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W. W. HANSEN

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HIGH-FREQUENCY FILTER STRUCTURE

Original Filed Oct. 31, 1941

FIG. 1

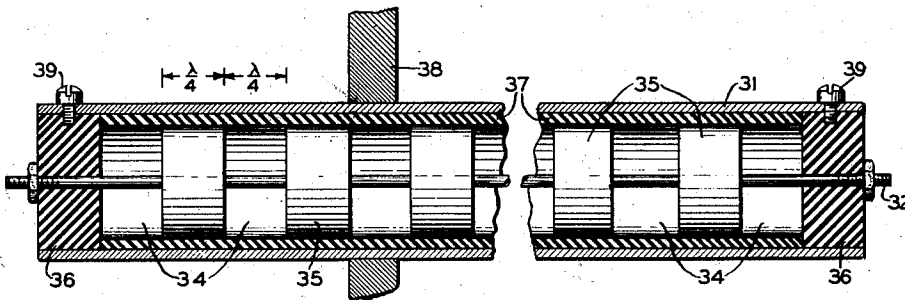


FIG. 2

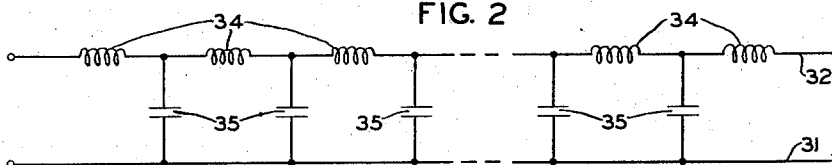
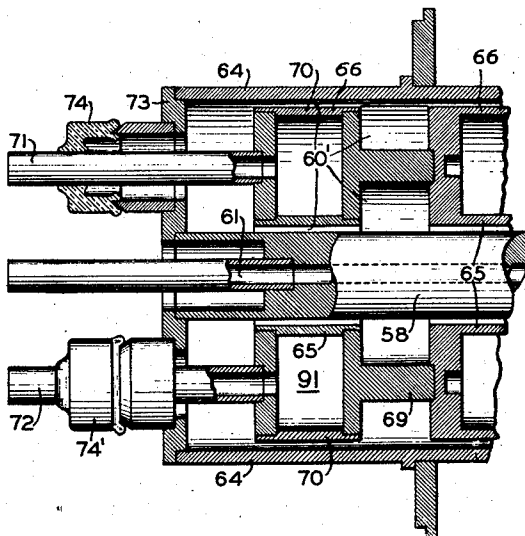


FIG. 3



INVENTOR
WILLIAM W. HANSEN
BY *Paul B. Hunter*
ATTORNEY

UNITED STATES PATENT OFFICE

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HIGH-FREQUENCY FILTER STRUCTURE

William W. Hansen, Garden City, N. Y., assignor
to The Sperry Corporation, a corporation of
Delaware

Original application October 31, 1941, Serial No.
417,229. Divided and this application Septem-
ber 2, 1942, Serial No. 457,095

16 Claims. (Cl. 178-44)

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The present invention relates, generally to concentric transmission line devices, and more specifically, to low pass filters adapted to have maximum attenuation for ultra high frequency electromagnetic energy of wavelength of the order of one meter or less. This application is a division of copending application Serial No. 417,229, entitled "High frequency tube structure," filed October 31, 1941, in the name of William W. Hansen.

In the above-mentioned application, there is disclosed an improved and practicable embodiment of high frequency tube structure utilizing principles disclosed in U. S. Patent No. 2,242,275, issued May 20, 1941, in the name of Russell H. Varian, the device employing two hollow resonators with an electron beam projecting through them, the second of said resonators being arranged in sections such that a unidirectional voltage may be applied between the sections of said resonator. A transmission line device incorporating principles of the present invention may be used to introduce the unidirectional voltage, and simultaneously to prevent leakage of ultra high frequency energy from the resonator.

