

July 10, 1934.

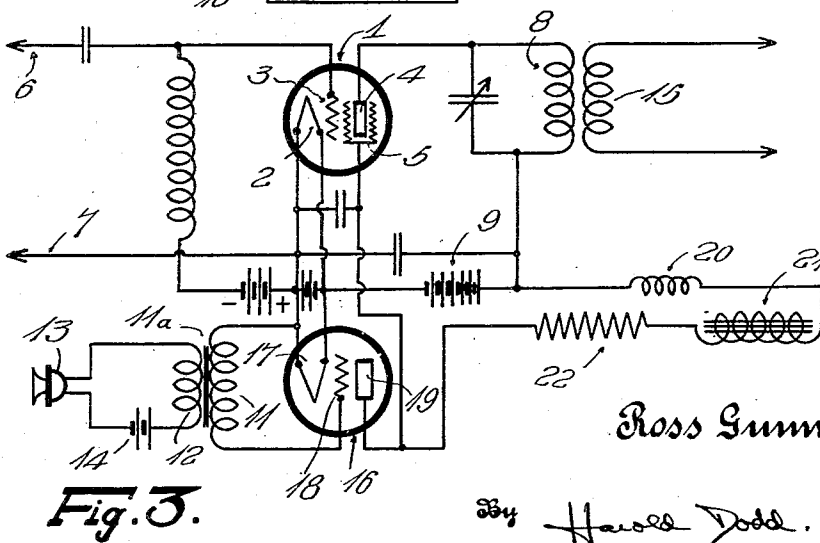
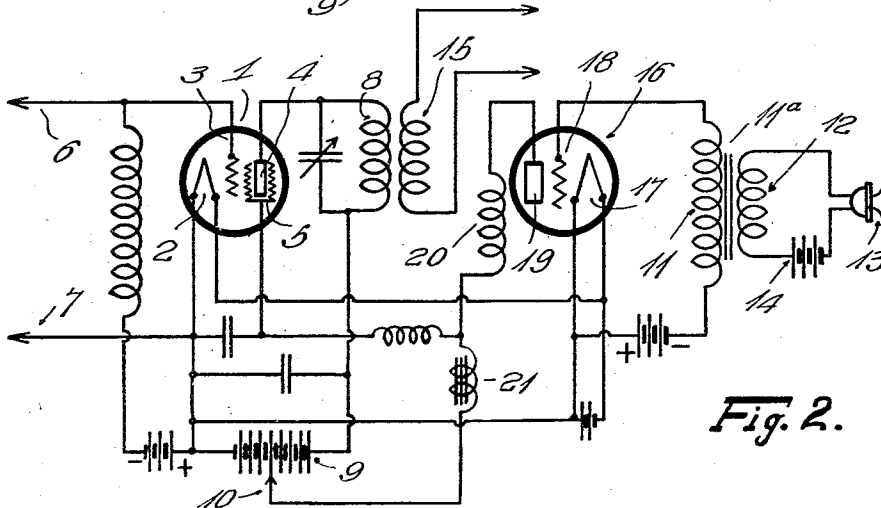
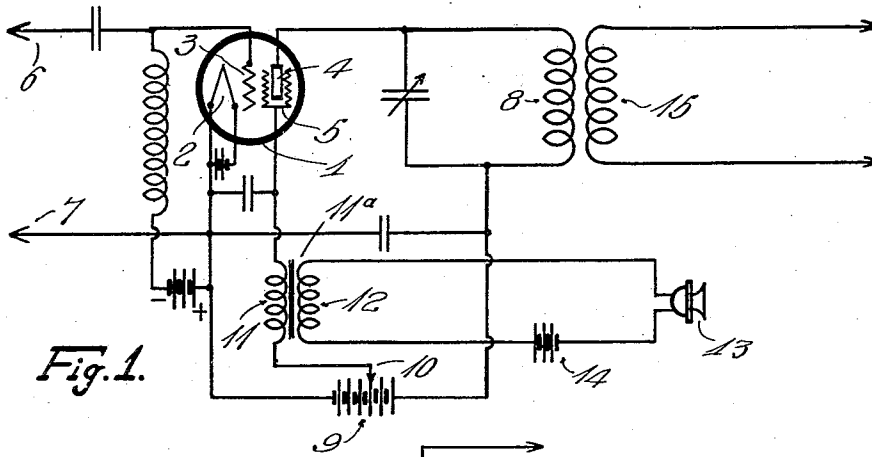
R. GUNN

