

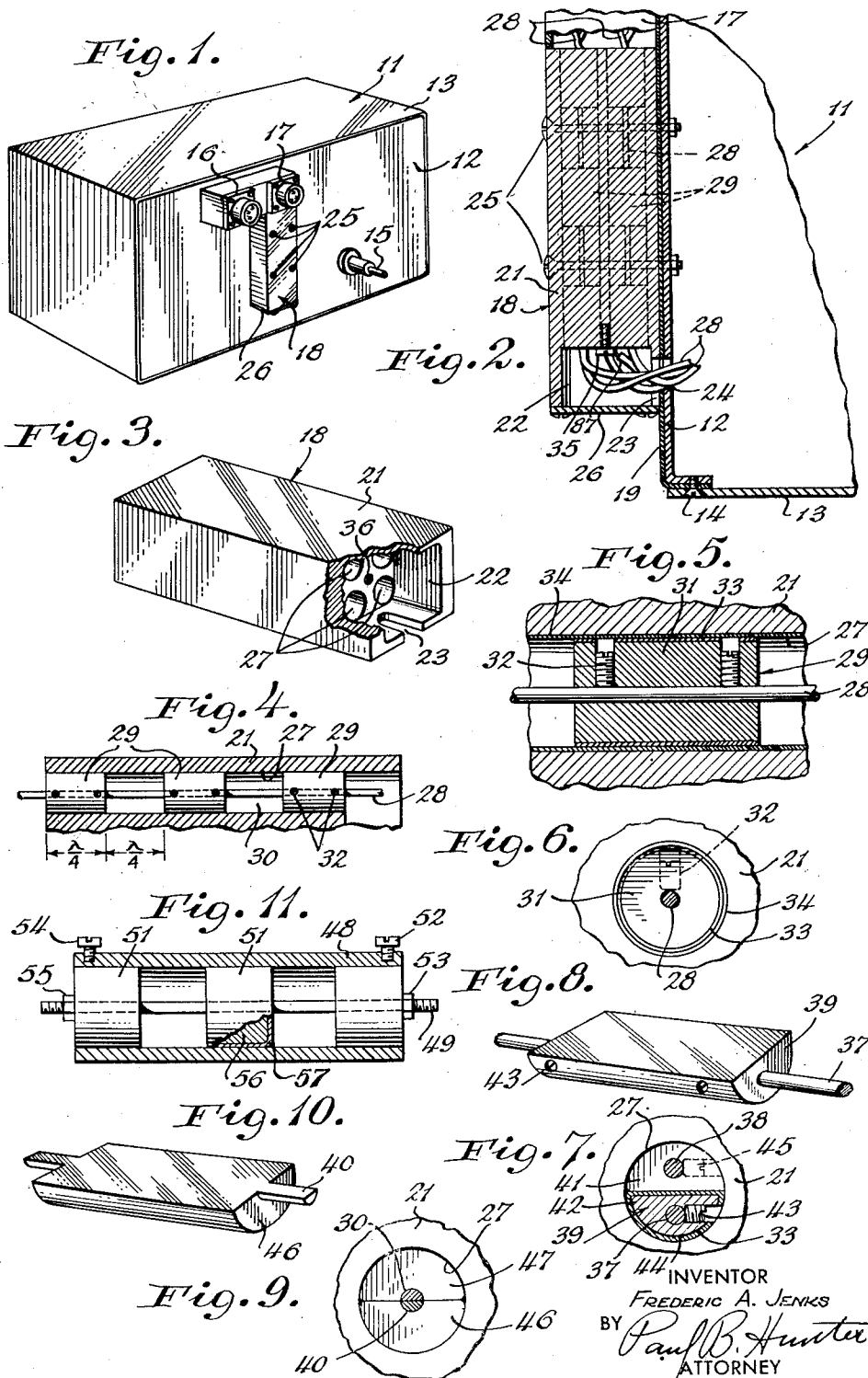
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HIGH-FREQUENCY FILTER

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## HIGH-FREQUENCY FILTER

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My invention relates to high frequency apparatus and particularly to arrangements for preventing undesired transmission of high frequency energy.

The invention will be described for its preferred embodiment as employed for blocking undesired passage of ultra high frequency energy into an ultra high frequency receiver or the like along input or output leads normally provided to carry low frequency or continuous current energy. It will be understood however that this use of the invention is only illustrative, and not restrictive.

