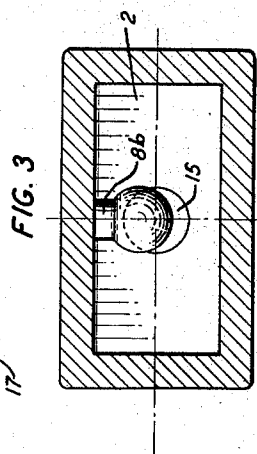
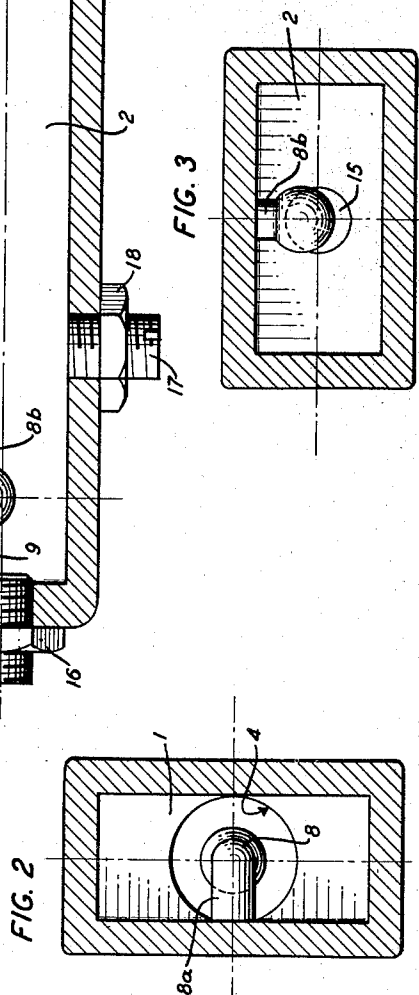
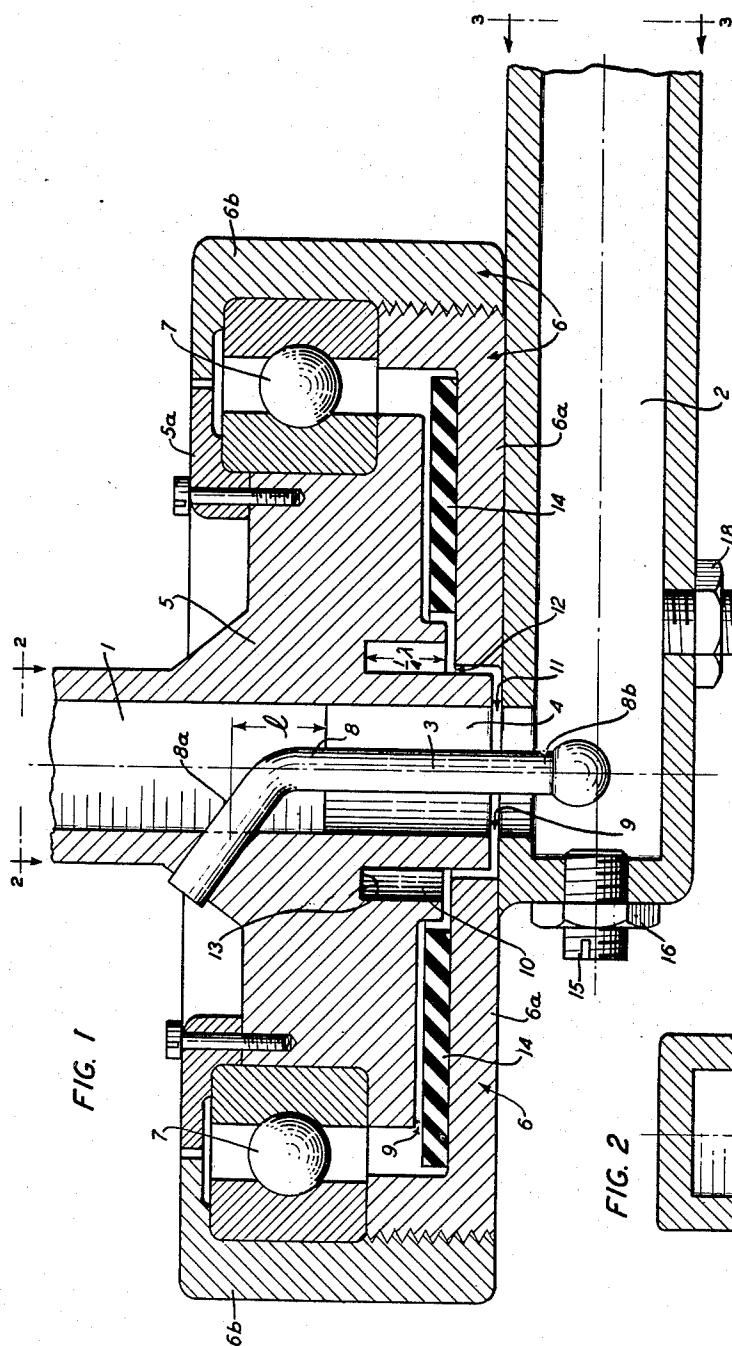