1,966,065

MODULATION SYSTEM

Filed Jan. 5, 1929

2 Sheets-Sheet 1



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MODULATION SYSTEM

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2 Sheets-Sheet 2

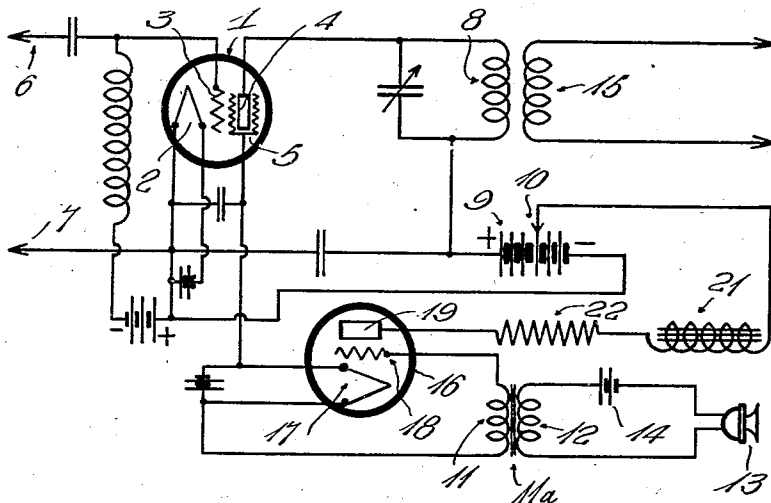


Fig. 4.

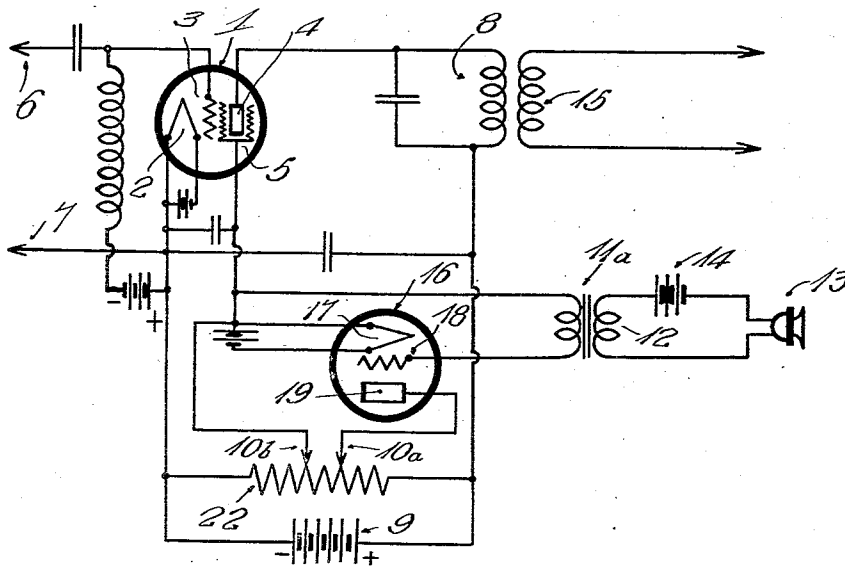


Fig. 5.

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UNITED STATES PATENT OFFICE

1,966,065

MODULATION SYSTEM

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Application January 5, 1929, Serial No. 330,579

20 Claims. (Cl. 179-171)

My invention relates, broadly to systems of modulating electron tube circuits and more particularly to a modulation system for electron tubes of the shield grid type.

5 One of the objects of my invention is to provide a circuit arrangement for shield grid tubes by which the shield potential may be variably controlled for modulating the output of the tube system.

10 Another object of my invention is to provide a circuit arrangement for a shield grid system where the potential of the shield grid may be variably controlled through a coupled system for effecting modulation of the output of the tube system over the voice frequency range.

15 Still another object of my invention is to provide a multiple electrode electron tube system having means for eliminating capacity coupling between the electrodes and circuits associated with the capacity eliminating means for effecting modulation in the tube system.

20 A further object of my invention is to provide a shield grid electron tube modulation system wherein the resistances of the tube system may be variably controlled according to voice frequencies by variably controlling the potential of the shield grid.

