SINUOUSLY FOLDED QUARTER WAVE STRIPLINE DIRECTIONAL COUPLER

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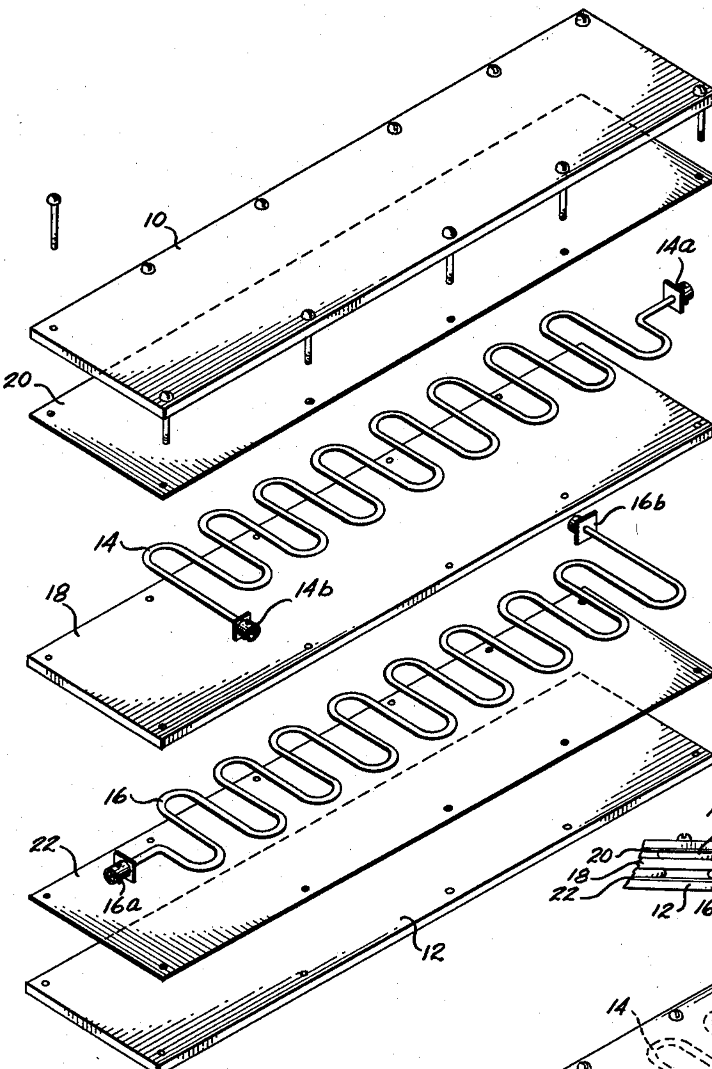
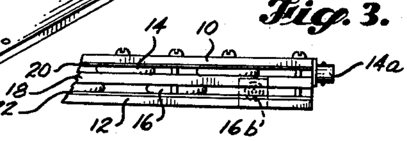


Fig. 1.

Fig. 3.



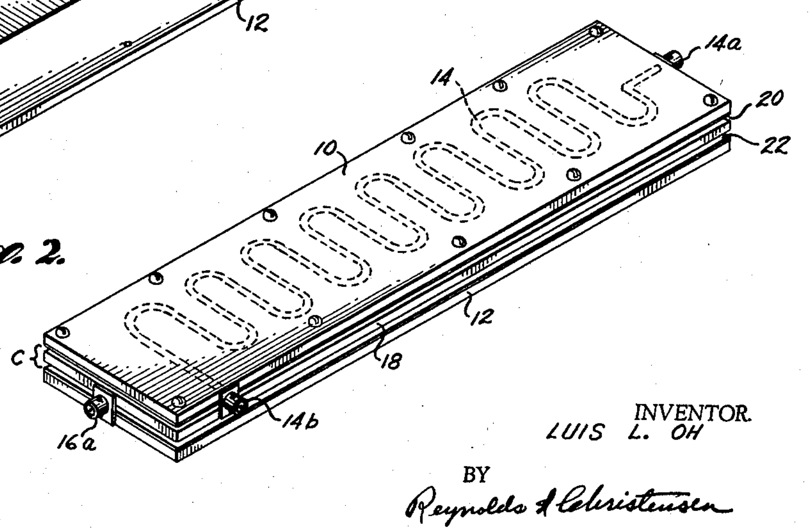


Fig. 2.

