June 7, 1932. H. A. SNOW ET AL 1,861,587

AUDION AMPLIFIER CIRCUIT

Filed Aug. 13, 1925

Fig. 1.

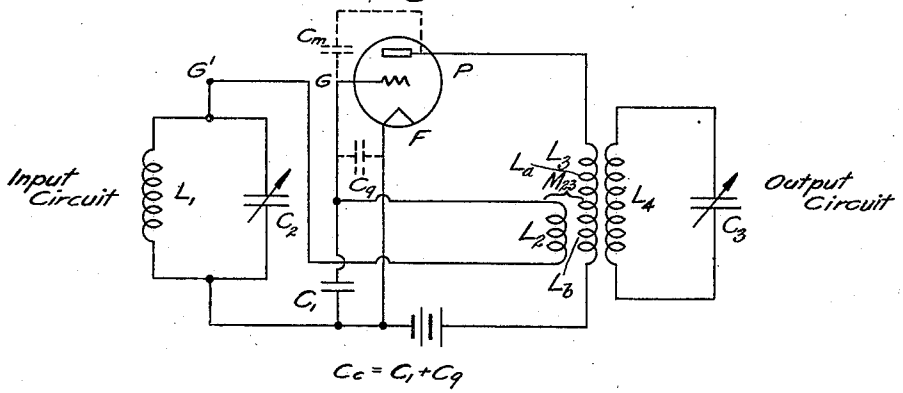
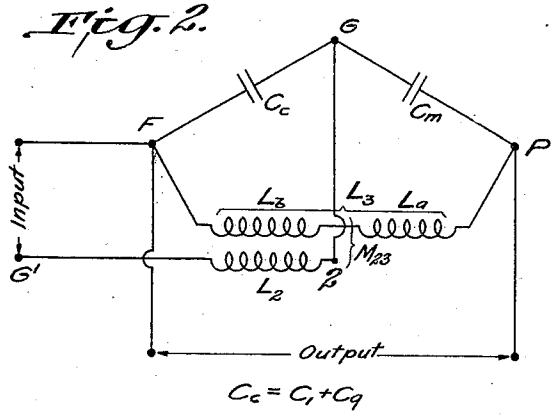



Fig. 2.



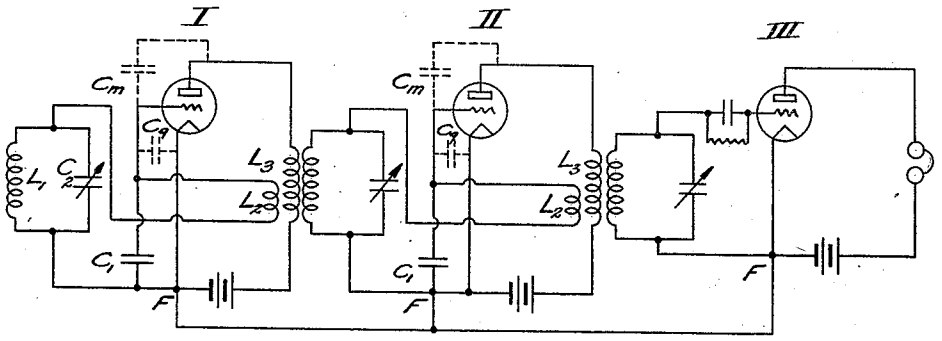




Fig. 3.

INVENTORS:
Harold A. Snow,
Lewis M. Hull,
By Byrnes, Townsend & Brickenstein,
ATTORNEYS.

