May 25, 1965 H. C. TURNAGE ETAL 3,185,944

COAXIAL FILTER

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Fig. 1

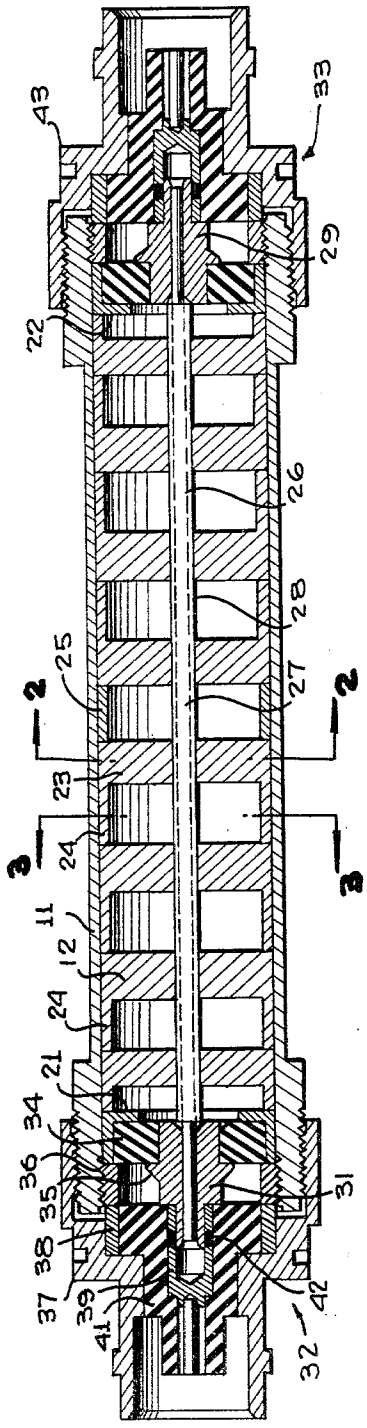
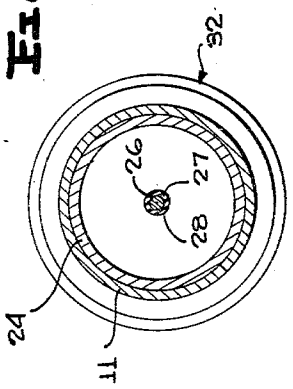


Fig. 3



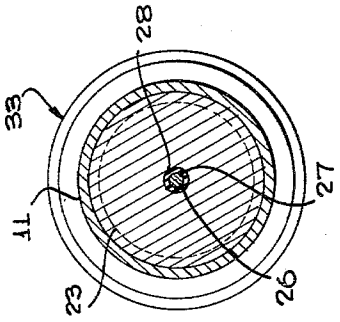


Fig. 2

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COAXIAL FILTER

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The present invention relates generally to coaxial microwave low pass filters and more particularly to a filter employing an outer conductor of varying spacing from the inner conductor.

It is known that low pass coaxial, microwave filters are obtainable by employing a plurality of cascaded coaxial sections having alternately high and low characteristic impedance. In the past, these sections have been constructed by providing variations in the diameter of the coaxial cable inner conductor while maintaining the outer conductor diameter constant. This structure has frequently necessitated utilization of a very thin central conductor upon which is mounted a plurality of relatively massive, metal annular members. Generally, there is nothing to prevent movement of the annuli longitudinally of the inner conductor axis and a certain amount of transverse movement is also possible.

When the prior art filter is subjected to shock or vibration along its axis, the inner conductor is frequently broken or stretched, causing a variation in the filter characteristics. Such poor performance of the unit results from the ability of the massive annuli to translate along the filter longitudinal axis. Attempts to solve the inadequacies of the prior art by driving retaining pins through the annuli or filling the volume between the annular sections with dielectric material proved unsatisfactory. Such practices either failed to cure the malfunction or resulted in a highly complicated assembly technique.

