Aug. 20, 1957 W. J. WILSON 2,803,805

ATTENUATORS

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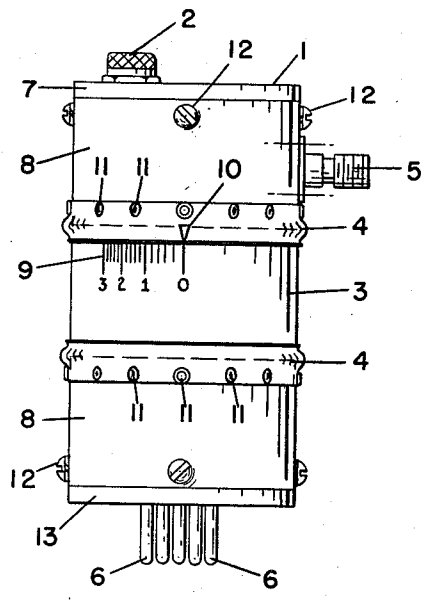


Fig. 1

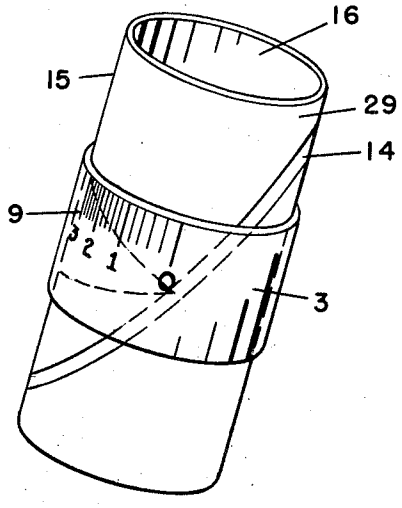


Fig. 2

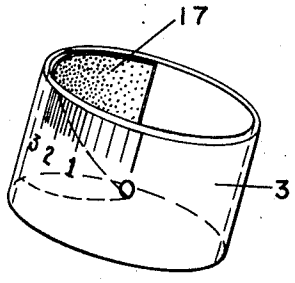


Fig. 3

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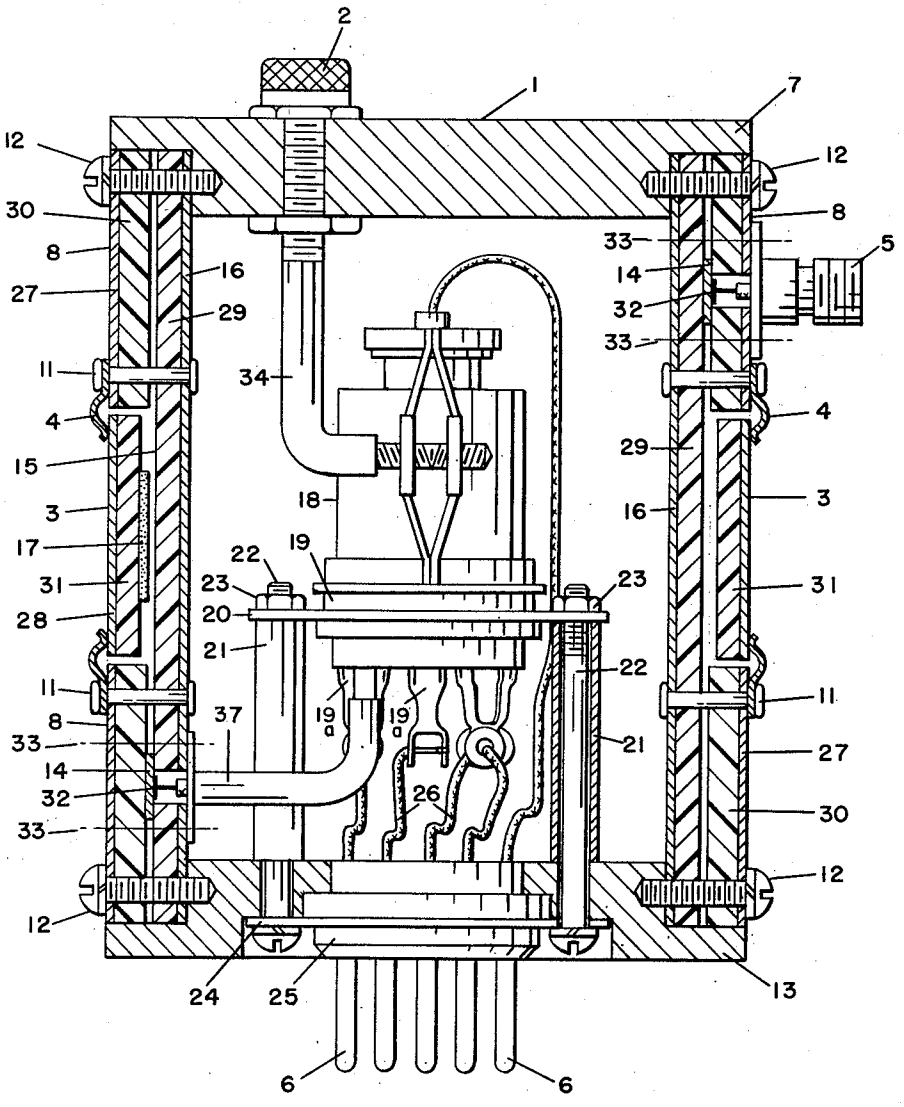