Patented June 7, 1932

1,861,587

# UNITED STATES PATENT OFFICE

HAROLD A. SNOW AND LEWIS M. HULL, OF BOONTON, NEW JERSEY, ASSIGNORS, BY MESNE ASSIGNMENTS, TO RADIO CORPORATION OF AMERICA, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

## AUDION AMPLIFIER CIRCUIT

Application filed August 13, 1925. Serial No. 50,114

This invention relates to audion amplifier circuits and in particular to a circuit which is compensated for the flow of retroactive currents through the grid plate capacity of an audion tube. By this compensation we diminish or completely eliminate the effects upon the input circuit terminals due to the variations in potential across the output circuit load. In the copending application of Stuart Ballantine, Serial No. 34,388, filed June 2, 1925, patented August 13, 1929, No. 1,724,819, there is described a Wheatstone bridge circuit whereby such compensation is produced. When this Wheatstone bridge is substantially balanced to eliminate or reduce the flow of retroactive currents through the grid plate capacity of the audion tube, the circuit when used as an amplifying stage is approximately one-way in action. Moreover this balance is substantially independent of frequency, and the circuit is admirably adapted for use in cascade amplification. We have discovered a circuit which while retaining all of these advantages, has the additional advantage that one of the terminals of the input circuit may be connected directly to the audion filament. This cannot be done in the construction of an amplifier according to the Ballantine circuit, although we are aware that in the Ballantine circuit, as well as in other well known circuits, an intermediate point of either the input or the output circuit may be brought to the filament potential. When the input circuit of an amplifier stage comprises a tuned circuit containing an inductance and a tuning condenser, it is in many cases a structural disadvantage to have both sets of plates of this condenser permanently above the ground or filament potential. Moreover when the Ballantine circuit is used in each stage of a cascaded amplifier, it is impossible to bring the tuning condensers of each stage to a common terminal, such as ground, or the common filament terminal of the several audions. By our invention we have overcome this difficulty and have succeeded in grounding one terminal of the input circuit, or in the case of a cascaded amplifier having tuned input circuits, bringing all the condensers to a common terminal.

Referring now to the drawing, Fig. 1 shows a single amplifier stage arranged according to our invention. Fig. 2 is a diagrammatic representation of the essential alternating current elements of this circuit as they appear when represented in the form of a conventional bridge diagram. Fig. 3 is a cascaded amplifier arranged according to our invention.

In Fig. 1 the inherent grid-plate capacity of the tube is represented by the dotted lines at *Cm*. The inherent grid-filament capacity is similarly shown at *Cg*. Connected in parallel with *Cg* there may be an external capacity *Cl* between the grid and filament. This external capacity has been shown for the sake of generality, but its use may be unnecessary. The sum of *Cg* and *Cl* is what we term *Cc*. One input terminal of the stage is connected directly to the filament while the other input terminal is connected to the grid through a coil L2 which is coupled to a coil L3 in the plate circuit. Coil L2, therefore, is in series with the capacity *Cc* and the grid and filament of the tube. L2 may be coupled to a part or all of L3 but in practice a close coupling with the lower portion *Lb* of the coil L3 is preferred.

This circuit arrangement will be seen to result in a Wheatstone bridge in which one arm is a capacity between grid and filament, another arm is a capacity between grid and plate, a third arm is the portion *La* of the coil L3, and the fourth arm comprises the portion *Lb* of coil L3, coil L2, and the mutual inductance M23. The input of the audion stage is between the filament and a point G' which is at the opposite end of coil L2 from that end 2, which is connected to the grid. The output of the stage is between the plate and filament. It is understood that our invention is not limited to any particular form of input and output circuits. We have, however, shown as a preferred form a tuned input circuit L1C2, and a tuned output circuit L4C3.

This arrangement of circuit elements and connections will be more clear in conjunction

with Fig. 2 which is a conventional bridge diagram of the essential alternating current elements of the circuit of Fig. 1.

In Fig. 3 two radio frequency stages of amplification I and II, each connected according to our invention, are shown working into a detector stage III.

In all figures such standard elements as filament batteries and rheostats, "B" battery by-pass condensers, and the like have been omitted for the sake of simplicity.

By partially or completely balancing the Wheatstone bridge arrangement herein described a diminution or complete elimination of retroactive effects may be obtained. The conditions for balance of the bridge may be seen from Fig. 2 to be:

$$\frac{Cc}{Cm} = \frac{L3 - M23}{M23}$$

and this balance is theoretically independent of frequency. In actual practice we obtain a balance substantially independent of frequency over a considerable range. We have found that the various circuit elements can be so designed and proportioned that the effects of distributed capacities in the coils and of other parasitic capacities in a physical structure are negligible over a substantial range of frequencies.

