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CONSTANT RESISTANCE PSEUDOHYBRID CHANNEL
BRANCHING MICROWAVE FILTERS
Original Filed Oct. 7, 1949

2,595,680

FIG. 1

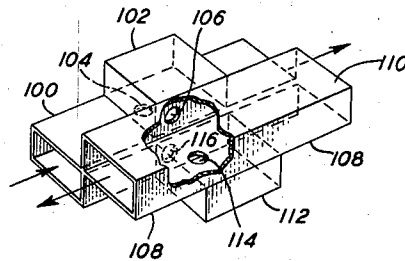


FIG. 2

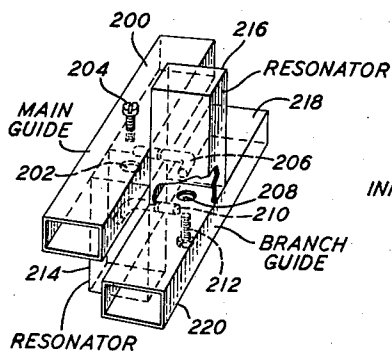


FIG. 3

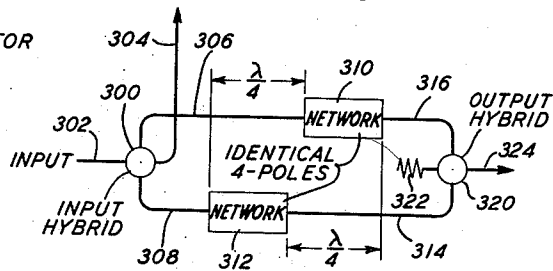
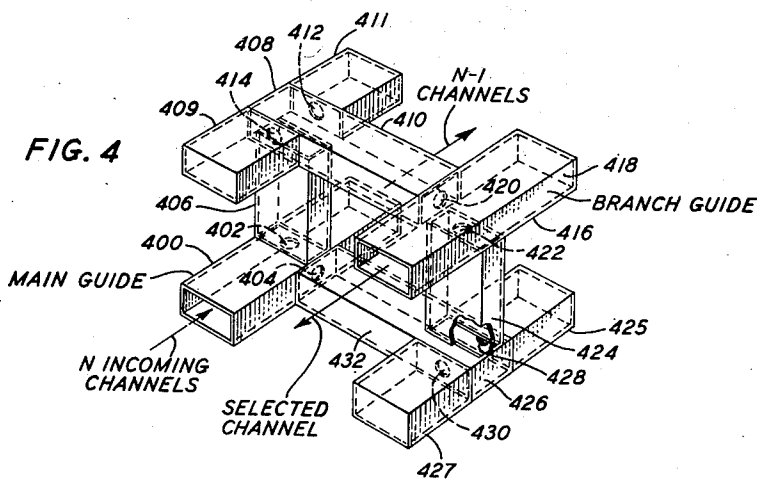


FIG. 4



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2,595,680

CONSTANT RESISTANCE PSEUDOHYBRID
CHANNEL BRANCHING MICROWAVE
FILTERSWillard D. Lewis, Little Silver, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New YorkOriginal application October 7, 1949, Serial No.
120,142. Divided and this application February
3, 1951, Serial No. 209,276

9 Claims. (Cl. 178-44)

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This invention relates to electromagnetic wave, microwave frequency, constant resistance, transducers. More particularly, it relates to transducers of the above-described character which employ pseudohybrid junctions.

This application is a division of my copending application Serial No. 120,142 filed October 7, 1949. The term "pseudohybrid" as applied to an electromagnetic wave, microwave frequency, junction, is to be understood in the present application to have the same meaning as is defined and explained in detail in my above-mentioned copending parent application. In general, all pertinent portions of the above-mentioned copending parent application are to be considered as being incorporated in and made a part of the present application by reference.

An object of the invention is to provide novel electromagnetic wave, microwave frequency, wave filtering devices.

Another object is to provide electromagnetic wave, microwave frequency, wave filtering devices which have a substantially constant resistive impedance over a very broad range of microwave frequencies.

Other and further objects will become apparent during the course of the following description and from the appended claims.

