the rectifier tube from its socket, and using a high range a-c voltmeter (0-1000), the plate terminal or terminals can be located by measuring from B minus or chassis to the various terminals. The terminal at which a high reading is obtained with respect to the chassis is a plate terminal. If a full-wave rectifier tube is used as such, there will be two such terminals. It should be noted that the voltage reading from plate to plate will be the total voltage across the high voltage secondary winding, while the reading from either plate to B minus will be half the plate to plate reading; because, in measuring from plate to B minus, the meter is actually connected across one half of the high voltage secondary. When the high voltage terminals have been found, a lower range on the voltmeter can be used to determine the filament terminals. If the tube is a directly heated cathode type, the filament terminals can be readily identified since there will be only these two additional connections. With the indirectly heated type cathode, there will be the two filament terminal connections and the cathode connection to the filter circuit.

Important reference test points in any receiver are the B plus and B minus terminals of the plate supply. To quickly identify these points, certain simple relationships can be used.

An examination of the schematic diagram will reveal the circuit arrangement of the parts of the power supply. If the schematic shows that the filter choke is connected to one side of the rectifier filament, one can expect that in the power supply one lead from the choke will connect to a filament terminal of the rectifier socket. The other side of the choke, as shown on the schematic, connects to the B plus terminal of the power supply output. Therefore, locating this lead in the chassis and tracing it from the choke to a terminal will locate the B plus point in the chassis.

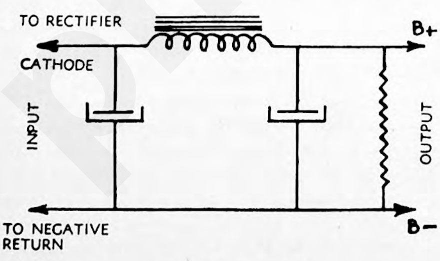
Checking with the schematic indicates that one filter condenser is connected from each side of the choke to B minus. By locating the filter condenser and identifying the leads connecting to the choke, the remaining condenser leads can be traced to B minus. Electrolytic condenser leads or terminals are usually color coded, although a standard code does not apply to all circuits. In general, it can be said that the black lead from the electrolytic condenser will connect to B minus.

The visual check outlined above can be supplemented by a continuity check with an ohmmeter. In many cases the actual circuit wiring is such that some of the leads are buried in cabling or hidden from sight. For such conditions, the use of a low range ohmmeter, aids in tracing the leads.

TESTING "B" SUPPLY FILTER CIRCUITS

a. One method of testing filter circuits for defective parts is by resistance analysis of the input and output circuits. By comparing the readings taken with those which are normal, and using a practical application of Ohm's Law for series-parallel circuits, the defective part may be determined. An advantage of this type of testing is that the power supply is inoperative during test; therefore, no damage can result to any part due to excessive current flow, should a short-circuit exist. By referring to Figure 2 it may be seen that the input of the filter is actually the output of the rectifier, and the output of the filter is the final output of the whole power supply.

If the ohmmeter test prods are connected across the input terminals of the filter circuit, a reading will be made of the equivalent resistance of a complex network, composed of the resistance of the choke in series with the parallel resistance of the second condenser leakage and bleeder resistor. See Figure 3. As the leakage resistance of normal electrolytic condensers is relatively very high, for practical purposes

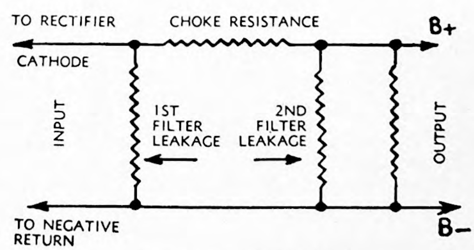


TYPICAL FILTER

FIGURE 2

it will not greatly affect resistance conditions. The ohmmeter would really read the resistance of the filter choke in series with the resistance of the bleeder resistor.

If the ohmmeter prods are connected across the output terminals of the filter circuit, a reading will be made of the equivalent resistance of the bleeder resistor, shunted by the leakage resistance of the second condenser, and also shunted by the resistance of the choke in series with the first condenser. In



EQUIVALENT LEAKAGE

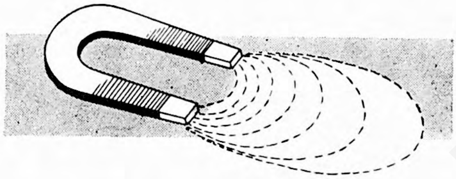
FIGURE 3

this case the ohmmeter would read, for practical purposes, the resistance of the bleeder resistor only. Thus the resistance of the input circuit is higher than that of the output circuit by the value of the choke.

