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WAVEGUIDE JUNCTION CIRCULATOR HAVING RESONANT IRIS BROADBANDING PLATES

Filed Nov. 7, 1968 3 Sheets-Sheet 1

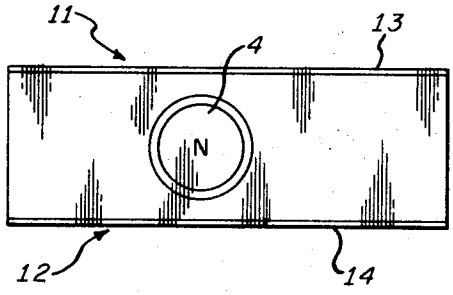


FIG. 1b.

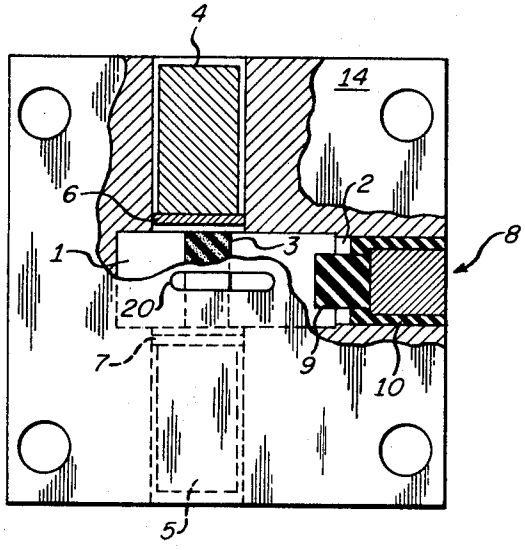


FIG. 1a.

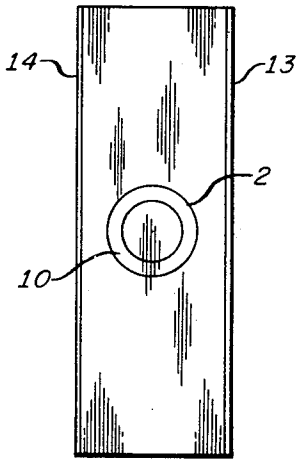


FIG. 1d.

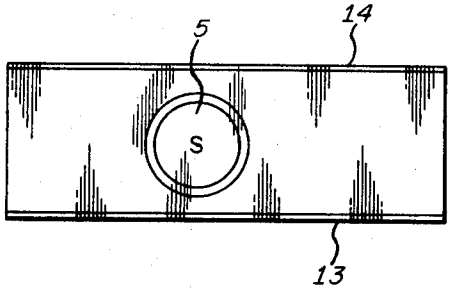


FIG. 1c.

