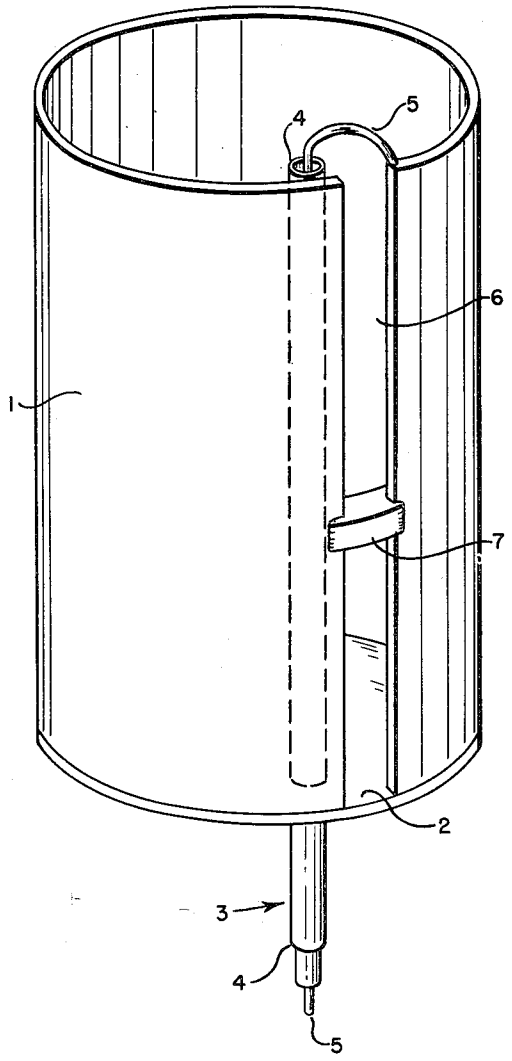
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SPLIT CYLINDER ANTENNA

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SPLIT CYLINDER ANTENNA

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This invention relates generally to electrical apparatus and more particularly to a radio frequency antenna whose horizontal pattern is free of deep nulls and has only relatively small directivity.

For certain purposes it is desirable to radiate radio frequency energy equally in all directions. That is to say, although there are advantages in antenna directivity for certain purposes, for other purposes it is quite undesirable. It is sometimes desirable that equal signal strength be emanated from a radiating element in every direction. For example, it might be expedient for a hovering aircraft to transmit radio frequency energy to fixed receiving stations. Such a plane, in cruising about, would have frequently to change direction in order not to fly away from the zone of its operation. If its antenna system were directive, movements of the plane would be felt in certain receiving apparatus as changes in signal strength and sometimes as complete disappearance of the signal. In effect there would be a kind of amplitude modulation superimposed upon the transmitted signals.

One type of antenna which might seem to have the proper form of radiation pattern is a quarter wavelength dipole protruding from the bottom of the aircraft and pointing toward the ground. It would, except for distortion due to reflections from the aircraft, radiate energy equally in all directions in the horizontal plane. However, since the energy polarization of this antenna is vertical, its use might not always be appropriate if the antenna systems of most receivers, associated with such a transmitting plane, were horizontally polarized.

It is an object of this invention to provide an antenna having a radiation pattern of relatively small directivity and without deep nulls in a plane that may be considered horizontal and is, in fact, a plane perpendicular to the axis of the main element of this antenna. It is also an object of this invention that this antenna offer a favorable impedance match for efficient power transfer from ordinary feed lines. It is a further object of this invention that this antenna may be conveniently used to radiate horizontally polarized waves. It is a further object of this invention that this antenna be adjustable for best operation at any particular frequency within a band of frequencies.

Generally, this invention comprises a substantially tubular structure conductive over at least its outer surface except for what may be a nonconductive strip running the length of the structure with its axis substantially coplanar with the axis of the tube. The width of this strip is small by comparison with its length. The interruption in the continuity of conductivity of the outer surface may take the form of a physical split, or slit, cut from the tubular structure (in the location described above) and particularly so if sheet metal is used to form this conductive element. This split tubular structure is fed with radio frequency energy applied from suitable transmission line means at selected points on each side of the slit and thereby communicated by way of the edges of the slit to substantially all of said outer conductive surface. Said outer conductive surface radiates said electromagnetic energy with its electric vector polarized in a plane, or planes, substantially perpendicular to the axis of said tubular element.