The potentials of the various points in an audion circuit are commonly measured with respect to the alternating current potential of the audion filament, which is usually at the lowest potential of the circuit and is commonly grounded. By the lower terminal of either the input or the output circuit we mean that terminal which has the lowest alternating current voltage and hence approaches most nearly to the alternating current potential of the audion filament.

We claim:

1. In the process of arranging the impedance elements of an audion amplifier stage as a Wheatstone bridge network having the output circuit and the input circuit of the stage as the conjugate arms thereof, the step which comprises connecting one terminal of the said input circuit of the stage directly to the filament of the audion.

2. The method of preventing retroaction from the output circuit to the input circuit of an audion amplifier stage having an audion with grid and cathode terminals, the elements of said stage being arranged as a Wheatstone bridge capable of being balanced at radio frequencies and including a balancing arm in series with the said input circuit between said grid and filament terminals, which comprises arranging said balancing arm between the grid terminal of the audion and said input circuit.

3. An audion amplifier stage of the type having a resonant input circuit and an impedance network of the Wheatstone bridge type and capable of being balanced to limit regeneration, said network including as adjacent balancing arms thereof a substantially pure capacity between the grid and filament of the audion, and an impedance between one terminal of the said resonant input circuit and the grid terminal of the audion.

4. An audion amplifier stage wherein an audion and a plurality of impedances form an alternating current Wheatstone bridge network, characterized by the fact that capacity between grid and filament terminals of the audion and capacity between grid and plate terminals constitute adjacent balancing arms of the bridge, and a third balancing arm is connected between said grid and the input circuit of the stage.

5. An anti-regenerative audion amplifier stage of the type in which the impedance net work is arranged in the form of a Wheatstone bridge circuit having as conjugate arms thereof the input and the output circuits of said stage, characterized by the fact that one input terminal of the amplifier stage is directly connected to the filament of the tube, and that the other input terminal of the stage is connected to the grid of the tube through a coil in inductive relation with the output circuit of the tube.

6. A cascaded audion amplifier each stage of which comprises an audion and a plurality of impedances arranged in the form of a Wheatstone bridge circuit having as the conjugate arms thereof the input and the output circuits of said stage and characterized by the fact that one input terminal of the amplifier stage is connected to the filament of the tube, and that the other input terminal of the stage is connected to the grid of the tube through a coil in inductive relation with the output circuit of the stage.

7. An audion amplifier stage the impedance net work of which is arranged in the form of a Wheatstone bridge circuit, having as the conjugate arms thereof the input and the output circuits of said stage, said net work comprising an input circuit having two terminals one of which is the filament of the audion tube, a capacity between the grid and filament of said tube, and an inductance connected in series between the grid of said tube and the remaining input terminal, said inductance being coupled to a coil in the plate circuit of said tube.

8. An audion amplifier stage the impedance net work of which is arranged in the form of a Wheatstone bridge having as the conjugate arms thereof the input and the output circuits of said stage, and which comprises an input circuit having a terminal connected to the filament of the audion tube, a capacity between the grid and filament of said tube, an inductance between the plate and filament of said tube, and a second inductance between the grid of said tube and a

second terminal of said input circuit, said second inductance being coupled to said first mentioned inductance.

9. A signal receiving network comprising a plate-filament circuit including an output inductance and a source of direct current energy, an input element between the grid and filament, and means for preventing retroaction of the output voltage variations upon the input element including a second inductance inductively coupled to the output inductance, said second inductance being electrically connected between the grid and input element, and an external condenser connected between the grid and one of the other electrodes, the capacity between grid and filament and between grid and plate being so proportioned with respect to the degree of coupling between the inductances that the network acts as a balanced Wheatstone type bridge wherein the terminals of the input element are conjugate with respect to the output circuit.

In testimony whereof, we affix our signatures.

HAROLD A. SNOW.
LEWIS M. HULL.