Fig. 4

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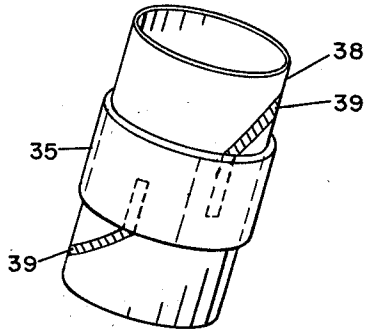


Fig. 5

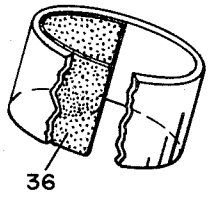


Fig. 6

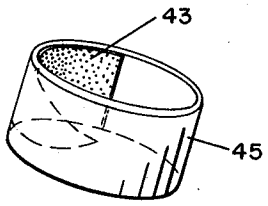


Fig. 7

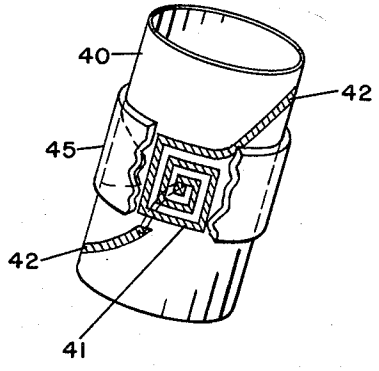


Fig. 8

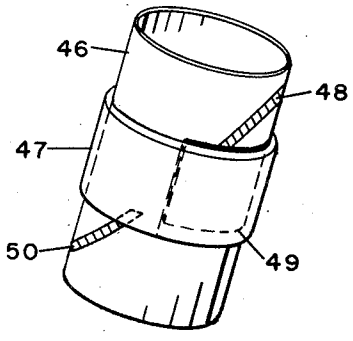


Fig. 9

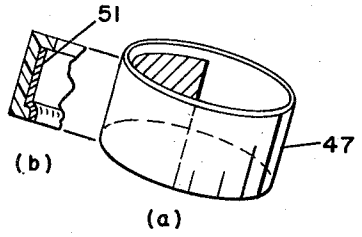


Fig. 10

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2,803,805

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Application July 2, 1954, Serial No. 440,951

7 Claims. (Cl. 333—81)

This invention relates to electric components. More particularly, it relates to transmission lines employed as components in high frequency electronic devices. More especially, the invention is concerned with the use of transmission lines as variable attenuators in a high frequency system.

In modern short wave techniques, transmission lines have been employed as impedance and resonator elements having similar properties to lumped constant circuit elements. It is frequently desirable to confine the physical length of a transmission line to a distance much less than the length that determines its electrical characteristics. This is particularly true of various variable attenuator devices of the prior art.

