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ADJUSTABLE ATTENUATOR

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Fig. 1.

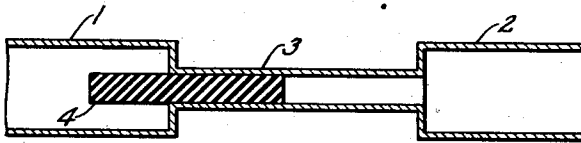
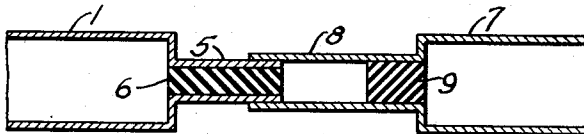


Fig. 2.



WITNESSES:

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ADJUSTABLE ATTENUATOR

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4 Claims. (Cl. 178-44)

My invention relates to ultra-high frequency electric conductors and, in particular, relates to hollow metallic conductors for ultra-high frequency magnetic energy which are known as hollow wave guides.

In ultra-high frequency electric circuits, it is frequently desirable to attenuate the flow of electrical energy in a particular section or a particular branch of the electrical circuits and my device constitutes an improvement over prior art arrangements for providing a circuit element capable of performing such an attenuating function. In particular, I provide an arrangement for attenuating the energy flow in the section of a hollow wave guide.

One object of my invention is accordingly to provide a hollow wave guide which may be connected into a network of hollow conductors which guide the flow of ultra high frequency electromagnetic energy and which shall rapidly attenuate such energy flow.

Another object of my invention is to provide a section of hollow wave guide with an arrangement by which the amount of attenuation taking place in a portion of the circuit may readily be varied at will over a very wide range.

Another object of my invention is to provide a hollow wave conductor system with an attenuator portion in which the amount of attenuation can be varied at will without providing sliding or other movable sections in the metallic conductor.

Other objects of my invention will become evident upon reading the following description taken in connection with the drawing, in which

Figure 1 shows a section of hollow wave guide provided with an attenuator embodying the principle of my invention; and

Fig. 2 shows another hollow wave guide attenuator section embodying the principles of my invention in a different manner.

It has been shown in the literature covering ultra-high frequency electromagnetic circuits that a hollow conductor or pipe can be made to transmit electromagnetic waves, with very little attenuation provided the wave length of the energy is properly related to the lateral dimensions of the hollow conductor. The electromagnetic energy flows through the interior of the conductor, and its attenuation, provided the interior wall of the guide or pipe be a good electrical conductor, has a very slight attenuation provided the radial dimensions of the conductor are properly related to the wave length of the electromagnetic energy. However, as is shown

for example in chapter 14, particularly at page 462, et. seq., of "Ultra-High Frequency Techniques," Brainard et al., Van Nostrand & Company, publishers, New York, 1942, there is a certain minimum cutoff related to the radial dimensions of the pipe below which the attenuation in the electromagnetic energy is a rapidly decreasing exponential.

In systems using such wave guides, it is frequently desirable to rapidly attenuate the electromagnetic energy, and the foregoing principles have been taken advantage of by inserting in the conductor or pipe which is itself of such dimensions that the electromagnetic energy has a frequency above the cutoff value, a section having radial dimensions so much reduced that the frequency of the electromagnetic energy is below the cutoff frequency for the reduced section. In the reduced section, the energy flow decays exponentially along the length of the section, and by making the section of suitable length, any desired attenuation can be attained. It is, however, in practice frequently necessary to be able to regulate or adjust the total amount of this attenuation, and this has been done by providing the pipe or conductor with sliding joints by which the length of the section of reduced radial dimensions can be increased or decreased at will. However, the presence of such sliding joints in the conductor creates difficulties and losses, and since it is impossible to move one portion of the pipe into the other when it is telescoped into the other by more than the length of one section without breaking engagement between the two, the minimum decrement introduced by such an arrangement can be no more than 50% of the maximum decrement. In other words, the range of variation in attenuation is decidedly limited.

In accordance with my invention, I avoid the foregoing disadvantages by providing a continuous wave guide with a section having reduced radial dimensions but constant length; and provide a dielectric rod which can be moved lengthwise into and out of this reduced section. Dielectric materials having a specific inductive capacity greater than unity tend to decrease the cutoff frequency in that portion of the lower diameter of pipe in which they are present. Hence if the dielectric rod be made equal in length to the pipe section of reduced cross section and be pushed entirely into the latter so as to completely fill its length, its cutoff frequency may be so reduced as to fall below the critical minimum value at which rapid attenuation takes

place in the section. The attenuating effect of the entire section of reduced diameter is accordingly eliminated.