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This invention relates to an improved directional coupler for high-frequency electrical energy transmission systems and has for its general object to provide an efficient directional coupler which is many times shorter than conventional couplers operable at the same wavelength of applied energy. The invention is herein illustratively described by reference to the presently preferred embodiment thereof; however it will be recognized that certain modifications and changes therein with respect to details may be made without departing from the essential features involved.

In particular it is an object hereof to devise a directional coupler having an electrical length which is approximately a quarter wavelength at the center frequency of the operating band, yet is of practicable physical length even at frequencies well below 200 megacycles per second. For example, the improved coupler may be made as short as one-fourth or less the length of conventional directional couplers of the coaxial line or strip line type.

A further object is to achieve the described results in a device which is relatively simple to construct, which is relatively inexpensive and which avoids problems of critical spacing and dimensioning of components.

A further object is to achieve such a device having high efficiency in terms of high directivity, low reflectivity and low loss factor. Moreover, the achievement of relatively broad bandwidth though operating on the principle of a quarter wavelength device is a further objective. Still another object is to devise a directional coupler compatible with miniaturized electronic systems in the VHF and UHF range, so as to be suitable for use in satellites and other space vehicles.

Still another object is to achieve the foregoing results in a coupler which lends itself well to manufacture by etching and lamination processes currently used in the successful manufacture of precision components of small size.

Directional couplers have a wide variety of uses including measurement of incident and reflected power, isolation or decoupling of components and selective power attenuation in high-power systems. Furthermore, they may be used in the injection of unidirectional signals into transmission lines.

In accordance with this invention a folded-line directional coupler of the quarter wavelength type achieving the foregoing objectives comprises two serpentine conductors of equal pitch mounted in mutually superimposed, coincident relationship between parallel ground plane surfaces. Each such conductor mounted in insulatively spaced relationship from the other conductor and from the adjacent ground plane surface 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 or waveguide connectors are connected to both ends of each serpentine conductor at the edges of the cavity space defined between the ground plane surfaces. It is found in practice that such a coupler capable of operating efficiently between 35 and 90 megacycles per second may be as short as twelve inches whereas a conventional coupler operable at that frequency range would be of the order of 48 inches in length. Tests with devices embodying the invention revealed directional coupling variations less than one and one-half db over an octave frequency range, with directivity in excess of minus

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33 db. Furthermore, it was determined that the novel coupler can be constructed on any scale, simply by scaling up or scaling down longitudinal dimensions in order to produce equivalent results at virtually any operating frequency range. The width dimension may be the same for couplers of different length, except where length is changed to a major extent.

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

FIGURE 1 is an exploded simplified isometric view of principal components comprising the illustrative embodiment of the folded-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.

As illustrated the coupler comprises two conductive plates **10** and **12** of planar form which, in assembled relationship, define a cavity space C therebetween. Two elongated conductors **14** and **16** folded into a planar sinuous configuration are mounted in mutually superimposed relationshiup within the cavity space C. The undulations of each conductor occur at the same pitch distance and preferably have the same amplitude or transverse dimension. Mounted in the cavity space, the two serpentine conductors are disposed in congruent co-phased relationship, that is with the crests of one superimposed upon corresponding crests of the other. Each conductor when stretched out has a lineal length approximately one-quarter wavelength at the mid-frequency of the intended operating band of the coupler. Coaxial transmission line fittings or connectors **14*a*** and **14*b*** are connected respectively to opposite ends of the serpentine conductor **14**, and similar fittings **16*a*** and **16*b*** are connected to the respective ends of conductor **16**. Each coaxial line fitting comprises an outer shell and a central conductor and is or may be of conventional form, the outer shell being grounded to the plates **10** and **12** and the central conductor being connected to the rods **14** and **16**.

