United States Patent

Thomas

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[54] COAXIAL HYBRID JUNCTION DEVICE HAVING IMPEDANCE MATCHED TERMINATIONS

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[21] Appl. No.: **60,385**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 790,990, Jan. 14, 1969, abandoned.

[52] **U.S. Cl.** .....**333/11,** 333/33, 333/97 R

[51] **Int. Cl.**.....**H01p 5/12,** H03h 7/38

[58] **Field of Search** 333/11, 10, 33, 97

[56] **References Cited**

UNITED STATES PATENTS

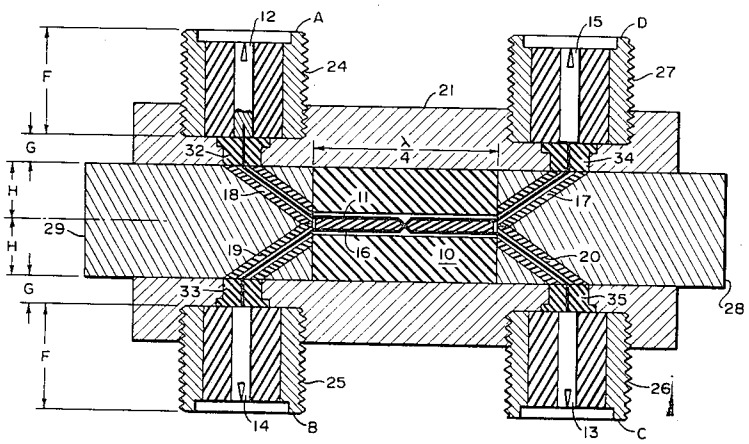
3,358,248	12/1967	Saad	333/10
3,264,582	8/1966	Hopfer	333/10
3,105,207	1/1962	Capewell et al.	333/10
2,679,632	5/1954	Bellows, Jr.	333/10

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Assistant Examiner—Marvin Nussbaum
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[57] **ABSTRACT**

A coaxial hybrid junction device employs an outer conductor through which extends a pair of center conductors which are side by side for a distance of approximately a quarter wavelength. The outer conductor is lined for the quarter wavelength distance by an insulative sleeve having a central longitudinal aperture in which the side by side center conductors are situated. The insulative sleeve is thick compared to the insulation between the center conductors. Coaxial connectors are mounted on the outer conductor. Each end of a center conductor is connected to the center pin of a different connector. A portion of the center conductor between the sleeve and the connector pin extends through a slanting channel in a plug to form a coaxial line that provides an electrically smooth path for coupling signals into and out of the hybrid junction by maintaining the characteristic impedance of the coaxial line substantially constant from the connector to the hybrid junction.

