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ULTRA HIGH FREQUENCY FILTER

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Fig. 1.

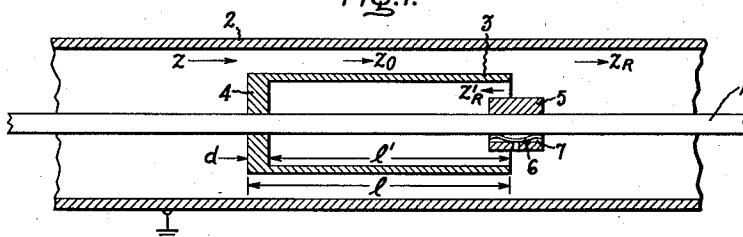


Fig. 2.

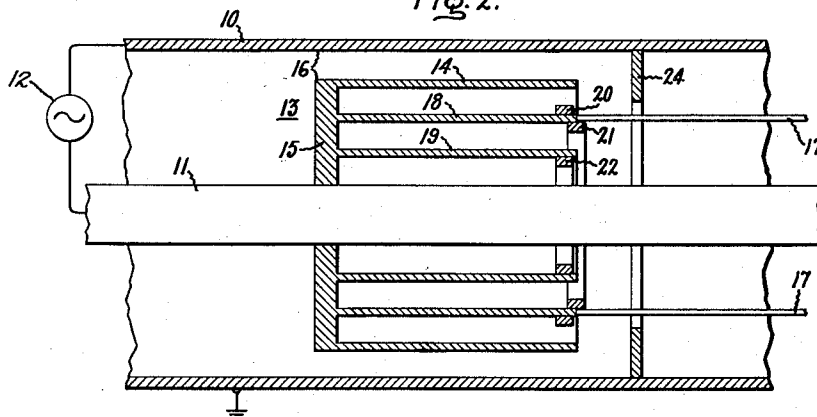
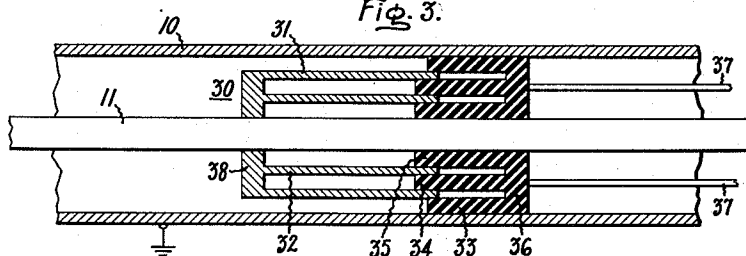


Fig. 3.



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ULTRA HIGH FREQUENCY FILTER

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9 Claims. (Cl. 178—44)

This invention relates to an electric filtering arrangement especially adapted to use at ultra high frequencies.

As is well known, it is frequently necessary in radio circuits and like apparatus to provide means for effectively separating direct current and alternating current paths. At the frequencies commonly used in radio broadcasting, such separation may be accomplished by the use of choke coils and condensers, properly arranged. At extremely high frequencies, however, such as frequencies corresponding to wave lengths of the order of a few centimeters, the conventional arrangements heretofore employed fail to produce desired results and it is necessary to resort to more complex expedients for current separation.

An object of my invention is to provide an improved form of ultra high frequency filter which is simple and compact in structure and which is easily adjusted to provide satisfactory filtering at very short wave lengths.

It is also known to use, in conjunction with space resonant cavities of the concentric transmission line type, capacitive tuning plungers to adjust the resonant frequency of such a capacity, the plungers taking the form of sleeves interposed between the concentrically disposed conductors and movably supported by one of the conductors. The length of the sleeves is made substantially equal to a quarter wave length of the wave which it is desired to confine within the space resonant cavity.

Another object of my invention is to provide a new and improved capacitive tuning plunger for a space resonant cavity which more effectively confines electromagnetic waves within the cavity.

Still another object of my invention is to provide a new and improved ultra high frequency choke which may be tuned to a plurality of frequencies.

Still another object of my invention is to provide a new and improved ultra high frequency filter operative effectively over a wide frequency band.

It is a further object of my invention to provide a new and improved filtering arrangement in conjunction with a capacitive tuning plunger for a space resonant cavity.