In the prior art various configurations have been attempted in order to effect a more compact assembly. Such devices, however, have generally been subject to the undesired coupling of energy within and without the device.

An object of this invention is to provide an improved high frequency variable attenuator.

A further object of this invention is to provide an improved electric variable attenuator which is relatively small and compact.

Other and further objects of the invention will be apparent from the following description of typical embodiments thereof, taken in connection with the accompanying drawings.

In accordance with the present invention there is provided a variable electrical attenuator comprising a first cylindrical member and a second cylindrical member. The second cylindrical member is concentric with and adapted to be moved relative to the first member. An electric circuit is disposed on one of the members. Means are carried by the other of the members, whereby relative movement of the two members adjusts the means with respect to the current circuit to effect an increased impedance to the flow of electric current.

In a preferred embodiment of the invention the composite high frequency variable electric attenuator comprises a first cylindrical conductor with a second cylindrical conductor surrounded by and coaxial with the first conductor. The first conductor is adapted to rotate relative to the second conductor. An inner conductor having the configuration of an electric circuit is disposed between and in spaced relation to the first and second conductors. Means are provided securing the conductors in their relative positions. Means extend from the first and second conductors to effect an electrical connection therebetween confining high frequency electric energy within the confines of the cylinders. Means are carried by one of the conductors whereby relative movement of the first and second conductors adjusts the means with respect to the inner conductor to effect an increased impedance with the flow of high frequency electric current. Means supported by the first conductor provide a visual indication of the degree of attenuation.

In the accompanying drawings:

Fig. 1 is a side elevational view of an embodiment of the present invention;

Fig. 2 is a three-dimensional view of a portion of the embodiment of Fig. 1;

Fig. 3 is a three-dimensional view of components of the embodiment of Fig. 1;

Fig. 4 is a cross-sectional view of the embodiment of Fig. 1;

Fig. 5 is a three-dimensional view of another embodiment of the present invention;

Fig. 6 is a fragmentary three-dimensional view of a component of the embodiment of Fig. 5;

Fig. 7 is a three-dimensional view of a component of another embodiment of the present invention;

Fig. 8 is a three-dimensional view of an embodiment of the invention incorporating the component of Fig. 7;

Fig. 9 is a fragmentary three-dimensional view of still another embodiment of the present invention; and

Fig. 10 is a three-dimensional view and a fragmentary cross-sectional view of a component of the embodiment in Fig. 9.

Referring now to the drawings and with particular referenc to Fig. 1, a high frequency oscillator **1** is shown. The unit is designed to provide variable output energy at the coaxial connector **5**. The unit contains a reflex klystron oscillator operating at a frequency of, for example, 5 kilo-megacycles. A knob **2** may be rotated to vary the frequency of oscillation by tuning the cavities of the klystron. A cylindrical section **3** is rotated to vary the attenuation of the energy appearing in the output. The degree of increase of attenuation is indicated by the graduations **9** compared with the stationary marker **10**. Cylindrical sections **8** are stationary and electrically connected to the rotatable section **3** by spring contacts **4** (formed for example of beryllium copper). A top mounting plate **7** and base mounting plate **13** are electrically and mechanically connected to the cylindrical sections **8** with mounting screws **12**. The spring contacts **4** are electrically and mechanically connected to the stationary sections **8** by rivets **11**.

The cylindrical sections **3** and **8** surround a second cylinder **15** as shown in Fig. 2. The second cylinder **15** carries a metallic surface **16** on the inside and conductive path **14** on the outside. Carried within the rotatable cylinder **3** is a resistive material **17** (formed for example from a mixture of carbon granules and a suitable adhesive) in a configuration as shown in Fig. 3. The klystron output is electrically connected to the bottom of conductor **14** and the energy is coupled to the top of path **14** to the output coaxial connector **5**.

