

Sept. 15, 1931.

C. A. CULVER

1,822,922

AMPLIFYING SYSTEM

Filed Aug. 3, 1928

2 Sheets-Sheet 1

FIG. 1

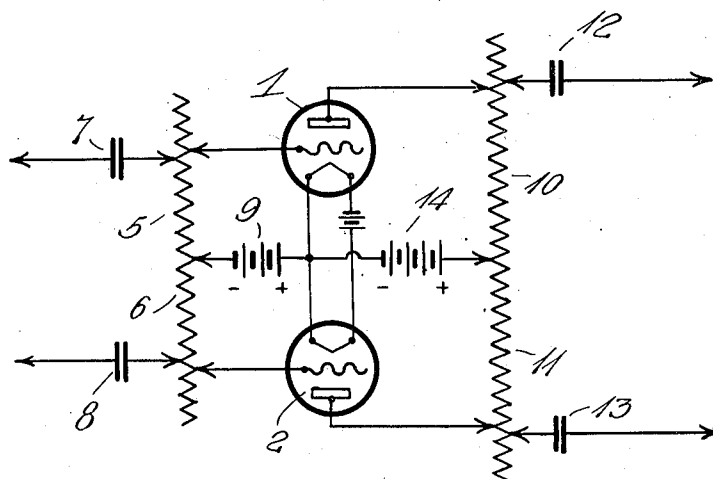
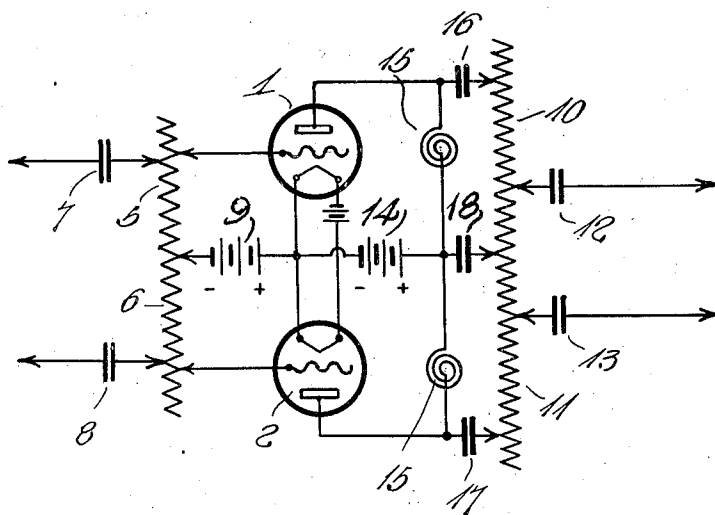


FIG. 2



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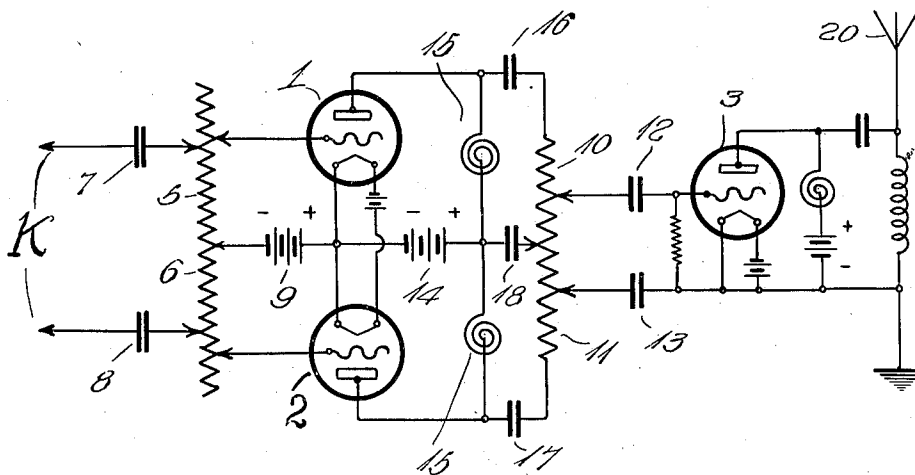
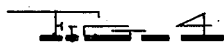
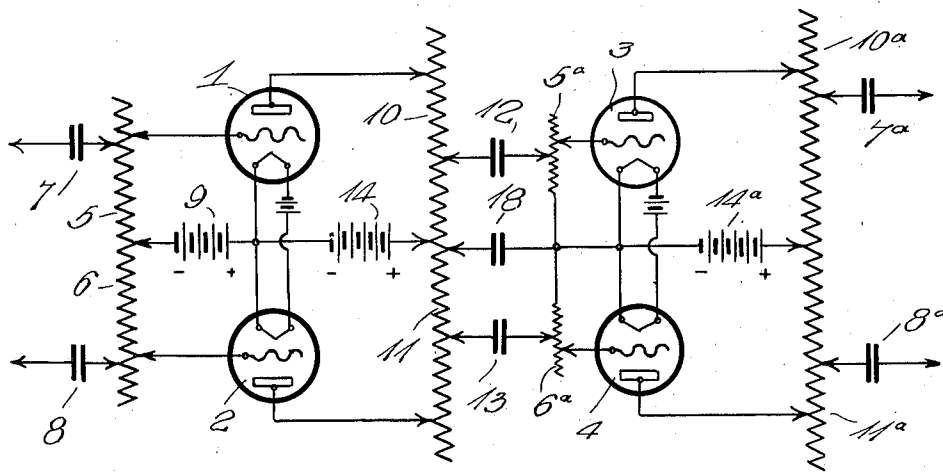
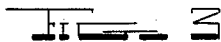
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2 Sheets-Sheet 2



