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ELECTRICALLY VARIABLE SIGNAL CHANGING DEVICE
USING VARIABLE PERMEABILITY MATERIAL
Filed March 16, 1960

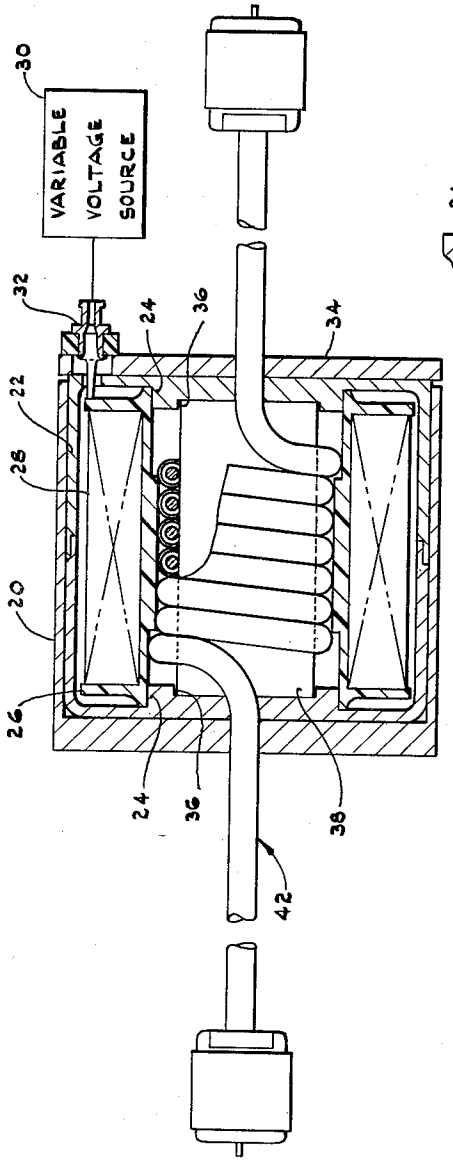

FIG. 1

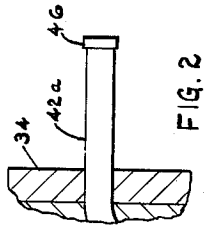

FIG. 2

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ELECTRICALLY VARIABLE SIGNAL CHANGING DEVICE USING VARIABLE PERMEABILITY MATERIAL

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This invention pertains to an electrical variable signal changing device which has no moving parts and can be varied by an electrical signal, and, further, is capable of miniaturization. The principles of this invention are applicable to many electrical devices including an attenuator disclosed hereinbelow and a phase shifter disclosed in copending application Serial No. 15,650, entitled "Electrically Variable Phase Shifter," filed March 17, 1960, by Ronald W. Kordos, et al.

It is an object of this invention to provide a variable ferrite attenuator which has a coaxial cable wound in the form of a helix with the outer conductor on its inner side and the insulation of the cable on the inside of the helix removed so that the inner conductor is tangent to the inside diameter of the helix. Inserted in the helix is a close fitting ferrite core and a field winding is placed about the helix with means to supply a signal of variable strength to the winding. When a signal is present in the winding, a proportional longitudinal magnetic field is generated in the ferrite core. The amount of attenuation of a signal passing through the helix will be inversely proportional to the strength of the voltage source applied to the winding.

It is another object of this invention to provide in the attenuator described in the previous paragraph means for shorting one end of the inner conductor of the coaxial cable to ground or to the outer conductor so that a signal supplied to the other end of the coaxial cable is reflected back through the cable increasing the amount of attenuation.

These and other objects and advantages will become more apparent when preferred embodiments of this invention are described in connection with the drawings in which:

FIGURE 1 is a sectioned, partially broken away view of a first embodiment wherein the signal is applied to one end of the coaxial cable and is received at the opposite end of the cable; and

FIGURE 2 shows a coaxial cable end having the inner and outer conductors shorted so that the signal applied at the other end is reflected to increase attenuation.

Referring now to the drawing and especially FIGURE 1, a housing **20** which, in this embodiment, is made of aluminum enclosed a drum shaped support **22** which is constructed of soft iron or other material having a low retentivity to magnetic fields. Support **22** has a boss **24** at each end which bosses extend inwardly and are aligned axially. Supported on bosses **24** is the center passage of a nylon bobbin **26** on which is wound a field or drive winding **28**. Winding **28** is supplied with a variable voltage from source **30** through posts **32** which are supported by and extend through end plate **34** which is bolted to housing **20**.

