

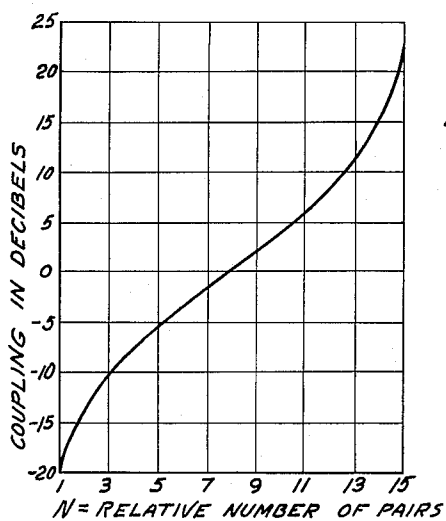
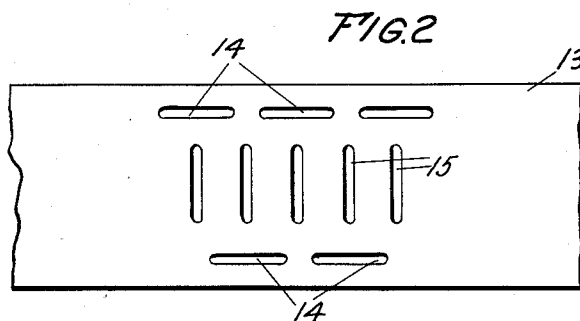
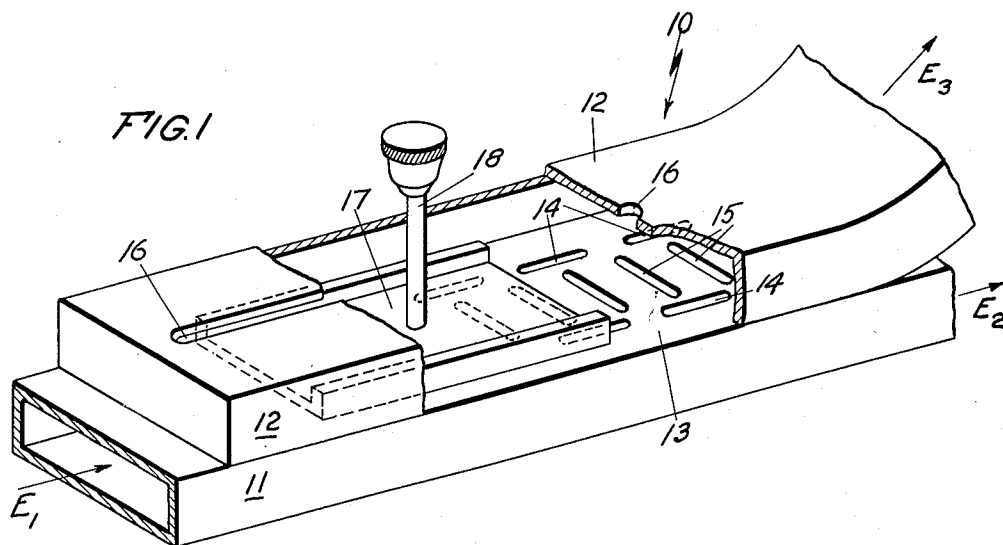
Feb. 14, 1956

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2,735,069

ADJUSTABLE POWER DIVIDER AND DIRECTIONAL COUPLERS

Filed March 4, 1952



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1

2,735,069

ADJUSTABLE POWER DIVIDER AND DIRECTIONAL COUPLER

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Application March 4, 1952, Serial No. 274,767

4 Claims. (Cl. 333—7)

This invention relates to a variable directional coupler, and more particularly relates to a compact wave guide arrangement for adjustably dividing R. F. energy.

One of the basic wave guide directional couplers now in use comprises two wave guides fastened together along a common wall with pairs of slots or apertures cut into said common wall to couple energy from one wave guide to the other. By suitable design, a single pair of slots or apertures by itself acts as a directional coupler so that these pairs may be cascaded to form a complex directional coupler in which the total coupling between guides is a function of the number of pairs of slots or apertures used.

In accordance with this invention, means are provided for continuously adjusting the coupling in a directional coupler of the type just described. A plate made of a material opaque to electromagnetic energy, such as metal, is so arranged as to be movable along the longitudinal direction of the two guides and in contact with the common wall thereof. As the plate is moved, the number of directional coupler slots covered by said plate is varied, thereby varying the number of slots effective in realizing the desired coupling, the greater the number of slots covered by the plate, the smaller the coupling between the two wave guides, that is, the smaller the ratio of the energy output of the auxiliary guide to the energy entering and leaving the main guide becomes. This variable coupling device is thus a compact and effective means for adjustably dividing R. F. energy in two wave guide transmission paths.

