

July 6, 1937.

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2,085,927

RECEIVING APPARATUS FOR COMMUNICATION SYSTEMS

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2 Sheets-Sheet 1

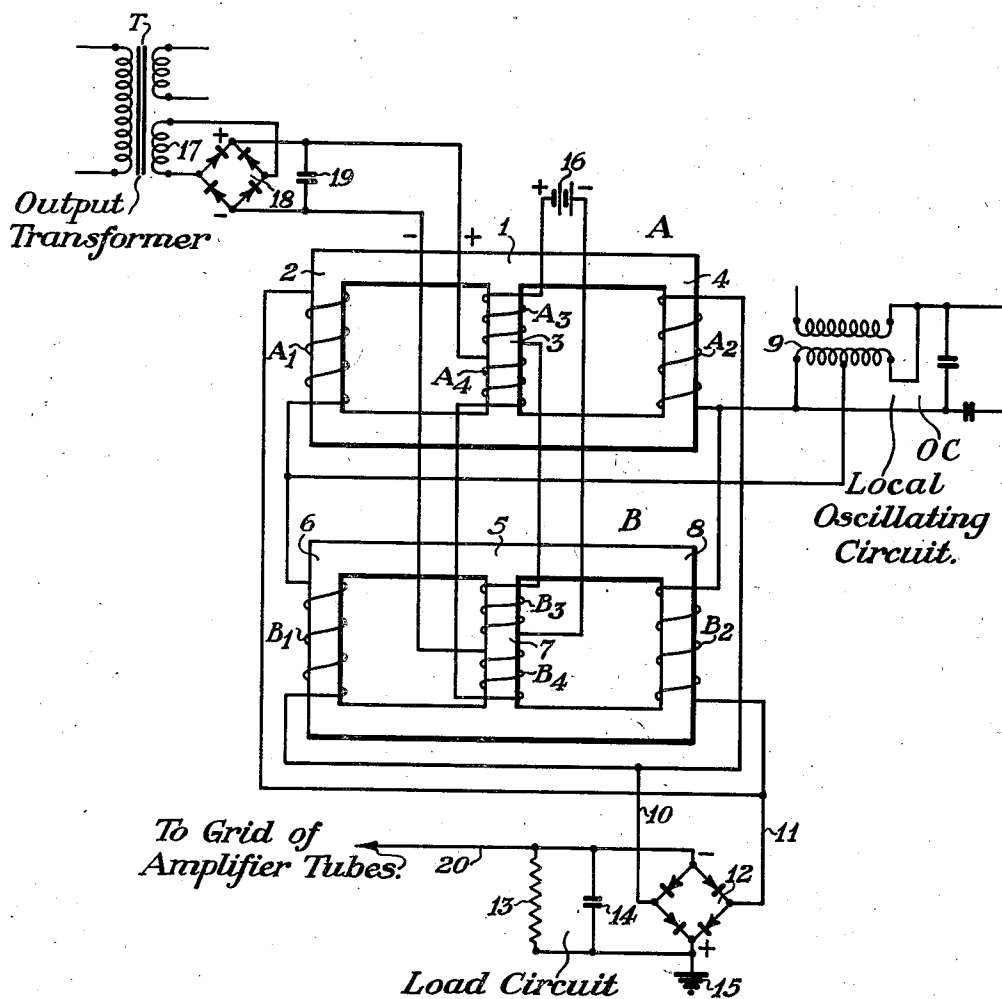


Fig. 1.

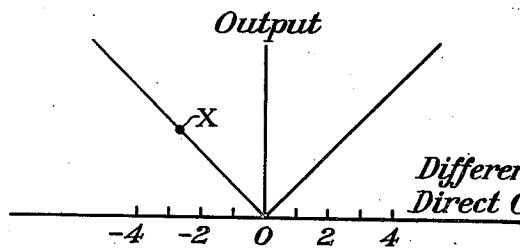


Fig. 3.