Such a transmission line device also may be used as a filter to introduce voltages such as heater voltages, cathode voltages, modulation voltages, etc., through a wall of a shielding box surrounding a high frequency tube, or other high frequency apparatus, thereby preventing any high frequency radiation from leaking out of the box to disturb other high frequency circuits in the vicinity of the shielded tube, or for other related purposes.

Therefore, a principal object of the present invention is to provide a low pass filter suitable for filtering out ultra high frequencies and passing only unidirectional voltages such as are useful for beam voltages, heater voltages, control voltages, or buncher resonator acceleration voltages, or for passing very low frequency modulation voltages such as are used in ultra high frequency tube structures of the general type disclosed in the aforementioned application.

Another object of the present invention is to provide a transmission line suitable for use with such ultra high frequency devices, whereby unidirectional voltages or such low frequency voltages may be applied through the transmission line to active portions of the ultra high frequency devices in such a manner that ultra high frequency energy does not leak out of the ultra

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high frequency devices at the point of application of the unidirectional voltage.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawing wherein the invention is embodied in concrete form.

In the drawing,

Fig. 1 is a longitudinal partial cross-sectional view of a low pass filter structure embodying the present invention.

Fig. 2 is a rough analogy of an equivalent circuit of the filter shown in Fig. 1.

Fig. 3 is a cross-sectional view of a modified form of the invention embodied in a high frequency tube structure.

Similar characters of reference are used in the above figures to indicate corresponding parts.

Referring to Fig. 1 the outer tubular conductor member 31 of the device encloses concentrically a thin tubular or other dielectric member 37 which fits closely against the inner periphery of tube 31. Concentric with both tubes is a conductor 32, which at intervals expands into approximately quarter-wavelength long conducting sections or members 35 that are substantially equal in diameter to the inner diameter of dielectric tube 37. Preferably such intervals are dimensioned to provide electrically one-quarter wavelength portions or chambers 34 between adjoining sections 35 as measured along the axis of the device. The illustrated filter contains distributed inductance and capacity along its length. Sections 34 are chiefly inductive, while sections 35 are chiefly capacitive, as diagrammatically illustrated in the approximately equivalent circuit of Figure 2. The relative distributed capacity and inductance values are thus determined by the proportions selected for the inter-conductor dimensions. Sections 35, which act effectively as capacitances, are preferably made electrically one-quarter-wavelength long, but may be less than a quarter-wavelength long, that is, by considering the equivalent wavelength in the particular dielectric for the corresponding wavelength in free space at a common frequency. The unit is held rigidly together by means of insulators 36 which fit into opposite ends of tube 31 and which are held in it by means of screws 39. The unit then performs as a series inductance multi-T-section uniform-section filter. Dielectric tubular member 37 may be omitted if desired, the peripheries of the two conductors cooperating to provide sections alternately having relatively large and relatively small inter-conductor springs.

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In Fig. 1 the device has been shown as projecting through conducting wall 38 of a shielding box, although it is to be understood that the present invention is adaptable to many uses, such as illustrated by its use in the aforementioned application Serial No. 417,229. Screws 39 and the ends of conductor 32 serve as terminals for the device. Normally very few sections are needed in such a filter to give substantially complete attenuation of the frequency that is desired to be suppressed, although any desired number of sections may be used.

It will be observed from Fig. 1 that the ratio of the respective conductor diameters differs according to the spacing between them. Accordingly the characteristic impedance of the respective sections increases and decreases alternately along the conductor, being a function of the ratio of the inner diameter of the outer conductor to the outer diameter of the inner conductor, thus permitting the device to operate as a transmission line for matching impedances.

