

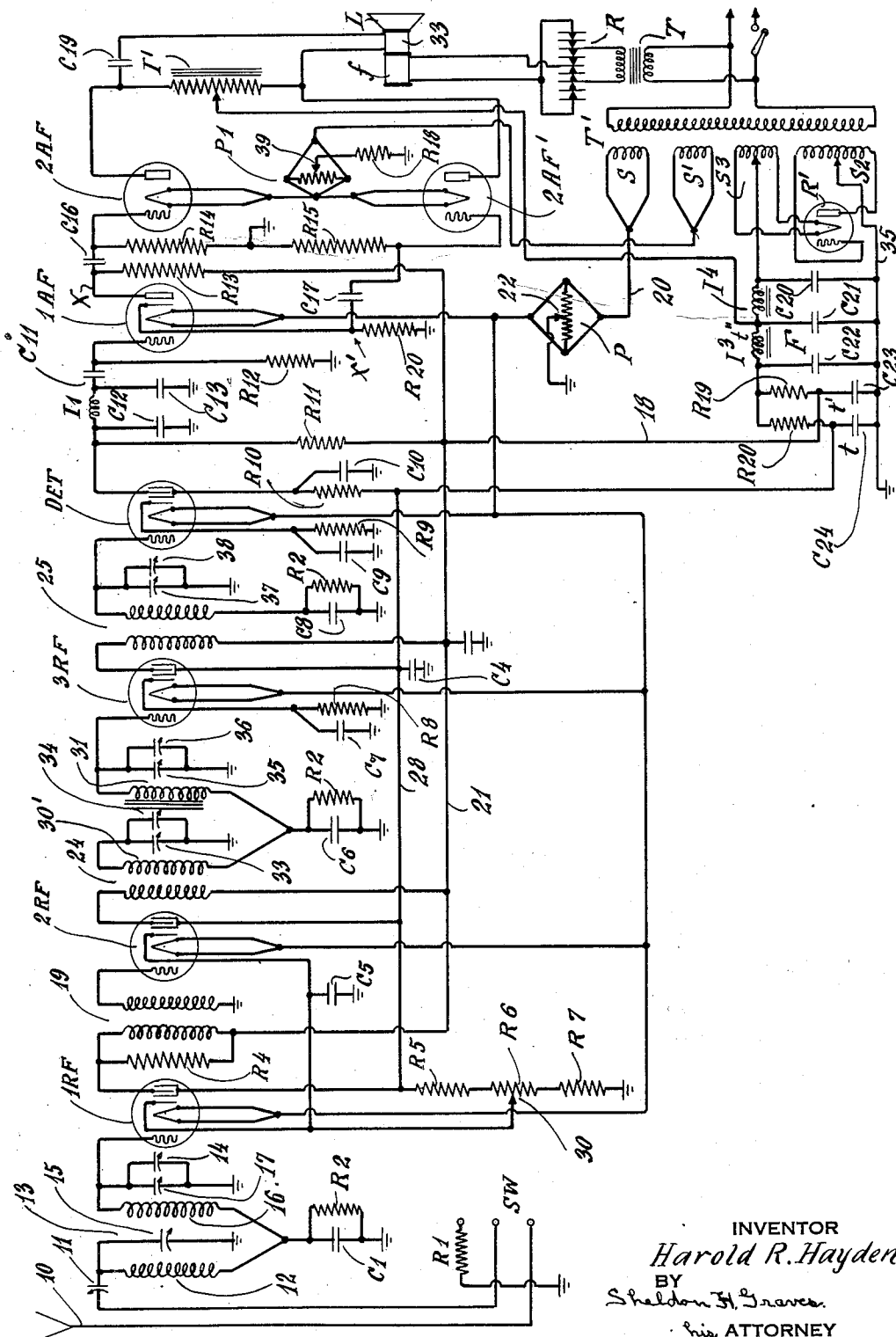
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SIGNAL REPEATING SYSTEM

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SIGNAL REPEATING SYSTEM

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This invention relates to vacuum tube signal repeating systems and more particularly to an improved amplifying system.

In the specific embodiment of my invention herein disclosed, the system comprises successive radio frequency amplifying stages, a detector stage and audio frequency amplifying stages. One of the audio frequency amplifying stages is a push pull stage and my invention consists in part of an improved resistance or similar coupling between the push pull stage and the preceding stage. One characteristic of such a coupling is that the impulses transmitted to the push pull are dependent upon variations of potential of points in the plate circuit of the preceding stage.

