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FREQUENCY DIVIDING FILTER FOR MULTIFREQUENCY ANTENNA SYSTEMS

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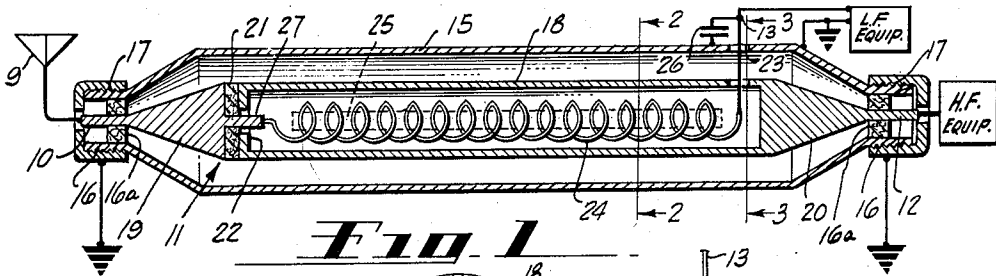


Fig. 1

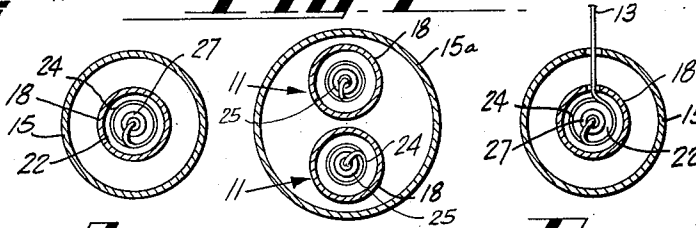


Fig. 2

Fig. 3

Fig. 7

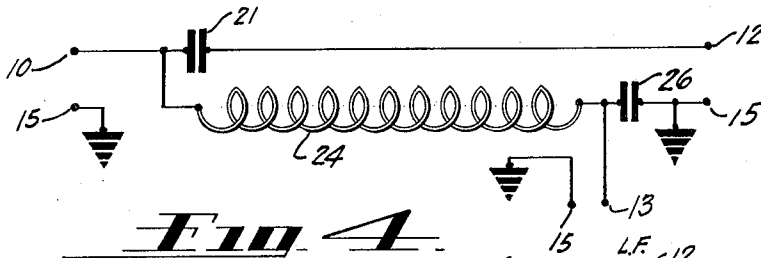


Fig. 4

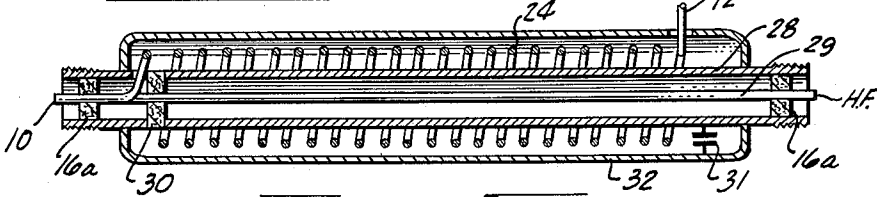


Fig. 5

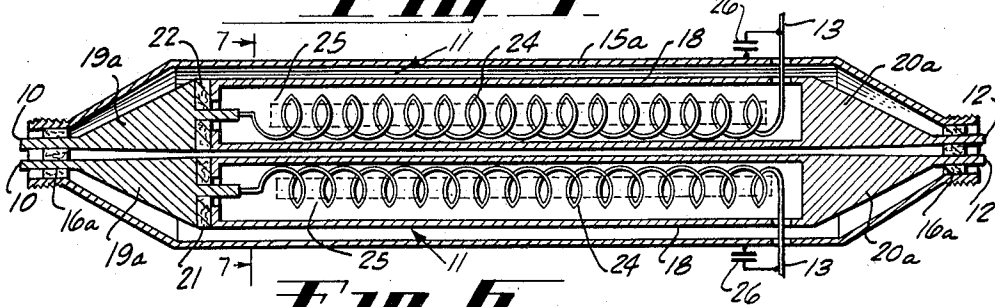


Fig. 6

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FREQUENCY DIVIDING FILTER FOR MULTI-FREQUENCY ANTENNA SYSTEMS

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5 Claims. (Cl. 333—6)

This invention relates to electrical systems for transmitting and receiving electromagnetic energy distributed over very large portions of the radio frequency spectrum. Although it will be disclosed hereinafter as particularly adapted to aircraft or other vehicle utilization, it will at the same time become apparent that the improvements provided hereby are by no means confined in their scope to such field of employment.

