

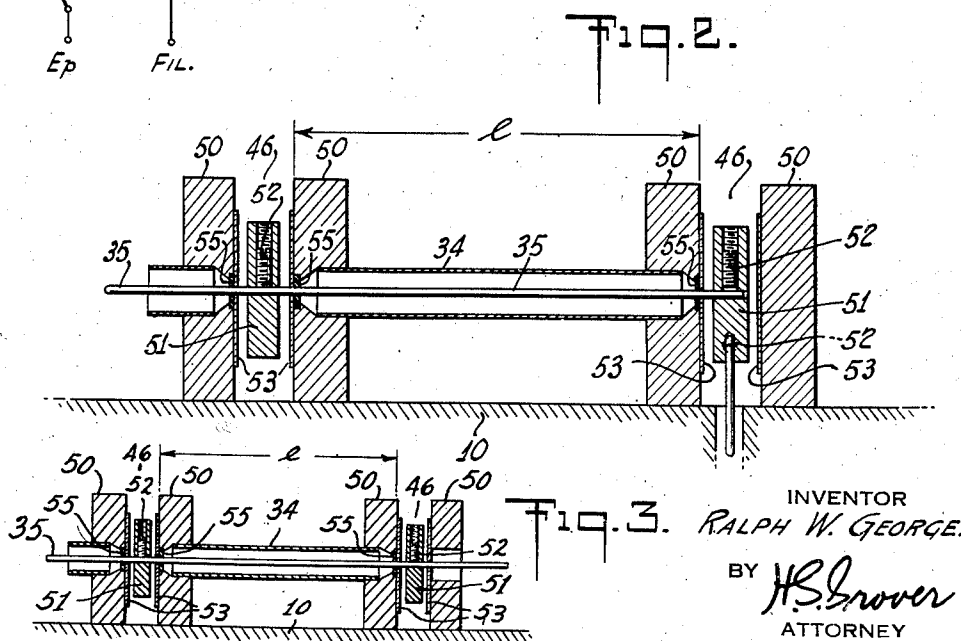
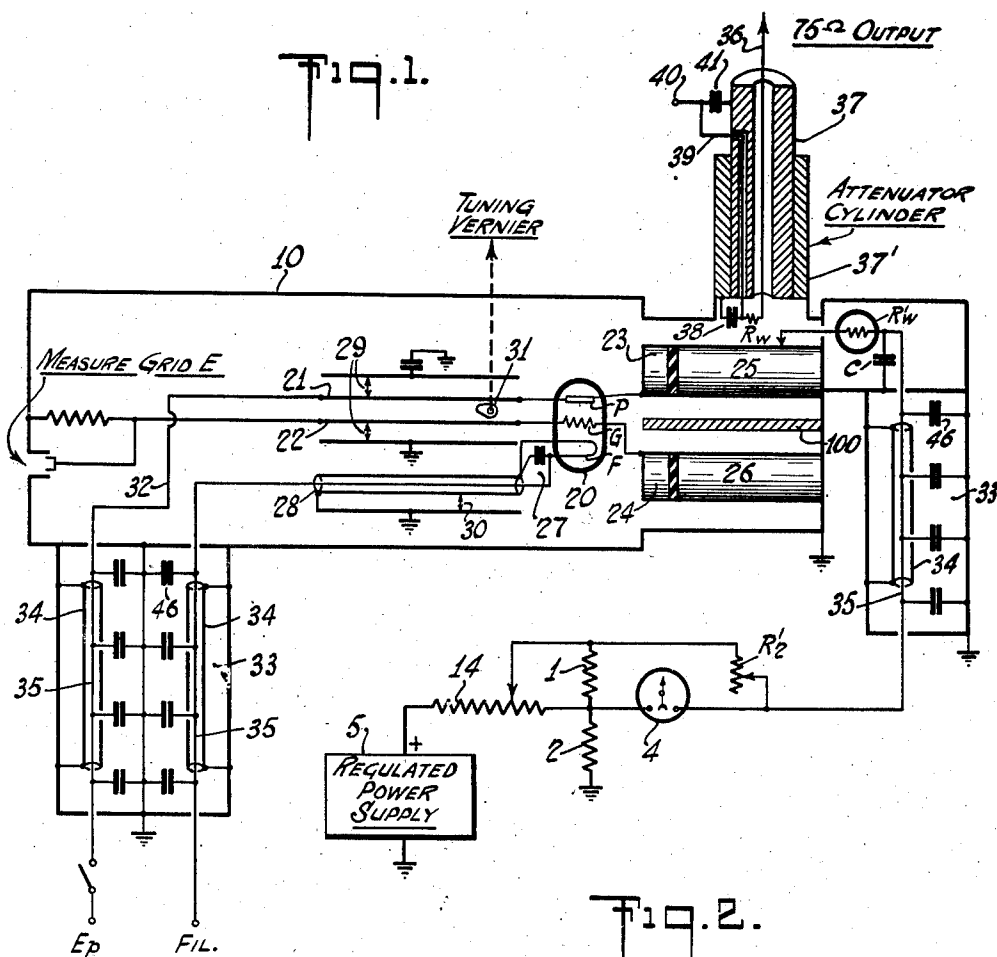
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FILTER

