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S. BALLANTINE

1,930,672

ELECTRICAL CIRCUIT FOR RADIORECEIVERS

Original Filed June 17, 1924

Fig. 1.

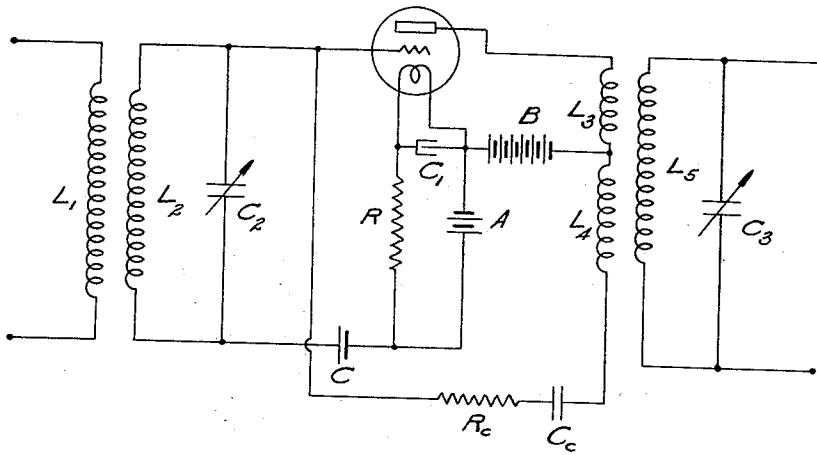
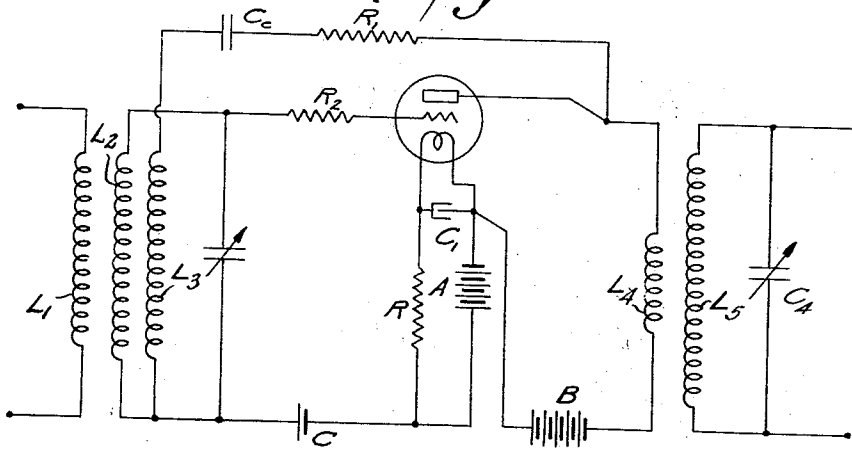


Fig. 2.



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UNITED STATES PATENT OFFICE

1,930,672

ELECTRICAL CIRCUIT FOR RADIO-RECEIVERS

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Original application June 17, 1924, Serial No. 720,708, patented June 3, 1930, No. 1,760,871. Divided and this application December 21, 1927. Serial No. 241,647

14 Claims. (Cl. 179—171)

This application is a division of my copending application, Ser. No. 720,708, filed June 17, 1924 patented June 3, 1930, No. 1,760,871.

The present application relates especially to electrical circuits adapted to reduce or suppress the undesired effects due to capacity existing between the anode and the control electrode of a vacuum tube employed in an electrical repeater or amplifier circuit, stage, or the like. Circuits intended to accomplish this result have heretofore been known and used. One such circuit is now generally known commercially as a neutralized circuit, and comprises, broadly speaking, a capacity and an inductance connected in series between the input and output circuits of a vacuum tube stage, the inductance being closely coupled (i. e. with substantially unity coupling) to a coil in one of these circuits and the capacity being connected to an electrode of the other circuit. I have found that circuits of this type, and similar circuits, as hereafter specifically described, while generally satisfactory, are subject to certain imperfections in operation. For example, experiments with such circuits lead to the conclusion that, so far as I am aware, they have never, before my invention, been so constructed and adjusted as to be even approximately unidirectional in action, i. e. so as to give approximately true theoretical repeater amplification. Although such circuits may be otherwise perfectly balanced, a proper control of the resistance balance has not been obtained prior to my invention. The absence of a proper resistance balance, or of a proper control of the degree of resistance unbalance, may very considerably decrease the actually-obtained amplification. In a typical specific case of a single amplifier stage of the neutralized type, I found that the amplification was 10%–15% less than the theoretical amount, so that the stage gave only about 85%–90% of the amplification which it would give if it were substantially unidirectional in action, i. e. if it gave its true theoretical repeater amplification. When, however, a proper resistance balance, according to my invention, was obtained (in addition to the usual capacity balance) this amplifier stage was found to give its true theoretical repeater amplification within less than one percent.

