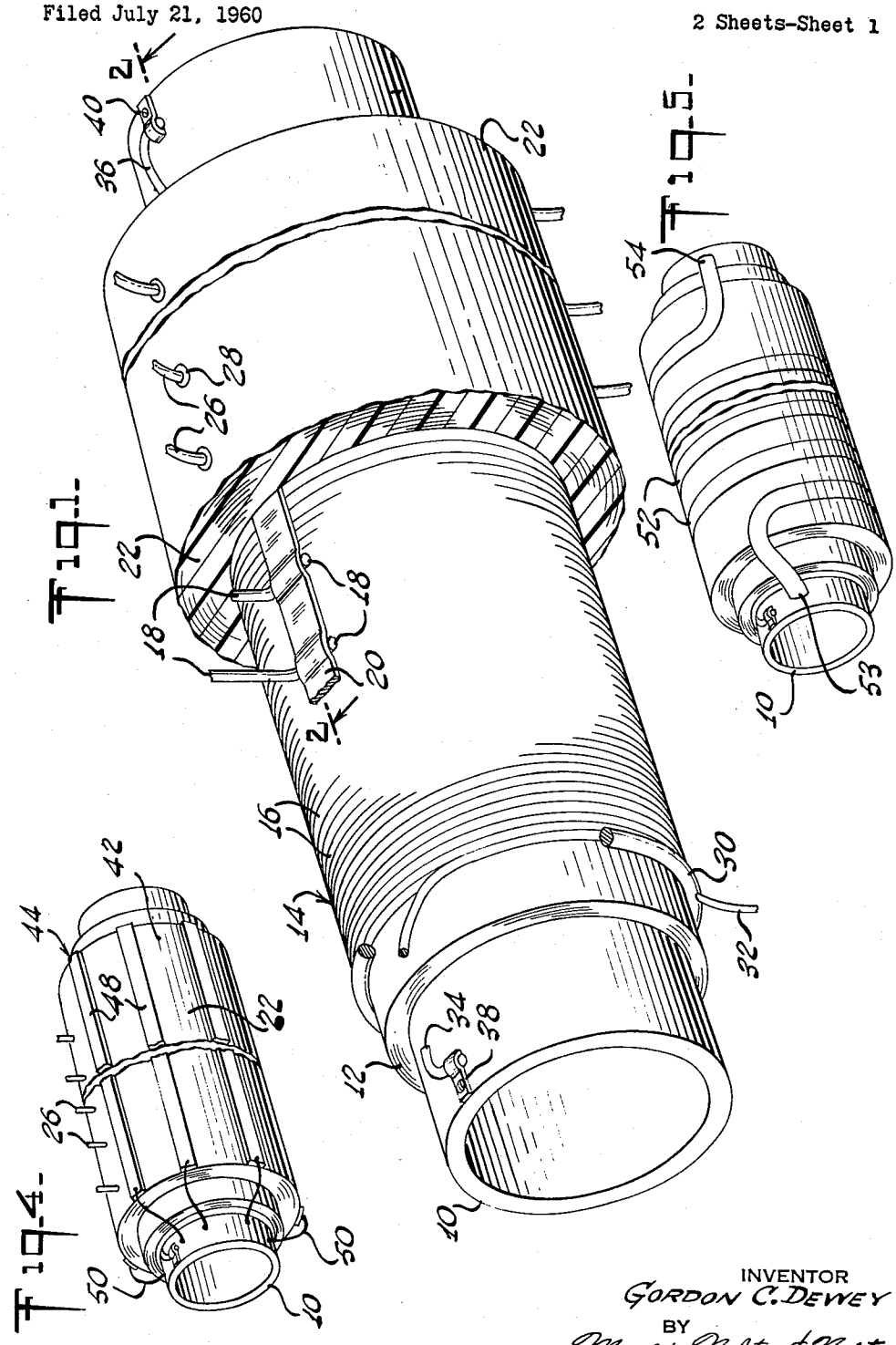
April 9, 1963 G. C. DEWEY 3,085,214

ELECTRICAL DELAY LINE WITH CAPACITIVE PICK-OFF

Filed July 21, 1960 2 Sheets-Sheet 1



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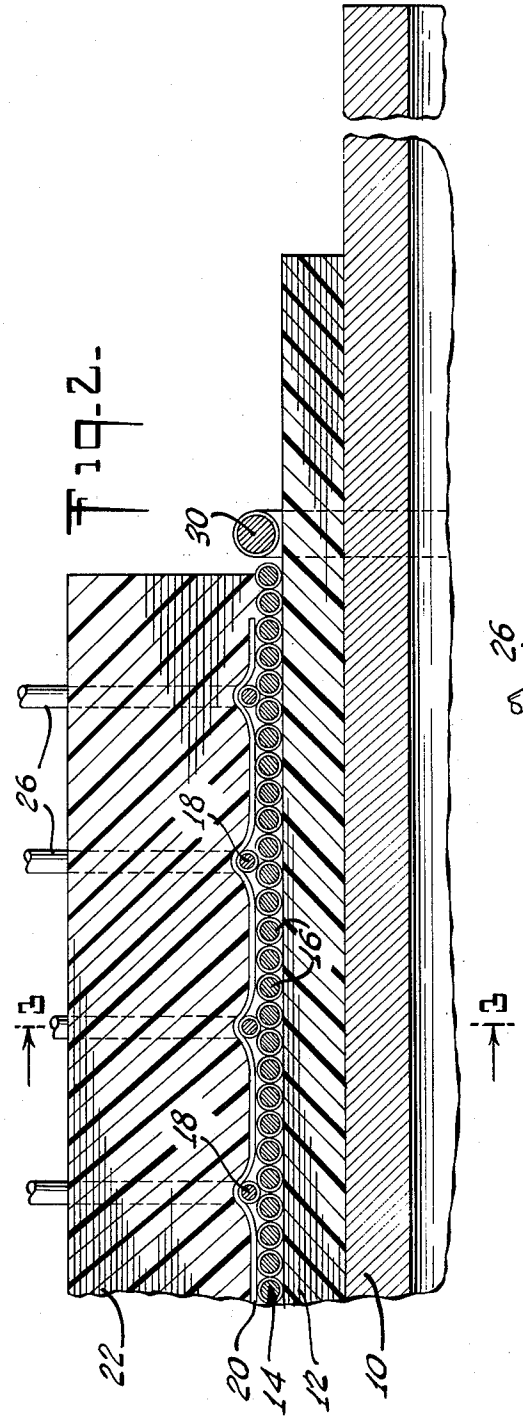


FIG. 2.

