

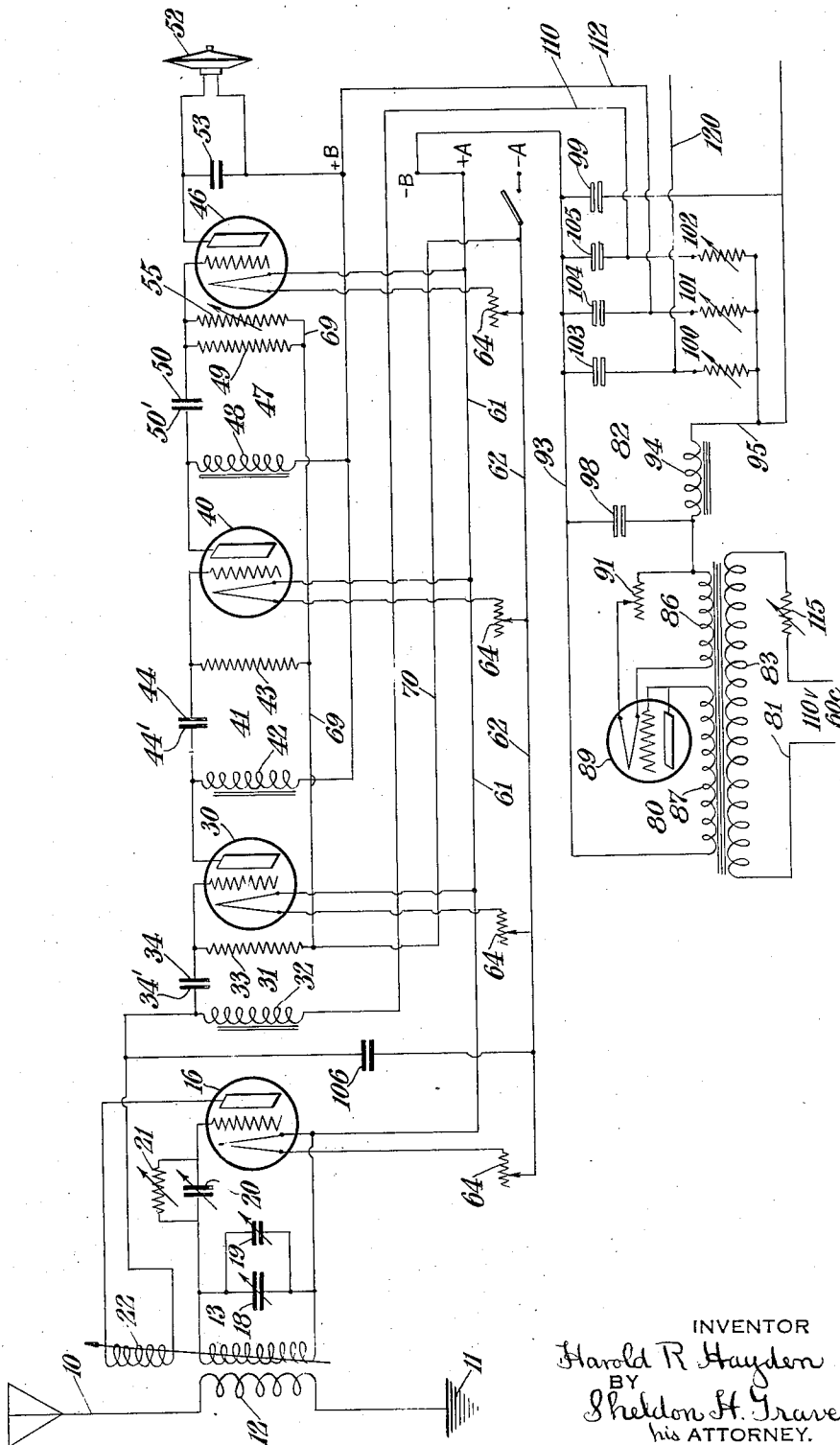
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ELECTRICAL SIGNALING SYSTEM

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ELECTRICAL SIGNALING SYSTEM

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This invention relates to electrical systems employing three-electrode vacuum tubes as repeaters or amplifiers.