The nature of structures of the invention will be more readily understood from the following detailed description of specific illustrative embodiments taken with the appended drawings, in which:

Fig. 1 shows one form of wave filter of the invention;

Fig. 2 shows an alternative form of wave filter of the invention;

Fig. 3 shows in schematic block diagram form the equivalent electrical circuit of the wave filters of the invention; and

Fig. 4 shows a still further alternate form of wave filter of the invention.

In Fig. 1, in more detail, a complex type of "microwave" or very high frequency structure is illustrated which employs two pseudohybrid junctions and, as will become apparent hereinafter, comprises a new form of constant resistance, channel branching, filter related to the structures disclosed in my copending application Serial No. 789,985, filed December 5, 1947, which matured into United States Patent 2,531,447 granted November 28, 1950, and in the copending application Serial No. 789,812, filed December 5, 1947 by A. G. Fox, assignor to applicant's assignee. This latter application matured into

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United States Patent 2,531,419 granted November 28, 1950.

In Fig. 1, the portion of wave guide 100 is, for example, a transmission line carrying a plurality of communication channels comprising discrete frequency bands in the microwave frequency region. The portion of wave guide 108 is a second transmission line into which it is desired to branch off one only, of the plurality of frequency bands being transmitted along the wave guide 100.

The two orifices 104 and 116 in the top and near side, respectively, of wave guide 100 couple the guide to resonant cavities 102 and 112, respectively, and the combination of a straight section of wave guide with two resonant cavities coupled through their respective orifices in a common vertical plane is readily recognizable as a form of band rejection filter of the general type described in detail and illustrated, for example, in connection with Fig. 7 of my above-mentioned parent application.

Likewise, the section of wave guide 108 coupled, in a common vertical plane, by orifices 114 and 106 in its lower surface and far side, respectively, to resonators, or resonant cavities 112 and 102, respectively, also constitutes a band-rejection filter of the same general type as described in connection with Fig. 7 of my parent application as mentioned above.

As described above, all of the frequency bands remote from the resonant frequency of resonators 102 and 114 pass freely along wave guide 100 from its input (left) end to its output (right) end.

At and near the resonant frequency of cavities, or resonators, 102 and 114, however, the energy introduced into the left end of wave guide 100 enters the resonators and passes by way of orifices 114 and 116 into the wave guide 108, the phase relations being such that it combines to pass out of the near or left end of wave guide 108. To avoid the possibility of establishing a balance in either of the cavities 102 or 112, the orifices 104 and 106 for cavity 102, and 114 and 116 for cavity 112, should be displaced from the lateral axes (i. e., the axes of the cavities which lie in a plane parallel to the plane of the axes of wave guides 100 and 108 but which cavity axes are turned 90 degrees in their plane with respect to the direction of the wave guide longitudinal axes). For maximum transfer of energy through a cavity from one wave guide to the other the orifices should be one-quarter wavelength nearer one side of the cavity than the other as shown in Fig. 1. Any substantial displacement would,

however, serve to effect the desired transfer of a substantial part of the energy.

The far (right) end of wave guide 108 can be closed by a copper or brass sheet or plate 110. Alternatively, a matching impedance can be connected to the far (right) end of wave guide 108 to absorb any energy of frequencies outside of the frequency band to be branched off the main guide 100 which may happen to leak through the pseudohybrid junctions described above and the resonators 102 and 112.

With respect to each pseudohybrid junction there is an inherent difference of 90 electrical degrees between the energy derived from an iris in the wider side (such as irises 104 and 114) and that derived from the iris in the more narrow side (such as irises 106 and 116) so that the structure of Fig. 1 can be accurately represented in electrical schematic diagram form, by the diagram of Fig. 3. This will become apparent during the detailed description of Fig. 3 given hereinafter.

In Fig. 2 an alternative arrangement of structure very similar to that of Fig. 1 is shown. In Fig. 2, however, one coupling of the main guide 200 to one cavity resonator 216 is effected by means of a probe 206 instead of an iris and the degree of coupling to the main wave guide 200 can be adjusted by turning screw 204 which is threaded through the upper surface of guide 200 adjacent to the end of probe 206 as shown. From elementary wave guide principles it is apparent that with the lower end of screw 204 just flush with the inner surface of the upper side of wave guide 200 the portion of probe 206 extending into wave guide 200 would have no coupling with the waves passing through the wave guide since that portion of the probe is perpendicular to the electric vector of the waves. The insertion of screw 204 downwardly and beyond the inner surface of the upper side of wave guide 200, however, distorts the wave form to a degree determined by the amount which screw 204 protrudes into wave guide 200 and thus establishes a coupling of the probe 206 to the waves passing along wave guide 200 which coupling is, obviously, in turn also dependent upon the protrusion of screw 204 into wave guide 200.

