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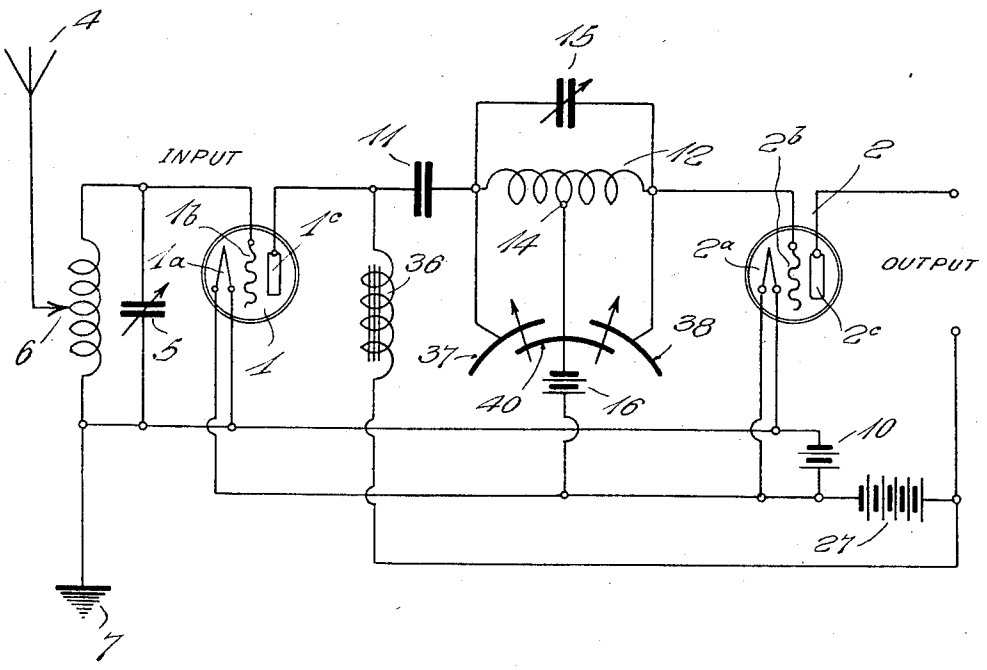
ELECTRON TUBE AMPLIFICATION SYSTEM

Original Filed April 25, 1928

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# UNITED STATES PATENT OFFICE

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## ELECTRON TUBE AMPLIFICATION SYSTEM

Original application filed April 25, 1928, Serial No. 272,766. Divided and this application filed September 21, 1931. Serial No. 564,170.

My invention relates broadly to electron tube amplification systems and more particularly to a coupling circuit for the input and output systems of electron tubes connected for amplification of energy at high frequencies.

This application is a division of my application Serial No. 272,766, filed April 25, 1928, for electron tube amplification system.

One of the objects of my invention is to provide a high frequency coupling system between the output circuit of one electron tube and the input circuit of a succeeding electron tube whereby the maximum voltage may be impressed upon the grid of the succeeding tube from the output circuit of the preceding tube and the impedance of the output circuit made equal to the internal impedance of the electron tube.

Another object of my invention is to provide a coupling system for stages of electron tube amplification including an inductance extending between the plate electrode of one stage of amplification and the grid electrode of the succeeding stage of amplification where a tapped connection is taken from a nodal point in the inductance to the filament side of the amplifier system for impressing all of the potential developed across the inductance upon the input circuit of the succeeding tube.

A further object of my invention is to provide a coupling circuit for cascaded electron tubes in which a resonance wave coil is disposed between the plate electrode of one tube and the grid electrode of a succeeding tube and the coil electrically balanced to establish a nodal point intermediate the ends with a connection taken from the nodal point to the filament circuit of the electron tubes for transferring the maximum amount of energy from the output circuit of one tube to the input circuit of the succeeding tube.

