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WAVE GUIDE MAGIC-TEE JUNCTIONS

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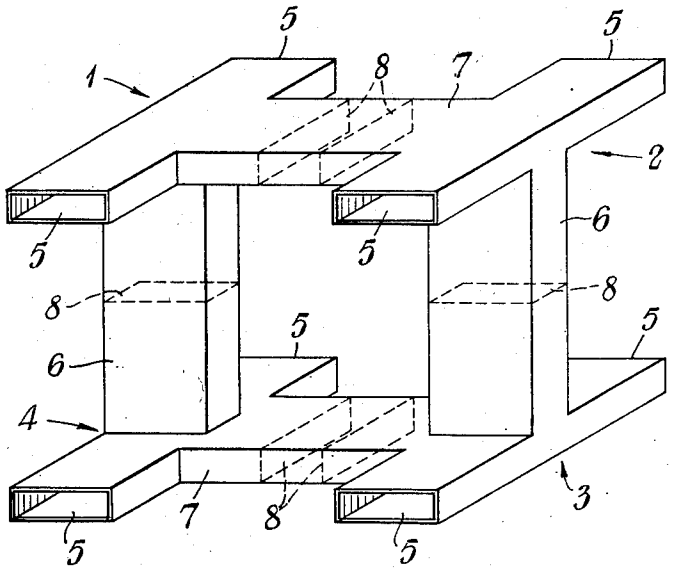

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WAVE GUIDE MAGIC-TEE JUNCTIONS

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This invention relates to waveguide junctions, i. e. rigid components formed with a plurality of internal passages each communicating with at least one other such passage and intended to serve for the propagation of electromagnetic waves therethrough, the passages constituting waveguide sections and being adapted to be connected, at any end which is open, to an externally arranged waveguide or other component.

A frequent requirement in current radar practice is a waveguide junction having eight open passage ends (an open passage end being termed an "arm") and having the internal passages inter-connecting these arms so arranged that when four of the arms are connected each to a different one of four receiving aerials, the amplitudes and phases of the waves incident upon which are represented by the four couplers designated A, B, C, —D, respectively, the outputs at the four remaining arms will have amplitudes $\frac{1}{2}(A+B+C+D)$, $\frac{1}{2}(A+B-C-D)$, $\frac{1}{2}(A-B+C-D)$ and $\frac{1}{2}(A-B-C+D)$, respectively. Such a waveguide junction will be termed herein "an eight-arm waveguide junction" and this invention is concerned more particularly with improvements in these junctions.

It has been known for some time that four four-arm waveguide junctions of the hybrid or "magic" Tee type may be interconnected to produce an eight-arm waveguide junction but other four-arm junctions, such as hybrid rings, have been employed in preference because of the difficulty of manufacturing hybrid Tee junctions which are matched and the difficulty of arranging these junctions in a convenient form which will avoid undue weight and complexity of the interconnecting waveguides.

I have now found that it is possible to produce a highly satisfactory and compact eight-arm waveguide junction by interconnecting four magic Tee waveguide junctions which are not themselves matched and that the resulting junction has considerable advantages over those produced from four-arm junctions of other types since the symmetry of the magic Tee junction guarantees the accuracy of the signal additions and subtractions which it is called upon to perform.

Accordingly, this invention consists in an eight-arm waveguide junction composed of four unmatched magic Tee junctions arranged symmetrically with the longitudinal axes of their straight-through passages parallel to each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs and the series arms of these junctions being also connected to each other in pairs, and matching devices located in the interconnected shunt arms and in the interconnected series arms either midway between the junctions of the respective pairs of magic Tee junctions or symmetrically one at either side of the corresponding midway point.

In order that the invention may be clearly understood, one form thereof will now be described by way of example with reference to the accompanying drawing which is a perspective view of an eight-arm waveguide junction.

