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HIGH-FREQUENCY GENERATORS

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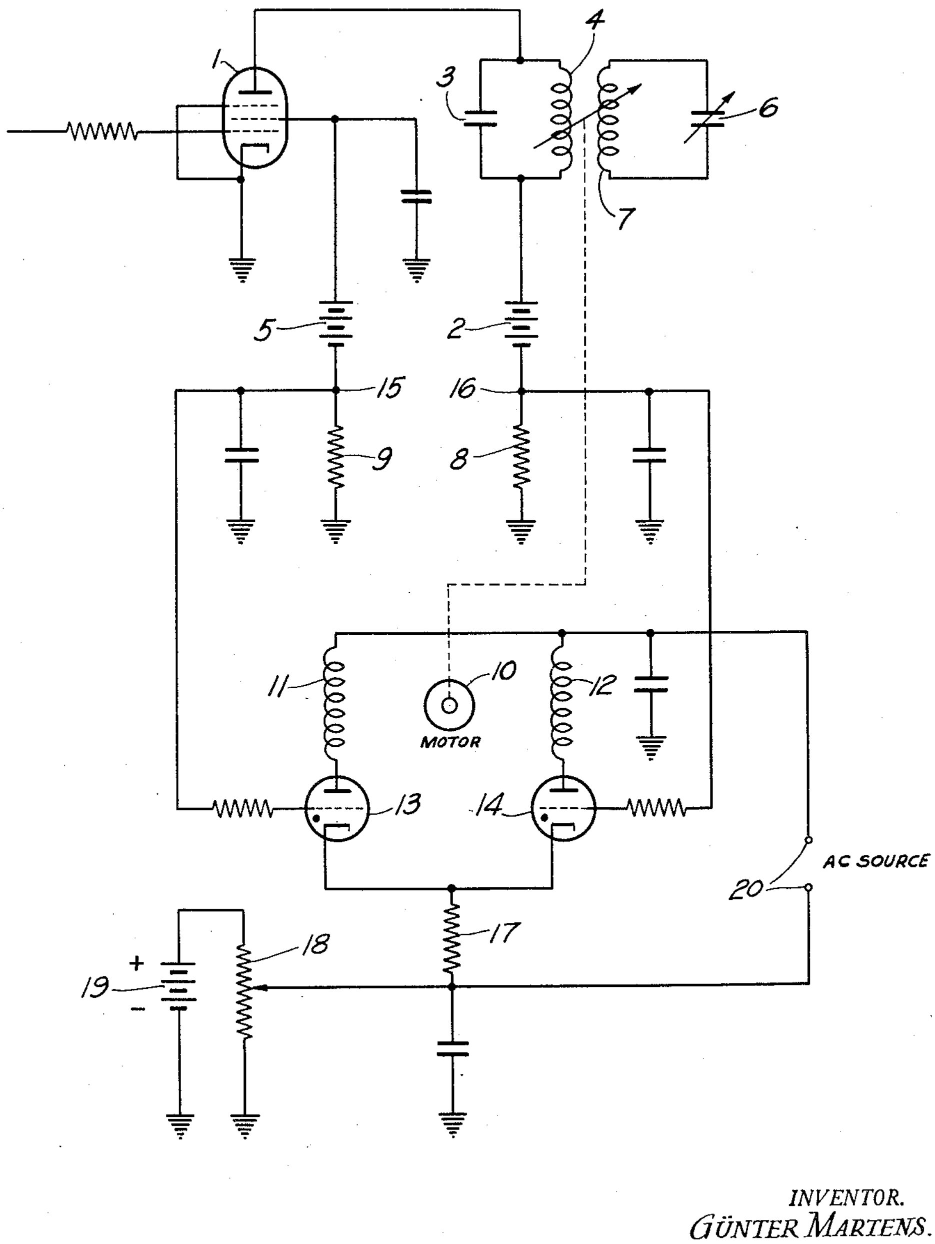

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HIGH-FREQUENCY GENERATORS

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This invention relates to high frequency generators. More particularly, the invention relates to a high-frequency generator comprising a device for automatic control of coupling between the generator output circuit and a load circuit. The generator is used more particularly for diathermy apparatus which operate with variable load. In order that the frequency of the generated oscillation may be maintained constant, the apparatus concerned frequently comprises an oscillation amplifier which is controlled by a quartz crystal. The output energy of such generators varies with the resonator resistance of the loaded anode circuit and exhibits its maximum at a determined value of this resistance, which is dependent upon the characteristic curve of the tube. If the resonator resistance exceeds the optimum value, the high-frequency output decreases, even though the efficiency is maintained. The output tube is in this case said to be overloaded. If however, the resonator resistance decreases, not only the high-frequency output decreases, but also the efficiency decreases. The output tube is in this case said to be underloaded. An overloaded output tube is liable to be deteriorated by the increased anode dissipation.

