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L. L. OH

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THREE CONDUCTOR COPLANAR SERPENTINE-LINE DIRECTIONAL COUPLER

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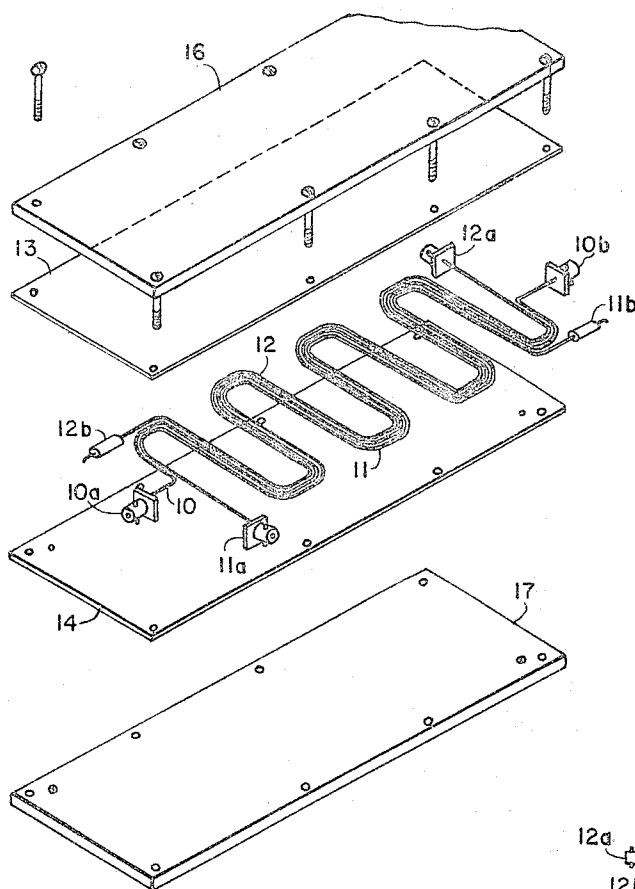


Fig. 1.

Fig. 3.

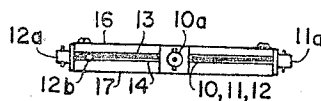
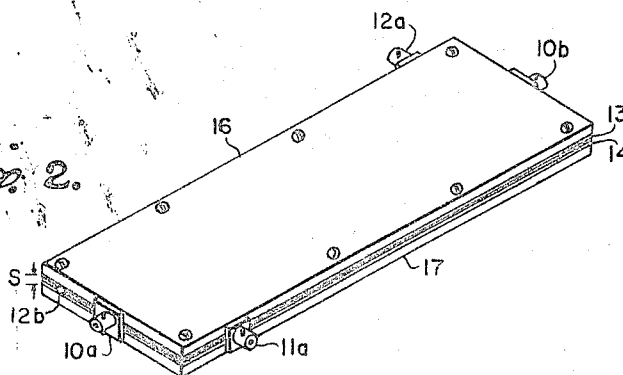


Fig. 2.



INVENTOR
LUIS L. OH

BY

Orland M. Christensen
Attorney

1

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Luis L. Oh, 832 Lake Washington Blvd. S.,
Seattle, Wash. 98144

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ABSTRACT OF THE DISCLOSURE

An improved broadband directional coupler is disclosed which includes a pair of ground plane conductors defining a transmission space therebetween and having three coplanar serpentine conductors sandwiched within the transmission space. Appropriate connectors are coupled with each end of one of the three conductors while appropriate connectors are coupled to only one end of each of the other two conductors. When R-F energy is applied to the first conductor, it is found that a small portion of the energy is coupled to each of the other two conductors. Simultaneous monitoring of incident and reflected power applied to one connector on the first conductor and reflected by a load connected to the second connector on the first conductor is therefore made possible with the apparatus being extremely compact.

The present invention relates to directional couplers for very high frequency electrical energy transmission systems, and more particularly to an improved and low-cost compact directional coupler making use of coplanar serpentine-line conductors.

Directional couplers are widely used at the present time for the measurement of incident and reflected power, for the isolation and decoupling of components, for selective power attenuation in high power systems, and for various other wellknown uses including the injection of unidirectional signals into transmission lines. Conventional directional couplers are generally either coaxial-line or strip-line structures having a length of approximately a quarter of a wavelength at the design center frequency. When such couplers are designed for operation at frequencies lower than 200 megacycles their length is such that they are impractical not only for mobile systems but for general laboratory use as well. To overcome many of the disadvantages of conventional coaxial-line or strip-line directional couplers the apparatus disclosed in my previously issued Patent No. 3,164,790 can be used to advantage. As disclosed in that patent, a directional coupler of the quarter-wavelength type is constructed through the use of serpentine conductors of equal pitch mounted in mutually superimposed coincident relationship between parallel ground plane surfaces. Each of the serpentine conductors in the apparatus of that patent is mounted in insulatively spaced relationship from the other as well as from the adjacent ground plane surface. As set forth in that patent, the length of an efficient directional coupler is thus substantially reduced and hence makes possible the utilization of directional couplers at frequencies well below 100 megacycles per second.