If the choke were short-circuited the readings at both input and output would be identical. If the choke were open-circuited the input reading would be very high (leaking resistance of first condenser), and the output reading would remain practically the same. If either condenser were open-circuited both readings would remain about the same. If the first condenser were short-circuited the input resistance would be low, and the output reading would be the value of the bleeder resistor in parallel with the choke. If the second condenser were short-circuited the input reading would be the value of the choke, and the output resistance would be very low. Likewise, other possible troubles may be found by similar analysis.

b. The choke performs a very important function in the operation of a filter circuit. To understand its action it will be necessary to review some fundamental ideas.

When direct current starts to flow through an inductance it is opposed by an opposition that is different from resistance. The opposition is a counter-E. M. F. set up in the inductance when the coil current, changing from zero, changes the magnetic field. The magnetic field was non-existent, or zero, until current started to flow.



Since a change in the magnetic field of a coil will produce an E.M.F., the variation in the magnetic field due to the current change, will produce an E.M.F. or voltage that opposes the change in current. Because of this, the current does not immediately reach a value as determined by resistance and the applied voltage according to Ohm's Law. The time required depends upon the inductance of the coil. The larger the inductance, the longer the time required for the current to reach its final value. If then, the applied voltage is suddenly decreased or removed the current in the coil will begin to decrease. This again will produce an inductive voltage, but it will have a polarity that will tend to sustain the current for some time after the applied voltage has decreased to zero. The characteristics of choke coils account for the opposition they offer to changes in current. When alternating current is applied to an inductance the current encounters this opposition as well as the opposition due to resistance. The opposition that an inductance offers to the change in current, or to a-c because of self-induced voltage, is called inductive reactance. Inductance reactance becomes greater as either the inductance, or frequency of the applied voltage is increased. Hence, the limiting or opposing action to the flow of current becomes greater when either the inductance or the frequency of the current changes is increased.

The ability of an inductance to store electric energy as a magnetic field and then later to return this energy to the circuit, together with the opposition it offers to changes in current, is put to good use in filter circuits. The current from a rectifier is a series of pulses. During a part of the rectified pulse the current increases from zero toward some maximum value. In this time the first filter condenser charges to a voltage approximately equal to the maximum value of the rectified pulse. The choke coil prevents these pulses from reaching the output of the filter, because of the high opposition it offers to them. When the pulse decreases toward zero, the condenser voltage causes a current to flow that adds to the current produced by the E.M.F. of self-inductance. Thus, the condensers and the choke tend to keep the current constant, thereby eliminating hum and making the rectified current flowing through the load a steady current rather than a series of pulses.

The inductance for a filter may be obtained from either a specially constructed iron core coil or by making use of the inductance of the loudspeaker field coil. It is economical to use the speaker field coil as the filter choke, because the current demanded by the equipment will produce a magnetic field sufficient to operate the speaker. The inductance of the field coil will be sufficient for filter action; hence, one less part will be required and additional current to magnetize the speaker field will be unnecessary. When the filter inductance is connected in the negative lead of the power supply, the d-c voltage drop across the coil due to its resistance is sometimes used to supply bias voltages.

Common troubles in filter chokes are: open or partially open coils, internal shorts across the terminals of the coils, leaks or partial leaks to the frame of the inductance, and shorted turns.

An open choke will be the cause of no voltage output from the power supply, and a partially open choke coil causes low voltage output. High hum or ripple in the output voltage will result if the coil develops a short across its terminals. Sometimes the filter condensers develop an internal short from one positive lead to the other. This will effectively short out the choke and cause a hum. Condensers that are used to resonate the choke should also be suspected when this type of trouble is encountered. If a large percentage of the coil turns short out, similar trouble may be expected. Leaks or shorts to the choke frame, or iron core, will cause low or no voltage output, and are similar in effect to shorted or leaky filter condensers.

c. It is known that the rectifier supplies a pulsating d-c voltage to the first filter condenser. The first condenser charges to a voltage approaching the highest value of this pulsating d-c voltage. When the value of the pulse begins to drop, current will flow out of the condenser and will tend to keep the flow of current constant. The second condenser acts in somewhat the same manner. However, both the input and output condensers serve another purpose as well. The first filter condenser serves as a low impedance path for the high voltage a-c applied across the rectifier. Hence, there will be very little drop in this a-c voltage. Therefore, the resultant rectified voltage will be higher than

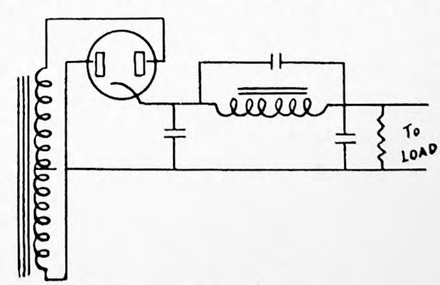


FIGURE 4

if no condenser were present at this position. The second condenser can be thought of as acting as a short circuit for any a-c voltage. Hence, no a-c voltage will be present at the output of the filter.

