

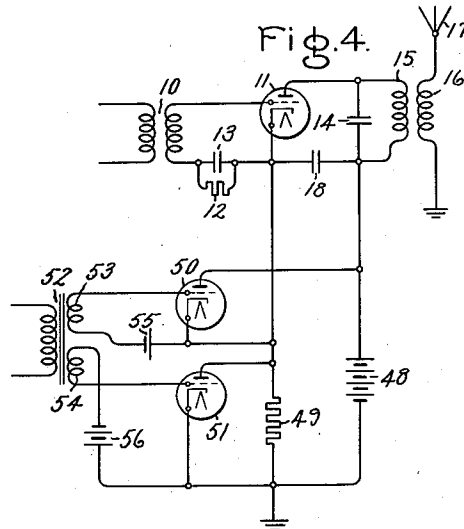
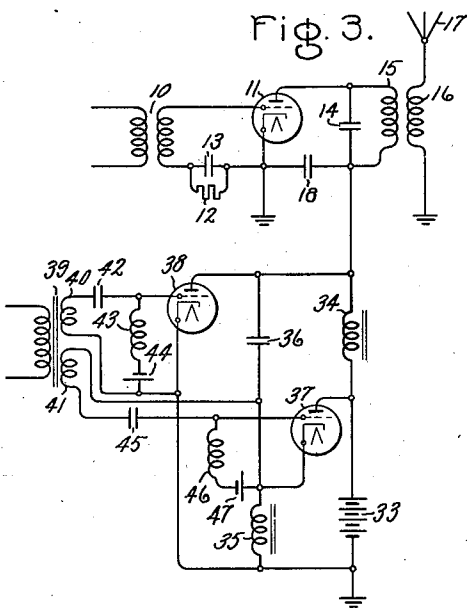
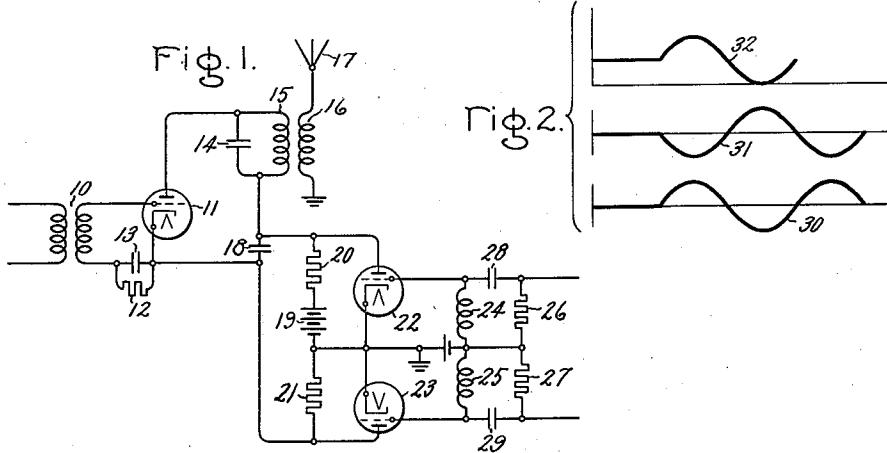
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MODULATOR

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UNITED STATES PATENT OFFICE

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MODULATOR

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This invention relates to apparatus for modulating an alternating current wave of radio frequency in accordance with a signal wave.

It is an object of my invention to provide improved and simplified circuits for modulating a carrier wave with a signal wave in a better and more convenient way than heretofore. It is a further object of my invention to provide a carrier modulating circuit which is suitable for modulating a carrier wave by a signal wave having a very broad range of frequencies.

In the attainment of my objects it is a principal feature of my invention to amplify the signal wave, with which a carrier wave is to be modulated, by a pair of amplifier tubes arranged in push-pull relation. One of these amplifier tubes is connected so as to reduce the voltage supplied to the anode of a carrier amplifier from a suitable source of operating potential to a minimum so that the carrier wave is amplified in minimum amount. The other of these signal amplifier tubes is arranged to decrease an impedance between the source of operating potential and the carrier amplifier tube to supply a maximum voltage to the carrier amplifier and hence produce a maximum amount of the carrier wave. Since the signal amplifier tubes are arranged in push-pull relation these operations occur alternately and may easily be adjusted to produce a faithfully modulated carrier.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is a schematic diagram representing my invention; Fig. 2 represents certain characteristics thereof; and Figs. 3 and 4 represent certain modifications of my invention.

