

June 8, 1954

P. G. SULZER

2,680,830

SERIES-RESONANT HIGH-VOLTAGE SUPPLY

Filed April 28, 1953

2 Sheets-Sheet 1

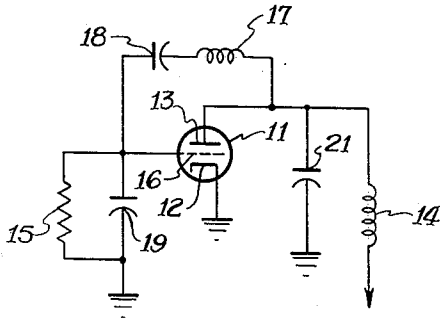


Fig. 1

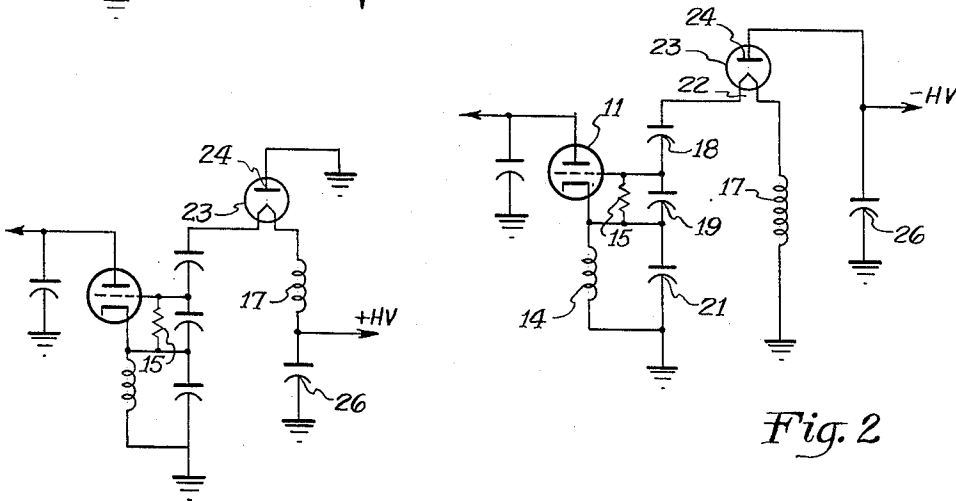


Fig. 2

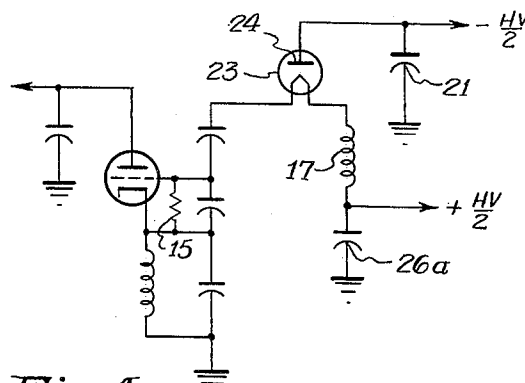


Fig. 4

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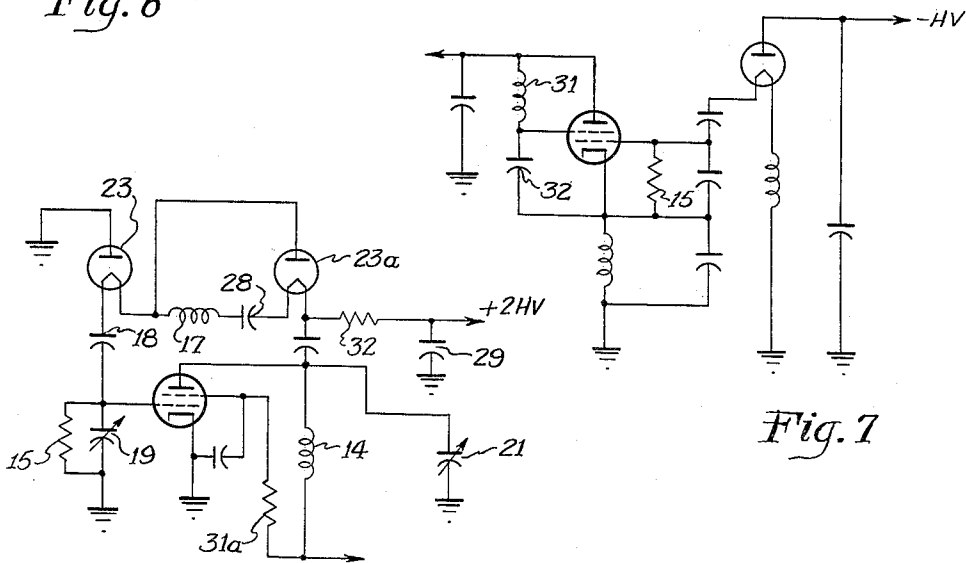
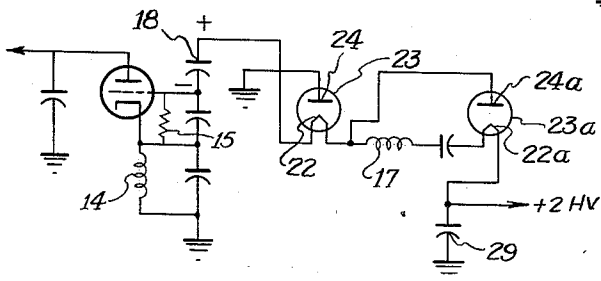
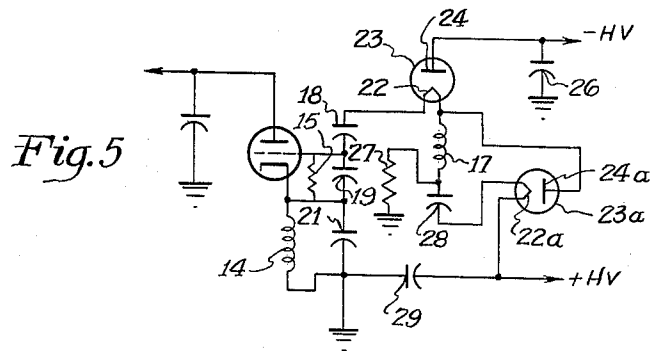


Fig. 8

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UNITED STATES PATENT OFFICE

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SERIES-RESONANT HIGH-VOLTAGE
SUPPLY

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United States of America as represented by
the Secretary of Commerce

Application April 28, 1953, Serial No. 351,765

11 Claims. (Cl. 321—2)

(Granted under Title 35, U. S. Code (1952),
sec. 266)

1

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The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of 35 U. S. Code (1952), section 266.

The present invention relates to a high-voltage supply and in particular to an oscillator type direct-current high-voltage supply which can be built with readily available components. The oscillator-type direct-current supply has been employed in oscilloscopes and television receivers in order to eliminate the heavy and bulky components required to produce rectified and filtered high voltages directly from the power frequency. The previous oscillator-type direct-current supply consisted of an oscillator tube, a transformer, and a rectifier and filter. The transformers used in such a supply were specially designed for specific purposes and are not readily available in sizes other than those used in oscilloscopes and television receivers. The design of such transformers for special purposes is often tedious and time-consuming and imposes a serious limitation upon the design of special supplies of this type.

It is therefore the primary object of the present invention to provide oscillator-type direct-current supplies which do not require the use of high-frequency transformers.

Another object of the present invention is to provide oscillator-type direct-current supplies which may be constructed from readily available electrical components.

Another object of the present invention is to provide oscillator-type direct-current supplies which may be designed to cover widely varying voltage and power requirements.

Another object of the present invention is to provide an oscillator-type D.-C. supply in which the filament of the rectifier tube is heated by the oscillatory voltage in the oscillator circuit.

Another object of the present invention is to provide an oscillator-type D.-C. supply in which a modified Colpitts-type oscillator may be used as the source of oscillatory voltage, the modification of the oscillator allowing higher voltages to be obtained than are normally available from this type of oscillator.

In accordance with the present invention there is provided a modified Colpitts-type oscillator in which there is a series-resonant circuit consisting of an R.-F. choke and several series capacitors. The voltage is rectified by a diode which has its filament connected in series with the resonant circuit. By various modifications of

this circuit, negative or positive direct-current voltages may be obtained, or both positive and negative voltages may be obtained from the same unit.