2 Claims, 6 Drawing Figures



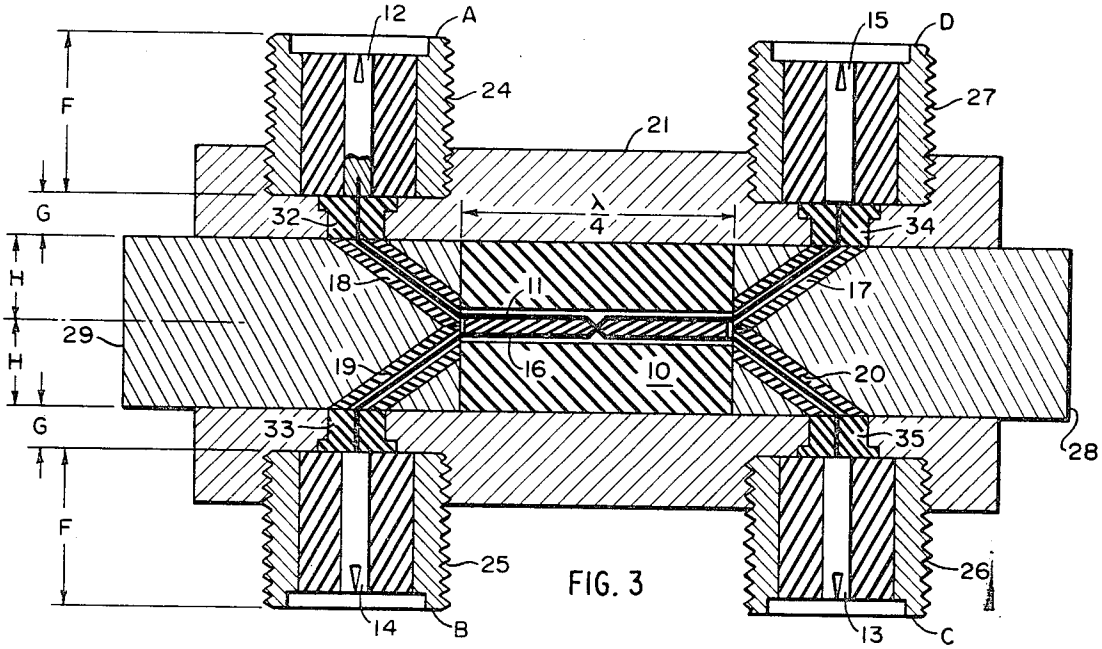


FIG. 3

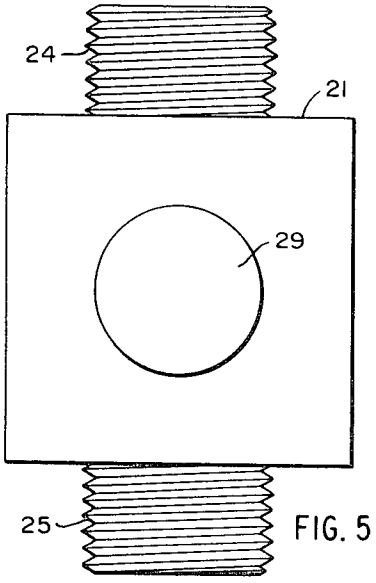


FIG. 5

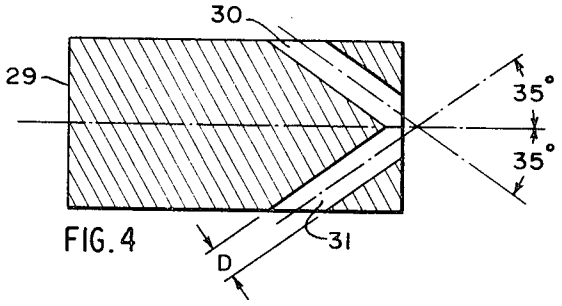


FIG. 4

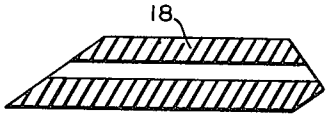
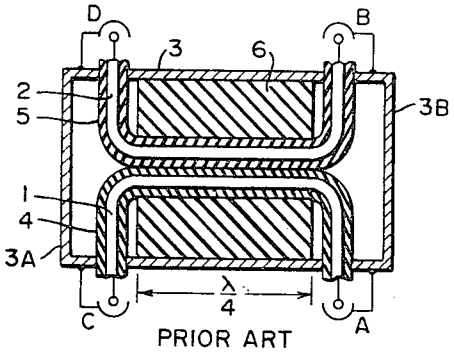
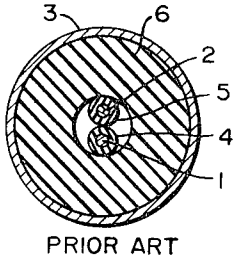


FIG. 6



PRIOR ART
FIG. 1



PRIOR ART
FIG. 2

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COAXIAL HYBRID JUNCTION DEVICE HAVING IMPEDANCE MATCHED TERMINATIONS

This is a continuation-in-part of my copending patent application Serial No. 790,990, now abandoned, filed in the United States Patent Office on Jan. 14, 1969.

The present invention relates in general to coaxial line devices. More particularly, the invention pertains to a coaxial hybrid junction device that is an improvement upon the coaxial hybrid disclosed in U.S. Pat. No. 3,358,248.

