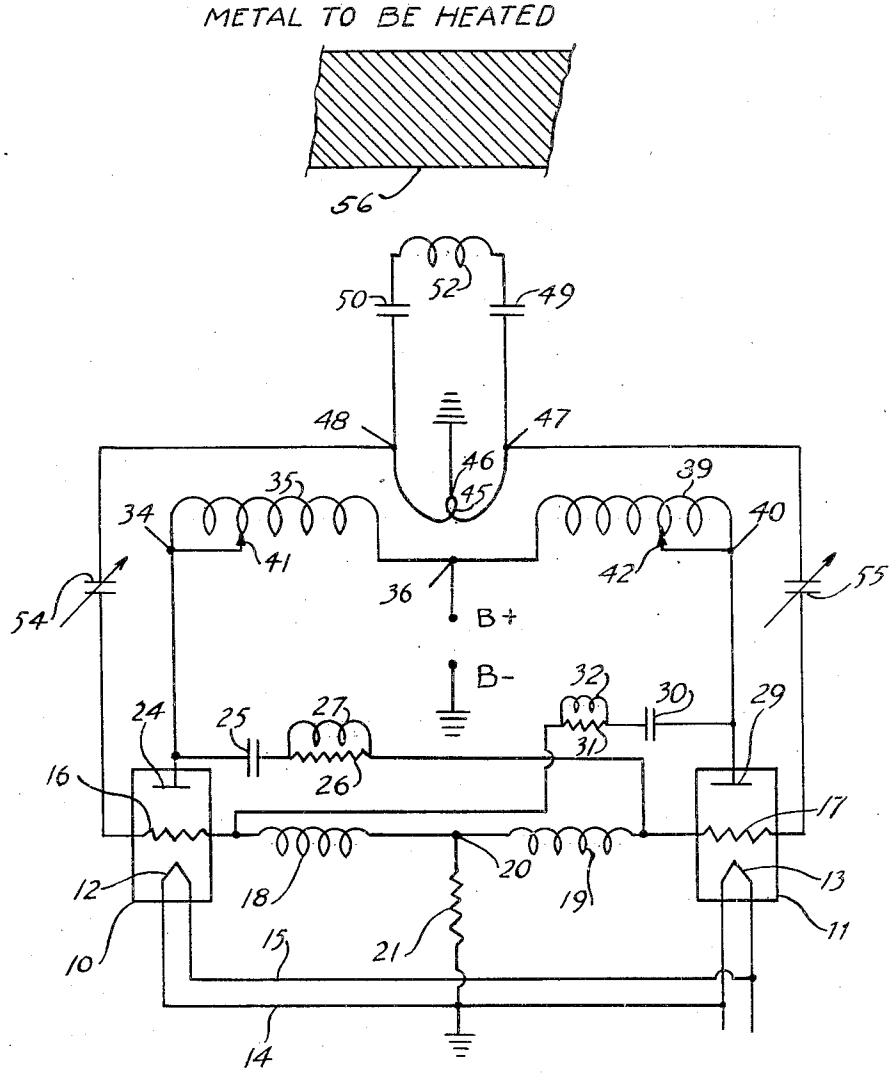
March 1, 1949. H. ROMANDER 2,462,903

OSCILLATOR GENERATOR

Filed May 7, 1945



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Patented Mar. 1, 1949

2,462,903

UNITED STATES PATENT OFFICE

2,462,903

OSCILLATOR GENERATOR

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Application May 7, 1945, Serial No. 592,408

10 Claims. (Cl. 250—36)

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This invention relates to electrical apparatus and particularly to an oscillator system for delivering substantial amounts of power such as might be used for induction heating of metals and the like. Oscillators for generating heat in metal are well known and may operate at any desired frequency. Where the coupling with the metal to be heated is not very close, as is true for example where parts of vacuum tubes are to be heated through an envelope, it is customary to operate the oscillator at comparatively high frequencies. Thus, an oscillator for heating the conducting portions of vacuum tubes after they have been positioned in the envelope will generally operate at several megacycles. The precise frequency may vary within wide limits depending upon the physical dimensions of the load, and the physical dimensions of the coil for application to the load, the types of vacuum tubes used, their efficiencies at various frequencies, and the physical layout of the apparatus.

