Aug. 25, 1959 S. R. FITZMORRIS 2,901,709

WAVE COUPLING ARRANGEMENT

Filed Dec. 14, 1954 2 Sheets-Sheet 1

FIG. 1.

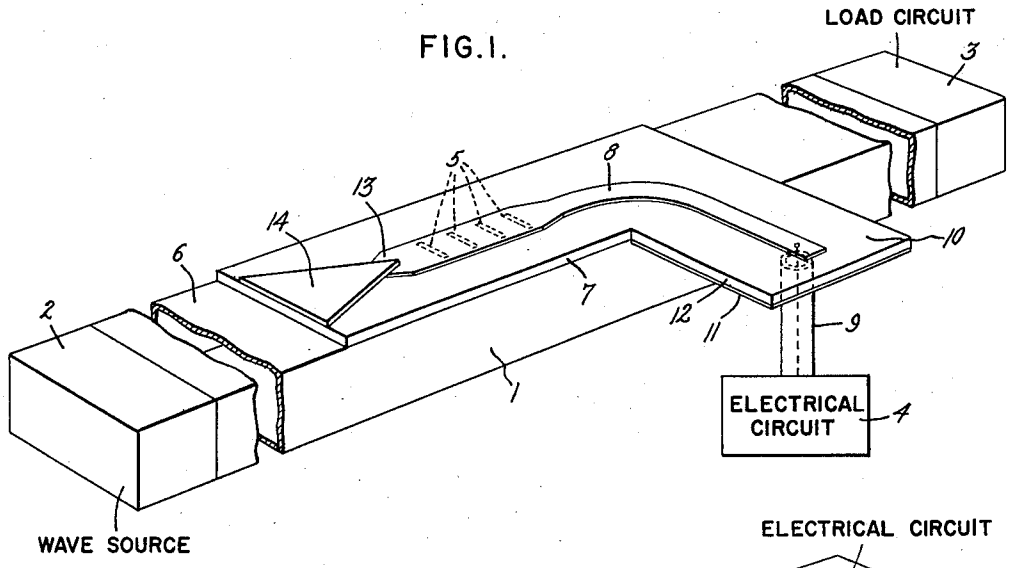
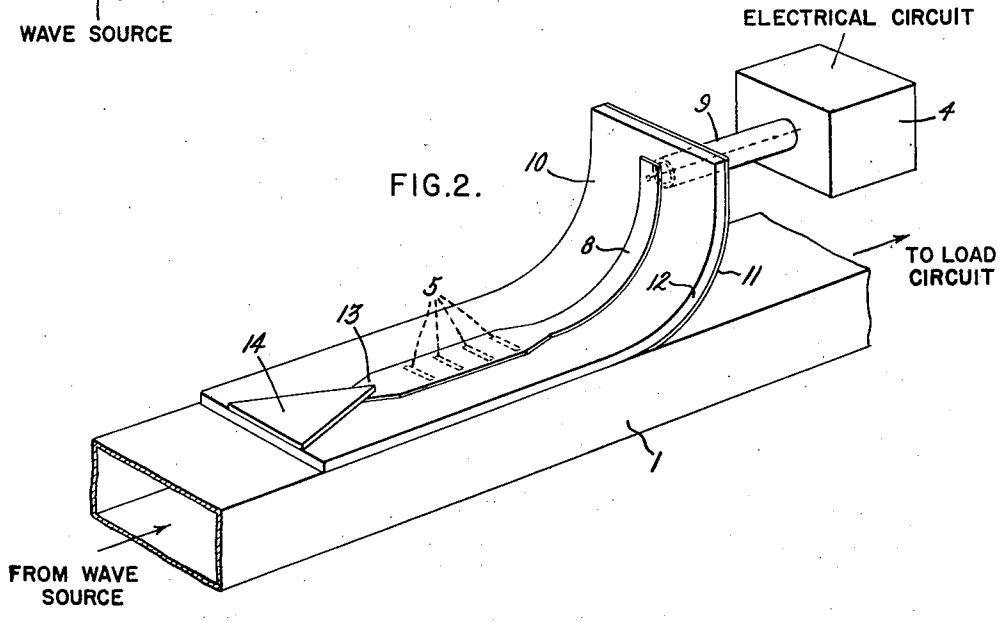


FIG. 2.



INVENTOR:
STANLEY R. FITZMORRIS,
BY Michael Masnik
HIS AGENT.

Aug. 25, 1959 S. R. FITZMORRIS 2,901,709

WAVE COUPLING ARRANGEMENT

Filed Dec. 14, 1954 2 Sheets-Sheet 2

FIG.3.