In Fig. 4 the construction of the embodiment in Fig. 1 is shown in detail. A reflex klystron **18** is inserted in a socket **19** which is carried by mounting plate **20**. The plate **20** is supported by spacers **21** which are held in position with respect to the base plate **13** by the bolts **22** secured with the nuts **23**. A second mounting plate **24** is secured as shown to the base plate **13** by the bolts **22** and nuts **23**. The plate **24** carries a connector **25** to which are affixed the pins **6**. Electrical connections from the klystron socket **19** are completed from the socket elements **19*a*** through wires **26** to the pins **6** below.

The high frequency energy output of the klystron **18** is applied through coaxial transducer **37** to a so-called three-plate transmission line wherein conductors **27** and **28** of the cylindrical sections **3** and **8** provide a first ground plane, the conductor **16** provides a second ground plane and the conductor **14** provides the inner conductor. The conductor **14** is held in insulated spaced relation to the conductors **16**, **27** and **28** by insulating material **29** (such as polystyrene tubing) of the inner cylinder **15** and

by insulators 30 and 31 of the cylinders 8 and 3, respectively.

Inner conductor connections of the coaxial transducer 37 and connector 5 to the conductor 14 are effected with solder joints 32. The outer conductors are flanged and held in electrical contact with conductors 16, 27 and 28 by screws in the positions indicated by the center lines 33.

The knob 2 is coupled to a flexible cable 34 to mechanically tune the klystron oscillators as shown.

The oscillator 18 is powered by D. C. voltages supplied through the pins 6. The output high frequency energy is coupled through the coaxial cable 37 to the inner conductor 14. The energy is confined within the conductors 16, 27 and 28 and transmitted to the output connector 5. By rotating the cylinder 3 counter-clockwise, an increasing degree of attenuation is obtained due to the power loss in the resistive material 17. It is obvious that more complex circuits may be disposed between the conductors 16, 27 and 28 and high frequency energy will be confined therein.

Referring now to Figs. 5 and 6, a variable resistor and switch are shown. A cylinder 38 carries a conductor 39 which is interrupted as shown and passes, for example, direct current when the circuit connection is completed. The rotatable cylinder 35 carries resistive material 36 in the configuration shown. The material 36 is characterized by a resistivity that varies with respect to the angular position. Thus, the resistance presented to the flow of current between the conductors 39 increases as the cylinder 35 is rotated from 0 degrees to 180 degrees. Rotation beyond 180 degrees effects an open circuit between the conductors 39.

In the embodiment as shown in Figs. 7 and 8, a variable inductor is illustrated. A cylinder 40 carries an inductance coil 41 which is connected to conductors 42. An alternating current passes through the coil 41. A rotatable cylinder carries magnetically permeable material 43 (such as a suitable ferrite). Rotation of the cylinder 45 counter-clockwise produces an increased inductance and, therefore, an increased impedance to the flow of alternating current.

Referring now to Figs. 9 and 10, a variable capacitor and switch are here shown. A cylinder 46 carries a stator plate 49 of the capacitor connected to a conductor 48. A rotatable cylinder 47 carries the rotor plate 51. The cylinder 47 is indented as shown to prevent direct contact between the plates, while permitting a continuous contact with a conductor 50. Rotation of the cylinder 47 counter-clockwise effects an increased capacity and, therefore, a decrease in impedance to alternating current flow in the path defined by conductors 48 and 50.

From the above description the flexibility and application of the present invention will be clear. While there has been hereinbefore described what are at present considered preferred embodiments of the invention, it will be apparent that many and various changes and modifications may be made with respect to the embodiments illustrated, without departing from the spirit of the invention. It will be understood, therefore, that all those changes and modifications as fall fairly within the scope of the present invention, as defined in the appended claims, are to be considered as a part of the present invention.