Wave guide 200 is coupled to resonator 214 by a simple iris 202 in the lower side of the wave guide, as shown.

Similarly, the branch wave guide 220 is coupled to resonator 216 by simple iris 208, as shown, and to resonator 214 by probe 210, the coupling of probe 210 to wave guide 220 being adjustable by turning screw 212 which is threaded through its lower surface, as shown, the arrangement being precisely that described immediately above for wave guide 200, probe 206 and screw 204. Aside from the adjustable coupling features just described the arrangement of Fig. 2 is substantially identical with that of Fig. 1. The branched channel is transmitted through resonators 214 and 216 to branch guide 220 and the phase relations are such that the energy of this channel is directed out the near or left end of branch guide 220. The other channels pass freely through guide 200 without let or hindrance. The far (right) end of branch guide 220 can be closed by a copper or brass sheet or plate 218 or it can be terminated in a matching impedance as for the branch guide 108 of Fig. 1.

In Fig. 3, as was mentioned previously, an equivalent electrical schematic diagram of the structures of Figs. 1 and 2 is shown. In Fig. 3

the input hybrid 300 having input terminal 302 and output terminal 304 can represent the main wave guide 100 of Fig. 1 or 200 of Fig. 2. The other two arms 306 and 308 of the hybrid represent the couplings effected by the irises 104 and 116 of Fig. 1 or of probe 206 and iris 202 of Fig. 2. As previously explained, there is an inherent 90 electrical degree phase difference between these two couplings in each instance which is represented in Fig. 3 by the additional length of one-quarter wavelength shown for arm 306 as compared with arm 308. Networks 310 and 312 represent the resonant cavities 102 and 112 of Fig. 1 or 216 and 214 of Fig. 2, respectively. In a similar way the output hybrid 320 having arms 324 and 322 which later may include a matching impedance termination or a simple short circuit can comprise branch guide 108 of Fig. 1 or branch guide 220 of Fig. 2. Arms 314 and 316 can represent the couplings of orifices 106 and 114 of Fig. 1 or of probe 210 and orifice 208 of Fig. 2. The circuit of Fig. 3 is demonstrated in my above-mentioned copending application Serial No. 789,985, filed December 5, 1947, to be a constant resistance, channel branching filter. Obviously, therefore, the structures of Figs. 1 and 2 of the present application are likewise of the same character.

In Fig. 4 a more complex form of the general type of constant resistance branching filter, illustrated in the above-described Figs. 1 and 2, is shown.

In Fig. 4 the two paths connecting the main guide 400 and the branch guide 416 each comprise a complete pseudohybrid band-pass filter of the type illustrated in Fig. 6 of my above-mentioned parent application and described in detail in that application.

One of these paths consists of vertical arm 406, horizontal arm 410 and a section of wave guide comprising a throat section 408 coupled by orifices 412 and 414 to closed resonant cavities 411 and 409, respectively, all of which are proportioned and arranged as described in connection with Fig. 6 of my parent application to form a pseudohybrid band-pass filter of the invention passing the single band or channel of frequencies which is to be branched off to the branch wave guide 416. Vertical arm 406 connects to the main guide 400 through orifice 402 in the upper (broad) surface of guide 400 as shown. Horizontal arm 410 connects to the branch guide 416 through orifice 420 in the far or left (narrow) side of guide 416.

The other path connecting the main and branch guides consists of horizontal arm 432, vertical arm 424 and a section of wave guide comprising a throat section 426 coupled by orifices 428 and 430 to closed resonant cavities 425 and 427, respectively, all of which are also proportioned and arranged as described in connection with Fig. 6 of my parent application to form a pseudohybrid band-pass filter of the invention passing the single band or channel of frequencies which is to be branched off to the branch wave guide 416. Horizontal arm 432 is coupled to main guide 400 through orifice 404 in the near (narrow) side of the main guide 400. Vertical arm 424 is coupled to the branch guide 416 through orifice 422 in the lower (broad) surface of branch guide 416.

