

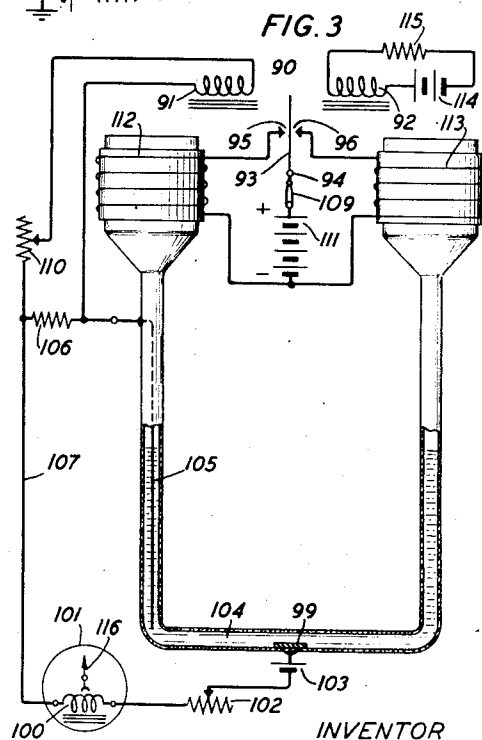
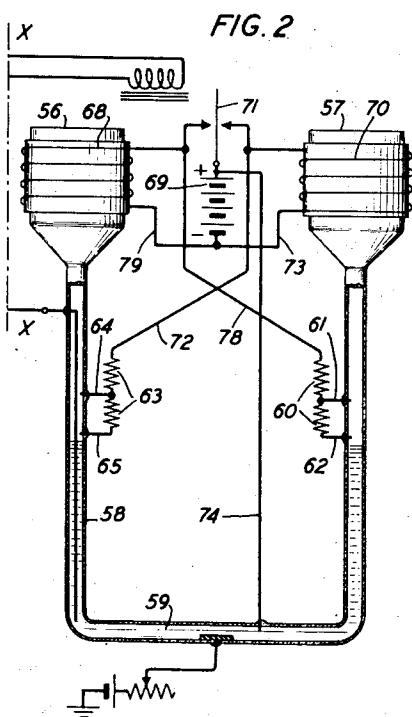
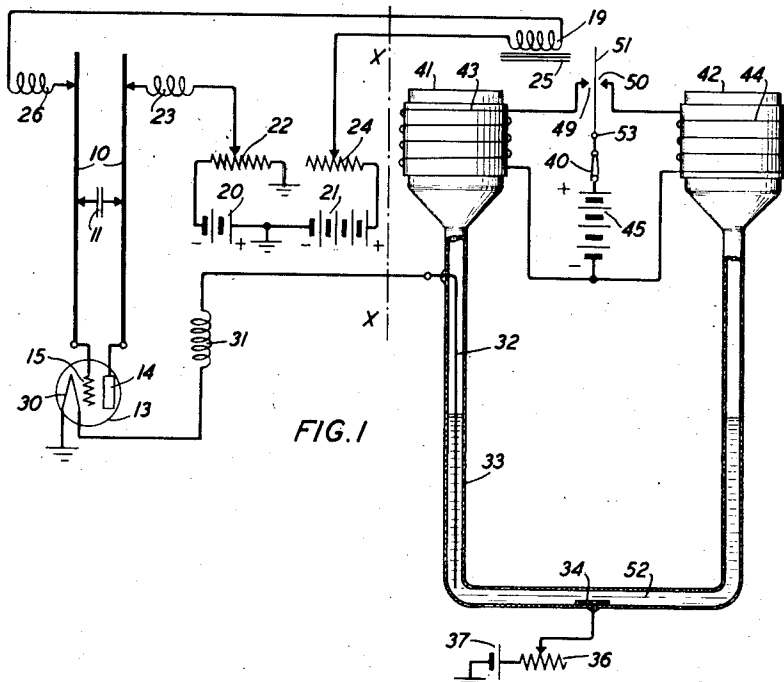
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# ELECTRICAL POWER REGULATING APPARATUS

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ELECTRICAL POWER REGULATING  
APPARATUS

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This invention relates to electrical power regulating apparatus, and more particularly to a device for automatically controlling the power supplied to a circuit.

