United States Patent

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[33] **Great Britain**
[31] **30,037/69**

[54] **WAVEGUIDE COUPLERS**
15 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **333/10,**
333/73 W, 333/82 R, 333/98 R

[51] **Int. Cl.** **H01p 5/14,**
H03h 7/02, H03h 7/04

[50] **Field of Search** 333/10, 1,
6, 11, 73, 73 W, 98, 98 M, 82

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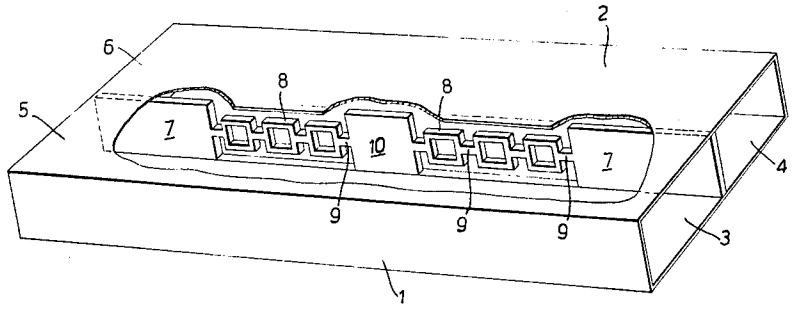
ABSTRACT: A coupler consists of two lengths of waveguide having a common narrow wall and which are capable of supporting the TE_{10} and TE_{20} modes of wave propagation, and inserted in a gap in said wall substituting for the part removed from the gap, a reactive structure having elements resonant at a predetermined operating frequency and situated in succession along the guide. The coupler can be used as a simple coupler when the elements are constituted by three closed rings and couple energy fed in at the input of one guide into the other guide or as a diplexer when there are six rings and energies at two different frequencies are fed to the input ends of the guides.



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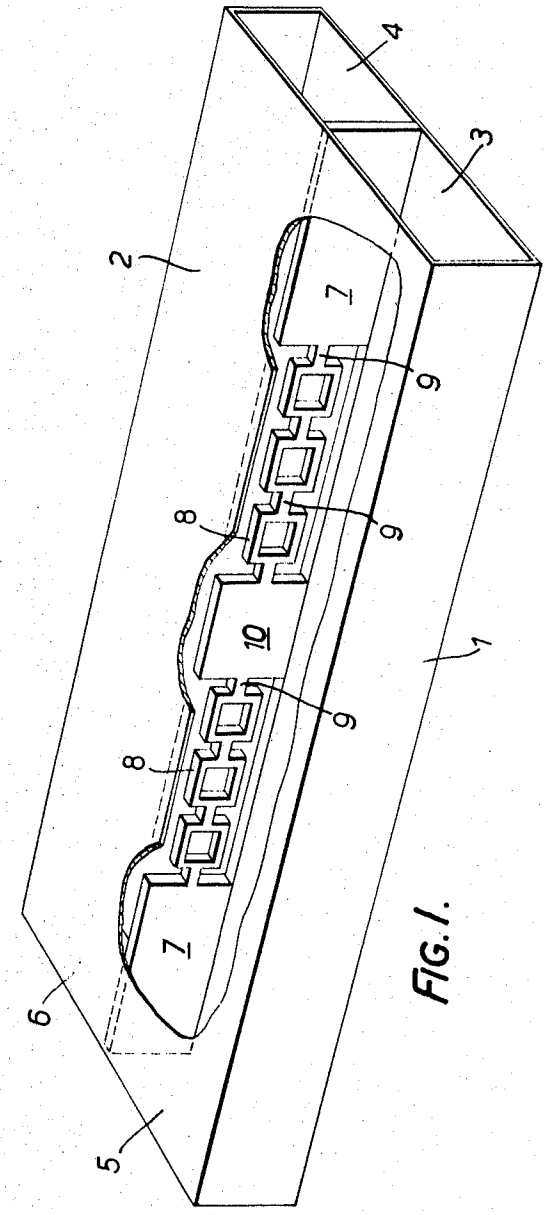

FIG. 1.

