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G. H. BAKER ET AL

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COAXIAL LINE COUPLER

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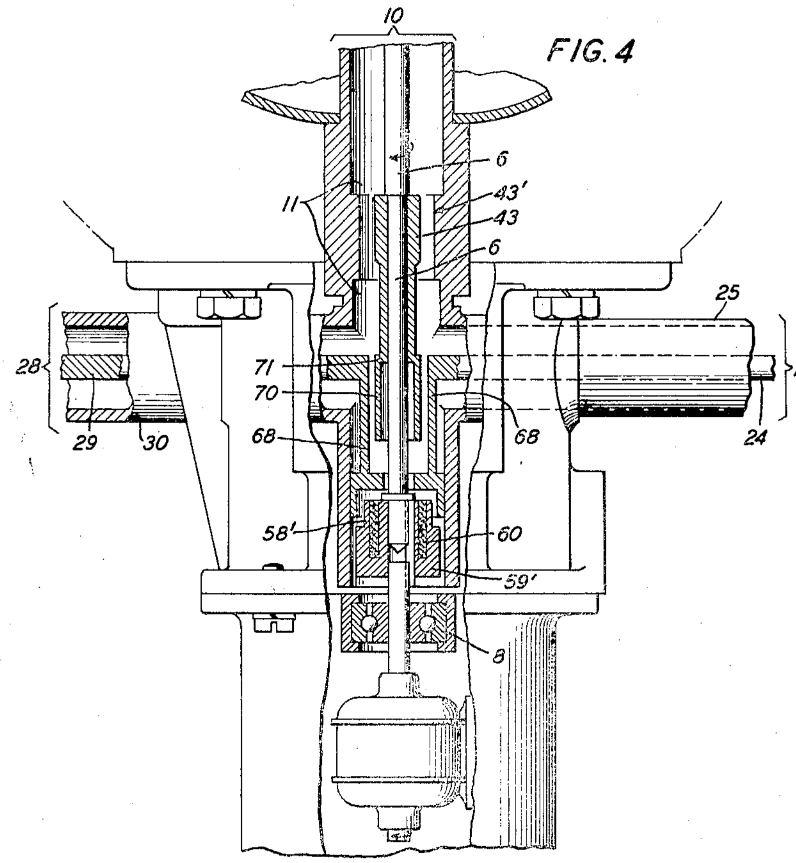

FIG. 4

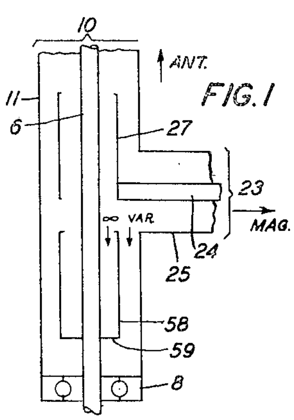

FIG. 1

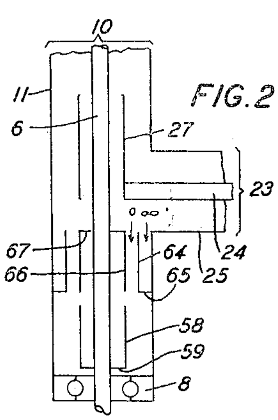

FIG. 2

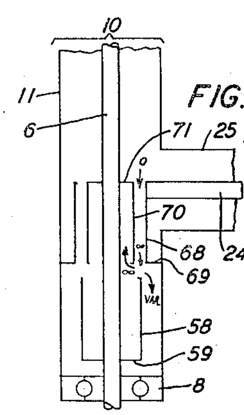

FIG. 3

INVENTORS: G. H. BAKER
P. H. SMITH

BY J W Schmied

ATTORNEY

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COAXIAL LINE COUPLER

George H. Baker, Morristown, and Phillip H. Smith, Denville, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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11 Claims. (Cl. 178—44)

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This invention relates to directive antenna systems and more generally to coaxial conductor systems in which a coaxial conductor of which the central conductor is rotated in operation is coupled transmissively for transmission of electric power to another coaxial conductor which has its axis at an angle to the first coaxial conductor system.

In the application of P. H. Smith Serial No. 498,622, filed August 14, 1943, patented February 20, 1951, Number 2,542,844, there is disclosed a system comprising a microwave directive antenna system including a half-dipole, a paraboloidal reflector and instrumentalities including a coaxial conductor system for conducting wave energy to and from the antenna and means for rotating the antenna bodily by rotating the central conductor of the coaxial conductor. By reference, the disclosure of the said Smith application is incorporated herein to the same extent as though set forth in full.