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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 of the invention taken in connection with the single figure of the accompanying drawing in which:

The figure is an isometric view of one embodiment of this invention.

Referring now more particularly to the figure, split cylindrical structure 1, in this embodiment of the invention, is composed of thin conductive material which may be sheet metal. It might be formed by bending a rectangular piece of sheet metal into a substantially cylindrical shape until two opposite edges of the originally rectangular piece of metal are brought together so as nearly to touch and to form, between them, a narrow slit whose axis is coplanar with the axis of the cylinder.

One end of this cylindrical structure abuts against and is attached to a flat end piece 2 which may be another piece of similar conductive sheet metal. Flat element 2 may be especially selected for the purpose and affixed to structure 1, or it may, in effect, be furnished by some portion of the bottom surface of the aircraft which is a conductive surface or is coated with a conductive material and is the part of the aircraft on which this antenna is installed.

Flat element 2 performs a mechanical function in adding to the rigidity of cylindrical structure 1. Besides this, it may sometimes also have an electrical function and affect the behavior of the radiating element. It may do this, in particular, by sometimes serving as a shorting element across one end of the open slit. However, it will be seen that this electrical function may be per-

formed by a separate additional element which is employed to make this antenna tunable. Coaxial transmission line 3, having an outer conductor 4 and an inner conductor 5 may be led to the inside of cylindrical structure 1 by coming through flat element 2 through a hole in it situated near an edge of slit 6. When the feed line is installed in this manner, it may be led along said edge to the opposite end of said edge (to the place where structure 1 remains open as shown in the figure). Outer conductor 4 may be mechanically and electrically connected to this edge of slit 6 either along its full length or at its above described end. In this embodiment, and particularly as shown in the figure, this connection is made at said above described end and is shown in the figure as a small, solidly inked-in area at this point of connection. Inner conductor 5 extends beyond outer conductor 4, at this point, and is bent over and electrically joined to the opposite edge of the end of slit 6. Shorting bar 7 is adapted to slide between, and to have good electrical contact with the edges of slit 6, thus short circuiting those edges at any point where it is positioned. Conventional types of spring contactors may be used and incorporated into shorting bar 7, or it may be designed as a clampable element which, at will, can be mechanically loosened, positioned, and retightened.

The length of slit 6 should be somewhat greater than one-half of one wavelength corresponding to the lowest intended operating frequency. For, while the velocity of propagation along slit 6 may, in occasional cases, happen to be exactly equal to the speed of light, it more often will vary so as to be either somewhat less or somewhat greater than that velocity. In most cases, the physical length of this slit, therefore, will be somewhat different than its electrical length, and sometimes it will be greater. Generous proportioning as to the length of the slit is advisable in order to give due allowance to this fact. In actual operation the whole length of slit 6 need not be used and the short circuiting bar may be set at a point on it which is distant from the feed point by an electrically effective half wavelength. By generous proportioning it will be possible to make this adjustment even if the velocity of propagation along the slit is greater than the speed of light.

It has been found empirically that the approximate circumference of the tubular element should be of the order of one whole wavelength in space. It is likely that reactance loading effects inherent in this metallic structure (which can be looked upon as a single turn of a wide strip of metal) may affect the electrical length measured around the outside of the tube between the edges of the slit so that the effective electrical length is really quite different than the physical measurement. But, however that may be, it has been determined as a fact that the cylindrical structure of conductive sheet metal should have a physical circumference about equal to eight-tenths of one wavelength in space which corresponds to the lowest operating frequency.

With proper adjustment of short circuiting bar 7 this antenna offers a good impedance match to a low impedance coaxial feed line.

