June 28, 1966 E. J. WALSH ETAL 3,258,724

STRIP LINE STRUCTURES

Filed Sept. 30, 1964

FIG. 1

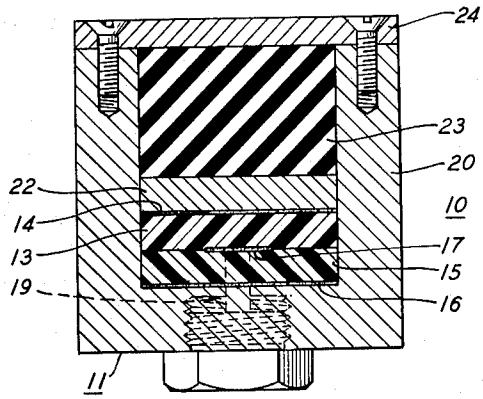


FIG. 2

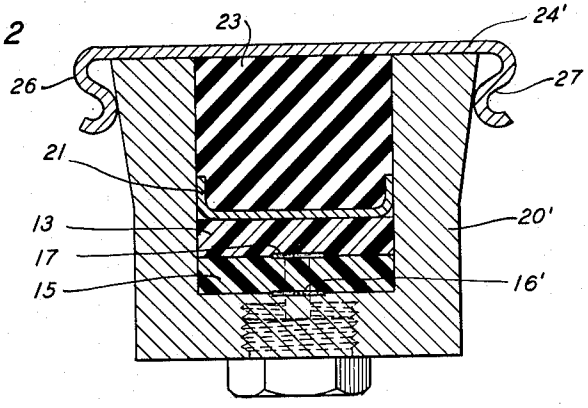
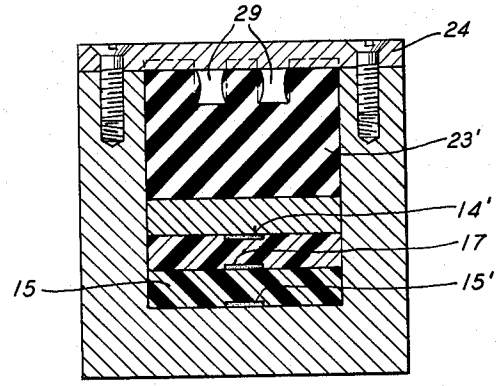


FIG. 3



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United States Patent Office 3,258,724 Patented June 28, 1966

3,258,724

STRIP LINE STRUCTURES

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Filed Sept. 30, 1964, Ser. No. 400,522
8 Claims. (Cl. 333—84)

This invention relates to strip transmission lines, and more particularly, to housings and other auxiliary structures for use with strip transmission lines.

Strip transmission lines, or strip lines, have become a major area of activity in the communications industry because of their simple construction and their capacity to transmit efficiently high frequency wave energy. Although a strip line can be defined by merely two parallel conductors, balanced strip lines, which are defined by three parallel conductors, have better shielding qualities and are in more general use. The propagating electromagnetic wave energy along the balanced strip line is defined by current on the surfaces of the conductors and by electric fields which extend from the central or "active" conductor to the outer or "ground" conductors.

Another advantage of strip lines is that they can be manufactured by known printed circuit techniques. A balanced printed circuit is typically made by bonding one side of two dielectric slabs with conductive material to form the ground conductors or ground planes. The central conductor is bonded on the other side of one of the dielectric slabs to define the desired circuit path between the ground conductors. The two dielectric slabs are typically bolted or riveted together between relatively heavy metal plates to give the circuit strength and rigidity. Electron devices may be inserted in apertures which extend through a ground conductor and at least one of the dielectric slabs to permit the device to make contact with the central conductor and with at least one of the ground conductors.

For many applications the assembly of strip line structures can be simplified, and their ruggedness, dependability, and shielding qualities enhanced, by providing a U-shaped trough or channel within a conductive housing for containing the strip line. The side walls of the housing electrically interconnect the two ground conductors to desirably maintain them at the same direct-current potential. A removable cover plate encloses the housing and provides ready access to the strip line. Electrically, the housed strip line is substantially identical to a coaxial cable though it can still be made by printed circuit techniques.

