Feb. 17, 1953 J. EDWARDS 2,629,014

ELECTRONIC RIPPLE SUPPRESSION FILTER

Filed June 8, 1949

Fig. 1.

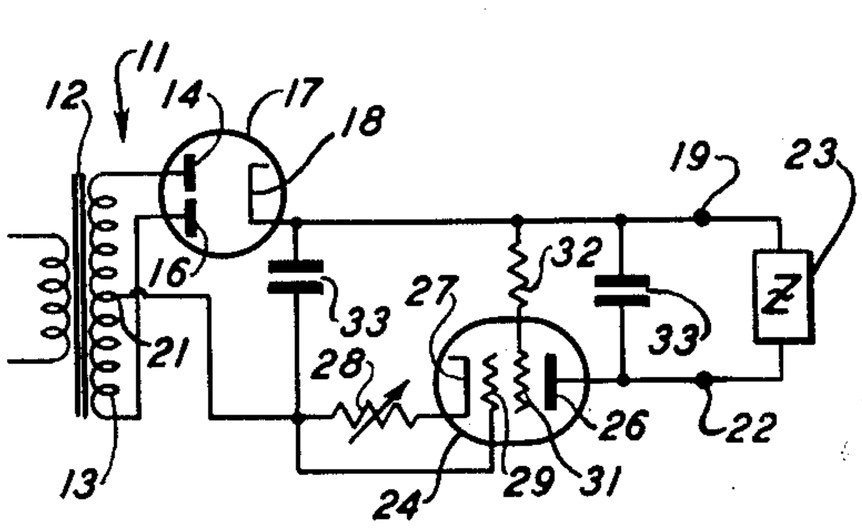

Fig. 2.

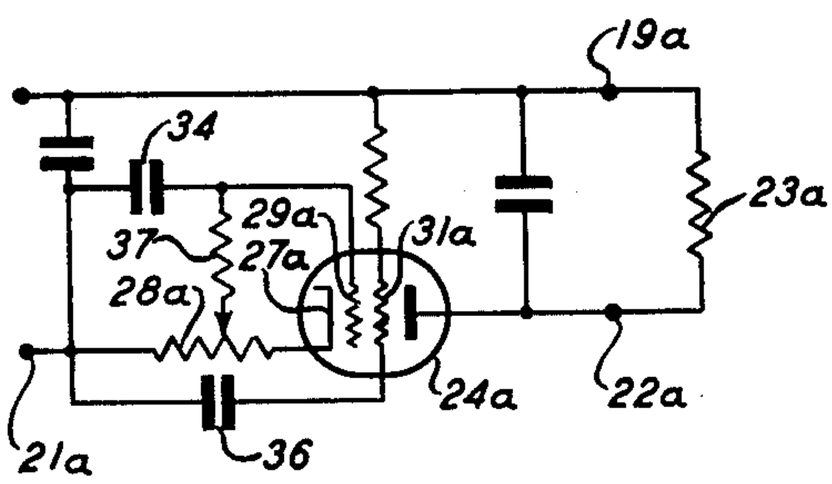

Fig. 3.

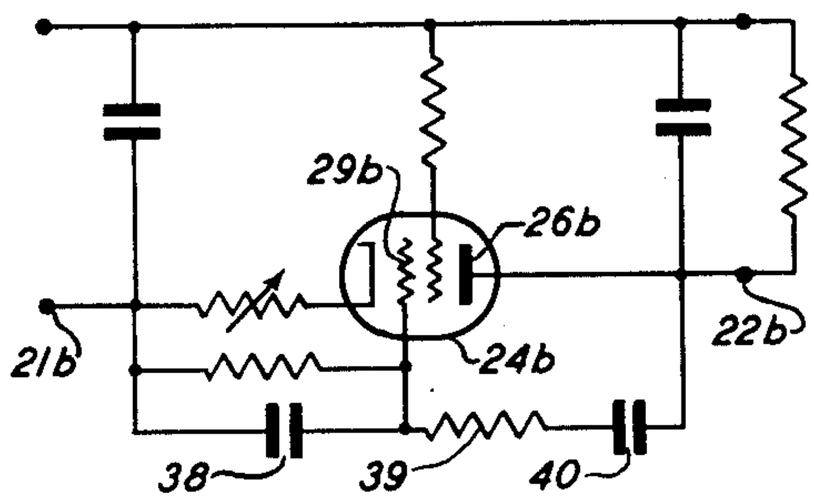

Fig. 4.

