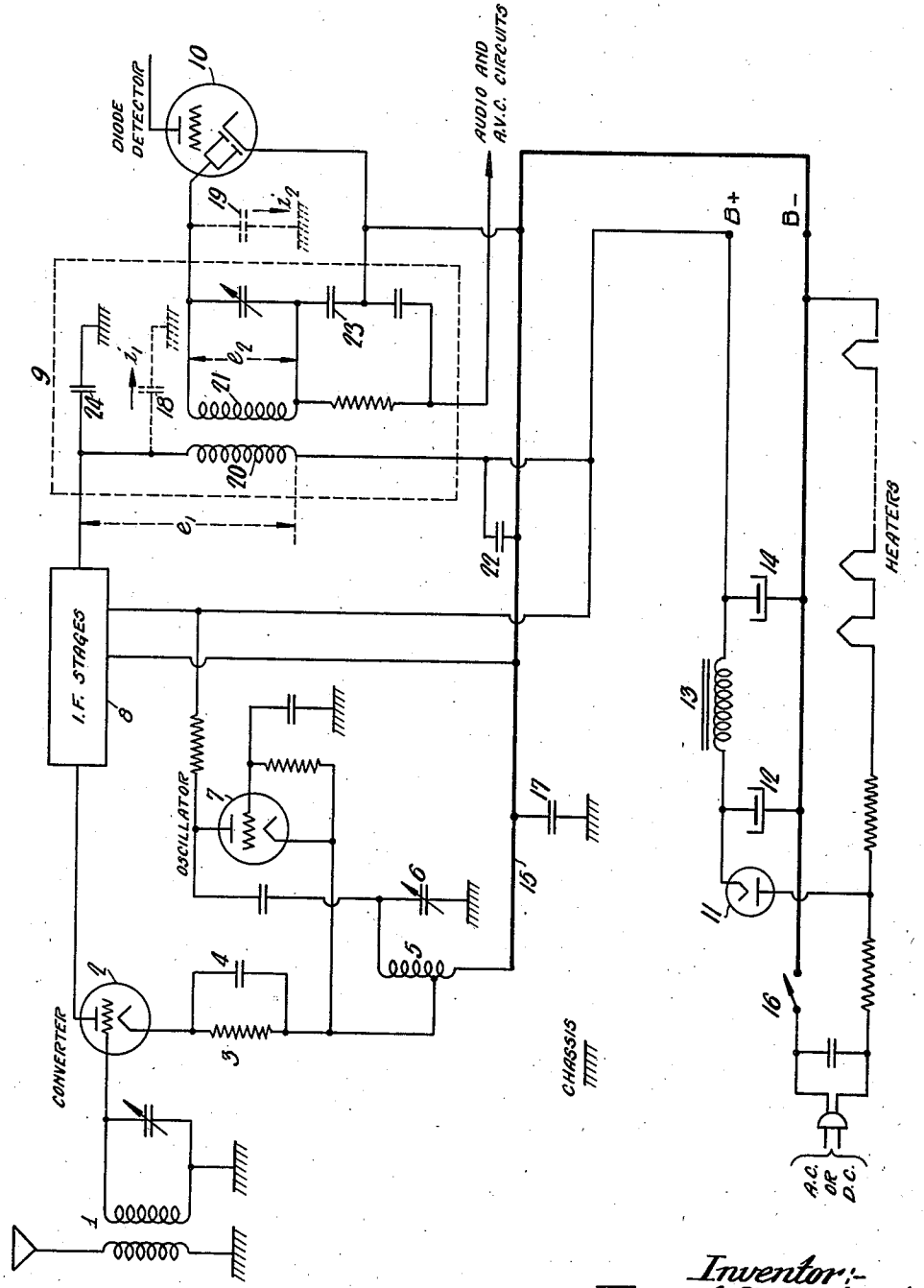
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RADIO RECEIVER

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## RADIO RECEIVER

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7 Claims. (Cl. 250—27)

This invention relates to an improvement in radio receivers, and more particularly to an improvement in radio receivers of the type which take their operating power from either direct current mains or alternating current mains, without the use of an interposed transformer. Such receivers are often adapted to be energized from either type of mains at will, and are then known in the art as A. C.-D. C. receivers.

