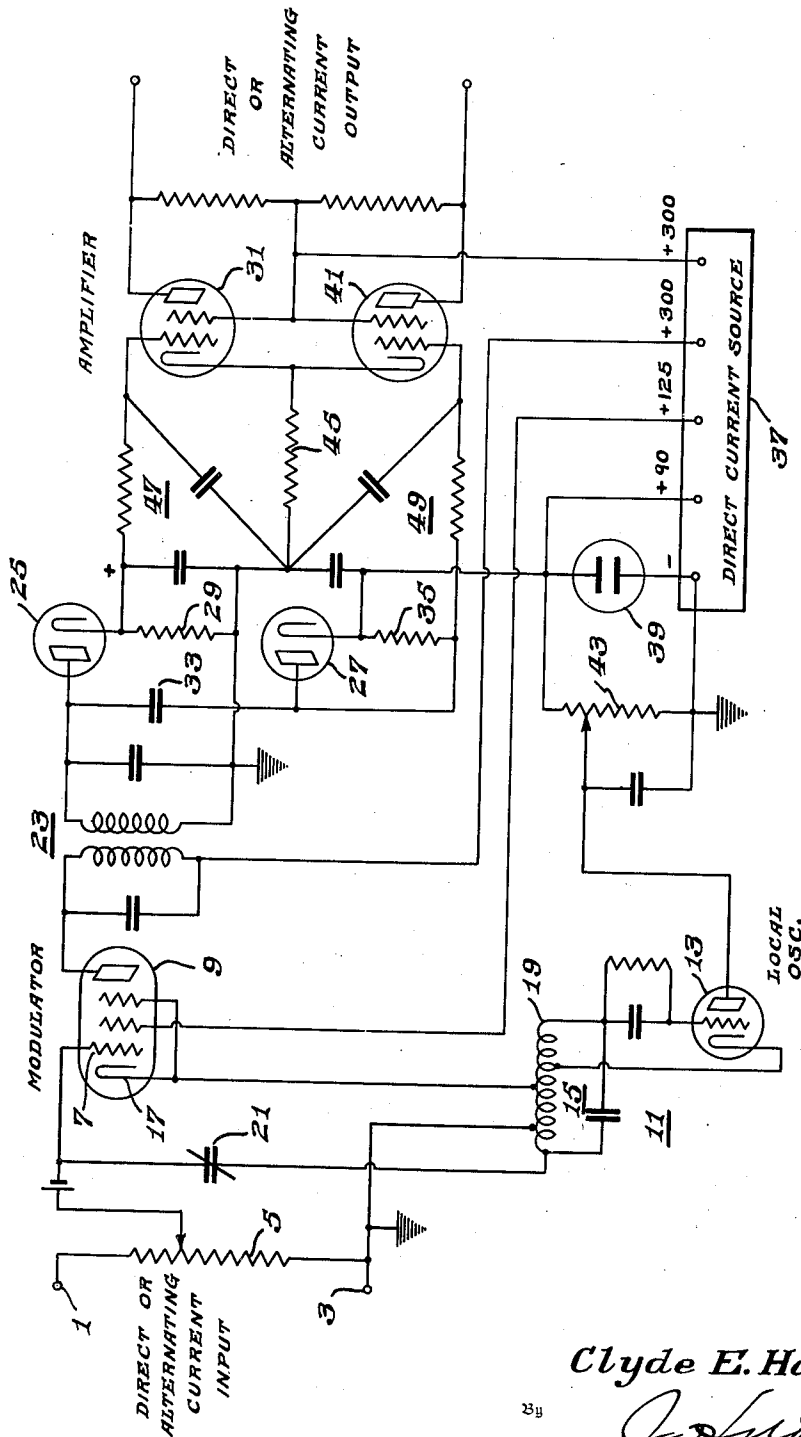


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C. E. HALLMARK
THERMIONIC AMPLIFIER
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Inventor
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Fig. 1

[Signature]

Attorney

UNITED STATES PATENT OFFICE

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THERMIONIC AMPLIFIER

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7 Claims. (Cl. 179-171)

This invention relates to thermionic amplifiers and more particularly to a device adapted to amplify currents having a wide range of frequency down to and including zero cycles per second.