The eight-arm waveguide junction illustrated comprises four unmatched magic Tee junctions indicated generally at 1, 2, 3 and 4 respectively arranged symmetrically with the longitudinal axes of their straight-through passages (each indicated by the reference 5) parallel to each other and the centre points of these axes located at the four corners of a rectangle. The shunt arms of the magic Tee junctions 1, 2, 3 and 4 are connected to each other to provide the two arms 7 interconnecting the junctions 1 and 2 and the junctions 3 and 4 respectively and the series arms of these junctions are also connected to each other in pairs to provide the two arms 6 interconnecting the junctions 1 and 4 and the junctions 2 and 3 respectively. A matching device 8 is located midway along the length of each of the arms 6 in one of the planes of symmetry of the combination of four-arm junctions 1, 2, 3 and 4. Two further matching devices 8 comprising a pair are located in each of the arms 7 of the combination, the component parts of each pair of devices 8 being symmetrically disposed with respect to the corresponding plane of symmetry of the combination of junctions. The matching devices 8 are preferably inductive or capacitive shunt elements, such as irises.

It will be appreciated that each pair of matching devices 8 located in the arms 7 may be replaced by a single matching device 8 located midway along the length of each arm 7 between the hybrid magic Tee junctions 1 and 2, and 3 and 4 respectively. Furthermore the single matching device 8 located in each arm 6 may be replaced by a pair of such devices so long as the component parts of the pair are symmetrically disposed with respect to the corresponding plane of symmetry. The eight-arm junction obtained may readily be matched accurately by appropriate adjustment of the matching devices 8 referred to, the matching devices 8 on opposing sides of the rectangular arrangement being identical by reason of the symmetry of the latter. It should be noted that the employment of pairs of matching devices 8 in each side of the rectangular arrangement makes possible a better match over a wide band of frequencies.

It will be understood that the lengths of the waveguides coupling the individual hybrid Tee junctions together are such that correct phasing of the various signals is obtained.

In the operation of the eight-arm waveguide junction described the output signals from four different receiving aerials are respectively fed into the open ends of two straight-through passages 5 the centre points of the axes of which passages are located at diagonally opposed corners of the rectangle on which are located the centre points of the axes of the four passages 5. Thus, for example, the four signals are respectively fed into the open ends of the passages 5 of the magic Tee junctions 2 and 4. Assuming that the amplitudes and phases of these signals are represented by the coupler numbers A, B, C and —D and that A and B are respectively fed into the ends of the passage 5 of the junction 4 and C and —D are respectively fed into the ends of the passage 5 of the junction 2 then the signal travelling along the series arm 6 of the junctions 1 and 4 towards the passage 5 of the junction 1 is $(A-B)$; the signal travelling along the shunt arm 7 of the junctions 3 and 4 towards the passage 5 of the junction 3 is $(A+B)$; the signal travelling along the series arm 6 of the junctions 2 and 3 towards the passage 5 of the junction 3 is $(C+D)$; and the signal travelling along the shunt arm 7 of the junctions 1 and 2 towards the junction 1 is $(C-D)$. This results in an output signal of $\frac{1}{2}(A-B-C+D)$ at one end of the passage 5 of the junction 1 and an output signal of $\frac{1}{2}(A-B+C-D)$ at

the other end thereof and also in an output signal of $\frac{1}{2}(A+B-C-D)$ at one end of the passage 5 of the junction 3 and an output signal of $\frac{1}{2}(A+B+C+D)$ at the other end thereof.

What I claim is:

1. An eight-arm waveguide junction composed of four unmatched magic Tee junctions each having a straight-through open-ended passage, a shunt arm and a series arm, said junctions being arranged symmetrically with the longitudinal axes of their straight-through passages parallel to each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs and the series arms of these junctions being also connected to each other in pairs, and a matching device located in each pair of interconnected shunt and series arms midway between the junctions of the respective pairs of magic Tee junctions.

2. An eight-arm waveguide junction composed of four unmatched magic Tee junctions each having a straight-through open-ended passage, a shunt arm and a series arm, said junctions being arranged symmetrically with the longitudinal axes of their straight-through passages parallel to each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs and the series arms of these junctions being also connected to each other in pairs, and at least one matching device located in each pair of interconnected shunt and series arms and disposed symmetrically with respect to the midway point of each such pair of interconnected arms.