In A. C.-D. C. receivers there is normally a direct connection between the mains and the vacuum tube circuits, as contrasted with the usual A. C. receiver in which a transformer is employed to supply the desired high voltage to the rectifier tube while at the same time isolating the vacuum tube circuits from the mains. In such transformer-equipped A. C. sets, it is usual practice to connect certain common parts of the vacuum tube circuits directly to the chassis, and often the chassis is in turn connected to the earth. However, this practice in the case of the transformer less A. C.-D. C. receiver is impractical, for grounding the chassis might place a direct short-circuit across the mains, since one side of the mains is ordinarily also grounded. On the other hand, if the chassis were left ungrounded, the receiver would be a source of hazard to life, since the mains voltage could exist between ground and the chassis. Nevertheless, in the interests of efficiency and stability, it is very desirable that there be a low impedance path between parts of the vacuum tube circuits and the chassis, at least for radio frequencies. It has, accordingly, been the practice in many cases to connect a condenser of relatively large capacitance between a common vacuum tube circuit and the chassis. However, the capacitance of this condenser must not be so large that the condenser might be able to deliver a dangerous shock to a person coming in contact with the ungrounded chassis. Thus, for the sage of safety, it is necessary to limit the capacitance which may be used in this service. Using the maximum safe capacitance, it is sometimes found that the impedance of the condenser is not so low but that the radio-frequency current flowing in it develops a voltage across it large enough to be troublesome. In particular, the impedance provides an unwanted coupling between various circuits of the receiver. It is an object of this invention to nullify this coupling without making use of a condenser whose capacitance exceeds the safe maximum.

In the drawing, the single figure is a schematic diagram showing portions of an A. C.-D. C. receiver which embodies the present invention.

Referring to the drawing, the receiver comprises an antenna circuit 1 and a frequency converter tube 2 with biasing means 3 and 4. Coil 5 and condenser 6 form a tank circuit for the oscillator tube 7. The rectangle 8 indicates the usual intermediate frequency stages. An intermediate frequency transformer 9 couples the I. F. stages to the detector tube 10. A usual form of power supply is employed including a rectifier tube 11 and filter elements 12, 13, and 14. The conductor 15 is the necessary common connection between the various vacuum tube circuits and the negative terminal of the power supply.

It will be observed that the common conductor 15 is connected through the switch 16 directly to one side of the supply mains. This is typical of the general type of receiver described. It is also typical that certain of the circuit elements are connected directly to the chassis (indicated symbolically) such as, for example, the tuning condenser 6. For reasons of circuit efficiency and stability, it is usually required that there be no substantial difference in radio frequency potential between the chassis and the common negative power supply conductor 15. To accomplish this, conductor 15 might be directly connected to the chassis, but this practice would be very undesirable for reasons already stated. Instead, the conductor is connected to the chassis through the condenser 17, the capacitance of which is limited in the interest of human safety. The maximum capacitance which may be safely used, however, still has appreciable impedance to radio frequency currents, and it will be noted that any voltage building up across the condenser 17 is included directly in the grid-cathode circuit of the converter tube 2.

The largest radio frequency voltages, in such a receiver as is described, ordinarily occur at the last intermediate frequency transformer 9, which is connected to the detector. Accordingly, capacitance currents from wiring and circuit elements to the chassis will be largest here. These stray capacitances to the chassis are shown lumped as 18 and 19 connected from the high potential ends of the transformer coils 20 and 21 to the chassis. The low potential ends of the coils are effectively connected to common conductor 15 through the radio frequency by-pass condensers 22 and 23.

Now it will be seen that there are at least two complete paths carrying radio frequency current and including the condenser 17. The current $i_1$ in the first of these paths, which may be thought of as caused by the voltage $e_1$ which appears

across coil 20, flows from the high potential end of coil 20 through stray capacitance 18 to chassis, then through condenser 17, returning to the low potential end of the coil through by-pass condenser 22. The current $i_2$ in the second of these paths, which may be thought of as caused by the voltage $e_2$ which appears across coil 21, flows from the high potential end of coil 21 through stray capacitance 19 to chassis, then through condenser 17, returning to the low potential end of the coil through by-pass condenser 23. The voltage appearing across condenser 17 will be proportional to the vector sum of these two currents, and since, in general, these currents will be neither equal in magnitude nor opposite in phase, their vector sum will have an appreciable value. The voltage drop across condenser 17 caused by this resultant current appears directly in the grid-cathode circuit of the converter tube 2. Since the voltage gain from the converter input to the last I. F. transformer 9 may be of the order of 50,000, it takes no great voltage across condenser 17 to produce noticeable feedback. As an illustration, suppose $e_1$ and $e_2$ are equal and in phase, condenser 17 has a capacitance of 0.25 microfarad, and capacitances 18 and 19 are equal and have a value each of 2.5 micromicrofarads. Then the voltage appearing across condenser 17, and inserted in the converter input, will be $\frac{1}{50000}$ of $e_1$. If the gain is 50,000, this corresponds to 100% feedback, and, if the phase is suitable, self-sustained oscillation will take place.