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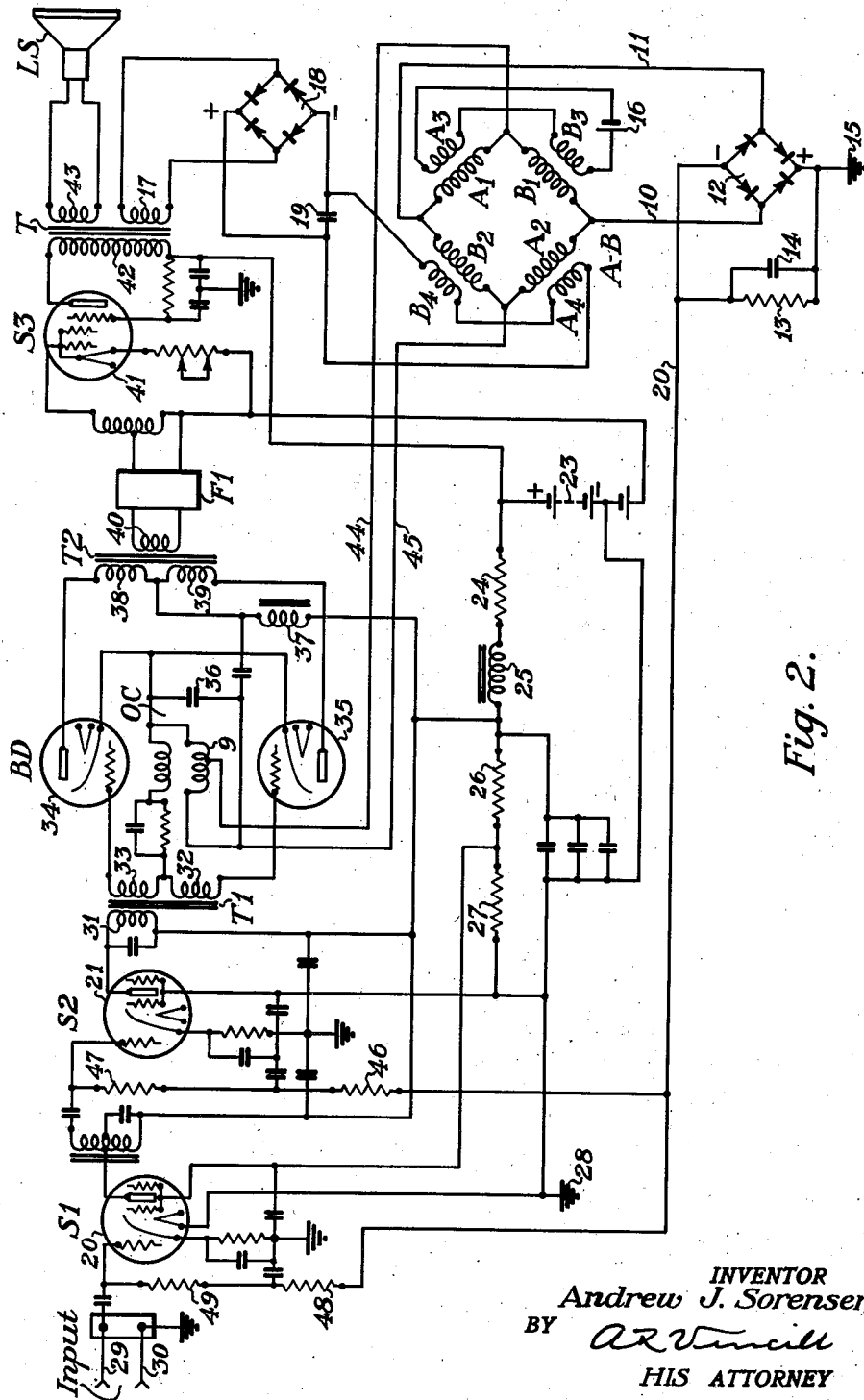
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,085,927

RECEIVING APPARATUS FOR COMMUNICATION SYSTEMS

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Application September 14, 1934, Serial No. 744,026

8 Claims. (Cl. 250—20)

My invention relates to receiving apparatus for communication systems, and has for an object the provision of apparatus which insures substantially maximum sensitivity for a receiving amplifier at the desired level of energy input, and by which apparatus a volume control is obtained for the amplifier at inputs below and above such desired level.

I will describe one form of apparatus embodying my invention, and will then point out the novel features thereof in claims.