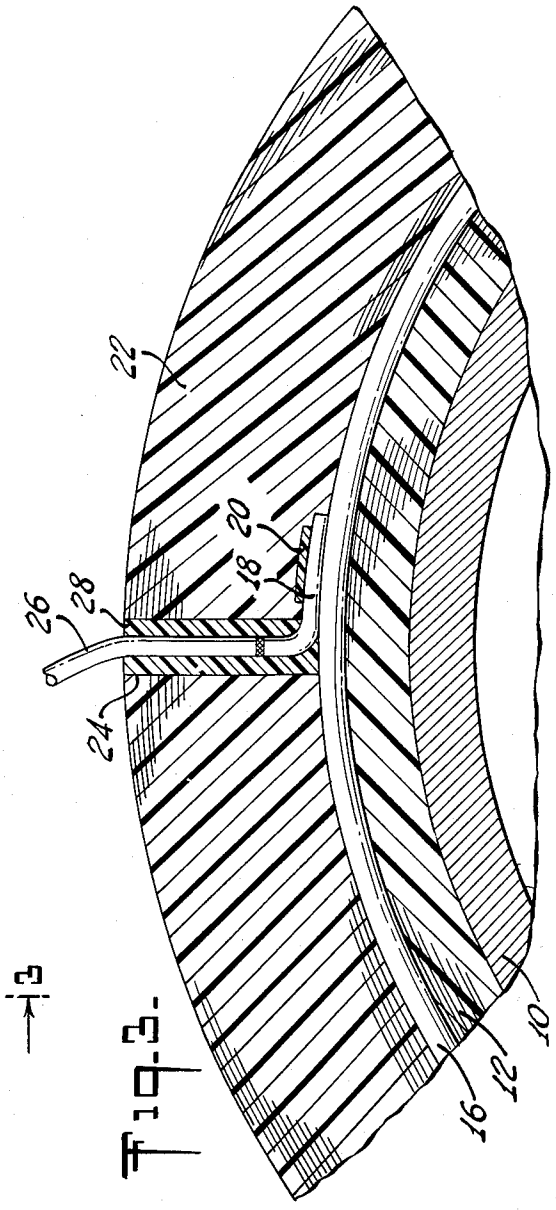


FIG. 5.

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ELECTRICAL DELAY LINE WITH CAPACITIVE PICK-OFF

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The present invention relates to an electrical delay line.

