

May 6, 1958

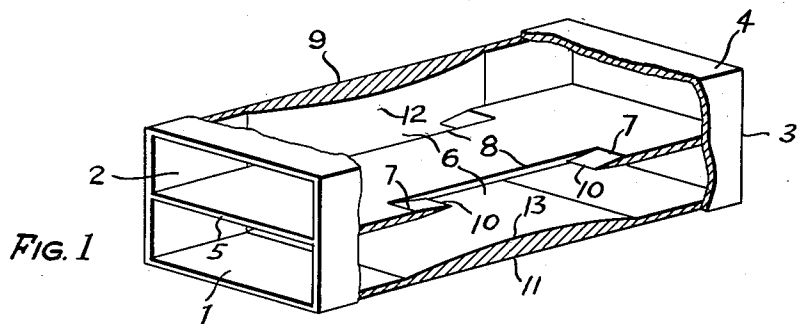
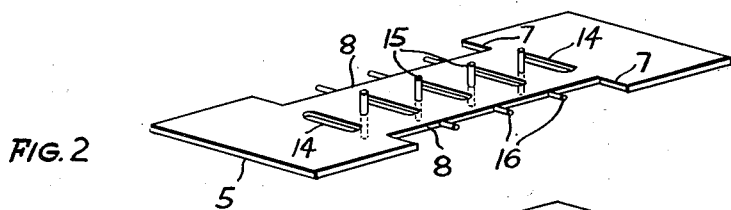
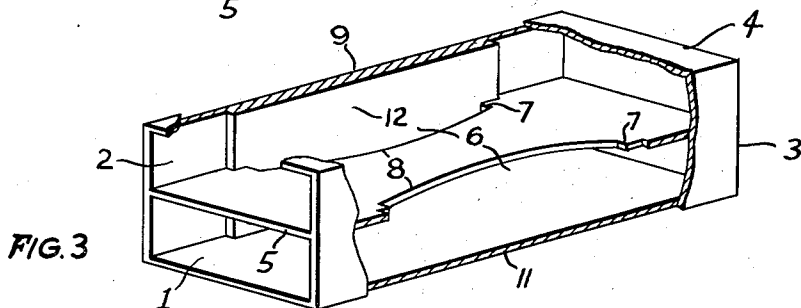
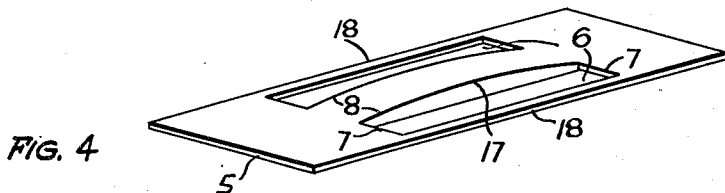
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2,833,993

TOP WALL HYBRID JUNCTIONS

Filed June 20, 1952

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

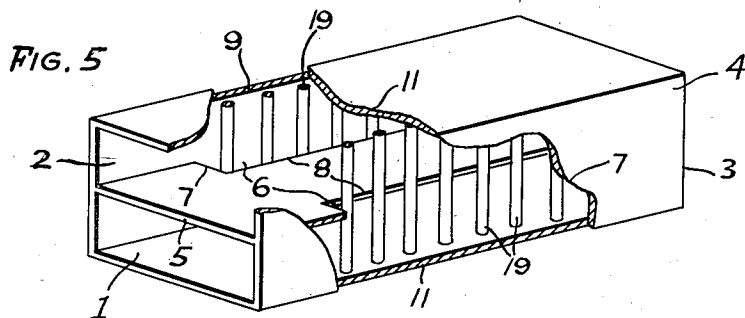
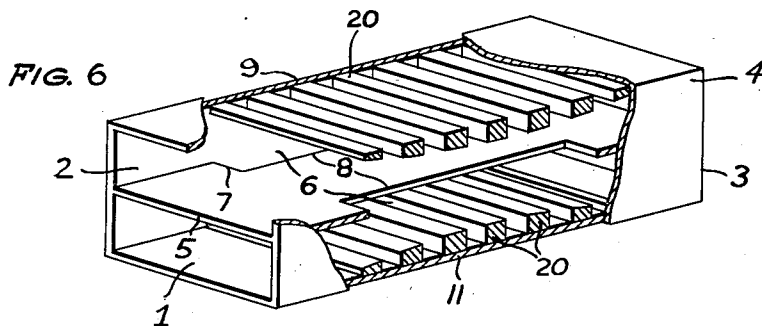
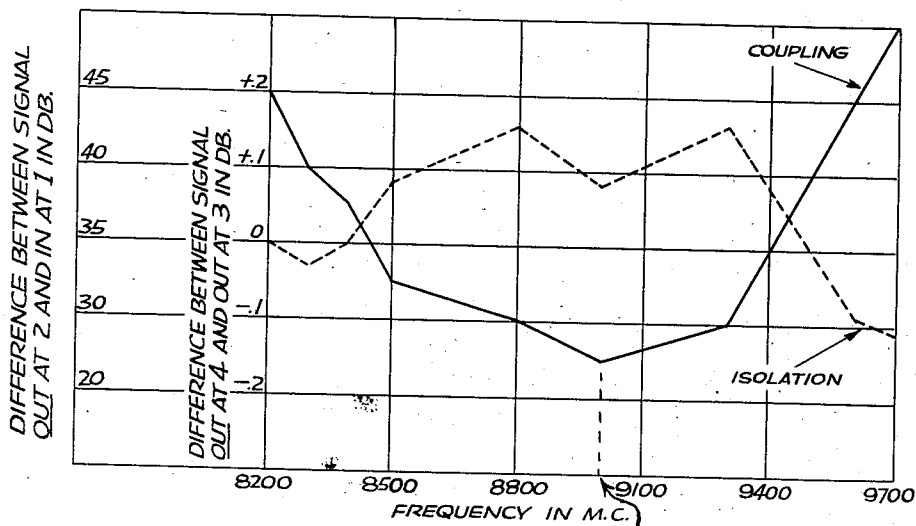