In ultra high frequency receivers of the type employed for example in radio object detecting and locating apparatus, wherein the antenna may be located at a different level than the receiver, it was noted that the metal receiver chassis itself and metal parts therein served as an antenna producing confusing signal reception under many circumstances. It was discovered that considerable high frequency energy was leaking into the receiver through the front panel and especially through such non-high frequency transmission lines as power input and meter output leads. It was specifically in correction of this problem that the present invention was developed, although the solution may be embodied in transmission lines or the like wherever high frequency suppression or similar filter action is desired.

It is therefore a major object of the invention to provide novel arrangements for preventing high frequency energy from entering a receiver or the like by way of input or output transmission lines or conductors normally adapted to carry only low frequency or continuous current energy.

A further object of the invention is to provide novel microwave suppression filter arrangements in a transmission line.

It is still a further object of the invention to provide a high frequency filter embodying an outer conductor enclosing a relatively small diameter inner conductor having one or more radially enlarged sections each presenting a peripheral surface substantially coextensive with the adjacent inner peripheral surface of the outer conductor, and wherein one or both of said peripheral surfaces are coated or otherwise covered with a relatively high voltage insulating film or covering, preferably of film thickness, which also serves to maintain the conductors in spaced relation. Specifically pursuant to this object, each said surface of said enlarged inner conductor section or sections, or each adjacent surface

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of the outer conductor, or both, may be provided with a permanently bonded insulation film, as by the process known as anodizing.

A further object of the invention is to provide a novel enlarged inner conductor section for a transmission line high frequency filter, said conductor section having an insulation-coated peripheral surface.

A further object of the invention is to provide a novel multi-conductor high frequency filter structure.

A further object of the invention is to provide a novel high frequency filter wherein a plurality of inner conductors extending through a single outer conductor are provided with individual filter sections within the outer conductor.

Further objects of the invention will presently appear as the description proceeds in connection with the appended claims and the annexed drawings wherein:

Fig. 1 is a perspective view of an ultra high frequency receiver equipped with my high frequency filter arrangements;

Fig. 2 is an enlarged elevation partly in section illustrating a portion of the receiver panel of Fig. 1 and the mounting of my high frequency filter thereon;

Fig. 3 is a perspective view partly in section illustrating details of the block comprising the outer conductor of the filter of Figs. 1 and 2;

Fig. 4 is a fragmentary section illustrating the inner conductor arrangements in the filter of Fig. 3;

Fig. 5 is an enlarged section illustrating details of one filter section of Fig. 4;

Fig. 6 is an end elevation of Fig. 5;

Fig. 7 is an end elevational view of an optional inner conductor arrangement employable with the block of Fig. 3, wherein two conductors may be passed through a single bore in the block;

Fig. 8 is a perspective view illustrating one of the inner conductors of Fig. 7;

Fig. 9 is a section illustrating a variation of the multi-conductor arrangement of Fig. 7;

Fig. 10 is an elevation partly in section of a still further form of high frequency filter embodying the invention; and

Fig. 11 is an axial section through a shielded cable transmission line joint embodying the invention.

Referring to Figs. 1 and 2, a radio receiver comprises a plurality of elements suitably mounted on a chassis fixed to a front panel 12 and enclosed by a rectangular metal box-like dust cover 13 which is removably secured to panel 12

as by screws 14. Since details of the receiver chassis and other elements therein are non-essential to understanding the invention, none are shown or described.

On the front face of panel 12 are an antenna plug connection 15, a power input receptacle 16 for introducing continuous current power into the receiver, and a meter output receptacle 17 for obtaining low frequency output meter actuating energy from the receiver. The invention is primarily designed to prevent received ultra high frequency wave energy from being transmitted to the interior of the receiver through receptacles 16 and 17 and their associated leads to the receiver elements, and the invention is mainly embodied in the microwave filter device indicated at 18 in Figs. 1 and 2.

As shown in Fig. 2, the front surface of panel 12 may be covered with a thin metallic conductor sheet 19 which is grounded to the receiver as by being clamped between panel 12 and cover 13 as illustrated. Such a conductor sheet 19 is substantially necessary where panel 12 is of an insulating material, but where panel 12 is metallic sheet 19 may be omitted as will appear. In a form of the invention successfully reduced to practice, filter device 18 comprises a solid conductive metal block 21 having a recessed lower end chamber 22 communicating with the receiver interior by means of a side wall aperture 23 and an aperture 24 through sheet 19 and panel 12.