For a better understanding of my invention, reference may be had to the accompanying drawings in which Fig. 1 is a diagrammatic view of one form of apparatus embodying my invention. Fig. 2 is a diagrammatic view illustrating a particular adaptation of the apparatus of Fig. 1 to the receiving apparatus of a railway train telephone system, and Fig. 3 is a diagram illustrating certain characteristics of the apparatus of Fig. 1.

In each of the several views like reference characters designate similar parts.

Referring first to Fig. 1, the reference characters A and B each designate a three-legged reactor which when taken together form a bridge type reactor such as disclosed and claimed in my Letters Patent of the United States No. 1,824,577, issued September 22, 1931, for Electrical translating apparatus. The reactor A comprises a magnetizable core 1, having two outer legs 2 and 4 provided with windings A₁ and A₂, respectively. The core 1 is also provided with a center leg or member 3 on which are wound two windings A₃ and A₄. The reactor B is similar to the reactor A and comprises a core 5 having two outer legs 6 and 8 on which are wound windings B₁ and B₂, respectively, and a center leg or member 7 having wound thereon two windings B₃ and B₄.

The windings A₁ and A₂ of reactor A and the windings B₁ and B₂ of reactor B are supplied with alternating current from any convenient source, here shown as an oscillating circuit OC such as, for example, the oscillating circuit ordinarily provided for the demodulator of receiving apparatus capable of amplifying and demodulating a carrier telephone current. In this instance, the alternating voltage is supplied from taps on the coil 9 of the oscillating circuit OC. It will be seen from Fig. 1 that a terminal of each of the windings A₂ and B₂ is connected with the left-hand terminal of the coil 9, and a tap terminal of coil 9 is connected with a terminal of each of the windings A₁ and B₁. The

opposite terminal of winding A₁ is connected with the second terminal of the winding B₂, and the opposite terminal of the winding A₂ is connected with the second terminal of winding B₁. It is clear, therefore, that these four windings A₁, A₂, B₁ and B₂ are connected in a closed circuit to form a bridge circuit of the well-known Wheatstone bridge type. The source of alternating current is connected across two opposite corners of the bridge circuit while the two remaining corners of the bridge circuit are connected by wires 10 and 11 with the input terminals of a full-wave rectifier 12, the output terminals of which are connected with a load circuit including a resistor 13 and a condenser 14. As here shown, the positive output terminal of the rectifier 12 is also connected with a ground electrode 15 and the negative output terminal of the rectifier is also connected with a wire 20 leading to the grids of amplifying tubes to be referred to later.

The alternating current flowing in the winding A₁ will create an alternating flux in the path including the legs 2 and 3 of the core 1, and the alternating current flowing in the winding A₂ will create an alternating flux in the path including the legs 4 and 3 of the core 1. The windings A₁ and A₂ are so disposed and connected that the two fluxes in the two paths just traced will oppose each other in the leg 3, so that the principal path for the alternating fluxes is through the outer legs and the outer magnetic circuit of the core. In a similar manner, the alternating fluxes created by the windings B₁ and B₂ are in opposition in the leg 7 of the core 5.

The windings A₃ and B₃ are serially connected with a battery 16 to provide a biasing direct current flux in each of the cores 1 and 5. The windings A₄ and B₄ are serially connected by an input circuit to a source of current, which is here shown as the secondary winding 17 of an output transformer T of receiving apparatus to be described later. A full-wave rectifier 18 is interposed in this input circuit for the windings A₄ and B₄, and hence the alternating current supplied from the secondary 17 will be rectified and such unidirectional current flowing in windings A₄ and B₄ will create a direct current flux in the cores 1 and 5. A condenser 19 may be connected across the output terminals of the rectifier 18 for removing the frequency ripples from the unidirectional current.

The windings A₄ and B₄ are so disposed and connected that the flux created by the unidirectional

tional current flowing therein aids the biasing flux in the core 1 of reactor A and opposes the biasing flux in the core 5 of reactor B. The biasing windings A₃ and B₃ and the input windings A₄ and B₄ are so proportioned that a desired permeability for each of the cores 1 and 5 is obtained in a manner to be shortly described.