In the well-known Barkhausen type of oscillation generator, it is recognized that its frequency of oscillation depends in a measure upon the quantity and velocity of electrons emitted by the cathode of an electron discharge device utilized therein. Hence, the frequency of oscillation is dependent on cathode temperature and grid and anode potentials. It has been found that if the frequency of oscillation were changed from a predetermined value due to a small variation in cathode temperature, or grid or anode potential, the predetermined frequency can be restored by varying the cathode temperature until the grid current effected by the electron discharge device attains that value fixed at the time when the frequency of oscillation was at the predetermined value. Despite the constancy of the potential applied to a cathode heater, a continuous and slow frequency drift may be occasioned by a deterioration of the cathode with age and use. This frequency drift, as well as the variations mentioned above, may be substantially minimized by automatically regulating the cathode heating current in a manner so that increased or decreased electron emission is effected in amounts adequate to maintain a constant grid current.

It is an object of the invention to maintain an oscillation generator at a constant frequency of oscillation.

It is a further object of the invention to effect recordings of variations of energy impressed on an electrical circuit.

In one embodiment, the apparatus comprises a tubular member formed with sealed ends and provided with a variable electrical resistance. The latter is connected in the cathode heating portion of a circuit embodying an electron discharge device. Each sealed end is arranged with a heater adapted to be energized under control of a relay operated in response to grid current variations so as to actuate the variable resistance.

In operation, the grid and cathode heating currents are initially adjusted to desired values. As the grid current varies therefrom, a relay is operated to effect an energization of one or the other of two heaters to actuate the variable resistance. Actuations of the latter occasion decreased or increased amounts of cathode heating current whereby corresponding variations in the electron emission are effected until the grid cur-

rent is returned to the desired value whereupon the relay is again operated to interrupt the heater energization circuit. In this manner, therefore, a substantially constant frequency of oscillation may be maintained.

In addition, several resistances may be associated with the tubular member so as to retain the variable resistance in the state into which it was previously actuated by the operations of the relay, thereby enabling comparatively large actuations of the variable resistance, while, at the same time, maintaining the number of operations of the relay to a minimum.

Fig. 1 is a diagrammatic circuit representing one embodiment of the invention;

Fig. 2 is a modification of the embodiment illustrated in Fig. 1; and

Fig. 3 is a diagrammatic circuit delineating another embodiment of the invention.

In a Barkhausen type of oscillator, the grid is maintained at a high positive potential while the anode is held at a slightly negative potential. The frequency of oscillation of the circuit is largely determined by the grid and anode potentials, and by the amount of the cathode heating current.

Referring to Fig. 1, a Lecher system comprising two parallel conductors 10, 10 short-circuited for high frequency currents by a slider 11 adapted to be moved longitudinally thereof is connected to an electron discharge device 13 having its anode 14 connected to one conductor 10 and its grid 15 connected to the other. Connected across the open ends of the conductors 10, 10 are batteries 20 and 21, the former being connected through variable resistance 22 and radio frequency choke coil 23 to the anode conductor and the latter being connected through variable resistance 24, winding 19 of relay 25, and radio frequency choke coil 26 to the grid conductor. As may be ascertained from the drawing, battery 20 places a slightly negative potential on the anode 14 while battery 21 effects a high positive potential on the grid 15. The relay 25 may be of any well known type such, for example, as a Weston model 30 relay.