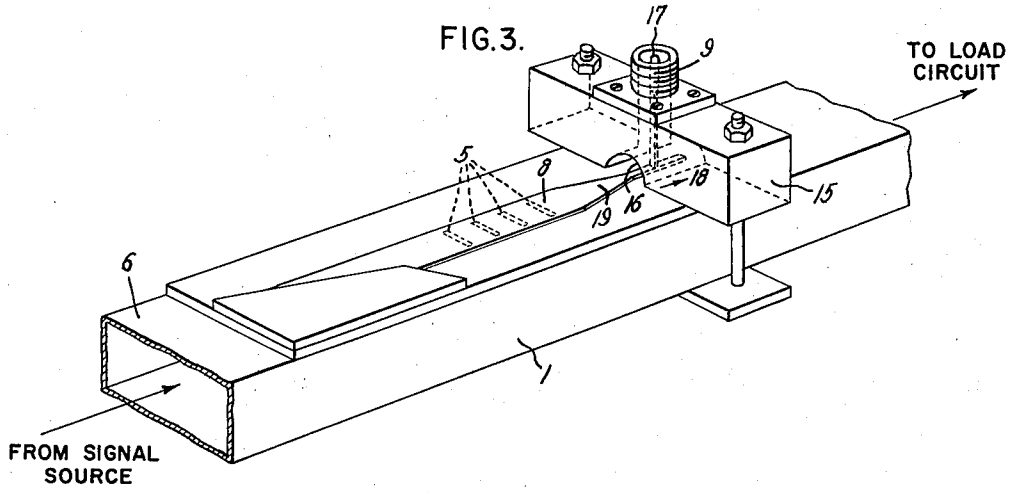


FIG.4.

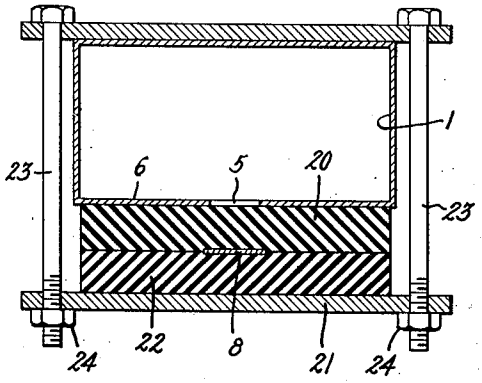
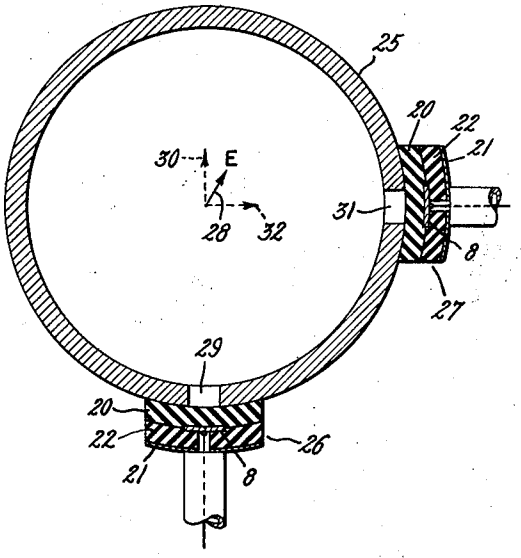


FIG.5.



INVENTOR:
STANLEY R. FITZMORRIS,
BY Michael Masnik
HIS AGENT.

United States Patent Office 2,901,709
Patented Aug. 25, 1959

2,901,709

WAVE COUPLING ARRANGEMENT

Stanley R. Fitzmorris, Baldwinsville, N.Y., assignor to General Electric Company, a corporation of New York

Application December 14, 1954, Serial No. 475,215

4 Claims. (Cl. 333—10)

This invention relates to wave coupling systems and particularly to arrangements for coupling waves between electrical circuits.

Often times the need arises for coupling electrical waves between two circuits for purposes of comparison, measurement, control, etc. For example, in certain applications it is sometimes desired to withdraw a small amount of radio frequency power from a waveguide for measurement. Heretofore, the arrangements utilized for these purposes have been found to be relatively bulky and expensive, difficult to construct, or have exhibited certain operational limitations.

Accordingly, it is an object of this invention to provide a novel arrangement for coupling electro-magnetic waves between two circuits,

Another object of this invention is to provide an improved wave coupling arrangement.

Another object of this invention is to provide a novel directional coupler for use with electro-magnetic waves.

Another object of this invention is to provide an improved circuit arrangement adapted for measurement of wave characteristics.

Another object of this invention is to provide an improved directional coupler for purposes of power measurement.

Another object of this invention is to provide a desired signal processing arrangement.

Still another object of this invention is to provide an improved arrangement for coupling waves between a wave guide and a strip transmission line.

The features of this invention which are believed to be novel are set forth with particularity in the appended claims. The invention and methods of operation, together with further objects and advantages thereof, may best be understood by reference to the following description when taken in connection with the accompanying drawing wherein:

Fig. 1 illustrates in schematic form an arrangement embodying the principles of the invention.

