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2,999,972

STABILIZED POWER SUPPLY

Filed March 13, 1958

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Fig. 1.

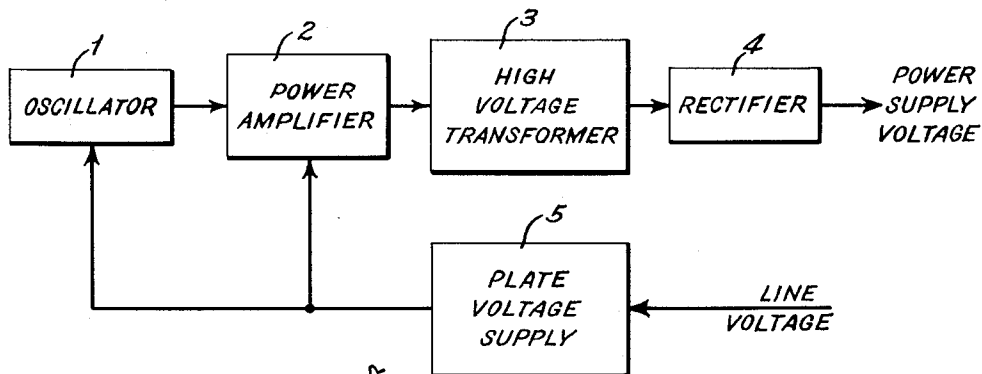


Fig. 2.

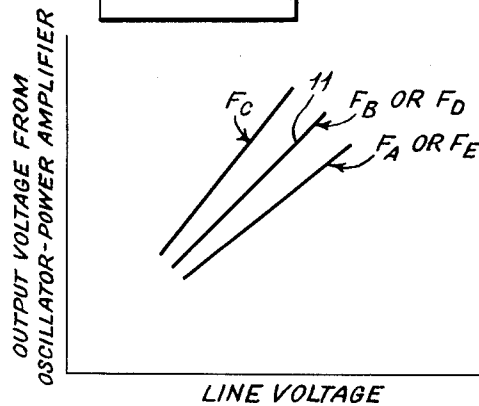
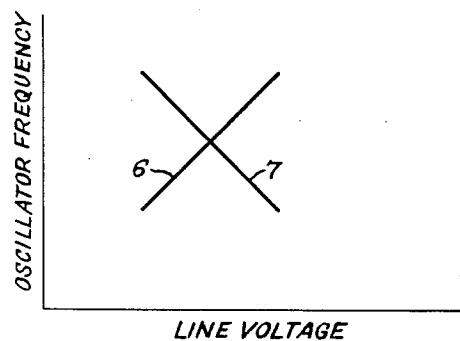


Fig. 3.



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Fig. 4.

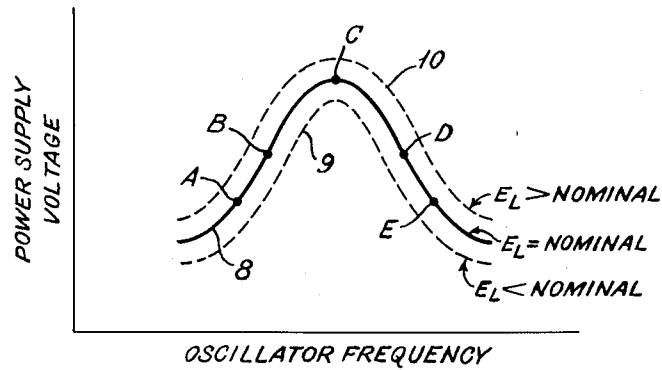
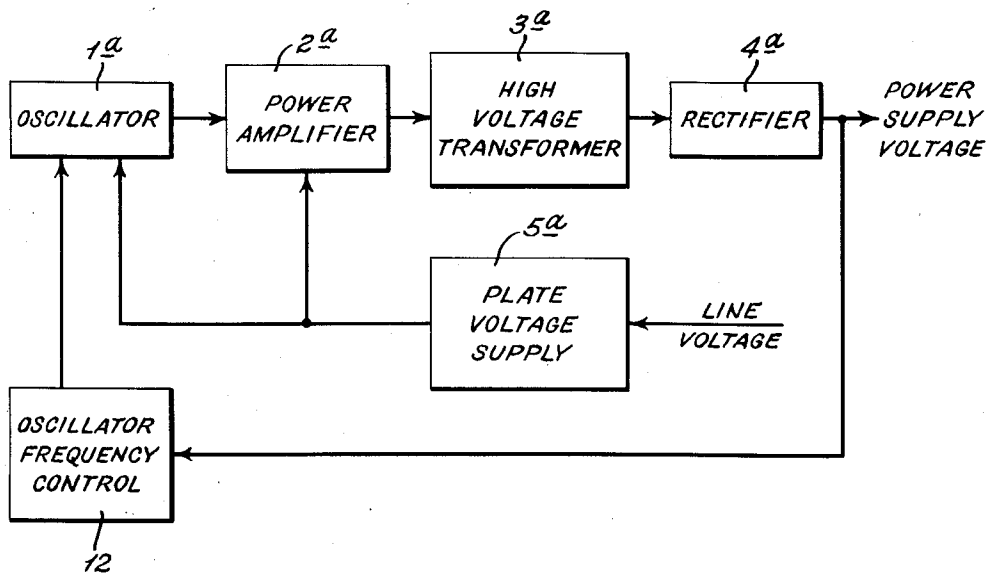