The present invention comprises an improvement in a coaxial line coupling arrangement not only applicable to the disclosure of the Smith application but as an energy transducer of general applicability in any similar system.

Objects of the invention are to couple a coaxial conductor system with a rotating center conductor to a coaxial conductor system at an angle thereto in such a manner that with a simple structure the bearings upon which the rotating conductor is carried are more effectively protected from influx of wave energy, the nonrotating central conductor is more firmly and rigidly mounted, and the effective transmission band of the coupling is increased.

In the accompanying drawings:

Figs. 1, 2 and 3 are theoretical diagrams illustrating steps taken on arriving at the invention; and

Fig. 4 is the ultimate embodiment as incorporated in an improved system of the type of the Smith application and employed for similar purposes.

A requirement of devices of the kind in question is freedom from loose or sliding contacts or other features which may lead to sparking or disturbances. In actual use of such structures it was found that the bearing upon which the central conductor rotated was corroded or caused to become defective; it was also found that the transmission loss was severely decreased away from the center of the wavelength band; experience demonstrated the need for a system which would transmit more effectively in a range at least ± 3 per cent above and below the center of the band .

Figs. 1, 2 and 3 illustrate the evolution of the invention, each of these figures being a simplified diagram in which the tuning stub is omitted; and

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Fig. 4 illustrates the actual structure of an exemplary form of the invention.

In the diagram, Fig. 1, the structure is a schematic of that disclosed in application Serial No. 498,622 (now Patent No. 2,542,844) and comprises motor bearing **8** rotating the central shaft **6** which also comprises the central conductor of the coaxial which supplies the radiating system. Sleeve **58**, annular member **59** and the corresponding portion of shaft **6** comprise a short-circuited quarter-wave line which serves as a wave trap or high impedance to waves traveling along the coaxial line toward the bearing **8**. The sleeve **27** comprises with the corresponding portion of shaft **6** means for coupling the main coaxial line **23** having an inner conductor **24** and an outer conductor **25** with the coaxial line **10** which comprises an inner conductor **6** and an outer conductor **11**. In operating practice it is found that the bearing **8** is insufficiently protected when the high powers are employed and, therefore, it was proposed to insert another wave trap with the result of a structure like that of Fig. 2. A sleeve **64** and annular member **65** together with the corresponding or matching surface of outer conductor **11** form a short-circuited quarter-wavelength line offering high impedance to waves tending to enter the motor bearing, this impedance being effectively in series with a zero impedance formed by the open-circuited quarter-wavelength line found by the sleeve **64** and the sleeve **66** which is attached to the conductor **6** by an annular member **67**.

Analysis now showed that the bearing is protected by a theoretically infinite or at any rate a very large impedance in series with a zero impedance and that the wave energy leaking through this construction is further attenuated by the very high impedance of wave trap **58, 59, 11** but, moreover, the structure may be converted into the theoretical form shown in Fig. 3.

In Fig. 3 the sleeve **27** is inverted and becomes combined with sleeve **64** to form sleeve **68** supported by annular member **69** which gives very effective support to conductor **24** thereby reducing the undesired effect attributed to a physical wobble in conductor **24**. Sleeve **68**, member **69**, and the facing portion of conductor **11** formed a short-circuited quarter-wave line, hence conductors **24** and **25** are not shorted by the solid physical connection between them. Sleeves **68** and **70** together with annular member **71** effectively couple line **23** to line **10**. The short-circuited quarter-wave line formed by sleeve **70**, annular member **71** and opposing surface of conductor **6** from a practically infinite or high impedance presented to the quarter-wave coupling line **68, 70**; this high impedance is effectively in series with the impedance presented by the high impedance quarter-wave line 58, 59, 6 and in series with the variable impedance presented by the motor bearings. The line 23 is effectively coupled to the line 10 for transmission of high frequency wave energy. The line 10 in a direction upward from the coupling may have impedance transformers or adjustable members or both in accordance with the disclosure of application Serial No. 498,622 (now Patent No. 2,542,844) supra, or any suitable equivalents or modifications thereof as may be necessary or convenient. Essential details of a practical embodiment of the theoretical form of structure indicated in Fig. 3 is diagrammed partly in section and partly in plan view in Fig. 4.

In incorporating the arrangement into an actual structure as per Fig. 4 it was found that sufficient space for the quarter-wave line 58, 59, 6 did not exist. Accordingly, use was made of a polystyrene cylinder 60 by virtue of which the sleeve 58′ could be shorter in the ratio

$$\frac{1}{\sqrt{2.55}}$$

with approximately similar results as would occur if air were used in the cylinder 60 and the sleeve 58′ were about

$$\frac{\sqrt{2.55}}{1}$$

longer.

