Oct. 25, 1949. R. M. SILLIMAN 2,485,930

CONNECTOR

Filed Sept. 6, 1945

FIG. 1

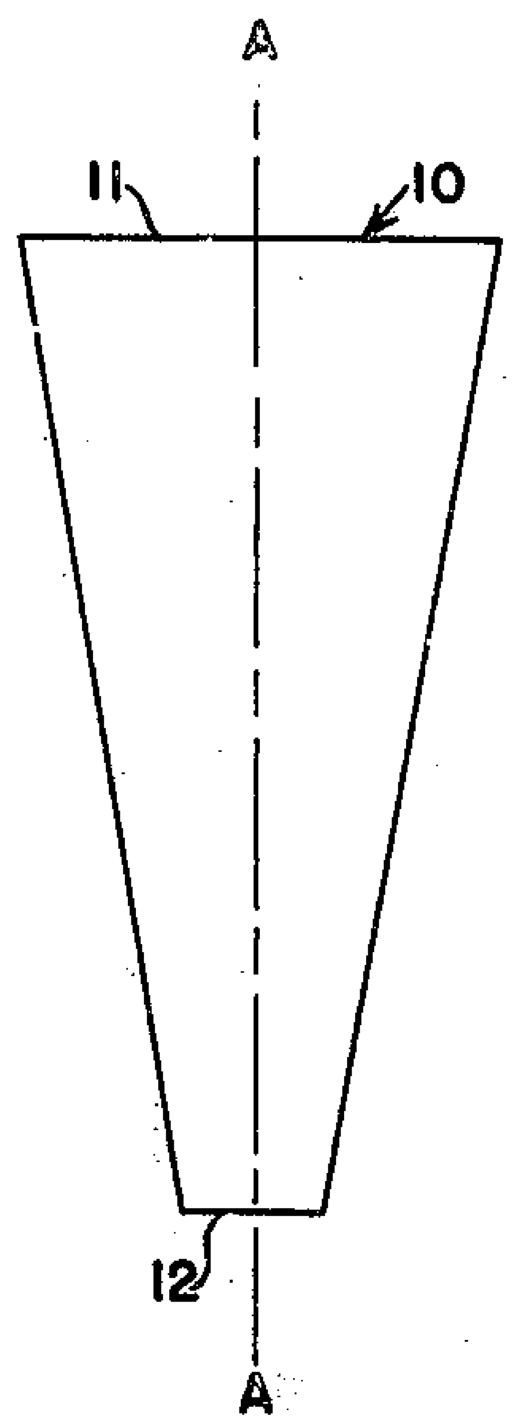


FIG. 2

