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PREVENTING FEED BACK IN AMPLIFIER TUBES HAVING COMMON PLATE SUPPLY

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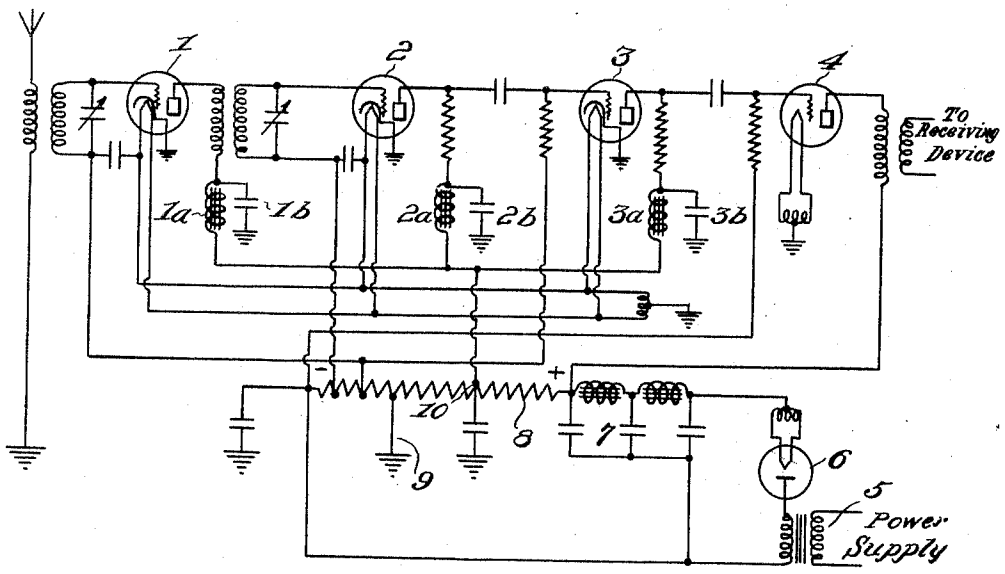


Fig. 1.

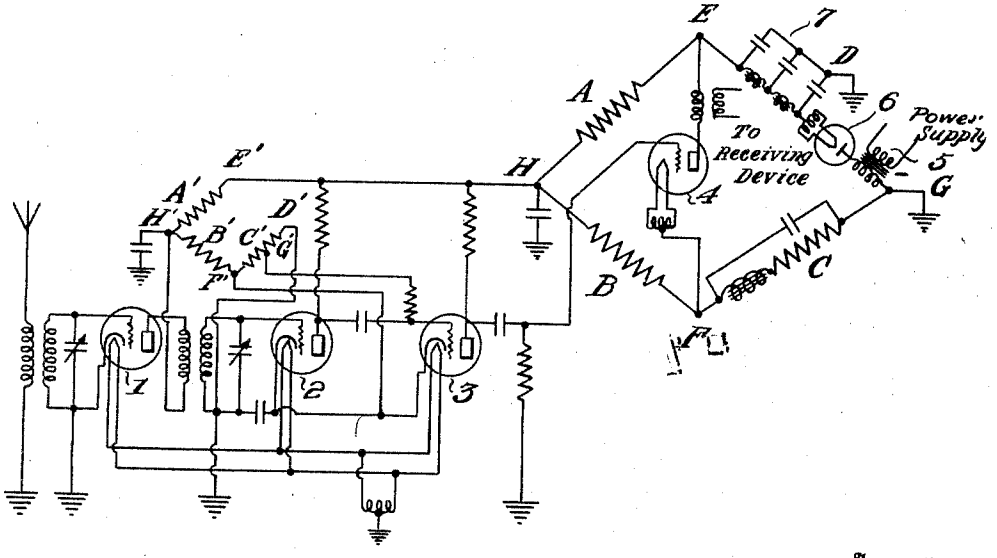


Fig. 2.

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UNITED STATES PATENT OFFICE

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PREVENTING FEED-BACK IN AMPLIFIER TUBES HAVING COMMON PLATE SUPPLY

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This invention relates to a signaling system, and in particular to a signaling system employing a plurality of vacuum tube relays connected in cascade and provided with a common source of space current.

An object of the invention is to devise a multi-stage vacuum tube relay or amplifier system in which the vacuum tubes of the various stages are supplied with space current from a common source and in which means is provided for preventing the variations in current in one stage from affecting a preceding stage through the mutual impedance of the common supply source.