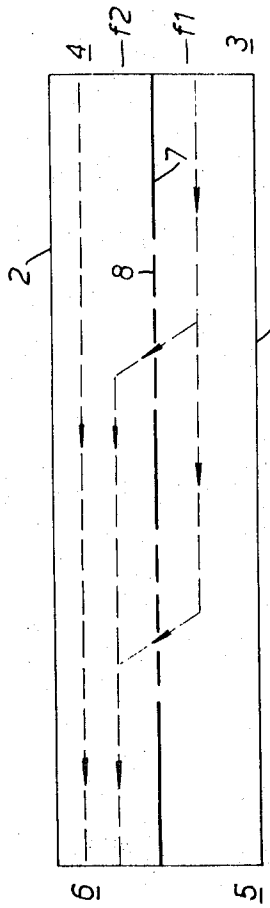

FIG. 2.

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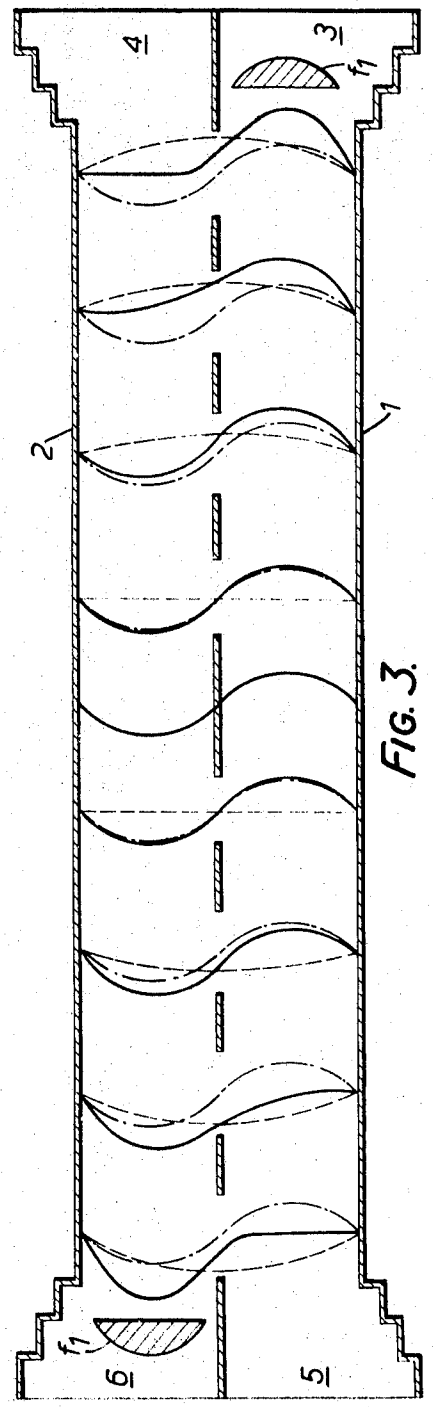

FIG. 3.

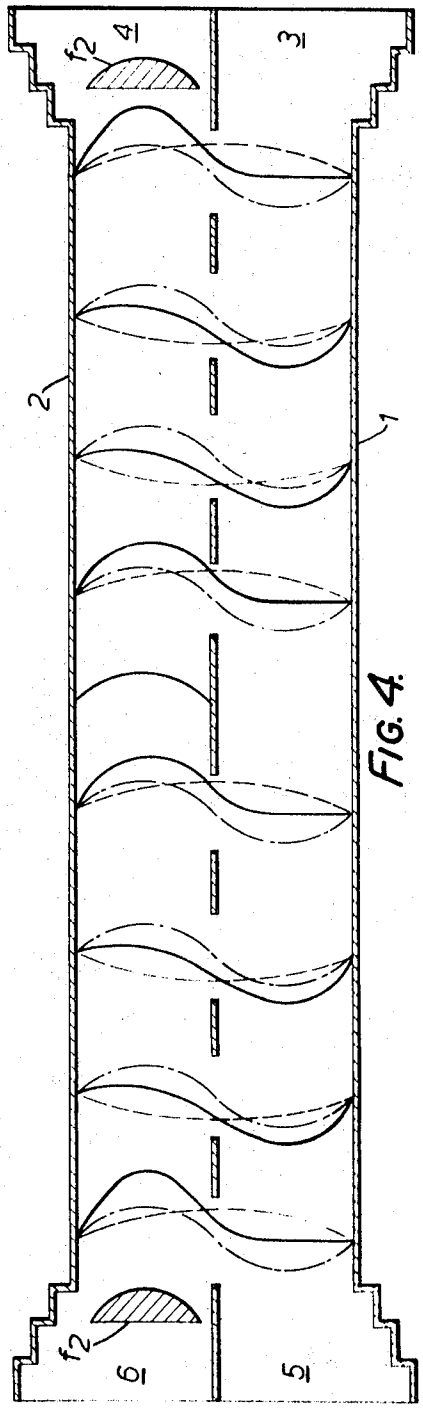

FIG. 4.

