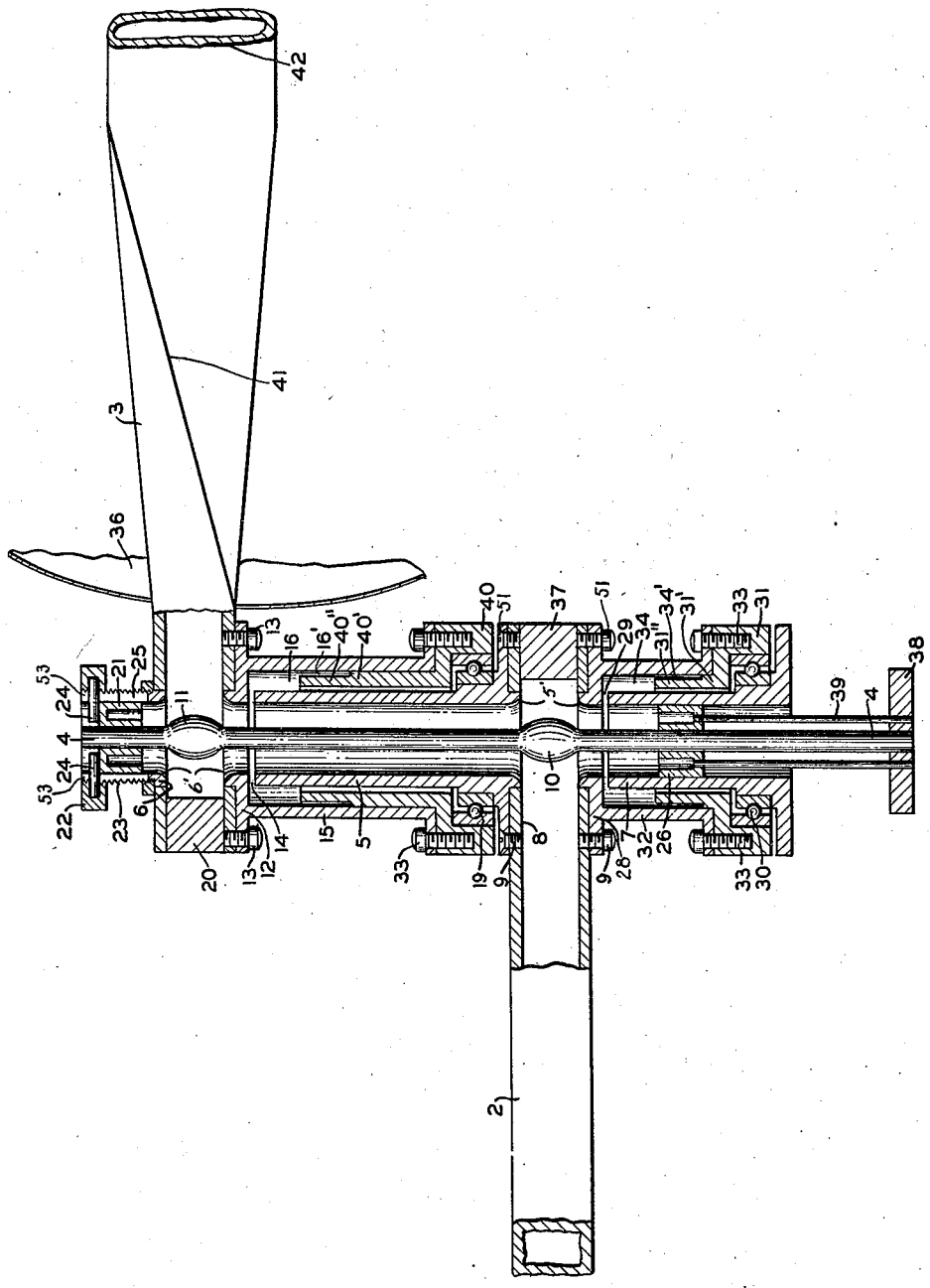
Jan. 27, 1948. R. O. HAXBY 2,434,925

COUPLING MEANS FOR RELATIVELY MOVABLE WAVE GUIDES

Filed May 27, 1942



INVENTOR
ROBERT O. HAXBY

BY Paul B. Hunter

ATTORNEY

Patented Jan. 27, 1948 2,434,925

UNITED STATES PATENT OFFICE

2,434,925

COUPLING MEANS FOR RELATIVELY MOVABLE WAVE GUIDES

Robert O. Haxby, Hempstead, N. Y., assignor to Sperry Gyroscope Company, Inc., Brooklyn, N. Y., a corporation of New York

Application May 27, 1942, Serial No. 444,661

19 Claims. (Cl. 178—44)

1

This invention relates, generally, to the propagation of electromagnetic waves along conductor means having relatively movable portions and the invention has reference more particularly to a novel construction of coupling means for transferring electromagnetic wave energy between said relatively movable portions.