In the actual structure of Fig. 4 it is noted that conductor 24 is rigidly supported upon sleeve 68 which gives it a point of support not present in prior constructions; conductor 24 is thus additionally restrained against wobble or vibration which would tend to introduce amplitude or frequency variations, or both, into the transmitted and/or received energy.

The tuning stub 28, which is in the form of a coaxial line comprising inner and outer conductors 30 and 29, shorted at their far end by an end piece (not shown), is in accordance with prior practice. The rotating conductor 6 extends upward to a half-dipole radiator and paraboloid or their equivalents, the half-dipole being carried by the conductor 6. A sleeve 43 cooperating with an enlargement 43′ upon conductor 11, these constituting a quarter-wave line which functions as in an impedance transformer for transforming the impedance of the line above 43, 43′ to match the impedance of the coupling with the line 23. The outer surface of sleeve 68 in cooperation with the adjacent surface of conductor 11 and annular piece 69 comprise a quarter-section line with the end shorted; the inner surface of sleeve 68 with the adjacent section of conductor 6 forms a quarter-wave coupling section which is a quarter-wave long, hence the impedance between these surfaces approaches zero or approximates a large capacity. The inner surface of sleeve 70 cooperating with the surface of conductor 6 and annular member 71 forms a quarter-wave line which is effectively in series with the line formed by coupling elements 68 as regards transmission toward the bearing 8. Any wave energy passing this quarter-wave line toward the bearing 8 is attenuated by the short-circuited quarter-wave line consisting of annular ring 60 of polystyrene located in an annular groove between the two surfaces of sleeve 58, the opposed enlargement of conductor 6 and the conductive end piece 60′. Bearing 8 supports conductor 6 and all elements mounted thereupon for rotation by motor 7. The shaft of motor 7 is keyed to the element 59′ and the conductor 6 by a conventional slot and key arrangement which causes them to rotate together. Consequently, the movable contacting surfaces of the bearing are effectively insulated from the wave energy transmitted through the coupling.

It has been found desirable to transmit a fairly board band of frequencies from line 23 to line 11 and vice versa with but small attenuation. Thus in a structure designed for a mid-band of 10-centimeter waves the attenuation of waves differing from 10 centimeters by a slight amount has been considerable in prior structures but it has been found that the construction described has the beneficial result, desirable for the intended uses, of transmitting waves effectively in a range of 9.67 centimeters to 10.30 centimeters or a total band having a band width of not less than 6 per cent of the median frequency.

In summary, therefore, the exemplary structure described has the advantages of better bearing protection with consequent longer bearing life, greater freedom from need of maintenance, and greater freedom from disturbances due to sparking in the bearing; a more rigid support for the central conductors 24 and 30 with greater freedom from irregularities of operation due to wobbling; and most important of all a wider effective transmission band.

What is claimed is:

1. Means for coupling a first coaxial line with a second coaxial line having a freely rotatable central conductor comprising a skirt on the rotatable central conductor, and a sleeve rigidly connected to the central conductor of the first coaxial line and the outer conductor of the second coaxial line, said skirt having a surface cooperating with a surface of the rotatable conductor to form a wave trap, said skirt having a surface cooperating with the sleeve to form a capacity coupling for energy transfer, and said sleeve cooperating with a surface of the outer conductor of the first coaxial line to form a wave trap of high impedance.

2. A transducer for electrically intercoupling with another line a coaxial line having a central conductor and an outer conductor, said lines being located at an angle to one another, the inner conductor of a first of said lines being freely rotatable with respect to its outer conductor, said transducer comprising a cylindrical member mounted upon the rotatable central conductor, said cylindrical member having one surface functioning with a surface upon said inner conductor as a quarter wavelength wave trap and a second surface functioning as an element of a quarter wavelength coupling line, a third surface which is fixed with respect to said outer conductor of said first line, which latter surface functions as a capacity coupling element in cooperation with said second surface to constitute said quarter wavelength coupling line, and said second line being coupled to the first by means including said coupling element.

3. In a coupling for transducing energy from one coaxial line to another coaxial line, a hollow cylindrical sleeve fixedly connected at one end to the inner conductor of one of said coaxial lines and rigidly affixed at the other end to the outer conductor of said other coaxial line by a conductive end piece closing said sleeve and said outer conductors, the sleeve having two cylindrical surfaces, one of which faces the outer conductor of said other coaxial line and another of which

faces the inner conductor of said other coaxial line, said first-named surface of said sleeve and the said outer conductor of said other coaxial line together with said end piece constituting a termination of high impedance to prevent a short-circuit for wave energy transmitted toward said coupling over said first-named coaxial line.