Fig. 5.



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STABILIZED POWER SUPPLY

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7 Claims. (Cl. 323-44)

This invention relates to power supplies, and more particularly to high voltage power supplies of the oscillator-power amplifier type, stabilized against line voltage variation.

One way of obtaining high D.-C. voltage from a line voltage source is to step-up the 60 cycle line voltage to a high voltage and rectify the high voltage. The apparatus necessary to accomplish this procedure is relatively expensive, because the step-up transformer must be very large and contain a large amount of iron. Further, the filter condensers must also be large because of the low frequency.

An alternative to the 60 cycle step-up apparatus is the combination of a high frequency oscillator, a power amplifier, step-up transformer, and a rectifier. Since this system operates at high frequency, the transformer does not require as much iron as a low frequency transformer and may be correspondingly smaller. Further, the filter condensers associated with the rectifier need not be as large. An objection to this system is that a separate oscillator and power amplifier must be provided, and another objection is that a plate voltage supply must be provided for these elements. However, if the power supply is operated in conjunction with other apparatus which also requires a plate voltage supply, the high frequency type of system may well be more economical than the 60 cycle type of system.

A very great disadvantage of the high frequency system is that it is inherently extremely sensitive to line voltage changes, generating a voltage output which increases with increasing line voltage in a substantially linear fashion. In the past, separate regulators have been employed to compensate for changing line voltage so that the power supply voltage might remain constant, despite variation in the line voltage. The provision of a separate regulator is disadvantageous, since the regulator occupies space which is often at a premium, and since the regulator represents an additional expense. This invention is intended to compensate for changing line voltage without the use of a separate line voltage regulator. Particularly if the load is a constant current load, this type of regulation may be very satisfactory as an alternative to the use of a separate regulator.

The invention, generally speaking, employs the characteristics of the high transformer and the characteristics of the oscillator to compensate for the tendency of the oscillator-power amplifier combination to provide an output voltage increasing with increasing line voltage. In one embodiment of the invention the oscillator has a frequency of output voltage versus line voltage characteristic of one slope or sense, and the step-up transformer has a power supply voltage versus frequency characteristic of the opposite slope or sense. For example, if the transformer provides an increasing voltage for increasing frequency of the oscillator output, the oscillator is designed to provide a decreasing frequency for increasing line voltage.

Another embodiment of the invention, usable when the oscillator frequency is not dependent upon line voltage, employs a separate frequency control for the oscillator which is operated by the power supply voltage and which changes the frequency of the oscillator with changing power supply voltage in a direction such as to compensate for the changing power supply voltages versus

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frequency characteristic of the high voltage transformer.

The invention will now be more fully described in conjunction with preferred embodiments thereof shown in the accompanying drawings.