As shown in Fig. 1, the cores 1 and 5 are symmetrical, and hence if the windings A₁ and A₂ and the windings B₁ and B₂ have the same number of turns, the alternating fluxes in each of the legs 3 and 7 are neutralized. Such symmetrical arrangement is not essential, for example, if the reluctance of the path including legs 2 and 3 of core 1 was greater than the reluctance of the path including legs 4 and 3, the alternating fluxes could still be made to equalize by constructing winding A₁ with a greater number of turns than winding A₂. Furthermore, if the biasing windings A₃ and B₃ and the input windings A₄ and B₄ are so proportioned and adjusted that the resultant direct current fluxes of the reactors are equal the bridge circuit is balanced and the current supplied to the load circuit through rectifier 12 is substantially zero. With the parts constructed in the manner just described, and the current supplied to the input windings A₄ and B₄ is varied, the direct current fluxes of reactors A and B will become unequal, since the windings A₃ and A₄ add their effects and the windings B₃ and B₄ oppose each other. Such changes in the flux densities of the reactors A and B will cause corresponding changes in the impedances of the windings A₁, A₂, B₁ and B₂, the amount of such increase and decrease in the impedances of the bridge windings will depend upon the variation in the current supplied to the input windings A₄ and B₄, since the biasing current remains substantially constant. The change in the impedances of the bridge windings will unbalance the bridge circuit with the result that current will be supplied to the load circuit through rectifier 12 and a charge built up on the condenser 14. It follows, therefore, that alternating current output of the transformer T is operative to unbalance the bridge circuit, whereby the condenser 14 is charged and a corresponding potential difference created between the ground electrode 15 and the wire 20, the ground electrode 15 being positive with respect to the wire 20.

In Fig. 3 is shown, in a qualitative way, the variations of the output of the bridge circuit with changes in the difference of the direct current fluxes created by the biasing and input windings. To fix the ideas, I shall assume the positive abscissas in Fig. 3 denote that the input current to the winding A₄ and the biasing current to the winding A₃ combine to produce a greater direct current flux in the core 1 than the corresponding currents in the windings B₄ and B₃ create in the core 5; the negative abscissas denote that the direct current flux in the core 5 is the larger; and at the origin the direct current fluxes of the two reactors A and B are equal, the bridge circuit is balanced and no output current is supplied to the load circuit. It follows that whenever the flux of one of the reactors A or B is greater than the flux of the other, the bridge circuit is unbalanced and a current flows to its output with the result that a charge is built up on the condenser 14 of the load circuit, the charge being of the same polarity irrespective of which reactor has the greater flux density. As stated hereinabove, the windings A₃

and A₄ are so disposed and connected that currents having polarities indicated by the plus and minus signs placed on Fig. 1, when supplied to these windings, create fluxes that are additive, but that the windings B₃ and B₄ are so disposed and connected that the fluxes created thereby are subtractive. It is to be seen, therefore, that if the biasing winding B₃ is provided with a larger number of turns than the biasing winding A₃, and no current is supplied to the windings B₄ and A₄, the direct current flux of the reactor B is greater than that of reactor A, and a current is supplied to the load circuit.

By way of illustration, I shall assume that the point marked x in Fig. 3 indicates the difference in the fluxes of the reactors A and B when the winding B₃ is made larger than the winding A₃. With such proportioning of the biasing windings and the input windings A₄ and B₄ made of equal number of turns, and a predetermined input current supplied to the windings A₄ and B₄, the difference between the fluxes created by the windings B₃ and B₄ will equal the sum of fluxes created by the windings A₃ and A₄. Hence, for such predetermined input current the flux density of the reactor B will be substantially equal to that of reactor A and no current will be supplied to the load circuit. That is to say, with winding B₃ made of a larger number of turns than the winding A₃ a charge is initially built up on the condenser 14 which charge will be reduced to zero at a predetermined input to the windings A₄ and B₄. Again, a larger current when supplied to the input windings A₄ and B₄ will cause the flux density of the reactor A to become greater than the flux density of the reactor B and current will again be supplied to the load circuit and reestablish the charge on the condenser 14.

