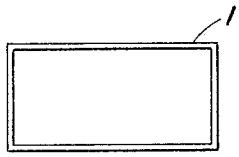
May 14, 1968 TAKAJI KURODA 3,383,630

ELECTROMAGNETIC WAVE TRANSMISSION DEVICE HAVING LARGE WAVEGUIDE JOINED TO TWO SMALLER RIDGED WAVEGUIDES

Filed June 1, 1966 2 Sheets-Sheet 1

Fig. 1.



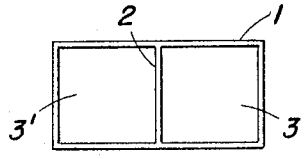
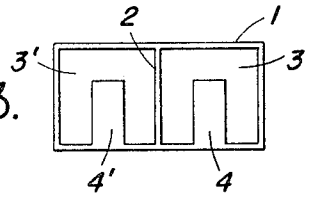


Fig. 2.

Fig. 3.



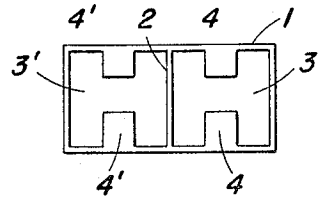
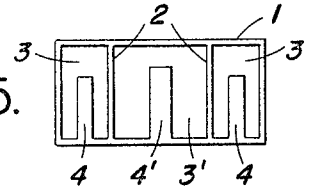


Fig. 4.

Fig. 5.



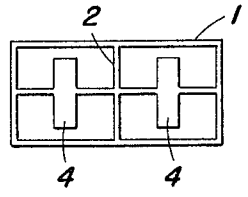


Fig. 6.

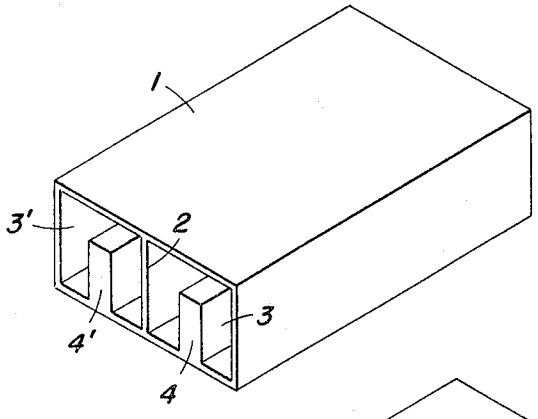


Fig. 7.

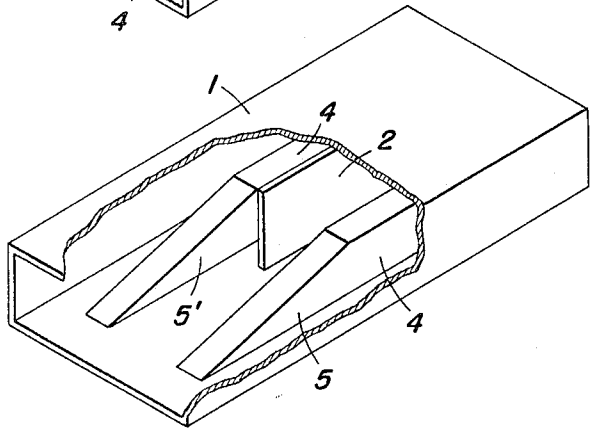


Fig. 8.

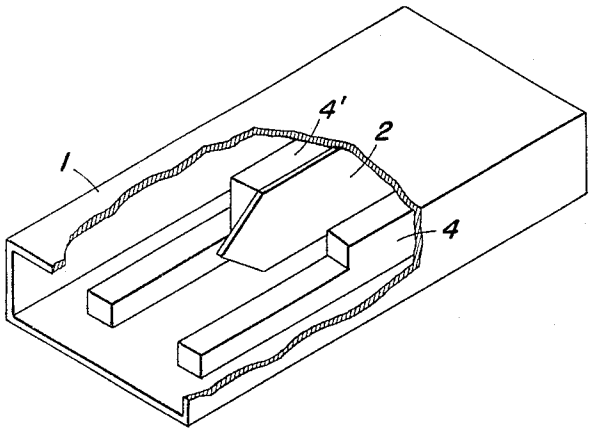


Fig. 9.