In the preferred form of the invention, as illustrated in Fig. 1, cathode 30 of the electron discharge device is connected through radio frequency coil 31 to resistance element 32 extending longitudinally of the internal length of one vertical leg of U-tube 33. An electrical contact member 34 mounted internally of the horizontal leg at a point substantially equidistant from both vertical legs of the U-tube is connected to the re-

sistance element 32 by a mercury column 52 and, also, to battery 37 through a variable rheostat 36. Formed on the ends of the two vertical legs of the U-tube are closed bulbous portions 41 and 42 provided with heating elements 43 and 44, respectively. An end of each heating element is connected to negative side of battery 45 while the free ends of both terminate in opposed electrical contact points 49 and 50. Positioned intermediate the latter is a floating contact arm 51 associated with relay 25 and pivoted at point 53 which is connected to positive side of battery 45. The contact arm 51 is actuated to engage either of the contact points to energize one or the other of the heating elements under control of the electrical energy flowing through the winding 19 in a manner that will be subsequently explained.

In the initial adjustment of the arrangement shown in Fig. 1 the heating elements 43 and 44 are disconnected from battery 45 by opening a suitable single pole switch 40 while the cathode heating current is adjusted by rheostat 36 to that value which will provide the required amount of grid current necessary to effect a predetermined frequency of oscillation of the circuit. Thereafter, the contact arm 51 is set in a neutral position with respect to contact points 49 and 50 by a manual adjustment of its restoring spring, not shown. In addition, battery 45 is connected to the heating elements 43 and 44 by closing the switch 40. In operation the contact arm 51 is actuated to engage either contact point 49 or contact point 50 depending on whether the grid current is less or greater than the desired value.

Assuming the grid current to decrease below the required amount, the contact arm 51 is caused to engage contact point 50 thereby closing a circuit through battery 45 and heating element 44 to heat the bulbous portion 42. In the latter the entrapped fluid which may be a gas or a compressible liquid such as pentane, is expanded to increase its pressure on mercury column 52. The mercury rises in the leg containing the resistance element 32 to envelop additional portions of the latter to reduce the effective resistance in the cathode heating circuit. Obviously, this decrease of resistance will effect an increase in the cathode heating current to produce an increased electronic emission which results in an increase in the grid current. When the latter reaches its initially required value, the contact arm 51 is disengaged from contact point 50. As the bulbous portion 42 cools to permit a contraction or compression of the fluid contained therein, the level of mercury enveloping resistance element 32 commences to recede to produce an increase in the effective resistance in the cathode circuit. However, it is obvious that further decreases of the grid current will produce repetitions of the above operation whereby the grid current is substantially maintained at its required value.

Assuming the grid current to increase above the required value, the contact arm 51 is caused to engage contact point 49 thereby closing a circuit through battery 45 and heating element 43 to heat bulbous portion 41. The entrapped fluid of the latter is expanded to increase its pressure on the mercury column 52. The mercury recedes in the leg containing the resistance element 32 to expose further portion of the latter thereby increasing the effective resistance in the cathode circuit to reduce the cathode heating current. Obviously, the decreased cathode heating current effects a decreased electronic emission which produces a decrease in the grid current until the de-

sired value thereof is reached when the engagement between contact point 49 and contact arm 51 is interrupted. As the bulbous portion 41 cools to allow a contraction of the fluid enclosed therein, the level of mercury enveloping resistance element 32 commences to rise to effect a decrease in the effective resistance in the cathode circuit. Further increases in the grid current will cause repetitions of the above operation whereby the grid current is substantially maintained at its desired value.

In the modification delineated in Fig. 2, it is to be understood that the circuit portion shown is to be substituted for the circuit portion to the right of the line  $x-x$  in Fig. 1. As illustrated in Fig. 2, a plurality of resistances 60, 60 are arranged with internal contacts 61 and 62 fastened in an upper portion of the right vertical leg of the U-tube 58, and a plurality of resistances 63, 63 are provided with internal contacts 64 and 65 secured in an upper portion of the left vertical leg of the U-tube 58. The resistance values are initially predetermined such that when the mercury column 59 filling a lower portion of the U-tube 58 is brought into engagement with either contact 61 or 62, or with either contact 64 or 65, the current flowing from battery 69 through heater elements 68 or 70 will be in an amount sufficient to retain the mercury column 59 in engagement with the particular contact for an indefinite period of time even though the relay contacts are open. Obviously, the effective resistance of the cathode circuit is maintained at a constant value while the mercury column 59 is held at any one of the several contacts.