Specifically, the invention is adapted for efficiently conducting polarized electromagnetic wave energy from one wave guide to another wave guide, the wave guides being relatively turnable with respect to each other.

An object of the present invention is to provide means for coupling two relatively turnable electromagnetic wave conducting means whereby electromagnetic energy may be efficiently transferred from one conducting means to the other.

Another object of the present invention is to provide concentric line coupling means between two relatively turnable wave guides, said coupling means being so designed as to enable the efficient passage of polarized electromagnetic waves from one wave guide through the coupling means and into the other guide.

Another object of the present invention is to provide means for conducting and radiating electromagnetic energy at varying angles comprising a stationary wave guide and a relatively movable emitting wave guide together with means for interconnecting said wave guides for conveying the energy therebetween in an efficient manner.

Still another object of the present invention is to provide relatively turnable wave guides having an interconnecting concentric line section, the outer conductor of which section is divided to enable relative turning movement between said wave guides, means being provided to reduce the escape of energy through said divided outer conductor to a minimum.

Another object of the present invention is to provide relatively turnable wave guides together with coupling means therefor comprising a concentric line structure having relatively turnable outer and inner conductors, the inner conductor being integral throughout its length to obtain operating efficiency and the outer conductor being broken to enable relative movement of the two wave guides, suitable wave trap means being provided in connection with said outer conductor to reduce escape of energy therefrom to a minimum.

A still further object of the present invention is to provide means for efficiently coupling a wave guide type transmission line to a concentric type transmission line, such coupling means being

2

adapted to operate over a relatively large range of operating frequencies without creating objectionable standing waves in either the wave guide or concentric transmission line.

Other objects and advantages will become apparent from the specification taken in connection with the accompanying drawing wherein the single figure shows one embodiment of the invention.

Referring now to the drawing, the reference numerals 2 and 3 designate wave guides shown as of rectangular form and adapted to convey polarized waves, said wave guides being interconnected by the novel coupling means of this invention. This coupling means comprises a concentric line structure consisting of a unitary inner conductor 4 and a divided outer conductor consisting of parts 5, 6 and 7. The outer conductor section 5 is provided with an external projection 28 which is socketed for receiving the end portion of the guide 2, such end portion being secured to the projection 28 as by screws 9. The portion of the projection 28 opposite the end of guide 2 is provided with a tuning plug 37 adjustable by set screws 51. Element 20 is a rectangular plug fitting within the portion of projection 12, situated at the closed end of wave guide 3, and locked in place by a locking screw 13. Its function is to provide an adjustable means for matching the impedance of guide 3 to that of the concentric line conductor. The projection 28 is provided with an annular extension 32 surrounding the outer concentric line conductor section 7 and spaced somewhat therefrom, said extension having a collar 31 secured thereto as by screws 33, which collar is internally recessed for receiving an anti-friction bearing 30 supporting the portion 7 of the outer conductor of the concentric line.

A tuning plug 26 is adjustably slidable within outer conductor portion 7 and over the inner conductor 4 by means of a knob 38 and connecting rods 39. The collar 31 is provided with an inner annular projection 31' having a reduced end portion 31'' spaced radially both from the extension 32 and from the outer conductor portion 7 whereby an annular recess 34' closed at the lower end is provided between extension 32 and reduced portion 31'' to provide a wave trap and impedance matching device, as will further appear.

As thusly constructed, the outer conductor portion 7 together with the inner conductor 4 and plug 26 are free to turn as a unit within collar 31 and extension 32, the inner end of outer conductor portion 7 having a slight clearance with respect to the opposing end of portion 5 of the outer

conductor as shown at 29. Thus, the bearing 30 serves to rotatably support the outer conductor portion 7 within the extension 32, this extension, it will be noted, being attached to the wave guide 2.