Oscillators of the above type may advantageously be of the push-pull type, thus permitting comparatively low power vacuum tubes to be used. As is well known, oscillators require substantially high voltages in the anode circuits. It is, therefore, necessary to provide adequate safeguards against operators contacting such high potential apparatus. The invention herein provides a push-pull oscillator system wherein the load circuit is isolated in a novel manner from the high voltage and permits of ready application of the circuit to a load without hazard.

A further advantage of the invention resides in the fact that the entire system is so designed that oscillations can only occur when the vacuum tube circuits are cooperatively associated with the work circuit. Thus, it is possible to provide for detachable work circuits, permitting removal and replacement of vacuum tube containing circuits without the danger of the vacuum tube circuits generating oscillations needlessly. A further advantage of oscillation control by the presence of the work circuit resides in the fact that the frequency of oscillations in the vacuum tube circuits is controlled by the natural frequency of the work circuit with elimination of parasitic oscillations. Thus, high power factors in the work circuit are provided and power loss due to heavy wattless currents or parasitic oscillations in various parts of the system are avoided.

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The invention will now be described in connection with the single figure, which shows a circuit embodying the invention.

A pair of vacuum tubes 10 and 11 have cathodes 12 and 13 connected to each other by wires 14 and 15, these wires being adapted to be connected to any suitable source of current. The cathode energizing current may be either direct or alternating current, and it is understood that cathodes 12 and 13 may either be as shown or be of the indirectly heated type.

Vacuum tubes 10 and 11 are preferably of the three electrode type as shown, although additional control electrodes may be provided under suitable conditions. Thus, tubes 10 and 11 have control grids 16 and 17 connected through radio frequency chokes 18 and 19 to junction 20. Junction 20 is connected through grid resistance 21 of a suitable value to line 14, which may be grounded. In the event that cathodes 12 and 13 are of the indirectly heated type, it will be understood that grid resistance 21 will be connected to such cathodes and, for convenience, to ground.

Vacuum tube 10 has anode 24 connected through neutralizing condenser 25 to resistance 26 shunted by inductance 27, thence to control grid 17 of vacuum tube 11. Similarly, vacuum tube 11 has anode 29 connected through condenser 30 and resistance 31, resistance 31 being shunted by inductance 32 to control grid 16.

Anode 24 is also connected to terminal 34 of primary winding 35. Winding 35 has terminal 36 connected to the positive terminal of a source of anode potential, indicated as B+ and B—.

It is understood that the anode potential source may be either direct or alternating current. Terminal 36 is also the terminal of a second transformer primary 39 whose terminal 40 is connected to anode 29 of vacuum tube 11. Windings 35 and 39 are preferably provided with adjustable taps 41 and 42, for the purpose of adjusting the inductance of these windings. Windings 35 and 39 form the primary of a radio frequency transformer, which may be constructed in a manner well known in the art. Any other means for varying the inductance of windings 35 and 39 may be provided. By suitable design, the need for varying the inductance of windings 35 and 39 may be eliminated.

Coupled to windings 35 and 39 is secondary 45 having its center 46 grounded with outer terminals 47 and 48 connected to condensers 49 and 50 respectively. Condensers 49 and 50 are preferably of equal capacitance and are connected to work coil 52. The physical dimensions and the electrical constants of work coil 52 will vary within wide limits depending upon the physical dimensions of the work, 56, the amount of power to be handled, the frequency desired, and various other factors.

As is understood, work coil 52 in reality forms the primary of a transformer of which the secondary is the load, 56. The work circuit will be considered as the alternating current circuit consisting of windings 45 and 52 and the two condensers 49 and 50. Due to the coupling between work coil 52 and the load, load conditions are reflected into the work circuit.

From terminals 48 and 47 of winding 45, or in fact from any suitable points in the work circuit, connections may be taken to variable coupling condensers 54 and 55 and thence to grids 16 and 17 respectively. The polarity of the connections from condensers 54 and 55 to the work circuit is such as to provide excitation to the grids substantially 180 degrees out of phase with their respective anode voltages. However, it is preferred that these connections be taken from symmetrical points on the work circuit, assuming of course that tubes 10 and 11 are twins. In the event that these tubes are not alike, it will be necessary to depart from the symmetry of connections. However, in general, the entire circuit is balanced, and it is preferred to have all connections symmetrical so that a voltage minimum will appear in the center of coil 52, thus minimizing the voltage between this coil and the load 56.