Among the objects of my invention is to provide an improved receiving and reproducing system of this general character which is free from disturbing noises, such as may be caused by regeneration, feed back or hum derived from an alternating current source of supply and further to provide a system which will accurately reproduce incoming signals over a wide frequency range.

The drawing shows diagrammatically one embodiment of my invention.

The system disclosed in the drawing comprises three stages of radio frequency amplification, a detector stage and two stages of audio frequency amplification, the second of which is a push pull stage which as shown is coupled to a dynamic loud speaker. Power for energizing the system is supplied from alternating current lighting means which are connected to a transformer T and thence through a rectifier R to supply the field coil F of a loud speaker L. A second transformer T' is provided with secondaries S and S1 for supplying alternating current for heating the tube cathodes, while secondaries S2 and S3 energize the plate and cathode heating circuits respectively of a rectifier tube R' which supplies the plate circuits of the signal tubes through a filter F.

Reference character 10 represents an antenna for receiving signal waves and Sw a double throw switch designed to connect the antenna to ground through a tuning condenser 11, primary 12 of a transformer 13 and a resistance R2 shunted by a fixed condenser C1 of small capacity. A tuning condenser 15 connects a point in the antenna circuit between condenser 11 and coil 12, with ground. The secondary 16 of the transformer 13 is connected at one end to the grid of tube 1RF and its opposite end is connected to ground through condenser C1 and resistance R2. Grid of tube 1RF is also connected to ground

through a tuning condenser 17 shunted by a trimming condenser 14.

When it is desired to receive incoming signals without using the antenna 10, switch Sw is moved to a position to connect the upper terminal of coil 12 to ground through condenser 11 and a resistance R1.

In the embodiment of the invention disclosed tubes 1RF, 2RF, 3RF and the detector tube DET are screen grid tubes having indirectly heated cathodes as shown conventionally in the drawing. Tube 1AF and tubes 2AF and 2AF' are three electrode tubes, the cathodes of the latter being directly heated by current passing therethrough. The plate or anode of each of the radio frequency tubes and the detector tube is connected to the supply conductors 18 and 21 through the primary of the coupling transformer 19, 24 and 25 respectively for the radio frequency tubes and a resistance R11 for the detector tube.

The heater for the cathodes of the radio frequency, detector and first audio frequency tubes are connected to the secondary S of the transformer T' through a supply circuit 20. A potentiometer P is connected across the supply circuit and an adjustable contact or slider 22 connects an intermediate point with the ground or negative side of the filter.

The screen grids of tubes 1RF, 2RF, and 3RF are connected to a common conductor 28 and the screen grid of tube DET is connected to this conductor through a high resistance R10 shunted by a condenser C10. Conductor 28 is connected to ground through a condenser C4 and is connected to a low voltage tap t of the filter F. Conductor 28 is also connected to ground through three resistances R5, R6 and R7 arranged in series. Resistance R6 is provided with a slider which is connected to the cathodes of tubes 1RF and 2RF and the cathodes of these tubes are also connected to ground through a condenser C5.

Radio frequency transformer 24 has two secondaries 30' and 31 respectively. Secondary 30 is grounded at one end through an adjustable condenser 33 shunted by a trimming condenser 34 and at the other end grounded through a fixed condenser C6 shunted by a resistance R2, this resistance and condenser also serving as a connection to ground for one end of coil 31. The other end of coil 31 is connected to the grid of tube 3RF and also connected to ground through a tuning condenser 35 shunted by a trimming condenser 36.

Cathode of tube 3RF is connected to ground

through a resistance R8 shunted by a fixed condenser C7.

One terminal of the secondary of the radio frequency transformer 25 is connected to ground through resistance R2 shunted by a fixed condenser C8 and the other terminal is connected to the grid of the detector tube and also to ground through a tuning condenser 37 shunted by a trimming condenser 38.

10 The cathode of the detector tube is connected to ground through resistance R9 shunted by a fixed condenser C9.

The detector tube is coupled to the first audio frequency amplifying tube by a resistance coupling, comprising a resistance R11 in the plate circuit of the detector tube, a resistance R12 between the grid of the tube 1AF and the ground, a coupling condenser C11 connected to this grid and to the plate of the detector tube through an inductance I and condensers C12 and C13 connected respectively between opposite ends of the inductance and ground.

