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R.F. LOW PASS FILTER

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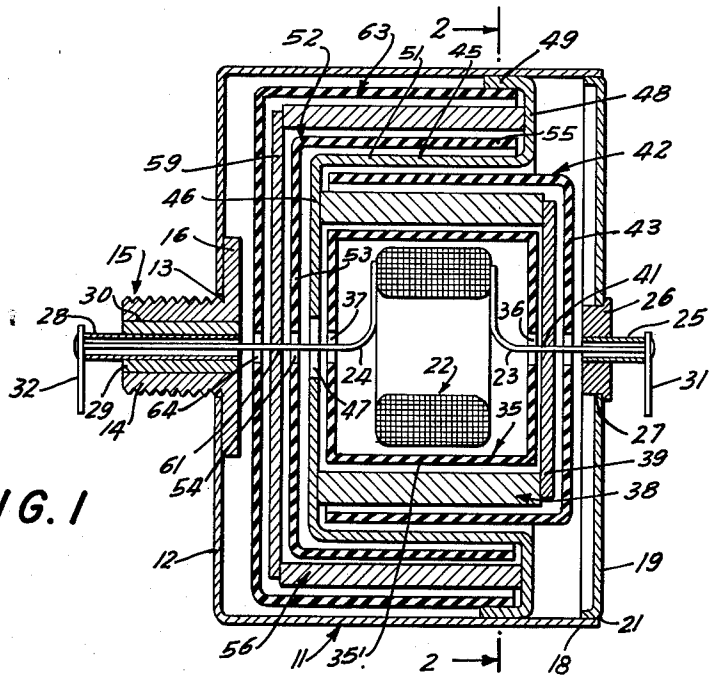


FIG. 1

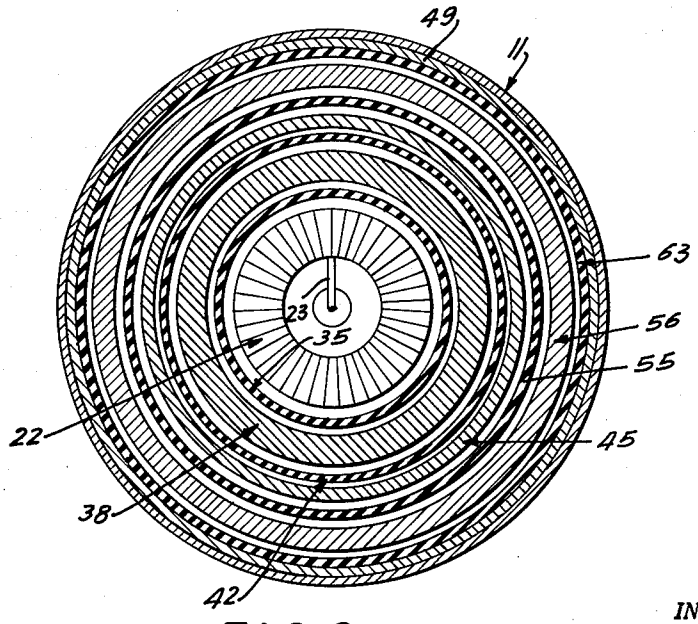


FIG. 2

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R.F. LOW PASS FILTER

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This invention relates to the art of filters, and more particularly to R.F. low pass filters.

As conducive to an understanding of the invention it is noted that where a filter is employed which utilizes at least one inductance coil and at least two capacitors, in order to remove from a conducting line, frequencies of a predetermined high range and to pass frequencies of a lower range, it is essential for efficient performance that the input and output terminals be electrically isolated from each other with respect to electrical radiation in order to prevent transmittal from input to output of frequencies which it is desired to eliminate and it is also essential in many applications that the unit be capable of withstanding shock, and vibration such as is encountered in aircraft and surface vehicles.

It is accordingly among the objects of the invention to provide a filter of the above type that is compact, sturdy and not likely to become deranged due to shock, or vibration, that will offer low impedance to the passage of desired low frequency components and that will provide electrical isolation between the input and output terminals thereof by transmitting to ground electrical radiation of undesired frequencies to prevent transmittal of such undesired frequencies from input to output without being subjected to the selective action of the filter itself.

