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REPLY TO ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3,588,751

Government or Corporate Employee : California Inst. of Tech. Pasadena, Calif.

Supplementary Corporate Source (if applicable) : JPL

NASA Patent Case No. : NPO-11031

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes [x] No [ ]
Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

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Enclosure
Copy of Patent cited above

FACILITY FORM 602

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United States Patent

[11] 3,588,751

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Administrator of the National Aeronautics and Space Administration with respect to an invention of;
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[21] Appl. No. 864,097
[22] Filed Oct. 6, 1969
[45] Patented June 28, 1971

[54] **HIGH POWER MICROWAVE POWER DIVIDER**
6 Claims, 6 Drawing Figs.

[52] U.S. Cl. 333/6, 333/7, 333/21A
[51] Int. Cl. H01p 5/12
[50] Field of Search .... 333/6, 8, 9, 21 (A), 24.1, 24.2, 20 (A), 7

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ABSTRACT: A microwave power divider is disclosed wherein microwave energy at a fixed rectangular waveguide input terminal is supplied in variable ratios to a pair of rectangular waveguide output ports of a fixed output orthomode transducer. The energy into the rectangular waveguide input terminal is transduced to the TE_{11} mode in a mode change transducer connected to the input rectangular waveguide. A first quarter-wave plate transduces the energy to a circular polarization mode. A second quarter-wave plate, rotatable with respect to the first quarter-wave plate, transduces the circularly polarized energy to a rotatable linear polarization mode, the angle of polarization being a function of the rotary setting of the second quarter-wave plate. The orthomode transducer, fixed relative to the input terminal, receives the linear polarized output from the second quarter-wave plate. The power into each port of the orthomode transducer is a function of the polarization angle of the linearly polarized energy. The ratio of the power supplied to each output port is therefore controlled by the rotary setting of the second quarter-wave plate.

