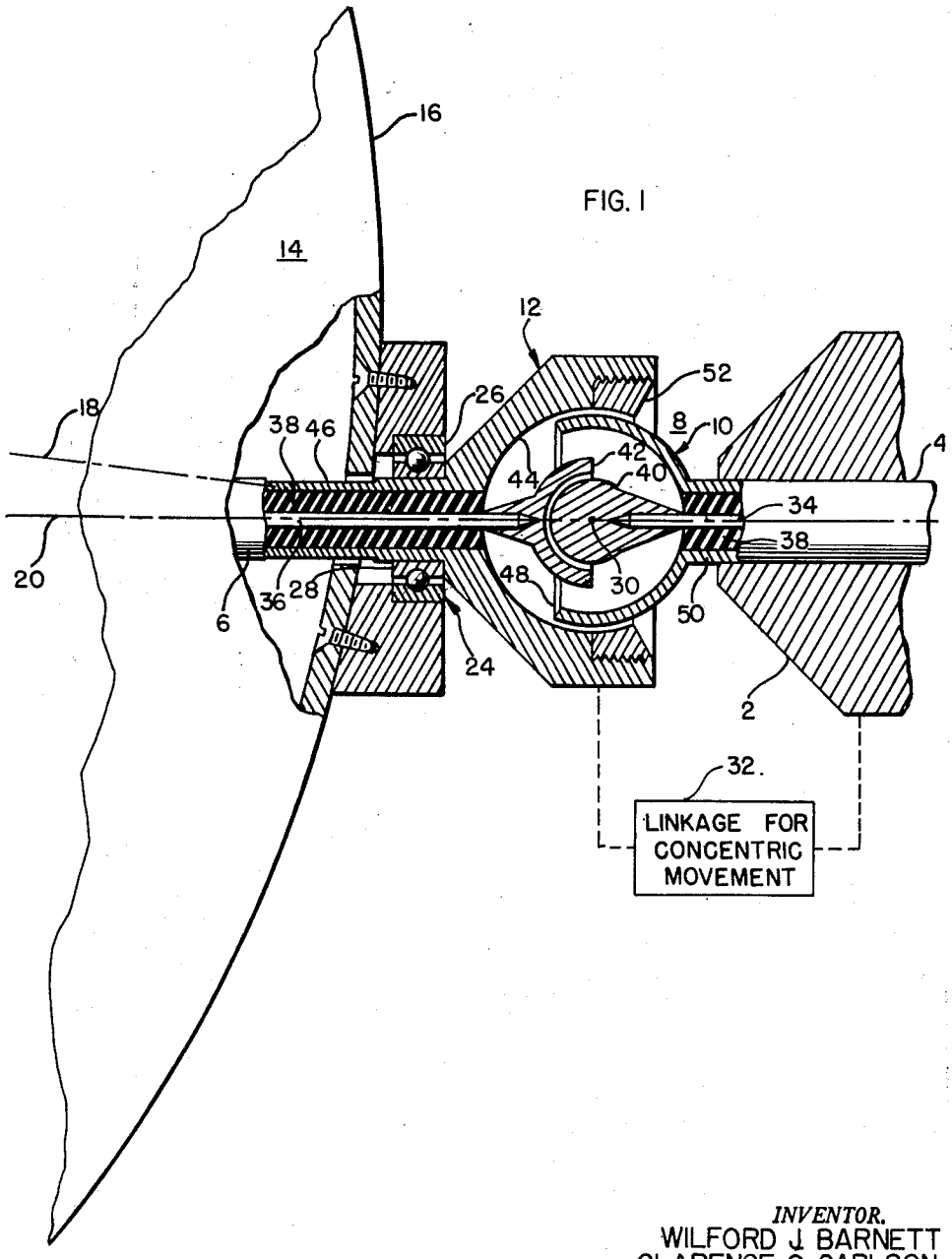
Jan. 26, 1954 W. J. BARNETT ET AL 2,667,578