One of the outstanding problems in the transmission and reception of radio frequency energy is to devise a means of separating signals lying in certain wide frequency bands from those in other frequency bands without thereby adversely affecting the efficiency of the transmission or reception or detrimentally affecting the strength of the various signal bands. Within radio frequency transmission line systems any attempt to make such separation of widely distributed frequency bands usually results in disturbing the impedance relationships of the various branches of such transmission line system so that an undesirable effect on the efficiency of energy transfer for one or more bands of signals results. A satisfactory solution can be easily made for operation at two particular frequencies or over narrow frequency bands but is extremely difficult when dealing with bands of great width. This problem is particularly severe when it is desired to separate and utilize signals of medium or low radio frequencies and signals lying in that portion of the radio frequency spectrum known to the art as very high, ultra high, and super high frequencies. This is due to the extreme sensitivity of such high frequencies to abrupt changes in the physical dimensions of radio frequency line systems within whose boundaries they are confined, or to branches or elements in the transmission line system placed there in order to separate various frequency bands.

The present invention enables the removal and use of one or more signal bands, each lying near one or the other extreme frequency, to the exclusion of the ones not wanted without adversely affecting the strength of any of the signals and without upsetting the impedance relationships of the several circuits. Essentially in order to accomplish these broad results, the invention provides, in an operative position between a signal receiving or transmitting source (such as a receiving antenna or video and audio broadcasting equipment emitting both ultra high frequency and low frequency signals) and a set of converse equipment, (such as a receiver) a single unitary compact filtering article which permits the use of the system simultaneously for both broad bands of the relatively higher frequencies, and broad bands of the relatively lower frequencies. The filter is such as to accomplish its result without impairing the strength of the signals or in any wise distorting them. The article is such as to enable the use of the combined equipment either unidirectionally, that is, entirely for transmitting or entirely for receiving these mixed signals; or bidirectionally, that is, for concurrently receiving signals of one frequency while transmitting signals of a greatly different frequency.

Broadly, the novel article comprises a radio frequency transmission component which essentially consists of two coaxial, but radially separated or spaced, end-driven filter channels—a channel for broad bands of the relatively lower frequencies and a coaxial channel for broad bands of the higher frequencies—the latter channel preferably consisting of an elongate rectilinear electrically conductive member suitably electrically interposed be-

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tween the input and output terminals of the other equipment and designed to offer very little, if any, attenuation or resistance or impedance to signals in the range of the wide band of the relatively higher frequencies and constructed to concurrently strongly attenuate or bypass signals in the low frequency range. The low frequency channel of the filter is coaxial with the first-said channel and consists of an inductance essentially so designed as to offer very little attenuation or signal reduction to signals in the low frequency range while concurrently effecting a very large attenuation or signal reduction in the range of the broad band of the relatively higher frequencies. The parameters of this low pass filter channel are moreover so correlated as to permit this frequency segregation in all instances where the signals carried by the low pass filter do not contain higher frequency components of the kind that lie in the pass band of the other channel. The low frequency channel is always herein disposed in concentric relationship with the broad band higher frequencies channel in compact relationship and may lie either radially outwardly or radially inwardly thereof.

The channel for the broad band of the relatively lower frequencies is electrically segregated from the channel for the broad band of relatively higher frequencies, (as by means of a bypass condenser interposed between the so-called high frequency channel and the so-called low frequency channel) although other capacitative means than a condenser are contemplated by the invention as being equally well employable.

Merely in order to further clarify the inventive concepts and to enable reproduction herefrom of at least one physical embodiment of the inventive principles, two of the presently preferred species of the invention are illustrated in the accompanying drawings and described in detail hereinafter by reference to the several parts shown in the drawings.