The outer conductor portion 6 of the concentric line coupling is provided with a tuning plug 21 slidable therein, the adjustment of this tuning plug being provided for by means of a nut 22 engaging threads 23 on the outer surface of outer conductor portion 6. Nut 22 is provided with an internal annular slot for receiving transverse pins 24 fixed upon the plug 21, which in turn slide in longitudinal slots 53 in conductor portion 6. Hence, by turning nut 22 the plug 21 is adjustable longitudinally within outer conductor portion 6 and along inner conductor 4. Thus, it will be noted that the inner conductor 4 of the concentric line is supported at one end within plug 21 and at its other end portion within the plug 26.

Wave guide 3 is fastened to portion 6 in the same manner as guide 2 is to portion 5. Outer conductor portion 6 is also provided with an annular extension 15 surrounding and spaced from the portion 5 of the outer conductor. A collar 40 is secured to the extension 15 as by screws 33 and is internally recessed for receiving an anti-friction bearing 19 interpositioned between this collar and the outer conductor portion 5, which is secured to wave guide 2. The outer conductor portion 5 terminates adjacent to, and has a slight clearance as indicated at 14 from the outer conductor portion 6. The collar 40 is provided with an inner annular projection 40' having a reduced end portion 40'' spaced radially both from the extension 15 and from the outer conductor portion 5. Here again an annular recess 16' closed at one end is formed between extension 15 and reduced portion 40'' to provide a wave trap and impedance matching device, as will further appear.

The inner conductor 4 is shown provided with somewhat enlarged portions 10 and 11 smoothly connected to the main conductor 4 at the points where guides 2 and 3 connect with the concentric line, which enlargements, in cooperation with substantially conformably shaped curvilinearly flared bore portions 6' and 5' formed in outer conductors 6 and 5, respectively, enhance the efficiency of the energy transferred, and also are believed to increase the allowable frequency range of the transferred energy.

As thus constructed, it will be noted that guides 2 and 3 are relatively turnable. In this connection it will be noted that guide 3 together with inner conductor 4, outer conductor portion 6, and outer conductor portion 7 and connected parts, are turnable by means of bearings 19 and 30 with respect to the outer conductor portion 5, extension 32 and wave guide 2.

In operation, assuming vertically polarized electromagnetic wave energy is supplied to guide 2 moving from left to right in the figure along guide 2, then the energy is picked off by the enlarged portion 10 of the inner conductor 4 of the concentric line, so that the electric vectors defining the direction of the electric field take up radial positions within this line, resulting in upward movement of energy which is conveyed to the upper end thereof and is reradiated into the guide 3 in the converse manner as vertically polarized energy. This guide is shown twisted at 41 so that this vertically polarized energy becomes horizontally polarized at the portion 42 of the guide.

One particular use of this construction which may be mentioned is that of scanning a desired field of view. This is accomplished by turning the guide 3 with respect to guide 2 through a desired angle, guide 3 having an open outer end for discharging the energy into space, a reflector 36 being illustrated in the drawing for directing this energy. Obviously, the same equipment may be used for receiving the energy radiated or reflected from a remote point. The construction is such as to provide an efficient energy transfer through guide 2 through the concentric line shown and into guide 3, or vice versa, and the construction shown substantially eliminates any escape of energy from the divided outer conductor 5, 6, 7.

In this connection it will be noted that a chamber 16 is provided exteriorly of outer conductor portion 5 communicating with the radial clearance opening 14 between outer conductor portions 5 and 6. The length of the annular chamber 16 corresponds to substantially a quarter wavelength of the energy being transmitted and hence effectively forms a wave trap. For efficient operation the impedance at the gap 14 should be low in order to enable currents to flow readily between outer conductor portions 5 and 6. The end of the wave trap space 16 removed from the gap 14 should therefore have a high impedance and this is insured by an additional wave trap 16' provided between the extensions 15 and 40'', this wave trap also being substantially a quarter wavelength in length and short-circuited at its remote end. Thus, with a current node provided at the end of the wave trap 16 adjoining wave trap 16' a current maximum is provided at the gap 14 representing a low impedance at this point. Since a current node occurs at the junctures of these two wave traps substantially no energy escapes down the annular slot between outer conductor portion 5 and sleeve 40' through the anti-friction bearing shown. This is highly desirable since it not only prevents the escape of energy but also prevents overheating of the bearing. Furthermore, the undeterminable impedance between conductor 5 and collar extension 40', caused by leakage of energy and conditions external to the apparatus, is rendered ineffective to change any conditions at the gap 14 by being effectively connected in series with the very high impedance of quarter-wave-shorted section 16'.