The system herein disclosed is a multi-stage signal receiving system, employing a detector stage followed by several stages of audio frequency amplification, and each of the audio frequency stages is coupled to the preceding stage by a so-called impedance coupling; the last audio frequency stage serving to operate a loud speaker of other signal-translating device. Each stage of the system includes a three electrode vacuum tube, the plate circuit of which is energized from a source of fluctuating direct current, such for example as from an alternating current supply system through a rectifier and filter. The filaments of the several tubes may be supplied with direct current from any suitable source, such as a battery or if desired means may be provided for maintaining the battery charged from the same source of alternating current as supplies the plate circuits. I may, however, if desired, supply the filament of the tubes with alternating current.

The use of alternating current as a source of supply for the tube circuits tends to create disturbing current variations in the output circuit of the last tube, thus interfering with the satisfactory reception of signals. With the plate circuits of the tubes supplied from a source of alternating current through a rectifier and filter the current supplied to the tube circuits, although unidirectional, is subject to variations of low frequency which tend to produce a disturbing noise in the loud speaker. This effect is more pronounced in systems employing a plurality of stages arranged in tandem and coupled to one another by audio frequency couplings, as in the case of a multi-stage audio frequency amplifier, because the low frequency hum variations in the plate circuits of the first stages are readily carried over through the audio frequency couplings to the grid circuits of succeeding stages and are amplified in the succeeding stages. Similarly when alternating current is employed in the filaments of the tubes, the alternate heating and cooling of the filament as well as other effects caused by the alternating current in the filament, tends to cause disturbing current variations in the tube plate circuits, which tendency is more pronounced in the case of multi-stage audio frequency amplifiers.

One important object of the present invention is to provide a system of this general character wherein a source of fluctuating current is em-

ployed for energizing one or more of the tube circuits and wherein disturbing current variations in the plate circuit of the last stage are substantially reduced or eliminated.

A further object of my invention is to provide a receiving system with the parts so constructed and arranged that the tube circuits may be supplied from a source of fluctuating current or potential and the disturbing effects caused by the fluctuations in the supply will be balanced out in the receiving system so that little or no disturbing variations will occur in the plate circuit of the last tube.

In systems constructed in accordance with my invention, which are designed to eliminate hum, I make use of an interstage coupling so constructed and arranged that disturbing current variations in an earlier stage are reversed in phase and the reversed variations are caused to oppose in their effect, the effect of similar disturbing current variations in a later stage. In that form of invention disclosed I employ as couplings between successive stages, reactance couplings or the so-called impedance couplings. These couplings serve to impress on the grid of the following tube, potential variations which are dependent upon potential variations at some part of or point in the plate circuit of the preceding tube. By proper construction and arrangement of the couplings or of the circuits with which they are connected I am able to cause variations occurring in a preceding stage to oppose similar variations arising in the following stage, and a further object of my invention is to provide a system of this character wherein the opposing variations are of substantially equal magnitude and substantially 180 degrees out of phase with one another, whereby the opposing variations substantially balance and neutralize one another, as will be more fully explained hereafter.

Further features of my improved signal receiving system include high selectivity in tuning for the reception of signal waves of different frequencies, a maximum amplification of the received signals, a minimum expenditure of power in the receiving circuits, the reproduction of the received signals without substantial distortion and the elimination of disturbing current variation due to regenerative or similar effects.

Other objects and advantages of my invention will appear from the following description taken in connection with the accompanying drawing which shows a circuit diagram of a signal receiving system embodying one form of my invention.

In the drawing reference character 10 represents an antenna adapted to receive signal waves. The antenna is grounded at 11 through a winding 12 positioned in inductive relation to a winding 13 included in the grid circuit of a detector tube 16. Connected across the terminals of the winding 13 is a condenser 18 which is adjustable to tune the grid circuit of the detector to the frequency of incoming signals to be received. For the purpose of providing a finer tuning adjustment, I may, if desired, employ a smaller condenser 19 in shunt to the condenser 18. One side of condenser 18 and 19 is connected to the filament of tube 16 and the other side is connected to the grid of tube 16 through an adjustable condenser 20 of small capacity and, in parallel with the condenser 20, a high resistance 21 which is also adjustable.