Hereinafter, the broad band of the relatively lower frequencies, lying anywhere in the spectrum other than at the uppermost limit thereof, will be referred to as the "low" frequency; and the broad band of the relatively higher frequencies, and lying anywhere in the spectrum above said "low" frequency, will be referred to as the "high" frequency.

In these drawings:

Figure 1 is a view showing one embodiment in longitudinal section;

Figure 2 is a cross section on line 2—2 of Figure 1;

Figure 3 is a cross section on line 3—3 of Figure 1;

Figure 4 is a schematic circuit diagram of this filter;

Figure 5 is a longitudinal section of another embodiment of the invention;

Figure 6 is a view similar to Figure 1 of a balanced line embodiment of the invention, and

Figure 7 is a cross-section on line 7—7 of Figure 6.

The drawings show, by way of example only, one of the present filters connected to a wide band antenna 9 by the antenna-end terminal 10 of the filter. However, the filter designated at 11 is equally well adapted for performing its function when suitably mechanically and electrically connected to any other source of wide-band signals than an antenna, which may be replaced by any other emitter or receiver of signals occupying very wide frequency bands concurrently. The opposite end of the filter is connected by means of terminal 12 to the high frequency equipment and by terminal 13 to the low frequency equipment, of the supporting station for the filter, which station may be either a ground station, an airplane, a marine vessel, or a land vehicle.

Since the system of the invention can be utilized as aforestated with both high frequency and low frequency signals, the terminals at each end and the filter apparatus intervening can be employed as both input and output devices, or, one of the terminals at one end can be employed as an input terminal, the other terminal at this end being concurrently employed as an output terminal and similarly at the opposite end of the filter.

In any of these cases, the filter comprises an outer electrically conductive shell 15 which is preferably a hollow metallic cylindrical body constituting the outer conductor of the high pass channel. Shell 15 is tapered as

shown toward each end and terminated at each end by a hollow cylinder 16 which is of reduced size and is preferably externally threaded as at 17, although other connection-establishing means may be employed if desired. The taper is such as to introduce the minimum discontinuity in transmission to or from the ultra high frequency equipment.

Coaxially disposed within the shell 15 and radially spaced inwardly therefrom is another hollow electrically conductive shell 18 constituting the inner conductor of the high pass channel and preferably also consisting of a metallic cylinder. It is capped at each end by solid metallic conical members 19 and 20 which terminate outwardly in the respective terminals 10 and 12, the latter being concentrically disposed within the cylinders 16.

The shell 18 is spaced longitudinally from the member 19 a certain distance which provides a gap sufficient to contain a capacitor 21, the adjacent end of the shell being inwardly annularly flanged as at 22. The opposite end portion of the shell contains a small radially directed aperture 23.

A high pass filter network path is provided from the antenna 9 to the high frequency equipment, or vice versa, by means including the terminal 10, a bypass condenser or other capacitor 21 connected in electrical parallel with the antenna by means of the terminal 10, the conical member 19, the hollow, light, electrically conductive shell 18 and the terminal 12. A low pass filter network path is also provided, and in this embodiment is formed inside the shell 18 from the antenna 9 to the low frequency equipment terminal 13 by means including the terminal 10, capacitor 21 dually functioning to exclude low frequencies from shell 18 while permitting high frequencies to pass through the capacitor and shell 18. These high frequencies are excluded from the axially central low frequencies path by virtue of the inductive nature of the coil 24. The aforesaid arrangement of the capacitor with respect to the respective conductor-paths and their input ends also enables the low frequencies path to be led physically through the center of condenser 21 without effective electrical contact or transfer of energy and on into a high frequencies excluding inductance coil 24. This coil is wound over a powdered iron core 25. The later two are connected in shunt with a capacitance, or button condenser, 26 mounted on shell 15, the condenser in turn being connected in shunt with terminal 13. Ceramic spacer rings or sleeves 16a are provided at each end of the inner tubular member to support and space the terminals 10 and 12 with respect to the cylinder ends 16.