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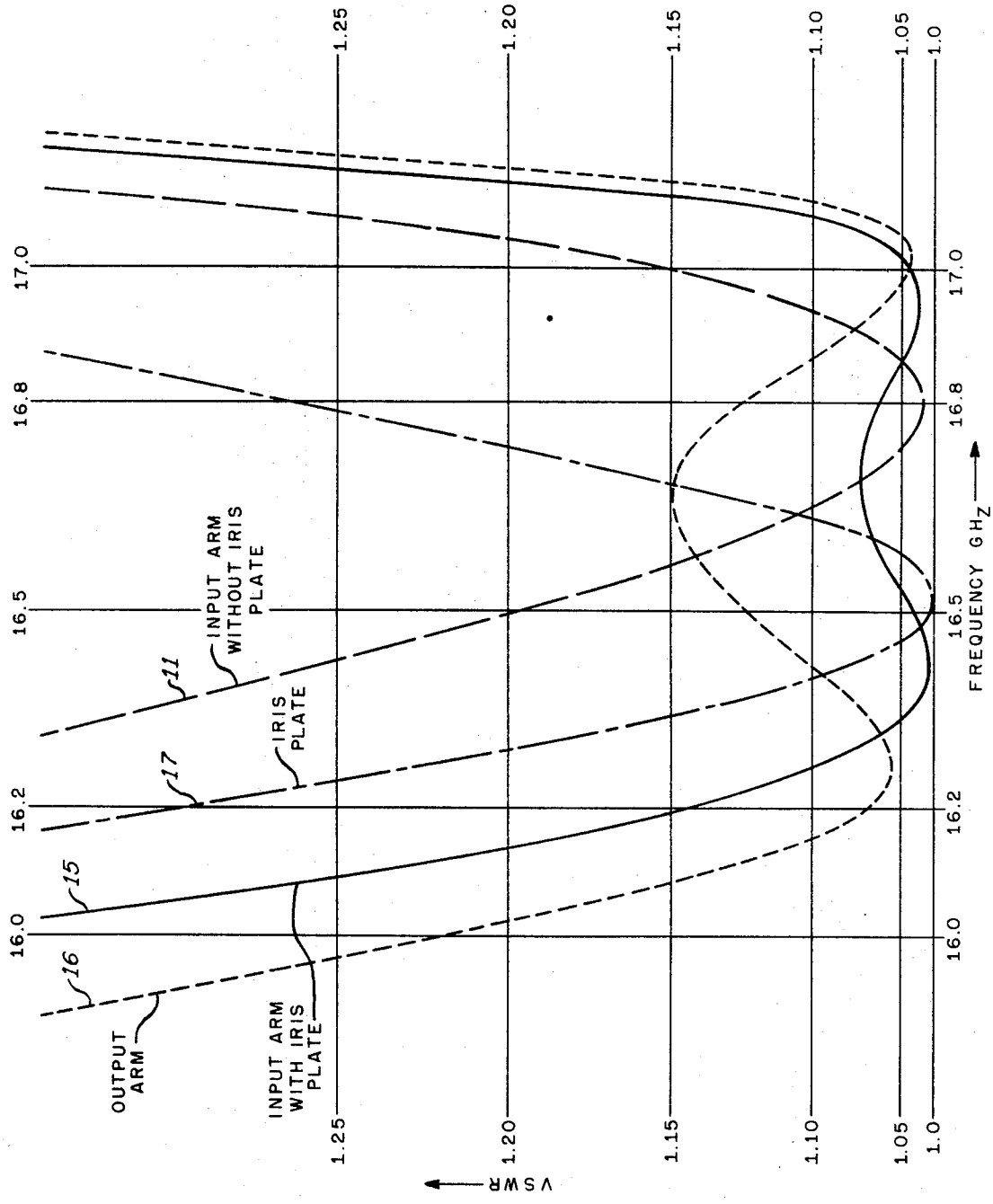


FIG. 2.

