Alternating Current Radio Tube Operation

In general, an alternating current-operated radio set is any set which may be connected directly to the light socket and operated without the use of batteries. There are, however, two distinct types of A. C. sets. The first type is the type which uses a rectified and filtered A. C. on the filaments, which is acquired by the use of either an "A" battery eliminator or D. C. supplied by the "B" eliminator circuit. In the second case it is essential that the current be low, because the transformer, rectifier and filter circuits of the "B" eliminator are not designed to carry a heavy current. This necessitates the use of tubes of the -99 type with filaments connected in series.

The second type of A. C. set is the one that uses the so-called "A. C. tubes", whose filaments operate directly on low voltage A. C. Of these A. C. tubes there are two types, the heavy filament and the cathode. In construction the heavy type filament tube is essentially the same as the battery type except that it has a heavy oxide-coated ribbon filament which requires a little over an ampere of current to operate. The reason for the use of this heavy filament will be given a little later.

In an amplifier circuit of a battery operated set the grid return is usually connected to the negative of the "A" battery, or to the negative of the "C" battery whose positive terminal is connected somewhere in the "A" circuit. If these connections were made in an A. C. set a terrific hum would be heard in the speaker which would badly distort even the strong local signals. Just how this hum originates and how to eliminate it requires a little reasoning. Consider a battery amplifier circuit whose grid-return is connected directly to the negative filament terminal. If a voltmeter were connected between the grid and different points of an incandescent portion of the filament it would be found that the voltage between the grid and filament would vary uniformly from Zero to IR volts. Where I equals the current in amperes flowing in filament and R equals the resistance of the filament this means that the grid voltage varies from Zero to IR volts. The mean of this, which is the actual grid voltage, equals -IR/2. In an A. C. set, where the filament is excited by A. C., the IR/2 grid volts become alternatey negative and positive which modulates the plate current and produces the hum. It will be obvious that the IR/2 grid volts could be eliminated to render the grid zero volts the hum would cease. The voltage is produced by the I flowing through R/2 ohms resistance or one-half the incandescent portion of the filament. Therefore, if the grid-return was connected to the midpoint of the incandescent portion of the filament the grid voltage would become zero. It is quite a difficult matter to make a permanent connection on the heated portion of the filament and it would also require an extra connection to the tube, which would be objectionable. This is overcome by either bringing out a center tap on the transformer, or connecting a 10 or 15 ohm resistance across the transformer terminals and taking a center tap off it. Either of these two methods are equivalent to making a connection at the mid-point of the filament. Let Ir1 and Ir2 equal the voltage drop of the left and right halves of the filament, and E1 and E2 the voltage of the left and right halves of the transformer winding. If a galvanometer were connected between the center of the heated portion of the filament and the center tap of the transformer winding and indicated zero the voltage at the two points would of course be equal. Consider Ir1, Ir2, Ir3 and Ir4 as the elements of a wheatstone bridge. To have a galvanometer read zero this following equation would have to be true: Ir2 x E1 equals Ir1 x E2. It is true because Ir1 equals Ir2 and E1 equals E2. This same method of analysis applies to the center tapped resistance across the transformer.

The question naturally arises, "Why not use the ordinary quarter ampere tube for this purpose?" The main reason why it is not used is because of the type of filament it uses. If we were to use a -99 or -O1A type for A. C. operation we would have an A. C. hum in the set which could not be balanced by our scheme of grid-return connection. Another peculiarity about this hum would be noticed. It would have a frequency twice that of the frequency impressed upon the filament. Most of the commercial A. C. lines have a frequency of 60 cycles, which means that the current rises to maximum and falls to zero 120 times per second. Although it cannot be seen, this rise and fall of current will cause an equally rapid rise and fall in the heat intensity of the filament. As the plate current will vary with some proportion to the heat intensity of the filament a 120 cycle hum will be heard in the speaker. The extent or amplitude of these undulations of heat intensity will depend upon the heat retaining qualities, or the thermal inertia or the filament. It is an established fact that as the temperature of an object rises the heat radiation is greatly increased. It is for these reasons that the heavy rugged ribbon filament operating at a low temperature is incorporated in the -26 type of tube.

The cathode type tube operates on an entirely different principle. This type of tube does not depend directly upon the filament for its electronic emission. The cathode, which is usually a round oxide-coated metallic cylinder of a diameter just large enough through which to pass the filament. The filament is heated by means of an A. C. current, which in turn heats the cathode, due to its proximity. The grid-return is connected directly to the cathode. No method of balancing out hum is required as the cathode is

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thoroughly insulated from the filament carrying the A. C. This type tube is used almost without exception in the detector circuit. If a -26 type tube were used in this circuit a bad 60 cycle hum would be generated because the grid-return is not connected directly to the center tap of the balancing resistor but is connected to the grid condensor. The grid condensor offers a very high impedance to a 60 cycle current, hence an A. C. voltage is built up on the grid due to electro-static capacity between the grid and the filament. This A-C. voltage on the grid produces a variation in the plate current which produces the hum. This is not the case with the -27 or cathode type tube as the cathode is at zero voltage in respect to the grid.

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