For example, when mercury column 59 is caused to engage contact 65 in the manner previously described in connection with Fig. 1, the double resistance 63, 63 will have a combined value adequate to effect an expansion of the fluid in bulbous portion 57 to hold mercury column 59 in this position for an indefinite period, thereby permitting a flow of cathode heating current sufficient to maintain the desired value of grid current. An energization circuit for heating element 70 may be traced from contact 65, double resistances 63, 63, lead 72, heating element 70, lead 73, battery 69, lead 74, to mercury column 59. Likewise, when mercury column 59 reaches contact 64, the single resistance will have a value sufficient to effect an expansion of the fluid in bulbous portion 57 to retain the engagement therebetween to allow a cathode heating current flow necessary to maintain the desired value of grid current. The energization circuit for heating element 70 is identical with the one described above except that the current from battery 69 now flows only through the upper one of the two resistances 63, 63.

Similarly, when mercury contact 59 touches contact 62, the double resistances 60, 60 will have a value adequate to cause an expansion of the fluid in bulbous portion 56 to hold mercury column 59 in this position for an indefinite period to permit a flow of cathode heating current adequate to maintain the grid current at its desired amount. An energization circuit for heating element 68 extends from contact 62, through double resistances 60, 60, lead 78, heating element 68, lead 79, battery 69, lead 74, to mercury column 59. Likewise, when mercury column 59 engages contact 61, the single resistance will have a value sufficient to effect an expansion of the fluid in bulbous portion 56 to hold the engagement therebetween to provide a flow of cathode heating cur-

rent necessary to provide the desired value of grid current. The energization circuit for heating element 68 is identical with that traced above in connection with contact 62 except that current from battery 69 flows only through the upper one of the resistances 60, 60.

It is to be understood that the number of resistances 60, 60 and 63, 63, and associated contacts 61 and 62, and 64 and 65, respectively, may be increased to any number to meet a particular circuit requirement. Also, it is obvious that by a use of these resistances comparatively large displacements of the mercury column 59 are made possible without, at the same time, greatly increasing the number of operations of the regulating relay.

In accordance with the embodiment illustrated in Fig. 3, recordings of comparatively slight variations in values of electrical energy impressed on a load may be expeditiously effected. Referring to Fig. 3, a two-way relay 90 comprises windings 91 and 92 having positioned therebetween a contact arm 93 pivotally mounted at 94 intermediate contacts 95 and 96. Current flows through the windings 91 and 92 in opposite directions so that when the current values are equal the arm 93 remains in a neutral position as indicated in Fig. 3. However, when the current flowing through winding 91 is the larger, arm 93 is actuated to engage contact 95; and, when the current flowing through winding 92 is the larger, arm 93 is moved to engage contact 96.

Winding 100 of a recording meter 101 is connected in a series circuit consisting of variable rheostat 102, battery 103, contact 99, mercury column 104, resistance element 105, fixed resistance 106 and lead 107. Winding 91 of the two-way relay 90 is shunted across fixed resistance 106 through a variable rheostat 110. One side of battery 111 is connected to the pivot 94 while its opposite side is connected through heating element 112 to contact 95, and, in addition, through heating element 113 to contact 96. Variations of current flowing from battery 114 connected in a series circuit with load 115 and the winding 92 are recorded by meter 100 in a manner which will now be explained.

