C. A. HOXIE.

AMPLIFYING SYSTEM.

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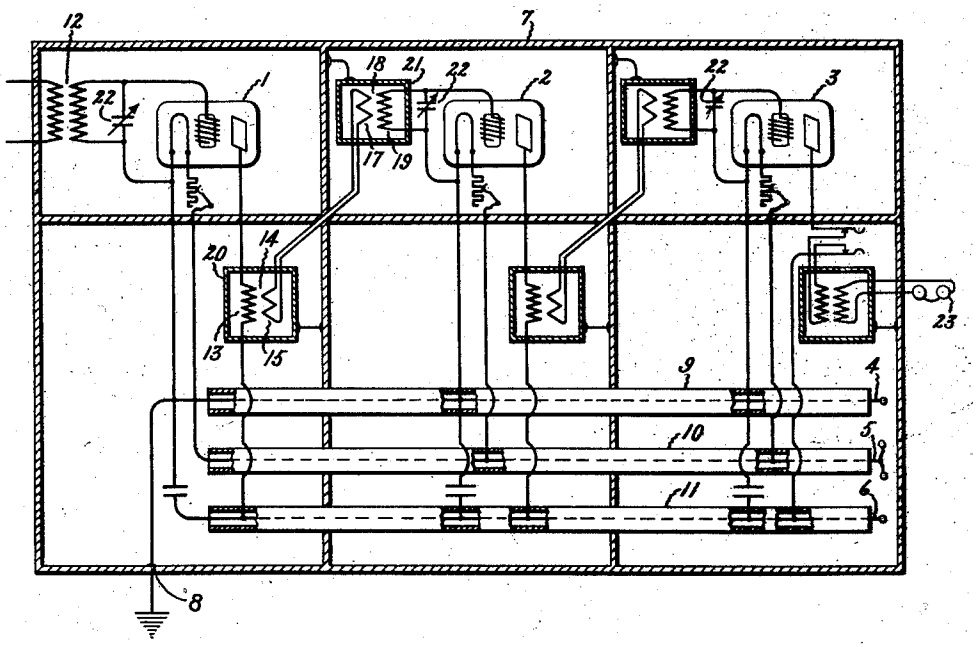
1,382,914. **Patented June 28, 1921.**



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UNITED STATES PATENT OFFICE.

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AMPLIFYING SYSTEM.

1,382,914. Specification of Letters Patent. Patented June 28, 1921.

Application filed May 10, 1920. Serial No. 380,038.

To all whom it may concern:

Be it known that I, CHARLES A. HOXIE, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Amplifying Systems, of which the following is a specification.

My present invention relates to the amplification of electric currents of small intensity, and especially to the amplification of high frequency currents used for signaling purposes. More particularly, it relates to the use of electron discharge relays, detectors or amplifiers.

It has been found that under certain conditions devices of the type mentioned produce oscillatory currents in the circuits associated therewith and in some cases the oscillatory currents so produced interfere with the efficient reception, amplification and detection of signals. This disadvantage is most likely to be present when it is attempted to secure a high degree of amplification by using a plurality of devices connected in cascade.

One of the objects of my present invention is to avoid the undesired production of oscillatory currents when such devices are used in cascade either as amplifiers or detectors, or to serve both functions. Another object of my invention is to provide an amplifying system which will be highly selective, that is, one which will give a high degree of amplification of currents of one particular frequency without producing an appreciable amplification of currents of other frequencies.

It is well known that the production of oscillations by such devices is due to coupling which is present between input and output circuits. When a plurality of devices are connected in cascade a very small amount of coupling between the output circuit of the last device and the input circuit of the first is sufficient to start the production of oscillations.

In the construction of multistage amplifiers therefore it has been customary, as far as possible to shield the different input and output circuits from one another in such a way as to overcome both electromagnetic and electrostatic coupling between the circuits. One source of coupling, however, which has not been avoided in previous cases lies in the transformers connecting the output circuit of each device with the input circuit of the next succeeding device of the series. These transformers as previously used have been constructed with high impedance primaries and secondaries in order to utilize the characteristics of the amplifiers to the best advantages. As a result there is usually a large capacity between primary and secondary which furnishes an electrostatic coupling between successive stages of the amplifier.

In carrying my invention into effect I overcome this last mentioned disadvantage by providing a low voltage coupling link between the output and input circuits. As a result there is substantially no electrostatic coupling between the different stages of the amplifier and it is possible by suitable shielding to entirely prevent any feed back action from an output circuit to the input circuit of a preceding stage.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawing in which I have indicated diagrammatically one way of carrying my invention into effect.

As indicated in the drawing the amplifying system comprises three amplifying tubes 1, 2 and 3, which are preferably of the high vacuum or pliotron type. It will of course be understood that as many tubes as desired may be connected in cascade and that I have indicated three only as this is a sufficient number for the explanation of my invention.