Other uses and advantages of the invention will become apparent upon reference to the specification and drawings.

Figure 1 is a circuit diagram of a modified Colpitts-type oscillator which may be used with the present invention.

Figure 2 is a circuit diagram showing a negative high-voltage supply.

Figure 3 is a circuit diagram showing another embodiment of the invention showing a positive high-voltage supply.

Figure 4 is a circuit diagram of another embodiment of the invention in which both negative and positive high voltages are obtained using a single rectifier.

Figure 5 is a circuit diagram of another embodiment of the invention in which both negative and positive high voltages are obtained, in which two rectifier tubes are employed.

Figure 6 is a circuit diagram of another embodiment of the present invention in which two rectifiers are used to obtain a positive voltage which is equal to twice the voltage obtained in the circuit of Figure 3.

Figure 7 is a circuit diagram of another embodiment of the present invention showing the use of a tetrode as the oscillator tube in the negative high-voltage supply.

Figure 8 is a circuit diagram of another embodiment of the invention in which a grounded cathode oscillator is used.

Referring to Figure 1, there is shown a modified grounded cathode Colpitts oscillator. The oscillator comprises a triode 11 having a grounded cathode 12 and a plate 13 connected through an R.-F. inductor 14 to the B+ supply. The grid 16 is grounded through capacitor 19 and grid-leak resistor 15. In this circuit feedback between the plate 13 and grid 16 is accomplished through the inductor 17 and capacitor 18. In the standard Colpitts oscillator the capacitor 18 has a very low reactance and is inserted for the purpose of direct-current blocking. In the circuit as modified for the purpose of the present invention the reactance of the capacitor 13 is comparable to the reactance of the inductor 17. The capacitive reactance of the capacitors 18, 19, and 21 in series, is equal to the inductive reactance of inductor 17; that is, in order that this circuit may oscillate, the capacitive reactance of capacitors 19 and 21 in series must equal

the inductive reactance of the series circuit of capacitor 18 and inductor 17. By this procedure the voltage in the series-resonant circuit is increased over that normally obtained at this point in the standard Colpitts oscillator by a factor equal to the Q of the inductor 17. Therefore by varying the Q of the inductor 17, it is possible to vary the direct-current output voltage.

Figure 2 is one embodiment of the present invention using the Colpitts oscillator modified as indicated above. In this figure a grounded-plate oscillator is used instead of the grounded-cathode oscillator of Figure 1. Elements corresponding to those of Figure 1 carry the same reference numerals. In this circuit the filament 22 of the diode 23 is connected in series with the series-resonant circuit between the capacitor 18 and inductor 17. The plate 24 of the diode is grounded through capacitor 26. The negative high voltage H_v is taken off between the plate and the capacitor 26. The oscillatory voltage in the series-resonant circuit provides the heater current for the filament 22. Upon a negative swing of the voltage in the series-resonant circuit the filamentary cathode 22 becomes negative with respect to the plate and the electrons flow through the inductor 17, filament 22, plate 24, and capacitor 26. This charges the capacitor so that the upper plate is negative with respect to the lower plate. Since the lower plate is grounded, the voltage on the upper plate is negative with respect to ground. During a positive swing of the voltage in the resonant circuit, the tube is biased off and capacitor 26 then provides the negative voltage. This capacitor is recharged during each negative swing of the oscillatory voltage to the extent that it is discharged while the tube 23 is nonconducting; that is, capacitor 26 also acts as a filter. The capacitor 26 is charged to a value approximately equal to the amplitude of the negative voltage peaks.

Figure 3 is another embodiment of the invention showing a positive high-voltage supply. In this figure the plate 24 of the diode 23 is grounded, and the capacitor 26 is connected between the inductor 17 and ground. The operation of this circuit is the same as in Figure 2 except that what was the upper plate in Figure 2 is now grounded and therefore the capacitor now has a positive voltage across it with respect to ground.

Referring to Figure 4, the plate 24 of the diode 23 is connected to ground through the capacitor 26 and the inductor 17 is connected to ground through the capacitor 23a. If the capacitors 26 and 23a are of equal value, the voltage will divide equally across these capacitors and the value of the output voltage at each point is equal to one-half the voltage obtained in Figures 2 and 3.