Referring to Fig. 1 of the drawing, there is illustrated a portion of a radio transmitter including a carrier wave amplifier and apparatus constructed according to my invention for modulating the carrier wave in accordance with a signal wave having a very broad range of frequencies. The carrier wave amplifier is a conventional one and is supplied from a source of waves of carrier frequency by a transformer 10. The secondary of the transformer 10 is connected between the grid and cathode of an electron discharge amplifier device 11. In circuit with the grid and cathode of the device 11 and the secondary of the

transformer 10 there is provided a grid leak resistor 12 by-passed by a condenser 13 which maintains a suitable bias potential between the grid and the cathode. The output circuit for the amplifier comprises a tuned circuit 14, 15, a source of operating potential 19, and a pair of resistors 20 and 21. A condenser 18 is connected in shunt to the source 19 and resistors 20 and 21 to transmit high frequencies thereacross. The tuned circuit 14, 15 may be coupled to any suitable load device, such as the antenna 17, which is connected to ground through a secondary winding 16 of a transformer, the primary of which is the inductance 15 of the tuned circuit 14, 15.

The source of operating potential 19 has means associated therewith for varying the potential applied to discharge device 11 in accordance with a signal wave. This means comprises an impedance, represented as discharge device 22 connected in shunt with the source 19 and resistance 20, and a second impedance, represented by discharge device 23 connected in shunt with resistance 21. These impedances are maintained at a constant value in the absence of a signal wave and are alternately reduced in value in response to alternate half cycles of the signal wave, so that the carrier wave operating potential first rises and then falls as first one and then the other of these impedances is reduced.

The discharge devices 22 and 23 have their cathodes connected together and to the point between the negative terminal of the source 19 and one terminal of resistance 21. Each of these devices is provided with a grid circuit and these circuits are connected in push-pull relation for signal currents, which may be applied to the grids through coupling condensers 28 and 29. Suitable bias potential may be applied to the grids through inductances 24 and 25 and, if desired, suitable resistors 26 and 27 may be connected between the cathodes and the opposite sides of the signal source.

The input coupling systems 24, 28, 26 and 25, 29, 27 for the discharge devices 22 and 23, being of the resistance-capacitive type, may be readily designed for faithful transmission of extremely broad ranges of frequency, such as those used in television. This is also true of the anode coupling system of these devices, which comprises only the resistances 20 and 21 and the small radio frequency by-passing condenser 18.

The operation of this circuit may be more readily understood by reference to Fig. 2 in which the curve 30 illustrates the signal voltage applied to the grids of the device 23 and the curve 31 illus-

trates the signal voltage applied to the grid of the device 22. The curve 32 illustrates the voltage appearing across the condenser 18 when the voltages represented by the curves 30 and 31 exist. When no signal voltage is applied to the grids of devices 22 and 23, as is indicated by the parts of the curves 30 and 31 to the left, a constant voltage appears on the condenser 18. This is represented by the level portion of the curve 32 to the left. As represented by the curves 30 and 31 when the voltage on the grid of the device 23 becomes more positive, the voltage on the grid of the device 22 becomes more negative. Tube 23 therefore practically short-circuits the resistor 21 and the device 22 becomes practically an open circuit; therefore, the voltage of the source 19 appears across the condenser 18 except for the voltage drop in the resistor 20. This higher voltage is represented by the rise in the curve 32.

As curves 30 and 31 also illustrate, when the voltage on the grid of device 23 becomes more negative, the voltage on the grid of the device 22 becomes more positive. Therefore, the device 23 becomes practically an open circuit and the device 22 becomes practically a short-circuit. The potential of the source 19 is almost entirely removed from the device 11 and the potential drop across the resistor 20 becomes practically equal to the potential of the source 19. Since the amplitude of the wave amplified in the device 11 varies as the operating voltage for that device varies, the amplitude of the carrier wave follows the curve 32.