Filter device 18 is secured to panel 12, as by bolts 25 passing through block 21, and the inner surface of block 21 is thus held in good conductive contact with grounded metallic sheet 19 or with the bared metal outer surface of panel 12 where sheet 19 is omitted. Apertures 23 and 24 are aligned as illustrated, and a removable cover plate 26 both physically and electrically closes the open end of recess 22. Plate 26 must have good electrical contact with block 21, and may be integral therewith, and must have good electrical contact with sheet 19 or the metallic front surface of panel 12 so as to prevent leakage of high frequency energy into the receiver at these points.

Block 21 is suitably formed with a plurality of spaced parallel cylindrical longitudinal bores 27, each of which is adapted to contain an inner conductor assembly as illustrated in Fig. 4. Each inner conductor assembly comprises a continuous conventional relatively small diameter wire 28 having provided thereon at regularly spaced intervals a plurality of radially enlarged sections 29.

Preferably each section 29 comprises a cylindrical annular conductive member 31 mounted upon wire 28, and secured tightly upon wire 28 as by set screws 32 which terminate well short of the outer peripheral surface of member 31. Preferably, also, each section 31 is made of solid aluminum or a suitable aluminum alloy and has its outer surface provided with an integrally bonded electrical insulating film or covering 33 of aluminum oxide produced by the electrolytic process known in the art as anodizing.

Briefly, anodizing of member 31 is accomplished by making member 31, which is of aluminum or an aluminum alloy, the anode of an electrolytic cell containing a suitable concentration of sulfuric or chromic acid electrolyte. Activation of the cell provides in due time an aluminum oxide coating on member 31. Upon removal from the cell, the oxide coating of member 31 is "sealed," as by immersion of member 31 in a boiling water or steam bath. By this step, the oxide coating

is probably converted to a monohydrate of somewhat greater volume but will be referred to herein as an oxide coating or oxide coating compound, and tendency of the coating to "chalk" upon prolonged exposure to air is largely prevented.

In general, substantially any known anodizing process may be employed for my purpose. For example, any of the anodizing processes described at pages 368 to 373 of Protective Coatings for Metals, by Burns and Schuh, American Chemical Society Monograph Series No. 79, published by Reinhold Publishing Corporation of New York, N. Y., may be employed.

As pointed out in the Burns and Schuh publication, conditions of the anodizing process may be varied according to the desired properties of the oxide coating 33. For my purpose, I desire the aluminum oxide compound coating to be smooth and resistant to abrasive action and to have a relatively high voltage insulation. I find that the process conditions best for obtaining such results include the anodization of a pure aluminum member 31, and the hot water sealing step. The oxide coating so produced has voltage insulation up to about 900 volts. Where member 31 comprises an aluminum alloy, the voltage insulation of the oxide coating is correspondingly lower, for example in the neighborhood of 250-400 volts in the case of Duralumin or like alloys.

The thickness of film 33 can be controlled by suitably regulating process conditions such as current density, time, etc. For my purposes, I find a film thickness of between about .0001 inch and .00075 inch satisfactory. This film thickness must be carefully controlled for my invention since member 31 should have a smooth sliding fit with bore 27, for properly and removably supporting the inner conductor and for providing maximum distributed capacitance between the inner and outer conductors at these sections. A force fit between member 31 and bore 27 must be avoided to prevent scraping away of the film.

Other surfaces of member 31 than its peripheral surface are of course oxidized during anodization, but these are incidental and unimportant, and Fig. 5 shows only the oxide coating 33 which is concerned with the invention.

According to the above therefore, each enlarged inner conductor section 29 is provided with an integrally bonded, permanent, smooth, hard, abrasive-resistant, non-porous, uniform-thickness film of insulating material. If desired, block 21 may also be made of aluminum or an aluminum alloy, and treated by anodization similarly to member 31 to provide a suitable aluminum oxide film 34 on the interior of bore 27. Film 34 preferably has the same properties as film 33. Alternatively, the invention may be carried out by provision of a suitable film 33 alone, film 34 alone, or both as illustrated in Fig. 5, the films being made of necessary thickness. Where block 21 is anodized, its rear surface is scraped to bare metal before mounting on sheet 19 or panel 12, to insure proper shielding.

Suitable coloring agents may be introduced into the anodizing process for obtaining oxide coatings of desired color, as described by Burns and Schuh. This fact may be employed in the present invention by providing oxide coatings of different colors on the various conductors in the several bores 27, for easy identification purposes.

