

[54] **GROUND PLANE PATTERN FOR DELAY LINES AND METHOD OF ASSEMBLY**

[75] Inventor: **Howard Bernstein**, New York, N.Y.

[73] Assignee: **Bel Fuse Inc.**, Jersey City, N.J.

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[58] Field of Search **333/31 R, 31 C, 84 M**

[56] **References Cited**

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Primary Examiner—Rudolph V. Rolinec

Assistant Examiner—Saxfield Chatmon, Jr.

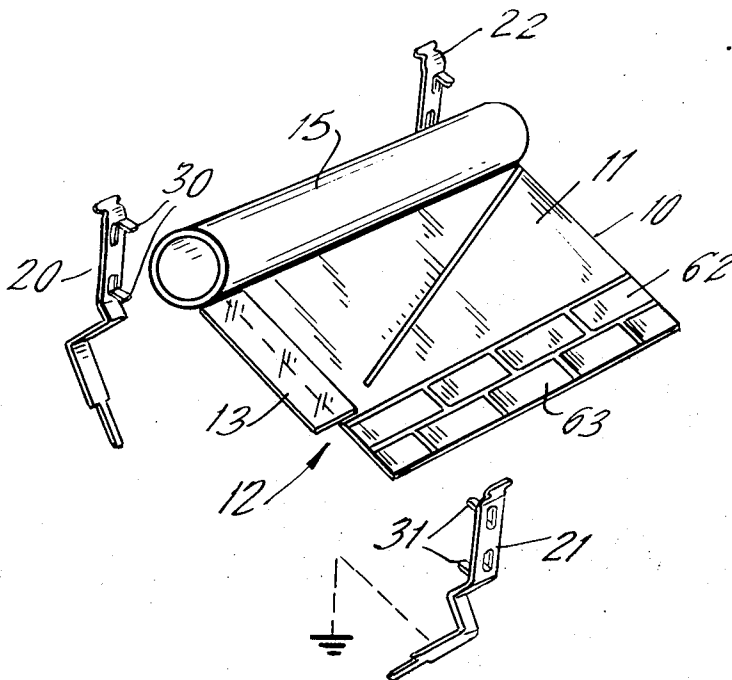
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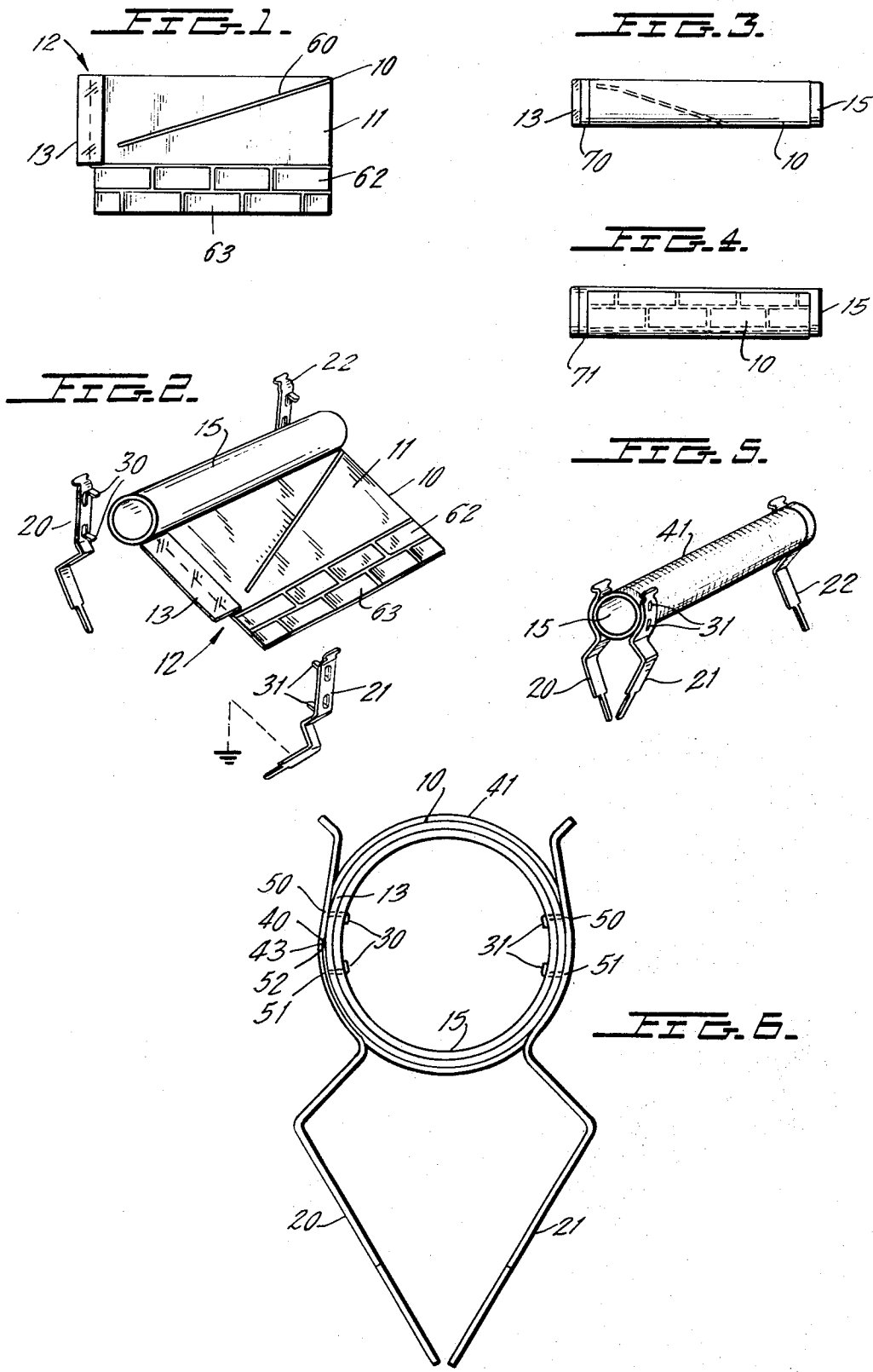
[57] **ABSTRACT**

