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A. J. DÉVOT

2,700,136

LINE FILTER

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FIG. 1

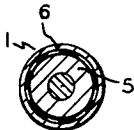
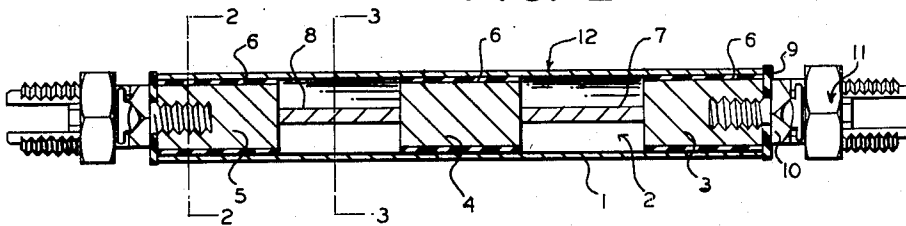


FIG. 2

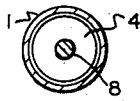


FIG. 3

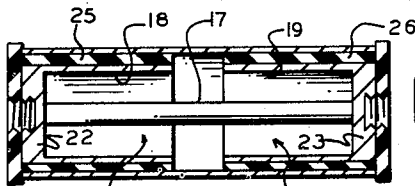


FIG. 4

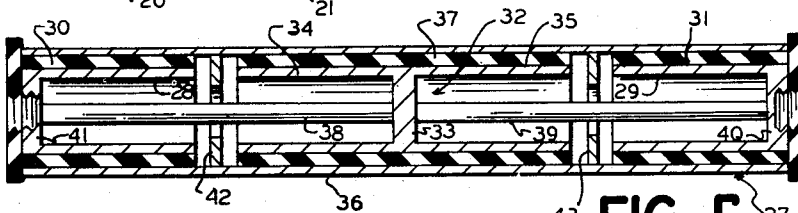


FIG. 5

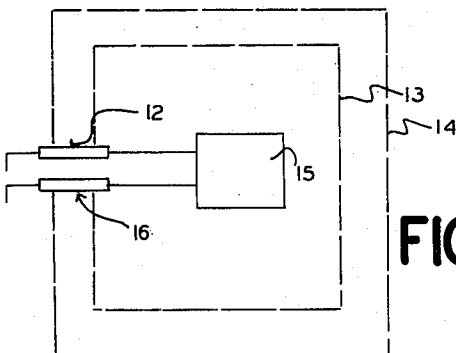


FIG. 6

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LINE FILTER

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1 Claim. (Cl. 333—73)

The present invention relates to a filter for filtering out high frequency electromagnetic waves and by-passing lower frequencies below a desired value. The filters of the present type are particularly useful in high frequency testing circuits where it is desired to eliminate from the testing apparatus system frequencies above a given range. The range of the present type of filter is designed to eliminate the transmission of frequencies from the neighborhood of 1,000 megacycles upwards.

The filter of the present invention employs a line of the coaxial cable type with abruptly changing sections for establishing reflections of the undesired frequencies which it is desired to filter out of the system. The invention is simple in its construction, is inserted directly in the line and may comprise a number of repeated sections for effectively reducing to an extremely small percentage the undesired frequency energy passed through the line.

The invention will be more fully described in the specification below when taken in connection with embodiments of the invention illustrated by the drawings in which:

Figure 1 shows a section through a filter of the present invention.

Figures 2 and 3 show sections taken on the line 2—2 and 3—3 respectively of Figure 1.

Figure 4 shows in section a modification of the filter shown in Figure 1.

Figure 5 shows a further modification in section of the filter shown in Figure 1; and

Figure 6 shows the manner in which the filter of the present invention may be employed in eliminating the undesired high frequencies in an electrical system.

In general it should be noted that the characteristic impedance of a coaxial line having an inner and outer conductor is equal to

$$K \log \frac{b}{a}$$

where b is the inner diameter of the outer conductor and a the outer diameter of the inner conductor. Where these two dimensions are substantially equal to one another or nearly so, the impedance is smaller than where the inner diameter of the outer conductor is large as compared to the outer diameter of the inner conductor. It is to be observed, however, that the phase of the impedance changes in character from the situation where the two diameters are the same to that where they are widely different. If the outer diameter of the inner cylinder is nearly that of the inner diameter of the outer cylinder, the impedance will mostly be made up of capacity between the outer and inner cylinders, while if the diameter above are far different, the impedance will be mostly inductance. Therefore, at the change in type of section, there will be an abrupt change in phase which sets up points of reflection to reflect a substantial part of the energy in the high frequency range. These reflections will be more pronounced at higher frequencies since the phase between sections will be greater the higher the frequency. The length of the filter sections also are used to produce a desired standing wave effect and sections of the order of one quarter of a wave length of the lowest frequency which it is desired to eliminate are desirable for that portion of the filter where the ratio of the diameters of the conductors are the greater.