Nov. 29, 1960

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WAVE GUIDE JOINT
Filed Oct. 4, 1945

2,962,677



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WAVE GUIDE JOINT

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Filed Oct. 4, 1945, Ser. No. 620,349

9 Claims. (Cl. 333—27)

This invention relates to wave guides.

An object of the invention is to provide a coupling between two wave guides which extend at an angle to one another and one of which is rotatable with respect to the other, which is effective for transmission of electrical energy, which has a substantial band width of transmission, and which will transmit considerable power without undue sparking or impairing of the bearings which are provided for permitting or causing the relative rotation.

Another object is to transfer wave energy of a given mode from one fixed guide to another rotary with respect thereto.

Another object is to produce a wave guide joint of desirable electrical transducing properties in all positions and rigid and having effective mechanical support which will permit free rotation.

A feature is the avoidance of the use of dielectric material to support the inner conductor of the coaxial line used in the joint or to support other parts of the structure.

An exemplary embodiment of the invention as described herein may be better understood from the accompanying drawings in which:

Fig. 1 comprises a sectional view through two wave guides and the interconnecting joint;

Fig. 2 is a cross-section of one guide looking toward the joint within the guide; and

Fig. 3 is a cross-section of the other wave guide looking toward the joint within the guide.

The wave guide 1 is preferably rectangular and the wave guide 2 is also rectangular in internal cross-section. In the embodiment illustrated it is contemplated that the transmission in each guide will consist of wave energy of the mode commonly termed the $TE_{0,1}$ (sometimes designated in accordance with later nomenclature $TE_{1,0}$) mode; however, the general electrical and structural principles residing in the invention are not limited to the specific embodiment illustrated.

The wave guide 1 is rotatable about its longitudinal axis with respect to the wave guide 2; the two guides being intercoupled for inter-transfer of electrical energy in either direction as may be desired in any relative position of rotation with the same efficiency. The guides may extend any desired distance from the joint and may be continued in length by added sections and may ultimately terminate in any desired known type of wave generating or wave utilizing devices.

The cross-sections of the guides preferably are rectangular as stated and their cross-sectional internal dimensions in a specific embodiment were in the ratio of about 2.25 to 1. The selection of dimensions appropriate for a particular mean wave-length is well known in the art. The coupling element may be considered to be a piece of coaxial line 3, 4 of which the central conductor 3 is accurately centered with respect to the surface 4 which constitutes the outer conductor.

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The wave guide 1 including the coaxial line outer conductor 4 is either continuous with or integral with a block 5 which may be constructed in the form of a two-part machined casting fastened together by suitable means. The machined casting consists of a body portion 5 with a ring portion 5a screwed thereto by machine screws as shown. In the specific embodiment the block 6 consists of a main body portion 6a, having a ring portion 6b screwed thereto. Soldered, brazed, welded or otherwise attached to the block 6a, 6b is the wave guide 2. The block 5 rotates with respect to the block 6a, 6b and the wave guide 2 on bearings which are preferably in the form of ball bearings 7 mounted in a conventional ball raceway allowing free rotary motion between the block 5 and a block 6a, 6b which is continuous with, attached to or integral with the wave guide 2.

The conductor 3 has a continuation in the form of a probe 8b extending from a portion 3 into the wave guide 2. The probe is terminated in a spherical ball; its extension into the guide 2 is transverse to the wide dimension and for a distance hereinafter stated. A straight portion 8 of the combined probe and conductor extends coaxially from the coaxial line into the central portion of the wave guide 1 and the bent portion 8a is solidly fastened into an opening in the wall of guide 1 by means of soldering, welding or brazing, or in any other suitable manner to produce a joint of negligible electrical resistance. The connection of extension 8a is made to the exact center of the wider wall of the wave guide.

