Aug. 31, 1965 R. C. HARMON 3,204,206

HIGH DIRECTIVITY TEM MODE COUPLER

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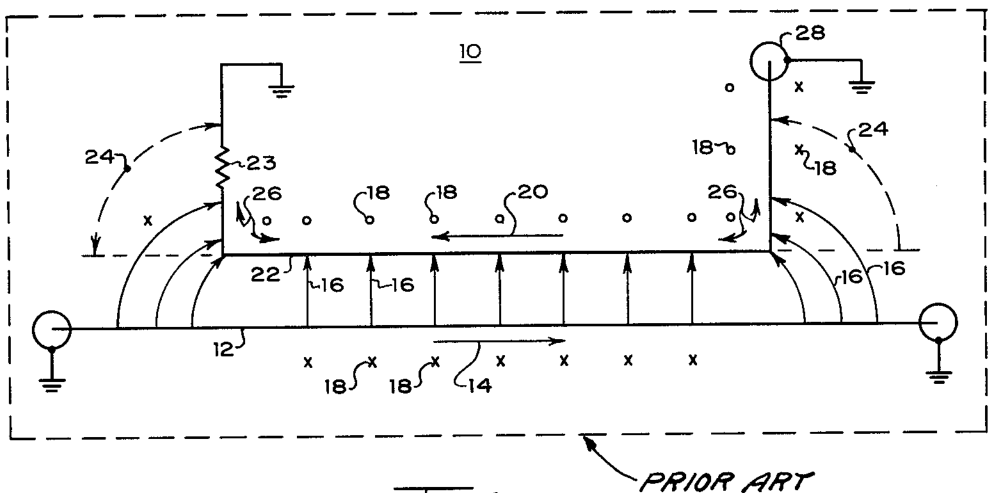

Fig. 1

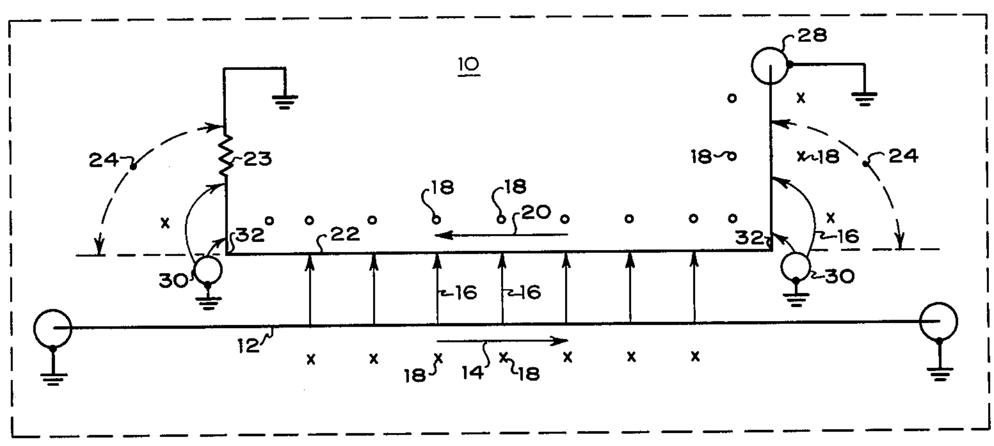

Fig. 2

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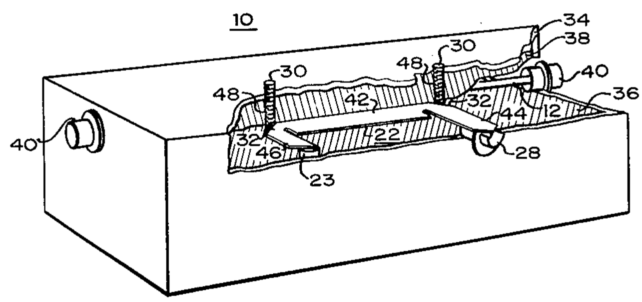