According to the invention these objects are accomplished by the arrangement and combination of elements hereinafter described and particularly recited in the claims.

In the accompanying drawings in which are shown one or more of various possible embodiments of the several features of the invention:

FIG. 1 is a sectional view of the filter taken along the axis thereof, and

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1.

Referring now to the drawings, the filter unit desirably comprises a cup-shaped casing 11, the floor 12 of which has an axial opening 13 through which extends the stem 14 of a screw 15, the head 16 of which is in the form of a flat plate. The screw 14 is securely retained in position as by soldering the head 16 thereof to the inner surface of the floor 12 and by soldering the area around opening 13 to the stem 14. The mouth 18 of the casing 11 is closed by a cover plate 19, the periphery of which is secured to the mouth of the casing as by soldering at 21.

Positioned in the casing is a coil 22, illustratively toroidal, the respective leads 23 and 24 of which extend through a conducting sleeve 25 secured in an insulating bushing 26 mounted in an axial opening 27 in plate 19, and through a conducting sleeve 28 secured in an insulating bushing 29 mounted in an axial bore 30 in screw 15, the ends of the sleeves 25, 28 having terminal lugs 31, 32 secured thereto, the leads 23 and 24 being soldered to said lugs.

Encompassing the coil 22 is a liner 35 of insulating material which has apertures 36, 37 through which the leads 23, 24 extend. Encompassing the side wall 35' of the liner 35 is an annular inner capacitor 38 of the wound paper-foil type having the usual alternate layers of foil and insulating material such as paper (not shown). The peripheral edges of the layers of foil which comprise one of the plates of the capacitor 38 are in electrical contact with and preferably soldered to the periphery of a conducting disc 39, the latter having an axial opening 41 through which the lead 23 extends, said lead being secured as by soldering to the periphery of said opening 41 to make an effective mechanical and electrical contact.

Encompassing the inner capacitor 38 and the disc 39 is a cup-shaped insulating liner 42, the floor 43 of which has an axial opening through which lead 23 extends.

Encompassing the side wall of the insulating liner 42 and the capacitor 38 therein contained, is a cup-shaped ground cap 45 of rigid conducting material. As is clearly shown in FIG. 1, the floor 46 of the ground cap is in electrical contact with and preferably soldered to the peripheral edges of the layers of foil that comprise the other plate of the capacitor 38, and said floor 46 has an axial opening 47 through which the lead 24 extends.

The mouth of the cup-shaped ground cap 45 has an outwardly extending annular flange 48, the periphery of which is reversely bent to define a lip 49 that is in engagement with and preferably soldered to the inner surface of casing 11 to provide a good electrical connection therebetween.

Encompassing the cylindrical side wall 51 and floor 46 of the cap 45 is a cup-shaped insulating liner 52, the floor 53 of which has an axial opening 54 through which lead 24 extends.

Wound around the side wall 55 of the insulating liner 52 is an annular outer capacitor 56 also of the wound paper-foil type having the usual layers of foil and insulating material (not shown). The peripheral edges of the layers of foil which comprise one of the plates of the capacitor 56 are in electrical contact with and preferably soldered to the flange 48 of the ground cap 45 which in turn is in mechanical and electrical contact with the casing 11. The peripheral edges of the layers of foil which comprise the other plate of the capacitor 56 are in electrical contact with the periphery of a conducting disc 59, the latter having an axial opening 61 through which the lead 24 extends, the latter being secured as by soldering to the periphery of said opening 61 to make an effective mechanical and electrical contact.

Encompassing the outer capacitor 56 and the disc 59 is a cup-shaped insulating liner 63, the floor of which has an axial opening 64 through which lead 24 extends.

With the construction above described, extreme mechanical rigidity of the internal assembly is provided. Thus, the cylindrical wall portion 51 of the ground cap 45 serves as a firm support for both the capacitors 38 and 56 in all radial directions from their centers, in one plane, the outer capacitor 56 fitting closely over the outer surface of wall 51 and the inner capacitor 38 fitting closely against the inner surface of said wall 51, portions of the insulating liners 52, 42 intervening.