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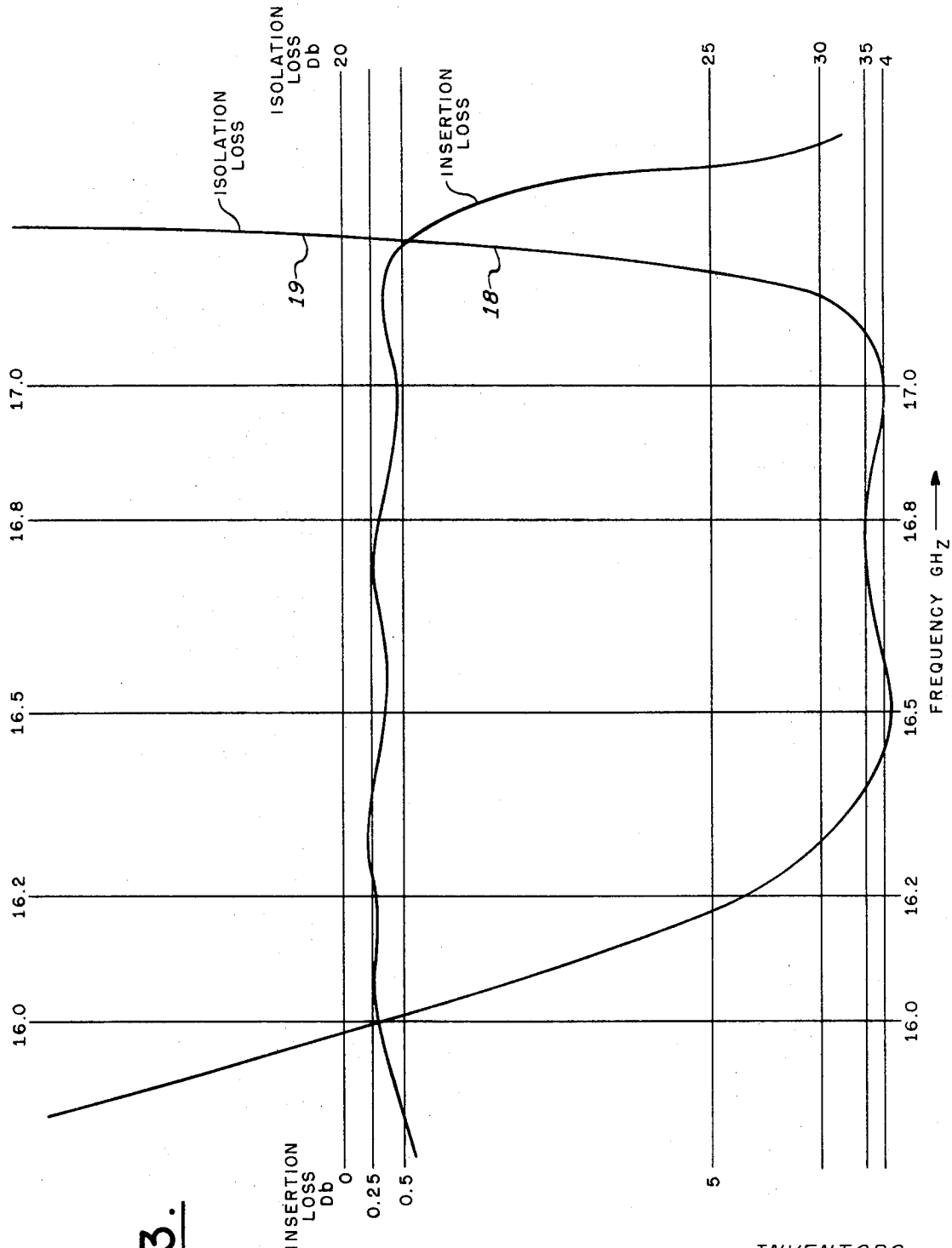


FIG. 3.

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WAVEGUIDE JUNCTION CIRCULATOR HAVING RESONANT IRIS BROADBANDING PLATES

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Int. Cl. H01p 1/32, 5/12
U.S. Cl. 333—1.1 4 Claims

ABSTRACT OF THE DISCLOSURE

An H-plane waveguide junction circulator-isolator characterized by increased bandwidth of impedance match between the circulator and the input and output waveguide transmission lines resulting from the use of a thin metal plate with a resonant iris opening connected across each said transmission line at the input and output arms of the circulator. The circulator is converted into an isolator by placing a load termination in the third arm of the circulator.

BACKGROUND OF THE INVENTION

Modern microwave systems place emphasis upon designs permitting high performance and small size of the constituent microwave components. In the case of waveguide junction circulators, however, broadband impedance match between the waveguide circulator per se and the mating waveguide transmission lines has been achieved only at the expense of objectionable size and weight. It is desirable to achieve an increase in operating bandwidth for units of restricted size or, alternatively, a reduction in size and weight for units having a given operating bandwidth.

SUMMARY OF THE INVENTION

In accordance with the present invention, an increase in the bandwidth of the impedance match between a waveguide junction circulator and the mating waveguide transmission lines at the circulator ports is achieved by providing a thin metal plate having a resonant iris opening connected across each waveguide transmission line at the respective circulator ports. Optimum match of the reactance slope of the iris with that of the circulator is achieved by choice of the proper iris opening aspect ratio and by making the iris resonant at a frequency below that of the unmatched circulator.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1*a* is a front elevation view, partly in cross-section, of a preferred circulator-isolator embodiment of the invention;

FIG. 1*b* is a top view of the embodiment of FIG. 1*a*;

FIG. 1*c* is a bottom view of the embodiment of FIG. 1*a*;

FIG. 1*d* is a side view of the embodiment of FIG. 1*a*;

FIG. 2 is a series of plots representing voltage standing wave ratio versus frequency characteristics typical of the embodiments of FIGS. 1*a*–1*d*.