Provided in each boss is a recess **36** which supports the ends of a cylinder or slug **38** of a ferromagnetic material such as ferrite or garnet. The cylinder **38**, in this embodiment, is composed of a ferrite material preferably having a saturation flux density of 1900 gauss ± 5%, a dielectric loss tangent of less than .002, a curie point of 270° to 370° C., a dielectric constant 10 to 15 and a line width of less than 500 oersteds. The particular core shown has a flux density of 1900 gauss, a dielectric loss tangent of less than .002, and a curie point of 320° C., a dielectric constant of 13, and a line width of 480 oersteds.

Wound in the form of a helix about core or cylinder **38** is a coaxial cable **42** with the outer portions of the outer conductor being soldered together and the inner portions of the outer conductor being removed along with a portion of the cable insulation so that the center conductor of cable **42** is tangent to the ferrite core **38**.

Operation of FIGURE 1 Embodiment

Attenuation of a signal applied to one end of cable **42** and passing through the device can be varied by varying the voltage applied to winding **28**, with the greater the voltage applied, the less the attenuation. A current in winding **28** causes a longitudinal magnetic field to be established through the ferrite core **38** which changes the permeability and signal absorption capability of the core. The permeability of the core **38** is changed in proportion to the strength of the current in winding **28** and the greater the change in permeability of the core **38**, the less the proportion of signal **28** applied to cable **42** is absorbed by the core, and a corresponding decrease in attenuation results. A device of this nature, which occupies less than 1¼ cubic inches volume, has a 30 decibel dynamic range with a minimum insertion loss of less than one decibel. The device has been found to operate satisfactorily in a temperature range from −65° F. to +250° F. The device has no moving parts and will stand severe mechanical shock and the power required to drive coil **28** through full attenuation is less than ⅓ watt.

In FIGURE 2 is shown a second embodiment which is similar to that in FIGURE 1 with the exception that coaxial cable **42A** has its inner and outer conductors shorted. This is accomplished by placing a metallic or conductive disc **46** over the exposed inner and outer conductors of the cable end. Satisfactory results have been obtained when the cable end which has been shorted is at a point where the cable has not had the outer conductor and insulation removed. A signal applied to the open end, not shown, travels to the closed end undergoing a first attenuation and then is reflected back and is further attenuated to the open end. In this manner a very small unit has increased attenuating capabilities.

Depending on the number of turns and size of wire of field winding **28**, the type of signal used to energize winding **28** can vary widely. Also, it is possible to vary the range of attenuation by varying the length of the coaxial helix and the ferrite rod. The principal transmission line characteristics of the exposed coaxial cable are retained.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

Having thus described my invention, I claim:

1. Apparatus comprising

a coaxial cable carrying an electric signal therein, said coaxial cable having its outer conductor removed along only one side thereof,

a magnetic member having a permeability dependent on the magnetic field applied thereto being adjacent the side of said coaxial cable having its outer conductor removed and fixed in relation thereto,

means for establishing a magnetic field through said magnetic member, thereby establishing a corresponding permeability in said magnetic member, affecting the electric signal in said coaxial cable in a corresponding manner.

2. Apparatus comprising

a coaxial cable having an inner conductor and a concentric outer conductor spaced therefrom by insulation,

said cable being wound in the form of a helix,

the inner sides of the loops of said helix having a portion of the outer cable conductor and insulation removed,

a magnetic core being in said helix and in close electromagnetic coupling thereto,

said magnetic core having a permeability dependent on the strength of the magnetic field applied thereto,

a winding being placed about said helix,

means for electrically energizing said winding being connected to said winding,

said winding when energized generating a magnetic field in said core to establish a corresponding value of permeability of said core.

3. The apparatus of claim 2 where said means for electrically energizing said winding is variable to vary the magnetic field in said magnetic member, thereby

varying the signal absorption capabilities and permeability of said magnetic member.

4. The apparatus of claim 3 having

a closed cylindrical member,

said cylindrical member being of a material having low retentivity to magnetic fields,

non-conductive and non-magnetic spool means about which said winding is wound,

said spool means being supported in said closed cylindrical member,

and said helix being supported within said spool means.

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