As the coil 22 fits snugly against the inside of the inner capacitor 38 and as the rim 49 of the ground cap 45 fits snugly in the case 11, radial movement of the coil is prevented.

Movement in an axial direction is precluded by reason of the floor 46 and flange 48 of the ground cap which prevent movement of the capacitors in one direction and the floor 12 and cover plate 19 of casing 11 which are in close proximity to the other sides of the capacitors and prevent their movement in other direction.

As far as the coil 22 is concerned, its axial movement is precluded by means of insulating material (not shown) to take up any gaps.

By reason of the configuration of the ground cap 45, a relatively great separation is provided between the discs 39 and 59 which in themselves form two plates of a capacitor. As the capacitance is inversely proportional to the spacing between the discs, i.e., the greater the spacing the less the capacitance, by the formula

$$X_c=\frac{1}{2\pi fc}$$

where f=frequency and c=capacitance. The capacitive reactance X_c will increase directly with the spacing. Thus with a relatively great spacing between discs 39 and 59, the capacitor defined therebetween will present a high impedance to the flow of R.F. which will not pass from input to output, but will be subjected to the filtering action of coil and capacitors. In addition the floor 46 of the ground cap 45 forms a partial shield between the two conducting discs to further decrease the possibility of direct capacitive coupling between the two conducting discs 39 and 59.

Although the capacitors 38 and 56 are in close proximity to each other, since they are separated by the ground cap which is returned to ground, capacitive coupling between capacitors 38 and 56 is largely prevented.

Since the coil leads 23, 24 are connected to the axes of discs 39, 59 respectively, there is presented a minimum impedance to high frequency currents in a flat disc which will spread out radially from the center of the discs whose circular cross section increases and therefore whose resistance decreases as the distance from the center increases. In addition, the discs will form part of the internal shielding system by closing up completely the openings of the capacitor.

The capacitors 38 and 56 which are of the wound paper-foil type have inductance and resistance as well as capacitance. The greater part of the inductance is represented by that of the turns of foil, and the resistance is represented by that of the entire length of foil. For improved filtering performance, it is advantageous to reduce this inductance and resistance as much as possible, because their presence in the capacitors tends to impede the transmittal to ground of the higher range of frequencies which the filter is to remove from the conducting line.

Reduction of the resistance and inductance to a minimum for the wound paper-foil type of capacitor is accomplished by extending the respective convolutions of foil of each capacitor beyond the edges of the intervening paper insulation on both sides thereof and soldering the peripheral edges of the foil together. In effect this connects each turn of foil together in both foils thereby largely eliminating the many turns of the winding as an inductance coil and the entire length of the foil as a resistance.

The capacitor may thus be considered as having many concentric cylindrical plates in parallel with each other, with the resultant inductance and resistance greatly reduced in value to that now only of the plate-end to plate-end length of the capacitor. In addition, the conductive cross section of the capacitor is greatly increased for minimum "skin-effect." The cylindrical shape of the capacitor also affords an equal current distribution radially and maintains the advantage of the circular connecting discs 39, 59.

The capacitors in addition to their inherent use as such also form part of the internal shielding arrangement by blocking to radiation all of the space between the connecting discs 39, 59 and the ground cap 45.

As the ground cap 45 with its circular shape has a relatively large cross section, it provides minimum "skin-effect." The radial connection in a complete circle is carried over from the capacitor to the ground cap 45 and from the ground cap 45 to the case 11 with the advantages of minimum "skin-effect."

The ground cap and the case complete the internal shielding system and together with the other components mentioned, place an unbroken arrangement of low impedance metallic barriers to radiation between the two terminals of the filter.

Although in the drawings the various elements are shown spaced, it is to be understood that this is merely for ease in representation, the elements being tightly packed to prevent jarring or dislodgment.

