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O. H. SCHADE

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RADIO FREQUENCY OSCILLATOR POWER SUPPLY CIRCUIT

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Fig. 1.

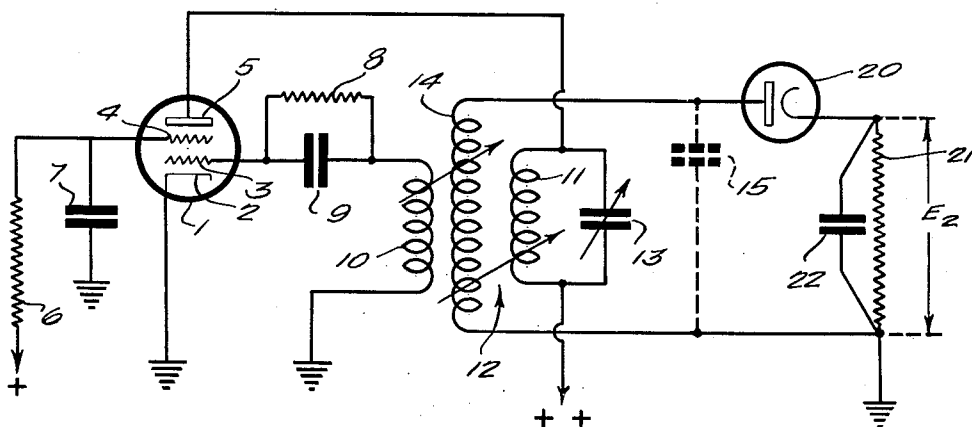
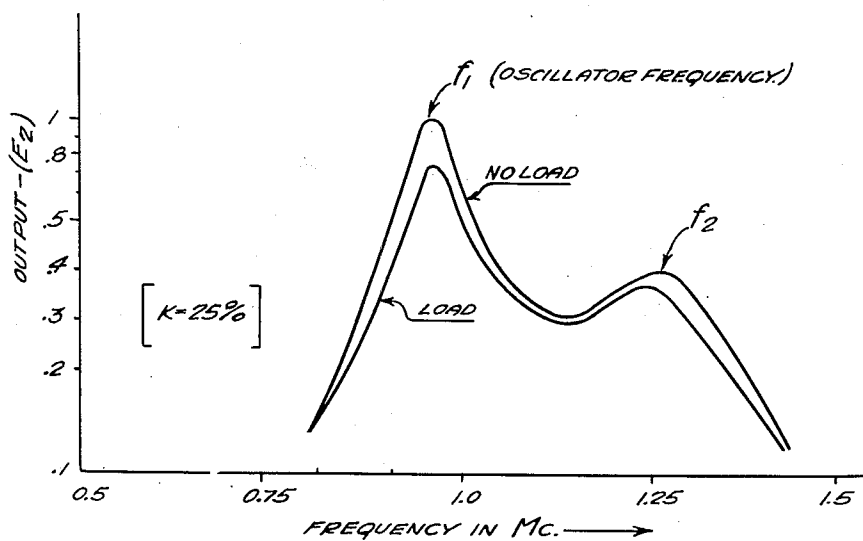


Fig. 2.



INVENTOR
OTTO H. SCHADE
BY *H. G. Brown*
ATTORNEY

UNITED STATES PATENT OFFICE

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RADIO FREQUENCY OSCILLATOR POWER
SUPPLY CIRCUITOtto H. Schade, West Caldwell, N. J., assignor to
Radio Corporation of America, a corporation of
Delaware

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11 Claims. (Cl. 250—36)

My present invention relates to high voltage-low power direct current supply circuits, and more particularly to a direct current supply source of the radio frequency oscillator type.

One of the main objects of my present invention is to provide a power supply source of high voltage and low power wherein a required direct current voltage step-up is obtained by means of a radio frequency oscillator having over-coupled tuned primary and secondary circuits in the plate circuit thereof.

Another important object of the invention is to provide a high voltage power supply circuit of good regulation, compactness and light weight; the circuit having particular utility in connection with television tubes, such as iconoscopes and kinescopes.

Another object of my invention is to improve the voltage regulation of high voltage supply sources; a multi-grid oscillator tube being employed in a radio frequency oscillator circuit to provide oscillations for a subsequent rectifier; a screen resistor being utilized in the oscillator tube screen circuit to limit and regulate its power output by having the screen voltage rise and fall in accordance with the load.

Still another object of my invention is to provide a high frequency step-up transformer energized by an oscillator requiring a comparatively low direct current supply voltage; and the natural frequency of at least one of the transformer coils being varied to produce a double-peaked resonance curve, the oscillator feedback phase being adjusted to operate the oscillator preferably at the lower frequency peak of said curve whereby excellent voltage regulation of the output circuit is maintained, irrespective of the variation in the load across the secondary coil, within the power output range of the oscillator.