Connected in series with the plate of the detector tube 16 is a winding 22 positioned in inductive relation to the grid circuit winding 13. Winding 22 is adjustable relative to winding 13 so as to alter the mutual inductance between the two windings. The windings 12, 13 and 22 form a so-called three-circuit tuner and these windings are preferably constructed and arranged as described in my copending application, Serial Number 299,680, filed August 15th, 1928, Patent No. 1,881,357, October 4, 1932.

The plate circuit of tube 16 is coupled to the grid circuit of the first audio frequency amplifying tube 30, through an impedance coupling 31 consisting of an inductance or inductive impedance 32 in the plate circuit of tube 16, a resistance 33 in the grid circuit of tube 30 and a condenser 34 connecting similar terminals of the impedance and resistance, as shown.

The grid circuit of the second audio frequency amplifying tube 40 is coupled to the plate circuit of the tube 30 by an impedance coupling 41 comprising an impedance 42, resistance 43 and condenser 44, connected as shown. Similarly the grid of the amplifier tube 46, which in the system shown, is in the last stage of amplification, is coupled to the plate circuit of tube 40 by an impedance coupling 47 comprising an impedance 48, resistance 49 and condenser 50. The highly amplified currents in the plate circuit of the final amplifier tube 46, serve to operate a loud speaker, or other signal translating device 52. The loud speaker may be shunted by a condenser 53 of small capacity. If desired, the resistance 49 of the coupler 47 may be shunted by a resistance 55 which is adjustable to control the volume of sound in the loud speaker.

Heating current for the filaments of the detector and amplifying tubes is supplied from a source of current connected to the terminals +A and -A. This source of current may be a battery or direct current lighting mains. In certain cases also I may employ alternating current in the filament heating circuits.

The +A terminal is connected to the positive terminal of each filament through a conductor 61 and the -A terminal is connected to the negative terminal of each filament through a conductor 62 and a rheostat 64 in each local filament circuit. It will be seen, in the particular circuit arrangement shown, that the filaments of the several tubes are connected with the source of supply, in parallel with one another and the current through each filament can be controlled by a rheostat 64, independently of the currents in the other filaments.

The grids of the amplifier tubes are connected

to the negative side of the filament supply through conductors 69 and 70. I find when employing 301-A tubes and using a five volt source of supply for the filaments, that with adjustment of the rheostats 64 to include several ohms in the filament circuits, the arrangement shown gives a satisfactory grid biasing voltage for the amplifier tubes. It will of course be understood that I may, if desired, to secure the grid biasing voltage, employ a potentiometer across the filament supply with a tap or taps to the respective grids. Also I may, if desired, employ a grid biasing battery. The system shown, however, has the advantage that such additional grid biasing means is unnecessary. The grid of detector tube 16 is connected to the positive terminal of the filament of this tube through the winding 13 and the grid biasing resistance 21.

Connected across the inductance 32 and source of filament supply is a condenser 106 of small capacity, which forms a path of low impedance for the high frequency components of the detector tube plate current.

For the purpose of supplying direct current for energizing the plate circuits of the tubes, I provide a rectifier 80, adapted to be energized from a source of alternating current indicated at 81, which source may be the usual alternating current house lighting mains, and connected with the output circuit of the rectifier 80 is a filter 82.