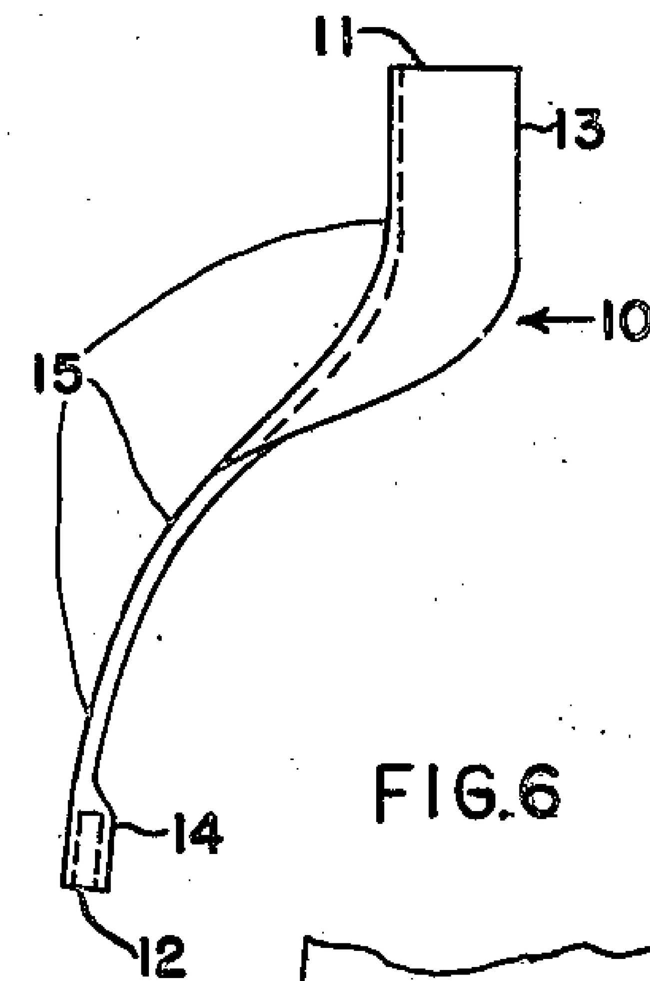


FIG. 4

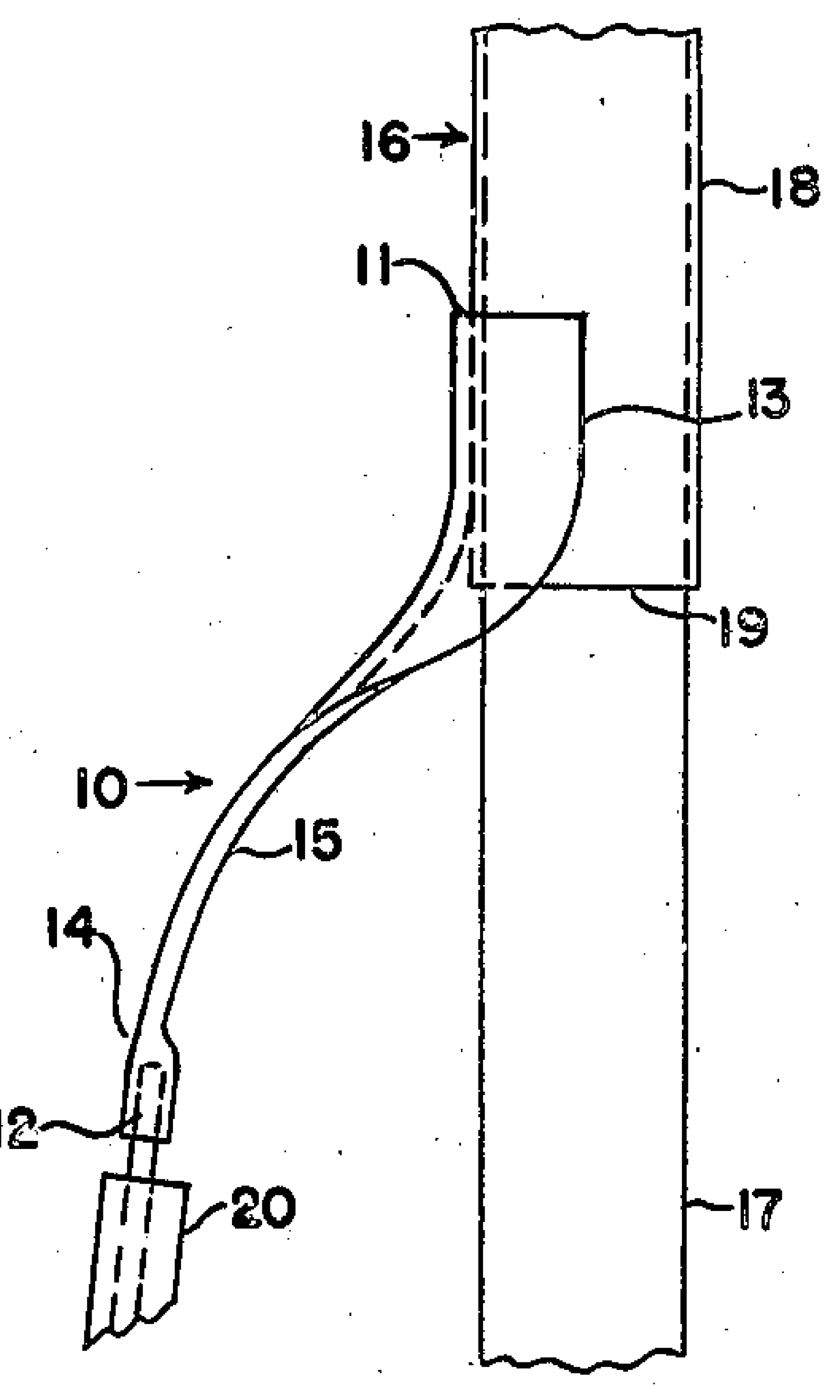


FIG. 6

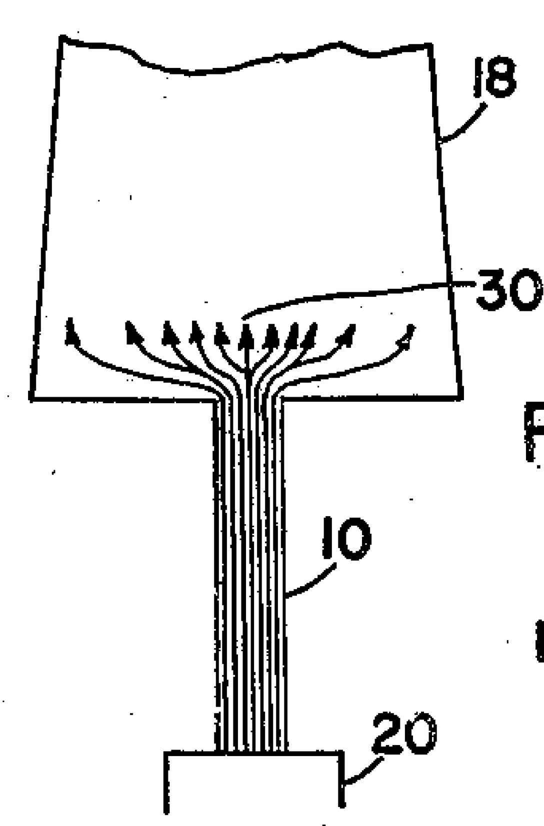