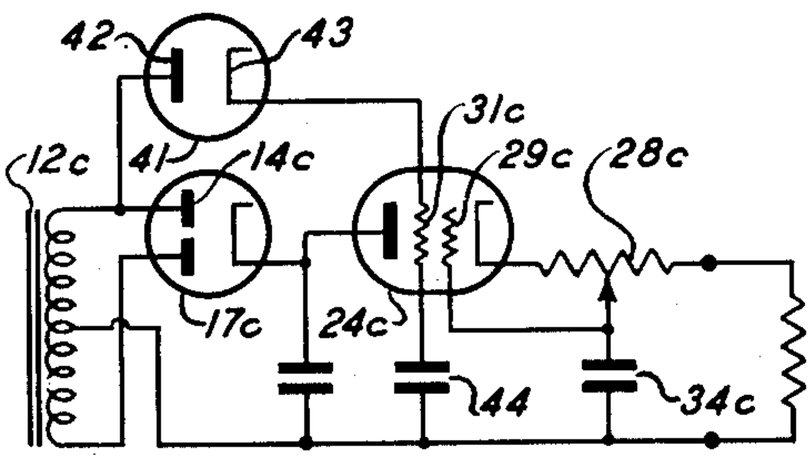

Fig. 5.

Fig. 6.

INVENTOR.
JONATHAN EDWARDS
BY M. C. Hayes
ATTORNEY

Patented Feb. 17, 1953

2,629,014

UNITED STATES PATENT OFFICE

2,629,014

ELECTRONIC RIPPLE SUPPRESSION FILTER

Jonathan Edwards, San Diego, Calif.

Application June 8, 1949, Serial No. 97,869

1 Claim. (Cl. 178—44)

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

1

This invention relates to filters for removing the ripple from a uni-directional voltage power supply, such as is used in electronic circuit work.

The use of a non-linear impedance, such as a saturated diode, biased to an operating point just above the knee of its characteristic curve, and inserted between a ripple-containing power supply and a load, is known in the art. The operating point is determined by the magnitude of the current flowing through the saturated diode, and hence through the load. Therefore, for each different load demand, it is necessary to have a different diode, inasmuch as each diode has a single characteristic curve.

It is an object of this invention to provide an improved non-linear ripple filter circuit which may be readily adjusted for different load currents drawn from the source of uni-directional voltage without necessity for changing the filter element.

It is another object of this invention to provide a filter circuit for suppressing the ripple in a source of unidirectional voltage which embodies not only the advantages of a non-linear impedance, but also has means for directly suppressing the ripple by feeding it back in phase opposition, i. e. negative feedback.

Another object of this invention is to provide a simplified inductive reactance in the form of a tube which may be substituted for the conventional choke coil, with a saving in space and weight and in power lost in the filtering element.

A further object of this invention is to accomplish the above outlined objects and still insert the filter element in the positive lead of the voltage source, rather than in the negative or ground lead, thereby simplifying use of the voltage source for many applications.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following description.

A principal feature of the instant invention resides in the employment of a screen grid tube, which has a family of characteristic curves, each one representing a typical non-linear impedance saturation curve, the particular curve in the family being determined by the voltage bias on the control grid of the tube. Thus, for any load current desired the control grid bias on the screen grid tube may be so chosen that the operating point lies just above the knee of the curve, thus giving optimum operating conditions, i. e. a high A. C. resistance, and a relatively low D. C. resistance.