The prior art filter was not satisfactory for large scale production because of the difficulty associated with assembly. The annuli and their surrounding di-electric sleeves, must of essence, be closely fitted into the outer conductor. Attempts to slide these annuli, when attached at discrete spacing to the small diameter inner conductor, into the outer conductor, caused stretching of the inner conductor. This resulted in distortion of the discrete spacing between annuli assemblies to a degree which precluded repetition of the predicted and desired electrical results. After assembly, no means could be taken to correct or repair electrical deficiencies without destroying the inner conductor/annuli assembly, the most costly portion of the coaxial microwave filter.

The prior device was also subject to transverse movement of the massive, centrally mounted annuli if they were not snugly fit against outer dielectric members. Transverse movement of the annular conductors also resulted in stretching and breaking of the inner conductor. In addition, it results in significant variation of filter impedance at the time the unit is subject to transverse shocks or vibrations, even if there is no permanent damage to the unit.

The present invention obviates these disadvantages of the prior art by employing a coaxial filter having an outer conductor that varies in interior diameter. The inner conductor is of constant diameter. A plurality of stacked annular members of varying inner diameter are employed as the outer conductor to obtain the successive high and low characteristic impedance sections of the filter. The outer conductor is maintained in place by retaining rings at either end of the stacked annuli to restrain longitudinal movement. Transverse movement is constrained by a sleeve within which the constant outer diameter annuli are inserted. Thus, the annuli are not supported by the fine center conductor but are maintained in situ by contact of the outer periphery with the sleeve interior. The annuli inner diameter, at its smallest periphery, is greater than the inner conductor diameter by the distance necessary to effect the desired characteristic impedance sections. Because it may be desirable to restrain all possible transverse movement of the inner conductor, it can be provided with an insulator which the annuli sections of minimum inner diameter engage.

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The stacked annular members comprise a first section of small inner diameter and a second section, extending from the first, which has a considerably greater inner diameter but the same outer diameter as the first section. This structure is easily fabricated on a lathe to very close tolerances. The entire unit is easily assembled by stacking the annuli within the sleeve around the inner conductor. The annuli may be manufactured of separate sections, depending on the tolerance build-up permissible by the degree of accuracy required by the electrical function of the completed filter.

Accordingly, it is an object of the present invention to provide a new and improved low pass microwave filter having great mechanical strength and which is able to withstand a great deal of shock and vibration with no deleterious effects.

It is an additional object of the present invention to provide a new and improved microwave, coaxial low pass filter that is manufactured to great degrees of accuracy to insure consistency in filter characteristics.

A further object is to provide a new and improved microwave, coaxial low pass filter that is easily and inexpensively manufactured, inexpensive to assemble, requires minimum servicing and yet is manufactured to great accuracy.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a sectional view of the filter according to a preferred embodiment of the present invention;

FIGURE 2 is a sectional view of FIGURE 1 taken along the lines 2—2; and

FIGURE 3 is a sectional view of FIGURE 1 taken along the lines 3—3.

FIGURE 1, a sectional view of the preferred embodiment of the present invention, comprises an outer, rigid sleeve 11 in which a plurality of annular, electrically conducting members 12 are stacked between end brackets 21 and 22. Each annulus 12 includes a first segment 23 having a relatively small aperture and a second segment or ring 24 having a considerably greater aperture than the first, the second segment thus forming an extension of the first. The annular members 12 are positioned and maintained within sleeve 11 to contact each other and thereby establish an electrical connection of negligible D.C. or A.C. impedance between end rings 21 and 22 and coaxial connector shells 37 and 43. The outer diameter of each annulus 12 is substantially equal to the inner diameter of sleeve 11 so it fits snugly therein to obviate any possible movement between the various elements. A further annulus 25, having the same inner diameter as segments 24 of annular members 12, is inserted between the sections 23 of the two rings 12, located most centrally within sleeve 11. Annulus 25 is necessary when an even number of coaxial sections is utilized in the low-pass filter to effect the desired impedance variation of the successive sections.