What is claimed is:

1. A composite high frequency variable attenuator for microwave energy comprising a sectional, cylindrical, outer conductor providing a first ground plane; a second cylindrical conductor surrounded by and coaxial with said first conductor and providing a second ground plane; an inner conductor strip confined to a substantially cylindrical surface and disposed between and in insulated, spaced relation to said outer and said second cylindrical conductors, a rotatable, cylindrical section of said outer conductor being adapted to rotate about said inner conductor, said strip extending in the direction of said outer conductor and being narrower than said surface; dielectric

means securing said conductors in their relative positions; a first connection means adapted to connect a source of microwave energy between an end of said inner conductor and said ground plane conductors; a second connection means adapted to connect an output load between the other end of said inner conductor and said ground plane conductors; means extending from non-rotatable sections of said outer conductor to said rotatable section to effect a continuous electrical connection therebetween and confine high frequency energy substantially between said outer and said second conductors; and attenuation means adapted to rotate with said rotatable section and of a configuration such that rotation of said rotatable section effects a variation in impedance to the propagation of microwave energy between said first and second connection means.

2. A composite high frequency variable attenuator for microwave energy comprising a sectional, cylindrical, outer conductor providing a first ground plane; a second cylindrical conductor surrounded by and coaxial with said first conductor and providing a second ground plane; a helical inner conductor strip confined to a substantially cylindrical surface and disposed between and in insulated, spaced relation to said outer and said second cylindrical conductors, a rotatable, cylindrical section of said outer conductor being adapted to rotate about said inner conductor, said strip extending in the direction of said outer conductor and being narrower than said surface; dielectric means securing said conductors in their relative positions; a first connection means adapted to connect a source of microwave energy between an end of said inner conductor and said ground plane conductors; a second connection means adapted to connect an output load between the other end of said inner conductor and said ground plane conductors; means extending from non-rotatable sections of said outer conductor to said rotatable section to effect a continuous electrical connection therebetween and confine high frequency energy substantially between said outer and said second conductors; and attenuation means adapted to rotate with said rotatable section and of a configuration such that rotation of said rotatable section effects a variation in impedance to the propagation of microwave energy between said first and second connection means.

3. A composite high frequency variable attenuator for microwave energy comprising a sectional, cylindrical, outer conductor providing a first ground plane; a second cylindrical conductor surrounded by and coaxial with said first conductor and providing a second ground plane; an inner conductor strip confined to a substantially cylindrical surface and disposed between and in insulated, spaced relation to said outer and said second cylindrical conductors, a rotatable, cylindrical section of said outer conductor being adapted to rotate about said inner conductor, said strip extending in the direction of said outer conductor and being narrower than said surface; dielectric means securing said conductors in their relative positions; a pair of conductive end caps enclosing the ends of said first and second conductors and connecting them together; a first connection means adapted to connect a source of microwave energy between an end of said inner conductor and said ground plane conductors; a second connection means adapted to connect an output load between the other end of said inner conductor and said ground plane conductors; annular, conductive, resilience means extending from non-rotatable sections of said outer conductor to said rotatable section to effect a continuous electrical connection therebetween and confine high frequency energy substantially between said outer and said second conductors; and attenuation means adapted to rotate with said rotatable section and of a configuration such that rotation of said rotatable section effects a variation in impedance to the propagation of microwave energy between said first and second connection means.

4. A composite high frequency variable attenuator for microwave energy comprising a sectional, cylindrical, outer conductor providing a first ground plane; a second cylindrical conductor surrounded by and coaxial with said first conductor and providing a second ground plane; a pair of inner conductor strips confined to a substantially cylindrical surface and disposed between and in insulated, spaced relation to said outer and said second cylindrical conductors, a rotatable, cylindrical section of said outer conductor being adapted to rotate about said inner conductor, said strips extending in the direction of said outer conductor and being narrower than said surface with adjacent ends sufficiently separated to provide an electrical disconnection; dielectric means securing said conductors in their relative positions; a pair of conductive end caps enclosing the ends of said first and second conductors and connecting them together; a first connection means adapted to connect a source of microwave energy between an end of said inner conductor and said ground plane conductors; a second connection means adapted to connect an output load between the other end of said inner conductor and said ground plane conductors; annular, conductive, resilience means extending from non-rotatable sections of said first conductor to said rotatable section to effect a continuous electrical connection therebetween and confine high frequency energy substantially between said first and second conductors; and resistance means, circumferentially varying in specific resistivity and adapted to rotate with said rotatable section and of a configuration such that rotation of said rotatable section effects a resistive connection between said inner conductors and a variation in impedance to the propagation of electric energy between said first and second connection means.