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## UNITED STATES PATENT OFFICE

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## AMPLIFYING SYSTEM

Application filed August 3, 1928. Serial No. 297,199.

My invention relates to amplifying systems in general and more specifically to amplifying systems employing thermionic tubes.

An object of my invention is to provide an amplifying system wherein distortion is prevented.

Another object of my invention is to provide an amplifying system wherein thermionic tubes are employed in an electrically balanced circuit arrangement.

Still another object of my invention is to provide an amplifying system wherein a plurality of balanced circuit arrangements employing thermionic tubes may be employed in combination without resulting in distorted signal energy.

A further object of my invention is to provide an amplifying system employing thermionic tubes whereby interoscillation between tubes is prevented.

A better understanding can be had of the amplifying system of my invention by referring to the specification to follow and to the accompanying drawings in which:

Figure 1 is a schematic circuit diagram showing the amplifying system of my invention; Fig. 2 is a schematic circuit diagram showing another form of the amplifying system of my invention; Fig. 3 is a schematic circuit diagram showing the amplification system of my invention applied to a plurality of thermionic tubes and Fig. 4 is a schematic circuit diagram showing the amplifying system of my invention associated with a space radio radiating system.

By employing thermionic tubes in a balanced circuit arrangement an efficient amplifier having a minimum of distortion is possible. There are disadvantages to the balanced circuit arrangements heretofore employed. With the systems heretofore employed the inductance and capacities, employed for intercoupling successive amplifier circuits, usually cause local oscillation to take place between the respective thermionic tubes resulting in modulation of the amplified signal which modulation is commonly referred to as distortion. Distortion can be caused in a number of ways and many times is disastrous to true transmission and reception of

the desired signal which is modulation of the carrier energy by a source of energy having frequency values of a lower order than the carrier of high frequency signaling energy. In broadcasting systems, wherein modulation is desired at voice or audio frequencies, it frequently occurs that distortion results from amplifying either the radio or audio frequency source of energy. Distortion is here and afterwards referred to as undesired modulation of the carrier frequency energy, as distinguished from desired distortion or modulation. This distortion in amplifying audio or radio frequency energy at the transmitting station usually is caused by employing inductance and capacity in some form or combination for inter-coupling successive amplifier circuits. It is well known that circuit arrangements employing inductance and capacity are periodic. Circuits that have aperiodic frequency characteristics should employ no combination of inductance and capacity. Non-uniform amplification of signaling energy of a wide band of frequencies is usually caused by employing periodic circuits or modifications thereof. As heretofore mentioned, the combination of inductance and capacity in thermionic tube circuits frequently causes distortion due to intercoupling of the circuits through the capacity of the thermionic tubes resulting in the generation of local oscillations. Such oscillations produce resultant frequencies which are to be avoided when amplification of a particular frequency is desired. With the amplifying system of my invention the foregoing disadvantages are overcome.

In the accompanying drawings, Fig. 1 is a schematic circuit arrangement of the amplifying system of my invention. Thermionic tubes 1 and 2 having cathode, control electrode, and anode circuits are connected in an electrically balanced arrangement. Energy to be amplified is transferred to capacities 7 and 8. The potential is distributed to the control electrode circuits of thermionic tubes 1 and 2. Resistors 5 and 6 are non-inductive and non-capacitive and therefore are aperiodic. Source of potential 9 supplies the proper operational potential for the control

electrodes of thermionic tubes 1 and 2. The output circuit of thermionic tubes 1 and 2 includes resistors 10 and 11 and source of potential 14. The output energy is transferred to additional amplifiers or load circuits by means of capacities 12 and 13. Resistors 10 and 11 distribute proper potentials to the anode electrodes of thermionic tubes 1 and 2 respectively and as resistors 5 and 6, are non-inductive, non-capacitive and therefore aperiodic.