It has been found, however, that with housings of this type, microwave leakage energy can flow past the upper ground conductor into the region of the cover plate to create spurious resonances which may interfere with the operation of the strip line and adjacent components. Additionally, the rugged housings do not entirely eliminate the problem of maintaining a dependable contact between the central conductor and active electron devices, primarily because such high frequency devices are frequently very delicate. It is difficult to maintain the strip line firmly enough within the housing to protect the fragile devices and their connections from the stresses of mechanical shock and differential thermal expansion and contraction. Further, if the cover plate is clamped too tightly over the housing the strip line may become distorted due to a "cold flow" of the dielectric separating slabs.

It is one object of this invention to contain a strip line firmly within a U-shaped housing.

It is another object of this invention to reduce the effects of microwave leakage in a strip line which is contained within a U-shaped housing.

These and other objects are attained in an illustrative embodiment of the invention comprising a printed strip line contained within a trough or channel of a housing having a substantially U-shaped cross-section as described above. In accordance with one feature of the invention, a slab of resilient microwave absorbing material, which is substantially coextensive with the strip line, is located within the housing and is supported by the strip line. In its unstressed condition, the absorbing slab extends slightly above the side walls of the housing. A cover plate is mounted on the top of the housing to enclose the absorbing slab and to compress it against the strip line. The compression of the resilient absorbing slab produces downward forces on the strip line which are equally distributed along the entire length of the strip line. This distribution of forces occurs in spite of structural irregularities of the housing or the cover and therefore eases manufacturing tolerances. It also compensates for localized stresses on the strip line which may result, for example, from differential thermal expansion or contraction.

The other main function of the resilient absorbing slab is to absorb and dissipate any microwave energy that may leak around the uppermost ground conductor of the strip line. This leakage energy tends to flow up the side walls of the housing; the compression of the absorbing slab against the strip line and against the housing walls therefore increases its effectiveness for dissipating leakage energy.

In accordance with another embodiment of the invention, the uppermost ground conductor is defined by a U-shaped conductor having detented side walls which bear against the walls of the housing. When the resilient absorbing slab is compressed, it forces the walls of the ground conductor against the walls of the housing to give a firm electrical contact which inhibits microwave leakage. In accordance with another feature of this embodiment, the outer surfaces of the side walls of the housing taper from a wider dimension at the top to a narrower dimension at the middle of the housing. The cover includes spring clip side portions which grip the outer side walls of the housing. Since the housing tapers downwardly, the spring clip portion forces the rest of the cover in a downward direction to exert substantially uniform downward forces on the resilient absorbing slab.

In accordance with another embodiment, two slots extend along the length of the absorbing slab along the surface which bears against the cover plate. The slots provide a space for the absorbing slab to deform when the cover plate bears down upon it. This compensates for the limited compressibility of the absorbing slab and tends to equalize the distribution of forces against the strip line.

As mentioned above, a printed strip line is normally defined by two dielectric slabs, each having conductive material bonded on one side to define the two ground conductors, with one of the slabs having a central conductor bonded on the other side. Since the central conductor covers a much smaller area than the ground conductors, differential thermal expansion and contraction may occur which tends to bend the strip line. With the housings described above, this effect can be reduced by eliminating the plating on the dielectric slabs which would normally define the ground conductor. In this case, the housing may define one ground conductor and a metal plate between the absorbing slab and the dielectric slabs may define the other ground conductor. Better compensation for thermal stresses can be made, however, by bonding a ground conductor on the dielectric slab op-

posite the central conductor which is of the same size, shape, and material as the central conductor. In this case, thermal stresses on one side of the slab will be compensated by equal and opposite stresses on the other side. Further compensation can be made by bonding the two dielectric slabs together and including ground conductors on both dielectric slabs which are the same size, shape, and material as the central conductor. The two slabs can be bonded by heat and pressure as will be described later.

These and other objects and features of the invention will be more fully appreciated from a consideration of the following detailed description taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a cross-sectional view of one embodiment of the invention;

FIG. 2 is a cross-sectional view of another embodiment; and

FIG. 3 is a cross-sectional view of still another embodiment.

Referring now to FIG. 1 there is shown a strip transmission line **10** which is contained within a housing **11**. The strip line comprises a first dielectric slab **13** to which is bonded a first ground plane or ground conductor **14**, and a second dielectric slab **15** having a second ground conductor **16** bonded on one side and a central conductor or active conductor **17** bonded on a limited central portion of the other side. The conductors are advantageously bonded to the dielectric slabs by known printed circuit techniques. Propagating electromagnetic waves are defined by electric fields which extend from central conductor **17** to both of the ground conductors **14** and **16**. An active element **19**, such as an electron device, is shown schematically. The device is contained within an aperture in dielectric slab **15** so that it can make electrical contact with central conductor **17** and ground conductor **16**.