FIG. 7

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TOP WALL HYBRID JUNCTIONS

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8 Claims. (Cl. 333—11)

The present invention relates to improvements in waveguide hybrid junctions in which a pair of rectangular waveguides have a common wide wall in common and are coupled by means of a pair of slots as shown in my prior application, Serial No. 146,700, filed February 28, 1950, now Patent No. 2,709,241. In particular my invention teaches how hybrid performance may be obtained with structures of this type over frequency bands from 10 to 20 percent wide by means of an improved coupling arrangement.

The general operation of this device is explained in my prior application already referred to, and is very similar in a general way to the operation of "The Short-Slot Hybrid Junction" described in P. I. R. E. February 1952 pp. 180-184, where the coaxial mode of my invention replaces the even mode of the short-slot hybrid junction.

As explained in these references, a voltage incident on one terminal of this type of hybrid junction can be resolved into equal symmetrical and antisymmetrical voltages of the same magnitude, and so phased that when they are simultaneously incident on two side by side terminals, the voltage incident on one of the terminals is zero while the voltage on the other terminal is just the said incident voltage. Now the antisymmetric voltages proceed through the coupling section of the hybrid junction as if the slots were not present, whereas the symmetric voltages are disturbed by the two slots and excite in the coupling section a mode essentially similar to the lowest mode on a coaxial line. Two reflections in this mode are set up at the beginning and ends of the slots, and are the source of any voltage which leaves the hybrid junction through the terminal next to the input terminal. Hence obtaining high isolation between these terminals requires that these reflections cancel each other. The other characteristic of a hybrid junction is that the voltages leaving the two adjacent terminals opposite the input terminal be equal or nearly so. As explained in the references, this is accomplished where the electrical length of the coupling section between the ends of the slots differ from each other by a quarter of a wavelength. As pointed out in the application previously referred to, both of these requirements for hybrid performance can be realized at a given frequency with a structure of the form shown in this invention.

My invention consists however in exhibiting limited values of certain critical dimensions in terms of the wavelength, for which hybrid performance is maintained over wide bands of frequency. In addition my invention differs from the prior application in that the width and height of the waveguide sections in the coupling region must be appreciably reduced below their width and height at the terminals of the hybrid junction, in order to realize the full bandwidth potential of my invention, assuming the use of standard commercially available waveguides.

These dimensions have been determined by trial and error, and make it possible to construct a hybrid junction of this type, whose performance is sensibly unchanged over frequency bands as large as 20%.

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The means and methods by which such improved performance is effected will best be understood from the description in the specification set forth below in which Figure 1 is an isometric view of an improved top wall hybrid junction in accordance with my invention with certain parts cut away to show the interior construction. Figures 3, 5 and 6 are similar views showing alternate constructions. Figures 2 and 4 are isometric views showing alternate constructions for the central wall. Figure 7 gives experimental data for a top wall hybrid junction constructed in accordance with my invention.

Referring now to Figure 1, there is shown two substantially similar rectangular waveguides 1—3 and 2—4, which are disposed parallel to each other, with a wide wall 5 common or adjacent to that of the other. Two substantially similar slots 6 are placed in the common wall 5 at or near the side walls 7 of the hybrid junction in such a way as to be parallel to the axis of waveguides 1—3 and 2—4, and in the same longitudinal relationship in the hybrid junction.