With battery 111 disconnected from the heating elements 112 and 113 by a suitable switch 109, and assuming current of a specified value flowing through winding 92, the rheostat 102 is adjusted until a recording pen 116 of the meter 101 is placed in a predetermined position on a chart associated with the latter. A portion of the current flowing through winding 100 will also pass through winding 91. By adjustment of the rheostat 110, the current flowing through winding 91 can be made an amount sufficient to balance the current flowing through winding 92 thereby retaining the arm 93 in its neutral position.

With battery 111 connected in the circuit with heating elements 112 and 113, it is obvious that in the event of an increase of current in the winding 92, the arm 93 will be caused to engage contact 96 to complete an energization circuit for heating elements 113 through battery 111. In the manner aforesaid this will produce a decrease in the effective resistance of the recording meter circuit to effect an increase in the amount of current flowing in the winding 100. This increase of current will result in a movement of the pen 116 along the chart of the recording meter. The pen movement records the extent of the increase of current in the winding 92 as reflected in the increase of current in the winding 100 and continues

until an increased current in the winding 91, effected by the increase of current in winding 100, is adequate to balance the current flowing through winding 92. As previously explained, a balance between the windings 91 and 92 returns the arm 93 to its neutral position thereby interrupting the energization circuit for heating element 113, and, accordingly, terminating further decreases in the effective resistance of the recording meter circuit. In addition, the balance serves to arrest the movements of the recording pen 116. Obviously, additional increases of current in the load 115 may be recorded in the above manner.

Similarly, a decrease of current in the winding 92 will cause an engagement between the arm 93 and contact 95 thereby completing an energization circuit for heating element 112 through battery 111. As previously described, this will produce an increase in the effective resistance of the recording meter circuit to accomplish a decrease in the amount of current flowing through the winding 100. This decreased current will result in a movement of the pen 116 along the chart of the recording meter. The pen movement records the extent of the decrease of current in the winding 92 as reflected in the decrease of current in the winding 100, and continues until a decrease of current in the winding 91, effected by the decrease of current in winding 100, is adequate to balance the decreased current flowing through winding 92. The balance between the windings 91 and 92 returns the arm 93 to its neutral position to interrupt the energization circuit for heating element 112, and, accordingly, terminates further increases in the effective resistance of the recording meter circuit. Also, the balance serves to arrest the movements of the recording pen 116. Obviously, further decreases of current in the load 115 may be recorded in the above manner.

In the operation of the embodiment as previously explained in connection with Fig. 3, it is seen that comparatively slight variations of current flowing in the load 115 may be reflected in comparatively large variations of current effected in the winding 100 of meter 101. Therefore, the apparatus may be utilized to record smaller variations of current flowing in an electrical circuit than could be recorded by the meter 101 functioning alone thereby avoiding a use of a more complicated device involving delicate and intricate mechanical movements. It is obvious, also, that the apparatus is limited in its application only by the sensitivity of the two-way relay 90.

While the embodiment illustrated in Fig. 3 is disclosed to record variations of current, the embodiment is not necessarily limited thereto and may be readily adapted to record variations in the potential applied to an electrical circuit. To effectuate this purpose, relay 90 may be selected and connected in the circuit so as to respond to variations in the potential to be recorded rather than to variations in current.

It is to be understood that the invention is capable of embodiment in forms other than those particularly disclosed herein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A regulator for an oscillation generator comprising in combination, an electron discharge device having a cathode, an anode, and a grid; circuit connections for the discharge device arranged for operation at a constant frequency, a supply of electrical energy connected to the cathode for effecting the circuit operation, the frequency of

the oscillation generator depending upon the energy supplied to the cathode, a variable resistance connected in the cathode circuit for controlling the amount of energy supplied thereto, and an instrumentality connected to the circuit and operatively responsive to variations of grid current for varying the effective resistance in the cathode circuit to maintain the constant frequency of the circuit.