25 A still further object of my invention is to provide a shield grid type of modulator tube wherein a variable resistance is introduced in series between a high potential source and the shield grid, and the effective value of the resistance changed in accordance with variation in voice frequencies for correspondingly controlling the functioning of the associated electrodes and circuits of the tube system.

30 Other and further objects of my invention are to provide circuit arrangements as described in the specification hereinafter following and set forth in the accompanying drawings in which:

35 Figure 1 diagrammatically shows the principle of my invention; Fig. 2 shows one of the practical forms of the circuit arrangement of my invention; Fig. 3 shows one of the circuits I employ for controlling the potential of the shield grid; Fig. 4 illustrates diagrammatically one form of variable resistance method for controlling the shield grid potential; and Fig. 5 shows a potentiometer circuit arrangement for a shield grid tube where-
40 in the shield grid potential may be controlled by resistance changes effected by variations in voice frequency.

45 I have found that extremely accurate modulation over the range of voice and music frequencies may be secured by use of electron tubes of the

shield grid type. The shield potential and not the plate potential determines the instantaneous output of the tube when other adjustments are correct. My invention is directed to systems for modulating the power output of a shield grid tube by superimposing on the direct current potential applied to the shield a potential which varies with the voice frequencies. Since the shield current is ordinarily very small, certain methods may be used that would be impractical for the ordinary tubes.

50 In circuits for the transmission of radio telephone signals or interrupted continuous waves, it is necessary to modulate the output of the oscillator and I have found that high quality modulation may be obtained when the capacity effects between electrodes of the tube system is eliminated by employing a shield potential modulated simultaneously with the modulation of grid potential in the tube system. By modulating the amplifier circuit in a high frequency transmitting system, the complete output energy of the system may be controlled in accordance with the modulating frequency. The shield grid type of tubes affords many advantages over other types and may be employed as power amplifiers to advantage. The modulating system of my invention is employed in combination with a shield grid type of thermionic tube in an amplifier circuit arrangement whereby the output of the amplifier is controlled in accordance with the low or audiofrequency.

55 In high frequency transmitters in general it has been the practice to employ a modulating system in combination with a relatively low power high frequency generator. The modulated energy from the generator is then usually amplified by one or more amplifying tubes designed to deliver a great amount of energy to the load circuit such as a space radio radiating system. In the steps of amplifying the modulated high frequency energy from the modulator and relatively low power generator circuits, it is not infrequent that certain frequencies of the original source of modulation are destroyed. This is due to certain frequency characteristics of the coupling means and the design of the amplifier circuits. The frequencies thus destroyed are usually referred to as "cut off" frequencies and the characteristics of the circuits causing such action given the same name. The cut off frequencies may be either the high audio frequencies or the low audio frequencies and it is not infrequent that the frequencies intermediate between the low frequency cut off and the high
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frequency cut off are not all amplified in the proper proportion. The old system known as absorption modulation affords excellent control of the carrier energy but the system has not been employed in transmitting arrangements of large power. It is, for the above mentioned reasons, desirable to control the output energy in as nearly a direct manner as is possible. The modulating system of my invention avoids the foregoing disadvantages as will appear from the specification following.

Figures 1, 2, 3, 4 and 5 show different modifications of the modulating system of my invention represented by schematic circuit diagrams. Thermionic tube 1 is of the shield grid electrode type where the shield grid 5 controls to a large extent the internal resistance between the cathode 2 and the anode 4. Control electrode 3 is associated with a source of high frequency energy by means of connecting wire 6. The cathode circuit is likewise associated with the same source by means of connecting wire 7. The high frequency energy impressed upon control electrode 3 controls the internal resistance of thermionic tube 1, in a manner well known to those skilled in the art, and the high frequency energy in the output circuit associated with anode 5 is of increased value. Source of electrical energy 9 is associated with anode 4 and adapted to supply the same with a potential of positive polarity with respect to cathode 2. The supply is herein associated with anode 4 by a series circuit. However, it is obvious that a parallel arrangement may be employed. Connector 10 is associated with source 9 to supply a potential of positive polarity to shielding grid 5 in respect to cathode 2. This potential is however of a lower order than that supplied anode 4 and may be derived from a source independent of source 9. Connected in series with the wire supplying the potential to shield grid 5, winding 11 of transformer 11a is provided which is electromagnetically associated with winding 12. Winding 12 is connected in series with source of electrical energy 14 and microphone 13. The current through winding 11 is of a relatively low order and may be easily controlled by the arrangement shown.