SWIVEL JOINT FOR COAXIAL TRANSMISSION LINES

Filed Jan. 31, 1950 2 Sheets-Sheet 1

FIG. 1



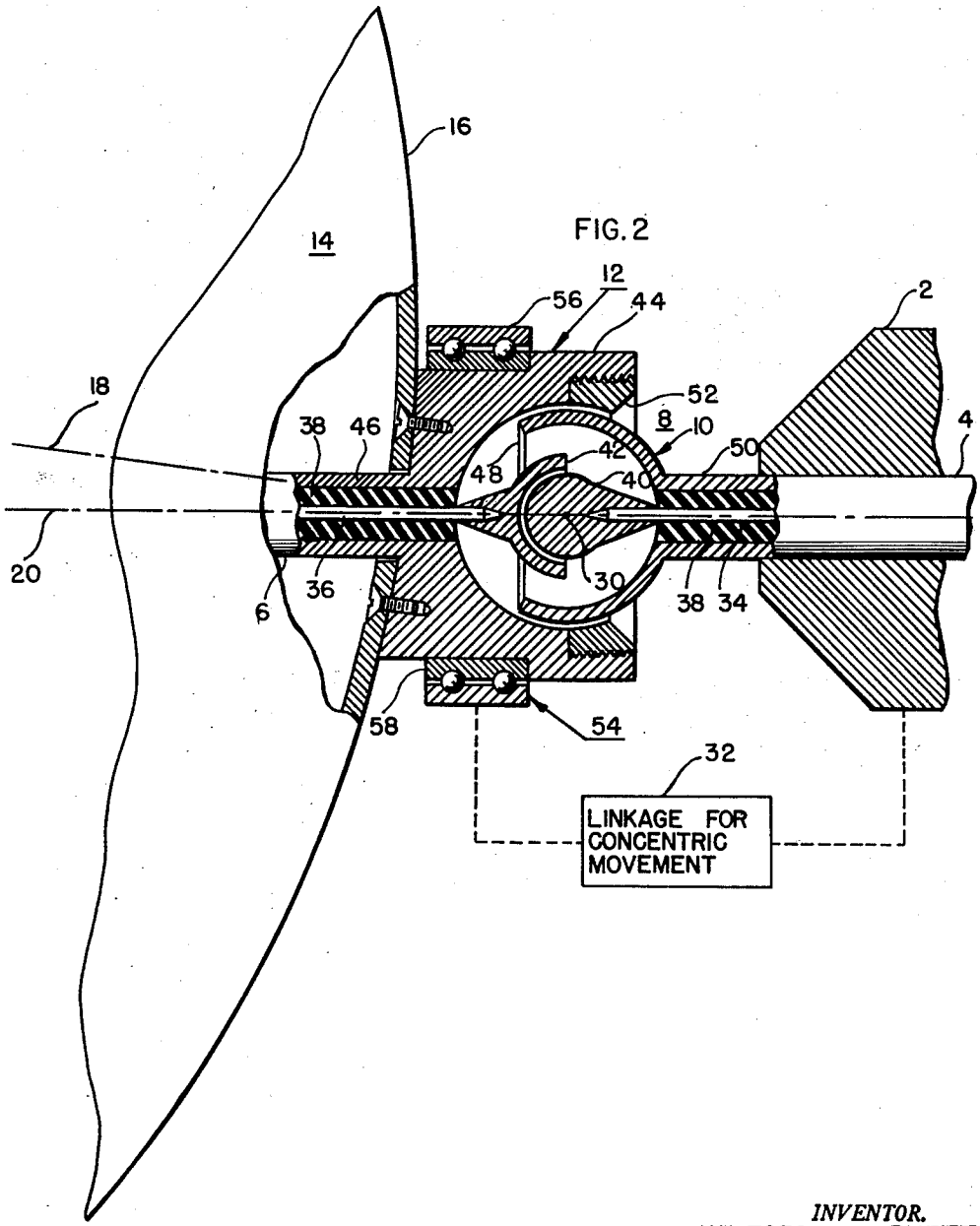
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FIG. 2



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SWIVEL JOINT FOR COAXIAL TRANSMISSION LINES

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3 Claims. (Cl. 250—33.65)

1

This invention relates to a directive antenna assembly and more particularly to a directive antenna assembly in which a transmission line swivel joint accommodates movements of a directive antenna.