I am aware of the existence of thermionic amplifiers which are adapted to amplify low frequency and direct current impulses. Such devices usually include a plurality of direct-coupled tubes. Since the grid of one tube necessarily has the direct current potential of the anode of the preceding tube, separate batteries for each tube are usually used. If the batteries are to be serially connected, or if a rectifier and filter system is to be used, the cathode of each successive tube must be connected to a more positive potential in order to maintain the proper grid bias. As a result the overall voltage required becomes very large.

This difficulty is overcome in accordance with the present invention by converting the signal which is to be amplified into a modulated radio frequency signal, amplifying the radio frequency signal as much as is desired, and demodulating to obtain the original signal frequency greatly amplified. In accordance with this invention a system is provided for obtaining from the rectifier an output voltage suitable for driving the grids of a pair of push-pull, direct-coupled output tubes which may be voltage or current amplifiers.

Among the objects of this invention are the provision of an improved method for amplifying currents having a wide range of frequency, down to and including zero cycles per second, the provision of an improved method of driving a pair of direct-coupled push-pull amplifiers; and the provision of means for carrying out the above objects.

This invention will be better understood from the following description considered in connection with the accompanying drawing and its scope is indicated by the appended claims.

The drawing is a schematic diagram of one embodiment of this invention.

A pair of input terminals 1 and 3 are provided to which the current impulse to be amplified may be applied. An attenuator, which may consist of a potentiometer 5, is connected across the input terminals 1 and 3. The variable arm of the potentiometer is connected to the control grid 7 of a multi-electrode modulator tube 9.

A local oscillator 11 is provided for the generation of radio frequency carrier currents. This oscillator consists of a thermionic triode 13 which is connected to a tank circuit 15 in the usual

manner. The cathode 17 of the modulator tube 9 is connected to a suitable point between the terminals of the tank circuit inductor 19. Input terminal 3 is connected to a point on inductor 19, and grounded. The terminal of inductor 19 which is near the ground connection, above referred to, is coupled by means of a capacitor 21 to the control grid 7.

It is to be noted that low frequency currents which are impressed on the input terminals are effectively connected between the grid 7 and the cathode 17 of the modulator tube, since the impedance of that portion of inductor 19 which is between the cathode and ground is negligible throughout the useful frequency range of the amplifier.

The purpose of capacitor 21 is to provide a neutralizing voltage for opposing the radio frequency voltage which is induced on grid 7 by the inherent capacity of the grid to the cathode 17, since the cathode 17 is not at ground potential with respect to the radio frequency currents. This neutralizing voltage is equal in amplitude and opposite in phase to the voltage induced on the grid from the cathode. Modulation of the radio frequency currents which are impressed on the modulator 9 is effected by varying the grid-cathode potential by means of the input voltage.

The modulated carrier current present in the plate of the modulator tube 9 has a greatly increased amplitude due to the amplification of this tube. The output is coupled by means of a resonant transformer 23 to a pair of diode rectifiers 25 and 27. Transformer 23 may be an intermediate frequency transformer of the type used in superheterodyne receivers, or the like, depending upon the frequency range desired in the amplifier.

The rectifying action of diode 25 produces a unipotential voltage across the diode load resistor 29 whose amplitude is substantially equal to the peak amplitude of the applied voltage. The plate side of the resistor 29 is grounded so that a potential which is positive with respect to ground appears across the resistor and is impressed on the grid of an output amplified tube 31.