Reference character 83 represents the primary of an alternating current transformer, supplied from the mains 81. Reference characters 86 and 87 represent respectively low and high voltage secondaries of the transformer. The rectifier 80 in the form of invention shown comprises a vacuum tube 89, the plate and grid of which are connected with one terminal of the secondary winding 87 and the filament of which is connected across the secondary winding 86 through a current controlling rheostat 91. The other terminal of the secondary winding 87 is connected to the positive terminal of the filament supply through a conductor 93 which forms the negative supply conductor for the plate circuits from the rectifier and filter. One terminal of the secondary 86 is connected through a reactance coil 94 of relatively high impedance to the conductor 95 which forms the positive terminal conductor of the filter. Connected across the filter output circuit at opposite sides of the reactance 94 are high capacity condensers 98 and 99, of say approximately 2 mfd. capacity each, more or less; and also connected across the output circuit between the conductors 93 and 95, are three parallel circuits, each comprising an adjustable resistance, 100, 101 and 102, respectively, of relatively high value, such for example as 10,000 to 100,000 ohms, and in series with each resistance a high capacity condenser, 103, 104 and 105, respectively. Condensers 103, 104 and 105 will ordinarily be of considerably less capacity than the condensers 98 and 99. All condensers employed may, if desired, be the usual by-pass condensers of relatively low voltage test.

Leading from a point between the resistance 102 and condenser 105 is a conductor 110 which connects through the reactance 32 and winding 22 with the plate of the detector tube. The plates of the remaining tubes are connected to a point between the resistance 101 and condenser 104 by a conductor 112.

The tap or conductor 110 supplies current to the plate of the detector tube at relatively low voltage, such for example at 15 volts. Tap or

conductor 112 supplies to the plate circuits of the amplifier tubes a relatively higher voltage, such for example as 75 volts. The conductor 95 or the tap 120, which connects with a point between the resistance 100 and condenser 103 may, with the resistance 100 properly adjusted, be employed, when higher plate voltages are required, as for example when a power tube is employed in the last stage of amplification. When the detector stages are preceded by one or more stages of radio-frequency amplification, I may energize the radio-frequency tube plate circuits from the tap 120 or tap 112. It will be understood that adjustment of the resistances 100 to 102 permits adjustment of the voltages of the taps over a relatively wide range to satisfy the requirements of the various tubes. While I have shown three taps in addition to the positive terminal conductor 95, it is obvious in certain cases that this number of taps is not necessary. Thus with the rectifier and filter designed to give proper voltage, I may supply the plates of one or more of the tubes, taking a higher voltage, directly from the terminal conductor 95.

The condensers 103 to 105 may also be adjustable to vary their effective capacities. Thus, in place of each of these condensers I may substitute a fixed condenser and a variable condenser in parallel therewith.

The rectifier and filter as above described may be built as a separate unit and designed to be connected with the receiving system by a conductor cord or cable containing the various output conductors.

In considering the operation of my improved system, in eliminating hum due to variations of current supplied by the filter to the tube circuits, it is to be noted that the hum current variations in the plate circuit of any tube except the first, are the result of two effects, that of filter voltage variations applied directly to the plate circuit of that tube and that of filter voltage variations supplied to plate circuits of preceding tubes, and carried over to the grid of that tube. Thus a momentary rise in voltage applied by the filter to the plate circuit of the last tube, would, if acting alone, cause an increase in current in the plate circuit. If, however, simultaneously with the increase of the voltage applied directly to the plate circuit of the last tube, the effect of the increase in filter voltage as applied to the plate circuits of the preceding tubes is to cause the potential of the grid of the last tube to become less positive, these two effects will oppose one another and reduce the resultant current variations in the plate circuit of the last tube. If the amplitude of the variations of grid potential and filter voltage variations applied directly to the plate circuit are properly related in value, these two effects may be caused to cancel one another. It is one feature of the present invention to secure this result or to so fix or control the relative values of these two effects with respect to amplitude and phase, that current variations in the plate circuit of the last tube are maintained at such low amplitude as not to mask or materially interfere with the reception of signals.