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FILTER

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The present invention relates to filter networks and, more particularly, to filters especially adapted for use with ultra high frequencies.

An object of the present invention is the provision of a band rejection filter which is suitable for ultra high frequencies.

Another object of the present invention is the provision of a filter which can be made to have a high attenuation over a wide range of frequencies.

Still another object of the present invention is the provision of a filter, as set forth above, which has a high current carrying capacity.

A further object of the present invention is the provision of a filter, as set forth above, which is simple in mechanical construction.

Still a further object of the present invention is the provision of means for preventing leakage of ultra high frequency energy from a signal generator along potential supply and control leads.

The foregoing objects, and others which may appear from the following detailed description, are attained by the provision of a filter in the form of a coaxial transmission line wherein the outer conductor is grounded and the inner conductor is by-passed to the outer conductor at predetermined points along its length. The inner conductor may be made large enough to safely carry any desired value of low frequency current. Furthermore, the inner conductor may be made in the form of a control shaft for operating tuning condensers and the like within the shielded case of a signal generator.

The novel features which, it is believed, are characteristic of the present invention are pointed out with particularity in the appended claims. The invention will, however, be more completely understood by reference to the following detailed description, which is accompanied by a drawing in which Figure 1 illustrates a signal generator structure in which the present invention may be employed and Figure 2 illustrates in enlarged section the filter network of the present invention, while Figure 3 illustrates in section a modification of the embodiment of Figure 2.

Referring, now, to Figure 1 there is illustrated an ultra high frequency signal generator tunable over a wide band of frequencies and having in its output circuit an attenuator including a Wollaston wire loop R_w which is slidable coaxially along the output cable to vary the output amplitude. The signal generator shown in this figure may be operated in the range between 600 and 1200 mc. Within the casing 10 of the signal generator of Figure 1 is provided a high frequency oscillator including a vacuum tube triode 20 whose plate P and grid G are connected at one end to a tunable Lecher wire system 21, 22 and at the other end capacitively coupled by means of metallic plates 23, 24 to fixed inductors

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25 and 26, respectively. Inductors 25 and 26 are each placed coaxially within separate shielding chambers separated by wall 100. The filament F of vacuum tube 20 has its terminals by-passed together by condenser 27 for energy of the operating frequency. One conductor for supplying energy to the filament F of the vacuum tube is comprised of a hollow tube 28 grounded at its far end while the other is comprised of a lead extending through the interior of the hollow tube to a suitable source of filament heating supply at the exterior of casing 10. Sliders 29 serve to tune the plate and grid tuned circuits simultaneously while the slider 30 serves to tune the filament circuit. A suitable eccentric 31 on a control-shaft extending to the exterior of the casing serves as a vernier tuning element for the plate and grid circuits. Polarizing potential for the plate P of the vacuum tube is provided through lead 32 which is connected to one end of the conductor 21. The output circuit of the signal generator within casing 10 includes an attenuator which comprises a hollow tube 37 slidable axially within a cylinder 37'. Coaxially arranged within the tube 37 is a conductor 36, the inner end of which is connected to a Wollaston wire loop R_w , the other end of the loop R_w being connected through condenser 38 to the casing of the signal generator and also through conductor 39 to terminal 40. Terminal 40 is also by-passed to the casing by condenser 41. The Wollaston wire R_w has a resistance of the order of 75 ohms thus insuring an impedance match between the coaxial output line formed by conductor 36 and hollow tube 37 and the pick-up loop R_w . The amplitude of the output of the signal generator is varied by sliding tube 37 axially in and out within the cylinder 37.

Conductively connected to inductor 25 at a suitable point along its length is a circuit including a Wollaston wire resistor R_w' and a lead 35 extending to the outside of casing 10 of the signal generator. A bridge circuit including resistors 1, 2, R_z' and Wollaston wire R_w' , together with the microammeter 4, together comprise a reference voltage indicator. It should be noted that the Wollaston wire R_w' forms one arm of the bridge, one of the terminals of which is tapped on to the inductance 25 to which the attenuator is also coupled. The flow of high frequency current through resistor R_w' unbalances the bridge circuit causing a deflection of microammeter 4. The output of the signal generator within casing 1 is preferably calibrated for a specific deflection of the reference meter 4. The sensitivity of the reference indicator is determined by an adjustment of resistor 14 in series with the regulated power supply equipment 5.