Cable 26 extends through the apertures in annuli 12 and is maintained in constant position with respect

thereto by the tension exerted on it by end retaining members 29 and 31. Cable 26 includes an inner electric conductor 27 surrounded by an insulating sleeve 28, preferably constructed of Teflon, to which it is bonded, as seen best in FIGURES 2 and 3. The inner diameter of segments 23 is preferably the same as the outer diameter of insulation 28 so a snug fit between them exists. Compression of Teflon sleeve 28, to a certain extent, by segments 23 is not detrimental and is frequently advisable to restrict transverse movement of the inner conductor cable by annuli 12. Complete constraint of transverse movement is provided when the inner and outer surfaces of annuli 12 are contacting insulation 28 and the interior of sleeve 11, respectively. This is highly desirable in order to maintain the filter impedance constant regardless of any physical shock to which the unit is subjected. Longitudinal movement of the stacked sections 12 relative to sleeve 11 is prevented by compression exerted thereon by cup shaped end rings 21 and 22 by virtue of threaded sleeves 36. Rings 21 and 22 relieve stress from annuli members 34 to prevent cold flow of the Teflon di-electric material used.

Annuli members 34, constructed of electrical insulating material (Teflon) maintain members 31 in place. Conductor 27 of cable 26 is crimped to the outer portions of members 31 and shoulders 35 of members 31 prevent inward movement of members 31. Conductor 27 is stretched between members 31 at assembly. Members 31 are retained in place by the inner surfaces of annuli 21 and 22 and sleeves 36. The outer surfaces of sleeves 36 are threaded to engage matching threaded portions of the inner surface at the ends of sleeve 11.

Connectors 32 and 33 are identical, conventional coaxial connectors (it is to be understood other types may be used), for electrically connecting the filter to its circuitry. Sleeve 38, connector 39 and bushing 41 are usual and common to this type connector. Contacts 39 are attached, by soldering, to the projections of members 36 to complete the electrical circuit of the inner conductor. Connector shells 37 and 43 are screwed in place with their internal threads which match the external threads at the ends of sleeve 11. Electrical contact between shells 37 and 43 and sleeves 38, 36, and annuli 21 and 12 provide a path of negligible D.C. resistance. Accordingly, sleeve 11 may be constructed from any suitable material, not necessarily a conductor. However, if a great deal of shielding is necessary or if there is any possibility of a slight separation between the components forming outer conductor 12 between the extremities of end assemblies 32 and 33, it is preferable that sleeve 11 be a conductor.

Disposed within member 37 and concentric therewith is a conventional coaxial interior female connecting element, soldered on its interior surface to end retainer 31.

Assembly of the filter is accomplished as follows: the insulation 28 of cable 26 is removed for an adequate length at one end to expose conductor 27 which is crimped at the protruding section of one of the members 31. Annular members 34, 21, 12, 25, etc., are slid over the wire in their proper sequence. This assembly is slid into rigid sleeve 11 after one of the threaded sleeves 36 has been screwed into one end of rigid sleeve 11. The second threaded sleeve 36 is screwed into the other end of rigid sleeve 11 retaining this assembly within rigid sleeve 11. The insulation 28 is now removed, flush with the inside face of annulus 22 to expose the remaining length of conductor 27 of cable 28. Member 29 is slid over this exposed portion so that its shoulder 35 is seated against di-electric annular 34. A predetermined tension is applied to the wire and member 29 is crimped to conductor 27. The excess wire is clipped off and the contacts 39 are soldered to each end over the protrusion of members 31. Parts of connectors 32 and 33 are assembled in sequence; that is, bushing 41 and sleeve 48 are assembled to the connector shell 37 from the large end and these assemblies are screwed to rigid sleeve 11 to complete the filter.