Referring to the drawing the couplings shown are reactance couplings, comprising coupling condensers 34, 44 and 50. These couplings serve to transfer to the grids of the succeeding tubes potential variations which are proportional to the potential variations of that point of the preceding tube plate circuit which is connected

to the coupling condenser. Thus, due to a rise in the filter voltage applied to the detector tube plate circuit, there is a rise in potential at the point 34' and a resulting increase in the potential of the grid of tube 30. The increase in potential of the grid of tube 30 causes a decrease in the internal impedance of the tube tending to allow more current to flow through the plate circuit of this tube and also tending to decrease the potential of the point 44' in the plate circuit, which is connected to the coupling condenser 44. Due also to the rise in the filter voltage, this voltage, applied directly to the plate circuit of tube 30 causes an increase in current in the plate circuit and a tendency to increase the potential of the point 44'. The point 44' is thus subject to two effects, one tending to raise its potential and one tending to lower its potential. If these two effects are equal and opposite, there will be no change of potential of the point 44' because of variations in this filter voltage and therefore no variations from this source will be passed on to the grid of tube 40. If the effect of variations in the grid of tube 30 predominates over the effect of filter voltage variations applied directly to the plate circuit of tube 30, the potential at the point 44' will decrease. If on the other hand, the filter voltage variations applied directly to the plate circuit of tube 30 predominate over the effect of the grid variations of tube 30, the potential of point 44' and consequently the potential of the grid of tube 40 will increase due to the rise of filter voltage.

It will thus be seen that by control of the amplitude of the voltage variations delivered directly to the plate circuit of tube 30, or of the amplitude of the variations in the grid potential of tube 30 and by control of the phase displacement of one of these variations relative to the other, the effects of these two variations may cancel one another or the two may combine to produce a resultant effect in phase or out of phase with one or the other of the two effects.

In considering the potential variation at the point 34' due to variations of filter voltage, it is to be noted that these variations lag with respect to the variations in filter voltage, due to the inductance of the coupling impedance 32. Similarly the voltage variations at the point 44', due to filter voltage variations applied directly to the plate circuit of tube 30, lag with respect to these filter variations, due to the inductance of coupling impedance 42. Also it is to be noted that variations of the grid potential of tube 30, caused by potential variations of the point 34', lead with respect to the potential variations of point 34', due to the capacity of the coupling condenser 34.

The potential variations at the point 50' in the plate circuit of the tube 40 are likewise dependent on variations of potential of the grid of tube 40 and variations of filter voltage applied directly to the plate circuit of this tube, and whatever variations result from the combined effects of the two former variations are carried over to the grid of the last amplifier tube.

The quantitative values of the potential variations at points 34', 44', and 50' may be expressed very closely as follows:

Neglecting the effect of the small condenser 106, and letting e be the voltage variations of the filter output circuit, that is, the variations between conductors 93 and 95, r_0 the value of resistance 102, C_0 the capacity of condenser 105, r_d the impedance of the detector tube, Z_1 the im-

pedance 32, then the potential variations at the point 34' will be

$$dV_1 = \frac{er_d}{r_0[1+j2\pi fC_0(r_d+Z_1)]+r_d+Z_1} \quad (1)$$

and if dV_1' represents the potential variations of the grid of tube 30, then

$$dV_1' = dV_1 \frac{r_{1g}}{\sqrt{r_{1g}^2 - \left(\frac{1}{2\pi fC_1}\right)^2}} \quad (2)$$

where r_{1g} represents the value of the resistance 33 and C_1 the capacity of condenser 34.

The voltage variations dV_1' on the grid of tube 30 will be amplified by the tube 30, and cause varying potential effects at the point 44' in the plate circuit of tube 30. These latter effects will combine with the varying potential effects at this point, caused by the varying filter voltage applied directly to the plate circuit of tube 30. The direct effects at the point 44' may be expressed quantitatively by an equation similar in form to Equation (1). Assuming that the resistance 101 is adjusted to a low value so that substantially the entire filter voltage is applied to the plate circuit of tube 30, the direct effect at the point 44' may be expressed quantitatively, as

$$dV_{2a} = e \frac{r_{2p}}{r_{2p} + Z_2} \quad (3)$$

where r_{2p} is internal impedance of tube 30 and Z_2 is the value of impedance 42. With the assumed conditions the actual potential variations, dV_2 , at the point 44' which is the sum of the direct and indirect effects at this point will be

$$dV_2 = \frac{1}{r_{2p} + Z_2} (er_{2p} - \mu_2 dV_1' Z_2) \quad (4)$$

where μ_2 is the amplifying factor of tube 30.