In Figure 5, two diode rectifiers are used to obtain both positive and negative voltage outputs, the amplitude of each of the output voltages being equal to the amplitude of the voltage obtained in Figures 2 and 3. In this figure the first diode 23 has its filament 22 connected in series with the capacitor 18 and inductor 17, and inductor 17 is grounded through the resistor 27. The second diode 23a has its filament 22a connected in series with the capacitors 23 and 29. The series circuit, comprising capacitor 23, filament 22a, and capacitor 29, is connected in parallel with the resistor 27. The plate 24a of the diode 23a is connected between the filament 22 and inductor 17. During a negative swing of the voltage in the resonant circuit, the filament 22 of the diode 23 becomes negative with respect to the plate 23

and the diode conducts, charging capacitor 26 through the circuit consisting of resistor 27, inductor 17, diode 23, and capacitor 26. The negative high voltage is taken across capacitor 26.

During a positive swing of the oscillatory voltage in the series-resonant circuit, the filament 22a of diode 23a becomes negative with respect to the plate 24a as the result of the drop across inductor 17. The diode 24 conducts and the capacitor 29 is charged through the series circuit consisting of capacitor 29, tube 23a, filament 22, capacitor 18, grid-leak resistor 15, and the R.-F. choke 14. Both of the latter elements offer low impedance paths to direct current. Since the left-hand plate of the capacitor is grounded, the right-hand plate is positive with respect to ground. In this circuit the resistor 27 provides a ground return for the D.-C. voltage through the diode 23, and the capacitor 28 isolates the filament 22a from ground.

Figure 6 is another embodiment of the invention in which a positive output voltage equal to twice the voltage obtained in the circuit of Figure 3 is produced. In this embodiment the plate 24 of the diode 23 is connected between the filament 22 and the inductor 17. In this modification the diode 23 operates as a clamp which causes the negative peaks of the oscillatory voltage in the resonant circuit to be at ground potential. This is accomplished in the following manner: Initially, upon a negative swing of the voltage in the resonant circuit, the tube 23 conducts and charges the capacitor 18 to a value equal to the value of the negative peak with respect to the center line of the oscillating voltage. Therefore, the charge developed across the capacitor prevents the filament 22 from going below ground potential during the negative swing of the voltage. During a positive excursion of the voltage, the diode 23 is nonconducting. As a result the voltage in the oscillatory circuit must vary above ground potential, and the voltage in this circuit rises to a value above ground equal to the voltage between the negative and positive peaks. During the rise of the voltage above ground the voltage drop across the inductor 17 causes the filament 22a of the diode 23a to be negative with respect to the plate 24a and the tube conducts, thereby charging the capacitor 29 to a value equal to the difference between positive and negative peaks of the oscillatory voltage of the resonant circuit. The capacitor 29 is charged through diode 23a, filament 22, capacitor 18, resistor 15, and inductor 14. This, of course, discharges capacitor 18 to the same extent that capacitor 29 is discharged when the tube 23a is not conducting. Therefore, the average voltage across capacitor 18 is slightly less than the negative peaks of the oscillatory voltage. As a result the output from capacitor 29 is not truly twice the voltage developed in Figure 3 but is slightly less, depending upon the amount the capacitor 29 is discharged when the tube 23a is nonconducting.

In Figure 7 there is shown an embodiment of the invention which is similar to that shown in Figure 2. In this case a tetrode is used as an oscillator tube. The inductor 21 operates to isolate the screen from ground for R.-F. voltages, and the capacitor 22 operates as a screen by-pass to hold the screen at cathode potential. Other than this the operation of the circuit is the same as that of Figure 2.

Figure 8 shows an embodiment of the invention in which a grounded cathode oscillator is used. The oscillatory circuit consists of capacitors 18

and 19, inductor 17, and capacitor 21. The rectifying action of the tubes 23 and 23a is the same as described in Figure 6. Resistor 31a performs the same function with regard to R.-F. blocking as the inductor 31 in Figure 7. The resistor 33 operates as an R.-F. block while passing direct current. The voltage output is taken across the capacitor 29, the same as in Figure 6.