Microphone 13, by controlling the current in winding 11 in accordance with low or audio frequencies, controls the positive potential impressed upon shielding grid 5 and hence controls the electronic stream or bombardment of anode 4. The electronic stream is caused to vary with the frequency of the energy associated with control electrode 3 which variation is afterwards controlled by shielding electrode 5. Shielding electrode 5 exerts a great influence on the space charge near anode 4.

The arrangement shown in Fig. 1 is suitable to control the operation of relatively large thermionic tubes. Thermionic tube 1 is essentially a high frequency power amplifier tube and the source associated with the input circuit is generally referred to as the master oscillator. The limitations of modulation are governed by the design of tube 1 and the modulating circuit associated with shielding grid 5. Fig. 2 shows another schematic circuit arrangement adapted to control the output of a high frequency power amplifier of great power. By great power is meant power of the order of ten or twenty kilowatts. Like reference characters are employed in all of the drawings. In Fig. 2, transformer 11a is associated with the input circuit of ther-

mic tube 16. Thermionic tube 16 is of the triode type having a cathode 17, control electrode 18 and anode 19. Normal operating potential is supplied shield grid 5 in a manner somewhat similar to the arrangement shown in Fig. 1. The output circuit of thermionic tube 16 includes high frequency choke coil 20 connected in series with audio frequency choke coil 21. Choke coil 21 is, however, connected in series with the supply of potential to shielding grid 5.

Choke coil 21 limits the current supplied shielding grid 5 of thermionic tube 1 and likewise limits the current supplied anode 19 of thermionic tube 16. The total current through choke 21 must divide between shielding grid 5 and anode 19. The sum of the current in the output circuit of thermionic tube 16 and the current in the shielding grid circuit of thermionic tube 1 remains substantially constant. The potential impressed upon control electrode 18 of thermionic tube 16 varies in accordance with the low frequency or audio frequency energy in winding 11. This variation of potential causes a variation in the internal resistance of thermionic tube 16 and hence a variation of the current in the output circuit associated with anode 19. When the current in this output circuit increases, the current in the shielding grid circuit of thermionic tube 1 decreases. Conversely, when the current in the output circuit of thermionic tube 16 decreases, the current in the shielding grid circuit of thermionic tube 1 increases. Considering the relation between the normal current in the anode circuit of thermionic tube 1 and the current in the shielding grid circuit of thermionic tube 1, it is obvious that the proportionate ratings of tubes 1 and 16 may be widely different. Considering the current in the anode circuit of tube 16 as compared with the current in the shielding grid circuit of tube 1 and the necessary potential variation in the control electrode circuit of thermionic tube 16, the simplicity and efficiency of the entire modulating system is obvious. The output of a tremendously large power amplifier tube may be easily and efficiently controlled. The arrangement schematically represented in Fig. 3 of the accompanying drawings is somewhat similar to the arrangement shown in Fig. 2. In this arrangement choke coil 21 may or may not be used depending upon the operating characteristics of thermionic tubes 1 and 16.

Fig. 4 of the accompanying drawings shows a further modification of the modulating system of my invention. This circuit arrangement is somewhat similar to the arrangement shown in Figs. 2 and 3. In the arrangement shown in Fig. 4 a separate source of energizing potential for cathode 17 of thermionic tube 16 is employed. The resistance of thermionic tube 16 is connected in series with the supply of energizing potential to shielding grid 5. The only potential supplied shielding grid 5 must depend upon the resistance of thermionic tube 16. Shielding grid electrode 5 of thermionic tube 1 is connected to cathode 17 of thermionic tube 16. Anode 19 of thermionic tube 16 is connected to source 9 by connecting member 10 at a position in respect to cathode 2 to supply a positive polarity to shielding grid 5. When the resistance of thermionic tube 16 is relatively high in respect to the necessary potential to be supplied to shielding grid 5 and the high potential supplied to anode 4, it is possible to connect anode 19 of thermionic tube 16 directly with anode 4 of thermionic tube 1. The resistance of

thermionic tube 16 is controlled by the potential impressed upon control electrode 18 and the induced E. M. F. in winding 11.

Fig. 5 of the accompanying drawings is a schematic circuit diagram showing still another modification of my invention. In this arrangement shielding grid electrode 5 of thermionic tube 1 is normally maintained at some convenient positive potential with respect to cathode 2, by a voltage dividing or potentiometer arrangement, Resistance 22 is herein connected in parallel with source 9. A portion of resistance 22 is likewise connected in parallel with the internal resistance between cathode 17 and anode 19 of thermionic tube 16.