Similarly, under these conditions the resultant variations at the point 50' in the plate circuit of tube 40 will be

$$dV_3 = \frac{1}{r_{3p} + Z_3} (er_{3p} - \mu_3 dV_2' Z_3) \quad (5)$$

where r_{3p} is the impedance of tube 40, Z_3 the value of impedance 48, μ_3 the amplifying factor of tube 40 and dV_2' the potential variations of the grid of tube 40 caused by the varying filter voltage applied to the preceding tubes.

For complete elimination of hum the direct and indirect effects from the filter should introduce equal and opposite E. M. F.'s in the loud speaker circuit. Calling the indirect effect $-\mu_3 n dV_3$ where n is a factor dependent on the capacity of condenser 50, the condition for no hum is

$$e - \mu_3 n dV_3 = 0 \quad (6)$$

By properly relating the electrical quantities in the system as expressed generally in the above equations, variations may be introduced into the grid of the last tube, the effect of which when combined with the effect of variations in the filter voltage applied directly to the plate circuit of the last tube, will so reduce the current variations in this plate circuit that no audible hum will be produced in the telephone or loud speaker. The system above described represents one embodiment of my invention wherein this result is attained and wherein signals may be received by the system and amplified efficiently. Not only may the opposing variations in the plate circuit of the last tube be made of equal amplitude, but they may if desired be made opposite in phase to the variations which they opposed.

By proper construction phase displacement caused for example by the coupling condensers may be compensated for and the potential variation passed on through one or more of the tubes be completely neutralized. Thus in order to compensate for the phase displacement of the indirect effects due to the coupling condensers, different coupling impedances may be made of different values, so that the direct effects at one or another of the points 44' and 50' shall be displaced from the indirect effects by 180 degrees or more or less as desired. In this connection it is to be noted that the plate circuits which are coupled to a following stage, each comprises a resistance at one side of the coupling point, namely the tube resistance, and a reactance and resistance at the other side of the coupling point. The phase of the direct effects at the coupling point with respect to the phase of the filter voltage variation is dependent on the relation of the inductance to the total resistance of the plate circuit and with a given phase displacement, the amplitude of the direct effects at the coupling point, with reference to the amplitude of the filter voltage variations, depends upon what proportion of the total resistance is at one side of the coupling point. It is therefore apparent that by properly arranging the resistance at opposite sides of this coupling point and by properly relating the inductance of the plate circuit to its total resistance, the direct effects at the coupling points may be made of the amplitude and phase required for neutralization. Furthermore, the system provides a number of adjustments whereby these effects may be controlled and at the same time secure efficient reception of signal. Thus, the rheostats for controlling the currents in the individual filaments provide a means for controlling the internal impedance of the tubes independently of one another by changing the grid bias of the tubes and by controlling the supply of electrons emitted from the filament. Also adjustment of the grid leak resistance 21 controls the internal impedance of the detector tube and thus controls the direct effect at the point 34'. Similarly the rheostats 100 and 101 control the voltages supplied to the plates of the several tubes and thus control the direct effects respectively at the point 34' and at the points 44' and 50'.

Inasmuch as variations in the earlier stages are amplified in succeeding stages, the same adjustments in the earlier stages produce much greater effect in the output circuit of the last tube than corresponding adjustments in the later stages. The arrangement in the filter circuit of the resistance 102 in series with the detector plate circuit and the condenser 105 across the detector plate circuit is of decided advantage. The condenser which does not permit the passage of the direct component of the filter current, forms a by-pass for the varying component, thus acting to reduce materially the variations applied to the detector tube circuit and at the same time avoids excessive consumption of current from the filter. In this connection it is to be noted that the filter does not comprise any connection across the filter output which will permit the passage of the direct component of the filter current.