A still further object of my invention is to provide a circuit arrangement for a cascade electron tube amplifier system wherein high frequency energy is transferred through a conductively connected circuit from the output system of one electron tube to the input system of the succeeding electron tube, with a circuit for controlling the biasing potential of the succeeding electron tube connected with a nodal point in the conductively connected circuit.

Still another object of my invention is to provide a circuit arrangement for coupling the output circuit of one tube with the input circuit of a succeeding tube consisting of an inductance having a balancing condenser connected therewith for shifting the nodal point of the inductance to a position corresponding to the point of introduction of biasing potential for the grid of the succeeding electron tube of the amplifier.

My invention will be more fully understood from the specification hereinafter following by reference to the accompanying drawing which diagrammatically illustrates the circuit of my invention.

My invention is directed to improvements in cascade amplification systems for use with radio receiving and transmitting apparatus and is particularly suitable in circuits of high frequencies.

In operating a vacuum tube as an amplifier, there are two conditions that have to be complied with to enable the tube to be operated most efficiently, viz: (1) The highest possible voltage should be impressed on the grid of the tube, and (2) the external impedance of the plate circuit should equal the internal plate impedance of the tube.

In employing vacuum tubes in a cascade amplifier circuit, some form of coupling has to be used to transfer the voltage or power developed in the plate circuit of one tube to grid of the adjacent tube. There are two methods of coupling vacuum tubes used in the art at the present time, viz: (1) transformer coupling; (2) impedance coupling.

Transformer coupling operates most efficiently at low and moderate frequencies, and is very extensively used in practice; but the transformer method is not suitable for use at the higher frequencies. The same may be said of the impedance method of coupling, because in using this method of coupling, a blocking condenser and grid leak are necessary. The object of the blocking condenser is to keep the positive B voltage of the plate

from the grid of the tube to which the tube is coupled. Since this blocking condenser is in the grid circuit a path must be provided from the grid of the tube to its filament to prevent the tube becoming inoperative because of the accumulation of electrons on the grid of the tube. This is usually in the form of a high non-inductive resistance connected from grid to the filament of the tube. Now, it is well known that a non-inductive resistance does not offer much resistance to high frequency currents, consequently, the impedance of the grid leak at such frequencies would not be high enough for most efficient operation, thus failing to fulfill condition (1) viz: that the highest possible voltage be impressed on the grid of the tube. Furthermore, in the usual coupled circuit an inductance and resistance are disposed in parallel and form the load for the plate circuit of the tube. Since two or more circuits in parallel have less resistance than the same circuits in series, the impedance of the plate circuit of such coupled systems is therefore comparatively low. Therefore such coupling methods do not fulfill condition (2) viz: The external impedance of the plate circuit should equal the internal plate impedance of the tube.

In the coupling system of my invention, I provide a resonance wave coil in series between the plate electrode of one electron tube and the grid electrode of a succeeding electron tube and impress upon the resonance wave coil the energy amplified by one electron tube for transfer to the imput circuit of the succeeding electron tube. In order to impress the required biasing potential on the grid of the succeeding electron tube, I select a point of zero potential in the resonance wave coil and introduce the required potential at that point in a manner which tends to eliminate losses in the coupling system.

In the radio frequency amplification system of my invention the circuits are tuned to secure maximum selectivity and the maximum impedance that can be inserted in the tuned circuit is the impedance of the tuning coil at resonance. Therefore, by putting the tuning coil and grid-filament circuit of the coupled tube in series in the plate circuit of the amplifying tube, condition (2) is fulfilled, viz: The external impedance of the plate circuit should equal the internal plate impedance of the tube. Also since there is no grid leak to shunt any of the high frequencies around the grid-filament circuit, the full voltage is developed by the resonance coil and impressed on the grid of the tube, thus fulfilling condition (1), viz: The highest possible voltage be impressed on the grid of the tube.

