

Feb. 7, 1928.

1,658,638

L. A. HAZELTINE
WAVE SIGNALING SYSTEM

Filed July 18, 1925

Fig. 1,

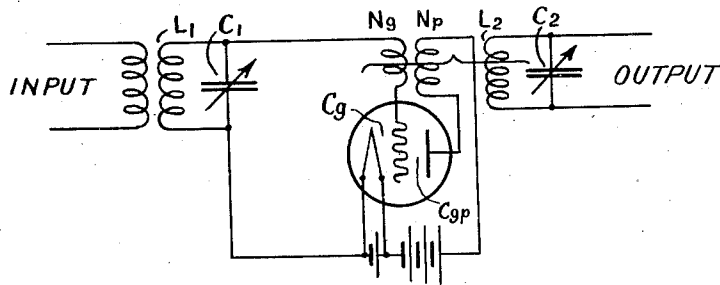


Fig. 2,

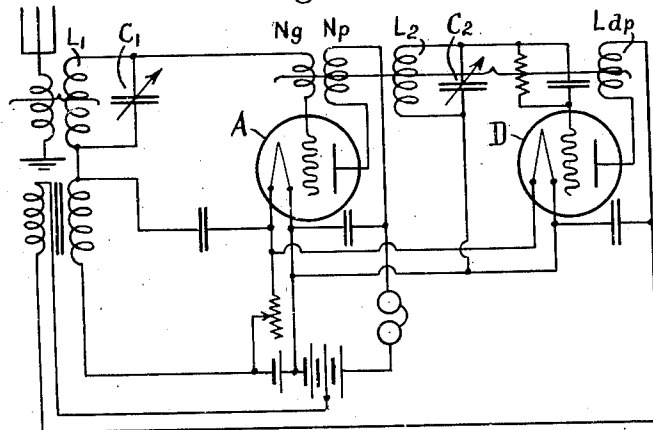
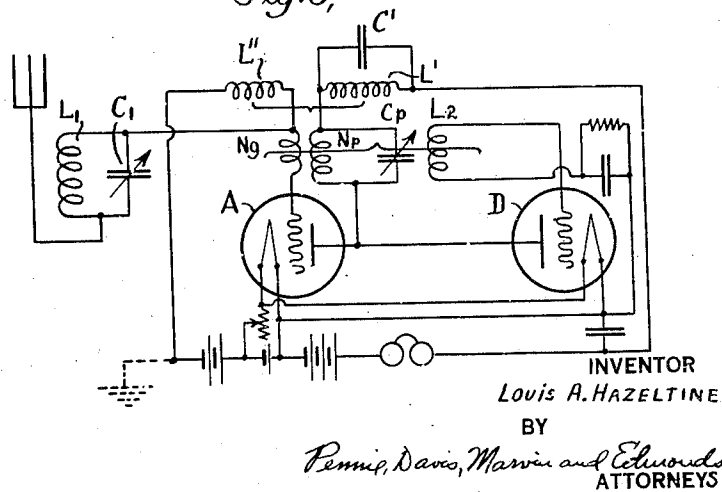


Fig. 3,



Patented Feb. 7, 1928.

1,658,638

UNITED STATES PATENT OFFICE.

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WAVE SIGNALING SYSTEM.

Application filed July 18, 1925. Serial No. 44,509.

The purpose of this invention is to annul the effect of the capacity coupling existing between the grid and the plate circuits of a vacuum tube so as to prevent regeneration and the consequent production of undesired oscillation, particularly when the grid and plate circuits are tuned to the same frequency. This invention differs from methods in which the capacity coupling between the grid and the plate circuits is neutralized in that the capacity coupling between the grid and the plate circuits is allowed to remain, but its regenerative effect is prevented. This is accomplished by arranging in a manner to be described an opposition coil connected in the grid circuit directly in series with the grid itself and with the tuned input circuit. This results in anti-regeneration with respect to the output circuit—that is, the effective resistance of the output circuit is increased. While such increases in resistance may be disadvantageous at times, it may under certain circumstances be an advantage, or at any rate no detriment because its effect may be counteracted. For example, if the vacuum tube in question is followed by a regenerative vacuum tube, its anti-regeneration may be counteracted by the regeneration of the following tube. Again, in a super-regenerative circuit added resistance, or its equivalent, is generally necessary; and this may advantageously and conveniently be provided by the arrangement of this invention.

