

June 10, 1958

A. S. DAVIS

2,838,735

ELECTROMAGNETIC DELAY LINE

Filed Dec. 17, 1953

Fig. 1A.

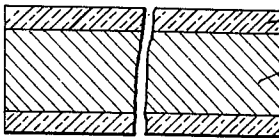


Fig. 1.

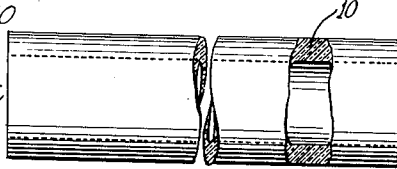


Fig. 2.

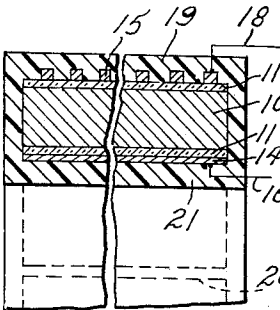
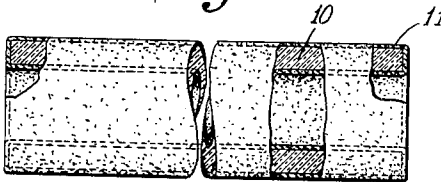


Fig. 3.

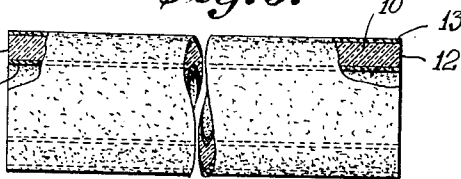


Fig. 4A.



Fig. 4.

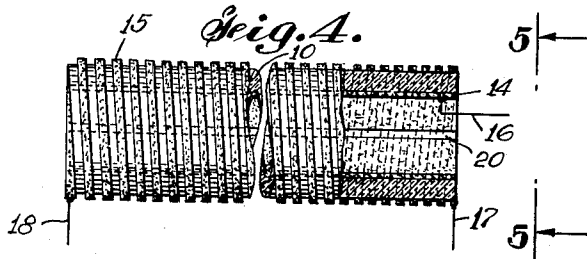


Fig. 6.

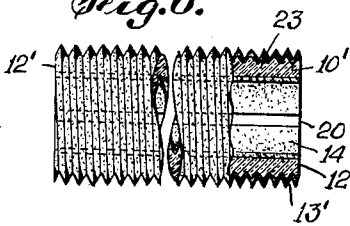


Fig. 5.

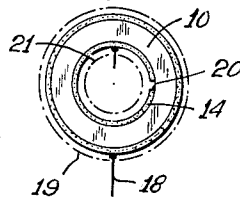


Fig. 7.

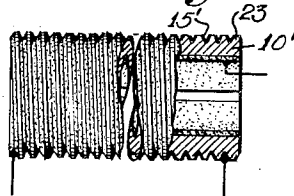
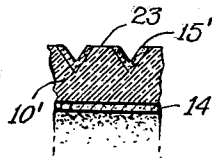


Fig. 8.



INVENTOR.
ARTHUR S. DAVIS

BY *Samuel J. Stree*

ATTORNEY

1

2,838,735

ELECTROMAGNETIC DELAY LINE

Arthur S. Davis, Forest Hills, N. Y., assignor to Dynamic Electronics-New York, Inc., Forest Hills, N. Y.

Application December 17, 1953, Serial No. 398,774

1 Claim. (Cl. 333—31)

This invention relates to the art of wave transmission and particularly concerns an electromagnetic delay line and method of manufacturing the same.

It is a principal object to provide a miniature electrical delay line of simplified construction.

It is a further object to provide an electrical delay line of simplified construction which can be fabricated in a simpler and more economical manner than conventional delay lines.

It is a further object to provide a novel method for fabricating an electrical component, particularly an electrical delay line.

Other and further objects of the invention will become readily apparent from the following description together with the drawing wherein:

Fig. 1 is an elevational view of core element which serves as the basis for the novel delay line herein disclosed.

Fig. 1A shows a modified core structure.

Fig. 2 is a longitudinal section of the delay line showing a principal step in the course of its fabrication.

Fig. 3 is a showing of a further step in the fabrication of the delay line.