And still other objects of my invention are to improve generally high potential direct current sources, as for cathode ray tubes, and more especially to provide such sources in a compact, readily-transportable and reliable form which is economical in manufacture and assembly, and which, because of its current limiting property, removes the danger of lethal shocks obtainable from powerful low frequency-operated supplies.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have in-

dicated diagrammatically a circuit organization whereby my invention may be carried into effect.

In the drawing:

Fig. 1 shows an embodiment of the invention, Fig. 2 shows response characteristics of the oscillator step-up transformer.

Referring now to the accompanying drawing, there is shown in Fig. 1 a tube 1 of the multi-grid type. It comprises at least a cathode 2, a control grid 3, a screen grid 4 and a plate 5. The plate and screen electrodes are maintained at positive direct current voltages from a direct current source (not shown). The screen 4 is connected to a point of desired positive voltage by a screen resistor 6 of predetermined magnitude. The condenser 7 by-passes the screen to ground for radio frequencies.

The control grid 3 is returned to ground through a path including grid resistor 8, shunted by condenser 9, and feedback, or tickler, coil 10. The cathode is grounded, while the plate 5 is connected to a point of higher positive potential than screen 4. The plate circuit includes a parallel resonant circuit which consists of the primary winding 11 of output transformer 12 shunted by the condenser 13. The latter may be adjustable for a reason later to be set forth. The secondary circuit of step-up transformer 12 consists of the secondary coil 14 shunted by capacitance 15. The latter is shown dotted to indicate that it is made up of the natural coil capacity, stray capacities and the diode capacity.

The arrow through coils 14 and 11 denotes the reactive coupling therebetween. The arrow passing through coils 10 and 14 designates the reactive coupling between the output circuit 14—15 and the feedback coil 10. The high frequency voltage built up across the circuit 14—15 is rectified to develop the high voltage-low power direct current. Thus, diode 20 may have its anode connected to the high side of the circuit 14—15, while the diode cathode is connected to ground by the load resistor 21. The condenser 22 is shunted across load 21, and by-passes radio frequency currents. The symbol E_2 represents the high voltage-low power source.

The high frequency step-up transformer 12 is a system comprising two tuned circuits of different resonant impedances, and having a certain degree of coupling. The high frequency energy transfer into the secondary tuned circuit 14—15 from the primary tuned circuit 11—13 may approach 100% when the coupling is increased sufficiently beyond the critical value. This does not cause instability of oscillation between the

two coupling frequencies, as the feedback phase is only correct for one coupling frequency because of the indirect coupling of 11 through 14 to 10. The effect of loading with tight coupling between the transformer tuned circuits is shown in Fig. 2. The coupling K is assumed to be of the order of 25%. In that figure E_2 , which is the voltage across the output circuit, is plotted against frequency in megacycles (mc.).

Both curves shown demonstrate a higher resonance rise at f_1 than at f_2 . These resonance peaks are caused by the tight coupling between coils 11 and 14 of transformer 12. This is a practical tuning condition used for producing oscillations at the lower frequency peak f_1 . A decrease of the capacity of condenser 13 causes a frequency increase of f_1 thereby increasing the resonant voltage at f_1 and vice versa. Tuning, therefore, provides a voltage control within certain limits. It is found that the change in secondary voltage from no-load condition ("No Load" curve) to a certain secondary load ("Load" curve) is a minimum when operating the circuits at the lower frequency peak f_1 of the response curve.

The secondary circuit 14—15 governs the operating frequency of the transformer. The capacitance 15 is kept at a minimum in order to secure a high circuit impedance. The primary circuit 11—13 is tuned by condenser 13 to the same frequency as the secondary circuit, or nearly so. In other words, the tuned frequency of 11—13 will be equal to, or higher than, the tuned frequency of 14—15. When the coupling K is equal to, or less than, critical coupling, the oscillating system has for equal tuning one degree of freedom, and will oscillate at one frequency. For the more efficient case K is made substantially greater than K_c (critical), and the oscillating system has two degrees of freedom, as shown in Fig. 2. An oscillator with grid winding coupled to the plate winding will in that case oscillate at either f_1 or f_2 requiring re-tuning every time it is started as it tends to select the frequency peak of least loading.

The oscillations become stabilized to one coupling frequency by coupling the feedback coil 10 to the secondary coil 14, as shown in Fig. 1. The voltage E_2 (secondary voltage) is in phase with the primary voltage only at one coupling frequency, and is 180 degrees out of phase at the other coupling frequency. The polarity of the feedback coil 10 then determines stable operation at either f_1 or f_2 . The direction of the feedback winding with respect to the primary 11, for oscillations at the lower coupling frequency f_1 , is that of a normal oscillator circuit.