Anode 19 is associated with contact member 10a. Cathode 17 is associated with contact member 10b. The potential difference between these two contact members is directly proportional to the internal resistance of thermionic tube 16. Since the portion of the resistance between members 10a and 10b is in series with resistance 22 in its entirety, variations in resistance of tube 16 produce the equivalent action of moving members 10a and 10b to a position along resistance 22 whereby a higher potential is impressed upon shielding grid electrode 5.

Many modifications of my invention are possible. Resistance 22, shown in Fig. 5 of the accompanying drawings, may be connected in series with the potential supply circuit to shielding grid 5 and the anode-cathode circuit of thermionic tube 16 may be connected across this resistance. In all of the illustrations batteries are illustrated as sources of electrical energy, however, it is obvious that any convenient sources may be employed. The microphones connected to the microphone transformers may be replaced by photoelectric cells or any sources desired to modulate the energy in the power amplifier circuits. The transformers may be replaced by the conventional impedance-capacity or resistance capacity methods of coupling. I realize that many modifications of my invention are possible without departing from the spirit of my invention and it is to be understood that my invention shall not be restricted by the foregoing specification or by the accompanying drawings but only by the limitations imposed by the appended claims.

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

1. A modulating system comprising in combination an amplifier circuit arrangement adapted to be connected with a source of high frequency electrical energy, said amplifier circuit arrangement including a thermionic tube having a shielding grid electrode, a control grid, an anode and a cathode, a source of potential for energizing said anode and shielding grid at differing potentials an auxiliary thermionic tube having its internal resistance connected in parallel with the source of potential for energizing said shielding grid electrode and a source of modulating energy connected with the control electrode and cathode of said auxiliary tube.

2. A modulating system comprising in combination an amplifier circuit arrangement adapted to be connected with a source of high frequency electrical energy, said circuit arrangement including a thermionic tube having a shielding electrode interposed between the control electrode and anode, a source of potential for energizing said shielding electrode and said anode an auxiliary thermionic tube having its internal resistance

connected in parallel with the source of potential for energizing said first shielding electrode and a source of modulating energy connected with the control electrode and cathode of said auxiliary tube.

3. A modulating system comprising in combination a shielded grid thermionic tube amplifier circuit, means for defining the potential of said shielding grid, an auxiliary thermionic tube having input and output circuits, the internal resistance of said auxiliary tube being directly disposed in circuit with said means for defining the potential of said shielding grid and a source of modulating energy connected with the input of said auxiliary thermionic tube.

4. A modulating system comprising in combination a shielded grid thermionic tube amplifier circuit, means for energizing the shielding grid electrode an auxiliary thermionic tube having the internal resistance thereof disposed in circuit with said first mentioned means, and a source of modulating energy connected to control the operation of said auxiliary thermionic tube.

5. A modulating system comprising in combination a shielded grid thermionic tube amplifier circuit, a potential source connected with the shielding grid electrode of said thermionic tube circuit an auxiliary thermionic tube having the internal resistance thereof disposed in a path including said potential source, said auxiliary thermionic tube being controlled in accordance with a source of modulating energy connected with the control electrode thereof.

6. A modulating system comprising in combination a thermionic tube amplifier circuit arrangement including a thermionic tube having an auxiliary electrode interposed between the control electrode and the anode thereof a source of electrical energy for energizing said auxiliary electrode, an auxiliary thermionic tube having the control electrode and cathode thereof associated with a source of modulating energy and the anode and cathode thereof connected in common with said auxiliary electrode of said first mentioned thermionic tube amplifier circuit and said source of electrical energy which energizes said auxiliary electrode.

7. A modulating system comprising in combination a thermionic tube amplifier circuit arrangement including a thermionic tube having an auxiliary electrode interposed between the control electrode and the anode thereof a source of electrical energy for energizing said auxiliary electrode, an auxiliary thermionic tube having the control electrode and cathode thereof connected with a source of modulating energy and the anode and cathode thereof connected in a circuit common with the auxiliary electrode of said first mentioned thermionic tube amplifier arrangement, an audio frequency choke coil in said common circuit and connections from said choke coil to said source of electrical energy.