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WAVEGUIDE COUPLERS

This invention relates to waveguide couplers and has for its main object to provide improved frequency selective waveguide couplers. Though not limited to its application thereto, the invention is particularly advantageous when applied to waveguide diplexers in which application it enables diplexers to be made of considerably smaller dimensions and lower insertion losses than comparable known waveguide diplexers.

According to this invention a waveguide coupler comprises two lengths of rectangular waveguide having a common narrow wall and capable of supporting the TE_{10} and TE_{20} modes of wave propagation and, inserted in a gap in said common wall so as to substitute for the part thereof removed to form said gap, a reactive structure having at least three reactive elements resonant at or near a predetermined operating frequency and situated in succession in the direction of length of the guide.

In the case of a simple coupler the reactive elements couple energy fed in at the input end of one guide into the other guide. Such a coupler can, however, be used as a diplexer by feeding in energies at two different frequencies to the input ends of the two guides. By making the reactive elements resonant at or near one of these frequencies the result is achieved that the input of that frequency fed in to one guide is coupled into the other guide whereas the input, fed into the other guide, and of the other frequency, remains in and passes virtually unchanged along the guide into which it was fed.

Preferably the reactive elements are in the form of closed rings situated one behind the other at quarter wavelength intervals along the centerline of the common wall, these rings being held in position by supporting links joining them one to another and to the said common wall at opposite ends of the gap therein, said links being situated substantially at positions of zero electrical field so as to be, from the electrical point of view, of no effect. The word "rings" is here used in a wide sense to include not only rings of circular shape but rings of other shapes, e.g., rectangular. Rings of rectangular shape are preferably locally thickened on the opposite horizontal members to reduce the possibility of voltage breakdown.

Preferably a simple coupler has only three rings.

Preferably a coupler being used as a diplexer has six rings. These may be connected in a single group. However for reasons of constructional strength and rigidity the rings are connected in two groups each having three rings.

In order to suppress unwanted modes of wave propagation the input and output ends of the guides are preferably stepped.

The invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a diagrammatic view partly in section of a coupler being used as a diplexer in accordance with this invention,

FIG. 2 is a simplified energy transfer diagram used for the purpose of explanation of the arrangement of FIG. 1, and

FIGS. 3 and 4 are explanatory mode theory diagrams also used in connection with the arrangement of FIG. 1.

Referring to FIG. 1 the frequency selective coupler is arranged for use as a diplexer and consists of two lengths of rectangular waveguide 1 and 2 capable of supporting the TE_{10} and TE_{20} modes. The guides 1 and 2 have input ports 3 and 4 and output ports 5 and 6 respectively and a common narrow wall 7. In the plane of the wall 7 and arranged in holes therein is a reactive structure of closed rings 8, There are six rings arranged in two groups of three, each ring in a group being spaced at quarter wavelength intervals along the common wall. The rings are held in position by supporting limbs 9 joining them one to another and to the common wall 7 both at the extreme ends of the groups and between the groups at the 3 db. point 10. The links are situated at positions of zero electric field.

An understanding of the operation of the diplexer of FIG. 1 will be assisted by reference to FIG. 2.

Input signals $f1$ and $f2$ which can be in practice signals of frequency 1,260 MHz. and 1,350 MHz. respectively are applied to input ports 3 and 4 of guides 1 and 2 respectively. These frequencies are given by way of example and other suitable frequencies could be used. The reactive rings 8 are made resonant at or near frequency $f2$ so that input $f2$ fed in into guide 2 remains in and passes virtually unchanged along that guide whereas the input $f1$ fed into guide 1 is coupled into guide 2. Half of signal $f1$ is coupled through structure 8 before the 3 db. point 10 and the remainder after. It can be seen that both signals $f1$ and $f2$ are taken off at port 6.