In Fig. 2, the bridge reactor of Fig. 1 is applied for automatic volume control to receiving apparatus particularly adaptable to railway train telephonesystems. It has been proposed for telephoning between two spaced locations on a railway train such as, for example, the locomotive and the caboose of a freight train, to transmit a carrier current modulated with voice frequencies, the two traffic rails in multiple being included in the transmitting circuit. In such systems, it is usually necessary to interpose an electrical amplifier of relatively high gain between the receiving means and the telephone responsive device or loud speaker in order to obtain sufficient energy to reliably actuate a device of desired ruggedness. In such railway train telephone systems, the receiving apparatus at each location remains normally in circuit ready to receive a message at any time except when a message is to be transmitted from that location. This normal receiving condition of the apparatus results in amplification of minute random currents flowing in the traffic rails. Such amplification of random currents may produce a noise at the loud speaker which may be quite objectionable to the listener during non-communicating periods, and which may impair the effectiveness of the system during a telephone conversation. For materially reducing the effects of such unwanted influences and to provide uniform output of the receiving apparatus, I propose to employ the bridge reactor of Fig. 1 as an automatic volume control device.

Although I am here disclosing a particular receiving apparatus to which the apparatus embodying my invention is adaptable as an automatic volume control device, it will be understood that I do not limit myself to this one application,

and my invention is equally useful for receiving apparatus of other signaling systems.

In this instance, the receiving apparatus comprises two stages of high frequency amplification, a balanced demodulator, a filter and one stage of low frequency amplification, these devices being designated by the reference characters S1, S2, BD, F1 and S3, respectively.

Stages S1 and S2 each include an electron tube designated by the reference characters 20 and 21, respectively, and these tubes are preferably of the well-known screen grid heater type, although other types of tubes may be used if found desirable. Plate current is supplied to each of the tubes 20 and 21 from a source such as a battery 23, which source is here provided with a voltage control circuit including a resistor 24, reactor 25, and resistors 26 and 27, the negative terminal of the source being grounded at 28. It is clear from Fig. 2 that a carrier telephone current when supplied over wires 29 and 30 to the input of tube 20 will be amplified at each stage S1 and S2 and will be reproduced in the primary winding 31 of a coupling transformer T1 greatly increased in amplitude, and will be effective to induce electromotive forces of corresponding frequencies in the two secondary windings 32 and 33 of that transformer.

The demodulating stage BD includes two electron tubes 34 and 35 which are provided with the customary push-pull balanced plate and grid circuits, and which have associated therewith an oscillating circuit OC consisting of a coil 9 and a condenser 36. The arrangement is such that the frequencies induced in the secondary windings 32 and 33 of the transformer T1 will be mixed with the oscillations supplied by the circuit OC in the usual manner. The oscillations delivered by the circuit OC will preferably be, of course, of the same frequency as the carrier of the sending station, which carrier modulated with voice frequencies is being received over the wires 29 and 30. The plates of tubes 34 and 35 are connected with the battery 23 over a reactor 37, the primary winding 38 of a transformer T2 being interposed in the connection with the plate of tube 34 and the primary winding 39 of transformer T2 being interposed in the connection with the plate of tube 35. It is deemed sufficient for the present application to point out that the amplified frequencies are mixed with the local carrier for demodulation and the corresponding audio frequencies and other products of demodulation are produced in the primary windings 38 and 39, and in turn induce corresponding frequencies in the secondary winding 40 of the transformer T2.

The audio frequencies and other products of demodulation induced in the secondary winding 40 are applied to a filter network F1 which is so proportioned and adjusted as to pass the audio frequencies and to suppress the other products of demodulation.

The low frequency amplifying stage S3 includes an electron tube 41. The tube 41 is here shown as a pentode one control grid of which is connected with the output of the filter F1 and the plate of which is connected with the battery 23 over the primary winding 42 of the output transformer T. It follows that the audio frequencies passed by the filter F1 will be amplified by tube 41 and reproduced in the primary winding 42 of transformer T where they will induce electromotive forces of corresponding frequencies in the secondary windings 43 and 44 of that