Referring to Fig. 3, there is shown a modified arrangement for supplying operating voltage, modulated in accordance with signals, to a high frequency amplifier. The high frequency amplifier is identical with that shown in Fig. 1 and functions in the same way. Its parts correspond to respective parts of the amplifier illustrated by Fig. 1 and like reference characters have been applied thereto. When there is no signal to vary the operating voltage which is applied across the condenser 18, a steady voltage is supplied by a source 33 of direct current through an inductance 34 to the junction between the condenser 18 and the coil 15 and hence to the anode of amplifier 11. The cathode of device 11 is grounded and the negative terminal of the source 33 is grounded. A steady voltage thus applied across the condenser 18 maintains a carrier wave of constant amplitude.

Means is provided for varying the amplitude of the carrier wave, which comprises an impedance in series with the source 33 of operating potential and a second impedance in shunt to the source. The series impedance is the inductance 34 which is shunted by a condenser 36 and a discharge device 37 connected in series. On one half of the signal wave the resistance of the device 37 is reduced and it, with the condenser 36, provides for a brief time a low impedance path around the inductance 34.

Although the condenser 36 does form a low impedance path momentarily, it also performs an additional function. The point between the condenser 36 and the cathode of the discharge device 37 is connected to one end of an inductance 35, whose other end is connected to ground. The average potential across condenser 36 must remain at the potential of the source 33. Therefore, when the resistance of the device 37 is reduced, the condenser 36 not only forms a low impedance path around the inductance 34, but also momentarily adds the voltage due to its

stored charge to the voltage of the source 33 appearing on the anode of device 11. Thus on that half cycle of signal voltage, the anode voltage of the device 11 rises nearly to twice the voltage of the source 33.

The second impedance connected in shunt to the source 33 comprises a second discharge device 38 connected in shunt to the source 33 and the inductance 34. On the other half of the signal wave the resistance of device 38 is reduced and substantially the entire voltage of the source 33 appears across inductance 34 so that the anode potential of amplifier device 11 is reduced nearly to zero.

Each of the devices 37 and 38 is provided with a grid circuit and these circuits are connected by a transformer 39 to a source of signal voltage so that first one and then the other device becomes conductive. One secondary 40 of transformer 39 is connected at one end to the cathode 42 and at the other end through a condenser 41 to the grid of device 38. This grid is connected to the cathode through an inductance 43 and a source 44 of bias potential. Similarly the other secondary 41 of the transformer 39 is connected at one end to the cathode and at the other end through a condenser 45 to the grid of the device 37. The grid is connected to the cathode through an inductance 46 and a source 47 of grid bias potential.

The grid bias potential sources 44 and 47 are arranged to maintain the devices 37 and 38 substantially nonconductive in the absence of a signal wave. The transformer windings are so poled that, when energized by a signal wave, first one and then the other grid of devices 37 and 38 is made more positive so that the devices are alternately conductive. Since the cathodes of the devices 37 and 38 are at different potentials, a transformer is employed to apply signal potentials to the grids.

Referring to Fig. 4, a third modification of my invention is shown wherein a source 48 of potential and a resistor 49 are connected in series relation between the two terminals of the condenser 18. In this figure, as in Fig. 3, the high frequency amplifier illustrated is identical with that shown by Fig. 1 and like reference characters have been applied to like parts. The source 48 of potential must be sufficiently large to supply across the condenser 18 not only the proper operating potential for the device 11 but also to supply the potential drop through the resistor 49 due to the flow of operating current there-through. An electron discharge device 50 has its anode connected to the positive terminal of the source 48 and its cathode connected to the cathode of the device 11. The anode of a second discharge device 51 is connected to the cathode of the device 11 and the cathode of the device 51 is connected to the junction between the resistor 49 and the source 48, which is grounded. Suitable control circuits for the devices 50 and 51 act first to reduce the impedance of one device on one half cycle of a signal wave and then to reduce the impedance of the other device on the other half cycle.

A circuit for controlling the impedances of these devices is connected to the control electrodes of the two devices and comprises a source of signal voltage including a transformer 52 which has a pair of secondary windings 53 and 54. One terminal of each of these windings is connected to a respective control electrode of the tubes 50 and 51 and the other terminal of the winding is con-

ected through respective sources of bias potential 55 and 56 to the corresponding cathodes. The sources 55 and 56 of the bias voltages are adjusted so that the devices 50 and 51 in the absence of signal voltages are substantially non-conductive.