There are many systems in which it is required to provide precisely known delays for electrical signals. In some systems it is necessary to provide a very large number of predetermined different delays.

It is an object of this invention to provide a precise delay line of this type having a low loss and substantially constant characteristics.

Another object of the invention is to produce a delay line capable of giving a large number of accurately predeterminable delays extending up to a relatively high value.

The delay line according to the invention comprises a rigid metallic tube having a sheath of low-loss dielectric material of a predetermined thickness. The metallic tube has a relatively long length. A wire is wound helically over the insulating sheath, which may be provided with a helical groove to facilitate accurate winding. The wire is preferably of the insulated type. A plurality of tap wires are then placed on the winding at predetermined points thereon and are held in place by any suitable means such as a tape. Another coating or sheath of insulation of low-loss material is then placed over the helical winding and the taps for completely enclosing the same. Holes are drilled in the outer insulating sheath down to the tap wires, which may then be brought into the drilled holes and connected to suitable leads which serve as the output taps of the delay line. Closed metallic guard rings are placed on the inner sheath of insulation near the ends of the winding to provide impedance matching at the ends of the delay lie in order to prevent abrupt terminations or changes of impedances. For this purpose the guard rings are energized with the same signals as the winding although they may be at different potentials. If desired, an outer conductor or envelope may be placed over the outer sheath of insulation and grounded to the center metallic tube at both ends. The outer conductor may be conveniently in the form of helical tape or longitudinal strips. The center tube forms a ground for the delay line and signals are impressed between one end of the winding and the center tube.

The invention will be fully understood from the following description and the drawing in which:

FIG. 1 is a perspective view partly broken away of one embodiment of the invention;

FIG. 2 is a partial sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a partial sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is a perspective view of another embodiment of the invention; and

FIG. 5 is a perspective view of still another embodiment of the invention.

Referring particularly to FIGS. 1, 2 and 3, the delay line includes a large rigid metal tube 10 of considerable length. On tube 10 there is built up a sheath or covering of insulation 12 of a predetermined thickness, since the thickness of the insulation controls the impedance of the delay line. The insulation may be of any suitable low-loss type, such as polyethylene or polystyrene and is conveniently formed by winding a tape on metal tube 10 in a sufficient number of layers to build up to the required thickness. The insulation is preferably applied or treated so that it is substantially solid and free of any air spaces. The insulation 12 may then be provided with a helical groove for receiving the winding 14 of insulation coated wire 16. A number of short lengths of wire are then placed along the winding 14 at accurately predetermined points thereof to serve as taps for the delay line. The tap wires 18 may be disposed along the delay line and at various points around the circumference, and are held in place temporarily by a suitable tape 20. Another outer layer of insulation 22 is then built up over the winding 14 and the taps 18 to the required thickness. The outer sheath of insulation 22 may be of the same material as the inner insulation and built up similarly by winding a sufficient number of layers of tape. After the outer layer 22 has been wound, holes 24 are drilled therethrough at the locations of the tap wires 18 and the ends of these wires are then turned upward into the holes. A suitable plug or tap 26 is then inserted into the holes and soldered to the tap wires 18 to provide the output taps of the delay line. Holes 24 are then filled with an insulating material 28, preferably of the same type as the insulation 22. The taps 18 thus form capacitive connections to the winding 14 through the insulation on wire 16. If desired, the taps could be connected directly to winding 14.

Beyond each end of the winding 14 a pair of closed metallic rings 30, called guard rings, are mounted on the inner sheath of insulation 12. The guard rings 30 are suitably positioned and are of sufficiently large area and size so that when energized with the same signals as is the delay line itself and at a suitable potential relative to the potential of the signals on the delay line, an abrupt change of impedance at the ends of the delay line may be avoided or greatly reduced. The abrupt impedance change is a result of magnetic field discontinuities occurring at the ends of an abruptly terminated delay line and resembles large shunt capacity in parallel with a helical transmission line. The addition of the guard ring has been found to sharply reduce distortion caused by these end effects and aid in achieving uniform time delay and frequency response. For this purpose, a lead 32 is connected to each guard ring through which it may be fed from the same amplifier as the winding 14 or a separate amplifier supplied with the same signals. The ends 34 and 36 of winding 14 may be fastened down by suitable clamps 38 and 40.