The present invention is an improvement over the apparatus disclosed in said U.S. Patent No. 3,164,790 and has for its general object to provide a low-cost directional coupler of simplified structure and which can be readily manufactured using low cost manufacturing techniques.

It is another object of the present invention to provide a compact and low-cost directional coupler of the quarter-wavelength type using coplanar serpentine conductors.

Another object of the present invention is to provide a compact directional coupler which provides constant power division with high load isolation over broad fre-

2

quency bands, including VHF and UHF, and which permits simultaneous sampling of incident and reflected energy.

In accordance with the present invention a coplanar, serpentine-line directional coupler of the quarter-wavelength type achieving the foregoing objects comprises a plurality of serpentine conductors of equal pitch mounted in coplanar relationship and in close proximity to each other between two parallel ground plane surfaces. Each such conductor has a total length (when stretched out) of substantially one-quarter wavelength at the mid frequency of the operating band. Input and output transmission-line connectors are connected to the ends of the serpentine-line conductors at the edges of the cavity space defined between the conductive ground plane surfaces. As set forth hereinafter, the arrangement is such that the serpentine conductors can be formed in place on a single sheet of insulating material by printed circuit or other techniques and hence the manufacturing cost maintained at a minimum. In addition, by using three coplanar serpentine conductors the directional coupler can be used to simultaneously sample incident and reflected power.

These and other features, objects and advantages of the invention will become more fully evident from the following description thereof when read with reference to the accompanying drawings.

FIGURE 1 is an exploded simplified isometric view of the principal components comprising an illustrative embodiment of the coplanar serpentine-line directional coupler.

FIGURE 2 is an isometric view of the assembled coupler.

FIGURE 3 is a fragmentary edge view of the coupler seen at right angles to its length.

The coupler shown for purpose of illustration in FIGURES 1-3 comprises two conductive plates 16 and 17 of planar form which, in assembled relationship, defined a cavity space S therebetween. Three conductors 10, 11 and 12 of serpentine configuration, with the undulations of each conductor occurring at the same pitch distance, are mounted in coplanar and parallel relationship within the cavity space S. The three serpentine conductors, with conductor 10 interleaved between conductors 11 and 12, are disposed in a co-pitch relationship. That is, the crest of one conductor occurs at a position corresponding to the crest of the other two. Each conductor when stretched out has a lineal length equal to approximately one-quarter wavelength at the mid-frequency of the intended operating band of the coupler. Coaxial transmission line fittings or connectors 10a and 10b are connected respectively to opposite ends of the serpentine conductor 10, and similar fittings 11a and 12a are connected to one end of conductors 11 and 12 respectively. Matching loads 11b and 12b are connected to the remaining ends of conductors 11 and 12. Each coaxial line fitting comprises an outer shell and a center conductor and is or may be of conventional form, the outer shell being grounded to the plates 16 and 17 and the central conductor being insulated therefrom and connected to conductor 10, 11 or 12, respectively. The matching loads may be conventional carbon-film, tubular-type resistors, one end of each load being grounded to plate 17 and the other end being connected to conductor 11 or 12, respectively.

As a matter of convenience the coaxial line fittings 10a and 10b lead outwardly from the cavity space S at respectively opposite ends of the coupler whereas the coaxial line fittings 11a and 12a lead outwardly from the cavity space at respectively opposite sides of the coupler at positions near the opposite ends thereof. The matching loads 11b and 12b are disposed substantially between the plates 16 and 17.

The three coplanar serpentine conductors 10, 11 and 12 are insulated from each other as well as from the conductive ground plane members 16 and 17. This is readily accomplished by using printed circuit techniques to form the conductors 10, 11 and 12 on a single flat sheet of insulating material. Thin sheets 13 and 14 of a low-loss dielectric material such as Rexolite are interposed between the three serpentine conductors and the conductive plates 16 and 17. The insulative layers may be of the dielectric base material on which the serpentine conductors can be formed as conductive films or deposits, and thus said base together with a single additional sheet disposed on top of the serpentine conductors would provide the necessary insulation.