It is a purpose of this invention to prevent this undesired feedback. According to the invention, this is accomplished, in general, by equalizing the magnitudes of the two currents $i_1$ and $i_2$ caused by $e_1$ *abde*$_2$, and by adjusting their relative phase so that the currents oppose each other in the condenser 17, effectively canceling out. If the total current in condenser 17 is substantially zero, there will be no voltage developed across the condenser, and, consequently, no feedback from this source.

In order that the two currents $i_1$ and $i_2$ shall oppose each other, it is desirable that the voltages $e_1$ and $e_2$ be very nearly in phase opposition. This is accomplished by making suitable adjustments to the coupling and to the tuned secondary circuit of the transformer 9 so that the quantity $k^2Q$ is considerably greater than unity. The symbol $k$ stands for the coupling coefficient, which may be defined as the ratio of the mutual inductance to the geometric mean of the self-inductances of the primary and secondary windings 20 and 21. The symbol Q stands for the ratio of the reactance of secondary winding 21 to the total effective series resistance of the tuned secondary circuit. If the above stated condition is met, the voltages $e_1$ and $e_2$ will be either very nearly in phase, or very nearly out of phase, depending upon the polarity of the transformer connections. According to the invention, the connections are made so that voltages are very nearly out of phase. The angle by which the voltages $e_1$ and $e_2$ then lack being exactly in phase opposition will in this case be given by the expression

$$\tan^{-1}\frac{1}{k^2Q}$$

In general, but particularly where the Q of the secondary tuned circuit is relatively low, it will be necessary to couple the windings 20 and 21 rather more tightly than is usual in order to secure the desired phase relationship between primary and secondary voltages.

In order that the two currents $i_1$ and $i_2$ may be made equal in magnitude, it is desirable that a certain relation exist between the capacitances 18 and 19, namely:

$$\frac{C_{19}}{C_{18}}=ka=\frac{e_1}{e_2}$$

The symbols $C_{18}$ and $C_{19}$ represent respectively the capacitances of condensers 18 and 19. The symbol $k$ has already been defined, while the symbol $a$ represents the ratio of the number of turns on primary winding 20 to the number of turns on secondary winding 21. In general, the stray capacitances 18 and 19 will not naturally comply with the above relationship, and it is then necessary to shunt one or the other, usually 18, with a small additional fixed capacitance to make them do so. This additional capacitance may be secured through the provision of a small fixed capacitor 24, or more economically by varying the distance between the ends from the high potential ends of the transformer and the chassis, or other metal parts of the receiver.

If the circuit is modified in accordance with the above teachings, the currents $i_1$ and $i_2$ in passing through condenser 17 will be opposite in phase, and equal in magnitude. The resultant R. F. current through 17 is, therefore, substantially zero, as is the R. F. voltage across it, and the possibility of the impedance of 17 being the means of undesired feedback of the type described is eliminated.

As will be readily understood by persons skilled in the art, the invention is not restricted to the embodiment disclosed and illustrated. For instance, the I. F. transformer 9 might have a tuned primary instead of an untuned primary, and its secondary might have been untuned instead of tuned as shown. In general however it is preferred that one of the windings be left untuned. Self resonance of the untuned winding should preferably occur at a frequency well outside of and preferably above the intermediate frequency band. The element 17, instead of being a single condenser, might be any sort of circuit having the function of providing a low impedance connection at radio frequency between the chassis and the common conductor. The receiver might be of the tuned radio frequency type instead of the superheterodyne shown.

I claim:

1. A radio receiver comprising a plurality of vacuum tube circuits, means for energizing said circuits directly from electric supply mains, said energizing means including a conductive connection between said mains and the anode circuits of said vacuum tubes, a metal housing or chassis for supporting the receiver components, means providing a low impedance radio frequency path between said conductive connection and said chassis, there being stray capacitance between said chassis and a relatively high potential radio frequency portion of the receiver, tending to cause undesired current flow in said low impedance path, and means including an impedance element connected between said chassis and the radio frequency portion of the receiver for causing substantially equal and opposite currents to flow in said path, thereby to prevent the building up of a radio frequency voltage across said path.