The main guide 400 provided with orifices 402 and 404 in a broad (upper) and narrow (side) surface thereof, the orifices being centered in a common vertical cross-sectional plane of the guide, constitutes a pseudohybrid junction as is

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described in detail in my above-mentioned copending parent application. Assuming the left (near) end of guide 400 to be the input terminal and the right (far) end of guide 400 to be the output terminal, energy of all of the frequency bands or channels of the system will normally be introduced into the near end of guide 400. One of these channels, depending upon which is passed by the above-described pseudohybrid junctions and pseudohybrid band-pass filters of Fig. 4 will be transmitted to the branch guide 416. The remaining channels will all be freely transmitted to the output terminal of guide 400.

Branch guide 416 with orifices 420 and 422 in its far (narrow) side and in its lower (broad) side, respectively, the orifices being centered in a common vertical cross-sectional plane of the guide, likewise constitutes a pseudohybrid junction, as described in detail in my parent application. The phase relation of the energies arriving in wave guide 416 via the two paths described in detail above, is such that they will combine to pass freely out of the left (near) end of branch guide 416. The right (far) end of guide 416 can be closed by a sheet of copper or brass 418 or it can be terminated by an impedance termination equal to the characteristic impedance of the guide 416 as discussed above in connection with Figs. 1 and 2.

The above-described illustrative structures by no means exhaust the possibilities of application inherent in the principles of the invention. Numerous and varied additional structures embodying the spirit and within the scope of the invention will occur to those skilled in the art.

What is claimed is:

1. An electromagnetic wave, microwave frequency, wave-guide structure comprising a pair of electromagnetic waves, microwave frequency, wave guides and a pair of electromagnetic waves, microwave frequency resonant cavities coupling said pair of wave guides, a first one of said cavities being parallel coupled to a first one of said wave guides and series coupled to the second one of said wave guides, the second of said cavities being series coupled to the first one of said wave guides and parallel coupled to the second one of said wave guides, the center points of the two couplings to each wave guide lying in a common plane perpendicular to the longitudinal axis of the wave guide.

2. The structure defined in claim 1, the four said couplings being electrically weak.

3. In an electromagnetic wave, microwave frequency system, a pair of wave-guide sections having like rectangular cross-sectional areas, one cross-sectional dimension of which is substan-

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tially greater than the other, a pair of resonant cavities coupled between said pair of wave-guide sections, one of said cavities being coupled to a surface of the larger cross-sectional dimension of a first one of said pair of wave-guide sections and to a surface of the smaller cross-sectional dimension of the second of said pair of wave guides, the other of said cavities being coupled to a surface of the smaller cross-sectional dimension of the first of said pair of wave guides and to a surface of the larger cross-sectional dimension of the second of said pair of wave guides, the center points of coupling to each of said pair of wave-guide sections being located in a common plane perpendicular to the longitudinal axis of the wave-guide section.

4. The structure of claim 3 in which the couplings between the cavities and the wave guides are electrically weak.

5. The structure of claim 3, in which the couplings are effected by small orifices or openings between the wave guide and resonant cavity in each instance.

6. The structure of claim 3, in which a number of the couplings are effected by probes extending through the adjacent surfaces.

7. An electromagnetic wave, microwave frequency, wave-guide pseudohybrid channel branching network comprising a main wave guide and a branch wave guide, a pair of wave-guide structures each coupled at one end to said main wave guide and at the other end to said branch wave guide, said wave-guide structures being coupled to said main wave guide with their coupling points displaced 90 degrees in one direction and to said branch wave guide with their coupling points displaced 90 degrees in the reverse direction, the coupling points on said main wave guide being in a common plane perpendicular to the longitudinal axis of said main wave guide and the coupling points on said branch guide being similarly related with respect to said branch guide.

8. The arrangement of claim 7 in which said pair of wave-guide structures connecting said main and branch wave guides each includes a pseudohybrid wave filter, the filters in said pair of structures being substantially identical.

9. The arrangement of claim 7 in which said pair of wave-guide structures connecting said main and branch wave guides each includes a pseudohybrid band-pass wave filter, the filters in said pair of structures being substantially identical.

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No references cited.