8. In an amplifying circuit arrangement a thermionic tube having a shielding grid electrode, a thermionic tube having a cathode, anode and control electrode, the cathode and control electrode thereof being connected with a source of modulating energy and the anode and cathode thereof being connected with a common source of energy common to said shielding grid electrode of said first mentioned thermionic tube.

9. In an amplifying circuit arrangement a thermionic tube having a shielding grid electrode, an independent thermionic tube having a cathode, anode and control electrode, the cathode and con-

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- trol electrode being connected with a source of
 modulating energy and the anode and cathode
 being connected with a source of energy common
 to said shielding grid electrode whereby said
 shielding grid electrode is energized in inverse
 proportion to the energy supplied to said anode
 of said independent tube.
10. A modulation system comprising a power
 amplifier including an electron tube having a
 cathode and control grid comprising an input
 circuit, a plate electrode and a connection to the
 cathode comprising an output circuit, a shield
 grid electrode disposed between the plate and
 control grid, an auxiliary electron tube including
 a cathode, a grid and a plate, an input circuit
 extending between said grid and cathode of said
 auxiliary tube, modulation means for variably
 controlling said input circuit, an output circuit
 connected with the plate electrode of said auxil-
 iary electron tube, a source of potential con-
 nected in common to the output circuits of each
 of said tubes, an impedance circuit connected
 in series between said source of potential and the
 plate electrode of said auxiliary tube and a con-
 nection between the shield grid of said first men-
 tioned electron tube and a point in the output
 circuit of said auxiliary electron tube for varying
 the potential of said shield grid according to the
 modulated control of the input circuit of said
 auxiliary electron tube.
11. A modulation system comprising a power
 amplifier including an electron tube having a
 cathode and control grid comprising an input cir-
 cuit, a plate electrode and a connection to the
 cathode comprising an output circuit, a shield
 grid electrode disposed between the plate and
 control grid, an auxiliary electron tube including
 a cathode, a grid and a plate, an input circuit
 extending between said grid and cathode of said
 auxiliary tube, modulation means for variably
 controlling said input circuit, an output circuit
 connected with the plate electrode of said auxil-
 iary electron tube, a source of potential con-
 nected in common to the output circuits of each
 of said tubes, impedance elements including a
 choke coil and a current limiting device disposed
 in series between said source of potential and the
 plate electrode in the output circuit of said auxil-
 iary tube, said choke coil operating to exclude
 currents of frequencies existent in the circuits
 of said first mentioned electron tube from the
 circuits of said auxiliary electron tube, and said
 current limiting device operating to modify the
 potential impressed upon the plate electrode of
 said auxiliary tube as compared to the potential
 impressed upon the plate electrode of said first
 mentioned tube, and a connection between said
 shield grid and a point in the output circuit of
 said auxiliary electron tube adjacent the plate
 electrode thereof for variably controlling the po-
 tential on said shield grid in accordance with the
 operation of the modulation circuit connected
 with said auxiliary electron tube.
12. In transmitting apparatus, the combina-
 tion of a master oscillator, a thermionic repeater
 including a thermionic tube having cathode, an-
 ode, grid electrode and a charged element located
 between said anode and said grid electrode, an
 input circuit connected between said grid elec-
 trode and said cathode, a tank circuit connected
 between said anode and said cathode, means for
 impressing the oscillations from said master os-
 cillator on said input circuit, a thermionic tube
 having input and output circuits, means for im-
 pressing signals on said input elements, and
- means for connecting the output circuit of said
 last named tube to the element located between
 said grid electrode and anode of said first named
 tube.
13. A modulating system comprising in combi-
 nation an amplifier circuit arrangement adapt-
 ed to be connected with a source of high fre-
 quency electrical energy, said amplifier circuit
 arrangement including a thermionic tube having
 a shielding grid electrode, a control grid, an an-
 ode and a cathode, a source of potential for ap-
 plying positive potential to said shielding grid
 electrode, an auxiliary thermionic tube having
 its internal anode to cathode resistance con-
 nected in parallel with the source of potential
 for energizing said shielding grid electrode and
 a source of modulating energy connected with
 the control electrode and cathode of said auxil-
 iary tube.
14. In an amplifying circuit arrangement a
 thermionic tube having a shielding grid electrode,
 a thermionic tube having a cathode, anode and
 control electrode, the cathode and control elec-
 trode of said last named tube being connected
 with a source of modulating energy, a source of
 direct current potential having its positive termi-
 nal connected to the anode of said last named
 tube and its negative terminal connected to the
 cathode of said last named tube, and means
 for connecting the shielding grid to cathode im-
 pedance of said first named thermionic tube in
 parallel with the anode to cathode impedance of
 said last named thermionic tube.
15. A signal repeating and modulating circuit
 including a thermionic repeater having input and
 output electrodes and an auxiliary electrode, an
 input circuit adapted to be energized by alter-
 nating current potentials connected between said
 input electrodes, an output circuit adapted to
 repeat the potential variations in said input cir-
 cuit, and means for varying the character of the
 potential variations appearing in said output
 circuit comprising an auxiliary thermionic tube
 having a cathode, anode and control electrode,
 the cathode and control electrode thereof being
 connected with a source of modulating energy, a
 source of potential having its negative terminal
 connected with the cathodes of both of said tubes,
 and means for connecting the anode to cathode
 impedance of said last named tube in parallel
 with the auxiliary electrode to cathode impedance
 of said first named tube and with said source.
16. Signalling means comprising, a thermionic
 repeater tube having input electrodes and output
 electrodes and a screening grid electrode, said
 input electrodes being adapted to be energized by
 carrier frequency oscillations and said output
 electrodes being connected with a work circuit,
 and means for modulating the carrier frequency
 oscillations repeated in said tube comprising, a
 circuit for applying a positive direct current po-
 tential to said screening grid electrode to deter-
 mine in part the conductivity of said tube, and
 means for superimposing on said positive direct
 current potential oscillations, the potential of
 which varies at signal frequency comprising, a
 thermionic tube having its anode electrode con-
 nected to said screening grid electrode and its
 input electrodes connected with a source of signal
 potential.
17. Signal repeating and modulating means in-
 cluding, a thermionic repeater tube having input
 and output electrodes and an auxiliary electrode,
 an input circuit adapted to be energized by car-
 rier waves connected between said input elec-