High frequency electron devices, such as varactor diodes, are typically quite fragile. It is important that device **19** be retained firmly within the strip line so that good electrical contact will be maintained and so that the device will not be damaged. For these reasons, the strip line is firmly contained within a U-shaped trough or channel defined by a conductive housing **20**. The side walls of the housing interconnect the ground conductors **14** and **16** to maintain them at the same direct-current potential. The housing shields the electric fields and results in wave propagation which is similar to that in a coaxial cable.

It is generally impractical to make housing **20** with such precise tolerances as to insure a firm electrical contact between the ground conductor **14** and the side walls of the housing along the entire length of the strip line. Because of imperfect contact areas, microwave energy tends, in the absence of other measures, to leak past ground conductor **14** and may establish spurious resonances within the housing cavity or it may undesirably fringe into other nearby apparatus. This problem is partially alleviated by including a conductive slab **22** along the length of ground conductor **14**. The conductive slab **22** is in close contact with ground conductor **14** and therefore electrically constitutes part of the ground conductor. It is to be noted that ground conductors **14** and **16** could be eliminated if so desired, in which case the housing **20** and the conductive slab **22** would act as ground planes for supporting strip line propagation.

In spite of the relative thickness of conductor **22**, microwave energy having a very high frequency, and a low depth of penetration or skin depth, may flow along the surface of the side walls of the housing past conductor **22**. Abutting against conductor **22** and extending along the length of the strip line is a microwave absorbing slab **23** for absorbing and dissipating this microwave frequency energy. In accordance with the invention, the absorbing slab is made of a material, preferably Eccosorb SF, which is both resilient and which has microwave absorbing qualities. Eccosorb SF is a trade name for a commercially available material made of silicone rubber having metal power interspersed throughout. In its unstressed condition the absorbing slab extends slightly above the top surface of the U-shaped housing. The slab is contained within the housing by a cover plate **24** which is bolted to the housing as shown in the drawing. When the cover plate is securely bolted to the housing, it compresses the resilient absorbing slab against conductor **22**. This compression forces the absorbing slab firmly against the side walls of the housing as required for efficiently absorbing leakage energy.

The other important function of the resilient absorbing slab is to exert substantially evenly distributed downward forces on the strip line to contain it firmly in place. If the absorbing slab were made of a rigid material, the fabrication tolerances of the housing and of the cover plate **24** would have to be very exacting in order to exert a substantially uniform downward pressure on the strip line. With the resilient absorbing slab, differential forces due to imperfections in the housing will be equally distributed along the strip line. Further, forces resulting from thermal stresses on the strip line will be distributed by the resilient action of the absorbing slab rather than becoming unduly concentrated. These considerations are of importance because of the delicate electrical contacts between the strip line and the relatively fragile active elements such as element **19** which are inserted into the strip line.

FIG. 2 illustrates another embodiment having a cover plate **24'** with spring-type clip portions **26** and **27** which clamp onto the sides of the housing **20'**. The housing has side walls which are wide at the top and taper along their outer surfaces to a narrower dimension at the middle of the housing. The spring clip portions **26** and **27** tend to pull down along the tapered outer surfaces of the housing and therefore force the cover plate **24'** firmly against the resilient absorbing slab **23**.

The upper dielectric slab **13** of FIG. 2 does not have a ground plane plated on one of its sides as in FIG. 1. Rather, the ground conductor is defined by a U-shaped conductor **21** which bears against the dielectric slab **13** and which has side walls that bear against the side walls of the housing. The compressed absorbing slab therefore forces the side walls of conductor **21** firmly against the side walls of the housing to inhibit microwave leakage energy.

In accordance with another feature, the central conductor **17** is bonded on one side of dielectric slab **15** with a ground conductor **16'** being bonded on the other side of the dielectric slab which is of the same size, shape, and material as the central conductor. This tends to eliminate the effects of differential thermal expansion and contraction between the central conductor **17** and the dielectric slab **15** because the structure is mechanically symmetrical and the thermal stresses balance. Hence, bowing and warping of the dielectric slab due to temperature change are substantially eliminated. As mentioned before, ground conductor **16'** could be entirely eliminated if so desired in which case the bottom surface of the housing would form an effective ground plane. However, the thin conductor **16'** as shown compensates for the thermal stresses generated by central conductor **17**.