In a structure of this kind a difficulty arises from energy passing into and effecting the bearings 7 and special features of construction are employed not only to reduce energy loss but also for the purpose of preventing electrical sparking or other detrimental action of the electric waves upon the bearings. In order that the parts may rotate freely it is necessary that there be some clearance between the block 5 and the block 6 which gives rise to a necessary small passageway 9 through which electric energy will pass at the ultra-high frequencies for which a device of this kind is intended to be used.

As one of the means for reducing the wave energy passing to the bearings, there is included a wave trap in the form of a toroidal-shaped chamber 10. Furthermore, I have found that the distance from the opening 11 to the opening 12 should be one-quarter wavelength. It is, however, of especial importance that the total distance from the gap opening 11 to the shorting point 13 be one-half wavelength. The vertical dimension of this chamber 10 is made approximately one-quarter of the wavelength at the mean frequency at which the device is to be used. The chamber 10 therefore functions as a wave trap. The clearance of the narrow portion 11, 12 is made as small as convenient to give this passage a low characteristic impedance to wave energy and the chamber 10 is made wide to render it of higher characteristic impedance than that of the passageway 11 but it is still of low impedance in the generally accepted use of the term. It has been found that additional means are necessary or desirable to further reduce wave energy passing to the bearings 7 and for this reason additional wave attenuating means are provided. This additional attenuating means as here embodied comprises a ring 14 of high loss dielectric material in the passageway 9. This ring 14 is thick enough to almost but not quite fill the passageway. The width of this ring may be quite considerable thereby leading to effective attenuation of the wave energy. A suitable dielectric material consists of iron or similar magnetic material in extremely finely divided form and dispersed through a solid molded block of phenol con-

densation product; other substances or compositions of similar properties may be used. The passage 9 may contain additional bends and be branched into additional wave trap chambers either inside or outside of the part of the passage which is lined with material 14. The trap 10 is typical and illustrative. In some cases and in similar and analogous structures another wave trap may be located at the outer end of passage 9.

Using the smaller inside dimension of the guide 1 as a unit base of comparison the diameter of the knob on the end of conductor 3 may be $\frac{1}{2}$ unit; the diameter of conductor 3 slightly less than $\frac{1}{4}$ unit; the inner diameter of the outer conductor of the coaxial line 3, 4, one unit; the total extension of conductor 3 into guide 2, 0.62 unit; the dimension l , $\frac{3}{4}$ unit; the radius of the bend in 8, $8a$, $\frac{1}{2}$ unit, and the angle of bend of the straight portion 8 away from a straight line to make the portion $8a$, 55 degrees. The length of the coaxial line is not critical. The width of chamber 10 may be $\frac{1}{4}$ unit; the width of passage 11, 12, $\frac{1}{16}$ unit; the total thickness of dielectric 14 plus the clearance space above it, $\frac{1}{4}$ unit, and the clearance space quite small.

The effectiveness of a joint of this kind depends considerably upon the relative dimensioning of the parts with respect to each other, having due consideration to the mean wavelength of the band which one wishes to transmit and also having due regard to the width of the band which one wishes to transmit in an effective manner.

The structure may be arranged into a coupling between a wave guide and a coaxial line fixed with respect thereto and another coupling between a coaxial line and a wave guide rotatable with respect thereto.

Assuming that in the case of a particular wavelength to be used in a particular wave guide of preestablished dimensions the best distance l and the best angle of bend of the member 8, $8a$ are to be determined in order to give a wide band of transmission, these dimensions may be determined experimentally by making several elements 8, $8a$ with assorted lengths l and several for each length l with assorted angles of bend between 8 and $8a$. These may then be successively mounted in a longitudinal slot in the wall of guide 1 of a model structure for experimental determination of the best combined length and angle. The factors involved are considered too complex for determination by mathematical solution. The reasons why this structure is wider in band width than other possible arrangements are abstruse.

Upon ascertaining the rate of change of the standing wave ratio in decibels for changes in the length, the best length may be ascertained, and then by ascertaining the rate of change of the standing wave ratio at the best length for changes in the angle, the best angle may be ascertained. With this structure only permissibly small changes of about 2 decibels in standing wave ratio are noted for wavelengths departing as much as ten per cent from the mean wavelength, thereby manifesting that the device is a wide band wave transducer. In other words, its transmission of power is down less than fifteen per cent at ten per cent departure from the mean frequency of the band. The transmission band width is therefore quite remarkable.

