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M. ARDITI

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DIRECTIONAL COUPLINGS

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2 Sheets-Sheet 1

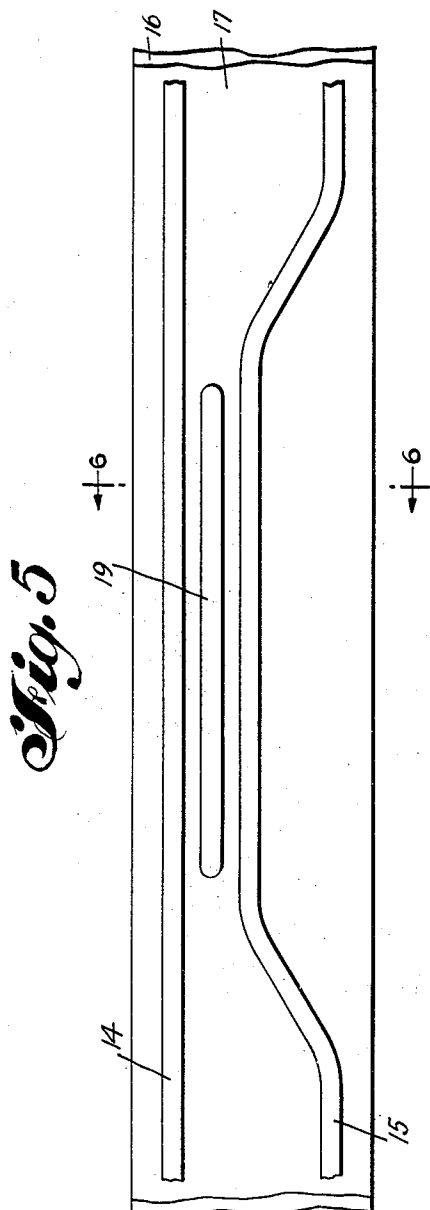


*Fig. 7*

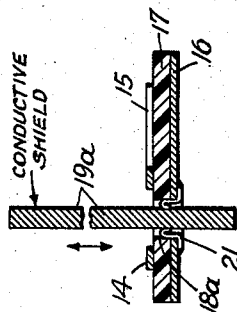
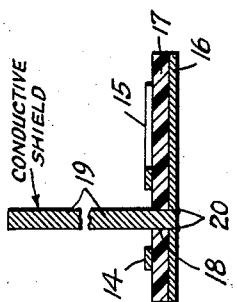


*Fig. 6*



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## DIRECTIONAL COUPLINGS

2 Sheets-Sheet 2



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## DIRECTIONAL COUPLINGS

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13 Claims. (Cl. 333—10)

This invention relates to radio frequency circuits and more particularly to radio frequency directional and hybrid couplers, this application being a continuation in part of application Serial No. 344,748, filed March 26, 1953, now Patent No. 2,868,966.

Microwave receiving apparatus heretofore proposed have required, particularly for the high frequency section thereof, expensive and bulky components including waveguides, special frequency couplers, and other structural elements commonly referred to as "microwave plumbing." As technical development has progressed in the use of microwave radio apparatus, such as in short wave radio receivers, radar, direction finding devices, and radio aerial navigation devices, the demand has grown for larger quantities of such apparatus and particularly for less expensive, smaller, and lighter weight microwave equipment.

In the U.S. Patent No. 2,774,046 of M. Arditi and P. Parzen, a line-above-ground type of microwave transmission line is disclosed comprising, in one of its simplest forms, two conductors printed or otherwise disposed in substantially parallel relation on opposite sides of a strip of dielectric material a small fraction of a quarter wavelength thick. It is one of the objects of the present invention to provide a radio frequency directional coupler employing the line-above-ground type of transmission line in the construction thereof whereby the degree of coupling between two circuits is accurately controlled without requiring cumbersome and expensive plumbing structure.

Another object of this invention is to provide a relatively simple radio frequency coupler of the hybrid junction type.

As hereinbefore suggested, one of the features of this invention is the use of an open line-above-ground type of transmission line which may be made by printed circuit technique utilizing a planar conductor in conjunction with a layer of dielectric material on which is printed or otherwise formed line conductors to provide with the planar conductor radio frequency transmission paths. By arranging the line conductors as hereinafter described, directional coupling arrangements and hybrid junctions may be provided for the guidance and transmission of radio frequency signals. The relationship of the line conductors to and from a coupling section may be selected so as to control the degree of coupling as well as to minimize radiation losses.