- 10 2. A regulator for an oscillation generator comprising in combination, an electron discharge device having a cathode, an anode and a grid; circuit connections for the discharge device arranged to operate at a constant frequency, a supply of electrical energy connected to the cathode for effecting the circuit operation, the frequency of the oscillation generator depending upon the energy supplied to the cathode, a variable resistance connected in the cathode circuit for varying the amount of energy supplied thereto, means connected in the grid portion of the circuit and actuated by current variations therein, and means operatively responsive to the actuation of the last mentioned means for varying the effective resistance in the cathode circuit to maintain the constant frequency of the circuit.

3. A regulator for an oscillation generator comprising in combination, an electron discharge device having a cathode, an anode, and a grid; circuit connections therefor arranged to operate at a constant frequency, a supply of electrical energy connected to the cathode for effecting the circuit operation, the frequency of the oscillation generator depending upon the energy supplied to the cathode, a variable resistance comprising a mercury contact and a resistance element projecting thereinto connected in the cathode circuit for varying the amount of energy supplied thereto, an instrumentality connected in the grid circuit and actuated by current variations therein, expansible fluid means engaging the mercury contact, and means responsive to the actuations of the instrumentality to control the expansion of the fluid for varying the effective resistance in the cathode circuit thereby maintaining the constant frequency of the circuit.

4. A regulator for an oscillation generator comprising in combination, an electron discharge device having a cathode, an anode, and a grid; circuit connections for the discharge device arranged to operate at a constant frequency, a supply of electrical energy connected to the cathode for effecting the circuit operation, the frequency of the oscillation generator depending upon the energy supplied to the cathode, a variable resistance connected in the cathode portion of the circuit for controlling the amount of energy supplied thereto, an instrumentality connected in the grid circuit and actuated by variations of current therein, means operatively responsive to the actuations of the instrumentality for varying the effective resistance of the cathode

circuit to maintain the constant frequency of the circuit, and means associated with the variable resistance and cooperating with the resistance varying means to maintain the effective resistance of the cathode circuit for an indefinite period of time.

5. A regulator for an oscillation generator comprising in combination, an electron discharge device having a cathode, an anode, and a grid; circuit connections therefor arranged to operate at a constant frequency, a supply of electrical energy connected to the cathode for effecting the circuit operation, the frequency of the oscillation generator depending upon the energy supplied to the cathode, an adjustable resistance comprising a mercury contact and a resistance element projecting thereinto connected in the cathode circuit for varying the amount of energy supplied thereto, an instrumentality connected to the circuit and actuated by variations of grid current therein, means operatively responsive to the actuations of the instrumentality for maintaining the constant frequency of the circuit including an expansible fluid engaging the mercury contact, a heating coil surrounding the fluid, and a source of electrical energy connected to the heating coil to expand the fluid in response to the actuations of the instrumentality to actuate the mercury column into certain positions thereby correspondingly varying the effective resistance of the cathode circuit; and means associated with the adjustable resistance and cooperating with the last mentioned electrical energy and the heating coil for retaining the mercury column in the certain positions without the aid of further actuations of the instrumentality.

6. In combination, a receptacle having sealed ends, a resistance element fixed in the receptacle, a mercury contact contained in the receptacle for varyingly enveloping the resistance element, an electrical circuit embodying the resistance element and mercury contact, an expansible fluid contained in the sealed ends for displacing the mercury contact to vary the effective circuit resistance, and a heating coil associated with the sealed ends and energized in response to predetermined circuit variations for effecting a control of the expansion of the fluid.

7. In combination, a U-tube provided with sealed ends on its vertical legs, a resistance element fixed in one vertical leg, a mercury contact contained in the U-tube for varyingly enveloping the resistance element, an electrical circuit embodying the resistance element and mercury contact, an expansible fluid contained in the sealed ends for displacing the mercury contact to vary the effective circuit resistance, and a heating coil associated with the sealed ends and energized in response to predetermined circuit variations for effecting a control of the expansion of the fluid.

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