trodes, an output circuit connected between said output electrodes, and means for varying the character of the carrier waves appearing in said output circuit comprising, an auxiliary thermionic tube having a cathode, anode and control electrode, the control electrode and cathode thereof being connected with a source of modulating energy, a source of potential having its negative terminal connected to the cathodes of both of said tubes, a choke coil connecting said source to the anode electrode of said auxiliary tube, and inductive means connecting the anode of said auxiliary tube to the auxiliary electrode in said thermionic repeater tube.

18. A signal repeating and modulating circuit including, a thermionic repeater tube having input and output electrodes and an auxiliary electrode, an input circuit adapted to be energized by carrier waves connected between said input electrodes, an output circuit connected between said output electrodes, and means for varying the character of the carrier waves appearing in said output circuit comprising, an auxiliary thermionic tube having a cathode, anode and control electrode, the cathode and control electrode being connected with a source of modulating energy, a source of potential having its negative terminal connected with the cathodes of both of said tubes, a circuit connecting the auxiliary electrode of said repeater tube to the anode of said auxiliary tube, and resistive and inductive means in series connecting the anode of said auxiliary tube to the positive terminal of said source of potential.

19. A signal repeating and modulating circuit including, a thermionic repeater tube having input and output electrodes and an auxiliary elec-

trode, an input circuit energized by carrier waves connected between said input electrodes, an output circuit connected between said output electrodes, and means for varying the character of the potential variations appearing in said output circuit comprising, an auxiliary thermionic tube having a cathode, anode and control electrode, a circuit connecting said auxiliary electrode in said repeater tube to the cathode in said auxiliary tube, a circuit connecting the anode of said auxiliary tube to the cathode of said repeater tube, said circuit including a source of potential in series with inductive and resistive elements, and a circuit for applying modulating potentials to the control electrode and cathode of said auxiliary tube.

20. A carrier wave repeating and modulating circuit including, a thermionic repeater tube having control grid, cathode and anode and an auxiliary electrode, an input circuit which may be energized by carrier waves connected between said control grid and cathode, an output circuit connected between said anode and cathode, and means for varying the character of the waves appearing in said output circuit at signal frequency comprising, a second thermionic tube having a cathode, anode and control electrode, a circuit connecting said auxiliary electrode in said repeater tube to the cathode in said second tube, a circuit connecting the anode of said second tube to the cathode of said repeater tube, one of said circuits including a source of potential in series with an impedance element, and a circuit for applying modulating potentials to the control electrode and cathode of said second tube.

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