One of the features of the invention is the use of a cup-like member connected to and concentrically surrounding a lead supplying power frequencies to an ultra high frequency system and which is concentrically spaced within a tubular outer conductor, the cup-like member forming with the lead and the outer conductor two partly

co-extensive sections of concentric transmission line of unequal electrical lengths. An adjustable capacitance is provided across the shorter of these sections to adjust its electrical length so that the two sections in series appear as an electrical short circuit to ultra high frequency currents traveling from the high frequency system along the power lead.

In a modification of the filtering arrangement as used in conjunction with a capacitive tuning plunger for a space resonant cavity of the concentric transmission line type, the space inside the plunger is utilized to provide a plurality of chokes connected in series and means are provided to adjust the frequency of each of these chokes.

The features of the invention desired to be protected herein are pointed out in the appended claims. The invention itself, together with further objects and advantages, may best be understood by referring to the following description taken in connection with the drawing in which Fig. 1 is a longitudinal sectional view of a high frequency filter of my invention; Fig. 2 is a longitudinal sectional view of a capacitive tuning plunger employing my improved high frequency filter; and Fig. 3 is a longitudinal sectional view of another modification of the high frequency filter.

Referring to Fig. 1, there is shown the power lead 1 concentrically disposed within a tubular conductor 2 which may be grounded. The lead 1 and the tubular outer conductor 2 form a concentric transmission line which may be connected at its left-hand end to an ultra high frequency space resonant system and the lead 1 may supply operating potentials to this system. In order to remove the high frequency currents of the system from the power lead 1, an electrical filtering arrangement is provided which comprises a cylindrical metallic cup-like member 3 concentrically surrounding the lead 1 within the conductor 2. At its end nearest to the source of ultra high frequency currents, the cup-like member 3 is connected to lead 1 by means of a transverse end wall 4.

The principle of operation of a filter of the type described is easily understood. The outer surface of the sleeve portion of the cup member 3 forms with the inner surface of tubular outer conductor 2 a short section of concentric transmission line, the length of which for any given system is made equal to an electrical quarter wave length or an odd multiple thereof of the ultra high frequency wave to be removed from lead 1.

The inner surface of the sleeve portion of member 3 forms with lead 1 a second short section of concentric transmission line which physically is reentrant within and electrically is connected in series with the short section comprised by members 2 and 3, the second short section providing a reversed path for high frequency currents flowing along transmission line 1, 2. The characteristic impedance of the outer of the two sections may be designated by Z_0 , the value of which is determined by the ratio of the diameters of members 2 and 3. The impedance of the inner of the two sections in the drawing is designated as Z'_R . The second or inner short section of transmission line is short-circuited at its left-hand end by means of the end wall 4.

If it is assumed, for simplicity of discussion, that the lines thus formed are dissipationless and that additional reactances due to discontinuities at the junction are negligible, the input impedance Z into the filter formed by the two short sections of transmission line is given by the expression:

$$Z = Z_0 \frac{(Z_R + Z'_R) \cos \beta l + Z_0 j \sin \beta l}{Z_0 \cos \beta l + (Z_R + Z'_R) j \sin \beta l}$$

where Z_R is the impedance of the transmission means beyond the filter. For optimum operation as a choke, the impedance Z of the filter must be made either zero or infinite. The above expression shows that this can be done only if the quantity $Z_R + Z'_R$ is made either zero, infinite, or purely reactive. In the usual applications, it is found desirable to make the performance of the filter independent of the impedance Z_R of the transmission means beyond the filter. In order that this result may be obtained, it is necessary that this section of transmission line formed by members 1 and 3 be resonant and also that the section of the transmission line formed by members 2 and 3 be resonant, which resonance is obtained when the length of both of these sections is made equal to a quarter wave length or odd multiple thereof of the electromagnetic wave to be removed from lead 1.

It is apparent that the inner and outer sections have different physical lengths l and l' due to the thickness d of wall 4 and also because of fringing capacitance at the junction and that without further means both of these sections cannot be made resonant at the same frequency. Such resonance is obtained in the structure shown in the drawing by the use of a small adjustable capacity to shorten electrically the length of the section of transmission line formed by members 1 and 3. In the drawing, the adjustable capacity is illustrated as a sleeve 5 of a suitable metallic or dielectric material which slides over conductor 1 and is maintained in contact therewith by means of a flat spring 6 disposed within a slot 7 in sleeve 5. As the sleeve 5 is adjusted along lead 1, it forms with member 3 an adjustable capacitance connected across one end of the inner section of concentric transmission line. This capacitance increases the electrical length of the line until it is made equal to that of the outer section. The two sections in series, therefore, form a concentric transmission line having a length equal to a half wave length and which is short-circuited at one end by means of wall 4. This short-circuit is reproduced at the opposite end so that the impedance Z appears as a short-circuit to high frequency electromagnetic waves traveling along the con-

centric transmission line formed by members 1 and 2.