Heretofore, it has been the general practice to provide a directive antenna assembly with a transmission line having a number of rigid sections coupled by several rotary joints, the rigid sections and rotary joints being suitably arranged to accommodate the necessary angular displacements of the directive antenna. An incidental disclosure of a simplifying departure from this conventional rotary joint system is made in U. S. Patent No. 2,411,472, issued November 19, 1946, to A. A. Slobod. The directive antenna there shown, intended for limited angular movements in airborne use, is connected to its waveguide feed line through the medium of a flexible section of waveguide and thus in effect is provided with a flexible transmission line joint, but without provision for rotary movements or conical scanning action of the antenna.

While a flexible waveguide joint such as shown in the abovementioned Slobod patent eliminates many of the mechanical and electrical complexities and attendant difficulties of the conventional rotary joint system, it nevertheless suffers the disadvantage of imposing sufficient mechanical restraint to be undesirable in certain directive antenna applications, and this would be particularly true of a flexible coaxial cable counterpart of such a joint. This and certain other disadvantages in the use of a flexible section of transmission line as a motional joint are overcome by application of principles of the present invention, as will appear.

The principal object of the invention is to provide an improved directive antenna assembly in which a single coaxial joint of special structure accommodates conical scanning action of a directive antenna and simultaneous angular displacements of the directive antenna about its transverse axes.

Another important object is to provide a novel coaxial line swivel joint which permits both continuous rotation of, and universal angular movement between, transmission components connected thereto.

The features and combinations which are believed novel and characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, and its further objects and advantages, may be best understood by reference to the following description, taken in connection with the accompanying drawing.

2

In the drawings, Fig. 1 represents a directive antenna structure embodying principles of the present invention; Fig. 2 represents a modified antenna structure in which the swivel joint accommodates continuous rotation. Each embodiment is in part shown in essentially a schematic manner without inclusion of such details as do not directly relate to the inventive concepts here disclosed, for many mechanical details or variations will occur to those skilled in the art without involving any departure from the spirit and scope of the invention.

Referring now to Fig. 1 of the drawing, there is shown a frame member 2 which may be here regarded as a fixed support or platform. Extending through frame member 2 and immovable with respect thereto is a coaxial line 4 which, together with another section of coaxial line 6, and a swivel joint 8 having a stationary member 10 and a movable member 12, provides a transmission path for transfer of energy to or from a directive antenna 14. The directive antenna may utilize the usual dipole type of electromagnetic energy radiator (not shown), connected to coaxial line 6 in conventional manner. The directive antenna here shown includes a paraboloidal reflector 16 and is arranged for nutating and conical scanning action for purposes which are conventional and familiar to those versed in the art. To this end, reflector 16 is supported for continuous spinning action upon movable member 12 of the swivel joint, in such manner that the reflector's beam direction or axis of symmetry 18 makes a constant small angle with respect to a spin axis 20. A ring bearing 24, having its outer race 26 secured to reflector 16 and its inner race 28 supported upon movable member 12, enables reflector 16 to be rotated about the spin axis 20. Spin axis 20 coincides with the axis of coaxial line 6 and extends through the phantom center 30 of swivel joint 8, as shown. Rotation of reflector 16 about spin axis 20 to produce conical scanning action may be effected in any desired manner, for example simply by means of a gear (not shown) secured to the reflector 16 and driven from a suitable motive source.

Complementing the motional freedom of swivel joint 8 which electrically connects coaxial lines 4 and 6, directive antenna 14 is rendered capable of searching or tracking movements within a relatively large solid angle by means of a suitable bearing system or mechanical linkage 32,

here indicated schematically. Linkage 32 couples movable member 12 to frame member 2 and functions to permit universal orientation of member 12, and of the structure carried thereby, about the swivel joint's phantom center 30. By way of example, the linking structure 32 may be a gimbal ring system, or may be a parallelogram type of linkage as taught in the previously cited Slobod patent. The particular types or details or linkage or bearing system which may be employed, however, are of no immediate importance here except insofar as they provide for angular orientation about center 30.