It is very important that the only energy allowed to escape from the generator do so through the output conductor 36. Therefore, I

provide low-pass filter systems 33 each having high attenuation over the wide range of ultra high frequencies over which the generator is designed to operate. Thus leakage of ultra high frequency energy from the signal generator through the power supply leads and the leads for the measuring bridge is minimized. The filter systems 33 each consist of a coaxial transmission line having grounded outer conductors 34 and inner conductors 35 by-passed to the outer conductor at predetermined points along its length by condensers 46. The details of construction of each of the filter systems will be more readily understood by reference to Figure 2 wherein one of the filters is shown in an enlarged cross-section view.

Here the outer conductor 34 is shown as being broken at spaced points to permit the insertion of by-pass condensers 46 having their outer plates 50 connected to the outer conductor 34 and, also, to the casing 10 of the signal generator. The inner plates of the condensers may take the form of comparatively heavy discs 51 having axial holes through which the inner conductor 35 passes. The discs are secured in place by set screws 52 though other fastening means may be employed. Mica insulating sheets 53 may be provided on each side of the discs 51 to prevent undesirable contact between the outer plates 50 and the inner plates 51. The inner conductor 35 of the coaxial line is maintained in coaxial relationship with the outer tubular conductor 34 by means of insulating centering washers 55 at the ends of each section of outer conductor 34. It will be noted that the outer conductor 34 at each end of each section is effectively grounded to the casing 10 of the generator by means of the outer plates 50 of the condenser. In some extreme cases better shielding may be provided by enclosing the by-pass condensers 46 individually or they may all be placed within extensions of the metal casing of the generator, as shown in Figure 1.

The operation of the filter network, as described, may be illustrated by the following example. It should be understood that no circuit losses are considered. Assuming that the by-pass condensers 46 constitute a short-circuit on the coaxial line, the reactance seen at the open end of a coaxial line which is short-circuited at the far end is given by the following equation:

$$X = Z_0 \tan B1$$

where Z_0 is the characteristic impedance of the coaxial line and $B1$ is the electrical line length in degrees.

The following table shows the variations of X with wavelength for a fixed length, l , of line, for the case where $Z_0 = 75$ ohms. X_c is the reactance of the by-pass condensers. The wavelength is denoted by λ .

B1 degrees	l	X	X_c Approximate short circuit	X/X_c Attn. ratio
135	$\frac{3}{8}\lambda$	Ohms	Ohms	
90	$\frac{1}{2}\lambda$	75	0.25	300
		∞	0.375	Max.
45	$\frac{5}{8}\lambda$	75	0.75	100

The voltage attenuation ratio is approximately X/X_c . From the above sample calculations it will be apparent that Z_0 should be as large as practical, that is, a high impedance line should be used. Furthermore, X_c should be as small as practical, that is, the capacity of the condensers 46 should

be large in order to obtain the greatest attenuation. As the frequency is increased X_c becomes smaller which is a help, but this effect will not be realized if there is any inductance present in the condensers 46. It is therefore important that the condensers be so arranged as to have a low inductance. This is assured by the form of construction shown in Figure 2 where the condenser plates are rather massive and are symmetrically arranged with respect to the inner conductor 35 of the transmission line.

It will be seen that an attenuation ratio greater than 100 to 1 may be had with a single filter section over a 3 to 1 frequency range. Obviously, a number of sections can be used to obtain greater attenuation. As a matter of fact, a number of sections are used in each of the leads of the signal generator of Figure 1. Thus for three sections in series the minimum attenuation would be of the order of 1,000,000 to 1. Furthermore, sections of different lengths may be employed to give a desired attenuation over a wider or narrower range of frequencies, as desired.

It will be seen that at one end of the modification shown in Figure 2 the inner conductor 35 is shown as arranged at right angles to the other end of the conductor 35. This was desirable in the particular construction used in the signal generator of Figure 1 but is not essential for, obviously, the conductor 35 may as well be arranged in the form of a single straight rod or shaft as shown in Figure 3. In some circumstances it may be useful to utilize this form of construction where it is essential that no signal energy is allowed to escape from a signal generator along a control shaft. Thus the shaft that controls the position of eccentric 31 in Figure 1, or the shaft which may be provided to adjust the positions of sliders 29 and 30 may be conveniently be surrounded by a low-pass filter construction, such as shown in Figure 3. The shaft will be free to turn and may be electrically continuous but still positively prevent the escape of high frequency energy along its length. Thus any back lash which may be troublesome in the case of insulated couplers in a control shaft or the inherent weakness of insulating materials as control shafts is avoided.