Referring to the drawing in more detail, the amplification system of my invention is shown connected to an antenna ground system 4—7 including electron tubes 1, 2 and 3. A tuned circuit 5—6 is employed for coupling the antenna ground system to the input of the radio frequency amplifier 1. Each electron tube contains cathode, grid and plate electrodes which I have designated by subscripts 1*a*, 1*b*, 1*c*, and 2*a*, 2*b* and 2*c*. The output circuit of the electron tube 1 includes impedance 36 and high potential source 27. A connection is established with the input circuit of the succeeding electron tube 2 through blocking condenser 11 and resonance wave coil 12. A condenser 15 is connected across the terminals of the resonance wave coil 12 and serves to tune the resonace wave coil. The opposite terminal of the resonance wave coil 12 connects to the grid 2*b*. The resonance wave coil transfers the energy from the output circuit of electron tube 1 to the input circuit of electron tube 2. In order to secure the proper biasing potential on the grid of electron tube 2, a connection is taken from the negative side of the source of potential shown at 16 and connected at 14 to a nodal point along the resonance wave coil.

The condenser system constituted by plates 37, 38 and 40 provides means for more accurately fixing the zero potential point in the resonance wave coil 12. The condenser system has a fixed plate 37 connected to one terminal of the resonance wave coil and a fixed plate 38 connected to the opposite terminal of the wave coil. The center point 14 of the resonance wave coil 12 connects to variable plate 40 and to the source of the biasing potential at 16. The zero potential point may be thus selected in the resonance wave coil and the proper bias introduced through the resonance wave coil at that point through the grid circuit to the grid electrode 2*b*. The plate potential for electron tube 1 which is supplied from source 27 is blocked from the grid circuit of electron tube 2 by means of condenser 11 and passes through impedance 36 to the plate electrode 1*c*. The output circuit of tube 2 connects to a succeeding stage or to a sound reproducer system.

I have found that in the operation of the amplification system of my invention that substantially all of the potential developed in the output circuit of one electron tube may be impressed upon the circuit of a succeeding electron tube. In this way, maximum volume of signal energy may be rendered effective to actuate a sound reproducer. The normal capacity of electron tube 2 is in series with the isolated circuit formed by inductance 12 and condenser 15. I am enabled to secure increased amplification by the circuit arrangement described over that amplification heretofore obtainable with a similar number of tubes.

While I have described my invention in

one of its preferred embodiments, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

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

1. An amplification system comprising means for coupling successive electron tube stages including a resonance wave coil disposed in series between the output circuit of one electron tube stage and the input circuit of a succeeding electron tube stage, a tuning condenser connected across the ends of said resonance wave coil, means for introducing a potential for biasing the input circuit of the succeeding amplification stage at substantially the midpoint of said resonance wave coil, and a balancing condenser for shifting the nodal point of said resonance wave coil to a position corresponding with the point of introduction of the biasing potential therein, said balancing condenser including a fixed plate connected with each end of said resonance wave coil and a movable plate connected with the midpoint of said resonance wave coil and shiftable to vary the capacity across either portion of said resonance wave coil.

2. A coupling system for high frequency electron tube amplifiers comprising in combination with the output circuit of one electron tube and the input circuit of a succeeding electron tube, a resonance wave coil, connections between one end of the resonance wave coil and the output circuit of one electron tube, connections between the opposite end of the resonance wave coil and the input circuit of the succeeding electron tube, tuning means connected across said resonance wave coil, a circuit connected with the midpoint of said resonance wave coil for introducing biasing potential for the input circuit of the succeeding electron tube and a balancing condenser system including three capacity areas, a connection between opposite ends of said resonance wave coil and one of each of said capacity areas, a connection between the remaining capacity area and the midpoint of said resonance wave coil, said last mentioned capacity area being adjustable with respect to the others of said capacity areas for locating the point of zero potential of said wave coil at the mid-connection point along said resonance wave coil.

In testimony whereof, I affix my signature.

BENJAMIN F. LEE.