In the arrangement indicated in Figure 1, the filter comprises an outer tubular conductor 1 with an inner

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unit which may be assembled as a whole and then slid into the outer conductor. This inner unit 2 comprises a plurality of shorter conducting cylindrical segments 3, 4 and 5 although two or more sections may be used if desired. These conductors are insulated from the outer shell 1 by sleeves 6 which may be made of some strong insulating material having a high dielectric constant as for instance "teflon" or some other suitable plastic material of the same nature. Between the sections 3, 4 and 5 are conductive connecting rods 7 and 8 which are rigidly joined to the cylinders 3, 4 and 5 by soldering, welding or by other suitable means. The rods 7 and 8 are preferably coaxial with the outer conductor and similarly the sections 3, 4 and 5 are also coaxial with the outer conductor. At the end of the sections there is an insulating disk 9 which is clamped to the end of the cylinder section 3 by means of a clamping bolt 10 which is threaded into the cylinder 3, which clamping bolt carries the clamping connector 11 by means of which the connecting cable is held tightly in position. Both ends of the filter are finished in the same way.

The filter 12 shown in Figure 1 is connected into the circuit as indicated in Figure 6 where 13 and 14 are wire screenings of a room in which electrical apparatus 15 may be situated. Power conducted into or out of the room or cage first passes through the filters 12 and 16, one in each line which will eliminate the higher frequencies from values for instance of 1,000 megacycles and upwards.

The form and construction shown in Figure 1 may be varied without departing from the present invention. The relative or absolute lengths of the narrow tubular section 6 to the larger sections 3 may be changed to provide for certain desired characteristics of the filter circuit. If the sections 3, 4 and 5 of the filter are made shorter, then the filter, by making the section 7 a length between a quarter to a half wave length of the frequency it is desired to eliminate, may act to have higher absorption near the frequency range corresponding to the adjustment of length to equal the quarter wave. In this case the sections having the large diameters act to reflect the waves transmitted through the filter and thereby set up standing waves in the sections where the small conductors are positioned. By varying the thickness of the insulating section, the capacitance of sections 3, 4 and 5 will be changed and changes in the capacitance will also occur with the choice of different insulation elements having different dielectric constants. It is preferable to terminate the filters in sections in which the inner conductor has the larger diameter as is shown by the elements 3 and 5.

A modified form of the filter shown in Figure 1 is shown in Figure 4. Here the inner conductor 17 runs substantially the length of the filter and the so-called outer conductors for the inner conductor 17 are the cylindrical walls 18 and 19 of the conductive cups 20 and 21 whose ends 22 and 23 correspond to the large end sections in Figure 1. The outer tube is conductive since the walls 18 and 19 also serve to provide the length of the end sections corresponding to those shown in Figure 1. Between the outer tube and the walls 18 and 19 are insulating sleeves 25 and 26. These may, if desired, be a single element extending throughout the inner wall of the tube.

The advantage of the arrangement in Figure 4 is that a greater length is obtained for the inner conductor 17 than in the construction in Figure 1 and if the cut-off wave length which it is desired to eliminate is fairly long, it will be possible to obtain this with a comparatively shorter filter. The cups 18 and 19 serve to provide the high capacitance sections of the larger diameter cylinder and the ends of the cup sections serve to cause reflections at the ends of the inner conductors 17.

The arrangement in Figure 4, therefore, will provide a cut-off forming lower frequency upwards corresponding to a longer wave length than in the arrangement of Figure 1 for the same overall length of filter.

Figure 5 shows a further arrangement in which the same principle shown in Figure 4 is used. Here the end sections of the filter 27 may have cup elements 28

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and 29 similar to those in Figure 4 and the construction with the insulating sleeves 30 and 31 may be the same as that of Figure 4. In the central section of the filter, the section for the conductive unit 32 may have a cross-sectional form longitudinally of a figure H lying down on its side. This element is, of course, cylindrical in shape with a cross web or partition 33 at its center, thus forming two substantial cup elements with walls 34 and 35, similar to those of the end sections, the open end of the cups facing the open end of the end cup sections. The member 32 will be separated from the outer conductive sleeve 36 by an insulating sleeve 37. The inner conductors 38 and 39 may be one continuous member in which case they will pass through the partition 33 and be welded to it or they may be made of two independent members which are securely connected mechanically and electrically to the partition 33 and the end plates 40 and 41 of the end cups.

In the arrangement indicated in Figure 5, electrical shielding disks 42 and 43 are shown between the facing ends of the cups. These will have a central opening through which the inner conductors pass, which opening should be sufficiently large so as to not interfere with the effectiveness of the functioning of the inner conductor. If the filter shown in Figure 5 is thereby lengthened, the same type of sections may be used or if desired two filters may be connected in series.

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Having now described my invention, I claim:

An electric line filter comprising a first inner conductor, a plurality of cylindrical inner conductors coaxial with the first inner conductor but spaced therefrom, said cylindrical inner conductors having end elements in the form of cups with the sides cylindrical and coaxial with the first inner conductor and with the open end of the cups directed longitudinally inwardly along the axis of the cylinders and an intermediate element formed as a pair of cups similar to said first cups with a common bottom, the open ends of said cups directed longitudinally outwardly along said cylindrical axis with said first inner conductor extending centrally through said cups from the bottom of the cups of said filter to the bottom of the cups at the other end of said filter and an outer conductor spaced and insulated from said spaced inner conductors and surrounding the same.

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