The second audio frequency stage which in the present form of my invention is the last stage, is a push pull stage, comprising tubes 2AF and 2AF' connected to the preceding stage by a resistance coupling of special construction. While my improved coupling may be used in connection with systems other than the one comprising a radio frequency and detector stage above described, the entire system disclosed represents one complete and operative embodiment of my invention.

The cathode of tube 1AF is connected to ground through a resistance R20. The plate of tube 1AF is connected to conductor 18 through a coupling resistance R13, the conductor 18 being connected through conductor 21 to an intermediate voltage tap t' of the filter F. Plate of tube 1AF is connected to the grid of tube 2AF by a coupling condenser C16 and the cathode of tube 1AF is connected to the grid of tube 2AF' by a coupling condenser C17. The grids of tube 2AF and 2AF' are connected to ground respectively through resistance R14 and R15 which in the present embodiment of my invention are of equal values.

The filaments of tubes 2AF and 2AF' are supplied with heating current from the secondary S' and across the supply circuit is connected a potentiometer P' having a slider 39 which is connected to ground through a resistance R18.

The plates of tubes 2AF and 2AF' are connected through an inductance I' an intermediate point of which is tapped and connected to the high voltage tap t'' of the filter. The output circuit to the coil 33 of the loud speaker includes a condenser C19 and this circuit is connected across the inductance I'.

The filter comprises inductances I³ and I⁴ in series with the line and parallel shunt circuits comprising condenser C20 connected across the output circuit of the rectifier tube RT, a condenser C21 connected from a point between the inductances I³ and I⁴ and the grounded negative conductor, a condenser C22 connected between the grounded conductor 35 and a point beyond the inductances and two circuits similarly connected, one including a condenser C23 and a resistance R19 in series and the other including a condenser C24 and a resistance R20 in series. The low voltage tap t for the screen grids is connected between a point condenser C24 and the resistance R20 and the intermediate tap for the plate circuit of the radio frequency tubes, the detector tube and the first audio frequency tube is connected

to a point t' between C23 and resistance R19, while the high voltage tap t'' for the plates of the tubes 2AF and 2AF' is connected to a point between inductances I³ and I⁴.

In the operation of the resistance coupled push pull stage it will be noted that changes of potential of the grid of tube 1AF produce opposite changes of potential of the plate and of the cathode of this tube. Thus an increase in potential of the grid lowers the internal impedance of the tube, lowers the potential of the plate of the tube with respect to ground at the same time, however, raising the potential of the cathode of tube 1AF. The changes in potential of the plate and cathode are transmitted respectively to grids of tubes 2AF and 2AF' through the respective condenser C16 and C17.

The resistance R13 in the plate circuit of the tube 1AF is of the same value as the resistance R20 in the cathode return circuit. Changes of impedance in the tube 1AF due to changes of potential of the grid of this tube will therefore effect equal and opposite changes of potential at the points X and X', that is, the plate and cathode respectively of the tube 1AF. The changes in potential of the grids of the push pull tubes 2AF and 2AF' will therefore be equal and opposite and the tubes 2AF and 2AF' will each bear one half of the signal load.

One important feature of my invention is the construction of a push pull amplifier of this character wherein variations of potential of the currents supplied to the tubes will not produce disturbing hum in the output circuit. It will, of course, be understood that the connections between tubes 2AF and 2AF' are such that disturbing variations due, for example, to variations of the potential of the source supplied to these particular tubes tends inherently to be eliminated. However, the portion of the system preceding this stage may be affected by fluctuations from the source of supply so as to feed into the push pull stages hum currents which would then be passed on to the loud speaker. It is one purpose of my invention to so construct the system disclosed, that substantially no hum, arising in the stages preceding the push pull stage, is carried forward to the loud speaker.

Considering for the moment, the effect of variations of the potential of the output of the filter F on the plate circuit of tube 1AF, these effects comprise the direct effect caused by the supply of varying current from the tap t' through resistance R13 to the plate of the tube 1AF and the indirect effect caused by the variations supplied to the plate circuit of the preceding tube or tubes. Considering first the direct effect; a momentary rise in potential of the source has the direct effect of raising the potential at the point X with respect to ground and this same rise has the effect of raising the potential at point X' with respect to ground, but the magnitude of the rise of potential at the point X' is much less than the magnitude of rise at the point X. Considering the indirect effects, a momentary rise of potential of the source causes a rise in potential of the plate of the detector tube, which rise, transmitted through the condenser C11, raises the potential of the grid of tube 1AF and this results in a lowering of the internal impedance of the tube. This tends to decrease the potential at the point X with respect to ground and to increase the potential at the point X' with respect to ground.