Use of a screen grid tube in the above-described manner readily lends itself to the operation of negative ripple current feedback to the tube also, so that in addition to utilizing the saturation characteristics of the screen grid tube, the tube may serve as a means by which

2

degenerative ripple feedback can be introduced into the system to further suppress the ripple from the uni-directional voltage power.

Use of a screen grid tube in the above outlined manner also readily lends itself to the application of a quadrature voltage through the control grid of the tube, whereby it may be made to appear as an inductive reactance—the full equivalent of a bulky and weighty choke coil, and with the added advantage of the saturation characteristics above discussed.

In accordance with the above general description, several embodiments of the instant invention will now be described with reference to the accompanying drawing, wherein:

Fig. 1 illustrates a simple form of the instant invention;

Fig. 2 shows a modification in which degenerative ripple feedback is applied to the filter tube;

Fig. 3 shows the use of the screen grid filter tube with quadrature feedback, giving it the added advantage of appearing as an inductive reactance in the power supply circuit; and

Figs. 4, 5, and 6 illustrate how the screen grid filter tube may be placed in the positive lead of the power supply rather than in the negative lead.

Referring to Fig. 1, 11 designates the usual source of ripple-containing uni-directional voltage, consisting of a transformer 12, the secondary winding 13 of which is connected to the anodes 14 and 16, respectfully, of a double rectifier 17. The cathode 18 of the rectifier 17 is connected to the positive output terminal 19, while the midpoint 21 of the secondary winding 13 is connected, through a filter circuit to be described, to the negative output terminal 22. Across the terminals 19 and 22 is connected any desired load, represented by the impedance 23.

In accordance with the instant invention, a screen grid tube 24 has its anode-cathode connected in series with the negative lead of the power supply. In Fig. 1, the anode 26 of the tube 24 is shown connected directly to the negative terminal 22, while the cathode 27 is connected through an adjustable impedance 28, to the point 21 constituting the negative terminal of the basic supply source 11. The control grid 29 of the tube 24 is connected to one terminal of the resistor 28, coinciding electrically with the point 21, so that the I voltage drop in the cathode impedance 28 provides a negative bias from the cathode 27 to the grid 29. The screen grid 31 of the tube 24 is returned through a resistor 32 to the positive terminal 19 of the power supply. Numerals 33 represent conventional filter capacitors.

It is characteristic of screen grid tubes such as 24 that when plate current is plotted as ordinate against plate voltage as abscissa, a series of typical saturation curves are derived

rising steeply and then bending sharply at a knee. The location of each member of the curve is determined by the bias on the control grid **29**. It is thus seen that in the instant invention as illustrated in Fig. 1, for any given load **23** drawing a particular current, it is only necessary to adjust the impedance **28** so that there is chosen that tube characteristic which has its knee just below the operating point as determined by the load current through **23**. In this way, the screen grid tube **24** may be made to serve as an efficacious ripple filter for different loads **23**, it being merely necessary to adjust the impedance **28** whenever the load **23** is changed, As is known from prior usage of saturable diodes, by placing the operating point just above the knee of the curve, a relatively high A. C., or ripple, resistance is obtained with only a relatively low D. C. resistance.

Fig. 2 illustrates the employment of the instant invention, with the addition of negative, or degenerative, ripple feedback, so that in addition to furnishing the saturation characteristic above described, the screen grid tube **24***a* also deliberately and specifically suppresses the ripple voltage, by means of negative feedback.

As shown in Fig. 2, the screen grid tube **24***a* is inserted in the negative lead between the point **21***a* and the negative terminal **22***a*. This figure differs principally from Fig. 1 in that it employs a capacitor **34**, which feeds back degenerative or negative ripple signals to the grid **29***a*, and the capacitor **36**, the latter feeding back degenerative ripple signals to the screen grid **31***a*. Both feedbacks tend to further suppress the passage of ripple voltage power through the tube **24***a*.