The cathodes of the amplifying tubes may all be supplied with heating current from a single source (not shown) connected to line conductors 4 and 5. The plate or output circuits may all be supplied with current from another source (not shown) connected to line conductors 5 and 6. The tubes 1, 2 and 3 with their respective input circuits are inclosed in separate compartments of a metal box 7 which is grounded at 8 and the output circuits are inclosed in other separate compartments of the box. In order to eliminate any coupling between stages by reason of capacity between leads

I also inclose line conductors 4, 5 and 6 in metal tubes 9, 10 and 11, which are in contact with box 7.

The currents to be amplified are impressed upon the input circuit of tube 1 by means of a transformer 12. The output circuit of tube 1 includes the primary 13 of a transformer 14. This transformer is preferably an iron core transformer with low distributed capacity between windings and the primary 13 may have a large number of turns and the high impedance desirable for use with tubes of the type indicated. The transformers which I make use of are preferably made up of a plurality of pancake coils each consisting of not more than two or three layers and these coils are separated from one another by a distance greater than the thickness of the coils. Instead of providing a high impedance secondary also, however, I provide a secondary winding 15 of only a few turns so that the potentials set up in the secondary will be comparatively small. Secondary 15 is connected to the primary 17 of transformer 18 by means of which the amplified currents from the output of tube 1 are impressed upon the input circuit of tube 2. The primary 17 also consists of a few turns only while the secondary 19 is made up of a large number of turns and has a high impedance, as desired. The coupling transformers 14 and 18 are inclosed in separate metal boxes 20 and 21, which are connected to the grounded box 7. These boxes should be made of great enough thickness to provide a complete electromagnetic shielding between the transformers. I thus provide a low potential connection from the output of one tube to the input of the next succeeding tube, and by the means described practically eliminate all electrostatic coupling between the successive stages.

I am also able to secure a marked gain in amplification by tuning the input circuits of the amplifiers by means of variable condensers 22 as indicated. The desirability of such tuning has heretofore been recognized but it has been impossible to obtain the full advantage of tuning because of the fact that it increases the tendency of the system to oscillate. The majority of transformers used between stages have also been constructed with large distributed capacity and this has prevented very sharp tuning. By employing transformers, as described, with small distributed capacity and using the construction illustrated, I am able to tune the input circuits of the amplifiers as sharply as desired without the production of oscillations and thereby obtain the advantages of tuning both as to selectivity and high degree of amplification.

In the operation of an amplifying system it is often desirable to produce both radio and audio frequency amplification. This may be done conveniently and efficiently by means of my system. Tube 1, for example, may be employed as radio frequency amplifier, tube 2 as radio frequency amplifier and detector, and tube 3 as audio frequency amplifier. By sharp audio tuning in the input circuit of tube 3 the current in the output circuit which is supplied to the receivers 23 will be so free from radio components that even though there may be an appreciable coupling outside of the box 7 between the output of tube 3 and the input of tube 1 there will be no tendency for the system to oscillate.

While I have illustrated and described only one form of my invention, it will be apparent that many modifications in the circuit arrangements used and the form of apparatus employed may be made without departing from the scope of my invention as set forth in the appended claims.

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

1. The combination in an amplifying system of a plurality of electron discharge amplifiers, each of which has an input and an output circuit, means for impressing currents which are to be amplified upon the input circuit of one of said amplifiers, a high impedance transformer primary in the output circuit of said amplifier, a transformer secondary in the input circuit of a second amplifier and a low voltage coupling between the transformer primary in the output circuit of the first and the transformer secondary in the input circuit of the second amplifier.

2. The combination in an amplifying system of a plurality of electron discharge amplifiers connected in cascade, each of which has an input and an output circuit, means for impressing currents to be amplified upon the input circuit of the first device, a high impedance in the output circuit of said device, means for transforming the electrical energy variations produced in said impedance to the form of low potential and large current, means for transforming this low potential high current energy to the form of low current high potential, and for impressing the same upon the input circuit of a second amplifier.

3. The combination in an amplifying system of a plurality of electron discharge amplifiers, each of which has an input and an output circuit, means for impressing currents which are to be amplified on the input circuit of one of said amplifiers, and means for impressing energy variations produced in the output circuit of said amplifier upon the input circuit of a second amplifier, the energy transforming means being so arranged as to avoid any appreciable electrostatic coupling between the circuits.

4. The method of operating an amplifying system comprising a plurality of electron discharge amplifiers connected in cascade, each of said amplifiers having input and output circuits which consists in applying the current to be amplified to the input circuit of one of said amplifiers, transforming the resultant energy variations produced in the output circuit of said amplifier to the form of low potential high current energy, retransforming this low potential high current energy to the form of high potential low current energy and applying the same to the input circuit of the second amplifier.

5. The combination in an amplifying system of a plurality of electron discharge amplifiers, each of which has an input and output circuit, means for impressing currents which are to be amplified upon the input circuit of one of said amplifiers, a high impedance transformer primary in the output circuit of said amplifier, a transformer secondary in the input circuit of a second amplifier, a low voltage coupling between the transformer primary in the output circuit of the first amplifier and the transformer secondary in the input circuit of the second amplifier, and means for electromagnetically shielding said transformers from the other portions of the system.

In witness whereof, I have hereunto set my hand this 7th day of May, 1920.

CHARLES A. HOXIE.