Fig. 3

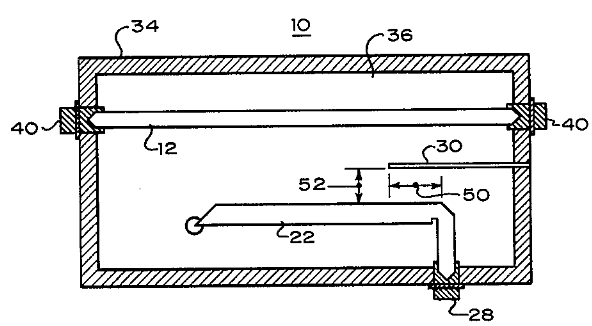

Fig. 4

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HIGH DIRECTIVITY TEM MODE COUPLER

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This invention relates to high directivity TEM mode couplers. TEM mode couplers are devices in which the combined effects of electric and magnetic fields couple power from a primary transmission line to an adjacent auxiliary transmission line in a directional manner.

Ideally all the power coupled to the auxiliary transmission line of a TEM mode coupler should flow in a reverse direction from the power flowing along the primary transmission line. Practically, however, some of the auxiliary line power flows in the same direction as the primary line power. The ratio of the auxiliary line power flowing in the reverse direction to that flowing in the same direction as the primary line power is the directivity of a TEM mode coupler. Since it is desirable to focus available power from a source in such a way that its primary flow is directed towards a specific receiving point, the directivity, of a coupler becomes important. For example, the use of couplers for such measurements as the magnitude of small reflections requires high directivity.

In the past the use of TEM mode directional couplers has been limited by a lack of high directivity over a broad frequency range. This lack of directivity is influenced in part by reflections from the termination or load normally located at one end of the auxiliary line. A second source of unwanted reflections is the output connector of the primary line. Attempts have been made to reduce the voltage standing wave ratio (VSWR) at these points and thereby diminish reflections and improve directivity. This reduction in VSWR has generally been accomplished by the insertion of tuning screws over the auxiliary line at the load and over the primary line at the connector. The result is to provide coaxial couplers of the one to two kilomegacycle (1–2 gc.) range, for example, with directivities around 30 db. Such directivities are still lower than desirable for some applications.

It is the general object of this invention to provide a TEM mode coupler with high directivity over a broad frequency range.

In accordance with the illustrated embodiment of this invention, a TEM mode coupler is provided wherein a conductive element is positioned in close proximity to one transmission line at a place where it diverges from another transmission line.

Other and incidental objects of this invention will be apparent from a reading of this specification and an inspection of the accompanying drawing in which:

FIGURE 1 is a schematic view of a TEM mode coupler illustrating the associated electric and magnetic fields and the power flow along the auxiliary line for a given direction of power flow along the primary line;

FIGURE 2 is a schematic view of a high directivity TEM mode coupler according to this invention;

FIGURE 3 is a cutaway view of the high directivity TEM mode coupler represented schematically in FIGURE 2; and

FIGURE 4 is a top view in section of a TEM mode coupler including a shim as a conductive element.

Referring to FIGURE 1, there is shown schematically a TEM mode coupler 10 with a primary line 12 having power 14 flowing therealong. The combined effects of the electric field 16 and the magnetic field 18 couple power 20 from the primary line 12 to the auxiliary line 22. Ideally all the coupled auxiliary line power 20

should flow in a reverse direction from the primary line power 14 and be absorbed at the load 23 since the electric field and the magnetic field couplings 16 and 18 cancel each other in the direction of primary line power flow 14. However, where the auxiliary line 22 diverges from the primary line 12 the magnetic field coupling 18 is decreased by the cosine of the angle 24, though the electric field coupling 16 remains substantially the same. The effect is that some power 26 is coupled non-directionally by the electric field 16 at these points of divergence into the auxiliary line 22. Half of this power 26 flows contra-directionally with reference to the desired auxiliary line power 20 and appears at the auxiliary line output connector 28 thereby reducing the directivity of the TEM mode coupler.

In accordance with this invention, as illustrated schematically in FIGURE 2, conductive elements 30 are positioned near the corners 32 formed by the divergence of the auxiliary line 22 from the primary line 12. Care is also taken to position the conductive elements 30 in close proximity to the auxiliary line 22 as compared to the primary line 12. The effect of such placement of the conductive elements 30 is to ground the electric field 16 at the corners 32. This prevents the electric field 16 from coupling between the two lines 22 and 12 at the corners 32 and producing the non-directional power 26 of FIGURE 1. Thus, this invention results in substantially increased directivities for TEM mode couplers over a broad frequency range. For example, a coaxial coupler of the 1 to 2 gc. range which normally has a directivity of around 30 db may achieve a directivity of around 40 db by the practice of this invention.