Fig. 2 of the accompanying drawings is a schematic circuit diagram showing the amplifying system of my invention, wherein thermionic tubes 1 and 2, having cathode, control electrode and anode circuits, are connected in an electrically balanced circuit arrangement. The reference characters shown in Fig. 2 correspond to those previously referred to in Fig. 1 with the addition of radio frequency choke coils 15 and capacities 16, 17 and 18. In this circuit arrangement, provision is made for supplying the necessary anode potential to thermionic tubes 1 and 2 from source 14 through radio frequency choke coils 15. By employing this circuit arrangement radio frequency energy is excluded from the source of potential and the resistance introduced in the anode potential supply circuits of thermionic tubes 1 and 2 is greatly reduced. Hence the D. C. resistance drop through resistances 10 and 11 of the circuit as shown in Fig. 1 is avoided in the circuit in Fig. 2, which arrangement is particularly useful in high frequency amplification. Since radio frequency choke coils are employed having a comparatively straight curve for all frequencies and resistors 10 and 11 which are non-inductive and non-capacitive, the output circuit is aperiodic.

The manner in which a large number of thermionic tubes may be employed in an electrically balanced circuit arrangement, is shown in Fig. 3. Reference characters shown in this diagrammatic circuit arrangement correspond to the reference characters shown in Fig. 2 with the addition of capacities 18, 7a and 8a, thermionic tubes 3 and 4, source of potential 14a, and resistors 5a, 6a, 10a and 11a. Resistors 5a and 6a are non-inductive and non-capacitive corresponding to resistors 5 and 6 respectively. Resistors 10a and 11a are non-inductive and non-capacitive corresponding to resistors 10 and 11 respectively. Capacities 7a and 8a correspond to capacities 7 and 8 respectively. Capacity 18 is common to resistors 5a and 6a completing the transfer of energy from resistors 10 and 11 to resistors 5a and 6a.

Fig. 4 is a schematic circuit diagram of the amplifying system of my invention employed in connection with a thermionic tube power amplifier 3 and a space radio radiating system 20. The system of my invention is particularly useful in such a method of am-

plifying high frequency energy. The values of the capacities 7, 8, 16, 17, 18, 12 and 13 will depend on the frequency characteristics of the energy in the circuits in which they are included. For audio frequency amplification such capacities will be of the order of one microfarad while for high frequency amplification, as illustrated by the circuit arrangement of Fig. 4, they will be of the order of one thousand micro-microfarads. The audio frequency amplifier circuit arrangement may be similar to the circuit arrangements illustrated in Fig. 1 or Fig. 3. Audio frequency energy amplified by such circuit arrangements may be caused to modulate the carrier frequency of a high frequency generating system. The modulated high frequency energy may be transferred to thermionic tubes 1 and 2 by means of input circuit K. As a result of the radio frequency energy transferred to the resistors 5 and 6, alternating potential will be impressed upon the control electrodes of thermionic tubes 1 and 2.

At any given instant the potentials of the two control electrodes will differ in phase by 180°. The resulting alternating current component in the two anode circuits will therefore be additive. The high frequency energy from the anode circuits is transferred to a load circuit, herein illustrated as a power amplifier 3 and space radio radiating system 20. Adjustable connection to all resistors is provided for adjusting the impedances of the input and output circuits. The amplifying system of my invention may be employed in circuits of relatively high impedance.

I realize that many modifications of the amplifying system of my invention are possible. Thermionic tubes having more than three electrodes, or other types of tubes such as photo electric tubes may be employed. Although batteries are illustrated as sources of electrical energy. It is obvious that any suitable source of energy may be employed. It is to be understood that the foregoing modifications and other modifications of the amplifying system of my invention may be employed without departing from the spirit of my invention and it is further understood that the embodiments of my invention are not limited to the foregoing specification or to the accompanying drawings but only as defined in the scope of the appended claims.

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

1. In an amplification system, in combination, two electron tubes each having filament, grid and plate electrodes, a source of power connected to said filament electrodes, an aperiodic input resistor, an aperiodic output resistor, each of said resistors being provided with a multiplicity of variable intermediate tap connections, two inductance elements, a

source of plate potential, a plurality of condensers, a balanced network wherein said filament electrodes are connected together and to a central tap of said input resistor, said filament electrodes being connected through  
 5 said source of plate potential and one of said condensers in series to a central tap on said output resistor, said grid electrodes connected to taps on said input resistor on opposite sides  
 10 of said central tap, each of said plate electrodes being connected through a condenser to a tap on said output resistor, said two plates being connected to opposite sides of  
 15 said central tap of said output resistor, said inductance elements being connected respectively from a point on said connection from filament to output resistor intermediate said  
 20 source of plate potential and said condenser respectively to points on said connections from said plate electrodes to said opposite taps on said output resistors intermediate  
 25 said plate electrodes and said condensers, input connections for said amplifying system connected to taps on said input resistor on opposite sides of said central tap thereof, output  
 30 connections for said amplifying system connected to taps on said output resistor on opposite sides of said central tap thereof, whereby the energy supplied to said input connections is amplified and delivered to said output connections substantially without distortion.