In the drawing:

Fig. 1 is an isometric view, partly broken away, of a directional coupler in accordance with the present invention;

Fig. 2 is a plan view of a portion of the common wall of the main and auxiliary wave guides; and

Fig. 3 is a graph illustrating the manner in which the coupling between wave guides is dependent upon the number of pairs of active slots in the directional coupler.

Referring now to Fig. 1, a directional coupler 10 is shown in which reference numeral 11 designates a first wave guide, here termed a main wave guide, which conveys electromagnetic energy from a source (not shown) to a load (not shown), the latter of which is connected to the end of the main wave guide remote from the end connected to the source. The direction of propagation of energy in the main wave guide is indicated by the arrows in Fig. 1. The directional coupler also includes a second or auxiliary wave guide 12 having the same cross-sectional area as the main wave guide. The wave guides are made in the form of rectangular channels, each of which forms one wide wall and the two narrow walls of each wave guide. A flat plate 13, preferably of the same thickness and material as that of the channel portions, is positioned between the two channels and provides a common wide wall. The channels may be soldered or otherwise joined to plate 13. It is, of course, possible to join two conventional closed wave guides along one of their wide walls. The term "common wall" as used in

2

the specification and claims refers to either a single wall common to both wave guides or to two adjacent walls of two separate closed wave guides.

The energy fed into one end of the main wave guide 11 from the source is indicated by the arrow labeled E₁. Some of this energy travels through main guide 11 and is recovered at the output or load end of said guide, as indicated by the arrow labeled E₂. A portion of the incident energy E₁ is coupled into auxiliary wave guide 12 and a second output is available at the far end thereof, as indicated by the arrow labeled E₃.

The two wave guides 11 and 12 are preferably energized in the fundamental or TE₀₁ mode in which the current flow in the wide walls is in the direction of the longitudinal axis of the wave guide along the longitudinal axis of the guide and in a direction perpendicular to the longitudinal axis in the region of the narrow or side walls.

The common wall 13 has a plurality of apertures or slots therein. These apertures may be of any desired shape whose coupling varies with their position in the common wall. Various arrangements of these slots are possible, one of which is illustrated in Fig. 2. A plurality of pairs of slots 14 and 15 is cut in common wall 13 with one slot 14 of each pair having its longitudinal axis parallel to the longitudinal axes of the main and auxiliary guide and the other slot 15 of each pair having its longitudinal axis transverse to the longitudinal axes of the main and auxiliary wave guides. In the position of maximum coupling, the slots are placed so that their longitudinal axes are transverse to the currents induced in the common wall 13 of the guides. For energization in the TE₀₁ mode the slot 14, which parallels the longitudinal axes of the wave guide, lies near one of the edges of the common wall while the slot 15, which is transversely positioned, is substantially centered on the longitudinal center line of the wave guides. The centers of both slots of a given pair fall on a line perpendicular to the longitudinal axes of the wave guides. A complete discussion of the arrangement of the various slots and the theory underlying said arrangement are given in application Serial No. 784,277 of Henry J. Riblet, filed November 5, 1947, now Patent No. 2,632,809, dated March 24, 1953. Briefly, the interactions of current flow in the wall surface by the slots create substantial electromagnetic fields about said slots whereby energy is coupled through the slots from the main wave guide to the auxiliary wave guide and propagated substantially in one direction only in the auxiliary wave guide.

By arranging a number of pairs of slots in cascade, the degree of coupling may be increased by any desired amount. A manner of variation of coupling with the number of pairs of slots used is shown in Fig. 3. This graph indicates that the coupling is proportional to a relative number of pairs of slots or apertures in the common wall 13.

The amount of energy coupled by the slot increases as the slot is made larger. When the frequency varies over a range of frequencies, coupling is more constant over a given frequency band in the case of small slots. The longitudinal and transverse slots have compensating frequencies characteristic, however, so that by increasing the length of longitudinal slots it is possible to obtain a very flat coupling characteristic.