When the radio equipment of the vehicle is receiving mixed signals, namely, high frequency and low frequency signals, the input is introduced from the antenna or generator into the terminal 10. All the signals pass inwardly into the filter unit lying within the shell 15 and such of them as lie in frequency ranges higher than a predetermined minimum above the low frequency category and for example, of the order of 30 megacycles, by their very nature as high frequency electromagnetic energy encounter no effective resistance in capacitor 21 and hence will pass effectively to the high frequency terminal 12 at the opposite end of the filter unit through the shell 18. By their very nature and the nature of the electrical components 24, 25 and 26, they are prevented from appearing across the low frequency terminal 13. Signals of a frequency appreciably lower than those above mentioned will, on entry through terminal 10 and conical member 19 be subjected to an effective amount of attenuation in capacitor 21 and will be so attenuated or bypassed therein that they cannot reach shell 15, shell 18 or terminal 12.

Such configuration thus effectively performs one of the steps of the invention in that it definitely segregates low frequency signals from high frequency signals at the inception of their passage from the antenna to the other equipment. The next phase of the invention consists in directing and transmitting the respective ones of these segregated signals in the desired respective paths and to this end, in all forms of this invention, these means are constituted by the inductance coil 24 connected to the insulated central projection 27 of the conical member 19 inside the capacitor. Also in all forms of the invention it is preferred to wind the inductance coil 24 over a powdered iron core 25 in order to increase the inductance and its pulverulency minimizes hysteresis and other losses

and does so in the minimum of space. It will be noted that the outer terminal of the coil is connected directly to the projection 27 and the inner terminal of the coil is shunt connected through the condenser 26 to the terminal 13. These combined elements form an effective low pass network for directing the segregated low frequency signals away from the outwardly shunted high frequency signals at the capacitor 21. This network is endowed with a high impedance and by virtue of this fact it effectively rejects high frequency signals attempting to enter it.

It should be noted that the low pass filter path is, by means of the shell 18, the iron core 25, and the condenser 26, effectively protected from the high frequency field, these aforementioned elements preventing the high frequency electromagnetic field from entering the inner channel of the coaxial line by virtue of the fact that the inner channel offers a high impedance. Thus the efficiency and effectiveness of the low pass filter channel is maintained high and furthermore the signals of whatever frequency that pass through the article are not distorted to any appreciable degree.

When the system is utilized to transmit signals outwardly from the high frequency and low frequency equipment of the vehicle both sending concurrently to the antenna, naturally the input terminals and direction paths are reversed from those employed when the system is receiving. Signals are, in the former case, concurrently applied to terminals 12 and 13 and enter the antenna through terminal 10, being selectively directed and undergoing segregation before reaching the antenna. The device as aforesaid, can also be concurrently employed as both a transmitter and receiver, signals then contemporaneously passing in opposite directions or bi-directionally. To this end, terminals 12 may be connected to the high frequency transmitting equipment to finally emit signals from one portion of the composite wide band antenna while terminal 13 remains connected to the low frequency equipment to receive the incoming signals intercepted in the other portion of the antenna. Thus, terminals 12-13 and 10 may be variously connected to receive and transmit signals in any sort of combination that may be desired.

The capacitor 26 prevents appreciable amounts of low frequency energy from passing on to the high frequency equipment. If the high frequency equipment did not incorporate a series capacitor in its antenna input circuitry, then when such low frequency energy reached the high frequency equipment, it would cause a reflected impedance to appear across terminal 10, causing a deleterious effect upon low frequency signals only. In other words, without the condenser 26, the high frequency channel would appear as a "short-shunt coaxial electrical stub" across the input terminals of the filter device.

From the circuit diagram of Figure 4, it will appear that the conductive casing 15 is, of course, grounded at each end and that condenser 26 is connected on the one side both to the ground and to the casing 15.