Figs. 2 and 3 illustrate in schematic form further modifications of the present invention.

Fig. 4 illustrates in schematic form a novel "sandwich" type construction embodying the principles of the invention, and

Fig. 5 illustrates schematically, the application of the invention to circular type wave guide transmission lines.

One application of my invention is with a wave coupler for sampling a desired portion of the energy being propagated in a main waveguide and coupling it by means of an auxiliary transmission line to an electrical circuit. The auxiliary transmission line employs strip construction and impedance matching elements in a form adapted to receive energy from a coupler circuit which comprises apertures or slots in a wall of the main waveguide.

Reference is now made to Fig. 1 showing the use of a strip transmission line with a rectangular waveguide for coupling small amounts of energy between the rectangular waveguide and another circuit. For purposes of discussion, the rectangular, or main transmission wave guide 1 is employed to transmit or propagate radio frequency energy from a circuit 2, such as a wave source or transmitter, to a load circuit 3, such as an antenna. It is desired to extract a known amount of the power being propagated through waveguide 1 for application to another circuit 4, which might be used for frequency or power measurements, etc. To permit a desired portion of the radio frequency waves traveling from circuit 2 to circuit 3 to be coupled to the circuit 4, while preventing undesired waves from reaching 4, such as those reflected from circuit 3 back into the main guide 1, wave coupling slots 5 are provided in the wide wall 6 of guide 1. The number, dimensioning and spacing of the slots are selected to insure the desired coupling and directivity. An auxiliary wave transmission line, employing strip construction, provides the necessary coupling to the circuit 4. This strip line 7 comprises a strip of electrically conductive material 8 which extends along a portion of the main guide 1, and is spaced from the major wall 6 thereof by dielectric material such as Teflon fibre glass laminate. To minimize undesirable radiation by the slots 5, the slots are selected to appear under the strip conductor 8 as shown. To minimize radiation from the strip transmission line to outer space, it is general practice to limit the width of the strip conductor 8 to approximately one third of the width of the ground plane, that is, the wall 6 of the main waveguide 1.

In the particular embodiment of Fig. 1, the circuit 4 is coupled to the strip transmission line by a coaxial transmission line 9. To achieve the desired coupling and impedance match while providing a desired right angle coupling junction, the strip line 7 is provided with an extension 10 oriented at the desired angle with respect to the main guide alignment. The extension 10 comprises a ground plane in the form of an electrically conductive plate 11. Alternatively 11 may comprise an extension of the waveguide wall 6, a conductive metal plate welded to the guide 1 or a conductive coating applied to the lower portion of the dielectric material 12 contained in the extension 10. The strip conductor 8 is carried over into the extension with appropriate curvature to minimize any impedance mismatch. Coupling between extension 10 and line 9 is by means of a coaxial transition connection provided in the form of an opening contained in the conductive material portion 11 and the dielectric slab portion 12 as shown.

It is well-known that radiating slots in the common wall joining two transmission lines operate to couple radio frequency energy between the two transmission lines and that by proper spacing, shaping and orientation of the slots the coupled radio frequency energy may be made to flow in a particular direction with respect to the original direction of energy flow. In the embodiment shown the slots are arranged to permit radio frequency energy received from circuit 2 to be coupled principally in one direction, along the strip line 7 to the circuit 4, and to couple energy received from the circuit 3 along the strip line 7 towards its end 13. When it is desired that energy from 3 be absorbed, an appropriate radio frequency power absorption circuit 14 may be provided at the end 13. In the particular embodiment shown, the absorption medium consisted of a layer or sheet of resistive material lying in sufficient proximity to the end of strip conductor 8 to absorb the required amount of undesired power. The distance between slots in a configuration where the coupling is the same for each slot could thus be expressed by the formula

$$d=\frac{\lambda_g\lambda_s}{\lambda_g+\lambda_s}\left(\frac{2n-1}{2}\right)$$

where λ_s is the strip line wave length, λ_g is the waveguide wave length, and n is equal to the number of pairs of slots, d being the distance between slots. It will be obvious that this formula is only descriptive of one possible embodiment and this invention should not be considered as being limited thereto.

If desired, the power absorption arrangement **14** may be replaced with an extension similar to **10** and be coupled by an appropriate coupling section, such as the coaxial transmission line **9**, to a control circuit for processing the undesired waves, or the waves received from the circuit **3**, in a manner similar to that described with respect to elements **4** and **9** through **12**. For example, in a possible radar application, the transmitted waves are desired to be compared to the waves reflected internally within the coupling system between the transmitter and an antenna load circuit to determine the standing wave ratio of the particular wave coupling arrangement and load circuit. This latter scheme will readily accommodate this purpose.