Fig. 2 also illustrates an alternative manner of deriving the adjustable bias for the grid **29***a*. In this case, the cathode impedance is made in the form of a potentiometer **28***a*, the slider of which is connected through a resistor **37** to the control grid **29***a*.

In Fig. 3, the basic circuit shown in Fig. 1 has been modified by the use of a reactive circuit to apply a quadrature voltage to the grid **29***b* of the tube **24***b*, so that the tube presents the appearance of an inductive reactance between the terminals **21***b* and **22***b*.

This is done by connecting a circuit consisting of capacitor **38** in series with resistor **39** between the terminal **21***b* and the anode **26***b*. **40** is a small blocking capacitor. The midpoint between the capacitor **38** and resistor **39** is connected to the control grid **29***b* as shown. When the resistance of the resistor **39** is made much larger than the reactance represented by the capacitor **33**, it may be readily shown that the A. C., or ripple, voltage applied to the control grid **29***b* lags the plate-to-cathode voltage of the tube **24***b* by substantially 90°, thereby causing the tube **24***b* to appear substantially as an inductive reactance to the A. C. ripple voltage appearing in the power supply circuit. In this way the advantages of a choke coil are achieved without the bulk and weight of the latter, and without the undue power loss resulting from the use of a choke.

In the modifications illustrated in Figs. 1–3, it has been necessary to place the tube **24** in the negative lead of the power supply in order to obtain a ready source of high enough biasing voltage for the screen grid **31**. In the embodiment shown in Fig. 4, placement of the screen

grid filter tube **24***c* in the positive lead of the power supply has been achieved by making use of an auxiliary single rectifier **41**, having its anode **42** connected to the anode **14***c* of the principal double rectifier **17***c*, and having its cathode **43** connected to the screen grid **31***c* of the tube **24***c*. A capacitor **44**, also connected to the screen grid **31***c*, serves to build up a charge of current rectified in the rectifier **41**, so as to maintain the bias on the screen grid **31***c* at substantially the full output voltage of the rectifier-transformer combination **17***c*–**12***c*.

As in Fig. 2, degenerative A. C. ripple voltage may be applied back to the control grid **29***c* through a capacitor **34***c*; and the capacitor **44**, in addition to holding the charge bias for the screen grid **31***c*, also serves to feedback degenerative A. C. ripple voltage. Proper bias for the control grid **29***c* is achieved in Fig. 4, in a manner similar to that shown in Fig. 2, by the use of a potentiometer **28***c*, the slider of which is connected to the control grid **29***c*.

Fig. 5 is substantially the same as is Fig. 4, with the addition of a series-connected R. C. circuit **46**, **47**, inserted in the circuit at the rectifier anode **42***a* for the purpose of cutting down the bias voltage on the screen grid **31***d*.

In Fig. 6, the use of any suitable amplifier **48** is shown for amplifying the ripple voltage appearing across the load **23***e* before applying it in degenerative fashion to the control grid **29***e* of the filter tube **24***e*.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

A ripple suppression circuit adapted to be interconnected between a source of ripple-containing unidirectional voltage and a load comprising an electronic tube having an anode, a cathode, a control grid, and a screen grid, means serially connecting said anode and cathode between the source of unidirectional voltage and the load, a first impedance consisting solely of a resistor connected to and in series with said cathode, first circuit means connecting said control grid to a point of biasing potential with respect to said cathode, said first circuit means comprising a second impedance connected between the control grid and a selectable point on said first impedance, and second circuit means including an impedance connecting said screen grid to a source of biasing potential.

JONATHAN EDWARDS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,075,966	Vance	Apr. 6, 1937
2,200,055	Burnett	May 7, 1940
2,237,420	Ferris	Apr. 8, 1941
2,309,352	Lewis	Feb. 2, 1943
2,456,638	Kenyon	Dec. 21, 1948