Swivel joint 8 comprises mating ball and socket members formed or mounted upon both the inner and outer conductors of coaxial lines 4 and 6, and, in the embodiment here shown, suitably small air gaps are provided between the mating members to effect electrical continuity in microwave operation. Inner conductors 34 and 36 of coaxial lines 4 and 6, respectively, are held fixed relative to their respective outer conductors 50 and 46, as by means of polystyrene dielectric material indicated as 38. Inner conductor 34 is provided with a pear-shaped protuberant element 40 having a spherical portion concentric to phantom center 30. A mating shell segment 42 having spherical inner and outer surfaces is secured to inner conductor 36 of coaxial line 6, and is likewise so positioned as to be concentric to phantom center 30. Similarly, the spherical socket member 44, from which extends outer conductor 46 of coaxial line 6, mates with a spherical shell or hollow ball segment 48 formed upon outer conductor 50 of coaxial line 4, and these elements are likewise positioned to be concentric to phantom center 30. Thus, the mating members of swivel joint 8, having spherical surfaces, and constrained by linkage 32 to universal movements about center 30 to which said surfaces are concentric, remain spaced at substantially fixed gap distances from each other for all angles through which transmission line 6 may be displaced, as is necessary for satisfactory operation from a transmission line standpoint.

It may be noted that in order to facilitate mating assembly of the ball and socket members, the inner spherical surface of outer socket member 44 is here in part provided by a removable ring member 52.

Various details of the ball and socket swivel joint, and the specific dimensioning of these details, are readily determined by application of design theory and principles familiar to those versed in the art. For example, first order reflections resulting from mismatch may be prevented by maintaining a reasonably constant diametric ratio between inner conductors 34 and 40 and outer conductors 50 and 46, respectively, within the spherical region of the joint. This ratio and resulting dimensions may be modified to compensate for the effects of the necessary capacitive coupling existent at the gaps between the mating coaxial terminations to maintain a substantially constant characteristic impedance. Still further modifications of dimensions might be dictated to allow sufficient angular movements between the mating coaxial members, as necessary for the antenna's nutation. One possible form of tapering is illustrated in Fig. 1 but many other forms exist, all of which may serve to provide the desired reflectionless transmission properties for the joint, and are within the scope and spirit of this invention. For example, one manner of designing the swivel joint for attaining a reasonably constant diametric ratio is to make the ratio of inner diameter of stationary member 10 to diameter of spherical portion of protuberant element 40, in the plane transverse to inner conductor 34 and through phantom center 30 (as shown in Fig. 1), so that said joint's electrical impedance in said plane equals the characteristic impedance of the coaxial transmission line. Then essentially the same ratio is maintained between inner conductors 34 and 40 and outer conductors 50 and 44, respectively, within the spherical region of the swivel joint. Said ratio is also slightly modified to compensate for capacitive effects of the spacings between mating coaxial terminals in order to maintain a substantially constant characteristic impedance and result in a low voltage standing wave ratio. It may also be here noted that the swivel joint may be suitably dimensioned to accommodate coaxial lines of different sizes or types, bearing in mind that the particular size of line employed is determined by the frequency of the electromagnetic energy coupled to the antenna.

The specific embodiment of the present invention as thus far described may be regarded as in part a compromise between desired electrical characteristics and a specific mechanical requirement of minimized friction in the transmission line swivel joint. It should be apparent, then, that many modifications of the described structure are available and will occur to those skilled in the art, still falling within the sphere of the present invention. For example, the air gaps between the mating ball and socket members may be eliminated, without loss of stable electrical characteristics, by provision of a film or thin layer of insulating dielectric material between mating members with the result that a wiping contact is effected between the mating members which are then electrically separated by the layer of dielectric rather than the gaseous dielectric illustrated in the figures.

Actual metal-to-metal contact within swivel joint 8 would be unsatisfactory since minute surface irregularities on the adjacent mating surfaces behave as transformers at the frequencies contemplated for the transmitted energy, and would serve to introduce considerable noise therein. The noise thus introduced would be a function of the nutated angular displacement of the antenna about phantom center 30 since the surface irregularities would not be consistent in magnitude or location. Also, since high frequency energy travels on the surface or skin of the metal conductors, the surface irregularities at the points of contact would vary the characteristic impedance of the joint in accordance with the antenna nutation.