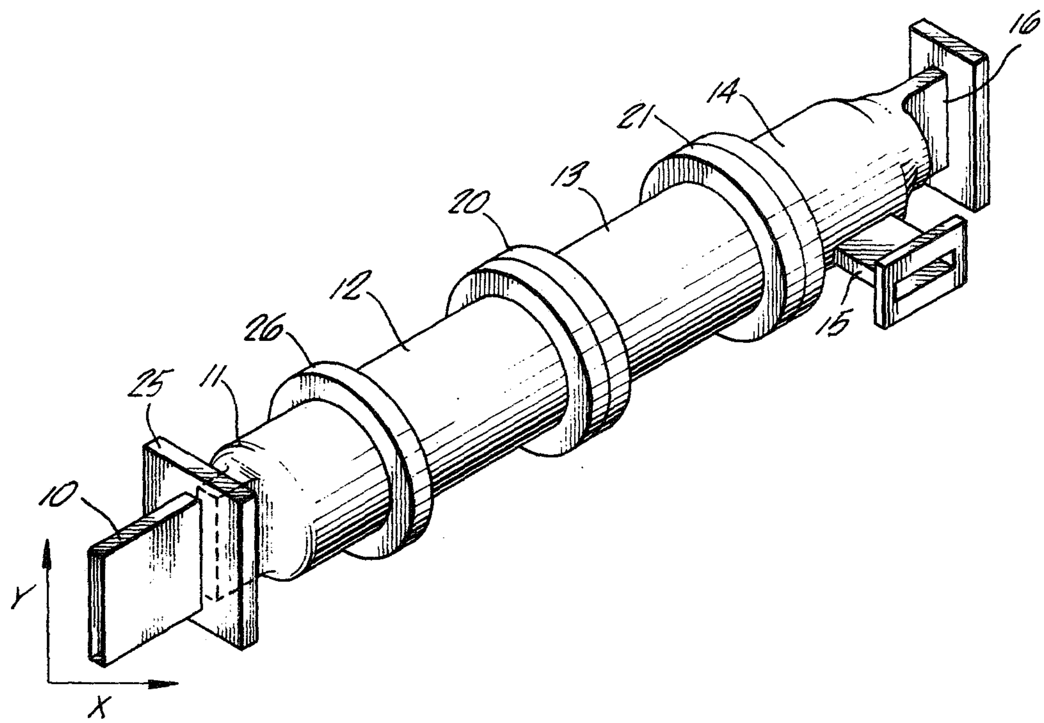

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FIG. 1

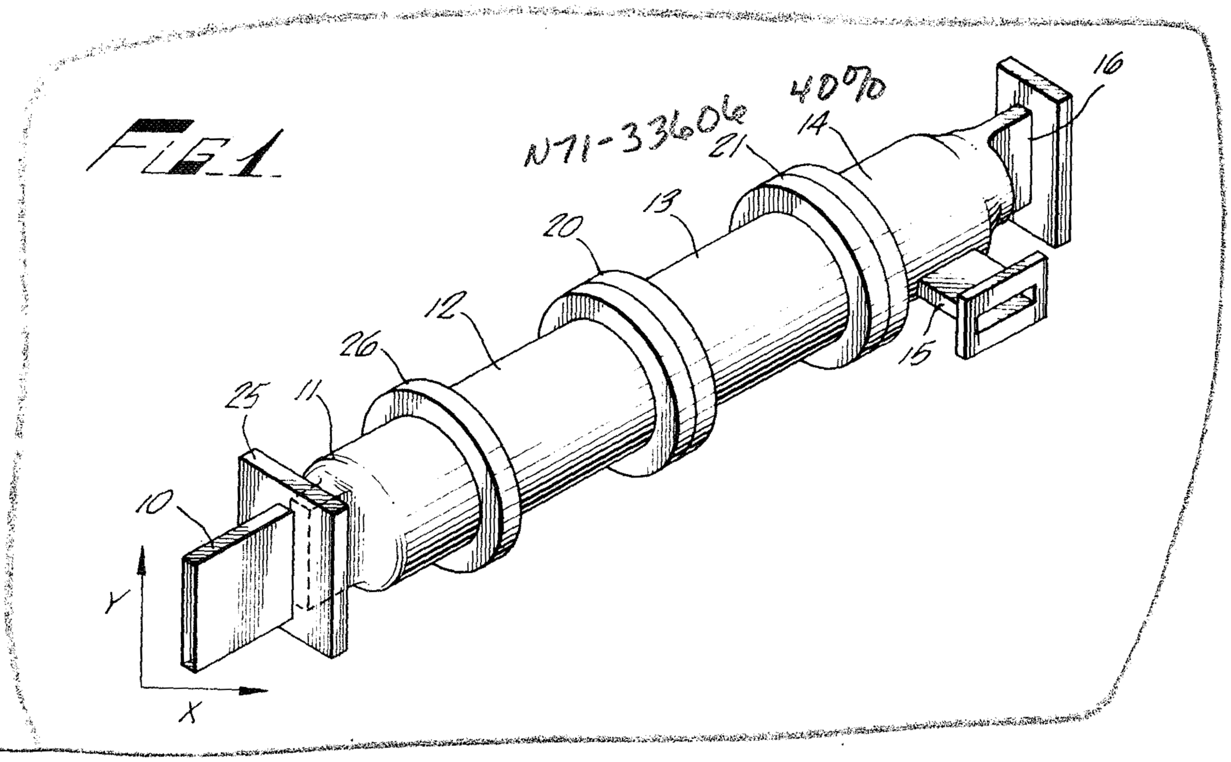


FIG. 2A FIG. 2B FIG. 2C FIG. 2D

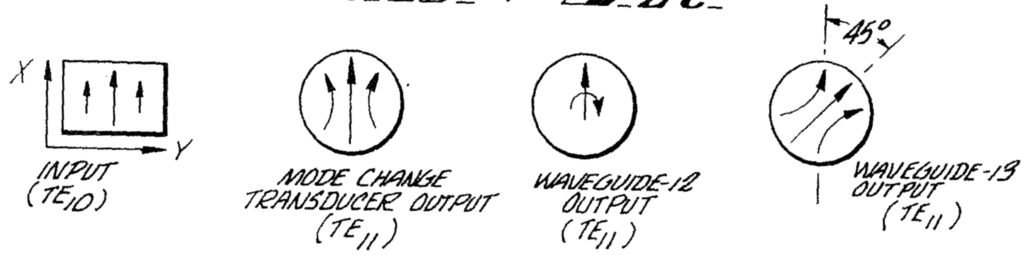
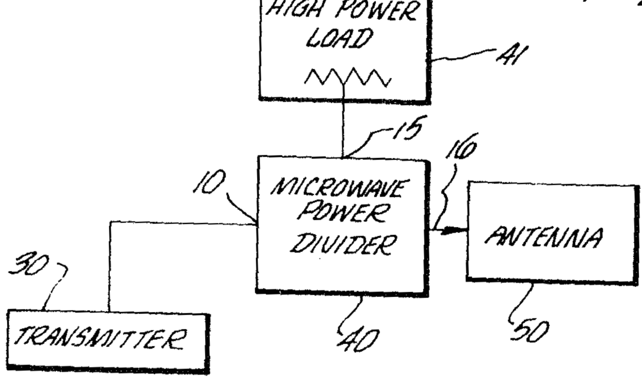


FIG. 3



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HIGH POWER MICROWAVE POWER DIVIDER

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 USC 2457).

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to microwave power dividing device and more particularly to high power microwave power dividers capable of providing variable output power to an output waveguide in a fixed waveguide system.

2. Description of the Prior Art

There is a requirement in certain applications to operate a transmitter at a set level while reducing the amount of power radiated by an associated antenna. This reduction in radiated power is desirable, for example, when a transmitter is part of a vehicular system such as a spacecraft and transmission is made in close proximity to a sensitive receiving station which may be overloaded by full power transmission over relatively small distances. In these and other applications, it is not desirable to reduce the antenna radiating power by reducing the transmitter output level, since such a procedure tends to degrade the bandwidth and modulation characteristics of the transmitter. Rather it is desirable to leave the transmitter power fixed and divide the supplied transmitter power between the antenna and a dissipative load.

To achieve the required power division function use has been made of microwave power dividers which are connected between the transmitter and an antenna load to vary the power delivered to the associated antenna.

Many types of power dividers are known in the art. These dividers are generally of two types. A first type has a rectangular input and a rectangular output waveguide section connected by an intermediate circular waveguide section. Typically, either the input or the output rectangular waveguide section rotates relative to the other section to attenuate the energy delivered to the output waveguide section connected to the antenna. This results, however, in the requirement that a portion of the transmission system connected to the power divider must be capable of rotating with either the input or output waveguide section. This is not desirable since the complicated mechanical couplings required degrade overall system reliability.