While the directional coupler can be constructed and used with only two of the serpentine conductors, namely 10 and 11 or 10 and 12, a distinct advantage of the coplanar construction is that incident and reflected power can be simultaneously monitored. That is, assuming some load to be connected to the connector 10b and a source of input signals connected to the connector 10a so that power fed into connector 10a flows out of connector 10b, the incident power (power traveling from 10a to 10b) can be sampled at the connector 11a and the power reflected by the load into connector 10b simultaneously sampled at the connector 12a. The load 12b acts to absorb any power in line 12 resulting from power applied to connector 10a, and load 11b acts to absorb any power in line 11 resulting from power entering connector 10b. The directional coupler shown in FIGURE 1 and including three serpentine conductors has an important advantage in that either of the terminals 10a or 10b can be used as the input for applied power and the other one of the two terminals 10a or 10b as the output, with both incident and reflected power sampling being available at the terminals 11a and 11b. That is, the terminal 11a provides a power sampling of power entering terminal 10a and terminal 12a provides a sampling of the power entering terminal 10b, regardless of whether such power entering the terminals 10a and 10b is applied power or power being reflected from a given load connected to the terminal. Since each of the three serpentine conductors are coplanar they are equidistant from the conductive plates 16 and 17 and hence have the same impedance. Thus in addition to simplified construction the coupler of FIGURE 1 having three serpentine conductors has major operational advantages over other devices in the art.

While the coupler can be used with various frequencies and can be made to be of various dimensions, one coupler corresponding in general to FIGURE 1 was only nine and one-half inches long, five inches wide, and one-half inch thick and operated successfully over a bandwidth of 40 to 80 megacycles per second with directivity in excess of minus 30 db and coupling variation of less than one and one-half db.

While the invention has been disclosed by reference to a preferred specific embodiment, it should be understood that the same was done only for purpose of teaching the invention and that those changes and modifications obvious to a person skilled in the art from the teachings hereof will be encompassed by the following claims.

What is claimed is:

1. A serpentine-line quarter-wavelength directional coupler comprising: first and second substantially parallel conductive members defining ground plane surfaces having an elongated cavity space therebetween of a length several times its thickness and of a width exceeding its thickness; three serpentine-line conductors each one quarter-wavelength long disposed in mutually coplanar, mutually insulated, and substantially parallel relationship between said surfaces, said conductors extending lengthwise in said cavity space and each having mutually co-pitched undulations; and energy transmission connector means coupled

to each end of one of said conductors and to one end of each of the other two conductors, whereby a portion of R-F energy applied to said one conductor will be coupled to each of said other two conductors and provide output information signals at the said connectors on the said one ends of said other two conductors.

2. The directional coupler defined in claim 3, and including first and second terminating load means respectively connected to an end of said two other conductors.

3. A directional coupler comprising in combination: ground plane conductor means defining an elongated transmission cavity; a first sinuously formed serpentine line conductor disposed in said cavity and defining a first plane therein; first and second transmission line connectors respectively connected to opposite ends of said first line conductor; second and third sinuously formed serpentine line conductors disposed in said cavity and coplanar with said first line conductor, said second and third line conductors being disposed on opposite sides of and adjacent to said first line conductor and each in parallel co-pitched relationship with said first line conductor; dielectric means insulating each of said conductors from the others and from said ground plane conductor means; a third transmission line connector connected to the end of said second line nearest to said first connector; a fourth transmission line connector connected to the end of said third line nearest to said second connector; first terminating load means connected to the end of said second line nearest to said second connector; and second terminating load means connected to the end of said third line nearest to said first connector, whereby a portion of the R-F energy applied to said first conductor will be coupled with said second and third conductors and both incident and reflected power can be sampled at said third and fourth connectors.

4. A coupler as defined in claim 5 wherein said ground plane conductor means includes first and second plates of conductive material defining second and third planes each parallel to said first plane and disposed equidistant from and on opposite sides of said first plane.

5. A broadband directional coupler comprising: first and second ground plane conductors defining a transmission space therebetween; first and second coplanar line conductors disposed in said transmission space and each substantially one-quarter wavelength long at the mid-frequency of the band, and each of said coplanar line conductors being of serpentine form of substantially equal pitch distance and disposed in parallel and co-pitch relationship; transmission line coupling means connected to said ground plane conductors and to each end of said first line conductor and to one end of said second line conductor; terminating load means connected to the other end of said second line conductor; a third serpentine line conductor coplanar with said first and second line conductors and disposed in parallel and co-pitch relationship therewith; transmission line coupling means connected to one end of said third line conductor; and second terminating load means connected to the other end of said third line conductor, whereby a part of radio frequency signals applied to said first conductor will be coupled to said second and third conductors for sampling at the said line coupling means connected to said second and third conductors.

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HERMAN KARL SAALBACH, *Primary Examiner.*
P. GENSLER, R. D. COHN, *Assistant Examiners.*