2. A radio receiver comprising a plurality of

vacuum tube circuits, means for energizing said circuits directly from electric supply mains, said energizing means including a conductive connection between said mains and the anode circuits of said vacuum tubes, a metal housing or chassis for supporting the receiver components, a by-pass condenser connected between said conductive connection and said chassis and forming a low impedance radio frequency path therebetween, there being stray capacitance between said chassis and a relatively high potential radio frequency portion of the receiver, tending to cause undesired current flow in said low impedance path, and impedance means between said chassis and the radio frequency portion of the receiver for causing substantially equal and opposite currents to flow in said path, thereby to prevent the building up of a radio frequency voltage across said path.

3. A radio receiver comprising a plurality of vacuum tube circuits, means for energizing said circuits directly from electric supply mains, said energizing means including a conductive connection between said mains and the anode circuits of said vacuum tubes, a metal housing or chassis for supporting the receiver components, means providing a low impedance radio frequency path between said conductive connection and said chassis, a radio frequency transformer having a primary and a secondary winding, the low potential ends of said windings being returned to said common connection, there being stray capacitance between the high potential ends of said windings and the chassis, tending to cause undesired current in said low impedance path, said primary and secondary windings being so coupled and polarized that the undesired currents are substantially equal and opposite in phase to effect cancellation thereof in said low impedance path, thereby to prevent the building up of a radio frequency voltage across said path.

4. In a radio receiver including a plurality of vacuum tube circuits, a common conductor connecting the anode circuits of said vacuum tubes to one side of an electric power main, a metal housing or chassis upon which various receiver components are mounted, a low impedance radio frequency path between said chassis and said common conductor, a radio frequency transformer having a primary and a secondary winding, said windings being sufficiently closely coupled and so polarized that the primary and secondary voltages are substantially in phase opposition, the low potential ends of said windings being connected through by-pass condensers to said common conductor, one of said windings having stray capacitance between its high potential end and the chassis which tends to establish a radio frequency current in said low impedance path, and a condenser connected between the high potential end of the other winding and the chassis, said condenser having such capacitance as to establish through said low impedance path a second radio frequency current substantially equal in magnitude to said first current but opposite in direction.

5. In a superheterodyne radio receiver including a plurality of vacuum tube circuits, a common conductor connecting the anode circuits of said vacuum tubes to one side of an electric power main, a metal housing or chassis upon which various receiver parts are mounted, a by-pass condenser connected between said chassis and said common conductor, an intermediate frequency transformer having at least a primary and a secondary winding, said windings being sufficiently closely coupled and so polarized that the primary and secondary voltages are substantially in phase opposition, the low potential ends of said windings being effectively returned to said common conductor, the high potential end of one of said windings having stray capacitance to said chassis which tends to establish intermediate frequency current in said by-pass condenser, and a small capacitance connected between the high potential end of the other winding and said chassis, said small capacitance having such a value as to establish through said by-pass condenser a second intermediate frequency current which is equal in magnitude to said first current but opposite in direction.

6. A superheterodyne radio receiver including a plurality of vacuum tube circuits, a common conductor connecting the anode circuits of said vacuum tubes to one side of an electric power main, a metal housing or chassis upon which various receiver components are mounted, a low impedance radio frequency path between said chassis and said common conductor, a radio frequency transformer, there being stray capacitance between the chassis and the wiring connected to one winding of said transformer which causes a radio frequency current to flow in said low impedance path, and means for deriving a second radio frequency current from another winding of said transformer and for passing said second current through said low impedance path, said second current being substantially equal in magnitude to said first current but opposite in direction.

7. A radio receiver comprising a plurality of vacuum tube circuits, means for energizing said circuits directly from electric supply means, said energizing means including a conductive connection between said mains and the anode circuits of said vacuum tubes, a metal housing or chassis for supporting the receiver components, means providing a low impedance radio frequency path between said conductive connection and said chassis, there being stray capacitance between said chassis and a relatively high potential radio frequency portion of the receiver which causes an undesired radio frequency current to flow in said low impedance path, and means for deriving a second radio frequency current from the radio frequency portion of the receiver and for passing said second current through said low impedance path, said second current being substantially equal in magnitude to said first current but opposite in direction, thereby to prevent the building up of a radio frequency voltage across said path.

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