A tuning plug 15 is screwed into the end of guide 2 and, after adjustment, is locked by a locknut 16; the adjustment required is a function of the wavelength; the total distance from the center of the sphere to the end of the guide may be around one-quarter wavelength. Another tuning plug 17 with locknut 18 may be located as indicated. The functions of the tuning plugs are largely for the purpose of trimming the effective dimensions to take care of incidental manufacturing variations.

The relative rotation of the wave guides may be accomplished in any desired manner, as by hand power or motors, and may be continuous or reciprocal, depending upon the particular purpose of the apparatus in which the joint is to be employed.

For the purpose of this specification the expression "wave guide" relates to a device for transmitting energy by means of electromagnetic waves of the kind described as such in Chapter 14 of a book entitled Ultra-High Frequency Techniques by Brainerd, Koehler and Woodruff, published by D. Van Nostrand Company, Inc., copyrighted 1942 and reprinted in December 1943.

What is claimed is:

1. In combination, two electromagnetic wave guides located at an angle to each other, a coupling element therefor comprising a section of coaxial line, the central conductor of the coaxial line terminating in a stub end in one wave guide and extending along a line running through the geometric center of the other wave guide and being grounded electrically on the wall of the other wave guide by an obtuse angled bend.

2. In combination, two wave guides having their elongated axes located in planes which planes are not parallel to each other, a coupling element for coupling said guides in energy transfer relation comprising a section of coaxial line, the central conductor of the coaxial line terminating in a stub end in one wave guide and being grounded electrically on the wall of the other wave guide by an obtusely bent end conductively connected to said wall.

3. A coaxial line terminating in a wave guide and having its central conductor extending along a line running through the geometric center of said wave guide, and bent at an obtuse angle of substantial obtuseness and firmly conductively affixed to the wall of the guide to establish an electrical connection to the wall of the guide.

4. A rotary joint for wave guides comprising a wave energy transducing chamber, a bearing structure upon which one guide rotates with respect to the other and means for keeping wave energy away from the bearing structure comprising an annular passage of low impedance to wave energy, an annular chamber of one-quarter wavelength functioning as a wave trap and being of high impedance, and a further passageway almost but not quite filled with an annular body of dielectric material of great energy absorbing power having a small clearance space adjacent thereto.

5. In combination, a first wave guide, a second wave guide, the second wave guide being rotatable about an axis parallel to its length which axis is at an angle to the longitudinal axis of the first named wave guide, and a short section of coaxial line intercoupling said wave guides for transfer of energy therebetween, the inner conductor of the coaxial line continued into and having its end portion bent at an obtuse angle and conductively affixed to said second named wave guide.

6. In combination, two wave guides which extend at an angle to each other, a section of coaxial line for intercoupling said guides, said section of coaxial line including a central conductor physically fixed in relation to one of said wave guides, said one wave guide being freely rotatable about its long axis, a bearing structure upon which said guide rotates, and means including an annular wave trap and annular wave energy dissipating means for shielding said bearing structure from wave energy transducing said guides.

7. In combination, a wave guide rotatable about its long axis with respect to a fixed structure for intertransferring wave energy between said guide and structure through intercoupling means, a bearing upon which said rotation occurs, means for reducing wave energy leaking from the guide to the bearing through the space between the guide and structure comprising a high impedance and slightly dissipative wave trap opening into said space and offering high impedance to wave energy passing there-through, and means in said space beyond the wave trap comprising highly dissipative wave attenuation means, whereby passage of leaking wave energy is first reduced by a non-dissipative trap and energy passing beyond the

trap is further attenuated by said highly dissipative attenuation means.

8. A coupling for connecting two wave guides for wide band transmission with small losses due to reflected waves throughout the band comprising sections of the two wave guides to be coupled lying at an angle to each other with respect to the direction of wave energy through each thereof, a section of coaxial line having an outer conductor and an inner conductor located between said sections, the central conductor of the coaxial line being parallel to the direction of transmission of wave energy through one guide and extended therinto and having its end bent at an obtuse angle and conductively affixed to the wall of the guide, and said central conductor being extended into the region bounded by the walls of the other guide with respect to which it extends at an angle to the direction of wave energy transmission, and wherein the coaxial line is sufficiently short that the sole support of the central conductor is the said conductive affixation.

9. A coaxial line terminating in a wave guide and having its central conductor extending along a line running through the geometric center of the guide, and bent at an obtuse angle closely approximating 125 degrees and firmly conductively affixed to the wall of the guide to establish an electrical connection to the wall of the guide.

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