It is also evident that the cross-section of the filter of Fig. 1 may be revolved about any axis eccentric thereto, as shown in the application of which this is a division, to generate a filter made up of annular components. Although relative dimensions of such generated devices may be necessarily slightly modified, they are equally useful as ultra high frequency filters. Fig. 3 illustrates one such section of revolution, generated from Fig. 1, and made up of annular concentric portions. One portion of the section consists of inner supporting cylindrical conducting member 58, and external conducting tubular member 64 secured to member 58, said member 58 being effectively an extension of tubular member 64. Another portion consists of annular tubular conducting members 65 and 66 joined by reduced diameter portions 69, all of which are concentric to support 58. Tubular member 65 affords low impedance capacitive coupling to support member 58 by virtue of the close inter-conductor spacing, while tube 66 likewise is capacitively linked to external tube 64, thus again providing a closed path for ultra high frequency current, while allowing a unidirectional and/or a low frequency modulating voltage to be transmitted along the separate members.

Annular filter sections 69, 70 function similarly to the filter described in Fig. 1. Filter element 70 has a hollow annular internal cavity 91, which may be supplied with cooling water through tubes or conduits 71 and 72, which extend through end wall 73 and are supported by two glass bell jar members 74 and 74' placed on the diameter of wall 73. Heat also may be removed by allowing a cooling fluid to flow through axial bore 61 in support 58.

It will be observed from Fig. 3 that the device comprises an internal member 58 cooperating with the surrounding walls of outer members 69 and of reduced diameter portions 65 to provide an elongated chamber between the members having inwardly projecting walls at spaced intervals, to provide the same rhythmic effect as the alternate outwardly extending sections 35 of Fig. 1. In any case the chambers 60' between the respective members are characterized by the opposite walls thereof having alternately close and wide spacing at intervals along the chambers corresponding to the electrical equivalent of one-quarter-wavelength. The cascaded sections suppress high frequency current, since the successively adjoining sections of close and wide spacing pro-

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vide discontinuities in the characteristic impedance, the successive sections of close spacing having progressively lower impedance and the successive sections of wide spacing having progressively higher impedance, thereby tending to increase the reflection of high frequency waves toward the source.

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 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 coextensive inner and outer conductors, means providing a plurality of axially separated sections of relatively small interconductor spacing within said filter, and means providing a plurality of axially separated sections of relatively large interconductor spacing within said filter alternating with said first sections and being equal in length to said first sections, the relative interconductor spacing in said sections being such that said filter suppresses high frequency energy and passes low frequency and unidirectional wave energy.

2. A high frequency filter comprising coextensive inner and outer conductors, means providing a plurality of axially separated sections of relatively small inter-conductor spacing within said filter, and means providing a plurality of axially spaced sections of relatively large interconductor spacing within said filter alternating with said first sections, wherein said sections are each equal in axial length to approximately one quarter of the wavelength to be suppressed, and the relative inter-conductor spacings in said sections being such that said filter suppresses high frequency energy and passes low frequency and unidirectional wave energy.

3. The filter defined in claim 1, including solid dielectric means interposed between said conductors at said sections of small interconductor spacing.

4. The filter defined in claim 1, including means providing passage of a cooling fluid interiorly of at least one of said conductors.

5. A transmission line filter device comprising an outer conductor; a substantially concentrically disposed inner conductor, said inner conductor having a plurality of axially separated enlarged sections extending radially outward from said inner conductor, said sections being equal in length to the separations therebetween and having an outer peripheral surface in closely spaced relation to the inner peripheral surface of said outer conductor; and a dielectric member interposed between said respective inner and outer peripheral surfaces.

6. A transmission line filter device comprising an outer tubular conductor; an inner conductor extending substantially coaxially within said tubular conductor, said conductors having a plurality of axially separated sections providing relatively close inter-conductor spacing; and having axially separated regions between said sections of greater inter-conductor spacing, said conducting sections being equal in length to said separating regions; and insulating mounting means at each end of said device extending between said respective conductors for maintaining said respective conductors in their normal positions relative to one another.