To overcome this disadvantage, attempts have been made to develop systems in which neither the input nor output terminal of the power divider is required to rotate. To achieve this, various complicated intermediately connected waveguide configurations interconnecting the input and output ports of the power divider have been developed. The function of these intermediate configurations is to attempt to rotate the electric field of the transmitted energy to attenuate the power passed by the rectangular waveguide output section.

One known device utilizes a rectangular waveguide vertebra section comprising a plurality of vertebra discs connected to the input port. Each disc has a rectangular transmission port which is rotatable so as to be selectively angularly disposed relative to all adjacent discs. The vertebra sections serve to "-skew" the electric vector of the transmitted waveform. This configuration, however, results in overlapping projections between passageways of adjacent vertebra discs. The projections attenuate and distort the energy of the signal being rotated as it passes through the vertebra section.

OBJECTS AND SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a fixed rectangular waveguide system power divider of considerably simpler design than that heretofore available.

A mode change transducer having a rectangular waveguide input port transduces the received TE_{10} mode linearly polarized energy to TE_{11} mode energy. A following first quarter-wave plate transduces the linearly polarized TE_{11} mode energy to a TE_{11} mode circular polarization mode. A following second quarter-wave plate rotatable with respect to the first quarter-wave plate transduces the circular polarized energy to TE_{11} mode linearly polarized energy wherein the angle of polarization is a function of the relative rotation angle between the second and first quarter-wave plate.

The linearly polarized energy thus obtained is applied to an orthomode transducer fixed relative to the input rectangular waveguide. The power into each output port of the orthomode transducer is a function of the polarization angle of the incident wave and is therefore controllable by the rotary setting of the second quarter-wave plate.

It is, therefore, an object of this invention to provide a high-power microwave power divider which includes a minimum of rotatable sections between fixed waveguide input and output sections.