In Fig. 2, a modification of the invention is shown as applied to a capacitive tuning plunger for a space resonant cavity of the concentric transmission line type and comprising a tubular outer conductor 10 and a centrally disposed inner conductor 11, between which oscillations are established by means of a source 12. The space resonant cavity defined by the conductors 10 and 11 is tuned by means of a plunger 13 of the capacitive type and comprising a metallic cup-shaped member having cylindrical sleeve portion 14 concentrically disposed between conductors 10 and 11 and a transverse metallic portion 15 connected to the sleeve 14 and slidable along inner conductor 11. In the conventional capacitive tuning plunger of this type, the outer surface of sleeve 14 forms with the inner surface of conductor 10 a short section of concentric transmission line equal substantially to a quarter wave length of the electromagnetic wave within the space resonant system defined by members 10 and 11. This section of transmission line is connected in series with a second section of transmission line formed by the inner surface of sleeve 14 and the outer surface of conductor 11, the transverse metallic wall 15 supporting the end of this second section of transmission line. This second section likewise has a length equal to a quarter wave length of the electromagnetic wave within the system. The two short sections of transmission line, being connected in series, may have a total length equal to a half wave length at the frequency of a wave to be confined, and the short-circuit constituted by wall 15 is reproduced at the other end of this half wave section of transmission line to appear as a short-circuit between member 15 and conductor 10 across the gap 16.

In order to provide a capacitive tuning plunger which may be operative over a broad range of frequencies to confine electromagnetic waves between conductors 10 and 11 as the frequency of these waves is varied through adjustment of the position of tuning plunger 13 by means of actuating rods 17, one or more cylindrical metallic members 18, 19 are provided within the hollow portion of the tuning plunger 13 and concentrically spaced with respect to conductor 11. The inner and outer surfaces of adjacent ones of these members constitute a short section of coaxial transmission line, these sections being connected serially so that they provide a more effective filtering action across the gap 16 to confine electromagnetic waves within the space resonant system defined by the conductors 10 and 11. Moreover, means are provided to tune each of these chokes to the same or different frequencies and are illustrated as a plurality of ring members 20, 21, 22. Ring 20 is adjustable along the outer surface of sleeve 18 and ring 21, along the inner surface of sleeve 18, while ring 22 is adjustable along the inner surface of sleeve 19. The rings 20, 21, 22 function as trimmer capacitances connected across the individual chokes to make them operative at a desired frequency. Where the space resonant system is to be operated at one particular frequency, each of the chokes may be adjusted by means of the trimmer capacitances constituted by the rings 20—22 to resonate at this particular frequency. Where the system is to be operated over a wide frequency band, the individual chokes may be tuned to different frequencies so that the total arrangement

provides an effective filtering action over the entire frequency band.

The rings 20-22 may be formed of any suitable conductive material or of the same or different dielectric materials, depending upon the result to be obtained. Since a certain amount of fringing capacitance is present at the ends of the individual chokes, a diaphragm 24 secured to the inner surface of conductor 10 may be used to improve the performance of the filter by shielding against any stray capacitance.

In the modification illustrated in Fig. 3, a cup-like member 30, provided with an outer sleeve 31 concentrically disposed within inner and outer conductors 10 and 11, may be given improved filtering action by the use of one or more sleeves 32 concentrically disposed between sleeve 31 and conductor 11, the sleeves 32 forming a plurality of serially connected chokes within the filter cup 30. The individual frequencies of these chokes are tuned by means of adjustable trimming capacitances connected across the ends of the short sections of transmission line defined by the adjacent surfaces of the sleeves. The trimming capacitances may be constituted by concentric sleeves 33, 34, 35 of a suitable dielectric material, all connected together at one end by means of transverse dielectric wall 36. The sleeves 33-35 may bridge completely the gaps between the concentric conductors 10, 11 and sleeves 31, 32. The position of the dielectric sleeves 33-35 within the chokes may be adjusted by any suitable mechanical means, such as the rods 37. Preferably, the length of the sleeve 33 is made shorter than that of the sleeves 34, 35 to compensate for the difference in length between the inner and outer surfaces of sleeve 31 because of the presence of transverse metallic wall 38.