FIG. 5

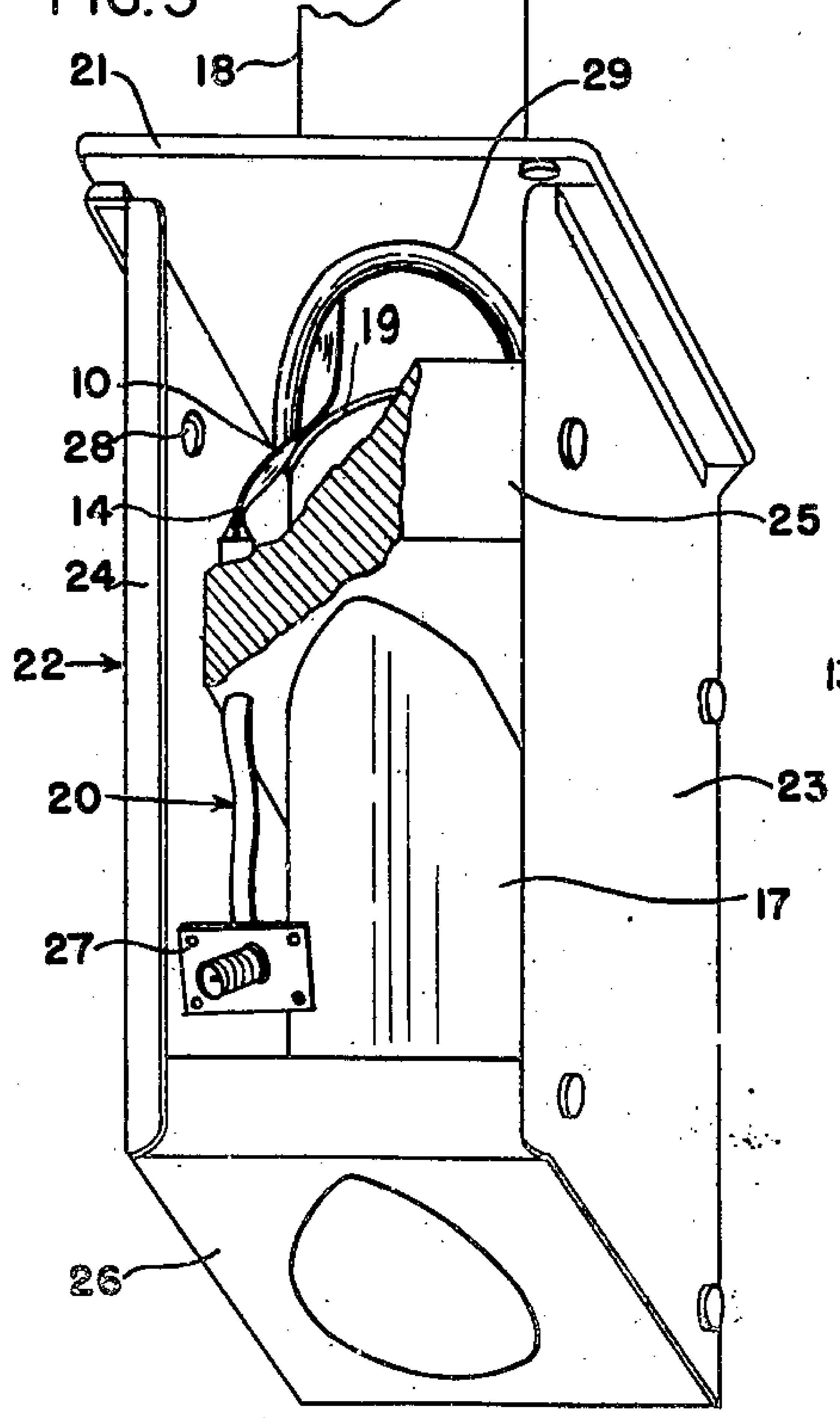


FIG. 3

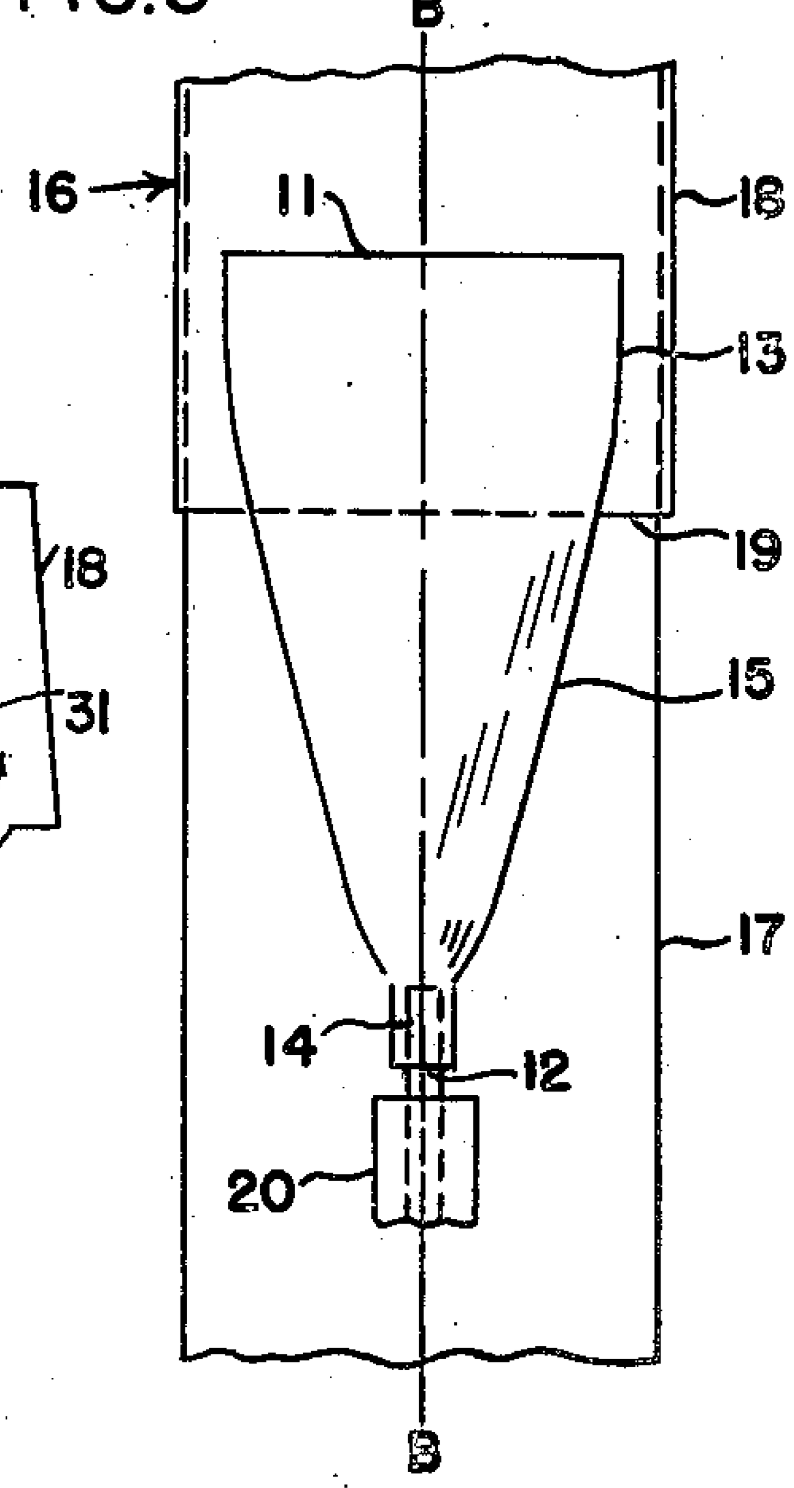
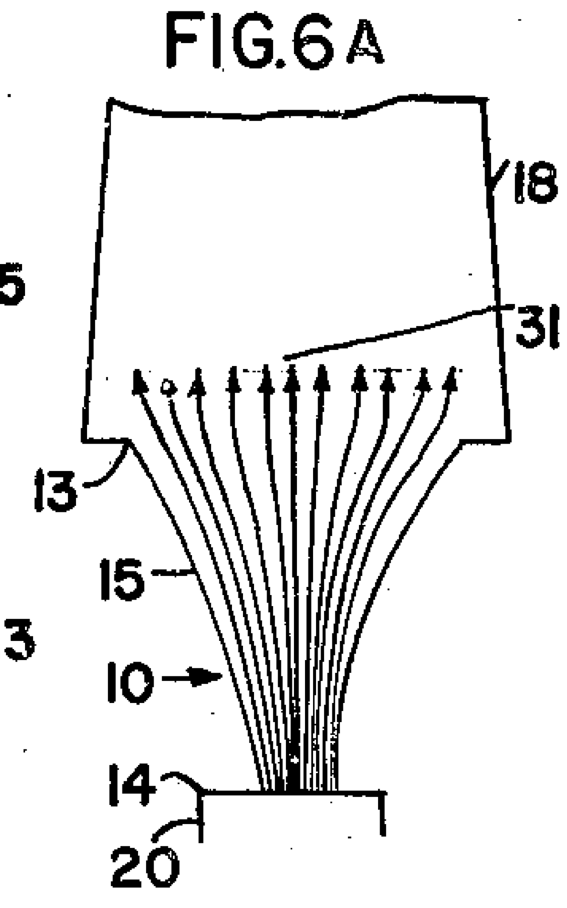


FIG. 6A



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CONNECTOR

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4 Claims. (Cl. 173—324)

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This invention relates to radio receivers and transmitters.