A novel ground plane structure for a delay line in

which a thin insulating carrier such as mylar has the ground plane printed thereon. The carrier is then placed on an insulating tube with the ground plane electrical structure on the inside against the face of the tube and the coil wound on the insulating carrier, the insulating carrier thereby providing controlled insulating spacing between the coil and the ground plane. A connection is made to the ground plane by means of an adhesive copper tape which engages a substantial portion at the edge of the surface of the printed ground plane electrical structure and extends beyond the insulated carrier; this copper extension serves as a connector and as a heat sink, avoiding thermal damage to the insulating carrier during soldering, where soldering occurs. The use of a single diagonal discontinuance or gap section in the ground plane printed surface which becomes a spiral gap section in the completed coil provides improved band width and avoidance of ripple in the time delayed pulse to an extent equal to or better than that previously obtained by the utilization of separate but connected ground plane electrical sections.

4 Claims, 6 Drawing Figures





GROUND PLANE PATTERN FOR DELAY LINES AND METHOD OF ASSEMBLY

The present invention relates to an electrical delay line, and more particularly to a novel ground plane structure therefor and means for interconnecting the ground plane structure with the coil and the remainder of the circuit. In electrical circuits, it is sometimes necessary to introduce a time delay in the transmission path of an electrical signal. Various time delaying networks are presently available to provide a discrete amount of delay within a practically realizable length. Such time delay networks are usually of the distributed constant variety and typically include an insulated support structure on which is mounted a conductive ground plane and a distributed winding. The capacitive coupling between the winding and the ground plane in conjunction with the inductance of the winding establishes a distributed constant impedance to provide the desired signal delay along the length of the support structure. The required magnitude of delay may be obtained by appropriately selecting the physical characteristics of the support structure, windings, ground plane and, if needed, additional bridge capacitive patches in a manner now well known in the art.

The ground plane structure has frequently created problems. It must, of course, be insulated along its length from the coil while at the same time, appropriate connections should be made at the coil end. Since the efficacy of the operation depends on the capacitive coupling between the coil and the ground plane, it is essential that the spacing between the coil and ground plane be minimal.

A prior method which has been used is one in which the ground plane is printed on an insulated carrier. The insulated carrier is then placed on an insulating tube, such as paper. An insulating sheet is placed over the printed surface of the carrier and then the coil is wound over the insulating sheet.

The present invention contemplates, and has for one of its objects, the arrangement of the ground plane in so-called printed form on an extremely thin sheet, such as a sheet of mylar of the order of $\frac{1}{4}$ mil to 1 mil in thickness, and placing the ground plane sheet on the tube or support with the metallic printed surface on the inside, adjacent the surface of the insulating tube and support. In this case, the insulating carrier for the ground plane, the very thin mylar sheet, provides an insulation barrier and accurate spacer between the coil and the ground plane without requiring the interposition of other insulating or spacing means therebetween.