A similar wave trap and impedance matching construction is provided by spaces 34 and 34' associated with outer conductor portions 5 and 7 of the concentric line so that a low impedance obtains at gap 29, enabling the ready flow of current along the outer conductor but preventing the escape of energy to or through the bearing 30.

As many changes could be made and many widely different embodiments of this invention could be made without departing from the scope thereof it is intended that all matter given in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a structure of the character described, a pair of relatively turnable wave guides and a concentric transmission line coupling said wave guides, said transmission line comprising an outer conductor portion fixed to one wave guide, bearings provided upon said outer conductor portion, additional outer conductor portions carried by said bearings and relatively turnable with respect to said first-mentioned outer conductor portion and connected to said other wave guide,

said concentric line coupling having its inner conductor supported from said additional outer conductor portions.

2. In a structure of the character described, a pair of relatively turnable wave guides and a concentric line conductor coupling said wave guides, said conductor comprising an outer conductor portion fixed to one wave guide, bearings provided upon said outer conductor portion, additional outer conductor portions carried by said bearings and relatively turnable with respect to said first-mentioned outer conductor portion and connected to said other wave guide, said concentric line coupling having its inner conductor supported from additional outer conductor portions, and wave traps between said first-mentioned outer conductor portion and said additional outer conductor portions to prevent the escape of electromagnetic energy.

3. In apparatus of the character described, a pair of wave guides, coupling means interconnecting said guides and allowing relative turning movement therebetween, said coupling means comprising a concentric line having external and internal conductors, the ends of said guides terminating in surrounding relation to the inner conductor of said concentric line coupling, said inner conductor being of expanded diameter within said guides and means for tuning the guides to the concentric line coupling and for tuning the ends of said line coupling.

4. An ultra high frequency apparatus comprising a concentric line having a unitary inner conductor and an outer conductor, said outer conductor having two spaced sections fixedly connected to said inner conductor, and also having a further section between said two spaced sections and rotatable with respect thereto, and wave trap means at the gaps between said rotatable section and said spaced sections for preventing leakage of energy through said gaps.

5. In an electromagnetic wave conducting means having relatively turnable sections and an interconnecting section having relatively turnable portions, means for securing the relatively turnable portions of said interconnecting section to said respective turnable sections, and wave trap means for preventing the escape of energy through the gap between the relatively turnable portions of said interconnecting section.

6. Apparatus as in claim 5, wherein said wave trap means comprises a quarter wave concentric transmission line section concentric with said interconnecting section connected at one end to said gap and at the other end to a further short-circuited quarter-wave line concentric to said interconnecting section, said short-circuited line being connected in series with the escape path of said energy.

7. An ultra high frequency coupling between a pair of axially aligned tubular conductors having a narrow gap therebetween, comprising an expanded portion formed on one of said conductors and surrounding the other conductor in spaced relation thereto whereby said expanded portion and said other conductor form a concentric transmission line section, a sleeve member connected to said expanded portion at the end remote from said gap and extending axially between said expanded portion and said other conductor to a point spaced from said gap such that the length of said concentric transmission line section is substantially equal to a quarter wavelength at the operating frequency, said sleeve member having a portion of reduced thickness

at the free end thereof spaced from said expanded portion, said reduced thickness portion being substantially a quarter wavelength long at the operating frequency and cooperable with said expanded portion to define a short-circuited quarter wavelength concentric transmission line section in series with said first-mentioned concentric transmission line section.

8. Conductor means for conveying electromagnetic waves comprising a wave guide, a concentric line connected with said wave guide, said concentric line having a divided outer conductor a portion of which is fixedly connected to said wave guide and another portion of which is relatively turnable with respect thereto and wave trap means connected between said portions, said wave trap means comprising a pair of serially connected quarter wavelength transmission line sections providing a relatively low impedance at the junction of said outer conductor portions.