2. In an amplification system, in combination, two electron tubes each having filament,  
 35 grid and plate electrodes, a source of power connected to said filament electrodes, an aperiodic input resistor, an aperiodic output resistor, each of said resistors being provided with a multiplicity of variable intermediate  
 40 tap connections, two inductance elements, a source of plate potential, a source of grid biasing potential, a plurality of condensers, a balanced network wherein said filament electrodes are connected together and through  
 45 said source of grid biasing potential to a central tap of said input resistor, said filament electrodes being connected through said source of plate potential and one of said condensers in series to a central tap on said output  
 50 resistor, said grid electrodes connected to taps on said input resistor on opposite sides of said central tap, each of said plate electrodes being connected through a condenser to a tap on said output resistor, said two plates  
 55 being connected to opposite sides of said central tap of said output resistor, said inductance elements being connected respectively from a point on said connection from filament to output resistor intermediate said source  
 60 of plate potential and said condenser respectively to points on said connections from said plate electrodes to said opposite taps on said output resistors intermediate said plate electrodes and said condensers, input connections  
 65 for said amplifying system connected to taps

on said input resistor on opposite sides of said central tap thereof, output connections for said amplifying system connected to taps on said output resistor on opposite sides of said central tap thereof, whereby the energy supplied to said input connections is amplified and delivered to said output connections substantially without distortion.

3. In an amplification system, in combination, a plurality of electron tubes arranged  
 75 symmetrically in two groups, each of said tubes having filament, grid, and plate electrodes, a source of power connected to said filament electrodes, the corresponding electrodes of the tubes of each of said groups  
 80 being connected together, an aperiodic input resistor, an aperiodic output resistor, each of said resistors being provided with a multiplicity of variable intermediate tap connections, two inductance elements, a source of  
 85 plate potential, a plurality of condensers, a balanced network wherein said filament electrodes are connected together and to a central tap of said input resistor, said filament electrodes being connected through said source  
 90 of plate potential and one of said condensers in series to a central tap on said output resistor, said grid electrodes connected to taps on said input resistor on opposite sides of said central tap, each of said plate electrodes  
 95 being connected through a condenser to a tap on said output resistor, said two plates being connected to opposite sides of said central tap of said output resistor, said inductance elements being connected respectively  
 100 from a point on said connection from filament to output resistor intermediate said source of plate potential and said condenser respectively to points on said connections from said plate electrodes to said opposite  
 105 taps on said output resistors intermediate said plate electrodes and said condensers, input connections for said amplifying system connected to taps on said input resistor on opposite sides of said central tap thereof, output  
 110 connections for said amplifying system connected to taps on said output resistor on opposite sides of said central tap thereof, whereby the energy supplied to said input connections is amplified and delivered to said  
 115 output connections substantially without distortion.

4. In a non-distorting amplifying system, a plurality of amplifier units, each of said  
 120 units comprising two electron tubes each having filament, grid, and plate electrodes, a source of power connected to said filament electrodes, an aperiodic input resistor, an aperiodic output resistor, each of said resistors being provided with a multiplicity of  
 125 variable intermediate tap connections, a source of plate potential, a plurality of condensers, a balanced network wherein said filament electrodes are connected together and to a central tap of said input resistor, 13

said filament electrodes connected through said source of plate potential to a central tap on said output resistor, said grid electrodes connected to taps on said input resistor on opposite sides of said central tap, said plate electrodes connected through a condenser to a tap on said output resistor, said two plates being connected to opposite sides of said central tap of said output resistor, input connections for each of said amplifier units connected to taps on its input resistor on opposite sides of said central tap thereof, output connections for each of said amplifier units connected to taps on its output resistor on opposite sides of said central tap thereof, connections between the output resistor of one amplifier unit and the input resistor of the succeeding amplifier unit wherein the mid point of said output resistor is connected through a condenser to the mid point of said succeeding input resistor, and points on said output resistor on opposite sides of the mid point thereof are respectively connected through respective condensers to points on said succeeding input resistor on opposite sides of the mid point thereof, whereby the energy delivered to the input of said first amplifier unit is amplified and delivered at the output of said last amplifier unit substantially without distortion.

In testimony whereof I affix my signature.

CHARLES A. CULVER.

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