This coupling effect is achieved by coupling to the TE_{10} and TE_{20} modes in the double width waveguide. The TE_{10} mode has a phase velocity less than that of the TE_{20} mode and by placing the reactance in the common narrow wall of the waveguides, the TE_{10} mode phase velocity is further decreased. This increases the relative phase changes of the two modes as they travel along the waveguide. This change may best be seen from FIGS. 3 and 4 of the drawings which show diagrammatically the relative phase changes which occur for the TE_{10} and TE_{20} modes in guides 1 and 2 for input signals $f1$ and $f2$ respectively. These changes have been drawn in separate diplexers for simplicity. However, it should be appreciated that in practice they occur in the same coupler. The TE_{10} mode waves are represented by broken dashed lines, the TE_{20} mode by chain lines and the resultant mode by solid lines.

As can be seen from FIG. 3 the input ends 3 and 4 and output ends 5 and 6 of the guides 1 and 2 are provided with stepped portions to suppress the undesirable TE_{30} mode. This stepping was not shown in FIGS. 1 and 2 for ease of drawing.

It should be noted that the horizontal members of the rectangular rings 8 may be locally thickened to reduce the possibility of voltage breakdown.

Couplers in accordance with the present invention have the advantage that using rectangular loops of dimensions of the order of 3×2 with ½-spacing links they can be made just 1 ½feet long as opposed to comparable known devices which are approximately 14 feet long. Similarly diplexers in accordance with this invention can be made 3 feet long as opposed to comparable known diplexers which are approximately 25 feet long. The above dimensions are given by way of example and are not intended to be limiting.

I claim:

1. A waveguide coupler comprising two lengths of rectangular waveguide having a common narrow wall and capable of supporting the TE_{10} and TE_{20} modes of wave propagation; means defining a gap formed in said common wall; a reactive structure inserted in said gap so as to substitute for the part of the common wall removed to form said gap, said reactive structure having at least three reactive elements in the form of closed rings resonant at or near a predetermined operating frequency and situated one behind the other at quarter wavelength intervals along the centerline of the common wall; and supporting links joining the rings one to another and to the said common wall at opposite ends of the gap therein, said links being situated substantially at positions of zero electrical field (when the coupler is in operation) so as to be, from the electrical point of view, of no effect.

2. A waveguide coupler as claimed in claim 1 wherein the rings are of rectangular shape and are locally thickened on the opposite horizontal members for reducing the possibility of voltage breakdown.

3. A waveguide coupler as claimed in claim 1 wherein said rings consist of three rings.

4. A waveguide coupler as claimed in claim 2 wherein said rings consist of three rings.

5. A waveguide coupler as claimed in claim 1 wherein said rings consist of six rings connected in two groups of three rings whereby the coupler may be used as a diplexer.

6. A waveguide coupler as claimed in claim 2 wherein said rings consist of six rings connected in two groups of three rings whereby the coupler may be used as a diplexer.

7. A coupler as claimed in claim 1 wherein input and output ends of the lengths of waveguide are stepped.

8. A coupler as claimed in claim 2 wherein input and output ends of the lengths of waveguide are stepped.

9. A coupler as claimed in claim 3 wherein input and output ends of the lengths of waveguide are stepped.

10. A coupler as claimed in claim 4 wherein input and output ends of the coupler are stepped.

11. A coupler as claimed in claim 4 wherein input and output ends of the lengths of waveguide are stepped.

12. A coupler as claimed in claim 5 wherein input and output ends of the lengths of waveguide are stepped.

13. A coupler as claimed in claim 6 wherein input and output ends of the lengths of waveguide are stepped.

14. A waveguide coupler as claimed in claim 1 wherein energies at two different frequencies are fed to input ends of the lengths of waveguide whereby the coupler may be used as a diplexer.

15. A waveguide coupler as claimed in claim 14 wherein the reactive elements are resonant at or near one of the said frequencies whereby the result is achieved that the input of that frequency fed into one of said lengths of waveguide is coupled into the other of said lengths of waveguide, and the input of the other of said frequencies remains in and passes virtually unchanged along length of waveguide into which it was fed.