7. A filter device comprising a tubular outer conductor; a substantially concentrically disposed inner conductor, said inner conductor having a plurality of axially separated enlarged sections extending radially outward from said inner conductor, each of said sections having an outer peripheral surface in closely spaced relation to the inner peripheral surface of said tubular outer conductor; and a tubular dielectric member located concentrically within said device between said respective conductors, said enlarged sections being electrically of quarter-wavelength along the axis of said device, and said enlarged sections being spaced along said conductor by similar quarter-wavelengths between adjoining sections.

8. A transmission line device comprising a tubular outer conductor, a concentric extension of said outer conductor, and a substantially concentrically disposed annular inner conductor having a plurality of axially separated reduced diameter sections extending radially inward toward said extension, each of said sections having an inner peripheral surface in spaced relation to the outer peripheral surface of said extension.

9. A transmission line device comprising a tubular outer conductor, and a substantially concentrically disposed inner conductor, said inner conductor having a plurality of axially separated enlarged sections extending radially outward from said inner conductor said sections being equal in length to the separations therebetween, each of said sections having an outer peripheral surface in closely spaced relation to the inner peripheral surface of said tubular outer conductor, at least one of said conductors being hollow, and said device being provided with conduit means for circulating a fluid within said hollow conductor.

10. A filter device for suppressing high frequency radio oscillations, comprising a first hollow tubular conductor, an axial extension on said first conductor, and a substantially annular second conductor disposed concentrically within said first conductor surrounding said extension of said first conductor, said respective conductors having at intervals spaced along their axis a plurality of similar sections of close inter-conductor spacing, with said sections being separated axially by portions of greater inter-conductor spacing, and said portions being equal in length along said axis to the length of said sections.

11. A filter device as claimed in claim 10 wherein said sections are defined by spaced inward and outward radial projections on said second conductor.

12. An ultra high frequency filter comprising a hollow tubular outer conductor, a concentric inner conductor, a plurality of spaced radially

enlarged conductive members, equal in length to the separation therebetween, on said inner conductor, and a sleeve of dielectric material interposed between the outer peripheries of said conductive members and the inner periphery of said outer conductor.

13. An ultra high frequency filter comprising a hollow tubular outer conductor, a concentric inner conductor, hollow radially enlarged portions on said inner conductor spaced along said conductor by separations equal in length to said portions, each of said portions having the outer periphery thereof adjacent to and coextensive with part of the inner periphery of said outer conductor, and means providing for passage of cooling fluid through said hollow inner conductor portions.

14. The filter defined in claim 13, wherein said outer conductor is provided with an axial extension, and said hollow inner conductor portions are substantially annular and surround said extension.

15. The filter defined in claim 13, wherein said outer conductor is provided with an axial extension, and said hollow inner conductor portions have the inner and outer peripheries thereof respectively adjacent to and coextensive with parts of the outer periphery of said extension and the inner periphery of said outer conductor.

16. A transmission line filter device comprising a tubular outer conductor having a coaxial reentrant extension and an inner conductor concentrically disposed therebetween, said inner conductor having a plurality of axially separated sections spaced along said inner conductor and extending radially therefrom, the separations between said sections being equal in length to the length of said sections, each of said radially extending sections having a peripheral portion thereof in close proximity to the inner periphery of said outer conductor and the outer periphery of said reentrant extension.

WILLIAM W. HANSEN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,030,178	Potter	Feb. 11, 1936
2,248,227	Gantet	July 8, 1941
2,178,299	Dallenbach	Oct. 31, 1939
2,127,408	Kaar	Aug. 16, 1938
1,935,313	Feldman	Nov. 14, 1933
2,243,851	Booth et al.	June 3, 1941
2,250,090	Buschbeck	July 22, 1941
2,253,393	Pakala	Aug. 19, 1941

Certificate of Correction

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WILLIAM W. HANSEN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 2, line 55, for the word "springs" read *spacings*; column 4, line 70, for "lenth" read *length*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of June, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.