A further form of construction embodying the invention is shown in Figure 5. In this species, the low pass channel 24, while still disposed coaxially with the high pass channel, is arranged externally of, that is, lies outside, the latter channel which may consist of a shell 28 and a conductor 29. The shell may be either conductive or non-conductive and may support the low pass channel in the form of a coil either directly or indirectly. Among other consequences the shell 28 may at the same time serve as the core of the low pass filter, to this end then being made of a suitable ferrous material in such a physical state as is conducive to enhanced impedance relationships and to hysteresis suppression. The conductor 29 is supported coaxially inside shell 28 substantially on the longitudinal axis of the latter by means of ceramic spacers 16a, which may be identical with those shown in Figure 1. Capacitances 30 and 31, somewhat similar to those previously described, as 21 and 26, are provided and employed for the purpose described. This configuration of the elements of the invention results in a much more compact, but equally efficient article than the aforescribed one, and which may have lesser weight where it is not mandatory to employ the outer shell. However, even if an outer screen or shell 32 of suitable material is disposed coaxially around the two filter channels (to prevent eddy currents from affecting other electric equipment in the supporting station) this need not increase

the diameter of the resultant article at all over the one previously described and, of course, the lengths thereof are equal.

In Figure 6 it is demonstrated that the invention can be applied not only to single conductor path lines which are coaxial but equally well to two coaxial conductor units connected in parallel, and arranged coaxially within a shell to, in effect, provide a multiple "coaxial" unit. Briefly, to this end the single element or unit 11 within shell 15 and constructed and functioning by itself as described with reference to Figure 1, is here duplicated. Two such units 11 may be employed and disposed in balance inside a single shell 15a thereby affording two balanced line paths through the filter, each path consisting of a so-called "coaxial" unit, with all the concomitant advantages. Except for the members 19a and 20a, which here are, instead of being regularly or symmetrically conical, cones flattened and tapered on their inner sides, all the electrical and other elements that correspond functionally to those in Figure 1, are identical structurally thereto.

Although certain specific electrical elements have been designated for performing certain functions, it is to be understood that electrical equivalents of these elements are contemplated by the invention for substitution therefor as well as the employment of materials of a different composition from those specified if electrically and mechanically equivalent. It is, therefore, to be understood that the invention is not limited in the specific nature of the elements or in their specific configuration or to specific frequency bands other than as required by the scope of the annexed claims defining the inventive concepts in terms of their broadest novel constructional and operational aspects.

We claim:

1. Means for separating desired low frequency signals and desired high frequency signals from a mixture of a broad band of high frequency signals overlapped with a broad band of low frequency signals, comprising: a first elongate electrical conductor having a helical shape and defining a low frequencies path thru the device; a second elongate electrical conductor having a substantially rectilinear shape and defining a high frequencies path thru the device; said two conductor paths being substantially coextensive and being arranged in mutual coaxiality; said second conductor-path being radially spaced from said first conductor path, throughout the extent of their mutual coextensiveness, that radial distance of which the mutual capacitative effects of said conductor paths on each other is substantially zero; signal input means disposed in electrical parallel with the input ends of said high frequency and low frequency conductor paths, and respective signal-activated means respectively connected to the output end of respective predetermined ones of the aforesaid conductor paths; and a capacitor disposed transversely of said conductor paths substantially at their input ends, said capacitor being arranged in series between the input means and the aforesaid means that define the high-frequency conductor path and being constructed so as to transmit input signals to said high frequencies conductor path, said low frequencies conductor path electrically by-passing said capacitor thereby to block out from said high frequencies conductor path the said low frequencies and to effect blockage out from said low frequencies path of said high frequencies; said capacitor having an axial extent exceeded by its radial extent and having an effectiveness based upon its excess of radial extent over its axial extent so as to sharply separate said overlapping broad bands from each other at the very inception of their reception in the device.

2. Means for separating desired low frequency signals and desired high frequency signals from a mixture of a broad band of high frequency signals overlapped with a broad band of low frequency signals, comprising: a first elongate electrical conductor having a helical shape and defining a low frequencies path thru the device; a second elongate electrical conductor having a substantially rectilinear shape and defining a high frequencies path thru the device; said two conductor paths being substantially coextensive and being arranged in mutual coaxiality; said second conductor path being radially spaced from said first conductor path, throughout their mutual coextensiveness, that distance at which their mutual capacitative effect is substantially zero; signal input means disposed in electrical parallel with the input ends of said two con-

ductor paths, and respective signal-activated means respectively connected to the output end of respective predetermined ones of the aforesaid conductor paths; and a substantially centrally perforate, disciform condenser unit, of the dielectric-spaced-plates type, extending transversely across said conductor paths substantially at their input ends and electrically disposed in series between the input means and the means defining the high-frequency conductor path, the low frequency conductor path passing through said central perforation free of electrical association therewith; said condenser-unit having a length axially of the device considerably less than its extent radially thereof, said condenser-unit being rendered effective mainly by its radial extent and its intrinsic electrical properties rather than by its axial extent thereby to sharply separate the broad band of high frequencies from admixture with the low frequencies.