transformer. The output of the secondary winding 43 is delivered to the operating winding of the loud speaker LS for reproducing the telephone message of the telephone current delivered over wires 29 and 30 to the first stage S1. The output of the secondary winding 44 is applied to the input windings A4 and B4 of the bridge reactor here designated by the reference character A—B, the current being rectified by the full wave rectifier 18 in the manner described for Fig. 1. In Fig. 2 the windings only of the bridge reactor A—B are shown for the sake of simplicity. It will be noted that the two opposite corners of the bridge circuit are connected by wires 44 and 45 with the oscillating circuit associated with the demodulating stage BD for supplying alternating current thereto. The remaining opposite corners of the bridge circuit are connected by wires 10 and 11 with the load circuit which includes the rectifier 12, resistor 13 and condenser 14 as described hereinabove. The negative terminal of the load circuit is in turn connected by wire 20 with the grids of the tubes 20 and 21 of the high frequency amplifying stages S1 and S2, resistors 46 and 47 being interposed in the connection with the grid of the tube 21, and resistors 48 and 49 being interposed in the connection with the grid of tube 20. The positive terminal of the load circuit is connected with the ground electrode 15 the same as in Fig. 1.

It is clear that a portion of the output of audio amplifying stage S3 will be supplied to the input windings A4 and B4 of the bridge reactor and will be operative through the reactor to govern the potential difference between the ground electrode 15 and the wire 20 in the manner described in connection with Fig. 1, this potential difference being utilized in turn to control the biasing grid voltage of the two high frequency amplifying tubes 20 and 21.

The biasing winding B3 of the bridge reactor of Fig. 2 will be provided with a larger number of turns than the biasing winding A3, whereby the bridge circuit will be unbalanced when no current flows in the input windings A4 and B4 and a predetermined difference of potential will exist between ground electrode 15 and wire 20 for establishing a normal biasing voltage for the grids of tubes 20 and 21. This proportioning between the biasing windings A3 and B3 with winding B3 of a larger number of turns will preferably be such that a carrier telephone current, having an input energy level just sufficient to give an audio response at the loudspeaker just great enough to make reception of the telephone message possible, will also supply current to the input windings A3 and B3 sufficient to substantially equalize the fluxes of the reactors and balance the bridge circuit and reduce the charge on condenser 14 substantially to zero. Under such adjustment of the biasing windings the amplifying tubes of stages S1 and S2 will be without volume control and will operate at maximum sensitivity at the energy level the incoming telephone current which is just sufficient to make reception possible. In other words, maximum amplification of the telephone current is obtained at the energy level the greatest amplification is needed. Noise currents passed to the amplifiers will ordinarily be of less input strength than the above-mentioned predetermined level of telephone current and hence the current flowing to the windings A4 and B4 in response to such noise currents will not balance the bridge and automatic volume control will be effective

for suppressing the noise. Exceptionally strong telephone current when passed to the amplifying apparatus will supply to the input windings A₄ and B₄ current of sufficient strength to unbalance the bridge to the right-hand side of the zero point as illustrated in Fig. 3 and consequently a corresponding volume control will be effected to keep the signal strength within bounds. A further advantage of the bridge reactor of Fig. 2 is that static noises when received alone are depressed in volume, due to the fact that such static conditions are ordinarily of sufficient strength that the bridge reactor will be unbalanced and an automatic volume control effected in the same manner as when an unusually strong signal is received.

Although I have herein shown and described only one form of apparatus embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, an electron tube amplifier, two magnetizable cores on which are mounted the four windings forming a bridge circuit supplied with alternating current, means including a winding on each of said cores for normally creating unequal permeabilities in said cores, means for rectifying a portion of the output of the electron tube and utilizing such unidirectional current to equalize the permeabilities of the two cores at a predetermined output volume of said tube and to again create unequal permeabilities in said cores when the output volume of the tube becomes greater than said predetermined volume, and other means for rectifying the output current resulting from an unbalanced condition of the bridge circuit and utilizing that unidirectional current to establish a grid bias voltage for the electron tube.

2. In combination, an electron tube amplifier, a first magnetizable core carrying two windings, a second magnetizable core carrying two windings, said four windings being connected in a closed circuit to form a Wheatstone bridge, a source of alternating current connected across opposite corners of said bridge, a full wave rectifier having its input terminals connected across the other two corners of the bridge, a load circuit including a condenser connected across the output terminals of said rectifier, circuit means coupled with the plate circuit of said tube and including a full wave rectifier and a winding having portions on each of said cores, said circuit means operative when supplied with current to produce opposite changes in the permeabilities of said cores for governing the supply of current to the load circuit to control the charge on said condenser, and other circuit means connected with said condenser and with the grid of said tube and operative to control the potential of the grid with respect to the cathode in response to the charge on said condenser.