The diode 27 is energized by an identical radio frequency voltage but is isolated with respect to direct current voltages by the coupling capacitor 33. Similarly, a unipotential voltage is developed across diode load resistor 35. In this case, however, the cathode side of the resistor is connected to a source of fixed positive potential. In the instant case, the fixed potential is obtained from a direct current source 37 and, for con-

venience, has a value of 90 volts. This value is conveniently maintained by a gaseous discharge regulator tube 39.

The plate end of the cathode resistor 35 is connected to the control grid of a second output amplifier tube 41. Consequently, the direct current potential, with respect to ground, present on the control grid of amplifier tube 41, is determined by the difference between the fixed positive potential of 90 volts and the voltage developed across resistor 35 by the rectifying action of diode 27. Returning to a consideration of the local oscillator 11, it is seen that the intensity of oscillation is controlled by a potentiometer 43 which is connected between a source of fixed potential and ground. The value of the voltage applied to the local oscillator is selected at that value which will cause a carrier voltage to be impressed on the rectifiers 25 and 27 whose peak value is in the order of 45 volts in the absence of a modulating input signal.

In the absence of an input modulating voltage, and after the adjustment mentioned above has been made, a positive direct current potential of approximately 45 volts will be impressed on the grid of amplifier tube 31. The grid potential of amplifier tube 41 will be equal to 90 volts minus 45 volts, or a positive direct current potential of 45 volts. In such a case, a source of biasing voltage must be provided. This is accomplished by means of a resistor 45 which is connected between the cathodes of amplifier tubes 31 and 41, and ground. The value of this resistor is chosen so as to develop 60 volts. Consequently, in the absence of an input modulating voltage, the steady state grid bias on the amplifier tubes 31 and 41 is substantially minus 15 volts, which is a suitable bias for the particular tubes used.

It is to be noted that there is a direct current path between the input terminal and the grid 7 of modulator tube 9. As a result, the voltage of grid 7 will be varied by the application of an input voltage having any frequency down to and including zero cycles per second. The input voltage thus changes the amplitude of the carrier frequency voltage which is applied to the rectifying tubes 25 and 27, and consequently changes the amplitude of the direct current potential which is developed across the respective diode load resistors 29 and 35. If the change causes the voltage across resistor 29 to become more positive, the voltage on the grid of amplifier 31 likewise becomes more positive, but the voltage on the grid of amplifier 41 becomes more negative since the difference potential increases negatively. Out of phase potentials are therefore applied to the two amplifier tubes thereby obtaining push-pull operation.

In addition to obtaining a push-pull voltage, an effective two-to-one voltage gain is realized by the system illustrated. A change in the amplitude of the radio frequency carrier which increases the potential of the grid of tube 31, with respect to ground, from 45 to 46 volts, at the same time reduces the voltage of the grid of tube 41 from 45 to 44 volts. Thus an effective change of 1 volt at the rectifier produces an effective change of 2 volts between the grids of the amplifiers which is the voltage doubling effect realized in addition to the amplification produced by the modulator tube 9.

Amplifier tubes 31 and 41 are coupled, respectively, to rectifiers 25 and 27 by means of resistive-capacitive networks 47 and 49 which serve to filter radio frequency currents from the input

to the amplifier tubes. In the circuit which I have illustrated it is to be noted that no low frequency bypass capacitors have been used. The present amplifier will amplify direct current impulses or audio frequency impulses up to a substantial frequency limited primarily by the band width of coupling transformer 23.

In the example illustrated, output tubes 31 and 41 are preferably beam power tetrodes, although other tubes are suitable. The particular application in mind was in connection with a cathode ray oscillograph, and the amplifier was utilized to provide horizontal or vertical deflecting voltages for the cathode ray beam. The particular cathode ray tube utilized was of the type having magnetic deflecting coils and consequently required high current amplifiers to operate the device. Other applications would require high voltage output and in such cases other output tubes would be more satisfactory.