Referring now to the drawing, Fig. 1 is a circuit diagram showing an audion or vacuum tube amplifier stage arranged according to my invention, the circuit being provided with arrangements for rendering it substantially unidirectional in action; Fig. 2 is a circuit diagram showing an am-

plifier stage arranged according to another modification of my invention.

Figure 1 illustrates a repeater unit in which the audion capacity coupling is eliminated by a neutralization method. The principle of such methods is disclosed in my copending applications, Ser. No. 629,702, filed April 3, 1923 and Ser. No. 167,701, filed Feb. 12, 1927. L_1 and L_2 constitute the input transformer which is tuned by the condenser C_2 ; C_c is a compensating condenser; L_3 and L_4 are either separate coils or parts of the same coil; L_5 and C_3 represent the output circuit; R_c is a compensating resistance; R is a resistance in the filament circuit, the direct current drop across which is used to give the grid a suitable negative bias; the "C" battery reinforces the biasing effect of R ; the "A" and "B" batteries have their conventional circuit locations; C_1 is a filament-shunting condenser of low impedance. The output circuit, represented by the coil L_5 , must be coupled to L_3 and L_4 so that the effective impedances between the terminals of L_3 and L_4 are of proper value to maintain a state of balance in the circuit; obviously also the coupling between L_3 , L_4 and L_5 must be fixed. It is not necessary that L_3 and L_4 be coupled together, but their couplings to L_5 must result in impedances between their terminals which satisfy the requirements of neutralization. For best results, with tubes of the usual 15,000 ohms plate resistance, as now constructed, the coils L_3 and L_4 are of small inductance compared with that of L_5 and the coupling between L_3 and L_5 and between L_4 and L_5 should be close. In order that persons skilled in the art may reproduce my results, I give the following constants of one specific circuit: $L_3=20$ microhenries; $L_4=20$ microhenries; $L_5=300$ microhenries; $C_3=0.00033$ microfarads; $C_c=0.000005$ microfarads. These values were found suitable for a unit designed to cover a wave length range of 200 to 600 meters.

Figure 2 illustrates a repeater unit in which an alternative method of neutralizing the audion capacity coupling is employed. This method is disclosed in my copending applications above referred to, and in substance in Hazeltine U. S. Patent 1,489,228, April 1, 1924. The other arrangements for eliminating the enumerated couplings other than that due to the audion capacity, are those already described. L_1 and L_2 are two coils of preferably tight coupling wound in opposite directions and so connected that their non-common terminal voltages are opposite in phase; C_c is a compensating condenser; R_1 and R_2 are compensating resistances, which make up the

departure of the voltages of L_1 and L_2 from exact 180° phase relationship and which also compensate for the resistance component of the variable space charge coupling; R is a filament resistance, the drop across which helps to bias the grid negatively; the battery "C" also has this function; C_1 is a filament-shunting condenser of low impedance; the batteries "A" and "B" have their conventional functions; L_3 and L_4 constitute the output transformer, tuned by the condenser C_4 .

Various modifications of the specific circuits herein described, and equivalent arrangements thereof, fall obviously within the scope of my invention. For example, arrangements in which the compensating or phase-adjusting resistances are wholly or partially embodied in one or more elements of the compensating circuit, as the compensating inductance or capacity, are contemplated by me, and fall within my invention. Moreover, my invention extends to the control of the resistance balance of the circuit in either direction, and is not limited to a circuit which is perfectly balanced.

I claim:—

1. An electrical amplifier circuit comprising, in combination, a vacuum tube including at least an anode, a cathode and a control electrode; an input circuit connected between said cathode and said control electrode; an output circuit connected between said cathode and said anode and including an output transformer; and a compensating circuit including a coil arranged in inductive relation to a winding of said output transformer and having one terminal connected to said cathode, and capacity and resistance connected in series between the other terminal of said coil and said control electrode.

2. An electrical amplifier circuit comprising, in combination, a vacuum tube including at least an anode, a cathode and a control electrode; an input circuit connected to said cathode and said control electrode; an output circuit including an output transformer having primary and secondary windings; and a series compensating circuit connected between said control electrode and said cathode and including a resistance, a capacity, and an inductance, said inductance being connected to the cathode terminal of said output transformer primary but having substantially zero electromagnetic coupling with said primary winding.