3. In combination, an electron tube amplifier, two three-legged reactors each having a magnetizable core and each carrying a winding on its two outer legs, said four windings being connected in a closed circuit to form a Wheatstone bridge, a source of current connected across two opposite corners of said bridge, a load circuit connected across the other two corners of said bridge, circuit means including a rectifier and a winding on the center leg of each reactor coupled with

the plate circuit of said tube and operative when supplied with current to produce opposite changes in the permeabilities of said reactors whereby the bridge becomes unbalanced and a corresponding current supplied to the load circuit, and other circuit means connected with the grid of said tube and with said load circuit and operative to govern the potential of said grid with respect to the cathode of the tube.

4. In combination, an electron tube amplifier, two three-legged reactors each having a magnetizable core and each carrying a winding on its two outer legs, said four windings being connected in a closed circuit to form a Wheatstone bridge, a source of alternating current connected across two opposite corners of said bridge, a load circuit including a rectifier and a condenser connected across the other two corners of said bridge, circuit means including a rectifier and a winding on the center leg of each reactor coupled with the plate circuit of said tube, and operative when supplied with current to produce opposite changes in the permeabilities of said reactors whereby the bridge becomes unbalanced and a corresponding charge is built up on said condenser, and other circuit means connected with the grid of said tube and with said condenser and operative to govern the potential of said grid with respect to the cathode of the tube.

5. In combination, an electron tube amplifier, circuit means coupled with the plate circuit of said tube and including a rectifier for supplying unidirectional current in accordance with the output of the amplifier, two magnetizable cores each provided with two windings, said four windings being connected in a closed circuit to form a Wheatstone bridge, an input winding on each core and connected in series with said circuit means for oppositely changing the permeabilities of said cores in accordance with the unidirectional current supplied to the circuit means, a source of alternating current connected with two opposite corners of the bridge, and a load circuit including a rectifier connected with the other two corners of the bridge and with the grid of said tube and operative to govern the grid bias voltage in accordance with the current supplied to the load circuit.

6. In combination, an electron tube amplifier, circuit means coupled with the output of said amplifier and including a rectifier, a reactor including two magnetizable cores each provided with two windings, said four windings being connected in a closed circuit to form a Wheatstone bridge, a biasing circuit including a source of direct current and a winding on each core, said biasing windings being of unequal turns for establishing unequal initial permeabilities of said cores, an input winding on each core connected in series with said circuit means and operative to oppositely change the permeabilities of said cores in accordance with the current supplied to said circuit means, a source of alternating current connected with two opposite corners of the bridge, and a load circuit including a rectifier connected with the other two corners of the bridge and having connection with the grid of said electron tube for governing the grid bias voltage in accordance with the current supplied to the load circuit.

7. In combination, an amplifier including an electron tube, two magnetizable cores having unequal initial permeabilities, two windings on each core, said four windings being connected in a closed circuit to form a bridge, a source of alter-

5 nating current connected with two opposite corners of the bridge, a load circuit including a rectifier connected with the other two corners of the bridge, an input winding on each core and operative when supplied with current to oppositely
10 change the permeabilities of said cores, circuit means coupled with the output of the amplifier and including a rectifier for serially supplying direct current to said input windings to govern the current flow of the load circuit, and other circuit
15 means connected with the grid of said electron tube and with said load circuit for governing the grid bias voltage in accordance with the current supplied to the load circuit.

20 8. In combination with modulated carrier current receiving apparatus comprising two high frequency amplifying stages, a demodulating stage and a low frequency amplifying stage; four windings connected in a closed circuit to form a bridge, a source of alternating current connected

across two opposite corners of the bridge, a load circuit including a rectifier connected across the other two corners of the bridge, two input windings one associated with each of two windings of the bridge, said input windings when supplied with direct current operative to oppositely
5 change the impedance of the respective bridge windings for governing the balance of said bridge, circuit means for serially connecting said input windings with the output of the low frequency
10 amplifying stage and including a rectifier whereby the balance of the bridge and the current supplied to the load circuit are governed in accordance with the output of the receiving apparatus, and other circuit means connecting the load circuit with the input of each high frequency
15 amplifying stage for governing the sensitivity of said stages in accordance with the current flow in the load circuit.

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