Fig. 2 illustrates a further embodiment of the invention wherein a right angle coupling to the circuit **4** is provided by gradually bending the extension **10**, as shown, such as to permit the desired coupling to the coaxial line **9**. The conductive ground plane **11** for the slab extension **10** may preferably comprise a metallic conductive coating deposited thereon.

Referring to the further embodiment of Fig. 3, a transition element for the coaxial line **9** is provided in the form of a block of conductive material **15** containing a right angle opening **16** through which the inner conductor **17** of line **9** is connected to the conductor **8**. Under certain conditions, it may be desirable to extend or continue the opening **16** in the direction **18**, a sufficient length to minimize any undesirable reflections due to its angled bend. Undesirable mismatch may then be conveniently corrected by appropriate short or open circuit terminations.

Furthermore, any mismatch between the coaxial transmission line **9** and the strip line extension **10** may be compensated for by appropriately tapering the end portion **19** of the strip line feeding the transition element **15**.

Referring to Fig. 4, a further embodiment of applicant's invention is disclosed, wherein the strip conductor **8**, associated with the main waveguide **1** is separated from the latter by a first dielectric layer **20**, and from a metallic electrically conductive member **21** by the second dielectric layer **22**. To provide a support for the transmission line arrangement of Fig. 4, a clamping arrangement is provided in the form of an electrically conductive member **21** positioned on the surface of the dielectric slab **22** and adapted to receive the bolts **23**. The bolts when tightened by the nuts **24**, clamp the entire assembly of guide **1**, and the strip, or sandwich line, comprising elements **6**, **8**, **20**, **21**, and **22**. The slot, or slots **5** permit the desired coupling of waves between the guide **1** and the sandwich line.

Fig. 5 illustrates an application of the invention to circular waveguide use. In Fig. 5, the circular waveguide **25** is shown with two sandwich line transmission sections **26** and **27**, similar to those illustrated in Fig. 4, provided at spaced points on **25**. In each case, the strip conductor **8** is separated from the wall of the circular waveguide by means of the dielectric material **20** and from the electrically conductive plate member **21** by means of dielectric material **22**. The arrangement of Fig. 5 can easily be adapted for polarization measurements. For example, if the E field within **25** is oriented as indicated by the arrow **28**, the slot **29** will couple the component of the wave having its E field polarized in the direction **30** into the sandwich line **26** whereas

the slot **31** will couple the component of the wave having its E field polarized in the direction **32** into line **27**. The signals coupled by the slots **29** and **31** into sandwich lines **26** and **27** may then be compared by means of conventional amplitude comparison circuits such as a power bridge measuring apparatus.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and therefore the aim of the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination a rectangular waveguide for propagating waves, a wave transmission line comprising a strip conductor extending outside and along a predetermined length of said guide and spaced therefrom by a sheet of dielectric material, said rectangular guide being provided with coupling slots in at least two points along said length of said guide, said slots being located in said rectangular guide opposite said strip conductor to a degree to provide a desired directional coupling of propagated waves to said transmission line.

2. In combination a source of waves, a first circuit, rectangular waveguide for propagating waves from said source to said first circuit, a wave transmission line comprising a strip conductor extending outside and along a predetermined length of said guide and spaced therefrom by a sheet of dielectric material, said rectangular guide being provided with coupling slots in at least two points along said length of said guide, said slots being located in said rectangular guide opposite said strip conductor to a degree to provide a desired directional coupling of propagated waves to said transmission line, a power absorbing circuit coupled to said strip line at one end thereof, and a load circuit coupled to said strip conductor at the other end thereof with said slots being located between said ends.

3. In combination, a waveguide in the form of a pipe having an electrically conductive wall for propagating waves, a wave transmission line comprising a strip conductor extending outside and along a predetermined length of said guide and spaced therefrom by dielectric material, means for coupling propagated waves from said guide to said line comprising at least two slots in said guide, said slots being confined to a space opposite said strip conductor to provide a desired degree of directional coupling with a minimum of undesired radiation.

4. In combination, a waveguide in the form of a pipe having an electrically conductive wall for propagating waves, a strip conductor extending outside and along a predetermined length of said guide and spaced therefrom by dielectric material, means for directionally coupling propagated waves from said guide to said line comprising at least one slot in said guide, said at least one slot being confined to a space opposite said strip conductor to provide a desired maximum degree of directional coupling with a minimum of undesired radiation.

References Cited in the file of this patent

UNITED STATES PATENTS

2,654,842	Engelmann	Oct. 6, 1953
2,705,305	Bailey	Mar. 29, 1955
2,735,073	Grieg	Feb. 14, 1956
2,759,099	Olive	Aug. 14, 1956

FOREIGN PATENTS

708,601	Great Britain	May 5, 1954