More specifically it relates to means for connecting a radio frequency receiver or transmitter through a transmission line to its associated antenna. It is of particular use in connection with apparatus installed on aircraft which is designed to operate over a wide range of high frequencies.

Heretofore, connections from transmission lines to antennas have been accomplished by wire conductors of relatively small cross section with relation to the cross-section of the radiating surface of the antenna. Such conventional arrangements will feed radio frequency energy into the antenna in the case of a transmitter or convey it from the antenna to the receiver in the case of a receiver in a satisfactory manner at relatively low radio frequencies. However, when the operating frequencies are such that their corresponding wavelengths approach the same order of magnitude as the dimensions of the circuit elements and their connections, wire conductors present abrupt changes in the dimensions of the system and cause serious electrical discontinuities because of the large differences in the characteristic impedances of the associated elements. This results in an increased standing wave ratio on the transmission line to the antenna and a resulting serious decrease in energy transfer.

It is an object of the present invention to provide means for electrically connecting the transmission line of a receiver or transmitter to its antenna by which electrical discontinuity is decreased and the standing wave ratio is greatly improved.

Another object of this invention is to provide a connection between an antenna and its associated apparatus in which current density along the connection and at the place where the current is introduced to the radiating surface of the antenna is substantially uniform.

It is a further object of this invention to provide means for efficiently transferring energy to or from an antenna over a wider range of operating frequencies than has been possible with devices of the prior art.

Other objects, features, and advantages of this invention will suggest themselves to those skilled in the art and will become apparent from the following description taken in connection with the accompanying drawings in which:

Fig. 1 is a plan view of a blank from which a device embodying the principles of the present invention might be made;

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Fig. 2 is a side elevation of a connector embodying the present invention;

Fig. 3 is a front elevational view showing the connection of a device embodying the present invention to a stub antenna;

Fig. 4 is a side elevation of Fig. 3;

Fig. 5 is an isometric view of a device embodying the present invention connecting an antenna mounted on an airplane to a transmission line and the associated supporting structure; and

Figs. 6 and 6A respectively are diagrammatic representations showing current distribution in devices of the prior art and in a device employing the present invention.

A connector 10 employing the principle of the present invention is in general of an isosceles trapezoidal shape as shown in Fig. 1. The dimensions of the connector are dependent upon the size of the antenna and transmission line used. Thus the large end 11 of the connector is of sufficient length to extend over a fair proportion of the side of a flat antenna or over a little less than a semicircle of an antenna of circular cross-section. The smaller end 12 is designed to fit around the circumference of the inner conductor of a transmission line. Preferably the connector should be of equal thickness throughout.

The connector may be made of any current carrying material but for best results it should be of the same material as the element forming the radiating surface of the antenna in order to eliminate any electrical discontinuity due to the use of metals having different contact potentials.

Adjacent to the larger end 11, as shown in Fig. 2, a portion 13 of the connector is bent to conform to the shape of the antenna with which it is to be used. At the narrow end 12, as shown in Fig. 2, a portion 14 is bent to encircle the end of the inner conductor of the transmission line. It is of great importance that the shape into which the connector is bent along its longitudinal axis, as generally shown at 15, Fig. 2, be a smooth curve having no abrupt changes in direction, kinks, or bumps. However, the exact form of the curve into which the connector is formed is to some extent dependent upon the shape, size, and position of neighboring metallic surfaces which may react on the radio frequency fields which are present.