It will be seen from an inspection of the foregoing equations that hum may be controlled by adjustments other than those above mentioned. Means may be provided for varying the values of the impedances in the plate circuit, adjustable rheostats may be placed in the plate circuit at

one or at both sides of the coupling points, thus providing means for controlling the direct effects at the coupling points. The circuit disclosed provides means for opposing the canceling disturbing current variations of altered phase whether the phase alteration is caused by an impedance coupling, transformer coupling, or coupling of any other type.

The phase displacement of the indirect effects due to the coupling condensers may be lessened by employing coupling condensers of greater capacity. I, however, find certain advantages in employing coupling condensers of relatively small capacity. By eliminating the condensers and employing the so-called direct coupling, I eliminate the phase shift from this source.

Inasmuch as hum is eliminated by causing the effect of variations in filter voltage applied to one part of the system to oppose or cancel the effect of filter variations applied to another part of the system, the amplitude of the filter variations may be changed without affecting the hum, thus making it possible to employ relatively cheap filters wherein the output voltage is subject to relatively large periodic variations. In one system built by me, the condensers have an aggregate capacity of 5.75 mfd. and I find that I can reduce this capacity by a substantial amount without affecting the reception, detection and amplification of the received signals.

For heating the filaments of the system disclosed, I may, if desired, employ alternating current and eliminate disturbing current variations arising not only from the filter variation, but also from the variations in the filament heating circuits. One embodiment of such a system would include an alternating current source of supply for the filament heating circuits, such for example as another secondary winding on the supply transformer which is connected to the filaments of the amplifier tubes to supply alternating current therethrough, and as a detector tube I may employ an alternating current tube of the indirectly heated type. The grid circuits are connected in the usual manner, employing potentiometers across the alternating current supply and suitable means is provided for supplying the requisite grid biasing voltages.

The alternating current in the filaments tends to cause fluctuations in the plate current due to variations in the supply of electrons and their flow to the plate. Thus the periodic cooling of the filament at times of low current tends to diminish the emission from the filament. Other effects tend to produce the same result as for example the magnetic effects due to the change in current in this filament. When these effects cause more current to flow in the plate circuit of a tube coupled to a succeeding tube by an impedance resistance or other coupling of the character shown, the potential of the coupling point in the plate circuit is lowered and as a result the grid potential of the succeeding tube is lowered. This tends to cause a decrease in the plate current in the following tube. If simultaneously with this tendency to decrease the plate current in the following tube, there is a tendency to increase the plate current in the following tube due to the effect of the alternating current in the filament of the following tube, these two tendencies will oppose one another, and can readily be controlled so that there will be no variations in the output circuit of the last tube. In a system such as that shown any residual variations derived from the filament

heating currents, such as might be caused by differences in magnitude or phase of the direct and indirect effects, can be substantially eliminated by introducing from the filter opposing variations of the proper amplitude and phase and of the same frequency which frequency will generally be twice that of the alternating current which supplies the filaments and rectifier.

I may, if desired, employ in connection with the system shown in the drawing one or more stages of radio-frequency amplification preceding the detector stage. In such case the coil 12 may be in the plate circuit of the last stage of radio frequency amplification. The first stage may be coupled to the antenna circuit and the successive stages of radio-frequency amplification may be coupled by radio-frequency transformers constructed as described in my copending application above referred to.

I preferably include in series with the primary of the supply transformer, a resistance which is adjustable to compensate for changes in the voltage of the supply mains.

Having now described my invention, what I claim and desire to secure by Letters Patent is:

1. A multi-stage vacuum tube signal repeating system, having a detector stage followed by a plurality of stages of audio amplification, couplings between successive stages, at least one of said couplings being an impedance coupling, a means for energizing the plate circuits of the several tubes, consisting of a rectifier, a filter connected to said rectifier, said filter offering substantially infinite shunt resistance to the flow of direct current and comprising a reactance in its output circuit, condensers across said output circuit at opposite sides of said reactance, a connection across said output circuit beyond said reactance, said connection comprising a resistance and a condenser in series therewith, the plate circuit of the detector tube being connected across said last named condenser and connections for supplying the plate circuits of the amplifier tubes from said filter, the parts being so constructed and arranged that disturbing variations supplied by the filter to the detector plate circuit, when carried forward through the impedance coupling, serve to eliminate disturbing variations supplied to subsequent stages whereby hum is eliminated from the output circuit of the system.