The resonator resistance of the anode circuit is substantially determined by the load which is coupled therewith. The primary circuit is damped more or less and the resonator resistance varies according to the strength of coupling.

High-frequency generators are also used for the heating of construction material. The resistance thereof may vary considerably during treatment in regard to both the dissipative component and the reactive component. This phenomenon occurs to a great extent in drying wood by means of high-frequency current. In certain cases it also occurs with diathermal treatment of patients. If the output is required to remain unvaried despite the variations in resistance, it is necessary for these variations to be compensated in some way or other.

For compensating the variations in reactive resistance use may be made of known devices for the automatic tuning in resonance. According to the invention, the variations in dissipative resistance may be neutralized by varying the coupling between the generator output circuit and the load circuit.

The variations which the anode and/or grid currents of an output tube undergo if this tube is overloaded or underloaded are utilized by the invention for varying the coupling between the output circuit and the load circuit in such manner that the position of overload or underload is obviated.

It is possible by this means to insure that the amplifier continuously operates with maximum efficiency and with the maximum output available. The advantages resulting therefrom are protection of the output tube against overload, shorter duration of treatment, and a treatment which may be defined evenly and clearly. In some cases, a saving is obtained in the proportioning of the output stage of the oscillation amplifier.

As is well-known, in case of overload, the anode current decreases, whereas the screen-grid current (of a tetrode or pentode) or the control grid current (of a triode) increases. On the other hand, in the case of underload, the anode current increases and the grid current decreases. According to the invention, said variations in current provide a criterion for the control of the coupling between the generator output circuit and the load circuit.

In the generator according to the invention variation in the dissipative resistance of the load may be compensated by varying the strength of the coupling between the output circuit and the load circuit and varying the reactive resistance of the load circuit by tuning means known per se.

In a preferred embodiment of the generator according to the invention, voltages which are proportional to the anode current and the grid current, respectively, of an amplifying tube serve as igniting voltages for gaseous discharge tubes, the anode current of the said tubes being used for energizing in one direction or the other an electric motor which acts upon a control device by which the condition of overload or underload is obviated. If it is necessary to compensate for the variations in dissipative resistance, the electric motor acts upon the coupling between the output circuit and the load circuit in such manner that the coupling is tighter if the tube is underloaded, and looser if the tube is overloaded.

If there are two control devices, one for compensating the variation in dissipative resistance and one for compensating the variation in reactive resistance, there is a possibility of an oscillatory phenomenon occurring, since the two control devices act upon one another by way of the circuit controlled by them. It is evident that such a phenomenon is undesirable, so that it is necessary to take suitable steps to prevent it. Thus, for example, it is possible to provide a relay which makes one control device inoperative, so long as the other is operative.

In order that the invention may be readily carried into effect, it will now be described with reference to the accompanying drawing, wherein the figure is a schematic diagram of an embodiment of the high frequency generator arrangement of the present invention.

In the figure, reference numeral **1** indicates the output tube of an oscillation amplifier which is controlled by a quartz crystal (not shown in the figure). The anode of this tube is supplied from an anode-voltage source **2** by way of an oscillatory circuit comprising a capacitor **3** and an inductance coil **4**. The screen grid of said tube is connected to a grid-voltage source **5**.

The oscillatory circuit **3**, **4** is coupled to an oscillatory circuit which comprises a capacitor **6** and an inductance coil **7** and which forms part of the load circuit. The coupling between the coils **4** and **7** is adjustable. The voltage sources **2** and **5** are connected by way of resistors **8** and **9** to ground and hence to the cathode of tube **1**.

For adjusting the coupling between the output circuit inductance coil **4** and the load circuit inductance coil **7**, use is made of an elecrtic motor comprising an armature **10** and two field windings **11** and **12**. Said windings serve to move the armature of the motor in the right-hand and in the left-hand sense of rotation, respectively. The field windings **11** and **12** are each traversed by the anode current of a thyratron (**13**, **14** respectively). The ignition grid of thyratron **13** is connected to a point **15** between voltage source **5** and resistor **9**; the ignition grid of thyratron **14** being connected to a point **16** between voltage source **2** and resistor **8**. The cathodes of the two thyratrons are connected by way of a common resistor **17** to the tap of a potentiometer **18**, which bridges a grounded voltage source **19**. The source **19** supplies a bias voltage to the tubes **13** and **14**. The thyratrons are supplied by an alternating-current source **20**.