It will thus be seen that the direct and indirect

effects at the point X are opposed to one another; whereas the direct and indirect effects at the point X' assist one another. In view, however, of the fact that the direct effect at the point X is much greater than the direct effect at the point X', it is possible by taking away from the direct effect at the point X and adding to the direct effect at the point X' to make the combined direct and indirect effects at the point X equal to the combined direct and indirect effect at the point X'. With this condition obtaining, the variations of potential of the grids of tube 2AF and 2AF' caused by these disturbing voltage variations will be equal and in phase with one another with the result that they will cancel one another in the push pull output circuit and no variations from this source will appear in the loud speaker circuit. If desired, the system may be so constructed as to feed variations of the desired magnitude and phase to the coil 33 of the loud speaker so as to buck out disturbing variations in the loud speaker field coil F. The direct and indirect effect at points X and X' may be expressed mathematically as follows: The direct effect at the point X' is:

$$DV_1 = -\frac{R}{R_p + 2R} e \quad (1)$$

where e represents the voltage variations applied by the filter to the plate circuit of tube 1AF, R the value of the resistance R12 or R13, R_p the internal impedance of the tube 1AF. The direct effect at the point X is:

$$DV_2 = \frac{R_p + R}{R_p + 2R} e \quad (2)$$

The indirect effect at the point X is:

$$DV_{10} = -\mu DV_2 \frac{R}{R_p + 2R} \quad (3)$$

where DV_g are variations of potential of the grid of tube 1AF. The indirect effects at the point X' are the negative of expression 3 or

$$DV_{20} = \mu DV_2 \frac{R}{R_p + 2R} \quad (4)$$

As previously stated the condition of elimination in the coil 33, of hum arising from this source is that the potential variations at the point X are equal in magnitude and phase to the potential variations at the point X'. To satisfy this condition it can be shown that the variations passed onto the grid of tube 1AF should not vary greatly from

$$DV_0 = e \frac{R_p}{2\mu R} \quad (5)$$

It can readily be seen that by varying the terms of the Equations 1 to 5 this equality may be obtained in a variety of ways.

The term DV_g is dependent upon the magnitude of the variations supplied by the filter to the detector tube plate circuit and to some extent upon the character of and the current supplied to that part of the system preceding the detector stage.

Similarly it is possible also to design the system so that hum, arising from varying currents for heating the cathodes, may be eliminated although in this case the operation is somewhat different from that described in connection with the varying potential of the filter current. Assuming that variations in the cathodes heating current supplied to the detector tube and to the first audio frequency tube 1AF produce periodic changes in the impedance of these tubes of sub-

stantially the same frequency and phase; a momentary lessening of the impedance of the tube 1AF will have the effect of lowering the potential at the point X and raising the potential at the point X'. However, the simultaneous decrease in the impedance of the detector tube lowers the potential of the detector tube plate and consequently lowers the potential of the grid of the tube 1AF, thus tending to increase the internal impedance of the tube 1AF which results in a tendency to raise the potential at the point X and lower the potential at the point X' with respect to ground. It will thus be seen that the direct and indirect effects of the variations in the tube impedance due to variations in the cathode heating current are opposed to one another at the point X and also at the point X'. It is thus possible substantially to eliminate hum variations at both of these points with the result that no hum variations are transmitted to the grids of the push pull or to transmit to the grids of the push pull variations of either one of two opposite phases and to any desired magnitude.

If DV_i represents the change in potential at the left hand side of condenser C11 the change in voltage at the point X due to DV_i will be

$$-\mu F DV_i \frac{R}{R_p + 2R} \quad (6)$$

where μ is the amplifying factor of the tube 1AF, the variations at the point X' will be

$$\mu F DV_i \frac{R}{R_p + 2R} \quad (7)$$

These effects will be opposed by the effects DV_{20} and $-DV_{20}$ respectively at the points X and X', of the alternating current for heating the cathode of the tube 1AF.

In practice, I find when using a 327 tube as the tube 1AF that resistances R12 and R13 may advantageously be made each of 10,000 ohms; where tube 2AF and 2AF' are each 345, I preferably make the resistances each 250,000 ohms with a tube 324 as the detector tube, R2 may be 1,000 ohms, R9 20,000 ohms, C9 1 mfd., R10 100,000 ohms, C10 .5 mfd., and R11 250,000 ohms.