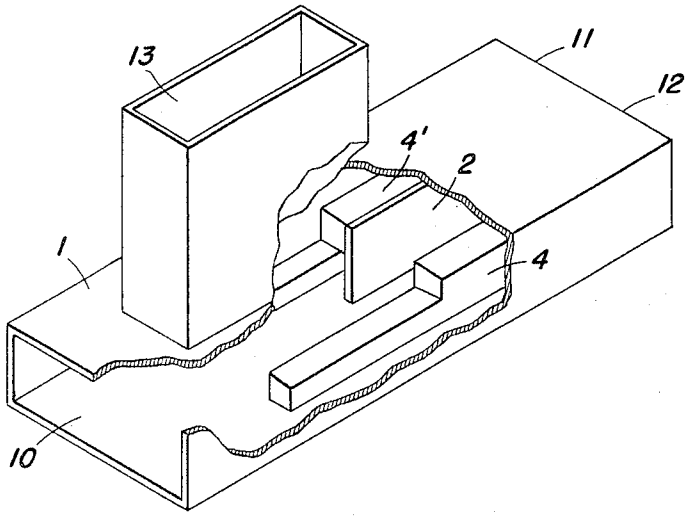


Fig. 10.

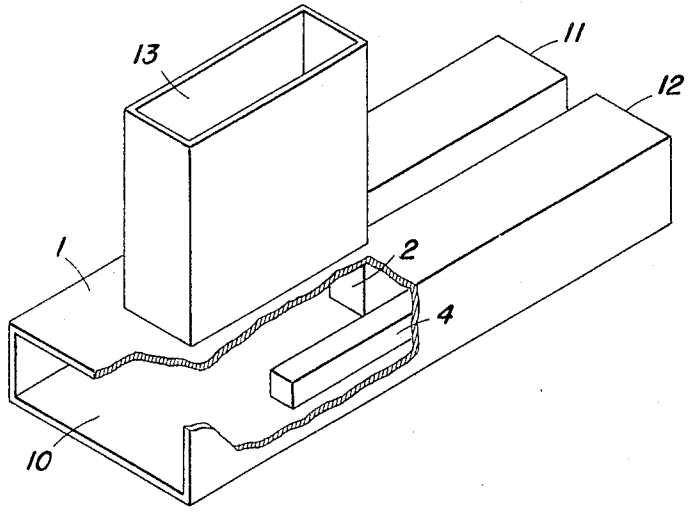


Fig. 11.

United States Patent Office 3,383,630 Patented May 14, 1968

3,386,630

ELECTROMAGNETIC WAVE TRANSMISSION DEVICE HAVING LARGE WAVEGUIDE JOINED TO TWO SMALLER RIDGED WAVEGUIDES

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Filed June 1, 1966, Ser. No. 554,462
Claims priority, application Japan, June 9, 1965, 40/34,207
2 Claims. (Cl. 333—11)

This invention relates to an electromagnetic wave transmission device and, more particularly, to such devices that function as microwave couplers.

It has been a detrimental characteristic of conventional wave transmission devices, such as microwave couplers defining branching or hybrid circuits, that they are of greater size than the waveguides to which they are coupled.

The object of the present invention is, therefore, to provide electromagnetic wave transmission devices that may serve as branching circuits of an optional number of branches, or as hybrid circuits, that do not exceed the dimensions of the waveguides to which they are coupled. With the present invention, it is possible to minimize the whole electromagnetic wave transmission circuit and thereby to provide a small-sized microwave communication equipment.

Now, some electromagnetic wave transmission devices in accordance with the present invention will be explained with reference to the accompanying drawings, in which:

FIG. 1 is a cross-sectional view of a conventional rectangular waveguide;

FIG. 2 is a cross-sectional view of the waveguide of FIG. 1 provided with a partition;

FIGS. 3–6 are cross-sectional views of electromagnetic wave transmission devices in accordance with the present invention;

FIG. 7 is a perspective view of the electromagnetic wave transmission device illustrated in FIG. 3;

FIGS. 8 and 9 are partly cut away perspective views, each showing the portion of conjunction between a rectangular waveguide and branch circuits; and

FIGS. 10 and 11 are partly cut away perspective views showing further embodiments of this invention.

Referring to FIG. 1, the ratio between or the dimension of the broad and the narrow walls of a generally used rectangular waveguide are standardized. It is usual to choose among them the waveguide of the desired dimensions according to the transmission characteristics desired. All these conventional waveguides will now be called standard waveguides.

Referring to FIG. 2, a standard waveguide **1** is provided with a partition **2**. The waveguide is divided by the partition **2** into two circuits **3** and **3'**, each of which is narrow and consequently has a cutoff characteristic for the transmission frequencies of the original standard waveguide so as no longer to serve as an electromagnetic wave transmission device for such frequencies.