3. An electrical amplifier circuit comprising, in combination, a vacuum tube including at least an anode, a cathode, and a control electrode; an input circuit connected between said cathode and said control electrode; an output circuit connected between said cathode and said anode and including an output transformer having primary and secondary windings; and a compensating circuit including a compensating coil wound in the opposite direction to the primary of said output transformer and coupled thereto so that the non-common terminal voltages of said compensating coil and of said transformer primary are substantially opposite in phase, said compensating coil having one terminal connected to said cathode and having its other terminal connected through a resistance and a capacity, in series, to said control electrode.

4. An electrical amplifier circuit comprising, in combination, a vacuum tube including at least an anode, a cathode, and a control electrode; an input circuit connected between said cathode and said control electrode; an output circuit connected between said cathode and said anode and

including an output transformer having primary and secondary windings; and a compensating circuit including a compensating coil wound in the opposite direction to the primary of said output transformer and tightly coupled thereto so that the non-common terminal voltages of said compensating coil and of said transformer primary are substantially opposite in phase, said compensating coil having one terminal connected to said cathode and having its other terminal connected through a resistance and a capacity, in series, to said control electrode.

5. An electrical amplifier circuit comprising a vacuum tube having at least an anode, a cathode and a control electrode; an electrical network associated with said tube and including a counter-feedback path around the tube for producing a substantial reactance balance of said network as regards disturbing feedback through the capacities of said tube and associated connections; and means associated with said counter-feedback path for controlling the resistance balance of said network.

6. In a radio receiver, an ionic repeater having resonant grid and plate circuits and a coupling between said circuits for establishing a current to oppose retroactive currents through the capacity between the grid and plate terminals of said repeater, said coupling including a resistance operative to bring the opposing current to the proper phase.

7. An electrical amplifier comprising a vacuum tube, an input circuit and an output circuit having capacitive coupling between them, a compensating circuit for establishing currents to oppose retroactive currents flowing through said capacitive coupling, and means operative to bring the opposing currents into phase with the retroactive currents.

8. An electrical amplifier stage comprising a vacuum tube, an input circuit, an output circuit, a circuit for compensating the undesirable effects of coupling between said output and input circuits, and a resistance associated with said compensating circuit for adjusting the phase of the compensating current.

9. An electrical amplifier stage comprising a vacuum tube having at least a plate, a cathode, and a control grid, and having capacity between said plate and control grid; an impedance having one terminal connected to said plate; a connection from an intermediate point in said impedance to said cathode, the two portions into which said impedance is divided by said connection to the cathode having negligible electromagnetic coupling with each other; capacity connected between the other terminal of said impedance and said grid; an input circuit for said amplifier stage associated with said grid and cathode; and an output circuit for said amplifier stage arranged across said impedance.

10. An electrical amplifier stage comprising a vacuum tube having at least a plate, a cathode, and a control grid, and having capacity between said plate and control grid; an inductance having one terminal connected to said plate; a connection from an intermediate point of said inductance to said cathode, the two portions into which the said inductance is divided by said connection to the cathode having negligible electromagnetic coupling with each other; a capacity connected between the other terminal of said inductance and said grid; an input circuit for said amplifier stage associated with said grid and cathode; and an

output circuit for said amplifier stage arranged across said inductance.

11. An electrical amplifier comprising a vacuum tube, an input circuit and an output circuit having capacitive coupling between them, a compensating circuit for establishing currents to oppose retroactive currents flowing through said capacitive coupling, and resistive means operative to bring the opposing currents into phase with the retroactive currents.

12. An electrical amplifier comprising a vacuum tube, an input circuit and an output circuit having capacitive coupling between them, a compensating circuit for establishing currents to oppose retroactive currents flowing through said capacitive coupling, and means in said circuit operative to bring the opposing currents into phase with the retroactive currents.

13. An electrical amplifier stage comprising a vacuum tube, an input circuit, an output circuit,

a circuit for compensating the undesirable effects of coupling between said output and input circuits, and a resistance associated with each of said input and compensating circuits for adjusting the phase of the compensating current.

14. In combination, an electron discharge tube provided with a control electrode circuit and an anode circuit, means for tuning the first circuit, means for neutralizing the capacity coupling between the two said circuits comprising a coil between the anode and cathode of the tube, a second coil coupled to the first coil for transmitting energy, an auxiliary coil and a neutralizing condenser connected in series between the control electrode and cathode of the tube, the electromagnetic coupling between said first coil and auxiliary coil being negligible, the said second coil being closely and separately coupled to each of said first and auxiliary coils.

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30	105
35	110
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60	135
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70	145
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