3. An eight-arm waveguide junction composed of four unmatched magic Tee junctions each having a straight-through open-ended passage, a shunt arm and a series arm, said junctions being arranged symmetrically with the longitudinal axes of their straight-through passages parallel to each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs and the series arms of these junctions being also connected to each other in pairs, and a pair of matching devices located in each pair of interconnected shunt and series arms and disposed symmetrically one on either side of the corresponding midway point between the respective pairs of magic Tee junctions.

4. An eight-arm waveguide junction composed of four unmatched magic Tee junctions each composed of an open-ended waveguide of constant rectangular cross-section throughout its length to provide a straight-through uninterrupted passage, one cross-sectional dimension of said passage being larger than the other, a shunt arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the smaller dimensioned walls of the latter substantially midway along its length and a series arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the larger dimensioned walls of the latter substantially midway along its length, said junctions being arranged symmetrically with the longitudinal axes of their straight-through passages parallel with each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs and the series arms of these junctions being also connected to each other in pairs, and a matching device located in each pair of interconnected shunt and series arms.

5. An eight-arm waveguide junction composed of four unmatched magic Tee junctions each composed of an open-ended waveguide of constant rectangular cross-section throughout its length to provide a straight-through uninterrupted passage, one cross-sectional dimension of said passage being larger than the other, a shunt arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the smaller dimensioned walls of the latter substantially midway along its length and a series arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the larger dimensioned walls of the latter substantially midway along its length, said junctions being arranged symmetrically with the longitudinal axes of their straight-through passages parallel with each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs and the series arms of these junctions being also connected to each other in pairs, and a matching device located in each pair of interconnected shunt and series arms and extending across these transversely to their direction of length.

6. An eight-arm waveguide junction composed of four unmatched magic Tee junctions each composed of an open-ended waveguide of constant rectangular cross-section throughout its length to provide a straight-through uninterrupted passage, one cross-sectional dimension of said passage being larger than the other, a shunt arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the smaller dimensioned walls of the latter substantially midway along its length and a series arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the larger dimensioned walls of the latter substantially midway along its length, said junctions being arranged symmetrically with the longitudinal axes of their straight-through passages parallel with each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs and the series arms of these junctions being also connected to each other in pairs, and at least one matching device located in each pair of interconnected shunt and series arms and disposed symmetrically with respect to the midpoint of each such pair of interconnected arms.

7. An eight-arm waveguide junction composed of four unmatched magic Tee junctions each composed of an open-ended waveguide of constant rectangular cross-section throughout its length to provide a straight through uninterrupted passage, one cross-sectional dimension of said passage being larger than the other, a shunt arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the smaller dimensioned walls of the latter substantially midway along its length and a series arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the larger dimensioned walls of the latter substantially midway along its length, said junctions being arranged symmetrically with the longitudinal axes of their straight-through passages parallel with each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs, and the series arms of these junctions being also connected to each other in pairs, and a pair of matching devices located in each pair of interconnected shunt and series arms and disposed symmetrically one on either side of the corresponding midway point between the respective pairs of magic Tee junctions.

8. An eight-arm waveguide junction composed of four unmatched magic Tee junctions each composed of an open-ended waveguide of constant rectangular cross-section throughout its length to provide a straight-through uninterrupted passage, one cross-sectional dimension of said passage being larger than the other, a shunt arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the smaller dimensioned walls of the latter substantially midway along its length and a series arm of the same rectangular cross-section opening at one end into the open-ended waveguide through one of the larger dimensioned walls of the latter

substantially midway along its length, said junctions being arranged symmetrically with the longitudinal axes of their straight-through passages parallel with each other and the centre points of these axes located at the four corners of a rectangle, the shunt arms of the magic Tee junctions being connected to each other in pairs, and the series arms of these junctions being also connected to each other in pairs, a pair of matching devices located in each pair of interconnected shunt arms and symmetrically disposed one on either side of the midway point of these interconnected shunt arms and a matching device located in each pair of interconnected series arms midway between the junctions of the respective pairs of magic Tee junctions.

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