Correspondingly, if the dielectric plug be moved lengthwise so that it fills only a portion of the section of reduced cross section, the attenuating effect of the latter will be eliminated only in the portion of its length filled by the rod, and substantially full attenuation restored to the unfilled portion.

Figure 1 illustrates a filled arrangement such as has just been described in which the portions 1, 2 of the wave guide have radial dimensions such that the electromagnetic waves flow through them without great attenuation. On the other hand, the portion 3 of the guide is made of a section so much reduced that its cutoff frequency is above that of the electromagnetic waves which are intended to traverse the system flowing, let us say, through the guide-section 1 to the guide-section 2. The electromagnetic energy would accordingly be exponentially attenuated in substantial degree in the pipe section 3. However, by providing a rod 4 of dielectric material such for example as which preferably fills the cross section of the portion 3 and has a length equal to that of section 3 and sliding this rod into section 3 until it completely fills the latter, the exponential attenuation which the wave experiences in traversing section 3 is decreased. The radial dimensions of the section 3 are so related by design to the specific inductive capacity of the rod 4 that the presence of the latter in any section of the portion 3 reduces the cutoff frequency of the latter below the frequency of the electromagnetic energy being transmitted. Under such circumstances the attenuation of the electromagnetic waves experienced in the guide-section 3 may be made substantially no greater than the attenuation occurring in an equal length of guide-section 1. The rod 4 may be provided with a mechanical linkage or other suitable device by which it can be displaced axially along the section 3; and when this is done the section 3 will attenuate the electromagnetic waves in an amount substantially proportional to the axial length thereof which is unfilled by the rod 4.

In the modification shown in Fig. 2, I employ a guide-section 1 similar to guide-section 1 of Fig. 1, but having an open ended projection 5 of smaller diameter. I fill this section 5 with a rod 6 of dielectric material. The section 7 of the wave guide differs from the section 2 of Fig. 1 in that it is provided with a sliding joint (not shown) connecting it to other portions of the system beyond it and has a section 8 of reduced diameter which is of just the right size to slide over the section 5. When the sections 7 and 8 are displaced to the left as shown in Fig. 2, to such an extent that the ends of section 8 strike the shoulder connecting sections 1 and 5, the waves flowing through section 8 suffer an attenuation because the dimensions of the latter are made such that the electromagnetic energy flowing in the system is below their cutoff frequencies. As the pipe section 7, 8 is displaced to the right in Fig. 2, the length of the section 8 which must be traversed by the waves increases, thereby increasing the total attenuation.

For many purposes, it will be desirable to provide a rod or plug 9 of dielectric material filling the portion of section 8 which lies to the right of the end of section 5 when section 8 is displaced as far to the left in Fig. 2 as possible. When this is done, there will be no attenuation in section 8, the dimensions of the latter being so related to the specific inductive capacity of the rods 6, and/or 9 that the cutoff frequency is lowered below that of the electromagnetic energy flowing in the section. When the section 8 is displaced to the right thereby opening a gap between the ends of the rods 6 and 9, the electromagnetic energy suffers attenuation in the section 8 for obvious reasons.

While I have illustrated the principles of my invention by means of a specific embodiment thereof, it will be understood by those skilled in the art that these principles are broader applications in ways which will be evident.

I claim as my invention:

1. In a transmission line for electromagnetic energy, a pair of cylindrical portions capable of axial movement relative to each other, a cylindrical portion of reduced section attached to each of said portions, one of said reduced sections telescoping in sliding engagement with the other reduced section, and a dielectric material having a specific inductive capacity greater than unity in one of said reduced sections.

2. In a transmission line for electromagnetic energy, a pair of cylindrical portions capable of axial movement relative to each other, a cylindrical portion of reduced section attached to each of said portions, one of said reduced sections telescoping in sliding engagement with the other reduced section, and a dielectric material having a specific inductive capacity greater than unity in one of said reduced sections.

3. In a transmission line for electromagnetic energy, a pair of cylindrical portions capable of axial movement relative to each other, a cylindrical portion of reduced section attached to each of said portions, one of said reduced sections telescoping in sliding engagement with the other reduced section, and a dielectric material having a specific inductive capacity greater than unity in one of said reduced sections, and a second dielectric having a specific inductive capacity greater than unity filling the cross section of the other of said reduced section for a portion of its length only.

4. In a transmission line for electromagnetic energy, a pair of cylindrical portions capable of axial movement relative to each other, a cylindrical portion of reduced section attached to each of said portions, one of said reduced sections telescoping in sliding engagement with the other reduced section, and a dielectric material having a specific inductive capacity greater than unity in one of said reduced sections, and a second dielectric having a specific inductive capacity greater than unity filling the cross section of the other of said reduced section for such a portion of its length as to engage the first-mentioned dielectric material when said reduced sections are completely telescoped together.

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