The above-mentioned and other features and objects of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a view in plan of a directional coupler in accordance with the principles of this invention;

Fig. 2 is a cross-sectional view taken along line 2—2 of Fig. 1;

Fig. 3 is a view in plan of another embodiment of coupler construction in accordance with the principles of this invention;

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Fig. 4 is a cross-sectional view taken along line 4—4 of Fig. 3;

Fig. 5 is a view in plan of another embodiment of this invention;

Fig. 6 is a cross-sectional view taken along line 6—6 of Fig. 5; and

Fig. 7 is a modification of Fig. 6 showing a variation of the embodiment of Fig. 5.

Referring to Figs. 1 and 2 the directional coupler shown comprises line conductors 1 and 2 and a base or ground conductor 3 with a layer of dielectric material 4 spacing the line conductors in close substantially parallel relation to the planar surface of the ground conductor. The conductive material of lines 1 and 2 and the planar conductor 3 may be applied and/or etched or shaped on a layer of dielectric material, such as polystyrene, polyethylene, quartz, Teflon, fiberglass or laminated fiberglass impregnated with Teflon or other suitable material of high dielectric quality, in accordance with known printed circuit techniques. The spacing of the line conductors with respect to the ground conductor is preferably selected a small fraction of a quarter wavelength of the radio frequency waves propagated therealong, a suitable fraction being in the order of one-tenth to one-fifth of a quarter wavelength.

Line conductor 2 is positioned into coupled relation with line conductor 1 by means of angularly disposed leads 5 and 6.

A third line conductor 7 is provided in parallel spaced relation between the first and second line conductors 1 and 2. The purpose of the third line is to vary the amount of coupling between the lines 1 and 2. The relative length of the three-line parallel section was found to be critical while the distance between the three parallel lines when varied produced a variable in the coupling and directivity of the embodiment. For example, a 30 db variation was obtained with over 1/8 inch variation in the length of the third line. The amount of decoupling provided by the line 7 may be changed by subdividing the line into segments as indicated at 8. Another method of determining the coupling is to provide conductive posts connected to the planar conductor at spaced intervals between the two lines 1 and 2.

In Figs 3 and 4 still another embodiment is shown wherein the degree of coupling is controlled between line conductors 9 and 10 by means of a slot 11 formed in the planar conductor, and if desired, also through the dielectric layer 12 in parallel relation in between the line conductors 9 and 10. In one example where the spacing between line conductors 9 and 10 was equal to 18 millimeters, a slot 6 millimeters wide was cut through the planar conductor and the dielectric layer. The coupling was reduced to 24 db and the directivity to 21 db as compared to a 17 db coupling and a 28 db directivity prior to the cutting of the slot. By painting the inside edges of the slot 11 with silver paint or other conductive material 13, the coupling was reduced still further to 28 db. In the place of such coating a conductive plate inserted in the slot and extending upwardly between the line conductors obtained still further reduction in the coupling.

With reference to Figs. 5 and 6 there are shown line conductors 14 and 15, planar conductor 16, dielectric 17 and an elongated slot 18 extending lengthwise through planar conductor 16 and dielectric 17 parallel to the conductors 14 and 15. A conductive shield 19 either solid or screen is disposed in said slot and extends upwardly beyond the upper surface of the dielectric 17. The lower surface of the shield 19 is soldered or otherwise fastened to the planar conductor 16 as shown at 20. The shield 19 provides a barrier to the interaction of the fields of the line conductors 14 and 15 and so minimizes

the coupling therebetween. Fig. 7 shows a variation of Fig. 6 wherein the shield 19a is made adjustable. Spring contacts 21 are fastened to the planar conductor 16 and extend into the slot 18a. The shield 19a is securely positioned within the slot 18a by the pressure of the spring contacts 21 against the opposed surfaces of the shield 19a. The positive contact of these springs against the shield 19a insures a good electrical connection of the shield 19a to the planar conductor 16. The shield 19a can be adjustably moved to any desired position vertically of the dielectric 17 until a desired condition of decoupling between the line conductors 14 and 15 is achieved.