4. A coaxial line having a central conductor rotatable with respect to its outer conductor, a coaxial line located at an angle thereto and coupled thereto for intertransmission of energy by coupling means comprising a cylindrical body mounted on the rotatable conductor, said cylindrical body having a surface cooperating electrically transducively with an adjacent cylindrical surface of a member mounted upon and rigid with respect to the outer conductors of both coaxial lines to effect the desired coupling.

5. A coaxial line having an inner conductor freely rotatable with respect to an outer conductor thereof, a cylindrical member mounted on said inner conductor having one cylindrical surface functioning together with the surface of a portion of said inner conductor and an end piece joining them as essential elements of a quarter-wavelength wave trap and another cylindrical surface functioning as a coupling element, and a cylindrical surface of an element fixed with respect to said outer conductor mounted adjacent to and cooperating with said second-named surface as a capacity coupling element for transduction of wave energy to or from said coaxial line.

6. A joint for connecting a first coaxial line, having a central conductor freely axially rotatable, to a second coaxial conductor line at an angle thereto, comprising a coupling surface rigidly attached to a member of said second coaxial line, a bearing upon which the rotatable conductor rotates, a wave trap for reducing wave energy flow to the bearing, a coupling skirt mounted on said freely rotatable conductor, said skirt having an outer surface cooperating electrostatically with said coupling surface for coupling said first coaxial line to said second line, and an inner surface on said coupling skirt cooperating with a surface of said rotatable central conductor to comprise a high impedance means to reduce the wave energy traveling to said wave trap.

7. The combination including a transducer for electrically coupling together a first and a second coaxial line each of which has a central and an outer conductor, the axes of said lines being at an angle to each other, the central conductor of the first line being rotatable about its longitudinal axis, said transducer including as essential elements an electrically conductive sleeve rigidly attached and electrically connected to the inner conductor of the first line, a second electrically conductive sleeve in non-contacting concentric relation to said first sleeve and a rigid connection of said second sleeve to the central conductor of the second line.

8. A transducer for electrically coupling two coaxial lines, each comprising a central conductor and an outer conductor, said lines having their axes at an angle to one another, the central conductor of the first line being rotatable about its long axis, a cylindrical body fixed upon the inner conductor of the first coaxial line, said transducer comprising a sleeve fixedly mounted upon the central conductor of the second coaxial line and fixedly mounted with respect to the outer conductor of the first coaxial line, said sleeve providing a surface mounted adjacent to and cooperating electrostatically with the surface of said cylindrical body to electrically couple said lines.

9. In a coupling arrangement for electrically intercoupling two coaxial lines having their axes arranged at an angle to one another, each of said coaxial lines including an outer conductor and a central conductor, the central conductor of one line bearing a solid body having a coupling surface, a cylindrical sleeve mounted upon the other said coaxial line, said sleeve having a surface coaxial with and adjacent to said coupling surface whereby to cooperate therewith to intertransfer energy from either line to the other, and said solid body having a second surface cooperating with a portion of the surface of the inner conductor of the said one line to function as essential elements of a wave trap.

10. In a joint for intercoupling two coaxial lines whose axes lie at right angles to one another and one of which includes means for freely rotating its central conductor with respect to its outer conductor and maintaining it longitudinally fixed with respect thereto, a bearing upon which said rotation occurs, two wave traps in series between the point of geometrical intersection of said conductors and said bearing for excluding wave energy from said bearing, one of said wave traps comprising elements rotatable along with said rotatable inner conductor and the other consisting of elements fixed with respect to the outer conductor within which the inner conductor rotates.

11. In an arrangement for intercoupling one coaxial line with another coaxial line arranged at an angle thereto, a central conductor in one coaxial line, said central conductor having mounted thereon a cylindrical sleeve, an end piece whereby said sleeve and conductor define a closed end chamber, said inner surface of said sleeve cooperating with the end piece and the central conductor, upon which it is mounted, as a wave trap, a second cylindrical sleeve having an end conductively connected to the central conductor of the other coaxial line mounted upon and supported by the outer conductor of the line having the first-mentioned sleeve, a second end piece, the surface of said second sleeve cooperating with the second end piece and the inner surface of its adjacent outer conductor as a wave trap, and the adjacent surfaces of said sleeves constituting an energy transducer for transferring energy from one said line to the other.

GEORGE H. BAKER.
PHILLIP H. SMITH.

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