2. In a multi-stage vacuum tube amplifier, a loud speaker, a source of current adapted to supply to the system currents which are subject to variations which tend to cause hum in the loud speaker, an impedance coupling connected with the plate circuit of a tube and adapted to produce in its output circuit variations which oppose in phase variations supplied from said source to a circuit succeeding said coupling, said coupling comprising a reactance which tends to cause such opposing variations to differ in phase from the variations supplied to such succeeding circuit by an amount other than 180° and impedances of different values in the circuits preceding and succeeding said coupling for causing such opposing effects to differ in phase by substantially 180° whereby hum in the loud speaker is eliminated.

3. In a multi-stage vacuum tube amplifier, a loud speaker, a source of current adapted to supply to the plate circuits of the system, currents which are subject to variations which tend to cause hum in the loud speaker, an impedance coupling between two of the stages, adapted to produce at the stage succeeding said coupling, variations which oppose in phase variations supplied

from said source to said latter stage, said coupling comprising a reactance which tends to cause such opposing variations to differ in phase from the variations supplied from said source to such succeeding stage by an amount other than 180° and impedances of different values in said stages for causing the opposing effects in a succeeding stage to differ in phase by substantially 180° , whereby hum in the loud speaker is substantially eliminated.

4. An inductance coupled multi-stage vacuum tube signal receiving and amplifying system having audio frequency amplifying and detector stages with couplings which serve to reverse the phase of preceding grid potential variations, means for energizing plate circuits by current subject to fluctuations which tend to produce disturbing variations in the output circuit, and means for relating the fluctuations in their respective circuits so as effectively to eliminate disturbing fluctuations in the output, said means comprising a filter for reducing the fluctuations supplied to the plate circuit of a detector tube to a small fraction of those supplied to the plate of a later tube.

5. An inductance coupled multi-stage vacuum tube signal receiving and amplifying system having audio frequency amplifying stages and a detector stage with couplings which serve to reverse the phase of preceding grid potential variations, means for energizing plate circuits by current subject to fluctuations which tends to produce disturbing variations in the output circuit, means for relating the fluctuations in their respective circuits so as effectively to eliminate disturbing fluctuations in the output, said means comprising a filter for reducing the fluctuations supplied to the plate circuit of a detector tube to a small fraction of those supplied to the plates of later tubes, and means for compensating for slight phase shifts through the couplings whereby variations carried forward from one stage to another are of substantially opposite phase to those supplied directly to a later stage.

6. In a multi-stage vacuum tube amplifier system, means for energizing tube circuits from a source of varying potential which causes disturbing variations in the plate circuits of said tubes, couplings adapted to transmit said variations to subsequent stages in altered phase, two of said couplings being inductance couplings and the inductances of different couplings having predetermined different values whereby the effect of variations supplied to a later stage through a subsequent stage are substantially 180° out of phase with variations supplied directly to said later stage and the alteration of phase caused by said couplings is compensated for and disturbing variations in the output circuit of the system are eliminated.

7. In a multi-stage vacuum tube amplifying system, means for energizing tube circuits from a source of varying potential which causes disturbing variations in the plate circuits of the tubes, couplings adapted to transmit said variations to subsequent stages in altered phase, two of said couplings being reactance couplings and the reactances of different couplings having predetermined different values whereby the effect of variations supplied to a later stage through a subsequent stage are substantially 180° out of phase with variations supplied directly to said later stage and the alteration of phase caused by said couplings is compensated for and disturbing variations in the output circuit of the system are eliminated.

8. In a multi-stage vacuum tube amplifying system, means for energizing a tube circuit from a source of varying potential which causes disturbing variations in the plate circuit of said tube, a coupling adapted to transmit said variations to a subsequent stage of said system in altered phase, and means for correcting the effect in a subsequent stage, of the alteration of phase introduced by said coupling.

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