9. Ultra high frequency energy conducting apparatus comprising a section of concentric transmission line having an inner conductor and an outer conductor, said outer conductor being separated into three separate portions, and means for connecting said inner conductor to the outer ones of said three sections, said center section of outer conductor being relatively rotatable with respect to the outer sections.

10. Apparatus as in claim 9, further comprising coupling means for supplying high frequency energy to said center section of outer conductor, and coupling means for abstracting high frequency energy from one of said outer sections of outer conductor whereby said two coupling means may be relatively rotated with respect to one another.

11. Apparatus as in claim 9, further including means for coupling high frequency energy to the center section of said outer conductor whereby said coupling means is relatively rotatable with respect to said inner conductor and said other outer conductor sections.

12. Apparatus as in claim 9, further comprising an ultra high frequency wave guide and means for coupling said wave guide to said center section of outer conductor and to said inner conductor whereby, said wave guide may be rotated relatively to said transmission line section while transferring energy therebetween.

13. A concentric transmission line for interconnecting two relatively turnable wave guides, comprising a unitary inner conductor and an outer conductor divided into a plurality of portions, said portions forming with said inner conductor concentric transmission line sections of substantially equal characteristic impedance, one of said portions being secured to one wave guide and another of said portions being secured to a second wave guide, and means for preventing the escape of energy from between said outer conductor portions comprising a pair of serially connected quarter wavelength transmission line sections providing a relatively low impedance at the gap between said outer conductor portions.

14. In combination, a wave guide, a coaxial transmission line having spaced outer and inner conductors, said wave guide and said line having mutually orthogonal axes of energy propagation, a curvilinearly flared connection between the outer conductor of said coaxial transmission line and said wave guide, and an expanded-diameter termination on said inner conductor projecting transversely within said wave guide.

15. An ultra high frequency energy coupling

junction comprising a wave guide of rectangular cross-section having aligned apertures formed in opposed side walls thereof and a pair of concentric transmission line sections having a common unitary inner conductor and axially aligned spaced outer conductors, said inner conductor extending through said apertures of said wave guide, the portion of said inner conductor contained within said guide being of expanded diameter, and flared connecting means connecting said outer conductors to said side walls of said wave guide at the apertures therein.

16. Ultra high frequency apparatus comprising a pair of wave guides and coupling means interconnecting said wave guides, said coupling means comprising a concentric transmission line section having inner and outer conductors, said inner conductor extending through each of said wave guides with the portions thereof within said guides being of expanded diameter, and flared connecting means joining said outer conductor to a wall of each of said wave guides.

17. Apparatus as in claim 16 wherein said expanded-diameter portions are of substantially ellipsoidal contour cooperable with said flared connecting means, whereby substantially increased bandwidth of operation is obtained.

18. Conductor means for conveying electromagnetic waves comprising two relatively turnable wave guides and an interconnecting concentric line, said concentric line having its outer conductor divided into a plurality of portions, one of which portions is secured to one wave guide and another of which portions is secured to the other wave guide, bearing means provided between said outer conductor portions, and means for preventing the escape of energy outwardly

from between said outer conductor portions, said last-named means comprising a wave trap having a low impedance looking at the juncture of said outer conductor portions and a high impedance looking away from said juncture.

19. Conductor means for conveying electromagnetic waves comprising two relatively turnable wave guides and an interconnecting concentric line, said concentric line having its outer conductor divided into a plurality of portions, one of which portions is secured to one wave guide and another of which portions is secured to the other wave guide, and means for preventing the escape of energy outwardly from between said outer conductor portions, said preventing means comprising a wave trap having a low impedance looking at the juncture of said outer conductor portions and a high impedance looking away from said juncture.

ROBERT O. HAXBY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,206,923	Southworth	July 9, 1940
2,153,728	Southworth	Apr. 11, 1939
2,119,168	Kus	May 31, 1938
1,927,393	Darbord	Sept. 19, 1933
2,332,952	Tischer et al.	Oct. 26, 1943
2,223,224	Newhouse	Nov. 26, 1940
2,232,179	King	Feb. 18, 1941
2,281,274	Dallenbach et al.	Apr. 28, 1942
2,351,895	Allerding	June 20, 1944
2,239,724	Lindenblad	Apr. 29, 1941