The slots 6 are bounded by ends 7, inner edges 8 and the inner surface of the side walls 9. The ends 7 of the slots 6 may be provided with tapers 10. It will be convenient to define that region of the hybrid junction consisting of the two substantially similar rectangular waveguides 1—3 and 2—4, the slots 6 and common wall 5 lying between the ends 7 of the slots 6 as the "coupling section" of the hybrid junctions. It is clear from Figure 1 that the side walls 9 and top and bottom walls 11 have been indented at 12 and 13 in the coupling section so that the dimensions between the corresponding walls of these surfaces in the coupling sections are less than the corresponding dimensions in the openings 1, 2, 3, 4 of the waveguides. The minimum width of the waveguide in the coupling section measured between inside walls 12 is denoted by W. The minimum height of the coupling section measured between the inside top and bottom walls 13 is denoted by H. The length of the slots 6 measured between the ends 7 of the slots is denoted by L and the width of the slots 6 measured at the ends 7 of the slots is denoted by W_s.

Figure 2 shows how the common wall 5 may be provided with transverse slots 14 and capacitive probes 15 and 16.

Figure 3 shows an alternate version of my improved top wall hybrid in which the indented portion 12 of the side walls 9 is planar instead of being gradually curved as in Figure 1. No indentations of the top and bottom walls 11 is shown, while the inside edge 8 of the slots 6 is curved instead of being straight.

Figure 4 shows how it is possible to indent the narrow portion of the common wall 5 lying between the slots 6 at 17, and how the slots 6 need not lie precisely next to the side walls 9, but may be separated from them by narrow strips 18.

Figure 5 shows a version of my improved top wall hybrid junction in which the indentation of the side walls 9 is effectively accomplished by closely spaced inductive rods 19.

Figure 6 shows a version of the improved hybrid junction in which the indentation of the top and bottom walls 11 is effectively accomplished by closely spaced capacitive bars 20.

Figure 7 gives the performance of a top wall hybrid junction constructed in accordance with this specification. For example at 8500 mc./s., energy in at waveguide opening 1 will divide so that the energy out at terminal 4 is .05 db below the energy out at terminal 3, while the energy out at terminal 2 is 39 db below the input energy.

For purposes of the present case, the mid-band wavelength of the hybrid junction will be defined as the wave-

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length at which the power transfer from the main waveguide to the auxiliary waveguide has its minimum value. For Figure 7, this occurs at a guide wavelength of about 3.34 cms. I have found that optimum performance from a hybrid of this type is obtained for fairly narrow limits of the significant dimensions. These may be set forth generally in terms of the mid-band wavelength, λ as follows:

Waveguide width, W, at the center of the hybrid junction equals	$.65\lambda \pm .03\lambda$
Total waveguide height, H, at the center of the hybrid junction equals	$.61\lambda \pm .04\lambda$
Slot width W_s at the ends of the slot equals	$.175\lambda \pm .08\lambda$
Slot length L equals	$.80\lambda \pm .07\lambda$

W is the more important of the first two dimensions. The optimum obtained for an H value of $.61\lambda$ is much flatter than that obtained for a W value of $.65\lambda$, consequently for some applications it may not be necessary to reduce the height of the waveguide. For optimum performance however, the average width of the waveguide will fall within the tolerance of $.65\lambda \pm .03\lambda$ even though the top and bottom walls are straight as shown in Figure 3. Although the optimum dimensions of the coupling section of the hybrid junction are expressed in terms of the mid-band frequency, and are hence independent of the size of the waveguide at the terminals of the hybrid junction, obtaining the required dimensions for the hybrid junction, will involve a pinching and constriction of the waveguide at the coupling section as shown in Figures 1 and 2 in most practical cases. For example, in the frequency band from 8200 megacycles to 12,400 megacycles waveguide where internal dimensions of .900" x .400" are used if no reduction in the width of the guide is permitted, the band center will fall at a frequency of about 8500 megacycles. Since it is clear that such a design will waste a major portion of the potential bandwidth of hybrid junction, it is clear that this will not generally be done. Accordingly Figures 1 and 2 show constrictions in the waveguide dimensions since this will, in almost all cases, be the most prominent structural difference between my invention and the hybrid junction of the previously cited application. Nevertheless the principal feature of my invention is the determination of the coupling section dimensions which give rise to broad band hybrid performance. The narrowing of the waveguide might be avoided by using special waveguides. Moreover for maximum usefulness, the mid-band frequency will exceed the lowest operating frequency of the waveguide at the terminals of the hybrid junction by at least 5% relative to said frequency.