The length of the connector along its longitudinal axis should be a small fraction of the wave length corresponding to the highest operating frequency, preferably not over one-eighth of a wavelength.

In Figs. 3 and 4 the attachment of the connector 10 to a flat stub antenna 16, constructed of a wooden core 17 surrounded by a metallic element 18 forming the radiating surface, is shown. Portion 13 of the connector is welded to the radiating surface 18 of the antenna. Preferably this is close to base 19 of the radiating surface but should be sufficiently far above the base to provide a large surface of contact between the radiating surface and the connector. The connector, as previously stated, is bent along a smooth curve for the portion 15, terminating in the portion 14 attaching it to the inner conductor of transmission line 20.

The connector is, for its entire length, symmetrical about its longitudinal axis. Any deviation from symmetry, especially in proximity to the radiating element of the antenna will tend, due to capacity effects, to disturb the electric balance of the whole connection and to cause a discontinuity in impedance.

It may be seen from the above description that neither the connector, its attachment to the transmission line, nor to the antenna presents any serious electrical discontinuity. The tapered shape of connector 10 provides, for its entire length, a gradual change in dimension resulting in a gradual change in electrical characteristics and a gradual change in distribution of the current carried by it to or from the antenna. No discontinuity occurs at the connection to the transmission line because there is there provided a large area of contact, a small change in cross-section of the current carrying member, and no abrupt change in direction. Similarly, electrical continuity is preserved at the attachment to the antenna by reason of the large contact area, of the gradual curve away from the radiating surface, and of the symmetrical position of the connector.

The detailed arrangement of one embodiment of the invention applied to apparatus mounted on aircraft is shown in Fig. 5. The antenna 16 is mounted so that all of the radiating surface 18 is outside of the metallic fuselage 21. The wooden core 17 of the antenna extends into the aircraft and is supported by a structure designed for that purpose and generally designated as 22. Structure 22 consists of two lateral metallic supporting plates 23 and 24 an intermediate wooden transverse support 25 and an end wooden transverse support 26. The lateral plates 23 and 24 are attached to fuselage 21 and the transverse supports are attached to the lateral plates by any suitable means. Transmission line 20 is supported by a plate 27 of any suitable type and passes through transverse support 25 to the point where its inner conductor is connected to connector 10 as above described. If desired transmission line 20 may be brought out through one of the lateral plates through an aperture 28, as shown in plate 24, provided for that purpose.

An opening in the fuselage fitted with an insulating grommet 29, preferably of soft rubber to provide a cushioning effect, is provided through which antenna 16 passes. The antenna is held firmly in position by transverse supports 25 and 26.

Connector 10 is attached in the manner above described to the antenna at the base of the radiating surface 18 which terminates a short distance outside of the fuselage 21. The shape into which connector 10 is bent, as above stated, must be free from abrupt changes in direction, kinks, or bumps but its exact shape is determined by the size, shape, and proximity of neighboring metallic surfaces such as fuselage 21 and lateral plates 23 and 24.

In some instances, the supporting structure for the antenna may be of such configuration that it is advantageous to add thereto a metallic element solely for the purpose of altering the capacity effects present in order that the shape of connector 10 may still be maintained to have the desired electrical characteristics.

An examination of Figs. 6 and 6*a* will show how an antenna connector employing the principles of the present invention attains a gradual change in current distribution from transmission line to antenna. If connection, as in the prior art, were made by wire, the pattern of current distribution, as shown in Fig. 6, would be very dense through connector 10, then would spread suddenly when reaching the much larger conducting area of the antenna. This sudden spread, as is shown at 30, results in an uneven distribution of current over the radiating surface 18. In a connector employing the principles of the present invention, the current as shown in Fig. 6A passes from transmission line 20 through portion 14, portion 15 and the connection to the antenna at 13. Since both the inductance and resistance of connector 10 steadily decrease in proportion to its increase in width, the current, steadily spreads out over the entire width as it travels along portion 15 and into the radiating element of the antenna. There is no abrupt change of area at the antenna so the gradual spreading out of the current continues. The result is that the current distribution in the antenna, as shown at 31 in Fig. 6A, is uniform over the width of the radiating element.