Referring to FIG. 4 there is shown a delay line which may be constructed similarly to that illustrated in FIGS. 1–3 and described above. The delay line of FIG. 4 differs from that shown in FIG. 1 principally in that an outer metallic conductor 44 is placed over the outer insulating sheath 22. Metallic conductor 44 may take various forms to provide a conductive envelope around the delay line. In the embodiment shown in FIG. 4, the envelope 44 is constructed of a plurality of longitudinal strips 48 extending substantially the entire length of the delay line, or at least the length of the winding thereon, and connected at both ends by leads 50 to the inner metallic tube 10.

Referring to FIG. 5 there is shown a delay line similar to that of FIG. 4 except that the outer metallic envelope is formed of a metallic tape 52 which is grounded to the metallic tube 10 at both ends 53 and 54. In other respects the delay line of FIG. 5 may be similar to that disclosed in FIGS. 1–3.

Although the dimensions of the delay line will depend on the characteristics desired, some typical dimensions of one embodiment will be indicated for the sake of definiteness. Metallic tube 10 may be formed of copper of sufficient thickness to be quite rigid and may have a diameter of about 1 foot and a length of, say 10–15 feet. The

insulating sheath **12** in a particular embodiment had a thickness of .120 inch and was formed of six layers, each .020 inch thick. The thickness of insulation **12** is a factor determining the impedance of the delay line. The wire **14** had insulation of the same material as the sheaths **12** and **22**. The thickness of the outer layer **22** affects the amount of delay which is obtained and in one embodiment had a thickness of about 1 inch. Where an outer metallic envelope such as **44** in FIG. 4 or **52** in FIG. 5 is used, the outer layer of insulation **22** need not be so thick and may indeed be of a thickness comparable to that of the inner layer **12**. In order to further increase the delay a dielectric material may be used having a permeability greater than 1, which can be achieved by loading the dielectric with carbonyl particles, for example. It will be understood by those skilled in the art that although I have described some particular embodiments of my invention, many variations and modifications thereof can be made without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. An electrical delay line comprising an elongated rigid metallic inner tube, a first sheath of insulation of constant thickness on said tube, a helical winding of insulation-coated wire on said insulating sheath, a plurality of taps comprising short lengths of wire spaced along said winding, said insulation coating forming a capacitive connection between said taps and said winding, means for holding said taps on said winding, an outer sheath of insulation enclosing said winding and said taps, said outer sheath of insulation having a plurality of substantially radial holes extending down to said taps, a plurality of output leads each extending through one of said holes and connected to one of said taps, and a pair of input terminals applying an input signal between said metallic tube and one end of said winding.

2. A delay line according to claim 1, including a metallic envelope surrounding said outer sheath and connected to said metallic tube.

3. A delay line according to claim 1, including means energized by said input signal and positioned adjacent an end of the winding for reducing the terminal impedances of the delay line.

4. A delay line according to claim 3, wherein the impedance reducing means includes a conductive guard ring at least one end of said winding insulated from said winding and said metal tube, and having a separate connection for said input signal, said guard ring being energized by a predetermined potential relative to said winding.

5. An electrical delay line comprising a metallic tube, a layer of insulation of substantial thickness on said tube, a helical winding of wire on said layer of insulation, a plurality of taps capacitively coupled to said winding at spaced points thereof, an outer sheath of insulation enclosing said winding, said taps extending through said outer sheath of insulation, and conductive means positioned between said layer and outer sheath of insulation for reducing the terminal impedance at either end of said delay line.

6. A delay line according to claim 5, wherein said last means includes a conductive ring adjacent each end of said winding, said ring being insulated from and having a predetermined potential relative to said winding.

7. A delay line according to claim 5, wherein at least one of the layers of insulation is a material having a permeability greater than one.

8. An electrical delay line comprising a rigid metallic tube, a sheath of insulation of constant thickness on said tube, a helical winding of insulation-coated wire on said insulating sheath, a plurality of taps coupled to and spaced along said winding, an outer sheath of insulation enclosing said winding and said taps, a plurality of output leads each extending through said outer sheath and connected to one of said taps, a pair of input leads applying an input signal between said metallic tube and one end of said winding, a conductive guard ring at one end of said winding, and a separate connection to said guard ring for supplying said signal thereto, said guard ring having a predetermined potential relative to said winding.

9. A delay line according to claim 8, including a metallic envelope surrounding said outer sheath and connected to said metallic tube.

10. A delay line according to claim 9, wherein said envelope comprises a plurality of longitudinally extending strips connected at both ends thereof to said tube.

11. A delay line according to claim 8, wherein said envelope is a helically wound metallic tape connected to the metallic tube at both ends.

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