Referring once more to Fig. 1, a longitudinal slot 16 is cut in the wall of wave guide 12 opposite the common wall 13. A flat metal plate 17 rests on common wall 13 and is adapted to make firm sliding contact with this wall. Plate 17 may be made in the form of a very shallow channel, as shown in Fig. 1, to enable the plate to be more easily and smoothly moved along the directional coupler; plate 17 may, of course, be a perfectly flat plate. An elongated handle 18 is attached at one end to the outer

surface of plate 17, as shown in Fig. 1. The handle extends through slot 16 exteriorly of said directional coupler 10 and may be moved along slot 16 either by hand or by any one of several mechanical drive means. As the plate 17 is moved along the common wall of the wave guides, the number of slots or apertures covered by the plate is varied. For example, if the plate 17 is moved along the wave guides toward the right, the number of slots covered by the plate is increased; the number of slots thus rendered ineffective for coupling is increased and the ratio of energy output at the auxiliary wave guide 12 to the energy entering and leaving the main wave guide 11 is decreased. To summarize, if it is desired that less energy be coupled into auxiliary wave guide 12, or if it is desired that the ratio of the energy output at the auxiliary wave guide 12 to the energy output of main wave guide 11 be decreased, plate 17 is moved to the right to decrease the number of slot pairs uncovered and therefore active in coupling energy between the two wave guides.

Numerous variations and applications within the scope of the invention will occur to those skilled in the art. For example, the arrangement, shape, size, and number of slots or apertures contained in the common wall of the directional coupler are not to be limited to those described and illustrated herein.

The directional coupler according to this invention, furthermore, should not be limited to one containing rectangular wave guides. Variable directional couplers having wave guides of any configuration may be within the scope of this invention.

It is intended, therefore, that the appended claims shall be given a broad interpretation commensurate with their scope within the art.

What is claimed is:

1. In combination, a pair of parallel rectangular wave guides adapted to convey electromagnetic wave energy substantially in one direction only and having a common wide wall, a plurality of pairs of cascaded mutually perpendicular slots each pair of which constitutes a directional coupler and consists of a transversely directed slot in said common wall arranged substantially along the center line thereof and a longitudinally directed slot in said common wall having its center along the axial line of said transversely directed slot, said longitudinally directed slots being arranged alternately adjacent to opposite side edges of said common wall, a member substantially opaque to said electromagnetic energy mounted for longitudinal sliding movement along said common wall for varying the amount of energy directionally transferred between said wave guides as a function of the number of pairs of slots covered by said member.

2. In combination, a pair of parallel rectangular wave guides adapted to convey electromagnetic wave energy substantially in one direction only and having a common wide wall, a plurality of pairs of cascading mutually perpendicular slots each pair of which constitutes a directional coupler and consists of a transversely directed slot in said common wall arranged substantially along the center line thereof and a longitudinally directed slot in said common wall having its center along the axial line of said transversely directed slot, said longitudinally directed slots being arranged alternately adjacent to opposite side edges of said common wall, an imperforate member substantially

opaque to electromagnetic energy positioned in contact with said common wall and slidable longitudinally past said slots for varying the number of pairs of slots covered by said member and consequently the amount of energy directionally transferred between said wave guides, the width of said movable member being at least equal to the lateral extent of said pairs of slots.

3. In combination, a pair of parallel rectangular wave guides adapted to convey electromagnetic wave energy substantially in one direction only and having a common wide wall, a plurality of pairs of cascaded mutually perpendicular slots each pair of which constitutes a directional coupler and consists of a transversely directed slot in said common wall arranged substantially along the center line thereof and a longitudinally directed slot in said common wall having its center along the axial line of said transversely directed slot, said longitudinally directed slots being arranged alternately adjacent to opposite side edges of said common wall, a movable imperforate member substantially opaque to electromagnetic energy positioned in contact with said common wall and slidable longitudinally along said common wall for varying the number of pairs of slots covered by said member and consequently the amount of energy directionally transferred between said wave guides, the width of said movable member being at least equal to the lateral extent of each of said pairs of slots, said member comprising a flat body portion substantially equal in width to that of said common wall and substantially equal in length to the slotted portion of said common wall, said member further comprising a pair of side portions at opposite sides of said body portion slidably engaging the narrow walls of one of said wave guides.

4. In combination, a pair of parallel rectangular wave guides adapted to convey electromagnetic wave energy substantially in one direction only and having a common wide wall, a plurality of pairs of cascaded mutually perpendicular slots each pair of which constitutes a directional coupler and consists of a transversely directed slot in said common wall arranged substantially along the center line thereof and a longitudinally directed slot in said common wall having its center along the axial line of said transversely directed slot, said longitudinally directed slots being arranged alternately adjacent to opposite side edges of said common wall, one of said wave guides having a longitudinally disposed elongated aperture in the wall opposite said common wall, a movable imperforate member substantially opaque to electromagnetic energy positioned in contact with said common wall and slidable longitudinally along said common wall for varying the number of pairs of slots covered by said member and consequently the amount of energy directionally transferred between said wave guides, said member having a handle portion extending through said aperture externally of said one wave guide.

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