Fig. 4 is an elevational view of a completely fabricated delay line with portions cut away to show the interior construction.

Fig. 4A is a fragmentary view of a completely fabricated delay line of alternative construction.

Fig. 5 is an end view of the delay line of Fig. 4.

Fig. 6 is a showing of a modified form of delay line in the course of fabrication.

Fig. 7 is a showing of the delay line of Fig. 6 at a further step in its fabrication.

Fig. 8 shows on an enlarged scale a portion of the delay line of Fig. 7.

In Figs. 1 and 2 are shown a hollow cylinder 10 formed of a dielectric or magnetic material depending on the characteristics of the delay line desired as will be hereinafter explained. The cylinder 10 is shown coated with a layer 11 of suitable conductive material. If desired the material may be sputtered, evaporated or electroplated on the cylinder 10. The coating may be applied in a liquid or paste form by painting, spraying, or dipping. The material forming the coating material will preferably be a mixture of powdered silver, a binder, thinner, and a low temperature melting, finely divided ceramic flux. After the conductive material is applied to all exposed surfaces of the cylinder 10, it is baked to evaporate the thinner and burn out the binder and cause the silver to become firmly embedded in the fused flux and securely bound to the base material. The material of cylinder 10 may be of a ceramic or vitreous nature. For the purposes of the present invention compounds of titanium such as the titanates inclusive of the barium-strontium titanate dielectrics may be used. Other acceptable dielectrics are glass bonded mica (known as Mycalex), plastics capable of withstanding high temperatures such as melamine formaldehyde resins, phenol form-

2

aldehyde resins, silicone resins, and other thermo-setting materials. The particular material selected to form the cylinder 10 will depend on the delay and characteristic impedance characteristics desired in the completed delay line. For certain purposes the cylinder 10 could be of magnetic material if a high characteristic impedance is required. A suitable magnetic material would be powdered iron compressed with binder. If magnetic material is to be used for the cylinder 10 a layer 11' of dielectric material of ceramic or vitreous nature as above described should be applied to the surface of the core to which the conductive layer is to be applied as shown in Fig. 4A. This dielectric layer is necessary because magnetic materials are generally conductive and would render the device inoperative if the conductive helix of the delay line were fused directly thereto. As an alternative structure the cylinder 10 may be of dielectric material as above described and a magnetic core C may be inserted in the cylinder as shown in Fig. 1A. The length of the cylinder 10 and outer surfaces will depend on the ultimate electrical characteristics desired of the delay line.

In Fig. 3 the core 10 is shown after the coating layer on the ends of the cylinder is removed as by abrasion to leave the bare ends 12, 12'. The cylinder 10 now carries a firmly bonded outer conductive layer 13 and an inner conductive layer 14. Layers 13 and 14 are of course electrically separated from each other by the core 10.

In Figs. 4 and 4A the delay line is shown completely fabricated. A slot 20 has been cut through the inner layer 14 longitudinally of the cylinder. This slot imparts the desirable characteristic to the delay line in that it reduces eddy currents and the consequent losses which occur at high frequencies of electrical operation. The outer layer 13 has been machined down to expose the core 10 and form a helical conductive coil 15. The removal of the excess material of layer 10 can be done on conventional thread cutting and turning machines by using conventional thread cutting techniques. The pitch of the thread and the number of turns of the coil will depend on the desired electrical characteristics of the delay line.

Wire leads 17, 18 are connected as by soldering to opposite ends of the coil 15. A wire lead 16 is also connected to the inner wall layer 14. If desired the delay line as thus constituted may be incased in a tough plastic material to form a coating on the inside and outside of the cylinder over the coil 15 and conductive layer 14 as shown by the layers 19, 21 in Figs. 4A and 5. The leads 16, 17, 18 are embedded in the encasement but of course project therethrough to enable convenient electrical connections to be made to them. The delay characteristic of delay line occurs between the two ends of the coil 15. The lead 16 serves as a center conductor or common connection so that leads 16, 17 may serve as the input end of the delay circuit and leads 16, 18 may serve as the output end or vice versa.