While I have illustrated a particular embodiment of the present invention it should be clearly understood that it is not limited thereto since many modifications may be made in the several elements employed and in their arrangement and it is, therefore, contemplated by the appended claims to cover any such modifications as fall in the sphere and scope of the invention.

I claim:

1. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, parallel conductive plates arranged in pairs connected to adjacent ends of each of said sections and a conductive disc between each of said pairs of plates and connected to said inner conductor, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected, the space between said conductive plates being such as to present a high impedance to the band of frequencies to be rejected.

2. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, parallel conductive plates arranged in pairs connected to adjacent ends of each of said

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sections and a conductive disc between each of said pairs of plates and connected to said inner conductor and insulating sheets interposed between the plates of each of said pairs of plates and said disc, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected, the space between said conductive plates being such as to present a high impedance to the band of frequencies to be rejected.

3. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, parallel conductive plates arranged in pairs connected to adjacent ends of each of sections and a conductive disc between each of said pairs of plates and connected to said inner conductor, said inner conductor passing through the center of each of said discs and said discs being secured thereto by set screws, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected, the space between said conductive plates being such as to present a high impedance to the band of frequencies to be rejected.

4. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, parallel conductive plates arranged in pairs connected to adjacent ends of each of said sections and a conductive disc between each of said pairs of plates and connected to said inner conductor, said inner conductor passing through the center of each of said discs and said discs being secured thereto by set screws and insulating sheets interposed between the plates of each of said pairs of plates and said disc, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected, the space between said conductive plates being such as to present a high impedance to the band of frequencies to be rejected.

5. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, parallel conductive plates arranged in pairs connected to adjacent ends of each of said sections, said parallel plates being connected along one edge to a conductive supporting plate, and a conductive disc between each of said pairs of plates and connected to said inner conductor, said inner conductor passing through the center of each of said discs and said discs being secured thereto by set screws, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected, the space between said conductive plates being such as to present a high impedance to the band of frequencies to be rejected.

6. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, parallel conductive plates arranged in pairs connected to adjacent ends of each of said sections, said parallel plates being connected along one edge to a conductive supporting plate, and a conductive disc between each of said pairs of plates and connected to said inner conductor, said inner conductor passing through the center of each of said discs and said discs being secured thereto by set screws and insulating sheets inter-

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posed between the plates of each of said pairs of plates and said disc, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected, the space between said conductive plates being such as to present a high impedance to the band of frequencies to be rejected.

7. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, parallel conductive plates arranged in pairs connected to adjacent ends of each of said sections, said parallel plates being connected along one edge to a conductive supporting plate, and a conductive disc between each of said pairs of plates and connected to said inner conductor, said inner conductor passing through the center of each of said discs and said discs being secured thereto by set screws and insulating sheets interposed between the plates of each of said pairs of plates and said disc, said inner conductor being arranged for rotation within said outer shell, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected, the space between said conductive plates being such as to present a high impedance to the band of frequencies to be rejected.

8. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, each having a length of the order of one-quarter of the mid-frequency of said band, parallel conductive plates arranged in pairs connected to adjacent ends of each of said sections and a conductive disc between each of said pairs of plates and connected to said inner conductor, said inner conductor passing through the center of each of said discs and said discs being secured thereto by set screws, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected.

9. A band rejection filter including a coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, each having a length of the order of one-quarter of the mid-frequency of said band, parallel conductive plates arranged in pairs connected to adjacent ends of said sections, said parallel plates being connected along one edge to a conductive supporting plate, and a conductive disc between each of said pairs of plates and connected to said inner conductor, said inner conductor passing through the center of each of said discs and said discs being secured thereto by set screws, the capacity between said conductive plates and said disc being so large as to present an extremely low reactance to the band of frequencies to be rejected.

10. A band rejection filter including a high impedance coaxial transmission line having an inner conductor and an outer shell, said outer shell being divided into sections, each having a length of the order of one-quarter of the mid-frequency of said band, parallel conductive plates arranged in pairs connected to adjacent ends of each of said sections and a conductive disc between each of said pairs of plates and connected to said inner conductor, the capacity between said discs and said parallel conductive plates being such that at the mid-band frequency the capacity therebetween presents a negligible impedance.

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