It is another object of the present invention to provide a high-power microwave power divider capable of providing a variable output which is varied by simply rotating an intermediate circular waveguide section while diverting excess power into a dissipative load.

It is a further object of the present invention to provide a novel fixed rectangular waveguide system microwave power divider characterized in that a minimum of moveable components are required between the input and output terminals thereof.

Still other objects, features and attendant advantages of the present invention will become apparent to those skilled in the art from a reading of the following detailed description of several embodiments constructed in accordance therewith taken in conjunction with the accompanying drawings and wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a preferred embodiment of a microwave power divider constructed in accordance with the principles of the present invention;

FIGS. 2A—D illustrate field modes present in various portions of the embodiment of FIG. 1; and

FIG. 3 is a block diagram of a system utilizing the power divider of FIG. 1 wherein energy received from a transmitter output may be attenuated for any adjustable level to an antenna while diverting the excess power into a dissipative load.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown an exemplary microwave power divider constructed in accordance with the principles of the present invention. A rectangular waveguide input section 10 is coupled to a mode change section 11 via a coupling flange 25 of any suitable type.

Input waveguide 10 is adapted to receive linearly polarized energy in the TE_{10} mode as illustrated by field mode diagram 2A, FIG. 2. As is well-known, linearly polarized microwave energy is represented by having an electric field vector along a fixed line. The TE_{10} mode as used in this application refers to the dominant mode of a rectangular waveguide. Although the specific embodiment described utilizes a rectangular waveguide input port the power divider could be used with other configured input ports such as elliptical ports wherein the dominant propagation mode is similar to that in a rectangular waveguide section.

Mode change section 11 may be any known mode change transducer which is adapted to receive linearly polarized microwave energy in the TE_{10} mode and transduce it to linearly polarized microwave energy in the TE_{11} mode as illustrated by field mode diagram 2B, FIG. 2. The mode change section 11 is connected to a first quarter-wave plate 12 via a connecting flange 26. The quarter-wave plate 12 is adapted in a well-known manner to convert the TE_{11} mode linearly polarized energy supplied by mode change section 11 to TE_{11} mode circularly polarized energy as illustrated by field mode diagram 2C, FIG. 2. As is known, circular polarization is represented by a vector representing the wave which has a constant magnitude and rotates continuously about a point.

A second quarter-wave plate 13 is rotatably connected between quarter-wave plate 12 and an output orthomode transducer 14 via rotatable joints 20 and 21. Joints 20 and 21 may be of any suitable type well-known in the circular waveguide art. The rotatable quarter-wave plate 13 converts the TE_{11} circularly polarized energy provided by first quarter-wave plate 12 to linearly polarized energy in a well-known manner wherein the angle of polarization is a function of the rotated position of quarter-wave plate 13. The output for one position of quarter-wave plate 13. The output for one position of quarter-wave plate 13 is illustrated by field mode diagram 2D, FIG. 2.

Orthomode transducer 14 receives the linearly polarized output of second quarter-wave plate 13. Transducer 14 is shown with a pair of orthogonally disposed rectangular waveguide ports 15 and 16. As is well-known in the art, the output energy will be distributed between output ports 15 and 16 in accordance with the angular orientation of the linearly polarized input to orthomode transducer 14.

OPERATION

Assume that 0° is the direction of polarization at input port 10 as shown in FIG. 2A. The mode change section 11 and the first quarter-wave plate 12 transduce the linearly polarized input waveform to a TE_{11} circular polarization mode, as previously described. The second quarter-wave plate 13 transduces the circularly polarized energy to linearly polarized energy which is rotatable through 360° in accordance with the rotated position of quarter-wave plate 13.