My invention is illustrated in the accompanying drawings in which:

Figure 1 is a circuit diagram showing a common type of cascade vacuum tube amplifier, and

Figure 2 shows the circuit arrangement of the same type of amplifier shown in Figure 1 having my invention embodied therein.

Referring to Figure 1, the numerals 1, 2, 3 and 4 indicate vacuum tube relays employed in the four stages of the amplifier. I prefer to employ tubes having heater type cathodes for the first three tubes of the amplifier, since these tubes can use a common source of heater current while retaining separate cathode connections. Tube 1 is a radio frequency amplifying stage, tube 2 serves as a detector, while the third and fourth stages amplify the detected low frequency signals, the last tube being of a size and type to supply the requisite amount of power for the operation of the receiving device. Space current for all of the relays is supplied from an alternating current source 5 through a rectifier 6, a filter 7 and a potentiometer or voltage divider resistance 8, connected across the terminals of the filter 7. The cathode heaters are shown as supplied with alternating current from low voltage secondary windings of the power transformer 5, but they may be supplied from any suitable source. The cathodes of tubes in the various stages are grounded, and an intermediate point 9 of resistance 8 is also grounded. Relays 1, 2 and 3 are supplied with plate current from a tap 10 on resistance 8, and relay 4 is supplied with plate current of maximum voltage from the positive terminal of the potentiometer. The portion of the potentiometer resistance 8 lying to the left of the grounded point 9 is utilized for providing proper biasing potentials for the grids of the various stages. Relays 1, 2 and 3 are each provided with a plate circuit filter comprising series inductances 1_a, 2_a, 3_a and shunt condensers 1_b, 2_b 3_b.

The last tube 4 shown in Figure 1 is commonly called the power tube of the amplifier, and this tube requires a larger plate current than the preceding tubes, or a current which dominates the plate current in the other tubes. It will be seen that the impedance of the rectifier tube and the smoothing filter in the circuit in Figure 1 is included in each of the plate circuits of the various stages, and consequently, current variations in the plate circuit of the power tube will produce voltage variations on the other tubes of the preceding stages. This gives rise to low frequency oscillations commonly known as "motor-boating" which are produced by the feeding back of energy from the power stage to a preceding stage through the mutual impedance of the plate supply source. This effect is particularly troublesome in resistance coupled amplifiers, and is present in a lesser degree in other types as well. One common method of mitigating the difficulty is to provide the individual plate circuit filters referred to above. These filters are bulky and expensive, and in the case of resistance coupled amplifiers, are frequently inadequate to prevent the low frequency disturbances.

In the arrangement shown in Figure 2 in which my invention is embodied, the plate current supply source, including the alternating current source 5, rectifier 6, and the filter 7, forms one arm D of a Wheatstone bridge, the remaining arms of which are indicated at A, B and C. Plate current to the power tube 4 is supplied over a path connected between the diagonal points E and F of the bridge, and plate current for relays 1 to 3 is supplied over a path connected between the diagonal points G and H of the bridge. When the bridge is properly balanced, these two diagonal circuit paths are

conjugated with respect to each other, and current variations produced in the plate circuit of relay 4 will not affect relays 1, 2 and 3 through the mutual impedance of the plate current supply. The values of the resistances constituting the arms A and B, and the values of the elements comprising the arms C will depend somewhat upon the resistance of the current supply source. It will be convenient to make the value of the resistance in arm C such that the resistance drop occasioned by the flow of current through this resistance will provide the required grid biasing voltage for the power tube 4. The proportion between resistances of arms C and D then establishes the ratio for the bridge arms A and B. As an example, the constants suitable for a common type of power tube may be stated: This tube requires a plate voltage of 400 volts, a grid voltage of 70 volts, and draws a plate current of 55 milliamperes. A resistance of approximately 1200 ohms in arm C will then supply the 70 volts necessary for biasing the grid of the tube. A common value of resistance found in the combined current supply elements 5, 6 and 7 is about 600 ohms. Thus the resistances in arm A and B should be in the ratio of approximately 1 to 2. Values of 5000 and 10,000 ohms respectively have been found satisfactory. The voltage supplied to tube 3 will then be two-thirds of that supplied to the power tube.