From the above, it should be apparent that the present invention may be used with a triode or tetrode oscillator tube and with a grounded plate, grounded cathode, or grounded grid oscillator. The values of capacitors 18, 19, 21, and inductor 17 will depend upon the magnitude of the voltage output. The current-carrying capacity of these elements will naturally depend upon the power consumed by the output load. Similarly, the types of diodes used will depend upon the voltage and power requirements of the system, but in general the tube type 1B3 is satisfactory. Also a heated-cathode type diode may be used. In such a case the filament will be connected as shown, and the cathode will be connected to one side of the filament.

It will be apparent that the embodiments shown are only exemplary, and that various modifications can be made in construction and arrangement with the scope of my invention as defined in the appended claims.

I claim:

1. A high-voltage, direct-current supply, comprising an electron tube oscillator, said oscillator having a series-resonant circuit, at least one electron tube rectifier, said rectifier having at least a filament, said filament connected in series with said series-resonant circuit.
2. A high-voltage, direct-current supply, comprising an electron tube oscillator, said oscillator having a series-resonant circuit, at least one electron tube rectifier, said rectifier having at least a filament and a plate, said filament connected in series with said series-resonant circuit, and means for connecting said plate so as to maintain said plate positive with respect to said filament during a portion of the negative swing of voltage in said series-resonant circuit.
3. A high-voltage, direct-current supply, comprising an electron tube oscillator, said oscillator having a series-resonant circuit, at least one electron tube rectifier, said rectifier having at least a filament and a plate, said filament connected in series with said series-resonant circuit, and means for maintaining said plate positive with respect to said filament during a portion of the negative swing of voltage in said series-resonant circuit.
4. A direct-current voltage supply, comprising means for producing an oscillating voltage, said means including a series-resonant circuit, second means for rectifying said oscillating voltage, said second means including at least one electron tube filament connected in series with said series-resonant circuit.
5. A high-voltage, direct-current supply, comprising an electron tube oscillator, said oscillator having a series-resonant circuit, a rectifier having a positive and a negative terminal, said negative terminal connected in said series-

resonant circuit, and means for connecting said positive terminal so as to maintain said positive terminal positive with respect to said negative terminal during a portion of the negative swing of the voltage in said series-resonant circuit.

6. A high-voltage, direct-current supply, comprising an electron tube oscillator, said oscillator having a series-resonant circuit comprising an inductor and at least one capacitor, a rectifier having a positive and a negative terminal, said negative terminal connected to said series-resonant circuit between said inductor and said capacitor, and means for connecting said positive terminal so as to maintain said positive terminal positive with respect to said negative terminal during a portion of the negative swing of the voltage in said series-resonant circuit.

7. A high-voltage direct-current supply, comprising an electron tube oscillator, said oscillator having a series-resonant circuit, at least one rectifier, said rectifier having at least a filament and a plate, said filament connected in series with said series-resonant circuit, a capacitor, said plate connected to ground through said capacitor.

8. The invention according to claim 7 in which said series-resonant circuit is grounded through a resistor, a second rectifier having at least a filament and a plate, a second capacitor, and a third capacitor, said second capacitor, said filament, and said third capacitor being connected in series with each other and in parallel with said resistor, the plate of said second rectifier being connected to the filament of said first-mentioned rectifier.

9. A high-voltage, direct-current supply, comprising an electron tube oscillator, said oscillator having a series-resonant circuit, a capacitor, one terminal of said series-resonant circuit connected to ground through said capacitor, at least one rectifier, said rectifier having at least a filament and a plate, said filament connected in series with said series-resonant circuit, and said plate connected to ground.

10. The invention according to claim 9, comprising in addition a second rectifier having at least a filament and a plate, said filament connected between said capacitor and said series-resonant circuit, and said plate connected to the filament of said first-mentioned rectifier.

11. A high-voltage, direct-current supply, comprising an electron tube oscillator, said oscillator having a series-resonant circuit, a capacitor, one terminal of said series-resonant circuit connected to ground through said capacitor, at least one rectifier, said rectifier having at least a filament and a plate, said filament connected in series with said series resonant circuit, a second capacitor, said plate connected to ground through said second capacitor.

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