While I have shown a preferred embodiment of this invention, it is to be understood that modifications may be made within the scope of this invention. Thus, a single rectifier tube may be used in place of rectifiers 25 and 27. In such an instance, two cathode load resistors would be utilized having their common point grounded. Likewise, additional stages of carrier frequency current amplification may be utilized.

I claim as my invention:

1. In a direct current amplifier, a local oscillator, an amplifier coupled to said oscillator, a pair of rectifiers coupled to the output of said amplifier, means including said rectifiers for obtaining unipotential voltages whose amplitudes vary in accordance with the amplitude of said local oscillations, a fixed biasing potential effectively connected in series with one of said unipotential voltages, said fixed potential having such a value that a difference voltage is developed which, for a given oscillation amplitude, is equal to the amplitude of the other of said unipotential voltages, and of like polarity with respect to ground, and means for varying the amplitude of said oscillations from said given value in accordance with a voltage which is to be measured, whereby an amplified output potential is developed between the other of said unipotential voltages and said difference voltage.

2. The method of amplifying an electrical impulse which includes the steps of generating local oscillations, modulating said oscillations in accordance with said impulse, amplifying said modulated oscillations, and demodulating said amplified oscillations, to obtain two unipotential voltages, combining one of said unipotential voltages with a fixed voltage to obtain a difference voltage whose amplitude is normally equal to that of the other of said unipotential voltages, and of like polarity, and obtaining an output voltage whose amplitude is proportional to changes from said normal condition due to changes in said voltage to be amplified.

3. In an amplifier responsive to a range of frequencies down to and including zero cycles per second, the combination which includes a local oscillator, a modulator, means for modulating the amplitude of said local oscillations in accordance with a signal, means for amplifying said modulated oscillations, a pair of rectifiers, means for impressing said amplified oscillations on said rectifiers, a load resistor connected to each of said rectifiers across which is developed a unipotential voltage whose amplitude varies in accordance with the amplitude of said local oscillations, a

fixed biasing potential effectively connected in series with one of said uni-potential voltages, said fixed potential having such a value and polarity that a difference voltage is developed which, for a given oscillation amplitude, is equal to the amplitude of the other of said oscillations cause said other uni-potential voltage and said difference potential to vary in like degree and opposite sense, a pair of thermionic output tubes having grid, cathode, and anode electrodes, said grid electrodes being connected respectively to said load resistors, a biasing source connected between said cathode electrodes and ground, and output terminals connected to said anode electrodes.

4. In an amplifier, the combination which includes a local oscillator, means for modulating said oscillator in accordance with an input voltage which is to be amplified to obtain a modulated carrier, means for amplifying said carrier, a pair of rectifiers coupled to said amplifying means, and means connected to said rectifiers for deriving two rectified voltages having normally equal amplitudes and polarities, with respect to ground, said rectified voltages changing in opposite directions in accordance with changes in the amplitude of said input voltage.

5. In an amplifier, the combination which includes a local oscillator, means for modulating said oscillator in accordance with an input voltage which is to be amplified to obtain a modulated carrier, means for amplifying said carrier,

and means connected to said amplifying means for deriving two rectified voltages having normally equal amplitudes and polarities, with respect to ground, said rectified voltages changing in opposite directions in accordance with changes in the amplitude of said input voltage.

6. In a device of the character described, the combination which includes a source of carrier frequency currents of normally constant amplitude, means connected to said source for deriving two rectified voltages of normally equal amplitudes and of the same polarity, their amplitudes changing in opposite directions upon the variation of said carrier frequency currents from said normal value, and means for varying the amplitude of said carrier frequency currents.

7. In a device of the character described, the combination which includes a source of carrier frequency currents of normally constant amplitude, a pair of rectifiers having input and output circuits, said input circuits being connected to said source, and said output circuits including means for developing output voltages of normally equal amplitude and polarity, but varying in opposite directions in accordance with variations of said carrier frequency currents from said normal amplitude, and a pair of output devices having their input circuits energized, respectively, by said output voltages.

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