Referring to FIGURE 3, a portion of the high directivity TEM mode coupler 10 illustrated schematically in FIGURE 2 is shown cut away to reveal its construction. A metallic case forms an outer conductor 34, usually at ground potential. The primary and auxiliary strip transmission lines 12 and 22 are positioned within the outer conductor 34 by suitable means, for example, by mounting them on a dielectric slab 36 with adhering cement. A second dielectric slab 38 is disposed on the other side of the transmission lines 12 and 22 occupying the space between them and the inner surface of the outer conductor 34. Each end of the primary transmission line 12, which extends longitudinally across the dielectric slab 36, is connected to the inner conductor of a coaxial connector 40. A first portion 42 of the auxiliary transmission line 22 is placed adjacent and parallel to the primary transmission line 12 and in coupling relationship therewith. The auxiliary transmission line 22 has a second portion 44 which leads to the side of the TEM mode coupler 10 and connects to the inner conductor of a coaxial connector 28.

A load 23 has one end connected to a third portion 46 of the auxiliary transmission line 22. Its other end is connected to the outer conductor 34. The load 23 is chosen such that it will absorb all of the incident power. It may be, for example, a resistor of appropriate value.

The conductive elements or screws 30 are tunably or adjustably supported by the outer conductor 34 thereby providing means for maximizing the directivity. A part 48 of each of the tunable screws 30 protrudes within the outer conductor 34 and is positioned in close proximity to the auxiliary transmission line 22 as compared to the primary transmission line 12. The protruding part of each of the tunable screws 30 is positioned directly adjacent the corners 32 formed by the divergence of the auxiliary transmission line 22 from the primary transmission line 12. It is essential that the tunable screws 30 be electrically insulated from both transmission lines 12 and 22. However, the gap between the tunable screws 30 and the auxiliary transmission line 22 should not exceed one half the distance between the adjacent parallel portions of the primary line **12** and the auxiliary line **22**. For most effective results the gap should not exceed one twentieth of the distance between the two parallel lines **12** and **22**. The effect of such placement of the tunable screws **30** is to provide a TEM mode coupler with substantially increased directivity.

The conductive element **30** may take any suitable form. For example, it has been found effective in some cases to use a metallic shim. Referring to FIGURE 4, the shim **30** extends between and parallel to the longitudinal axes of the primary and auxiliary transmission lines **12** and **22**. The shim **30** is positioned normal to a plane containing the longitudinal axes of the transmission lines **12** and **22**. It is supported by opposite portions of the outer conductor **34**. Longitudinal penetration of the shim past the point of divergence of the auxiliary line **22** should not exceed the distance **50** which is substantially equal to twice the width of either of the transmission lines **12** or **22**. The distance **52** between the shim **30** and the auxiliary transmission line **22** is less critical than in the case of a tunable screw. However, for most effective results the distance **52** should not exceed one half the distance between the adjacent parallel portions of the primary line **12** and the auxiliary line **22**.

This invention is not limited to TEM mode couplers of the configuration illustrated in FIGURES 1, 2, 3 and 4, but may advantageously include any TEM mode coupler having one line which diverges from another. However, the results obtainable vary under different conditions. For example, most effective results are obtained in TEM mode couplers where the ratio of the length of the diverging line to its width is small.

I claim:

1. A TEM mode coupler for coupling energy over a broad frequency range with high directivity comprising:
- an outer conductor,
- a first transmission line,
- a second transmission line having a portion adjacent said first transmission line and in coupling relationship therewith,
- a conductive element serving to increase the directivity of said coupler,
- said conductive element being electrically insulated from both of said transmission lines and being positioned within said outer conductor and near said second transmission line where it diverges from said first transmission line.

2. A TEM mode coupler as in claim **1** wherein said conductive element is electrically insulated from said second transmission line by a gap which does not exceed one half of the distance between the adjacent and parallel portions of said transmission lines.