Should an intermediate tube or tubes produce objectionable feed-back into a preceding stage, a second bridge may be provided to supply the plate current for such tube or tubes. For example, as shown in Fig. 2, the plate current for tube 2 and tube 3 is supplied over circuit paths connected between diagonal points E′ and F′ of a second bridge A′—B′—C′—D′, and the plate current for relay 1 is supplied over a path connected between diagonal points H′ and G′ of the second bridge. In this case it is only necessary that the arm C′ balance the combined resistance of the current supply network up to the second bridge. When the second bridge is balanced in the manner described above for the first bridge, plate current variations in tubes 2 and 3 will not react upon tube 1. Due to the type of tube usually employed in intermediate stages this second bridge will not generally be necessary.

From Figure 2, it will be seen that two Wheatstone bridges are provided, and one arm (arm D′) of one bridge is included in a diagonal path of the other bridge, and the plate current supply of power tube 4 is over the second diagonal path of bridge A—B—C—D. The plate current supply for tubes 2 and 3 is over a diagonal path of bridge A′—B′—C′—D′, and plate current supply for tube 1 is over the second diagonal path for bridge A′, B′, C′.

The arrangement above described has been found successful in curing persistent low frequency oscillation in resistance coupled amplifiers. The nature of the balance is not critical, which is a useful feature, inasmuch as the resistance of the rectifier tube varies somewhat in accordance with the voltage of the main power supply. The impedance of the combined power supply elements is primarily resistive, but series inductance and shunt capacity may be added if necessary to secure a satisfactory balance. As a rule, the ratio of the resistances in arms D and C will be greater than one so that the voltage available for the preceding tubes will be somewhat larger than one-half the value of the maximum rectified voltage. This method of feed-back neutralization is applicable also where plate current is supplied by a relatively low resistance battery. It may be desirable in that case to add series resistance in arm D to secure the desired voltage proportions.

While the invention is illustrated as embodied in a particular type of amplifier which is particularly susceptible to low frequency oscillations, it is applicable generally to any group of devices having a common source of potential possessing impedance.

I claim:

1. In combination, a plurality of current consuming devices connected in cascade in an alternating current circuit, a common source of direct current for energizing said devices, and circuits connecting said devices to said source in circuit paths conjugate to each other.

2. In combination, a plurality of electric relays, a common source of direct current for said relays, and circuits connecting said relays to said source in circuit paths conjugate to each other.

3. In combination, a plurality of vacuum tube relays, a common source of space current for said relays having sensible impedance, one of said relays having a dominant plate current, and neutralizing means for preventing current variations of said relay from reacting on the other relays through the space current source.

4. In combination, a plurality of vacuum tube relays, a common source of space current for said relays, and circuits connecting said relays to said source in circuit paths conjugate to each other.

5. In combination, a plurality of vacuum tube relays, a common source of space current for said relays, and means for connecting the anode-cathode elements of said relays to said source in circuit paths conjugate to each other.

6. In combination, a pair of vacuum tube relays, a common source of space current for said relays, a Wheatstone bridge network including said source in one of the arms, one of said relays being connected in one diagonal

path of said bridge and the other relay in the second diagonal path.

7. In a signaling system, a plurality of vacuum tube relays connected in cascade for amplifying variable currents, a common source of space current for said relays, and space current supply circuits connecting said relays to said source in circuit paths conjugate to each other.

8. In a signaling system, a plurality of vacuum tube relays connected in cascade for amplifying variable currents, a common source of space current for said relay, a circuit network connecting said source and relays including a Wheatstone bridge, said source being included in one arm of said bridge, and adjacent tubes of said cascade being included in the diagonal paths respectively of said bridge.

9. In combination, a pair of vacuum tube relays, a common source of space current for said relays, a circuit for said relays, a circuit network comprising a Wheatstone bridge one arm of which includes said source and one diagonal path includes one of said relays, a second Wheatstone bridge one arm of which includes the second diagonal path of said first bridge, said second relay being included in a diagonal path of said second bridge.

10. In a signaling system, a plurality of vacuum tube relays connected in cascade for amplifying variable currents, a common source of space current for said relays, space current circuits connecting said source and said relays including a plurality of Wheatstone bridge networks each including one of said relays in one of its diagonal paths, and each bridge except the last including in one of its arms a diagonal path of another bridge.

11. In a signaling system, a plurality of vacuum tube relays connected in cascade for amplifying variable currents, a common source of space current for said relays, space current circuits connecting said source and said relays including a plurality of Wheatstone bridge networks each including one of said relays in one of its diagonal paths, and each bridge except the last including in one of its arms a diagonal path of another bridge, said source of space current being included in an arm of the last bridge in the cascade.

In testimony whereof I affix my signature.

JOHN R. HYNEMAN.