From the foregoing it will be clear that radio frequency sections of microwave and UHF receivers may be constructed with a simple form of line-above-ground circuitry thereby avoiding the complicated and expensive waveguide plumbing heretofore believed necessary. The coupling arrangement of Fig. 1 illustrates a coupling between a local oscillator 22 and line conductor 1. The lead 23 from the local oscillator 22 may comprise a coaxial line or other suitable coaxial coupling connected between the oscillator 22 and the line conductor 2. The lead 2 is coupled through the angular portion 6 to a parallel section 24 for directive coupling of oscillator energy to conductor 1 which connects directly with a utilization means (not shown) such as a mixer. The conductor 1 is suitably terminated with an attenuator pad 25. The output lead 5 of the conductor 2 may likewise be loaded with an attenuator pad 26.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A directional coupler comprising a planar conductor, first and second line conductors, a layer of dielectric material supporting said line conductors in dielectrically spaced, substantially parallel overlying relation with respect to the plane of said planar conductor whereby each line conductor provides in conjunction with said planar conductor a radio frequency transmission path, at least one of said line conductors and said planar conductor having a source of radio frequency coupled thereto for transmission therealong, said line conductors being disposed throughout a given section in close parallel spaced relation to each other so that each line conductor lies within frequency coupling relation of the electromagnetic field of the transmission path of the other, and decoupling means altering the fields of said paths between said first and second line conductors within said section to limit the amount of coupling between said first and second line conductors, said layer of dielectric material supporting said decoupling means with at least a portion thereof in the plane of said first and second line conductors.

2. A directional coupler according to claim 1, wherein said decoupling means comprise a third conductor disposed between said first and second conductors in parallel relation thereto and to said planar conductor.

3. A directional coupler according to claim 2, wherein said third conductor comprises a series of spaced conductor segments.

4. A directional coupler according to claim 1, wherein said decoupling means includes an elongated slot in said planar conductor parallel to said first and second conductors within the region between said first and second conductors.

5. A directional coupler according to claim 4, wherein said line conductor supporting means comprises a layer of dielectric material and said slot extends through said layer with the side edges of the dielectric defining said slot coated with conductive material.

6. A directional coupler comprising a planar conductor,

first and second line conductors, a layer of solid dielectric material supporting said line conductors in dielectrically spaced, substantially parallel overlying relation with respect to the plane of said planar conductor whereby each line conductor provides in conjunction with said planar conductor a radio frequency transmission path, at least one of said line conductors and said planar conductor having a source of radio frequency coupled thereto for transmission therealong, said line conductors being disposed throughout a given section in close parallel spaced relation to each other so that each line conductor lies within frequency coupling relation of the electromagnetic field of the transmission path of the other, and a third conductor carried by said dielectric layer between said first and second conductors in parallel relation thereto.

7. A directional coupler according to claim 6, wherein said third conductor comprises a series of spaced conductor segments.

8. A directional coupler comprising a planar conductor, first and second line conductors, a layer of solid dielectric material supporting said line conductors in dielectrically spaced, substantially parallel overlying relation with respect to the plane of said planar conductor whereby each line conductor provides in conjunction with said planar conductor a radio frequency transmission path, at least one of said line conductors and said planar conductor having a source of radio frequency coupled thereto for transmission therealong, said line conductors being disposed throughout a given section in close parallel spaced relation to each other so that each line conductor lies within frequency coupling relation of the electromagnetic field of the transmission path of the other and said planar conductor having an elongated slot therein disposed parallel to said first and second conductors within the region between said first and second conductors.

9. A directional coupler according to claim 8, wherein said layer of dielectric material includes a slot in alignment with the slot in said planar conductor and conductive means disposed within the aligned slots.

10. A directional coupler according to claim 8, wherein said layer of dielectric material includes a slot of alignment with the slot in said planar conductor and a conductive shield is disposed in said aligned slots connected to said planar conductor and extended upwardly beyond the upper surface of said layer of dielectric material.

11. A directional coupler according to claim 8 wherein said layer of dielectric material includes a slot in alignment with the slot in said planar conductor and a plate-like shield disposed in said aligned slots, and conductive means coupled to said planar conductor resiliently engaging said shield, whereby said shield may be adjusted relative to the plane of said line conductors.

12. A directional coupler comprising a planar conductor, first and second line conductors, means supporting said line conductors in dielectrically spaced, substantially parallel overlying relation with respect to the plane of said planar conductor whereby each line conductor provides in conjunction with said planar conductor a radio frequency transmission path, at least one of said line conductors and said planar conductor having a source of radio frequency coupled thereto for transmission therealong, said line conductors being disposed throughout a given section in close parallel spaced relation to each other so that each line conductor lies within frequency coupling relation of the electromagnetic field of the transmission path of the other, and decoupling means altering the fields of said paths between said first and second line conductors within said section to limit the amount of coupling between said first and second line conductors, said decoupling means comprising a conductive shield disposed within said given section in spaced relation between said first and second conductors and in coupled relation with respect to said planar conductor.

13. A directional coupler according to claim 12, where-

in said planar conductor has a slot therein and conductive means resiliently engaging said shield in adjusted position in said slot, whereby said shield may be adjusted relative to the plane of said line conductors to vary the coupling between said transmission paths thereof.

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