Resistors **8** and **9** are so proportioned that, if the resonator resistance of the oscillatory circuit 3, 4 is at its optimum value, a voltage loss, sufficient to prevent ignition of the thyratrons, occurs across each of the resistors **8** and **9**. If the tube **1** is underloaded, the point **15** becomes less negative and the thyratron **13** is ignited. If the tube **1** is overloaded, the point **16** becomes less negative and the thyratron **14** is ignited.

The armature **10** of the regulating motor turns to the right or to the left according to which thyratron is ignited. The movement of the armature **10** may be transferred to the mechanism for varying the coupling between the coils **4** and **7** by a combination of worm and worm wheel. The sense of rotation is such that, if the tube **1** is underloaded, the coupling is made tighter. The coupling continues to vary until the resonator resistance has approached its optimum value so closely that the tube **1** operates again in the limiting range between the positions of underload and overload. The negative component of the grid voltage of the thyratron which is operative then predominates again, so that this thyratron is not ignited again after the next time that the alternating voltage supplied by source **20** passes through zero. Resistor **17** serves to prevent the two thyratrons from being ignited simultaneously.

The generator circuit of the present invention affords the advantages of avoiding reaction of variations in load upon the generator; maintaining the power supplied to the load and the efficiency of the amplifier at a maximum, even if the resistance of the effective load during treatment varies within wide limits; and permitting the loading of the output tubes, without objection, up to the maximum permissible limit, since the output tubes are protected against excessive load.

It is to be understood that the invention is not limited to the details disclosed but includes all such variations and modifications as fall within the spirit of the invention and the scope of the appended claims.

What I claim is:

1. A high frequency generator for supplying high frequency oscillations to a variable load comprising an amplifying stage having an input circuit and an electron discharge tube having an anode and a grid, means for applying high frequency oscillations to said input circuit, an anode circuit connected to said anode, an oscillatory output circuit connected in said anode circuit, a load circuit coupled to said output circuit, a grid circuit connected to said grid, and control means responsive to the voltage in both said anode and grid circuits to vary the coupling between said output circuit and said load circuit to maintain maximum output energy in said output circuit for all load values, said control means comprising an electric motor connected to vary said coupling, a first discharge device coupled to said motor for rotating said motor in one direction to tighten said coupling, a second discharge device coupled to said motor for rotating said motor in the opposite direction to loosen

said coupling, means connecting one of said discharge devices to be responsive to the current in said anode circuit of said discharge tube, and means connecting the other of said discharge devices to be responsive to the current in said grid circuit of said discharge tube.

2. A high frequency generator for supplying high frequency oscillations to a variable load comprising an amplifying stage having an input circuit and an electron discharge tube having an anode and a grid, means for applying high frequency oscillations to said input circuit, an anode circuit connected to said anode, an oscillatory output circuit connected in said anode circuit, a load circuit coupled to said output circuit, a grid circuit connected to said grid, and control means responsive to the voltage in both said anode and grid circuits to vary the coupling between said output circuit and said load circuit to maintain maximum output energy in said output circuit for all load values, said control means comprising an electric motor connected to vary said coupling, a first discharge device having an anode, a cathode and a grid, coupled to said motor for rotating said motor in one direction to tighten said coupling, the grid of said first discharge device being connected in said grid circuit of said discharge tube, a second discharge device having an anode, a cathode and a grid, coupled to said motor for rotating said motor in the opposite direction to loosen said coupling, the grid of said second discharge device being connected in said anode circuit of said discharge tube, a common cathode connection between said discharge devices, a common cathode resistor, a variable source of direct current voltage connected to said common cathode connection through said common cathode resistor, a common anode connection between said discharge devices, and a source of alternating current voltage connected to said common anode connection and to said common cathode connection through said common cathode resistor.

3. A high frequency generator as claimed in claim 2, wherein said motor comprises an armature and two field windings, one end of one of said field windings being connected to the anode of said first discharge device, one end of the other of said field windings being connected to the anode of said second discharge device, said common anode connection joining the other ends of said field windings.

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