FIG. 3 is a pair of plots representing insertion loss and isolation loss versus frequency characteristics typical of the embodiment of FIGS. 1*a*–1*d*.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the waveguide junction circulator-isolator embodiment of FIGS. 1*a*–1*d*, a conventional H plane-T circulator is provided comprising rectangular waveguide **1**, circulator waveguide **2**, ferrite element **3**, magnets **4** and **5** and respective pole pieces **6** and **7**. The circulator is converted into an isolator by the addition of dielectric loaded,

tunable, circular waveguide termination **8** which is inserted in the circular waveguide shunt arm **2** of the circulator. A similar circulator-isolator is described in the paper "Tee Circulator" by W. E. Swanson and G. J. Wheeler in the 1958 IRE WESCON Convention Record, part I, pp. 151–156. The termination **8** comprises a tuning slug **9** and sleeve **10**. The exposed surfaces of tuning slug **9** and sleeve **10** are coated with a conducting paint.

The voltage standing wave ratio versus frequency characteristic at input port **11** of the circulator-isolator comprising the elements represented by the numerals 1–10 is represented by dashed curve **11** of FIG. 2. A substantial increase in the frequency band over which the voltage standing wave ratio is minimized by the addition of thin metal plates **13** and **14**, each having a resonant iris opening such as opening **20** in iris **14**; the resulting VSWR versus frequency characteristic at input port **11** is represented by solid line **15** of FIG. 2. The corresponding VSWR versus frequency characteristic at output port **12** of the circulator-isolator including the iris plates is represented by dashed line **16** of FIG. 2. Line **17** of FIG. 2 represents the VSWR versus frequency characteristic of the iris plate apart from the circulator-isolator. It will be observed that the iris plate is resonant at a frequency below that of the circulator-isolator without the iris plates.

A resonant iris aperture in a transverse partition within a waveguide manifests the characteristics of a shunt resonant circuit connected in parallel with the waveguide. It has been found that the reactive components of the admittance of a resonant iris aperture can be used to substantially cancel the reactive components of the admittance of an unmatched H-plane junction circulator by placing a resonant iris partition across the mating waveguide at each port of the circulator. The reactance slope of the iris is set for optimum match at the respective circulator port by properly selecting the iris opening aspect ratio and, hence, the iris Q. The iris opening may take various forms including rectangular, square, elliptical, circular and others with or without tuning posts or screws projecting into the opening.

It has been observed that optimum broadbanding results are achieved when the iris resonant frequency is appreciably below the resonant frequency of the unmatched circulator rather than at the same resonant frequency. This is the case with curves **11** and **17** of FIG. 2. It is thought that the interaction of the various closely spaced components comprising the waveguide junction circulator-isolator of the preferred embodiment makes the separation of the two resonant frequencies preferable.

The insertion loss and isolation characteristics of a typical design of the embodiment of FIGS. 1*a*–1*d* are given in FIG. 3, insertion loss being represented by curve **18** and isolation loss being represented by curve **19**. It should be noted that the very significant increase in the operating bandwidth evidenced by a comparison of curves **11** and **15** of FIG. 2 is achieved by the addition of a simple element (thin metal plate having a resonant iris opening) of insignificant size and weight to an otherwise conventional waveguide junction circulator.

While the invention has been described in its preferred embodiment, it is to be understood that the words which have been used are words of description rather than limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of the invention in its broader aspects.

What is claimed is:

1. In an H-plane waveguide junction circulator having at least one each input port and output port,

said ports comprising rectangular waveguide transmission lines,

a pair of conductive plate means having resonant iris openings,

said iris resonant frequency being substantially below the resonant frequency of the circulator in the absence of said conductive plates having resonant irises for the purpose of broadbanding said circulator,

each said plate means being placed across a respective one of said waveguide transmission lines.

2. The circulator defined in claim 1 wherein said input and output waveguide ports are joined end to end to form a continuous waveguide.

3. The circulator defined in claim 2 and further having a circulator waveguide shunt arm.

4. The circulator defined in claim 3 wherein said shunt arm is terminated with a load.

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U.S. Cl. X.R.

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