I-F Wave Trap Formed By Special Capacitor

Excerpted from Rider's Volume XVII, *"How It Works"*, 1948

In many ac-dc receivers most of the units within the set are kept above ground by a number of methods as illustrated schematically in Fig. 1. Some use just a capacitor of 0.2 uf or so [Fig. 1 (A)], others use a similar capacitor and shunt it by a high-valued resistor anywhere between 100,000 and 250,000 ohms [Fig. 1 (B)], and still others use a resistor shunted by a series network of a capacitor and a coil [Fig. 1 (C)]. In the latter case, besides producing a return path from B minus to ground, the series capacitor and inductance are usually made resonant somewhere around the I-F. of the set. Therefore, this L-C combination presents a ready path to ground for any stray I-F currents that may find their way into the B-minus lead and thus prevent I-F feedback to the circuits through this common B-minus lead. This inductance-capacitance combination in most instances represented a somewhat crude resonant circuit in that it did not present so sharp a response curve as the I-F transformers. However, its purpose as an I-F trap in the B-minus circuit was served adequately. Many of these L-C circuits, as used in the B-minus lead, do not make as fine I-F traps as those that appear in the R-F sections of receivers. Many of these **typical B-minus I-F wave traps** appear in table model ac-dc receivers and essentially consist of a paper capacitor varying in the vicinity of 0.2 uf and around or near this capacitor is usually wound some simple connecting wire of enough inductance to make it resonate with this capacitor at the I-F.

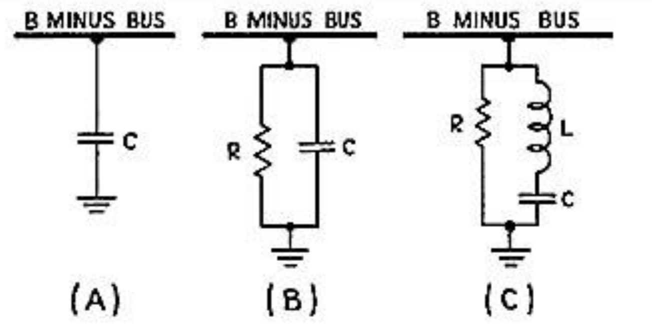

FIG. 1.—Three methods of keeping most of the units of ac-dc receivers above ground: (A) use of a capacitor, about 0.2, μf, (B) addition of a high-valued resistor to shunt a similar capacitor, (C) use of a resistor shunted by a series network of a capacitor and coil.

Usual B-Minus I-F Trap Construction

This process of using a separate piece of wire to form the resonant circuit does take some time and effort besides the small amount of cost involved. One main disadvantage of such an arrangement is that the coil of wire may become loose or somewhat disconnected from its original position, and then may be mistaken for a lead elsewhere in the receiver and may confuse the serviceman. This is especially likely when the circuit diagram of the receiver does not exactly identify this coil, and it appears only as seen schematically by L in Fig. 1 (C).

To overcome the use of a separate coil and retain the advantageous features of an I-F wave trap in the B-minus return, the Philco Model 48-214 (code 125) uses what is called a "special" capacitor. In this ac-dc receiver, the schematic of which appears on Philco page 17-11, 12 in Rider's Vol. XVII, (and Philco Service Bulletin PR-1424), this unit appears as a normal paper capacitor. The label on it reads in part: 2 MFD. 400 V.D.C. Special. The construction of this capacitor essentially consists of two sheets of tinfoil such as appears in most paper capacitors, but the method of attaching the pigtail leads differs from the usual paper capacitor. The knowledge that the tinfoil itself is a metallic substance and possesses its own self-inductance made it possible, by special attachments of the pigtails, to use a paper capacitor to form an I-F wave trap.

Construction of a Paper Capacitor

Every paper capacitor that uses tinfoil or some similar metallic substance for the effective capacitor plates represents a series inductive-capacitive circuit which is resonant at some frequency. With reference to Fig. 2, this resonant effect of most paper capacitors is best explained as follows :

The two tinfoil plates used in a typical paper capacitor are indicated in Fig. 2 (A) as flattened . out. The plates are separated by paper which is usually impregnated with wax or oil. Paper insulator also appears on the underside of the inside foil. The outside foil is designated as L_1 in Fig. 2 (A), the inside foil as L_2 and it is readily conceivable that each foil has a certain amount of self-inductance, the exact amount being determined by the dimensions of the foils themselves. These two foils in conjunction with the impregnated paper are rolled up together so that foil L_1 is on the outside and foil L_2, is on the inside.

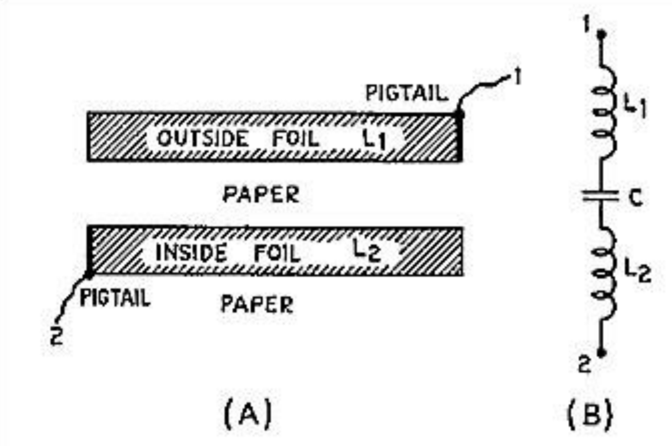

FIG. 2.—Unwound, the tinfoil plates of a typical capacitor appear as in (A). The circuit representing the capacitor appears in (B).

