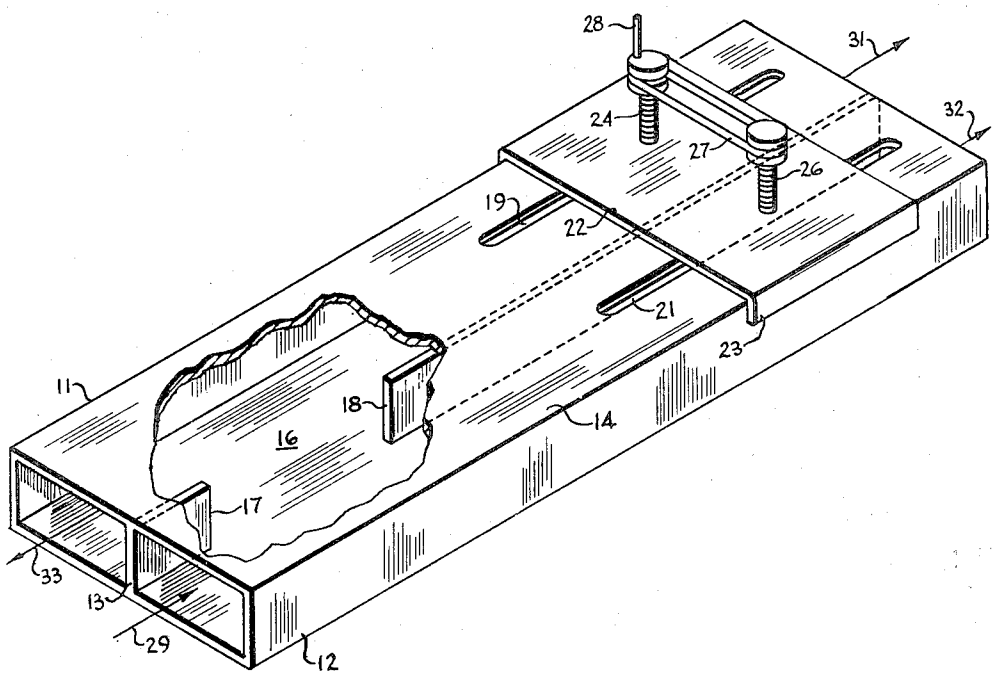
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MICROWAVE POWER DIVIDER

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MICROWAVE POWER DIVIDER

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1 Claim. (Cl. 333—9)

This invention relates to microwave power dividers for dividing power among three output branches.

In designing microwave rectangular waveguide circuits it is highly desirable to have choices of components with the guide terminals variously positioned and angled, so that the components may be conveniently joined together within the space and position limitations of the particular problem. In employing microwave power dividers it is additionally desirable to have continuous adjustment of the power division ratio, and to have control of the phase of one output or of the relative phases of the outputs. These requirements are important, for example, when microwave power is subdivided for transmission to several microwave antennas for simultaneous energization at selected power amplitudes and in selected phase relations.

The present power divider provides two hollow rectangular microwave guides having one narrow side in common and having a port in the common narrow side, so that for energy introduced into one end of one guide the device as so far described is a 3-db directional coupler. Such a device is described by Henry J. Riblet in an article entitled "The Short-Slot Hybrid Junction," in Proceedings of the Institute of Radio Engineers for February 1952, on pages 180–184.

The instant invention additionally provides, in the output part of each guide, an adjustable reflecting post adjustably positioned in a longitudinal slot. These two reflecting posts are positioned at all adjustments at identical distances from the port, the resulting phase relations being such that no energy is reflected to the input terminal source. Output energy is taken from the other three terminals in relative amounts and phases regulated by the post adjustments.

The principal purpose of this invention is to provide a microwave power divider having adjustable power division and adjustable phase.

Another purpose of this invention is to provide a power divider based on the directional coupler principle of phase cancellation to eliminate reflections toward the microwave source.

Another purpose of this invention is to provide a directional coupler having a pair of adjustable reflecting devices for controlling the output power ratio.

A further understanding of this invention may be secured from the detailed description together with the single figure of the drawing representing an embodiment of the invention.

Referring now to the drawing, a pair of microwave rectangular hollow guides **11** and **12** are positioned side-by-side and parallel, with one narrow side wall **13** common to the two guides. This wall **13** is interrupted by an opening, aperture or port extending from the upper broad face **14** to the lower broad face **16** and having wall or septum edges **17** and **18**. The port serves as a power dividing opening, and is so arranged that it serves as a three-decibel power divider, the port being impedance matched for highest efficiency. Thus, when microwave

energy approaches the port through either one of the guides, one-half passes on through that guide past the port and the other half passes through the port and on in the same direction in the other guide.

The guides are provided with longitudinal slots **19** and **21**, one slot being positioned in the upper face longitudinal center line of each guide, it of course being understood that these slots may be protected by conventional choke grooves if desired. A metal plate **22** is arranged to slide along the guides above the face **14**, its two edges, such as edge **23**, being bent snugly over the edges of the guide structure so that only longitudinal movement can be imparted to the plate. Two conductive screws, **24** and **26**, are threaded through the plate **22** at such positions as to project through slots **19** and **21** into the interiors of the guides. These screws are at equal distances from the port. The heads of screws **24** and **26** are belted together by an endless steel cable **27**, so that when one of them, such as screw **24**, is rotated by its crank handle **28**, both screws are rotated by like amounts, so that at all adjustments the insertions of the screws into the guides are equal and constitute equal reactances.