BACKGROUND OF THE INVENTION

A hybrid junction, as is well known, is a circuit or device having four pairs of terminals arranged to cause a signal entering at one terminal pair to divide and emerge from two terminal pairs while, in the ideal device, none of the signal couples to the remaining terminal pair. In U.S. Pat. No. 3,358,248, there is described a coaxial hybrid junction in which the insulated center conductors extend side-by-side for a quarter wavelength in a manner permitting those conductors to be substantially coaxial with the outer conductor. While that hybrid performs satisfactorily, it has been found that its performance can be improved by reducing impedance discontinuities which occur in coupling signals into and out of the hybrid junction.

OBJECTS OF THE INVENTION

Accordingly, the principal object of the invention is to provide a hybrid junction device having improved means for coupling signals into and out of the junction which reduce impedance discontinuities in the signal transmission paths. A subsidiary object of the invention is to provide such means in a manner which permits the improvement to be inexpensively embodied in the hybrid junction device.

THE INVENTION

The invention resides in a coaxial line arrangement between the hybrid junction and the coaxial connector which insures that the coaxial line connection is substantially free of impedance discontinuities to provide an electrically smooth path that does not cause wave energy reflections. The hybrid junction is approximately a quarter wavelength long and utilizes a pair of side-by-side center conductors which are insulated from one another and are centrally situated in a thick insulative sleeve lining the outer conductor of the coaxial line. Somewhat removed from the hybrid junction are coaxial connectors which are mounted on extensions of the outer conductor. Each center conductor has its ends connected to the center pins of different connectors. The portion of the center conductor between the hybrid junction and the connector pin extends through a slanting channel in a plug to form a coaxial line that has a substantially constant characteristic impedance. The channel in the plug is lined with an insulative sleeve and the plug is, electrically, an extension of the outer conductor of the coaxial line. Each end of the outer conductor has a plug in it and each plug has two slanting channels which diverge in the direction proceeding away from the hybrid junction toward the connectors. Thus, the center conductors diverge sharply where they emerge from the hybrid junction.

THE DRAWINGS

The invention, both as to its operation and its construction, can be better understood from the following exposition when considered in conjunction with the accompanying drawings in which:

FIG. 1 is a vertical cross-section of the device upon which the invention is an improvement;

FIG. 2 is a section taken along the parting plane 2—2 of FIG. 1;

FIG. 3 is a vertical cross-section of the preferred embodiment of the invention;

FIG. 4 depicts the slanting channels in the end plug employed in the preferred embodiment;

FIG. 5 is an end view of the preferred embodiment of the invention utilizing a square shaped outer conductor; and

FIG. 6 depicts an insulative lining used in the slanting channel.

THE EXPOSITION

Referring now to FIG. 1, of the drawings, there is shown a coaxial hybrid of the kind disclosed in U.S. Pat. No. 3,358,248. Essentially the hybrid has a pair of center conductors 1 and 2 which are substantially coaxial for a distance of a quarter wavelength ($\lambda/4$) with the outer conductor 3. As indicated in FIG. 2, the outer conductor 3 is cylindrical and is closed at its ends, as depicted in FIG. 1, by circular caps 3A and 3B. The center conductors extend through an insulative sleeve 6 which lines the interior of the outer conductor for the quarter wavelength distance. The center conductors, being contiguous, are prevented from shorting together by a thin layer of insulation. The thickness of the sleeve 6 is many times greater than the thickness of the insulation separating the center conductors. For convenience, both center conductors are shown as having insulation 4, 5 bonded to them; it is, however, necessary only to insure that the two center conductors are separated by a layer of insulation which is of uniform thickness over the quarter wavelength distance. For that quarter wavelength, the impedance of the coaxial lines is constant. However, impedance discontinuities occur where the center conductors 1 and 2 emerge from the annular insulating wafer 6 and bend toward terminals A, B, C, and D. Those impedance discontinuities cause reflections of wave energy which degrade the electrical performance of the device.