5 In the drawings:

FIG. 1 is a block diagram of one embodiment of the invention;

FIG. 2 is a graph of the output voltage of the oscillator-power amplifier for changing line voltage;

10 FIG. 3 is a graph of the oscillator frequency versus line voltage characteristic of the apparatus of FIG. 1;

FIG. 4 is a graph of the power supply voltage versus oscillator frequency for different line voltages, of the apparatus of FIG. 1; and,

15 FIG. 5 is a block diagram of another embodiment of the invention.

The apparatus of FIG. 1 is an embodiment of the invention wherein the oscillator employed has a characteristic of changing frequency for changing line voltage.

20 The transistor oscillators now commonly used in high voltage power supplies have such characteristics.

The apparatus of FIG. 1 includes a high frequency oscillator 1 which supplies voltage to a power amplifier 2 whose output voltage is supplied to the primary of a high voltage step-up transformer 3. The output of the transformer is supplied to a rectifier 4 which may include the conventional filter and which furnishes at its output the high D.-C. power supply voltage. Line voltage for operation of the system is supplied to a plate voltage supply 5 whose output is furnished to the oscillator 1 and the power amplifier 2.

25 All of the individual elements of FIG. 1 are conventional in form and need not be more fully described. However, they are designed in accordance with characteristics well known to the power supply designer in order to perform the functions of the invention, in a manner now to be described.

The graphs of FIG. 2 show the characteristics of oscillator power supplies for increasing line voltage and constant frequency. Each of these graphs represents the linear increase in output voltage of the combination of oscillator 1 and power amplifier 2 for increasing line voltage, and for different frequencies of the output voltage of oscillator 1.

30 The oscillator 1 is designed in accordance with the invention to have a characteristic of either of the types shown in FIG. 3, specifically, to have a positive slope of oscillator frequency versus line voltage characteristic such as indicated on curve 6, or to have a negative slope of oscillator frequency versus line voltage as indicated on curve 7. The ordinary skilled power supply designer will readily appreciate how an oscillator can be designed to have either of these characteristics.

35 The high voltage transformer 3 of FIG. 1 may have a characteristic of the type shown in FIG. 4, or may have a characteristic corresponding to any portion of this graph. The solid line characteristic 8 of FIG. 4 is of the resonant transformer type and shows the power supply voltage increasing with increasing oscillator frequency up to a peak and then decreasing with further increase in frequency. The solid line of graph 8 is for a particular line voltage called nominal voltage, while the dashed line curve 9 is for a line voltage less than nominal and the dashed line curve 10 is for a line voltage greater than nominal. The characteristic of curve 8 may be obtained by the use of series or parallel capacitors in conjunction with the transformer windings, or any portion of the graph may be obtained through the use of conventional transformer design methods.

40 Assuming that the transformer 3 of FIG. 1 has a characteristic such as indicated between the points A and C of graph 8 of FIG. 4, the oscillator 1 will be designed to

have an opposite slope characteristic such as shown at 7 in FIG. 3. Assume first that the oscillator is operating at a frequency corresponding to the point B in FIG. 4. Then, if the line voltage increases, the output voltage of the oscillator-power amplifier combination will increase along the curve 11 of FIG. 2, which will tend to cause the power supply voltage to increase in like manner. However, the increase in line voltage will cause the oscillator frequency to decrease along the curve 7 of FIG. 3, which decrease as shown in FIG. 4 will cause a compensating decrease in power supply voltage. This compensation is for the tendency of the increase in output voltage of the oscillator-power amplifier to increase the power supply voltage. Depending upon the actual design of the oscillator and the high voltage transformer, the power supply voltage may be maintained substantially constant over a substantial range of line voltage variation, or the power supply voltage may increase or decrease relatively slight amounts for increasing line voltage.

If the transformer 3 has a characteristic corresponding to the portion of graph 8 between the letters C and E of FIG. 4, the oscillator 1 will be designed to have a characteristic such as that shown in graph 6 of FIG. 3. Then, if the frequency at one instant is that corresponding to the point D in FIG. 4, and the line voltage increases, the output voltage of the oscillator-power amplifier combination will increase along curve 11 of FIG. 2, thereby tending to cause an increase in power supply voltage. However, curve 6 of FIG. 3 shows that the oscillator frequency will increase with this increase in line voltage, and curve 8 of FIG. 4 shows that this increase in frequency will tend to cause a decrease in power supply voltage. Again, the transformer and the oscillator may be designed to have characteristics such that the power supply voltage is maintained relatively constant or is subject to a slight change, over a substantial range of line voltage variation. Of course, the characteristics of the oscillator and the transformer must be selected in accordance with the graph of FIG. 2, namely, the output voltage from the oscillator-power amplifier versus the line voltage.