3. A TEM mode coupler for coupling energy over a broad frequency range with high directivity comprising:
- an outer conductor,
- a first transmission line,
- a second transmission line having a portion adjacent and parallel to said first transmission line and in coupling relationship therewith,
- said transmission lines being positioned within said outer conductor,
- a terminating load connected to one end of said second transmission line and serving to absorb energy coupled thereto,
- said terminating load being positioned within said outer conductor,
- a conductive element serving to increase the directivity of said coupler,
- said conductive element being supported by said outer conductor,
- said conductive element being electrically insulated from both of said transmission lines and being positioned within said outer conductor and in close proximity to said second transmission line where it diverges from said first transmission line,

- said conductive element being electrically insulated from said second transmission line by a gap which does not exceed one half of the distance between the adjacent and parallel portions of said transmission lines.

4. A TEM mode coupler for coupling energy over a broad frequency range with high directivity comprising:
- an outer conductor,
- a primary transmission line,
- an auxiliary transmission line having a portion adjacent said primary transmission line and in coupling relationship therewith,
- said transmission lines being positioned within said outer conductor,
- a conductive element serving to increase the directivity of said coupler,
- said conductive element being tunably supported by said outer conductor and having one end protruding within said outer conductor,
- said conductive element being electrically insulated from both of said transmission lines with said one end being positioned in close proximity to said auxiliary transmission line relative to said primary transmission line where said auxiliary transmission line diverges from said primary transmission line.

5. A TEM mode coupler as in claim **4** wherein said conductive element is electrically insulated from said auxiliary transmission line by a gap which does not exceed one twentieth of the distance between the adjacent portions of said transmission lines.

6. A TEM mode coupler as in claim **5** wherein said coupler includes a terminating load connected to one end of said auxiliary transmission line and serving to absorb energy coupled thereto,
- said terminating load being positioned within said outer conductor.

7. A TEM mode coupler for coupling energy over a broad frequency range with high directivity comprising:
- an outer conductor,
- a primary transmission line,
- an auxiliary transmission line having a portion adjacent said first transmission line and in coupling relationship therewith,
- said transmission lines being positioned within said outer conductor,
- a conductive shim serving to increase the directivity of said coupler,
- said conductive shim being supported by said outer conductor,
- said conductive shim being electrically insulated from both of said transmission lines and being positioned within said outer conductor and near said auxiliary transmission line where it diverges from said primary transmission line.

8. A TEM mode coupler as in claim **7** wherein the distance between said conductive shim and said auxiliary transmission line does not exceed half the distance between adjacent portions of said transmission lines.

9. A TEM mode coupler as in claim **8** wherein the longitudinal penetration of the shim past the point of divergence of the auxiliary line does not exceed substantially twice the width of one of said transmission lines.

10. A TEM mode coupler as in claim **9** wherein said coupler includes a terminating load connected to one end of said auxiliary transmission line and serving to absorb energy coupled thereto,
- said terminating load being positioned within said outer conductor.

11. A TEM mode coupler for coupling energy over a broad frequency range with high directivity comprising:
- an outer conductor,
- a first transmission line positioned within said outer conductor,
- a second transmission line positioned within said outer conductor adjacent to said first transmission line and

in electric and magnetic field coupling relationship therewith,

said second transmission line having a portion which diverges from said first transmission line, and

means included within said outer conductor for altering one of the electric and magnetic fields coupling between the diverging portions of said first and second transmission lines to increase the directivity of said coupler.

12. A TEM mode coupler for coupling energy over a broad frequency range with high directivity comprising:

a first electromagnetic wave energy transmission line dielectrically spaced within an outer conductor,

a second electromagnetic wave energy transmission line dielectrically spaced within said outer conductor,

said first and second transmission lines being positioned in the same plane in transverse electric and magnetic field coupling proximity with a finite dielectric spacing between the adjacent edges of said transmission lines,

said second transmission line including a portion which diverges from said first transmission line, and

means for increasing the directivity of said TEM mode coupler,

said means being disposed within said outer conductor in the coupling region between the diverging portions of said first and second transmission lines for one of decreasing the electric field coupling and increasing the magnetic field coupling between the diverging portions of said first and second transmission lines.

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