Although the indentations 12 and 13 shown in Figure 1 are a convenient means for achieving the required performance, it should be emphasized that the electrical and hence important effects achieved by these constrictions can be obtained in equivalent ways having rather different appearances. For example in Figure 2, pins 15 and 16 and slots 14 and in Figure 4, indentations 17 have a capacitive effect similar to the constriction 13 of the top and bottom walls 11 of the hybrid junction, while the rods 19 of Figure 5 have an inductive effect similar to the constriction 12 of Figures 1 and 3 in the side walls 9 of the hybrid junction.

As will readily be seen, because of the many possible variations in construction to obtain the same effect, it is difficult to define the present invention other than in terms of the varying or narrowing of the width, height and slot width and length in the hybrid junction, and therefore it is to be understood that the terms herein apply more to the effective modifications of the dimensions in the hybrid junction, rather than to the actual or particular manner in which these effects may be obtained since they may be obtained as indicated by the figures in a considerable number of ways.

λ Throughout the specification refers to free space wave length.

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Having now described my invention, I claim:

1. A microwave hybrid junction comprising, a hollow generally rectangular conductive structure having substantially parallel broad and narrow walls, a conductive plane partition extending longitudinally and centrally through said structure coextensively with and parallel to said broad walls, said partition thereby dividing said structure into first and second like rectangular waveguides having a common broad wall and input and output sections dimensioned for normal microwave energy propagation throughout a relatively broad frequency spectrum, each pair of said input and output sections being disposed on opposite sides of a coupling section, said common broad wall in said coupling sections being formed with a pair of longitudinal elongated slots adjacent said narrow walls, said broad and narrow walls of said structure being indented in said coupling sections, whereby said slots and said indented coupling sections coact to yield hybrid performance for said junction over a frequency band lying wholly within the aforesaid frequency spectrum normally transmitted by said input and output sections.

2. A microwave hybrid junction comprising, a hollow generally rectangular conductive structure having substantially parallel broad and narrow walls, a conductive plane partition extending longitudinally and centrally through said structure coextensively with and parallel to said broad walls, said partition thereby dividing said structure into first and second like rectangular waveguides having a common broad wall and input and output sections dimensioned for normal microwave energy propagation throughout a relatively broad frequency spectrum, each pair of said input and output sections being disposed on opposite sides of a coupling section, said common broad wall in said coupling sections being formed with a pair of longitudinal elongated slots adjacent said narrow walls, said broad and narrow walls of said structure being curved inwardly in said coupling sections to provide central regions of reduced cross-section symmetrically disposed relative to said slots, whereby said slots and said central reduced cross-section regions coact to yield hybrid performance for said junction throughout a frequency band lying wholly within the aforesaid frequency spectrum normally transmitted by said input and output sections.

3. Apparatus as in claim 2 wherein said conductive partition in the region of the ends of each of said elongated slots is tapered inwardly to enhance the signal isolation characteristic of said hybrid junction.

4. A microwave hybrid junction comprising, a hollow generally rectangular conductive structure having substantially parallel broad and narrow walls, a conductive plane partition extending longitudinally and centrally through said structure co-extensively with and parallel to said broad walls, said partition thereby dividing said structure into first and second like rectangular waveguides having a common broad wall and input and output sections dimensioned for normal microwave energy propagation throughout a relatively broad frequency spectrum, each pair of said input and output sections being disposed on opposite sides of a coupling section, said common broad wall in said coupling sections being formed with a pair of longitudinal elongated slots adjacent said narrow walls, and means for reactively loading said coupling sections in the regions of said elongated slots, whereby said slots and said reactive loading coact to yield hybrid performance for said junction over a frequency band lying wholly within the aforesaid frequency spectrum normally transmitted by said input and output sections.

5. A microwave hybrid junction as in claim 4 wherein said reactive loading means includes a pair of confronting planar indentations in said narrow walls effective to provide central regions of reduced cross-section symmetrically disposed relative to said elongated slots.

6. A microwave hybrid junction as in claim 4 wherein said reactive loading means includes a portion of said

common broad wall between said elongated slots, said portion being curved symmetrically from the ends of said slots to provide a central region of said common wall of increased thickness.

7. A microwave hybrid junction as in claim 4 wherein said reactive loading means includes a plurality of spaced inductive rods extending between said broad walls, through said elongated slots, and parallel to said narrow walls.

8. A microwave hybrid junction as in claim 4 wherein said reactive loading includes a plurality of closely spaced capacitive bars affixed to said broad walls transversely of said elongated slots.

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