One of the major problems that occurs in the utilization of a thin sheet such as mylar to carry the ground plane is that if any solder connection is attempted to the printed ground plane surface, the soldering heat may damage or destroy the mylar carrier adjacent the point of soldering. Consequently, various attempts have been made to secure such connection mechanically and without the application of heat. Since a solder connection, however, is highly desirable because it at least fixes the point of electrical engagement, solder techniques with respect to such thin based ground planes have become exceedingly complex, or in the alternative, the manufacturer of the delay line was required to resort to other types of connection techniques.

The present invention therefore contemplates and has for another and principal object the utilization of a separate connecting element to the ground plane in which an efficient connection may be made over a broad area by pressure alone, and thereafter using the connection thus made as an element to which a solder connection can be made.

More specifically, the present invention contemplates the utilization of an adhesive coated copper tape. A length of the copper tape is laid down along an edge of the ground plane with the adhesive surface engaging the ground plane printed surface. The copper tape extends beyond the said edge so that the adhesive surface thereof may also be used for securing that side and that portion of the ground plane from which the adhesive copper tape extends to the support tube — where the copper tape is thus adhesively coated on both sides. Where the copper tape is adhesively coated on only the side which engages the ground plane, then of course, the clear side will be in engagement with the base support tube and will be held in position by other means hereinafter described. Such copper tapes with a conductive adhesive coating are known and are commercially available. One example of such an adhesive coated copper tape of this type is a product of Minnesota Mining and Manufacturing Company, known as X-1170 tape, in which the adhesive coating has the characteristic of being highly conductive directly transversely of the adhesive into the copper on which it is coated.

Another object of this invention therefore is the utilization of a copper tape as a terminal connector for a printed ground plane supported on a thin flexible sheet, which in turn, is carried by the principal support of a delay line.

Thus, in summary, the ground plane for the delay line is coated on an extremely thin insulating sheet such as a mylar sheet. An adhesive copper tape which is conductive through the adhesive is secured to the ground plane with the tape extending beyond an edge of the thin support sheet. The thin support sheet with the ground plane printed thereon is placed on an insulating support tube with the ground plane surface adjacent the tube. The coil is then wound on the support surface for the ground plane, being insulated from the ground plane by the said insulating support surface. A terminal connection to the ground plane is then made through the copper tape extension from the ground plane.

A further object of the invention is the provision of a single diagonal slot in the ground plane which, when wrapped over the support tube, becomes a spiral slot which increases band width and obviates rippling.

The foregoing, and many other objects of the present invention will become apparent in the following description and drawings in which:

FIG. 1 is a plan view of the novel ground plane structure of the present invention, showing the copper tape connector therefor mounted thereon.

FIG. 2 is an expanded view showing the ground plane structure about to be placed on an insulating tube and the connectors in position to be inserted.

FIGS. 3 and 4 are side elevations showing the ground plane in place on the insulating tube.

FIG. 5 is a view in perspective showing the completed delay line prior to the placement of a protective sleeve thereover, where one is required, with the coil wound over the ground plane support.

FIG. 6 is an end view of the coil of FIG. 5 showing one manner in which connections are made to the coil and to the ground plane.

Referring first to FIG. 1, the new ground plane structure consists of a thin, flexible sheet of mylar 10, which is from ¼ mil to 1 mil in thickness, and has a silver ground plane pattern 11 placed thereon in any suitable manner, as for instance, by a silk screening process having an appropriate pattern to form the ground plane of a delay line. This pattern will be hereinafter more specifically described in detail.

A copper tape 12 is placed on the pattern 11 in the manner shown in FIG. 1, so that it establishes contact with the silver pattern and extends beyond the edge of the mylar base 10 in order to form a terminal connector strip 13. As previously pointed out, the copper tape 12 is provided with an adhesive particularly on the surface which engages the ground plane printed pattern 11, this adhesive being of such a nature that electric current may readily flow therethrough into the copper tape 12 and thus to the terminal extension of the ground plane structure consisting of the remainder 13 of the copper tape which extends beyond the edge of the ground plane structure.

The ground plane structure 10 is then, as seen in FIG. 2, placed on an insulating tube 15 and wrapped around to produce the end result shown in FIGS. 3 and 4.

One of the essential elements of the present invention is that the printed ground plane surface 11 is arranged so that it is adjacent the surface of the tube 15 so that the mylar material forming the insulating base 10 provides an insulating cover for the ground plane, while at the same time providing accurate spacing for the coil which is thereafter to be wound on the outside of the tube and ground plane support.

Terminal connectors 20, 21 and 22 are provided, which as hereinafter pointed out in connection with FIG. 6, will not only serve to secure the coil ends in position, but terminal connector 21, which is connected to a ground, will be arranged so that its stapled prongs 31 will also engage the extension 13 of the copper tape 12. At the same time, the prongs 30 of said terminal connector 20 will also serve to engage the end 40 of the coil 41 (see also FIGS. 5 and 6).