Referring to the drawings:

Fig. 1 is a circuit diagram showing a single tube arranged in accordance with this invention.

Fig. 2 shows an amplifying vacuum tube employing this invention and followed by a regenerative detector.

Fig. 3 shows this invention applied to a super-regenerative system.

Referring to Fig. 1, the input circuit is led to the primary coil of a transformer whose secondary circuit C_1 , L_1 is tuned. For convenience, a combination of capacity and inductance, at least one of which is variable, may be called a "tuning unit". In series with this secondary circuit is a coil having the number of turns N_g . The plate circuit of the vacuum tube includes a coil having the number of turns N_p closely coupled to the coil N_g and also coupled to the

coil L_2 , which is tuned by condenser C_2 and which leads to the output circuit. The capacity whose regenerative coupling effect to be annulled is that indicated by C_{gp} existing between the grid and the plate. There will also exist natural capacity C_g between the grid and the filament, which will affect the opposition relation, although complete opposition could equally well be effected in accordance with this invention in case this capacity C_g were negligible.

The theory of operation in Fig. 1 is as follows: Assume that the turns N_g and N_p are coupled together with a coefficient of coupling substantially equal to unity and are arranged so that the grid and plate are of the same polarity. Then, if an oscillation should be started in the output circuit, voltages would exist across N_p and N_g in proportion to their respective numbers of turns. If there is to be zero voltage across C_1 and L_1 , as is desired, the same current must flow through C_{gp} as through C_g . The current through C_g will be proportional to C_g and to N_g . The current through C_{gp} will be proportional to C_{gp} and to the difference between N_p and N_g . We must then have the relation

$$C_g N_g = C_{gp} (N_p - N_g);$$

or

$$\frac{N_g}{N_p} = \frac{C_{gp}}{C_g + C_{gp}}.$$

The result of the above relation then is that an oscillation in the tuned output circuit is not communicated to the tuning unit in the input circuit; so no interaction between these circuits can occur. However, an oscillation present in the output circuit does affect the potential of the grid (by the voltage induced in the coil N_g), and this potential is of such a sense as to have an anti-regenerative effect with respect to the output circuit, adding effectively to its resistance, but not affecting the resistance of the input circuit. This effective increase in resistance may readily be counteracted, as described below.

Fig. 2 shows the arrangement of Fig. 1 applied to radio reception in which the vacuum tube A is a combined radio-frequency and audio-frequency amplifier, in accordance with the reflex principle, and the vacuum tube D is a regenerative detector. The

coils N_g , N_p and L_2 correspond with those of Fig. 1 and operate in the same way to prevent interaction between the tuned circuits C_2 , L_2 and C_1 , L_1 . However, there is added to the detector tube the plate coil L_{ap} which is adjustably coupled to N_g , N_p and L_2 . It functions to effectively reduce the resistance of the tuned circuit C_2 , L_2 , and thereby overcomes the anti-regenerative effect due to N_g .

In the adjustment of the set it may not be convenient to have the coil N_g coupled with N_p at substantially unity coefficient of coupling. In practice, the number of turns N_g or the coupling of this coil with N_p is adjusted by trial in such a way that an oscillation present in the detector tube circuit is not transmitted to the tuning unit C_1 , L_1 in the input circuit. This is most simply ascertained by adjusting N_g in such a way that the variation of C_1 does not appreciably affect the oscillation in the detector tube circuit.

The resistances, fixed condensers, audio-frequency transformer, telephone and batteries in Fig. 2 have their usual functions.

Fig. 3 shows a two-tube super-regenerative circuit in which the tube A generates the variation frequency and the tube D is the detector. The variation frequency is the natural frequency of the unit C' , L' , which is coupled to the coil L'' in the grid circuit of A. The transfer of oscillations from the tuned circuit of the detector tube to the tuned antenna circuit C_1 , L_1 is prevented by the use of the coils N_g and N_p as in the preceding figures. This has, as in Fig. 2, the important advantage of preventing radiation from the antenna, even though an oscillating detector tube is employed. In Fig. 3 the two coils N_p and L_{ap} of Fig. 2 have been combined into a single coil N_p ; and, in place of connecting the tuning condenser across the secondary coil L_2 , it is now connected across N_p , as represented by the variable capacity C_p . The plate circuit of A thus acts as the variable load on the plate circuit of D. This is a particularly suitable arrangement as the conductances of the two plate circuits will be of the same order of magnitude if like tubes are employed; and this gives a proper value of conductance for good super-regenerative action. The adjustment of the turns N_g and their coupling to N_p is effected in the same way as in Fig. 2.