Block 21 is apertured for passage of four inner conductors 28, the internal surface of each bore 27 serving as the associated outer conductor. A

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post 35, threaded into a tapped hole 36 in the bottom of recess 22, serves as a common outer conductor terminal.

In use, the various inner conductors 23 projecting from the upper end of block 21 are secured to the proper receptacle terminals. The inner conductors 28 projecting from the lower end of block 21, and wire 87 from post 35, are led through apertures 23 and 24 into the interior of the receiver for suitable connections.

As shown in Figs. 2 and 4, each filter assembly embodies three sections 29 separated by spaces 30. Preferably each section 29 and each space 30 is made equal in axial length electrically to one-quarter of the wave length of the main high frequency to be suppressed but may be any suitable length. This idea of employing such quarter wave length spacing or other suitable length is known and is not part of the present invention, which invention comprises an improvement over such known filter arrangements.

The number of sections 29 depends chiefly on the use and efficiency of the filter. An accurately made filter may require only one section 29 for eliminating the high frequency energy. The number of sections 29 is not critical therefore, but each added section increases the filter efficiency.

While the receiver is in use, outer conductor block 21 is grounded with sheet 19 or metal panel 12. The quarter wave filter sections on each conductor, while permitting passage of low frequency or continuous current energy, act to effectively short circuit high voltage ultra-high frequency energy, and thereby prevent high frequency energy from being passed into the receiver except by means of antenna plug 15.

In the filter assembly of Figs. 1-6, each bore 27 surrounds a single inner conductor. This assembly may be adapted for introducing more than four input or output leads 28 by the arrangement illustrated in Figs. 7 and 8.

In Fig. 7, a bore 27 contains two inner conductors 37 and 38 which have enlarged sections 39 and 41 corresponding to sections 29 of conductor 28. Each section 39 comprises a solid aluminum substantially semi-cylindrical member 42 threaded on conductor 37, and secured thereto by suitable set-screws 43. Member 42 is anodized as above described to provide an insulating aluminum oxide peripheral film 44 similar to film 33. Section 41 is identically constructed and is secured upon conductor 38 as by set-screws 45. Sections 39 and 41 are so disposed as to be coextensive with the aluminum oxide films on their adjacent flat faces in flush contact and so that together they support the conductors within bore 27 as if a solid cylindrical member was employed.

By the above arrangement each bore 27 may be made to accommodate two inner conductors. The disposition and dimensions of sections 39 and 41 are the same as for sections 29 above described. If desired, each bore 27 may be adapted to accommodate three, four, or even more inner conductors by suitably shaping and anodizing the enlarged inner conductor sections. For example these sections would be quadrants where four conductors are accommodated.

Figs. 9 and 10 illustrate an embodiment of the invention similar to that of Figs. 7 and 8, but wherein separate integral inner conductor members are provided. As shown in Fig. 9, two inner conductors 30 and 40 are supported within a single bore 27. As shown in Fig. 10 each semicylindrical conductor 40 is integrally formed with a semicylindrical enlarged section 46, similar in

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shape to section 41. Semicylindrical conductor 30 is identically formed with an enlarged integral semicylindrical section 47 similar to section 39. Preferably each inner conductor member is cast in one piece from aluminum or an aluminum alloy in one or more sections as required, and then both are anodized to provide over-all aluminum oxide coatings similar to film 33. These oxide coatings are not shown in detail in Figs. 9 and 10.

In use, the two integral conductors are assembled within bore 27 with their oxide coated flat sides in full surface contact, and with sections 46 and 47 coextensive. The oxide coatings insulate the inner conductors from each other and the other conductors for low voltages as in Figs. 7 and 8. The arrangement of Figs. 9 and 10 enables me to locate the two inner conductors in maximum proximity and thereby avoid as much as possible undesirable high frequency effects which may arise by reason of the parallel wire assembly entailed in the construction.

If desired of course inner conductors 28, 29 of Fig. 4 may also be an integrally cast member for simplicity of construction.

Fig. 11 illustrates a form of the invention which may be embodied as a microwave filter unit adapted to be employed in a single transmission line. This unit comprises an outer conductor tube 48 having a concentric inner conductor 49 which projects from opposite ends of the unit. A series of cylindrical enlarged sections 51 are provided along conductor 49 within tube 48.

Each section 51 preferably comprises an anodized cylindrical plug 56 threaded on conductor 49, the aluminum oxide film 57 on its periphery fitting snugly and smoothly within the inner periphery of tube 48. Each section 51 is preferably of an axial length equal to one-quarter of the operating frequency but may be any length desired, and is spaced by an equal distance.