It is evident that if the capacity of the first condenser is low, the output voltage of the filter will be lower than normal, and will have considerable ripple voltage in it. This will cause the radio apparatus to work inefficiently, and hum.

Lack of sufficient capacity in the second filter condenser will cause the filter circuit to act in a similar manner as to the hum or ripple voltage, but the d-c output voltage will be only slightly affected. Sometimes insufficient capacity will cause motor-boating or oscillation, because of the common impedance path that the filter presents to the signal currents. If the second filter is large enough, and in good condition, there will be no common impedance in the filter circuit, as the condenser will act as a short circuit across the impedance. Therefore, there will be no common coupling impedance to cause either regeneration or degeneration. If regeneration occurs, the equipment might break into oscillation whereas degeneration would cause lower amplification. This may cause distortion if some frequencies are amplified more than others.

Summing up these facts, low amplification, instability, and high hum level can be caused by the second filter having insufficient capacity, or having decreased in capacity. These are common troubles when electrolytics dry out or lose electrolyte through evaporation or decomposition, the results being a decrease in capacity, and the troubles just discussed. When a condenser decreases in capacity, it is equivalent to a good condenser that is partially open-circuited. Shorted filter condensers are the cause of very low or no voltage output from the filter.

Partially shorted filter condensers cause the voltage to be lower than normal, and the hum level to be high. The resistance of the dielectric used in filter condensers other than electrolytic types should be several megohms. Values of 20 to 100 megohms are not uncommon for these types. For electrolytic filter condensers to be considered good, the dielectric resistance should be higher than 500,000 ohms; however, they often work satisfactorily with leakage resistances of 100,000 ohms. Generally, if the leakage resistance of electrolytic filter condensers is less than 100,000 ohms, they should be replaced. Exceptions to this are cathode by-pass condensers or other low voltage by-pass condensers of the electrolytic type, as leakage values of less than 100,000 ohms in these types are often not troublesome. These figures are arbitrary, being dependent upon the satisfactory operation of the equipment. The voltage applied and the capacity of the condenser, are factors that influence the leakage resistance. Increasing the applied voltage and the capacity of the condenser, increases the leakage. Another method of stating the condition of an electrolytic condenser is in terms of milliamps per microfarad. Usually 0.5 milliamp per microfarad is the maximum acceptable leakage current. An 8-mfd. condenser with a leakage current of 4 milliamps would just pass as being acceptable. Leakage current higher than this would mean that the condenser should be replaced.

Some filter circuits use a condenser across the filter choke to resonate it to the frequency of the hum voltage. (See Figure 4.) Since a parallel resonant circuit offers very high impedance to its resonant frequency, very little hum voltage will be apparent at the output of the filter.

When the current taken from the power supply is low, the choke can be dispensed with, if efficiency is not of paramount importance. Instead of the choke coil, a resistor can be used (see Figure 5) to offer opposition to the hum frequencies. Unfortunately, the resistor offers practically the same resistance for both the hum frequencies and the d-c flowing through it. Since this will cause a d-c power loss, this type filter is not as efficient as the choke type of filter. However, it is much cheaper to construct, and is very compact. As the resistor offers nearly the same opposition to a wide range of frequencies, it is used to good advantage in many circuits. Filter circuits making use of this idea use a resistor of a few hundred ohms before the filter choke. (See Figure 6.) Condensers are connected across the ends of the resistor to B minus in the same way they were when the choke was used. This circuit is effective in eliminating a wide band of disturbance frequencies.

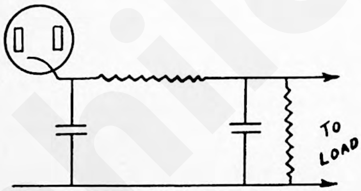


FIGURE 5

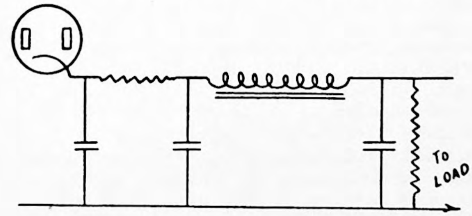


FIGURE 6