Mode FIG. 2D illustrates a specific example wherein the linear polarized output from quarter-wave plate 13 is disposed at an angle of 45° relative to the 0° reference mode FIG. 2A. The amount of power distributed to loads connected respectively to output ports 15 and 16 is therefore a function of the angular position of the second quarter-wave plate 13. The power delivered to output ports 15 and 16 may be determined from the equations

$P_{16}=P_{input} \cos^2 \theta$ (1)

$P_{15}=P_{input} \sin^2 \theta$ (2)

where θ is the angular orientation of the quarter-wave plate 13 with respect to quarter-wave plate 12. The attenuation from input port 10 to output port 16 may be given as:

$A_{(db)}=\log \cos^2 \theta$ (3)

$A_{(db)}=\log \cos \theta$ (4)

Since attenuation is clearly a function only of the angular position of quarter-wave plate 13, the proportion of input power delivered to output ports 15 and 16 respectively is completely determined by controlling the rotated position of quarter-wave plate 13.

Referring now to FIG. 3, there is shown a block diagram of a microwave transmission system constructed in accordance with the principles of the present invention. As shown in FIG. 3, a microwave transmitter 30 is connected to an antenna 50 via microwave power divider 40. Power divider 40 in accordance with this invention receives linearly polarized microwave energy at input port 10 and is adapted as above-described to divide the output energy in accordance with any desired output ratio between output ports 15 and 16.

Output port 16 provides the energy supply to antenna 50. Output port 15 is connected to a high-power dissipative load 41. The embodiment of FIG. 3 is adapted to allow the full transmitter output to be supplied to the antenna or to allow any fractional proportion of the transmitter output power to be dissipated in the high-power load. The high load termination 41 is selected so that it may dissipate the full power output cable of being supplied by divider 40. Such a dissipative characteristic for load 41 allows the power supplied to antenna 50 to be varied over any desired amount without degrading the bandwidth modulation or other characteristics of the transmitter, since the impedance as seen by the transmitter 30 never varies. This is so since all power supplied by the transmitter is dissipated by the antenna-dissipative load combination without any power being reflected back to the transmitter.

We claim:

1. A device for receiving polarized microwave power and variably orienting the electric vector of said microwave power comprising:
   first microwave guide means receiving said polarized microwave energy in a dominant mode for converting said energy to linearly polarized microwave energy in a TE_{11} mode;
   second microwave guide means including a first quarter-wave plate and receiving said linearly polarized TE_{11} mode energy for providing a TE_{11} mode circularly polarized energy output, said output having a predetermined angular phase at the output portion of the second guide means; and
   third rotatable microwave guide means including a second quarter-wave plate and receiving said TE_{11} mode circularly polarized energy for providing a TE_{11} mode linearly polarized output, the angle of the electric vector of said third guide means linearly polarized output being variable with respect to the predetermined output of said second microwave guide means as a function of the relative rotated angle of said third microwave guide means relative to said second means.

2. The device of claim 1 further comprising an orthomode transducer fixed with respect to said first microwave guide means, said orthomode transducer receiving the output of said second quarter-wave plate, said transducer having first and second orthogonal output ports whereby the microwave energy into each port is a function of the polarization angle of said third guide means linearly polarized output.

3. The device of claim 2 further comprising an antenna connected to receive the output of said first output port.

4. The device of claim 3 further comprising: a dissipative load connected to receive the output of said second output port.

5. A microwave power divider for providing controllable proportions of available microwave energy at first and second output ports, said power divider comprising:
   an input waveguide adapted to receive linearly polarized microwave energy;
   a first circular waveguide serially connected to said input waveguide for receiving said linearly polarized microwave energy therefrom, said first circular waveguide including a first quarter-wave plate for converting the linear polarization of said energy to a circular polarization;
   a second circular waveguide serially connected to said first circular waveguide for receiving said circular polarized microwave energy therefrom and adapted to be rotated with respect to said first circular waveguide in a direction tangential to the longitudinal axis of said power divider, said second circular waveguide including a second quarter-wave plate for converting the circular polarization of said energy to a linear polarization, having a plane of polarization that is controlled by the rotation of said second circular waveguide; and
   an output waveguide serially connected to said second circular waveguide to permit said rotation thereof and for receiving linearly polarized microwave energy therefrom, said output waveguide including said first and second output ports, said first output port being aligned parallel to said longitudinal axis, said second output port being positioned orthogonal to said longitudinal axis.

6. The apparatus defined by claim 5 wherein said input waveguide and said first and second output ports are rectangular waveguides, having a long and a short transverse dimension, the long transverse dimension of said input waveguide and said first output port being mutually aligned.