As many changes could be made in the above construction, and many apparently widely different embodiments of this invention could be made without departing from the scope of the claims, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. A radio-frequency filter comprising a pair of concentric capacitors, a rigid cylindrical conducting member separate and distinct from said capacitors and interposed therebetween, one of the plates of each of said capacitors being electrically connected to said conducting member, a coil encompassed by the innermost capacitor and having a pair of leads connected respectively to the other plates of said capacitors, said leads defining the input and output terminals of the filter and a casing of conducting material encompassing said coil, said capacitors and said conducting member and electrically connected to the latter.

2. A radio frequency filter comprising a pair of concentric capacitors, a cylindrical conducting member interposed between said capacitors, said conducting member being cup-shaped and having a body portion with a floor at one end and an outstanding lateral flange at the other, said capacitors being positioned internally and externally of said body portion and insulated therefrom, one of the plates of each of said capacitors being electrically connected to said floor and said flange respectively, a coil encompassed by the innermost capacitor and having a pair of leads connected respectively to the other plates of said capacitors, said leads defining the input and output terminals of the filter and a casing of conducting material encompassing said coil, said capacitors and said conducting member and electrically connected to the latter.

3. A radio-frequency filter comprising a pair of concentric capacitors, a cylindrical conducting member interposed between said capacitors, said conducting member being cup-shaped and having a cylindrical body portion with a floor at one end and an outstanding annular lateral flange at the other, said capacitors being annular, and comprising interposed layers of foil and insulating material, the peripheral edges of the layers of foil on each side of the capacitors defining the plates thereof, said capacitors respectively encompassing and being encompassed by said cylindrical body portion and insulated therefrom, said floor and said flange of said cylindrical body portion respectively engaging the peripheral edges of the layers of foil on one side of each of the capacitors, a coil encompassed by the innermost capacitor and insulated therefrom, said coil having a pair of leads connected respectively to the other plates of said capacitors, said leads defining the input and output terminals of the filter and a casing of conducting material encompassing said coil, said capacitors and said conducting member and electrically connected to the latter.

4. The combination set forth in claim 3 in which a pair of discs of conducting material are axially aligned with said capacitors and straddle the latter and are insulated from said case, said conducting member and said coil, the peripheries of said discs engaging the peripheral edges of the layers of foil on the other side of each of the capacitors, said coil leads being connected respectively to said discs.

5. The combination set forth in claim 3 in which said flange has an annular lip at its outer periphery engaging said casing for electrical engagement therewith.

6. A radio-frequency filter comprising a pair of con-

centric capacitors, a cylindrical conducting member interposed between said capacitors, said conducting member being cup-shaped and having a cylindrical body portion with a floor at one end and an outstanding annular flange at the other end, said capacitors being annular, comprising interposed layers of foil and insulating material, the peripheral edges of the layers of foil on each side of the capacitors defining the plates thereof, said capacitors respectively encompassing and being encompassed by said cylindrical body portion of said conducting member and insulated therefrom, the floor and the flange of said cylindrical body portion of said conducting member respectively engaging the peripheral edges of the layers of foil on one side of each of the capacitors, a pair of discs of conducting material axially aligned with said capacitors and straddling the latter, the peripheries of said discs engaging the peripheral edges of the layers of foil on the other side of each of said capacitors, a coil encompassed by the innermost capacitor and insulated therefrom, and having a pair of leads connected respectively to said other side of each of said capacitors, said leads defining the input and output terminals of the filter and being connected respectively to said discs, and a cup-shaped casing of conducting material having a floor and a cylindrical wall portion having a mouth, a cover plate positioned over said mouth, said casing encompassing said coil, said capacitors and said conducting member, said floor of said conducting member being adjacent to and spaced from the floor of said casing and

said flange of said conducting member being adjacent to and spaced from said cover plate, the outer periphery of said flange having an annular lip engaging the wall portion of said casing, the outer capacitor being insulated from the wall portion of the casing, said discs being insulated from the floor and cover plate of said casing and from said coil.

7. The combination set forth in claim 6 in which the floor of said casing and said cover plate each has an axial opening, said coil leads extend respectively through said openings and are insulated therefrom.

8. The combination set forth in claim 6 in which the floor of said casing has an axial opening, a hollow conducting member extends from said opening and one of said coil leads extends through said hollow member and is insulated with respect thereto.

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