I claim:

1. In a vacuum tube amplifier having a grid, a plate and a filament, an input circuit including a tuning unit tunable over a substantial range in frequency, said tuning unit comprising inductance and a variable capacity in parallel connected to the grid and the filament, an output circuit connected to the plate and the filament, and inherent capacity coupling between the grid and the plate and the circuit leads connected thereto, the

method of annulling the regenerative effect of said capacity coupling which comprises introducing directly in series with the grid and external to said tuning unit a voltage derived from the output circuit, whereby any oscillation occurring in the output circuit is prevented from being communicated through said inherent capacity to said tuning unit in the input circuit.

2. In a vacuum tube amplifier having a grid, a plate and a filament, an input circuit including a tuning unit tunable over a substantial range in frequency, said tuning unit comprising inductance and a variable capacity in parallel connected to the grid and the filament, an output circuit connected to the plate and the filament, and inherent capacity coupling between the grid and the plate and the circuit leads connected thereto, the method of annulling the regenerative effect of said capacity coupling which comprises introducing directly in series with the grid and external to said tuning unit a voltage derived from the output circuit and proportional to and in phase with the voltage of the output circuit, whereby any oscillation occurring in the output circuit is prevented from being communicated through said inherent capacity to said tuning unit in the input circuit.

3. In a vacuum tube amplifier having a tuned input circuit and a tuned output circuit, the latter including a coil in the plate circuit, a coil connected directly in series with the grid, external to said tuned circuit, coupled to said coil in the plate circuit with a coefficient of coupling substantially equal to unity and with such polarity that the grid and plate are of like polarity, and having a ratio of turns to said coil in the plate circuit equal to the ratio of the grid-plate capacity to the sum of the grid-plate capacity and the grid-filament capacity.

4. In a vacuum tube amplifier having a grid, a plate and a filament, an input circuit including a tuning unit tunable over a substantial range in frequency, said tuning unit comprising inductance and a variable capacity in parallel connected to the grid and the filament, an output circuit connected to the plate and the filament, inherent coupling capacity between the grid and the plate and the circuit leads respectively connected thereto, whereby a tendency towards oscillation is produced, and means associated with the input circuit and with the output circuit for introducing directly in series with the grid and external to said tuning unit a voltage derived from said output circuit, whereby any oscillation occurring in the output circuit is substantially prevented from being communicated thru said inherent capacity to the tuning unit in the input circuit.

5. In a vacuum tube amplifier having a

grid, a plate and a filament, an input circuit including a tuning unit tunable over a substantial range in frequency, said tuning unit comprising inductance and a variable capacity in parallel connected to the grid and the filament, an output circuit connected to the plate and the filament, inherent coupling capacity between the grid and the plate and the circuit leads respectively connected thereto, whereby a tendency towards oscillation is produced, and means associated with the input circuit and with the output circuit for introducing directly in series with the grid and external to said tuning unit a voltage derived from the output circuit and proportional to and in phase with the voltage of the output circuit, whereby any oscillation occurring in the output circuit is substantially prevented from being communicated thru said inherent capacity to the tuning unit in the input circuit.

6. In a vacuum tube amplifier having a grid, a plate and a filament, an input circuit including a tuning unit tunable over a

substantial range in frequency, said tuning unit comprising an inductance and a variable condenser in parallel, and being connected to the grid and to the filament, an output circuit connected to the plate and to the filament, inherent coupling capacity between the grid and the plate and the circuit leads respectively connected thereto whereby a tendency towards oscillations is produced, and means including a coil connected in series with said tuning unit between said grid and filament, and another coil connected in the output circuit between said plate and filament and electromagnetically coupled to said first-named coil for introducing directly in series with the grid and external to said tuning unit a voltage derived from said output circuit, whereby oscillations occurring in the output circuit are substantially prevented from being communicated through said inherent capacity to said tuning unit in the input circuit.

In testimony whereof I affix my signature.

LOUIS A. HAZELTINE.