energy from said oscillator to said secondary including a transformer primary, means operatively connecting the anode of said magnetron to the mid-

point of said secondary including a resistance so connected and related to the aforesaid energy transfer means that the potential drop due to the passage of anode current from said magnetron through said resistance diminishes the transfer of energy to said secondary in proportion to said potential drop.

4. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising a transformer secondary coil in series with said cathode, an oscillatory network including a vacuum tube having an anode, a cathode and a control grid, an output coil coupled to said secondary, and a resistance connecting said anode to said cathode; a blocking tube having an anode, a grid and a cathode, an output circuit connecting said anode and said cathode, said output circuit including said resistance whereby anode current of said blocking tube negatively biases the grid of said tube in the oscillatory circuit; a photo-electric cell disposed to be excited proportionately to the temperature of the cathode of said magnetron, and means connecting said photo-electric cell to impress a positive bias upon the grid of said blocking tube proportionately to the current from said photoelectric cell.

5. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising a transformer secondary coil in series with said cathode, a capacitance-resistance bridge whereof said cathode is one arm, said bridge being balanced when said cathode has the proper operating temperature, a circuit including a coil and a variable capacitance in parallel connected across said bridge to be energized when said bridge is unbalanced, a transformer primary coupled to said secondary, an oscillatory network including a vacuum tube having a plurality of electrodes and an anode connected to one terminal of said primary, a second vacuum tube connected to the other terminal of said secondary, common supply means for both said vacuum tubes, a third vacuum tube coupled to said parallel connected coil whereby the output of said third vacuum tube is controlled by said parallel connected coil, and means connecting said third vacuum tube to said second vacuum tube whereby the output of said second vacuum tube is controlled by said third vacuum tube, the phase of energization of said parallel connected coil when said bridge is unbalanced being such that the output of said second vacuum tube is additive to or subtractive from the output of said first vacuum tube in said primary, to control the current through the cathode of said magnetron to maintain the temperature of said cathode substantially constant.

6. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising means including a voltage controlled discharge device through which all heating energy for said cathode passes to supply to said cathode an alternating heating current, means traversed by the anode-cathode current of said magnetron to develop a potential difference proportional to said anode-cathode current, and means to apply said potential difference as a potential difference directly to said discharge device to control said heating current to maintain said anode-cathode current substantially constant.

7. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising means including a voltage controlled discharge device through which all heating energy for said cathode passes to supply to said cathode a heating current, means traversed by the anode-cathode current of said magnetron to develop a potential difference proportional to said anode-cathode current, and means to apply said potential difference as a potential difference directly to said discharge device to control said heating current to maintain said anode-cathode current substantially constant.

8. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising means to supply heating current to the cathode of said magnetron, a photo-cell disposed to be excited by light from said cathode, a vacuum tube, said photo-cell being connected to increase the output of said vacuum tube as the output of said photo-cell increases, and means connecting said vacuum tube to said supply means whereby the output of said supply means is decreased by increased output of said vacuum tube.

9. The combination with a magnetron tube having an anode and a cathode, of apparatus to control the temperature of said cathode during operation, comprising means to supply heating current to the cathode of said magnetron, a vacuum tube, means responsive to the intensity of light from said cathode to supply current proportional to said intensity connected to said vacuum tube to increase the output of said vacuum tube as the output of said light responsive means increases, and means connecting said vacuum tube to said heating current supply means whereby the output of said heating current supply means is decreased by increased output of said vacuum tube.

LA VERNE R. PHILPOTT.