If the particular oscillator design selected is not sensitive in frequency to line voltage variation or if it does not have a characteristic which by itself is satisfactory for the purpose of this invention, the apparatus of FIG. 5 may be employed. The apparatus of FIG. 5 includes an oscillator 1a, a power amplifier 2a, a high voltage transformer 3a, a rectifier 4a, and a plate voltage supply 5a, all similar to the corresponding elements of FIG. 1. However, in order that the oscillator may have the appropriate characteristic corresponding to either of graphs 6 and 7 of FIG. 3, the power supply voltage in the apparatus of FIG. 5 is furnished to an oscillator frequency control 12 whose output controls the frequency of oscillator 1a. The oscillator frequency control, like the other elements of the combination, may be of conventional design and may be selected to increase or to decrease the oscillator frequency with increasing power supply voltage in accordance with either of curves 6 or 7 of FIG. 3.

The apparatus of FIG. 5 will operate in the same manner as that of FIG. 1, so that the description of the operation need not be repeated.

It will be evident from the above description that the various elements of the combinations of FIGS. 1 and 5 may be of any conventional type, as long as their characteristics are designed to fulfill the functions specified. Further, additional or fewer elements may be employed than illustrated in these figures without departure from the scope of this invention. Therefore the invention is not to be considered limited to the specific embodiments disclosed, but rather only by the scope of the appended claims.

I claim:

1. A power supply operable to translate a line voltage into a power supply voltage and to regulate the amplitude of the power supply voltage against changes in line voltage

comprising means including an oscillator supplied with said line voltage and operable to supply an output voltage increasing with increasing line voltage, said means having a frequency of output voltage versus line voltage characteristic of one sense, and means including a transformer connected to said means including an oscillator to receive said output voltage and operable to supply said power supply voltage, said transformer having a power supply voltage versus frequency characteristic of the opposite sense to compensate for the said characteristic of said means including an oscillator.

2. A power supply operable to translate a line voltage into a power supply voltage and to regulate the amplitude of the power supply voltage against changes in line voltage comprising an oscillator-power amplifier combination supplied with said line voltage and operable to generate an output voltage increasing with increasing line voltage, said oscillator-power amplifier combination having a frequency of output voltage versus line voltage characteristic of one sense, and a transformer having a winding on said transformer connected to the output of said power amplifier to receive said output voltage, said transformer being operable to supply said power supply voltage and having a power supply voltage versus frequency characteristic of the opposite sense to compensate for the said characteristic of said oscillator-power amplifier combination.

3. The apparatus of claim 2 in which the frequency versus line voltage characteristic of said oscillator-power amplifier combination is of positive slope and the power supply voltage versus frequency characteristic of said transformer is of negative slope.

4. The apparatus of claim 2 in which the frequency versus line voltage characteristic of said oscillator-power amplifier combination is of negative slope and the power supply voltage versus frequency characteristic of said transformer is of positive slope.

5. A power supply operable to translate a line voltage into a power supply voltage and to regulate the amplitude of the power supply voltage against changes in line voltage comprising means including an oscillator supplied with said line voltage and operable to supply an output voltage increasing with increasing line voltage, means including a transformer supplied with the output voltage of said means including an oscillator and operable to furnish a power supply voltage at its output, said transformer having a power supply voltage versus frequency characteristic of one sense, and means for controlling the frequency of said oscillator said frequency controlling means being supplied with said power supply voltage and being operable to vary the frequency of said oscillator with changing power supply voltage in opposite sense.

6. The apparatus of claim 5 in which the power supply voltage versus frequency characteristic of said transformer is of positive slope and said frequency controlling means decreases the oscillator frequency with increasing power supply voltage.

7. The apparatus of claim 5 in which the power supply voltage versus frequency characteristic of said transformer is of negative slope and said frequency controlling means increases the oscillator frequency with increasing power supply voltage.

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