5. A composite high frequency variable attenuator for microwave energy comprising a sectional, cylindrical, outer conductor providing a first ground plane; a second cylindrical conductor surrounded by and coaxial with said first conductor and providing a second ground plane; a pair of inner conductor strips confined to a substantially cylindrical surface and disposed between and in insulated, spaced relation to said outer and said second cylindrical conductors, said strips extending in the direction of said outer conductor and being narrower than said surface with adjacent ends separated to provide an electrical disconnection; a stator capacitor plate connected to one of said inner conductor strips, a rotatable, cylindrical section of said outer conductor being adapted to rotate about said stator plate; a rotor capacitor plate affixed to said roatable, cylindrical section and adapted to contact the other of said inner conductor strips and so disposed relative to said stator plate as to enable relative rotational movement therebetween while maintaining said plates in insulated, spaced relation; dielectric means securing said conductors in their relative positions; a pair of conductive end caps enclosing the ends of said first and second conductors and connecting them together; a first connection means adapted to connect a source of microwave energy between an end of the first said inner conductor strip and said ground plane conductors; a second connection means adapted to connect an output load between an end of the other said inner conductor strip and said ground plane conductors; and annular, conductive, resilience means extending from non-rotatable sections of said first conductor to said rotatable section to effect a continuous electrical connection therebetween and confine high frequency energy substantially between said outer and said second conductors, whereby rotation of said rotatable section effects a variation in impedance to the propagation of electric energy between said first and second connection means.

6. A composite high frequency variable attenuator for microwave energy comprising a sectional, cylindrical, outer conductor providing a first ground plane; a second cylindrical conductor surrounded by and coaxial with said first conductor providing a second ground plane; a pair of helical inner conductor strips confined to a substantially cylindrical surface and disposed between and in insulated, spaced relation to said outer and said second cylindrical conductors, a rotatable, cylindrical section of said first conductor being adapted to rotate about said inner conductors, said strips extending in the direction of said outer conductor and being narrower than said surface; an inductance connected between adjacent ends of said inner conductors; dielectric means securing said conductors in their relative positions; a pair of conductive end caps enclosing the ends of said first and second conductors and connecting them together; a first connection means adapted to connect a source of microwave energy between an end of one of said inner conductor strips and said ground plane conductors; a second connection means adapted to connect an output load between an end of the other of said inner conductor strips and said ground plane conductors; annular, conductive, resilience means extending from non-rotatable sections of said first conductor to said rotatable section to effect a continuous electrical connection therebetween and confine high frequency energy substantially between said outer and said second conductors; and ferromagnetic means adapted to rotate with said rotatable section about said inductance and of a configuration such that rotation of said rotatable section effects a variation in impedance to the propagation of microwave energy between said first and second connection means.

7. A composite high frequency variable attenuator for microwave energy comprising a sectional, cylindrical, outer conductor providing a first ground plane; a second cylindrical conductor surrounded by and coaxial with said first conductor providing a second ground plane; an inner conductor strip confined to a substantially cylindrical surface and disposed between and in insulated, spaced relation to said outer and said second cylindrical conductors, a rotatable, cylindrical section of said first conductor being adapted to rotate about said second conductor, said strip extending in the direction of said outer conductor and being narrower than said surface; dielectric means securing said conductors in their relative positions; a pair of conductive end caps enclosing the ends of said first and second conductors and connecting them together; a first connection means adapted to connect a source of microwave energy between an end of said inner conductor and said ground plane conductors; a second connection means adapted to connect an output load between the other end of said inner conductor and said ground plane conductors; annular, conductive, resilience means extending from non-rotatable sections of said first conductor to said rotatable section to effect a continuous electrical connection therebetween and confine high frequency energy substantially between said first and second conductors; a plurality of conductive rods connecting said ground plane conductors together to prevent propagation of said energy in extraneous modes; and attenuation means adapted to rotate with said rotatable section and of a configuration such that rotation of said rotatable section effects a variation in impedance to the propagation of microwave energy between said first and second connection means.

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