By employing anodized inner conductor enlargements in this filter unit, I am enabled to provide a more easily assembled arrangement which eliminates the polystyrene sleeve hitherto used between the conductors, as well as obtaining the other above enumerated advantages. Terminals 52, 53 and 54, 55 are provided at opposite ends of the filter unit for attachment of suitable conductors. To maintain the conductors against axial displacement in the assembly of Fig. 11, the outer surface of sections 51 may be wet during assembly with a suitable adhesive which dries to secure the conductors together.

The invention is not limited to the provision of insulating films such as 33, 34, 44, 53, etc., by anodization of aluminum. It contemplates any manner of providing a substantially permanent insulating film or coating suitable for the purpose. For example sections 29 may be of copper or any suitable conductive material, while film 33 may comprise a suitable layer of varnish or resin lacquer having the required insulation, hardness and other properties.

Since 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 thereof, 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.

What is claimed is:

1. A high frequency filter comprising a hollow

outer conductor, a pair of spaced inner conductors disposed within said outer conductor, a plurality of coextensive radial projections of substantially semi-circular cross-section attached to said inner conductors, the length of each of said projections and the spacing between the respective pairs of projections exceeding the inner diameter of said hollow outer conductor and each of said projections having a peripheral surface closely adjacent the coextensive inner surface of said outer conductor and each pair of coextensive projections having mated adjoining faces, and a permanently bonded film of insulating material covering each of said projections.

2. A high frequency filter comprising a hollow outer conductor, a plurality of spaced inner conductors disposed within said outer conductor, partially cylindrical-shaped coextensive radial conductive projections on each of said inner conductors having a preferable axial length equal to one-quarter of an operating wavelength, and means insulating said inner conductors from each other.

3. A high frequency filter comprising a hollow outer conductor, inner conductors disposed therein, a plurality of conductor slugs encircling said inner conductors, said slugs extending from said inner conductors toward said outer conductor, means supporting said inner conductors within said slugs, means insulating said outer conductor from said conductor slugs, and further means insulating said conductor slugs from each other said slugs being preferably a quarter of an operating wavelength long and separated from the next slug by an equal distance.

4. A high frequency filter comprising a hollow outer conductor, inner conductors axially disposed therein, a plurality of conductor slugs encircling and affixed to said inner conductors, said slugs extending from said inner conductors toward said outer conductor, means insulating said outer conductor from said conductor slugs, and further means insulating said conductor slugs from each other said slugs having an axial length equal to the axial length between successive slugs.

5. A high-frequency filter comprising a hollow outer conductor, inner conductors axially disposed therein, a plurality of conductor slugs encircling and affixed to said inner conductors, said slugs extending from said inner conductors toward said outer conductor, means insulating said outer conductor from said conductor slugs, and further means insulating said conductor slugs from each other, said conductor slugs being substantially semi-circular in cross-section and closely diametrically abutting each other, and having axial lengths of the order of one-fourth the wavelength at the operating frequency.

6. A high frequency filter comprising a hollow outer conductor, inner conductors disposed therein, and extending throughout the length

thereof a plurality of conductor slugs of circular segmental cross-sections encircling said inner conductors, said slugs extending from said inner conductors toward said outer conductor and having closely abutting diametric faces and being of the order of one-fourth wavelength long at the operating frequency, means insulating said abutting faces from each other, means supporting said inner conductors within said slugs, and further means insulating said conductor slugs from said outer conductor.

7. A high frequency filter comprising a hollow outer conductor, an inner conductor axially disposed therein, said inner conductor being split diametrically to form separate conductors having diametrically abutted faces, a plurality of pairs of semi-cylindrical conductor slug sections, each pair having diametrically abutted faces, said split conductors being axially aligned with said pairs of semi-circular slug sections and forming continuations thereof, means insulating each of said split conductor faces and said slug section faces from its abutted diametric face, and further means insulating said slug sections from said outer conductor.

8. A high frequency filter embodying a multi-conductor transmission line section comprising an outer conductor having a bore therethrough and a plurality of inner conductors disposed axially symmetrically of said bore, said inner conductors having radially extending enlarged diameter conductive sections spaced in seriatim and at predetermined regular intervals, and a film of insulating material between the peripheral surfaces of said sections and said outer conductor said enlarged conductor diameter sections and said predetermined regular intervals being preferably equal to a quarter of an operating wavelength long and alternating with each other.

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