It is apparent that by the structures illustrated and described, effective filtering arrangements are provided for electromagnetic waves of a given frequency or band of frequencies. Where it is desired that the filter operate to remove waves of a single frequency, the form of the invention illustrated in Fig. 1 may be employed and the filters may be tuned by adjustment of the position of member 5. Where the filtering arrangement is to suppress waves of a wide frequency band, the arrangement of Fig. 2 provides a choke which may be tuned to a plurality of frequencies throughout the band.

While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since various modifications may be made, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, a transmission line connected to a source of ultra high frequency electromagnetic waves, said transmission line comprising two parallel spaced conductors, one of said conductors being utilized to supply power currents to said source, and means for filtering said waves from said one conductor, said means comprising a conductive member positioned between and parallel to said conductors, said member having a length substantially equal to a quarter wave length of said waves, transverse conductive means connected between said member and said one conductor, said member forming with said conductors two serially connected

sections of transmission line of unequal electrical lengths, and means to equalize the lengths of said sections.

2. In combination, a transmission line connected to a source of ultra high frequency electromagnetic waves, said transmission line comprising two parallel spaced conductors, one of said conductors being utilized to supply power currents to said source, and means for filtering said waves from said one conductor, said means comprising a conductive member positioned between and parallel to said conductors, said member having a length substantially equal to a quarter wave length of said waves, transverse conductive means connected between said member and said one conductor, said member forming with said conductors two serially connected sections of transmission line of unequal electrical lengths, and means connected to said one conductor and extending partly between said one conductor and said conductive member to form with said conductive member a capacitance connected across one of said sections for adjusting the electrical length of said one section.

3. A device for filtering a lead connected to an ultra high frequency system comprising, a tubular conductor surrounding said lead, a cylindrical metallic cup-like member concentrically surrounding said lead within said conductor and having an end wall connected to said lead, said member forming with said conductor and with said lead two partly co-extensive sections of concentric transmission line of unequal electrical lengths, and means to equalize the electrical lengths of said sections.

4. A device for filtering a lead connected to an ultra high frequency system comprising, a tubular conductor surrounding said lead, a cylindrical metallic cup-like member concentrically surrounding said lead within said conductor and having an end wall connected to said lead, said member forming with said conductor and with said lead two partly co-extensive sections of concentric transmission line of unequal electrical lengths, and means to equalize the electrical lengths of said sections, said means comprising a cylindrical member surrounding said lead and extending into said member to form therewith a capacitance connected across the shorter of said sections.

5. A filter for high frequency currents comprising three concentric conductors arranged to provide a reversed path for said currents, said path comprising a pair of sections of unequal electrical lengths, and means to equalize the electrical lengths of said sections, said means comprising a metallic cylinder connected to the inner of said conductors and extending partly between said inner conductor and the intermediate one of said conductors.

6. A capacitive tuning plunger for a cavity resonator of the type defined by a tubular outer conductor and a centrally disposed inner conductor comprising a cylindrical conductive sleeve disposed between said conductors and connected to one of said conductors through a transverse metallic wall, a second conductive sleeve concentrically disposed between said first sleeve and said one conductor, said sleeves and said conductors providing a plurality of sections of concentric transmission line serially connected between said cavity resonator and said transverse wall, and means to adjust the lengths of said sections.

7. A capacitive tuning plunger for a cavity resonator of the type defined by a tubular outer con-

ductor and a centrally disposed inner conductor comprising a cylindrical conductive sleeve disposed between said conductors and connected to one of said conductors through a transverse metallic wall, a second conductive sleeve concentrically disposed between said first sleeve and said one conductor, said sleeves and said conductors providing a plurality of sections of concentric transmission line serially connected between said cavity resonator and said transverse wall, and means to adjust the lengths of said sections, said means comprising a ring member adjustably positioned between said sleeves.

8. A filter for high frequency currents comprising a plurality of concentric conductors arranged to provide a reverse path for said currents, said path comprising a plurality of sec-

tions of concentric transmission line, and means to adjust the electrical lengths of said sections, said means comprising ring members supported by said conductors, said ring members individually being movable to an adjustable position between said conductors.

9. An adjustable filter for high frequency currents comprising a plurality of concentric conductors arranged to provide a reverse path for said currents, said path comprising a plurality of sections of different electrical lengths, and means to adjust the electrical lengths of said sections, said means comprising dielectric means disposed between said conductors, and means to adjust the position of said dielectric means between said conductors.

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