3. Means for separating low frequency signals and desired high frequency signals from a mixture of a broad band of high frequency signals overlapped with a broad band of low frequency signals, comprising: a first elongate electrical conductor having a helical shape and defining a low frequencies path thru the device; a second elongate electrical conductor having a substantially rectilinear shape and defining a high frequencies path thru the device; said two conductor paths being substantially coextensive and being arranged in mutual coaxiality; said second conductor path being radially spaced from said first conductor path, throughout their coextensiveness, that distance at which their mutual capacitative effects are substantially zero; signal input means disposed in electrical parallel with the input ends of said conductor paths, and respective signal-activated means respectively connected to the output end of predetermined respective ones of the aforesaid conductor paths; and a substantially centrally perforate, disciform condenser unit of the dielectric-spaced plates type extending transversely across said conductor paths substantially at their input ends and electrically disposed in series between the input means and the means defining the high-frequency conductor path, the low frequency conductor path passing through said central perforation free of electrical association therewith; said condenser unit having a length axially of the device considerably less than its extent radially thereof, said condenser unit being rendered effective mainly by its radial extent and its intrinsic electrical properties rather than by its axial extent, thereby to sharply separate the broad band of high frequencies from admixture with the low frequencies; each of said conductor paths holding to its original, initial direction throughout its extent from one end of the elongate device to the opposite end thereof with each of said conductor paths being devoid of abrupt changes of direction therein; thereby to obviate any and all energy-reflection, and all alterations in impedance relationships, in said paths.

4. A differential frequency-bands filtering device, comprising: a helical inductance-member defining a low-frequencies path thru the device; a hollow support therefor disposed coaxially inside said inductance member and substantially coextensive therewith; a substantially rectilinear substantially axially coextensive conductor member disposed coaxially inside said hollow support and defining a high frequencies path thru the device, and radially spaced from said inductance member sufficiently to obviate mutual capacitative effects; signal-input means electrically connected in parallel to the input end of said inductance member and the input end of said rectilinear conductor, there being respective signal-activated means electrically connected respectively to the output ends of said inductance and said rectilinear conductor; and discrete capacitative means disposed substantially at and transversely of the input end of the inductance and of the rectilinear conductor, the capacitative means having an axial extent that is short relative to its radial extent and being disposed electrically in series between the input means and the means defining the high-frequency conductor path, said capacitative means being arranged to be electrically transmissive to said rectilinear conductor and being arranged to be electrically by-passed by said inductance thereby to block out low frequencies from the rectilinear conductor and enabling said low frequencies to pass into said inductance while enabling high frequencies to traverse said rectilinear conductor thereby to sharply separate said overlapping broad bands from each other at the beginning of their reception in the device.

5. A device for differentially filtering overlapping broad bands of high and low frequencies, comprising: a substantially hollow elongate shielding member; a plurality of hollow elongate conductive bodies defining high frequencies paths thru the device disposed in said shielding member physically in substantial parallelism therewith; said bodies being radially spaced mutually apart and radially spaced away from the shielding member thereby to obviate mutual capacitative effects; an elongate inductance member defining a low frequencies path thru the device disposed in mutually coaxiality in each of said bodies in radial separation therefrom; signal-input means electrically connected in parallel to the input ends of the inductance members and the hollow bodies, and respective signal activated means electrically connected respectively to the output ends of said inductances and said bodies; and a discrete capacitative means disposed substantially at and transversely of the input end of the inductances and the input end of said elongate conduc-

tive bodies and said discrete capacitative means being disposed in electrical series between the input means and the means defining the high-frequency conductor path; said capacitative means having an axial extent which is short relative to its radial extent and being electrically transmittive to its associated hollow conductive body, and said capacitative means having the input end of the electrically associated inductance passing therethrough free of electrical association therewith.

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