Still another modification is shown in FIG. 3 wherein the central conductor **17**, and the ground conductors **14'** and **16'** are all of the same size, shape, and material. In this embodiment the two dielectric slabs **13** and **15** are bonded together to give the strip line further rigidity. Because the three conductors **14'**, **17**, and **16'** are of the same size and material their thermal stresses will be compensated and there will be substantially no tendency of the bonded dielectric slabs **13** and **15** to bow. The slabs **13** and **15** are preferably made of Tellite and are sealed

by subjecting them to a pressure of 12 to 15 pounds per square inch at a temperature of 150 degrees centigrade for five minutes. Tellite is a commercially available material made of irradiated polyethylene. In addition to giving the line added rigidity, the sealing insures an unvarying dielectric constant because air gaps between the slabs are eliminated.

The resilient absorbing slab **23'** contains two elongated slots **29** which extend along the length of the absorbing slab. Materials such as Eccosorb SF are resilient, but they have limited compressibility. The slots **29** provide space in which the absorbing slab can be deformed. The slots therefore permit the cover plate **24** to be bolted securely to the housing even though the compressibility of the absorbing slab **23'** is limited and even though the housing and cover plate do not exactly match due to structural imperfections. The unstressed rectangular configurations of the slots **29** are shown by dotted lines which represents the shape of the absorbing slab when the cover plate **24** is removed.

The foregoing embodiments are intended to be merely illustrative of the various features of the invention. These features can be used in various combinations as desired. e.g., the slots **29** of FIG. 3 can be used in the embodiment of FIG. 2; the U-shaped conductor **21** of FIG. 2 could be used in the embodiment of FIG. 1. Various other arrangements may be made by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A strip line structure comprising:
a conductive housing defining a substantially U-shaped channel;
a strip transmission line contained within the channel;
said strip line comprising a flat active conductor which is insulated from the housing by electromagnetic wave permeable dielectric material;
a slab of resilient microwave absorbing material substantially coextensive with the strip line;
and means for compressing the resilient slab against the strip line;
said compressing means comprising a cover plate which encloses at least part of said housing.

2. The strip line structure of claim **1** wherein:
the slab of absorbing material contains at least one slot extending along the length thereof and along the side of the slab which is contiguous with the cover.

3. The strip line structure of claim **1** wherein:
the strip line further comprises a ground conductor having a U-shaped cross section and side portions which bear against opposite interior walls of the housing; and
said resilient slab bears against said ground conductor.

4. The strip line structure of claim **1** wherein:
the housing tapers from a wider width at the top thereof to a narrower width near the bottom;

and the cover includes spring clip portions which abut against the tapered sides of the housing.

5. In combination:
a conductive elongated housing defined by parallel side walls and a bottom wall;
a balanced strip transmission line defined within said housing;
said strip line comprising a first ground conductor extending parallel to said bottom wall;
an active conductor between said first ground conductor and said bottom wall;
said first ground conductor abutting against said parallel side walls;
said active conductor being insulated from said ground conductor and from said housing by electromagnetic wave permeable dielectric material;
a slab of resilient microwave absorbing material extending substantially coextensively with said strip line and abutting against said first ground conductor;
and means for compressing the resilient slab against the strip line comprising a cover plate which is removably attached to said parallel side walls.

6. The combination of claim **5** wherein:
the slab of absorbing material contains a plurality of slots extending along the length thereof and along the side which abuts against the cover.

7. The combination of claim **5** wherein:
the first ground conductor has detented side portions which bear against said parallel side walls;
the U-shaped housing tapers from a wider width at the top thereof to a narrower width near the bottom;
and the cover includes spring clip portions which abut against the tapered sides of the housing.

8. The combination of claim **5** further comprising:
a second ground conductor between the bottom wall and the dielectric material;
said second ground conductor being of the same size, shape and material as the first ground conductor, and wherein:
the dielectric material comprises a first dielectric slab between the first ground conductor and the active conductor and a second dielectric slab between the second ground conductor and the active conductor;
the first ground conductor is bonded to the first dielectric slab;
the second ground conductor is bonded to the second dielectric slab; and
the first and second dielectric slabs are bonded together.

No references cited.

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