Assuming that secondary 45 of the radio frequency transformer is not coupled to the primary windings, it is preferred to choose such a value for neutralizing condensers 25 and 30 as to prevent the tubes from oscillating. The provision of resistances 26 and 31, together with their shunting inductances, further prevent oscillations due to the connections from one tube anode to the other tube grid. When secondary 45 is coupled to the primary portions, the system will go into oscillation at a frequency determined by the resonant frequency of the work circuit.

The resonant frequency of the work circuit will be determined by a number of factors. Thus, the inductance of the work coil 52 will depend in a large measure upon the proximity to its load. It is obvious that, if work coil 52 is operating on a mass of metal, this mass of metal may be considered as a short circuited secondary. In such case, the net result will be that the effective inductance of work coil 52 will be less than its inductance when the work coil is free in air. Condensers 49 and 50 may be fixed or variable to adjust the resonant frequency of the work circuit to a desired value.

Condensers 54 and 55 are preferably variable principally to control the excitation voltage applied to grids 16 and 17. While these condensers will have some effect upon the oscillator frequency, in general their effect will be negligible. However, it is important that the voltage applied to the tube grids be correct. In lieu of variable condensers 54 and 55, blocking condensers of fixed value may be used, and the connections 47 and 48 to coil 45 made variable, the amount of inductance between each point of connection and the grounded center 46 being a measure of the excitation voltage.

A variation of current in either the primary or secondary due to load conditions will indicate a substantial variation of resistance. This will directly influence the excitation voltage available to grids 16 and 17 and, under some conditions, might tend to throw the system out of oscillation. Hence, tuning of condensers 54 and 55 or adjustment of connections 47 and 48 to coil 45 is necessary to insure proper feedback.

By virtue of the cross connections between the anode of one tube and the grid of the other tube, feedback through the grid-plate capacities is neutralized and parasitic oscillations are eliminated during operation of the system. In this manner oscillations at other than the work circuit frequency are prevented, and the oscillator generates energy at a frequency which is most efficiently transferred to the work circuit which, in turn, transfers this energy to the work. While a pair of tubes has been shown in a preferred form, a single tube properly neutralized might be used.

What is claimed is:

1. A power oscillator comprising a pair of vacuum tubes, each tube having a cathode, control grid and anode, a resistance between each grid and cathode, a primary connected between said anodes, said primary having its mid-point connected to a source of anode potential, cross connections between the control grid of one tube and the anode of another for suppressing oscillations, a work circuit including a transformer secondary coupled to said primary winding and connections from said work circuit to said control grids, each connection including a condenser whereby said system tends to oscillate at a frequency determined by the work circuit.

2. The system of claim 1 wherein the primary winding consists of two portions divided at the center and wherein said transformer secondary is coupled to both portions of the winding.

3. The system of claim 1 wherein said work circuit includes a coupling or secondary winding, a work coil and a pair of condensers, each condenser being connected between the two windings.

4. An oscillator comprising a pair of vacuum tubes each having a cathode, grid and anode, a resistance between each grid and cathode, a pair of neutralizing condensers, each condenser being connected from one anode across to the other grid, a radio frequency transformer having a primary, said primary having a center tap connected to a source of anode potential, the outer terminals of said primary being connected to the two anodes, said transformer having a secondary, a work coil connected to said secondary, a connection from each terminal of said secondary to each control grid respectively, said connections including condensers, said neutralizing condensers being provided to prevent oscillations in the absence of said work circuit.

5. The system of claim 4 wherein said secondary has its center grounded.

6. The system of claim 4 wherein said secondary has its center grounded and wherein the work coil is connected to the secondary through tuning condensers.

7. A push-pull oscillator comprising a pair of vacuum tubes, each tube having cathode, grid and anode, a resistance between each grid and cathode, a neutralizing circuit connected from the anode of each tube to the grid of the other tube, each neutralizing circuit containing a con-

denser and resistance in series, a pair of primary transformer windings having a common terminal for connection to a source of anode supply, a connection from each anode to each free terminal of the winding, a secondary winding disposed between said two windings to have coupling with both windings, a condenser connected to each terminal of said secondary winding, a work coil connected to each condenser so that said two condensers, secondary and work coil form a work circuit, and symmetrical connections from points on said work circuit to said control grids, each such symmetrical connection including a condenser.

8. The system of claim 7 wherein said secondary winding has its center grounded.

9. The system of claim 7 wherein each resistance is shunted by a radio frequency choke.

10. The system of claim 7 wherein the grid to cathode circuit for each tube includes a choke.

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