FIG. 3 depicts, in section, an embodiment of the invention which is an improvement over the FIG. 1 coaxial hybrid device. In the FIG. 3 embodiment, the central quarter wavelength $\lambda/4$ section is essentially identical with the corresponding central $\lambda/4$ section of the FIG. 1 device. The four terminal pairs in the FIG. 3 embodiment are designated A, B, C, D and are represented as the female portions of conventional coaxial connectors of 50 ohm impedance. When the terminal pairs are terminated in reflectionless terminations, energy applied to terminal A, for example, divides equally between terminals B and C, while virtually no energy couples to terminal C. The wave energies proceeding to terminals B and C are in phase quadrature with respect to each other. Conductor 11 connects center pin 12 of terminal A to the center pin 13 of terminal C. Conductor 16 connects center conductor pin 14 of terminal B to the center pin 15 of terminal D. Conductors 11 and 16 extend side-by-side through the center of insulative sleeve 10 which lines the inside of housing 21. The conductors 11 and 16 couple to one another for approximately one-quarter wavelength $\lambda/4$, or an odd multiple thereof, where λ is the wavelength at the center frequency in the operational range of the device. The housing 21 acts as the outer conductor of the coaxial line for the $\lambda/4$ hybrid region. The housing also has the outer conductors 24, 25, 26, 27 of the coaxial connectors threaded into it.

In the region designated F, the impedance of the coaxial line is the impedance of the connector, which is here taken to be 50 ohms. To avoid discontinuities, the impedance is maintained substantially unchanged through regions G and H, up to the $\lambda/4$ hybrid region.

The characteristic impedance of a coaxial line is given approximately by the equation

$$Z = \frac{138}{\sqrt{e}} \log \frac{D}{d}$$

where

Z is the characteristic impedance,

e is the dielectric constant of the medium in the line,

D is the internal diameter of the outer conductor,

d is the diameter of the inner conductor.

Where the medium in the line has a fixed dielectric constant and the diameter d of the inner conductor changes, the characteristic impedance can be maintained at a fixed value by altering D, the internal diameter of the outer conductor to compensate for the change in d.

The diameter of center conductors 11 and 16 is less than the diameter of the center pins 12, 13, 14, 15. In the FIG. 3 embodiment, the ends of center conductor 11 are secured in pins 12 and 13; the ends of center conductor 16 similarly are secured in pins 14 and 15. As indicated in FIG. 3 by pin 12, each pin has a central bore which accepts the end of the center conductor and the connection is made fast by soldering or crimping. In the H zone, the center conductors 11 and 16 extend through channels 30, 31 in the end plug 29 which acts as the outer conductor of the coaxial lines, As indicated in FIG. 4, each channel 30, 31 is a cylindrical bore whose center line is at an angle of 35° with respect to the longitudinal axis of the plug. Each channel is lined with an insulative sleeve 18 or 19, such as is shown in detail in FIG. 6, through which the center conductors 11 and 16 extend. The diameter *D* of channels 30 and 31 is chosen to retain the characteristic impedance of the coaxial line in zone H at 50 ohms. Thus with an inner conductor 0.020 inch in diameter and using a sleeve of Teflon, a diameter D of 0.067 inch gave the desired 50 ohm impedance. The 35° angle of the channels 30, 31 was chosen merely because it was a convenient angle, there being no reason why a greater or lesser angle could not be used for the diverging center conductors 11 and 16 in the H zone.

The plug 28, at the other end of casing 21 is essentially the same as plug 29 and therefore is not described in detail. The plugs 28, 29 close the ends of housing 21 in a manner insuring good electrical contact between the plugs and the casing.

In the G zone, the ends of conductors 11 and 16, emerge from sleeves 17, 18, 19, 20 and are bent to enter straight into pins 12, 13, 14 and 15. To maintain the 50 ohm characteristic impedance, the ends of the center conductors in the G zone extend through sleeves 32, 33, 34, and 35 which fill bores in the casing 21. Where the sleeves 32, 33, 34 and 35 are of the same dielectric material as sleeves 17, 18, 19 and 20, the bores in the casing are of the same diameter *D* as the channels in plugs 28 and 29.