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

1. In a signal repeating system, a push pull stage comprising two vacuum tubes, a stage preceding said push pull stage comprising a vacuum tube having impedances in its plate supply and plate return circuits, a connection between a point of relatively negative potential of the former of said impedances and the grid of one of said push pull tubes, a connection between a point of relatively positive potential of the latter of said impedances and the grid of the other of said push pull tubes, means for supplying a plate circuit electrode of said preceding tube with current subject to variations, and means for supplying the grid of said preceding tube with variations of substantially the same frequency and bearing a predetermined relation in phase and magnitude to said first named variations so as substantially to reduce disturbing variations in the output of the system.

2. In a signal repeating system, a push pull stage comprising a vacuum tube having equal resistances respectively in its plate supply and plate return circuits, a connection between the negative side of the former of said resistances and the grid of one of said push pull tubes and a connection between the positive side of the latter of said impedances and the grid of the other of

said push pull tubes, means for supplying the tube circuits with current subject to variations which tends to produce disturbing variations in the output circuit, and means for proportioning the variations supplied to different tube circuits so that variations carried forward to the grids of the push pull tubes are substantially nullified in the output of the system.

3. In a signal repeating system a push pull stage comprising two vacuum tubes, a stage preceding said push pull stage comprising a vacuum tube having impedances in its plate supply and plate return circuits, a connection between a point of relatively negative potential of the former of said impedances and the grid of one of said push pull tubes and a connection between a point of relatively positive potential of the latter of said impedances and the grid of the other of said push pull tubes, means for supplying the plate circuit of said preceding tube with current subject to variations, and means for supplying the grid of said preceding tube with variations of substantially the same frequency and bearing a predetermined relation in phase and magnitude to said first named variations so as to cause variations of substantially the same frequency, phase and magnitude to be supplied to each of the grids of the push pull tubes.

4. In a signal repeating system, a push pull stage comprising two vacuum tubes, a stage preceding said push pull stage comprising a vacuum tube having impedances in its plate supply and plate return circuits, a connection between a point of relatively negative potential of the former of said impedances and the grid of one of said push pull tubes, a connection between a point of relatively positive potential of the latter of said impedances and the grid of the other of said push pull tubes, means for heating the cathode of said preceding tube with current subject to variations which tends to produce disturbing variations in the plate circuit, and means for supplying the grid of said preceding tube with variations of substantially the same frequency and bearing such a relation in phase and magnitude to said first named variations as to cause substantially no variations to be transmitted to the grids of the push pull tubes.

5. In a signal repeating system, a push pull stage comprising two vacuum tubes, a stage preceding said push pull stage comprising a vacuum tube having impedances in its plate supply and plate return circuits, a connection between a point of relatively negative potential of the former of said impedances and the grid of one of

said push pull tubes, a connection between a point of relatively positive potential of the latter of said impedances and the grid of the other of said push pull tubes, means for heating the cathode of said preceding tube with current subject to variations which tends to produce disturbing variations in the plate circuit, and means for supplying the grid of said preceding tube with variations of substantially the same frequency and bearing such a relation in phase and magnitude to said first named variations as to cause variation of any desired magnitude and either of two opposite phases to be transmitted to the grids of said push pull tubes.

6. In a signal repeating system, a push pull stage comprising two vacuum tubes, two stages in tandem preceding said push pull stages and each comprising a vacuum tube, the later of said last named tubes having equal impedances respectively in its plate supply and plate return circuits, a connection between the negative side of said former impedance and the grid of one of said push pull tubes, a connection between the positive side of the latter impedance and the grid of the other of said push pull tubes, and means for supplying the plate circuits of said preceding tubes with current subject to fluctuations which tend to cause disturbing variations in the plate circuits, the parts being so proportioned and arranged that the combined effect of current supplied to the earlier of said tandem tubes and that supplied directly to the plate circuit of the later of said tandem tubes is to cause variations of the same frequency, phase and magnitude to be impressed on the grids of the push pull tubes.

7. In a signal repeating system, a push pull stage comprising two vacuum tubes, a stage preceding said push pull stage comprising a vacuum tube having equal impedances respectively in its plate supply and plate return circuits, a connection between the negative side of the former of said impedances and the grid of one of said push pull tubes and a connection between the positive side of the latter of said impedances and the grid of the other and said push pull tubes, means for supplying the plate circuit electrodes of said preceding tube with current subject to variations, and means for supplying the grid of said preceding tube with variations of substantially the same frequency and bearing a predetermined relation in phase and magnitude to said first named variations so as substantially to reduce disturbing variations in the output of the system.

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