As seen in FIGS. 5 and 6, the coil is then wound around the wrapped ground plane structure of FIGS. 3 and 4.

When the connectors are applied, the prongs 31 of connector 21 and the prongs 30 of connector 20 pass through the copper connector 13 of the ground plane structure 10 through the paper tube 15, and are bent over in staple fastener arrangement. The connector 20 also acts as a connector for the end 40 of the coil 41, and this end 40 may be captured against the base section 43 of the connector 20. The other end of the coil may be similarly connected to connector 22. Solder may then be placed at appropriate points such as points 50, 51, 52 to ensure not only a good connection to the coil, but also a good connection between the connectors 21 and the ground plane connector 13.

It will be obvious that the copper strip connector 13 for the ground plane may be conductively secured in any manner, even by the staple elements 31 alone, and the appropriate pressure applied in completing the staple operation to obtain an efficient connection to the ground plane through the copper strip 13. It should be noted that when solder is used, however, the extension

13 of the copper tape 12 is sufficiently thick to act as a heat sink to protect the sensitive and thin mylar sheet from thermal damage.

The present invention therefore accomplishes the result (1) by placing the ground plane on the surface 11 on the inside of the mylar sheet against the tube 15, the ground plane is automatically insulated by its own carrier from the winding and is accurately spaced with respect thereto, thereby obviating the need for other spacing means or insulation, and (2) the utilization of the copper connector tape 12 provides a simple method of making a connection to the ground plane on the thin mylar sheet, without damaging the thin mylar support sheet for the ground plane, whether the connection is a pressure-type connection or is further enhanced and fixed in position by soldering.

A third improvement within the scope of the present invention is in the novel ground plane pattern which is used.

In order to improve band width, it has previously been known to have a plurality of parallel slots in the ground plane and to connect the insulated conductive areas together at the ends of the ground plane. Such slots are known to have the characteristic of widening the band width and to cause less ripple in the pulse wave shape transmitted by the delay line. In the present invention, it has been found that a single diagonal slot 60 in the ground plane rectangular pattern, which becomes a spiral slot as shown in FIG. 3, when wound on the base 15, provides the same improvement in band width as the prior plurality of parallel slots, increasing the band width and decreasing or obviating the ripple. It will be obvious that such a single diagonal slot is much easier to form, and obviates the necessity to connect isolated patterns of the ground plane.

The novel ground plane also contains patch sections in the areas 62, 63 which tend to make the time delay of the delay line independent of frequency. The utilization, however, of a patch pattern for this purpose is known.

When the ground plane is placed on the tube, it may initially be held in position by a narrow stretch of adhesive tape 70 as shown in FIGS. 3 and 4. It is, of course, firmly held in position when the coil 41 is wound thereon.

After the delay line is completed by the winding of the coil on the insulation surface 10 of the ground plane structure and the connectors 20, 21 and 22 are applied, the assembly of the device is completed by impregnating the winding with appropriate material such as wax and, if necessary, covering the impregnated winding with a suitable sleeve.

In the foregoing, the present invention has been described only in connection with preferred illustrative embodiments thereof. It is preferred, therefore, that the scope of the invention be defined not by the specific embodiments herein disclosed, but only by the appended claims.

The embodiments of the invention in which an exclusive privilege or property is claimed are defined as follows:

1. A ground plane structure for a delay line, said ground plane structure comprising a thin flexible insulating support capable of being wrapped cylindrically, a ground plane web of conductive metal carried by a surface of said support,

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and a diagonal slot in said web of conductive metal, an end of said slot terminating within the area of said conductive web, said slot assuming a spiral configuration when said thin flexible insulating support is wrapped cylindri- 5 cally.

2. The ground plane structure of claim 1 in which: a conductive band is secured to and in electrical contact with said ground plane web;

said conductive band extending beyond an edge of said web and providing a terminal connector there- 10 for.

3. A delay line having the ground plane structure of claim 2;

said delay line having a principal insulating support; 15 said ground plane structure being wrapped on said

6

principal insulating support; said ground plane web of conductive material lying against said principal insulating support; a coil wound over said ground plane structure; the thin flexible insulating ground plane support pro- 5 viding insulating spacing predetermined by the thickness thereof between the ground plane web and said coil.

4. The delay line of claim 3 wherein the portion of said conductive band extending beyond said ground plane has an adhesive surface on the side adjacent said principal insulating support forming a member which secures said ground plane surface in position and pro- 15 viding a means for electrical connection.

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