An alternative construction for the delay line and another method of fabricating the same is shown in Figs. 6, 7, 8. In Fig. 6 the hollow cylinder 10' formed of the same material as the cylinder 10 is initially formed with a helical groove or thread 23. The outer threaded surface of the cylinder 10' is coated with a conductive layer 13' as by painting, spraying or dipping. The coating is fused to the threaded surface of the core and the ends faced to leave the bare ends 12, 12' of the cylinder exposed. Slot 20 is made as before in the inner layer 14. The coated thread 23 is now turned down to remove or strip off the conductive coating from the high points of the thread to leave the core 10' exposed as shown in Figs. 7 and 8. Now the coil 15' is embedded in the groove of thread 23. This construction has the advantage in that the conductive coil 15' is not exposed so that it is

not subject to abrasion or damage as would be the case if it were exposed on the surface of the core 10'.

All of the constructions of Figs. 4, 4A and 7 are capable of modification in that the coils 15, 15' could be formed on the inside of the hollow core in the layer 14 instead of in the layer 13. In the modification of Fig. 7 it would be necessary to pre-thread the inside of the core 10' before applying the conductive coating. Generally the outer layer of conductive material would be left intact or might be slotted. The advantage of this construction would be that the outer conductive layer would serve as an electrical shield so that in electrical equipment where many miniature delay lines would be used together in close quarters the outer conductive layers would prevent radiation and electrical interference from and among the delay lines. Of course if desired both inner and outer conductive layers may be formed into coils, depending on the time delay characteristics required.

The delay lines herein described in the several modifications thereof will be of smaller construction than those conventional in the art. The simplicity of construction and relatively simple fabrication process makes possible mass production at low cost. A great range of delay line characteristics may be achieved by judicious selection of the materials for the core depending on the parameters desired. As an example of the adaptability of the present construction for varied purposes a magnetic core can be inserted inside the hollow cylinders 10 or 10'. This magnetic core may also serve as the common conductor for the input and output of the delay line. It should be noted that by the unique structure herein disclosed there is constituted an electrical element which possesses the characteristic of inductance in the outer coil and capacitance between the inner conductive layer and the outer conductive coil. The inductance and capacitance are in effect connected in parallel so that there exists an anti-resonant circuit. This type of electrical element has widespread applications in the electrical arts in addition to delay line uses.

The coatings for the cores 10, 10' have been heretofore indicated as conductive. It is of course possible to impart to them limited conductivity so that the parameter of resistance can be added to the delay line to modify its characteristics. Many other conductive materials instead of silver can be used in the coating. Suitable metals are copper, aluminum and nickel-silver.

Although several embodiments of the invention have been disclosed it is only intended that these be taken as exemplary of the invention which is not to be considered as restricted thereto. The invention is subject to many modifications without departing from the spirit thereof. The invention is to be limited only by the scope of the appended claim.

I claim:

A delay line comprising a hollow magnetic cylinder, a first layer of dielectric material covering one major surface of the cylinder, a conductive helix fused to said layer, said conductive helix being insulated from said cylinder by said first layer, a second layer of dielectric material covering an opposite major surface of the cylinder, a conductive layer having a longitudinal slot fused to the second layer, said conductive layer being insulated from said cylinder by said second layer, the end faces of the cylinder being free of conductive material, wire leads attached to said helix and conductive material, and a plastic encasement for the entire delay line with said leads projecting through the encasement, said conductive helix and said conductive layer being substantially co-extensive with each other and with the magnetic cylinder, the first and second dielectric layers of material which insulate said conductive helix and said conductive layer from said cylinder being also adapted to insulate said conductive helix and said conductive layer from each.

References Cited in the file of this patent

UNITED STATES PATENTS

1,767,715	Stoeckle	June 24, 1930
1,820,240	Mitchell	Aug. 25, 1931
2,258,261	Roosenstein	Oct. 7, 1941
2,299,605	Willers	Oct. 20, 1942
2,391,038	Rifenbergh	Dec. 18, 1945
2,457,212	Di Toro	Dec. 28, 1948
2,512,945	Kallman	June 27, 1950
2,514,337	Reid	July 4, 1950
2,583,854	Kehbel	Jan. 29, 1952
2,608,610	Thulin	Aug. 26, 1952

FOREIGN PATENTS

632,834	Great Britain	Dec. 5, 1949
---------	---------------	--------------