Referring to FIG. 3, an electromagnetic wave transmission device of this invention is formed by providing such a modified waveguide with metal or dielectric ridges **4** and **4'** of suitable dimensions such that the circuits **3** and **3'** may become ridge waveguides, respectively, explained on page 598 of "Musen-kogaku Handobukku" (Wireless Engineers' Handbook), published by Maruzen Company, Limited, on July 10, 1957, or circuits having the same cutoff frequency as the cutoff frequency f_c of the original standard waveguide or the common transmission frequency band. It will now be understood that the electromagnetic wave transmission device of FIG. 3 works, when connected with a standard waveguide of FIG. 1, as a two-branch branching circuit from the standard waveguide.

While only one partition and only one ridge are mentioned in the above explanation for a standard waveguide and for each partitioned portion, respectively, it is possible to use more than one partition and/or more than one aligned ridge, as illustrated in FIGS. 4–6 showing modifications of the embodiment of this invention.

FIG. 7 is a perspective view of the electromagnetic wave transmission device illustrated in FIG. 3.

Referring to FIG. 8 showing a partly cut away perspective view of the portion of conjunction between the standard waveguide and the branch circuits of this invention, the ridges **4** and **4'** are provided with slight tapers **5** and **5'**, respectively, for preventing any reflection which may otherwise occur at the junction. As shown in FIG. 9, each of the ridges **4** and **4'** may be provided with one or more steps instead of the taper. Also, the partition **2** may be provided with a taper or one or more steps, similar to the ridge.

Referring to each of FIGS. 10 and 11 showing partly cut away perspective views of further embodiments of this invention, another standard waveguide is attached perpendicularly to a device of the kind shown in FIGS. 8 and 9 at the portion of conjunction. With this device, the electromagnetic wave entering at a terminal **10** is transmitted to both terminals **11** and **12** in phase, but not to another terminal **13** because their electric-field vectors are perpendicular to each other. The electromagnetic wave entering at the terminal **13** is transmitted to both of the terminals **11** and **12** in opposite phase, but not to the terminal **10** because their electric-field vectors are perpendicular to each other. This means that the waveguide combination of FIG. 10 is a novel electromagnetic wave transmission device that serves as a hybrid circuit like a magic tee. The device of FIG. 11 works in principle as that of FIG. 10, differing therefrom only in that the portion ending at the terminals **11** and **12** is formed of separate ridge waveguides.

While the terminal **13** of FIG. 10 is illustrated as a rectangular waveguide, it may instead be formed of a circular waveguide, a ridge waveguide, a coaxial line, or any other electromagnetic wave transmission device for transmitting the electromagnetic wave in any mode, but so arranged as to make the electric-field vectors perpendicular to each other at the terminals **13** and **10**.

As so far explained, this invention provides a two-branch or more-than-two-branch or hybrid electromagnetic wave transmission device without any change in the width of the standard waveguide and thus minimizes the circuitry as compared with that formed of conventional ones. This invention therefore makes it possible to achieve remarkable technical merits when applied to microwave circuits of all sorts. Furthermore, it is possible, like with a standard waveguide, to make a crystal mount, a branching filter, a phase compensator, a coupler, and the like with an electromagnetic wave transmission device of this invention.

While the electromagnetic wave transmission device of this invention has so far been explained as being formed by providing a standard waveguide with one or more partitions, this invention covers any electromagnetic wave transmission device comprising a rectangular waveguide used in wireless communication equipments and branch circuits branching out from said waveguide and having equal total width as said waveguide, each of said branch circuits being provided with such at least one aligned ridge that makes the transmission frequency bands of the branch circuit and said waveguide identical or have a common portion.

What is claimed is:

1. An electromagnetic wave transmission device comprising a first rectangular waveguide and a plurality of second waveguides branching out from said first waveguide and having equal total width as said first waveguide, each of said second waveguides including at least one aligned ridge that provides a common transmission path to a band of frequencies between said second waveguides and said first waveguide.

2. A combination of an electromagnetic wave transmission device in accordance with claim 1, wherein the number of second waveguides is two, and further comprising a third waveguide so connected to the first waveguide with respect to the second waveguides that the electric-field vectors with the first waveguide and within the second waveguides are perpendicular to each other.

References Cited

UNITED STATES PATENTS

2,989,709	6/1961	Seidel et al.	333—33 XR
3,308,469	3/1967	Drabowitch	333—33 XR

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M. NUSSBAUM, *Assistant Examiner.*