As a matter of convenience the coaxial line fittings **14*a*** and **16*a*** lead outwardly from the cavity space C at respectively opposite ends of the coupler whereas the coaxial line fittings **14*b*** and **16*b*** lead outwardly from the cavity space at respectively opposite sides of the coupler at positions near the opposite ends thereof.

For purposes of maintaining the two serpentine conductors **14** and **16** in insulatively spaced relationship from each other and from the conductive ground plane members **10** and **12** a low-loss styrafoam panel **18** is interposed between the serpentine conductors whereas thin Teflon sheets **20** and **22** are interposed between conductor **14** and plate **10** and between conductor **16** and plate **12**, respectively. These insulative layers may be of any suitable material and may in fact comprise plastic or other dielectric material bases upon certain of which the serpentine conductors are formed as a conductive film or deposit produced by an etching process or other suitable technique.

In operation, high-frequency energy fed into the coaxial line connector **16*a***, for example, flows through and out connector **16*b***, with a small portion of this incident energy being sampled by the line structure **14** and appearing in output connector **14*b***. Under these conditions practically no power appears in connector **14*a***. Likewise radio-frequency energy fed into connector **16*b*** flows through connector **16*a***, with a small portion of this energy appearing at connector **14*a*** and practically no energy appearing at connector **14*b***. In representative cases a coupler of the invention only seven inches long operated successfully over a bandwidth of 65 to 175 megacycles per second and one twelve inches long operated over a bandwidth from 35 to 90 megacycles per second. In each case the coupler was of the order of three inches wide and of the order of one inch or less thick. By employing laminating and etching processes size can be further reduced and performance further improved. In each case the directional coupling efficiency was of the order of —33 db and better, with coupling variations less than one and one-half db.

These and other aspects of the invention will be evident to those skilled in the art based upon the foregoing disclosure of the presently preferred embodiment, which is intended to illustrate and not delimit the novel subject matter.

I claim as my invention:

1. A broadband directional coupler comprising two transmission line conductors each substantially one-quarter wavelength long at the mid-frequency of the band, said conductors being of sinuously folded form of substantially equal pitch distance, a pair of ground plane conductors defining a transmission line space therebetween, means mounting said line conductors in mutually superimposed substantially co-phased relationship sandwiched between said ground plane conductors, said line conductors being insulatively spaced from each other and from the respectively adjacent ground plane conductors, and transmission line coupling means having co-operable elements connected to the ends of the respective transmission line conductors and to the ground plane conductors for conducting of energy to and from said transmission lines base.

2. The broadband coupler defined in claim 1, wherein the ground plane surfaces and the sinuously folded line conductors are of planar form.

3. The directional coupler defined in claim 1, including thin sheets of dielectric material interposed between the respective line conductors and the adjacent ground plane surfaces and a dielectric panel interposed between the line conductors.

4. A folded line quarter-wavelength directional coupler comprising means including two substantially parallel conductive ground plane surfaces forming an elongated cavity space of a length several times its thickness and of a width exceeding its thickness, two elongated quarter-wavelength conductors formed sinuously and disposed in mutually superimposed substantially parallel relationship between said surfaces, said conductors extending lengthwise in said cavity space and each having undulations substantially co-phased with those of the other, said conductors being insulatively spaced from each other and from said surfaces, and energy transmission connector means coupled to the respective ends of said conductors and extending outwardly from said cavity space.

5. The directional coupler defined in claim 4, wherein the first-mentioned means comprises two conductive plates and the energy transmission means comprises coaxial line connectors having outer shells grounded to the plates and center conductors connected to the respective ends of the quarter-wavelength conductors.

References Cited by the Examiner

UNITED STATES PATENTS

2,749,519	6/56	Kostriza et al.	333—10
2,892,163	6/59	Todd	333—84
3,012,210	12/61	Nigg	333—10

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