That is to say, the voltage of control grid 3 has the opposite phase with respect to the plate potential assuming absence of coil 14. Summing up, then, the relation between the feedback coil and the step-up transformer, it is pointed out that, according to my present invention, it has been found preferable to obtain grid excitation from the secondary circuit rather than from the primary. In this way oscillations are obtained only at one of the two degrees of freedom of the network. Oscillations may be generated at either of the two peak frequencies of the doubly-peaked response curve according to the relative polarity chosen for the grid coil 10. Furthermore, in accordance with my invention the feedback coil polarity is so chosen as to produce oscillations of a frequency which is substantially equal to the lower frequency peak f_1 . This meth-

od of operation has been found to give improved regulation of voltage across the load 21 with respect to variations thereof. The oscillator of my invention is well adapted to deliver very high alternating voltage to a high resistance load, and to deliver such voltage with good regulation and good frequency stability.

As explained previously, another important feature of this invention resides in the use of a multi-grid oscillator tube wherein a screen resistor is employed in the screen grid lead to control the oscillator power output thereby to enhance the voltage regulation. The oscillator tube may be one of the 6F6, or preferably a beam tube of the 6L6 or 6Y6G type may be used. The effect of screen resistor 6 is to permit the screen voltage to be self-adjusting. With low power output, that is with a high plate load, the screen current increases. This, in turn, causes a reduction of screen voltage due to the series resistance. This, again, increases the control grid current thereby causing a further increase of screen current. This action will be emphasized if a fixed bias or cathode bias is used, because then the control grid current is permitted to increase much more. With certain adjustments of bias, screen resistor, excitation and tuning, even negative regulation may be obtained for certain load changes. In so far as the present screen regulation is concerned, the screen voltage will fall or rise in accordance with the load and thereby maintain good voltage regulation.

The oscillator operating frequency depends on the resonant frequency of the high voltage circuit, which is designed for high impedance and reasonably high Q-value (about 150 to 300). For example, a frequency between 600 and 300 kc. results for good coil design for 2,000 to 10,000 volt sources respectively. By means of the present invention a comparatively low direct current supply voltage source can be used to energize the oscillator tube. Cathode ray tubes requiring high potentials may be supplied from the output load resistor of a rectifier. Indeed, voltages up to 75,000 volts, as in the case of theatre projection kinescopes, may be secured from supply circuits embodying the present invention. For high efficiency and good regulation class C operation of the oscillator tube is preferably employed. For example, a 6Y6G tube, embodied in a circuit of the present invention, is capable of delivering 15 watts of radio frequency power at a plate voltage of 300 volts with 75 percent efficiency. Practical values of output voltage regulation are between 5 percent and 15 percent, depending upon the change of load current, the percentage of utilization of possible oscillator power and the circuit tuning.

It will be understood that the rectifier shown in Fig. 1 is purely illustrative. Various other rectifier circuits may be utilized. Voltage doubling diode circuits may be used. Those skilled in the art are fully acquainted with the various ways of rectifying high frequency currents. Furthermore, the rectifier load resistor may be tapped at different points to provide different magnitudes of high potential for utilization by the load devices.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. An oscillator generator comprising a tube having at least a cathode, control grid and plate, a pair of resonant circuits, mutual impedance therebetween substantially in excess of the value required to produce two natural frequencies in said circuits, a connection between the plate and one of said pair, a load coupled to the second of said pair, and a feedback coupling between said second circuit and the grid for sustaining oscillations at one of said frequencies.

2. An oscillator generator comprising a tube having at least a plate, cathode and grid, a pair of resonant circuits, mutual impedance therebetween substantially in excess of the value required to produce two natural frequencies in said circuits, a coupling between the plate and one circuit of said pair, a load coupled to the second circuit of said pair, and a feedback coupling between said second circuit and the grid for sustaining oscillations at one of said frequencies, the polarity of grid coupling being chosen to produce oscillations at the lower of said frequencies.

3. In a high frequency oscillation generator adapted to deliver high voltage alternating power to a high resistance load with improved voltage regulation and with good frequency stability, said generator comprising an electron discharge device provided with at least an electron emitter, an output electrode and an electron control electrode, an output transformer comprising a first resonant circuit connected directly to said output electrode, a second resonant circuit coupled to said load, a reactive element coupling said control electrode to said second resonant circuit, each of said resonant circuits including resonating capacity, said capacities being so relatively chosen as properly to load the oscillator, means for reactively coupling said two resonant circuits to provide a doubly-peaked response curve for the coupled resonant circuits whereby said oscillating system has two degrees of freedom, and the polarity of said reactive element being so chosen as to generate oscillations at that one of the two degrees of freedom of the oscillating system at which the loading on the tube is increased by a small decrease in the tuning capacity of the first resonant circuit.