It should thus be apparent that there is provided a low pass microwave coaxial filter having an outer conductor of alternately large and small interior diameter. By utilizing the outer conductor, rather than the inner conductor, to obtain variation in the ratio of inner to outer conductor diameter a considerable increase in mechanical strength is obtained. Also, it is possible to machine annuli 12 to a great degree of accuracy because they are separate from inner conductor 26 during the entire fabrication process. The present invention is easily assembled because of the relative ease with which slugs 12 are inserted within sleeve 11 around conductor 26.

While we have described and illustrated one specific embodiment of our invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

We claim:

1. A coaxial low pass filter comprising an elongated inner conductor of substantially constant diameter, an outer elongated hollow conductor concentric with, insulated from and substantially surrounding said inner conductor, said conductors having substantially the same length, first coaxial connector means connected to both of said conductors at one end of said filter, second coaxial connector means connected to both of said conductors at the other end of said filter, said outer conductor comprising a plurality of discrete annuli of substantially the same outer diameter positioned in stacked relationship throughout the distance between both said connector means and held in place longitudinally of said inner conductor by both said connector means, said annuli, together in the stacked relationship, including a plurality of sections having high and low characteristic impedances, said sections of high and low characteristic impedance being alternately disposed along the length of said inner conductor, said sections of low characteristic impedance including annuli having their innermost surface separated from said inner conductor by a relatively short distance to provide relatively large capacity and inductance with said inner conductor, said sections of high characteristic impedance including annuli having their innermost surface separated from said inner conductor by a relatively large distance to provide relatively small capacity and inductance with said inner conductor, said elements having no fixed connection with said inner conductor and being slidable relative thereto when one of said connector means is detached, a sleeve having an inner diameter substantially equal to the outer diameter of said annuli and having its inner surface in contact with the outer surfaces of all of said annuli throughout the distance between said connector means so that said conductors bear primarily against said sleeve and said connector means, wherein one of said annuli comprises: a cup-like member having a cylindrical base segment with a bore through which said inner conductor extends, a cylindrical flange segment extending from one face of said base segment; said base segment of said cup forming one of said high characteristic impedance sections, said flange segment of said cup forming one of said low characteristic impedance sections.

2. The low pass filter of claim 1 wherein an insulating sleeve is carried by and surrounds said inner conductor, said insulating sleeve having a diameter substantially equal to the diameter of said bore.

3. A coaxial low pass filter comprising an elongated inner conductor of substantially constant diameter, an outer elongated hollow conductor concentric with, insulated from and substantially surrounding said inner conductor, said conductors having substantially the same length, first coaxial connector means connected to both of said conductors at one end of said filter, second co-

axial connector means connected to both of said conductors at the other end of said filter, said outer conductor comprising a plurality of discrete annuli of substantially the same outer diameter positioned in stacked relationship throughout the distance between both said connector means and held in place longitudinally of said inner conductor by both said connector means, said annuli, together in the stacked relationship, including a plurality of sections having high and low characteristic impedances, said sections of high and low characteristic impedance being alternately disposed along the length of said inner conductor, said sections of low characteristic impedance including annuli having their innermost surface separated from said inner conductor by a relatively short distance to provide relatively large capacity and inductance with said inner conductor, said sections of high characteristic impedance including annuli having their innermost surface separated from said inner conductor by a relatively large distance to provide relatively small capacity and inductance with said inner conductor, said elements having no fixed connection with said inner conductor and being slidable relative thereto when one of said connector means is detached, a sleeve having an inner diameter substantially equal to the outer diameter of said annuli and having its inner surface in contact with the outer surfaces of all of said annuli throughout the distance between said connector means so that said conductors bear

primarily against said sleeve and said connector means, wherein: one of said annuli forms one of said low impedance sections comprising a disc with a bore through which said inner conductor extends; another of said annuli forms one of said high impedance sections comprising a ring with an aperture of circular cross section through which said inner conductor extends; an edge of said ring being juxtapositioned with a face of said disc.

4. The low pass filter of claim 3 wherein an insulating sleeve is carried by and surrounds said inner conductor, said insulating sleeve having a diameter substantially equal to the diameter of said bore.

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