The operation of a screw post projecting into a rectangular guide at its center line is well understood. It behaves as a capacitive shunt susceptance varying from zero susceptance at a zero length of projection to maximum susceptance at a length of approximately one-quarter wavelength in free space, becoming inductive at greater lengths. At the maximum susceptance length substantially all of the microwave energy incident upon it is reflected, while at zero length none is reflected. At intermediate adjustments intermediate amounts of energy are reflected, the remainder in each case passing on through the guide.

While the posts **26** and **24** have been described as conductive it will be understood that they can alternatively be made of a low-loss dielectric, since dielectric posts also interpose susceptance, and will partially reflect incident microwave energy in accordance with the depth of insertion.

In the operation of the port serving as a 3-db divider energy may be applied to either guide terminal as, for example, to guide **12** as indicated by the arrow **29**. One-half of the energy then passes through the port and on toward the right in guide **11**. It has been shown that the phase of the voltage of this energy at any point in guide **11** is advanced 90° compared to the phase of the voltage passing to the right in guide **12**.

In the operation of the power divider the slider is set at a selected position and the screw posts are screwed into the guides for equal selected distances. Microwave energy applied to the left end of either guide, as for example, to the left end of guide **12**, then is divided into two halves by the port and each half impinges on one of the posts. At each post the same fraction of the impinging energy is reflected while the remainder passes on to the right in the guide as indicated by arrows **31** and **32**. The reflected energies combine in phase and pass out the left end of guide **11** as indicated by arrow **33**. None of the reflected energy passes to the left in guide **12**, so that no standing waves are generated in this guide, no loss is incurred here, and the microwave generating source is not affected.

The explanation of this behavior is as follows. Input voltage passing through the port is divided in half and advanced by 90° in phase. The post **24** reflects a fraction x of the voltage impinging thereon and one-half of this reflected voltage is again passed through the port with an additional phase advance of 90° to pass toward the left in guide **12**. Its amplitude in terms of input voltage E is therefore $xE/4$ and its phase is 180° relative to E, thus being in phase opposition. One-half of the input

voltage impinges on post **26** and a fraction x is reflected. The magnitude is again halved at the port so that the amount at the input terminal is $xE/4$ with the phase unaffected by the port. It is, therefore of the same amplitude but of opposite phase referred to that reflected from post **24**, so that these reflected voltages completely neutralize each other at the input terminal **29**. Thus since these reflected energies are phase neutralized, they draw no energy from the system and represent no loss.

The energy reflected from post **24** to the left in guide **11** at arrow **33** has a voltage amplitude of $xE/4$ and a voltage phase advance of 90°. The voltage reflected from post **26** has an amplitude of $xE/2$ and, after passage through the port into guide **11**, an amplitude of $xE/4$ and a phase advance of 90°. Thus the two energies passing to the left as represented by arrow **33** have equal amplitude and like phase, and therefore combine. The absolute phase, relative for example to the input voltage phase at any selected point, is dependent upon the positioning of the slider **23**, but this slider positioning has no effect whatever either upon the magnitude of voltages added to form voltage **33** or upon the neutralization of voltages at the input since the screw posts **24** and **26** are always equidistant from the port at all slider adjustments.

The energy passing to the right past the screws and in each guide has a voltage magnitude

$$\frac{E}{2}(1-x)$$

These voltage phases are unaffected by the screw posts, the voltage phase of output energy represented by arrow **31** being advanced by 90° relative to that represented by arrow **32** for all adjustments in concert of the screws **24** and **26** and of the slider **23**. The phase of the output energy **33** relative to the phase of either **31** or **32** is therefore adjustable by slider **23**, and if the slots **19** and **21** have a length of at least one wavelength in guide any desired phase relation can be obtained.

The total energy passing out the three terminals very nearly equals that applied over a relatively wide wavelength band, since none is lost in reflections to the source and since the device is efficient over a relatively wide band of wavelengths. Therefore if the input power be P, the power output at arrow **33** is xP and the sum of outputs at arrows **31** and **32** is $(1-x)P$.

It is obvious that, in place of the reflecting posts **24** and **26**, other reflecting elements may be employed, such as tuned reactive hollow guide stubs as taught in Patent No. 2,685,065, granted to the same inventor. The mechanical arrangement of such stubs to provide control of the phase of one output is, however, not so simple as the arrangement of screw posts.

What is claimed is:

A microwave adjustable power divider and phase adjuster having three output terminals comprising, a pair of parallel hollow rectangular waveguides having a common narrow wall provided with a single port directionally coupling one-half of the power applied to one of said waveguides to the other of said waveguides, slide means transversely spanning said pair of waveguides and movable longitudinally thereon, a pair of screw posts supported by said slide means, each said screw post protruding into the interior of a respective one of said pair of waveguides in the median longitudinal plane thereof and perpendicular to a broad face thereof, said screw posts being in side-by-side relation on the same side of said single port and at the same common distance therefrom, said common distance being adjustable by movement of said slide means whereby the phase of one said outut terminal is controllable relative to the phases of the other two said output terminals, the protrusions of said screw posts into the waveguide interior spaces being adjustable in concert and equal at all adjustments whereby the division of power between one said output terminal and the other two said output terminals is controllable.

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