Along the same lines, various other modifications falling within the scope of the present invention may come to mind. For example, while Fig. 1 illustrates a presently preferred assembly, the described swivel joint may be employed in a directional antenna assembly in such manner that a conical scanning action of the directive beam may be accommodated by spinning action within the swivel joint. Thus, referring to Fig. 2 in which parts corresponding to those in Fig. 1 bear like designations, reflector 16 may be mounted upon movable member 12, again in such manner that its beam direction 18 makes a suitable angle with spin axis 20. A ring bearing 54 having its outer race 56 supported for universal movement, relative to phantom center 30, by means of the linkage 32 as shown, and having its

inner race 58 secured to the reflector assembly including movable member 12, enables directive antenna 14, as a unit, to be continuously rotated about spin axis 20. In this embodiment, then, reflector 16 is carried by movable member 12 and may be rotated therewith about spin axis 20, as distinguished from the structure shown in Fig. 1 in which member 12 and the dipole radiator (not shown) fed therefrom are constrained against rotation about spin axis 20.

It is therefore apparent that while particular embodiments have been here shown and described in order to provide a better understanding of the invention, many modifications may be made without departing from the spirit thereof, and it is intended by the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An antenna reflector assembly comprising: a frame member; a first coaxial line section having an inner and an outer conductor, said first coaxial line section being connectable to a source of high frequency electromagnetic energy; means securing the outer conductor of said first line section to said frame member; a second coaxial line section having an inner and an outer conductor; a swivel joint capacitively coupling said first and second line sections for passing high frequency elecetrical energy therebetween, said joint comprising two pairs of spaced spherical mating elements having a common phantom center, one pair of said mating elements being connected to the inner conductors of said first and second line sections, respectively, and the other pair of said mating elements being connected to the outer conductors of said first and second line sections, respectively; an antenna reflector for radiating said energy mechanically coupled to the outer conductor of said second line section; and linkage means coupled between said frame member and the outer conductor of said second line section to mechanically support said reflector and said second line section for nutational movement relative to said first line section about said phantom center.

2. An antenna reflector assembly comprising: a frame member; a first coaxial line section having an inner and an outer conductor, said first coaxial line section being connectable to a source of high frequency electromagnetic energy; means securing the outer conductor of said first line section to said frame member; a second coaxial line section having an inner and an outer conductor; a swivel joint capacitively coupling said first and second line sections for passing high frequency electrical energy therebetween, said joint comprising two pairs of spaced spherical mating elements having a common phantom center, one pair of said mating elements being connected to the inner conductors of said first and second line sections, respectively, and the other pair of said mating elements being connected to the outer conductors of said first and second line sections, respectively the inner conductor of said first line section having a portion thereof extending into said swivel joint and being proportioned for a substantially characteristic impedance; an antenna reflector for radiating said energy; bearing means coupled between said reflector and the outer conductor of said second line section for rotatably mounting said reflector on said second line section; and linkage means coupled between said frame member and the outer conductor of said second line section for mechanically supporting said antenna reflector and said second line section for nutational movement relative to said first line section about said phantom center.

3. An antenna reflector assembly comprising: a frame member; a first coaxial line section having an inner and an outer conductor, said first coaxial line section being connectable to a source of high frequency electromagnetic energy; means securing the outer conductor of said first line section to said frame member; a second coaxial line section having an inner and an outer conductor; a swivel joint capacitively coupling said first and second line sections for passing high frequency electrical energy therebetween, said joint comprising two pairs of spaced spherical mating elements having a common phantom center, one pair of said mating elements being connected to the inner conductors of said first and second line sections, respectively, and the other pair of said mating elements being connected to the outer conductors of said first and second line sections, respectively the inner conductor of said first line section having a portion thereof extending into said swivel joint and being proportioned to introduce an impedance to compensate for the impedance effect of the capacitive coupling between said two pairs of spaced spherical mating elements and for a substantially characteristic impedance throughout said swivel joint; an antenna reflector mechanically coupled to the outer conductor of said second line section for radiating said energy; and means coupled between said frame member and the outer conductor of said second line section for mechanically supporting said reflector and said second line section for nutational movement relative to said first line section about said phantom center, said means including a linkage means mechanically coupled to said frame member, and bearing means coupled between said linkage means and the outer conductor of said second line section for rotatably mounting said reflector and said outer conductor.

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