4. In a generator as defined in claim 3, said one degree of freedom being such that oscillations are produced at the lower of the two natural frequencies of the system.

5. In an oscillation generator of the type comprising a tube provided with at least a cathode, a control electrode, a screen grid and output electrode, means establishing said output electrode at a substantially higher positive potential than said screen grid, a resonant circuit, means connecting the output electrode to a point of relatively high potential of said resonant circuit, a second resonant circuit, means reactively coupling said two resonant circuits, a load, means connecting said load across said second resonant circuit, means reactively coupling said control electrode to at least one of said resonant circuits to provide proper feedback for oscillation production, said reactive coupling being sufficiently great to provide a doubly-peaked response curve for said coupled resonant circuits, and said feedback coupling being chosen to cause oscillations to be produced at the frequency of the lower frequency peak of said curve.

6. In an oscillation generator of the type comprising a tube provided with at least a cathode, a control electrode, a screen grid and output elec-

trode, means establishing said output electrode at a substantially higher positive potential than said screen grid, a resonant circuit, means connecting the output electrode to a point of relatively high potential of said resonant circuit, a second resonant circuit, means reactively coupling said two resonant circuits, a load, means connecting said load across said second resonant circuit, means reactively coupling said control electrode to at least one of said resonant circuits to provide proper feedback for oscillation production, said reactive coupling being sufficiently great to provide a doubly-peaked response curve for said coupled resonant circuits, and said feedback coupling being chosen to cause oscillations to be produced at the frequency of the lower frequency peak of said curve, and a resistor in circuit with said screen grid for obtaining regulation of oscillator power.

7. An oscillator generator comprising a tube provided with at least a cathode, control grid, screen grid and plate, means for establishing said screen grid and plate at positive potentials, a pair of resonant circuits, reactive coupling therebetween substantially in excess of the value required to produce two natural frequencies in said circuits, a connection between the plate and one of said pair, a load coupled to the second of said pair, a feedback coupling between said second circuit and the grid for sustaining oscillation at one of said frequencies, and a resistor of predetermined magnitude in circuit with the screen grid to limit and regulate the oscillator power output.

8. An oscillator generator comprising a tube including a cathode, a grid, a plate and a screen grid, a pair of resonant circuits, mutual impedance therebetween substantially in excess of the value required to produce two natural frequencies in said circuits, a coupling between the oscillator tube plate and one of said pair, a load coupled to the other of said pair, a feedback coupling between said other circuit and the grid for sustaining oscillation at one of said frequencies, and a resistor in the screen grid circuit for limiting the oscillator power output.

9. In a high frequency oscillation generator adapted to deliver high voltage alternating power to a high resistance load with improved voltage regulation and with good frequency stability, said generator comprising an electron discharge device provided with at least an electron emitter, an output electrode, an electron control electrode and a screen grid, an output transformer comprising a first resonant circuit connected directly to said output electrode, a second resonant circuit coupled to said load, said two resonant circuits being sufficiently reactively coupled by mutual inductance therebetween to provide a doubly-peaked response curve for the two resonant circuits whereby the oscillating system has two degrees of freedom, a reactive element coupling said control electrode to said second resonant circuit, the polarity of said reactive element being so chosen as to generate oscillations at one of two degrees of freedom of the oscillating system.

10. In an oscillation generator of the type comprising a tube provided with at least a cathode, a control electrode and output electrode, a resonant circuit, means connecting said output electrode to a high potential point of said resonant circuits, a second resonant circuit, means reactively coupling said two resonant circuits, a resistive load connected to said second resonant circuit, means reactively coupling said control electrode to at least one of said resonant circuits to provide

proper feedback for oscillation production, and said reactive coupling being sufficiently great to provide a doubly-peaked response curve for said coupled resonant circuits, said feedback coupling being chosen to cause oscillations to be produced at the frequency of the lower frequency peak of said curve.

11. A direct current supply source comprising a tube having at least a cathode, control grid, screen grid and plate, a relatively low direct current voltage supply source connected to said tube to apply positive potentials to said screen grid and plate, a transformer having resonant primary and secondary circuits each tuned to substantially an oscillation frequency chosen from a range of high frequencies, means connecting said primary circuit between said plate and cathode, a rectifier

5 coupled to said secondary circuit and including a resistor load in circuit therewith, a coil coupling said control grid to said secondary circuit to provide feedback thereby to produce high frequency oscillations for rectification by said rectifier, said primary and secondary resonant circuits being coupled in excess of critical coupling thereby to impart a doubly-resonant response curve to the transformer whose resonant peaks are relatively widely spaced, said coil coupling being chosen to cause the feedback phase to be correct for producing said oscillations at a frequency equal to the lower one of said frequency peaks, and resistive means in circuit with said screen grid to permit 15 the screen voltage to be self-adjusting.

OTTO H. SCHADE.