Pigtail leads are attached to the foils in different ways, but for the case under discussion we chose the type that has the pigtails attached to opposite ends of the foils as shown by pigtail points 1 and 2 in Fig. 2 (A). The capacitance of this unit, is directly proportional to the common area between the two tinfoils and inversely proportional to the separation distance between the foils. The capacitance is also a direct function of the dielectric constant of the paper insulator. (The exact equation for the capacitance value of two parallel plate capacitors is included at the end of the section of this book called "Special I-F Transformer.")

If we were to draw the true circuit of this "capacitor," neglecting any resistance or leakage losses, we would have to take into account the self-inductances of each tinfoil. Under this circumstance the circuit representing the capacitor of Fig. 2 (A) is illustrated in Fig. 2 (B). Coil L_1 represents the inductance of the outside foil, capacitor C represents the effective capacitance between the two foil plates, and coil L_2 represents the inductance of the inside foil. By tracing the capacitor of Fig. 2 (A) from point 1 to point 2, you will note that the circuit of Fig. 2 (B) is truly represented.

Since the network in Fig. 2 (B) is a series inductance-capacitance, it will be resonant at some frequency offered by the amount of inductance and capacitance in the circuit. If we can fix the total value of inductance of the capacitor and keep the capacitance constant, we have a ready means of making the circuit resonant to a desired frequency.

Design of the Special Capacitor

This is exactly what is accomplished in the Philco special capacitor. A drawing of the layout of this capacitor is illustrated in Fig. 3 (A). The difference in design between this capacitor and that of Fig. 2 (A) is that pigtail connection point 1 is moved down 2/3 of the length of the foil from the point at the right end of the outside foil where it formerly was connected. This means that the outside foil has a tap on it to which the pigtail lead is connected. Consequently, inductance designated as L_a exists between points X and Y and

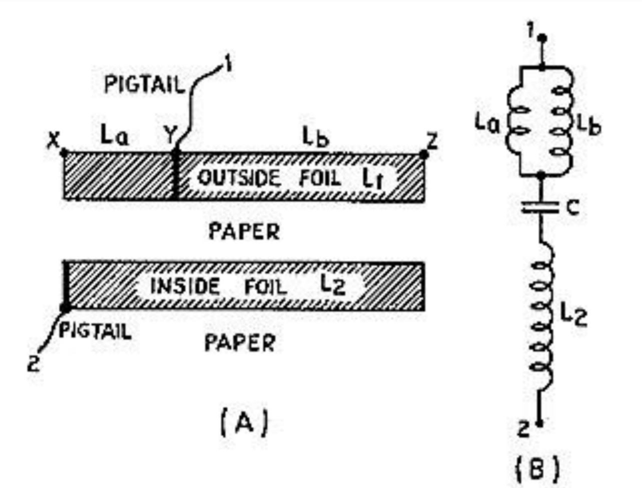

FIG. 3.—(A) The pigtail lead, 1, on the outside foil has been moved to Y from its position in FIG. 2. (A). The schematic circuit for this new condition is shown at (B).

inductance designated as L_b exists between points Y and 2 of the outside foil. Under this division inductance L_a equals l/3 of the total inductance of L_1 and L_b equals 2/3 of the total inductance L_1; likewise $L_a + L_b$ equals inductance L_1.

To trace the path from pigtail to pigtail starting with that of the outside foil, we can take either of two paths. One path encompasses inductance L_a and the other inductance L_b. With this understanding of choice of paths we can draw the circuit diagram representing this capacitor arrangement. This is indicated in Fig. 3 (B). From this circuit it is noted that inductances L_a and L_b of outside foil L_1 are represented schematically as two coils in parallel. The capacitance C is not changed, because, no matter where the pigtails are connected along either foil, the factors determining the value of capacitance do not change. The inductance of the inside foil L_2 also does not change, inasmuch as the pigtail connection to this foil remained as it was in Fig. 2 (A).

Effective Inductance of Outside Foil

Consequently, the circuit of Fig. 3 (B) consists of inductance L_a in parallel with L_b. This combination, in series with the capacitor C and L_2 altogether represents the series resonant circuit. The tap at point Y of the outside foil of Fig. 3 (A) is especially chosen so that the parallel combination of L_a and L_b will offer a lower inductance than L_1. By this method of lowering the inductance, the resonant frequency of the series circuit is increased.

Since the inductance of L_a is equal to 1/3 of L_1 and that of L_b equal to 2/3 of L_1, we can readily evaluate the inductance of L_a and L_b in parallel in terms of L_1. Two inductors in parallel are like resistors in parallel-thus:

$$\frac{L_a \times L_b}{L_a + L_b}$$

Substituting for L_a and L_b in terms of L_1 we find:

$$\frac{1/3\ L_1 \times 2/3\ L_1}{1/3\ L_1 + 2/3\ L_1} = \frac{2/9\ L_1^2}{L_1} = 2/9\ L_1$$

The foregoing answer tells us that when the pigtail tap on the outside foil is so situated that L_b is equal to twice L_a, the total inductance offered by the outside foil to the series circuit of Fig. 3 (B) is equal to 2/9 of its complete self-inductance. The total value of the inductance of this special capacitor in conjunction with its value of 0.2 uf is designed so that it will be broadly resonant at the I-F of the receiver, which is 455 kc. At this frequency and with 0.2 uf, the total value of series inductance offered by this special capacitor should be approximately equal to 0.6 microhenry.

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