In an embodiment of the invention that was constructed to obtain 3 db coupling, it was ascertained that the coupling over the frequency range 8 to 12.4 GH_z was 3 db ± 0.6 db while the voltage standing wave ratio (VSWR) did not exceed 1.35 over that entire range.

An important feature of the invention is the definiteness with which the coupled center conductors 11 and 16 are decoupled at finite, ascertainable positions. In the illustrated embodiment, the decoupling occurs at the plugs 28 and 29 where the center conductors diverge at 70° angles. The angle of divergence can be increased if more pronounced decoupling is desired. The plugs 28 and 29, while providing the divergence decoupling also act to provide substantially reflectionless transmission by maintaining the characteristic impedance of the diverging coaxial lines at the desired value.

While in the preferred embodiment, the device is designed for 50 ohm impedance termination at each of the four paths, it is apparent that the device can be modified to accommodate impedances of other values. Further, if one or more of the ports were designed for any other impedance level, the G and H zones could be readily changed to attain substantially reflectionless transmission by incorporating impedance transforming components in those zones. In the G and H zones, the dielectric sleeves can be selected to achieve the correct impedance levels.

An important feature of the invention is its adaptability to accommodate terminal pairs at different locations on the casing while providing substantially reflectionless transition between the coupled center conductors and the terminals. In the FIG. 3 embodiment, the terminal pairs are brought out at diametrically opposed locations on the casing 21. For example, in FIG. 3, connectors A and B are aligned respectively with connectors D and C. If desired, any of those connectors may be arranged to be in space quadrature (viz., at right angles) to any of the other connectors. In the illustrated embodiment, the center conductors 11 and 16 are depicted, in the hybrid junction region as being separated by a thin layer of insulation and crossing over one another at the mid-point of the hybrid junction region. It is to be understood that the center conductors are separated by insulation along the entire length of the hybrid junction region and that those center conductors are crossed simply to have them terminate at the desired connectors.

Although in the preferred embodiment, the conductors are shown to be coaxial lines of the conventional round form, the invention can be adapted to utilize conductors which are square, rectangular or of ther forms. Other modifications and departures from the specific embodiment described herein may be practiced by those skilled in the art without departing from the essential inventive concept.

In FIG. 5, the outer conductor 21 is shown to be a square block having a central cylindrical aperture in which the plugs 29 and 28 are received. It is at once obvious that the outer conductor need not be a square block but can be of circular or other form.

It is to be understood that the center conductors 11 and 16, shown in FIG. 3, completely fill sleeves 17, 18, 19, 20. To more clearly depict the invention, the diameter d of the center conductors has been reduced somewhat in that figure to better show the disposition of those center conductors.

In view of the various forms in which the invention can be embodied, it is not intended that the invention be limited to the precise embodiment here illustrated and described. Rather, it is intended that the invention be delimited by the appended claims and include only those devices which utilize the invention.

What is claimed is:

1. In a coaxial hybrid junction device of the type having
an outer conductor,
a pair of center conductors extending side-by-side within the outer conductor for a distance of approximately a quarter wavelength $\lambda(-)/4$, where λ is the wavelength at the mean frequency in the operational band of the device, the side-by-side conductors being insulated one from the other,
an insulative member lining the interior of the outer conductor for the quarter wavelength distance, the insulative lining member having a central longitudinal aperture in which the side-by-side conductors are situated, the insulative sleeve being thick compared to the insulation between the center conductors, and
coaxial connectors mounted on the outer conductor, each coaxial connector having its center pin connected to a different end of the center conductors,
the improvement comprising
plugs positioned in the outer conductor at opposite ends of the lining member, each plug being connected to the outer conductor and being at the same electrical potential therewith, each plug having two channels in it diverging from the central aperture in the adjacent end of the lining member and providing a slanting passage from the central aperture in the lining member to a different one of the coaxial connectors, and
the center conductor connected to each coaxial connector extending through a different one of the slanting channels to form a coaxial line which provides an electrically smooth path for coupling signals into and out of the hybrid junction.

2. The improvement according to claim 1, further including
an insulative sleeve lining the entire extent of each slanting channel and the center conductor extending through the insulative sleeve.

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