When signal voltages are applied through the transformer 52, first one device and then the other becomes conductive and changes the anode operating voltage for the device 11 above and below its steady value in the absence of signals. When the device 50 becomes conductive the voltage supplied to the anode of the device 11 drops to a very low value and substantially all of the potential of the source 48 appears across the resistor 49. When the device 51 becomes conducting the potential drop across the resistor 49 substantially disappears and practically the entire potential of the source 48 appears on the anode of the device 11. The resistance 49 and device 51 may be considered as an impedance in series with the source 48 whose magnitude decreases on one half cycle of the signal and the device 50 may be considered as the impedance in shunt to the source whose magnitude decreases on the other half cycle.

In each figure there are certain optimum values for certain of the elements which are instrumental in varying the operating voltage for the high frequency amplifier. For example, in the circuit illustrated by Fig. 1, the values of the resistors 20 and 21 should be so chosen that the depth of modulation produced by device 22 is substantially equal to that produced by the device 23. The values of the inductances 34 and 35 and the condenser 36 in the circuit illustrated by Fig. 3 should be made such as to give as nearly as possible equal depths of modulation on succeeding half cycles of the signal valve. In the circuit illustrated by Fig. 4 the resistor 49 should be of such size that, when no signal is applied to the circuit, a potential exists across it equal to half the potential of the source 48. Of course, the relative depth of modulation produced by the two tubes 22 and 23, 37 and 38, or 50 and 51, may be varied over a considerable range by adjusting the relative amounts of signal voltage applied to the respective grids.

While I have shown particular embodiments of my invention, it will, of course, be understood that I do not wish to be limited thereto, since different modifications may be made both in the circuit arrangement and instrumentalities employed, and I aim by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a power supply for an amplifier through which a carrier wave is transmitted to be modulated by a signal, the combination of means for applying an operating voltage to said amplifier, said means comprising a source of operating potential and an impedance in series with said source, means for by-passing said carrier wave around said first means, means in shunt to said impedance for transmitting current therearound on one half cycle of said signal to increase said voltage, and means in shunt to said source and said impedance to transmit current from said source through said impedance on the other half cycle of said signal to decrease said voltage, whereby the carrier wave generated in said amplifier is varied in amplitude in response to said signal.

2. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a source of unidirectional operating potential for said amplifier, an impedance in series with said source, means for by-passing said high frequency wave around said source and said impedance, means for reducing the magnitude of said impedance from a constant value in correspondence to increasing intensities of one half cycle of said signal, thereby to increase the current through said amplifier, and means for reducing the potential applied from said source to said amplifier from a constant value in correspondence to increasing intensities of the other half cycle of said signal, thereby to reduce the current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

3. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a source of unidirectional operating potential for said amplifier, an impedance in series with said source, means for by-passing said wave around said source and said impedance, an electron discharge device connected in shunt to said impedance, means to make said device conductive on one half cycle of said signal, thereby to increase current through said amplifier, a second electron discharge device connected in circuit with said source to reduce the potential applied from said source to said amplifier, and means to make said second device conductive on the other half cycle of said signal, thereby to decrease current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

4. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a source of unidirectional operating potential for said amplifier, a pair of impedances connected in series with said source, an electron discharge device connected in shunt to the first of said impedances, means to make said device conductive on one half cycle of said signal, thereby to increase the current through said amplifier, a second electron discharge device connected in shunt to said source and the second of said impedances, and means to make said second device conductive on the other half cycle of said signal, thereby to decrease the current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

5. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a source of unidirectional operating potential for said amplifier, a resistance in series with said source, an electron discharge device connected in shunt to said resistance, means to make said device conductive on one half cycle of said signal, thereby to increase current through said amplifier, a second electron discharge device connected in circuit with said source to reduce the potential applied from said source to said amplifier, and means to make said second device conductive on the other half cycle of said signal, thereby to decrease current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

6. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a source of unidirectional operating potential for said amplifier, an impedance in series with said source, means for by-passing said wave around said source and said impedance, means for reducing the magnitude of said impedance from a constant value in correspondence to increasing intensities of one half cycle of said signal, thereby to increase the current through said amplifier, and means for reducing the potential applied from said source to said amplifier from a constant value in correspondence to increasing intensities of the other half cycle of said signal, thereby to reduce the current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

tional operating potential for said amplifier, a pair of resistances in series with said source, an electron discharge device connected in shunt to the first of said resistances, means to make said device conductive on one half cycle of said signal, thereby to increase current through said amplifier, a second electron discharge device connected in shunt to said source and the second of said resistances, means to make said second device conductive on the other half cycle of said signal, thereby to decrease current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

7. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a capacitance in circuit with said amplifier for by-passing said wave from said power supply, and means in shunt to said capacitance for maintaining operating voltage for said amplifier across said capacitance, said means comprising a source of unidirectional operating potential for said amplifier, an impedance in series with said source, means for reducing the magnitude of said impedance from a constant value in correspondence to increasing intensities of one half cycle of said signal, thereby to increase current through said amplifier, a second impedance in circuit with said source to reduce the potential applied from said source to said amplifier, and means for reducing the magnitude of said second impedance from a constant value in correspondence to increasing intensities of the other half cycle of said signal, thereby to decrease current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

8. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a capacitance in circuit with said amplifier for by-passing said wave from said power supply, and means in shunt to said capacitance for maintaining operating voltage for said amplifier across said capacitance, said means comprising a source of unidirectional operating potential for said amplifier, an impedance in series with said source, an electron discharge device connected in shunt to said impedance, means to make said device conductive on one half cycle of said signal, thereby to increase current through said amplifier, a second electron discharge device connected to said source to reduce the potential applied from said source to said amplifier, and means to make said second device conductive on the other half cycle of said signal, thereby to decrease current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

9. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a capacitance in circuit with said amplifier for by-passing said wave from said power supply, and means in shunt to said capacitance for maintaining operating voltage for said amplifier across said condenser, said means comprising a source of unidirectional op-

erating potential for said amplifier, a condenser, means connecting said condenser in conductive charging relation with said source thereby to maintain the average potential on said condenser at the potential of said source, means connected across said capacitance for reducing the voltage thereacross on one half cycle of said signal, thereby to decrease the current through said amplifier, and means for effectively connecting said condenser and said source in series across said capacitance on the other half cycle of said signal, thereby to increase the current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

10. In a power supply for an amplifier through which a high frequency wave is transmitted to be modulated by a signal, a source of unidirectional operating potential for said amplifier, a condenser, means for connecting said source and said condenser in conductive charging relation with each other to maintain said condenser charged to the average potential of said source, means connected in circuit with said source for reducing the potential applied from said source to said amplifier on one half cycle of said signal, thereby to reduce the current through said amplifier, and means for connecting said source and said condenser effectively in series to said amplifier on the other half cycle of said signal, thereby to increase the current through said amplifier, whereby said wave is modulated according to the varying intensities of said signal.

11. In combination, an electron discharge amplifier for amplifying a carrier wave, said amplifier having an anode and a cathode, a source of variable operating potential connected between said anode and cathode through an impedance, means for by-passing said carrier wave around said source and said impedance, a source of signal current, means responsive to one half cycle of said signal current to shunt said impedance thereby to increase the operating potential applied between said anode and cathode, and means responsive to the opposite half cycle to shunt said source and impedance in series thereby to reduce the operating potential applied between said anode and cathode.

12. The combination with an amplifier having an anode and a cathode and adapted to amplify a carrier wave in an amount determined by operating voltage applied between said anode and cathode, of means for impressing operating potential between said anode and cathode, said means including substantial impedance, a signal source, means for reducing said impedance on one half cycle of said signal so that the operating potential on said anode is increased, and means in shunt to said first means whose impedance is reduced on the other half cycle of said signal so that the operating potential between said anode and cathode is reduced, whereby said carrier wave is modulated in response to said signal.

ROBERT B. DOME.

CERTIFICATE OF CORRECTION.

Patent No. 2,235,549.

March 18, 1941.

ROBERT B. DOME.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 39, for the word "valve" read --wave--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of April, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.