The above descriptions of specific embodiments of the invention and discussion of the electrical and mechanical principles affecting its operation will instruct one skilled in the art how to make and attach connectors employing the present invention for varying conditions encountered and for various operating characteristics required. Thus having before one fixed electrical conditions and mechanical arrangement of antenna and supporting structure, by the application of the principles herein disclosed, a connector may be designed to present a minimum of electrical discontinuity between transmission line and to provide even current distribution in the antenna resulting in optimum energy transfer.

While there has been here described what is at present considered to be the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention.

What is claimed is:

1. In a radio signaling apparatus including an antenna, a supporting structure therefor and a metallic conductor for supplying high frequency energy to said antenna; an electrical connector comprising a sheet of conductive material having greater width at one end than at the other and symmetrical about a longitudinal axis, said sheet having said wider end and a substantial area adjacent thereto formed into a substantially cylindrical shape having dimensions substantially equal to the outer dimensions of said antenna, said cylindrically formed portion flowing smoothly and gradually into a section of said connector intermediate the ends thereof, said intermediate section being substantially flat in a direction perpendicular to said longitudinal axis but curved in a direction along said axis, said sheet also being

provided with a second cylindrically formed portion adjacent its narrow end, said second cylindrically formed portion having inner dimensions substantially equal to the outer dimensions of said conductor, said second formed portion flowing smoothly and gradually to the shape of said intermediate portion, and means for joining said first and second formed end portions of said connector respectively to said antenna and said conductor whereby electrical energy flowing between said conductor and said antenna encounters no abrupt changes in cross section of said connector.

2. A connector for joining two circular conductors of different diameters in non-coaxial alignment, comprising a sheet of conductive material of greater size at one end than at the other and symmetrical about a longitudinal axis, said sheet having the end of greater size and a substantial area adjacent thereto formed in the shape of a cylinder having an inner diameter equal to the outer diameter of the larger of said two conductors, said sheet having the narrower end thereof and a substantial area adjacent thereto formed in the shape of a cylinder having an inner diameter equal to the outer diameter of the smaller of said two conductors, said sheet having a substantially flat portion intermediate the ends thereof, the areas between said flat portion and said formed end portions being curved so as to provide a smooth transition between said portions, and means for connecting said formed end portions to said conductors respectively whereby high frequency electrical energy flowing between said two conductors encounters no abrupt change in electrical impedance.

3. An electrical connector for joining two conductors having incongruent cross sections and unaligned axes, comprising a sheet of conductive material symmetrical about an axis, said sheet having first and second ends thereof and substantial areas adjacent thereto curved to conform with the cross sections of said first and second conductors respectively, and having the portion intermediate the ends thereof curved so that said connector forms a smooth curve between the surfaces of said two conductors, and means for joining one of said conductors to each end of said connector, whereby a continuous electrical path for high frequency currents is afforded between the surfaces of said conductors that is free from abrupt changes in shape or electrical impedance.

4. A connector for high frequency currents for connecting a cylindrical terminal of an antenna to a circular inner conductor of a coaxial line, said inner conductor being of smaller diameter than said terminal, comprising a sheet of conducting material having substantially constant thickness throughout but being of tapering cross-sectional area so as to have a large end and a small end, said large end having the configuration of a portion of a cylindrical surface of a size to extend at least partly about said terminal and be secured thereto, said small end having the configuration of a portion of a cylindrical surface of a size to extend at least partly about said inner conductor and be secured thereto, the portion of said connector intermediate said ends being shaped to curve smoothly into said ends, whereby said conductor forms a high frequency path between said terminal and said inner conductor which is substantially free from electrical discontinuities and in which the variations in current density and impedance are substantially uniform.

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