The foregoing portion of this disclosure has indicated some of the controlling facts about the structure of this antenna. The following portion is a suggested theory as to the principles of its operation. The R. F. potential difference between the conductors of the feed line, when applied between the open ends of the slit, causes a wave to travel along the slit toward short circuiting bar 7. This wave is reflected by the short circuiting bar and, because the attenuation of the forward and reflected waves is not very great, a standing wave is formed along the slit. If the position of short circuiting bar 7 is adjusted properly, the standing wave will include one whole voltage loop with voltage nulls occurring at the feed point end of the slit and at the short circuited end. Thus tuned the slit presents a load of pure resistance to the feed line, and, moreover, the value of this resistance is a low one which may be of the order of 30 ohms.

The phases of the R. F. potentials at different points along the slit will be practically the same even though the potential differences will vary according to the standing wave ratio.

The potential differences existing between the two edges of the slit will cause R. F. currents to flow around the conductive outer surface of the tubular element causing an electric field to be set up whose lines of force are roughly parallel to those currents. As a result, the entire outer surface will radiate R. F. energy which is polarized in a plane, or planes, perpendicular to the axis of the tubular element.

The cylindrical structure acts as though it consisted of a number of individual loops piled up coaxially and energized in phase.

By reference to well known facts about the behavior of closed loops it could be inferred that the horizontal radiation pattern of this device, if its polarization be termed horizontal for purposes of convenience, would be rather nondirectional.

It has been observed by actual experiment that the radiation emitted by this antenna is so distributed, in those planes which include the axis of the tubular structure, that it forms, in those planes, radiation patterns which are all substantially the same and have the form of a figure 8 lying on its side, that is a figure 8 with its nulls lying along the axis of the cylindrical structure. The radiation emitted by this antenna is so distributed in planes at right angles to said axis, planes herein referred to as horizontal, as to form patterns which vary with the applied frequency. These patterns are generally cardiodal at higher frequencies and change gradually so as to be essentially oval at lower frequencies. This is true even though the short circuiting element is readjusted for each change in frequency. At any frequency reasonably within the operating range of the antenna it is free of pronounced nulls in the horizontal plane and generally has relatively small directivity. Horizontal radiation is often somewhat greater in the general direction of lines starting at the axis of the structure and extending out of the slit than in any of the other directions in "horizontal" planes.

It will be seen that the antenna herein set forth will radiate energy having horizontally polarized waves; that it will do so with relatively small directivity in the horizontal plane and without deep nulls in the radiation pattern in that plane; that it will present a suitable input impedance; and that it is adjustable for most efficient use at various frequencies within a band of frequencies.

It is obvious that there may be deviations from the shape and proportions of this device as herein described and in the manner of feeding

and tuning it without departing from the scope and spirit of this invention.

Accordingly all such deviations are claimed which fall fairly within the spirit and scope of the invention as identified in the hereinafter appended claims.

What is claimed is:

1. A radio frequency antenna for radiating energy in a predetermined frequency range and polarized in planes perpendicular to the axis of its principal component with no deep nulls and with small directivity in its radiation patterns in said planes, said antenna comprising a hollow, substantially cylindrical structure having one end closed and being conductive over most of its exterior surface and non-conductive over a narrow longitudinal strip portion of said surface, said strip having edges which are generally coplanar with the axis of said structure and having an effective length of at least a half wavelength at the lowest frequency in said frequency range and having at least one electrically open end, said cylindrical structure having a circumference substantially equal in physical measurement to substantially eight-tenths of said wavelength, transmission line feed means having its conductors electrically connected to conductive points on said surface at opposite edges of the open end of said structure and means tuning said slit to a half of said wavelength, the last-named means comprising a shorting bar slideable engaging the edges of said strip.

2. An antenna adapted to operate in a predetermined wavelength range, comprising a conductive sheet generally in the form of a cylinder closed at one end and having a narrow slit-like opening extending from the open end of said cylinder along the length thereof, the edges of said opening being substantially parallel and coplanar with the axis of said cylinder, the electrical length of said edges being at least one-half the longest wavelength in said range, said cylinder having an effective circumference approximately equal to said wavelength, transmission line means having its conductors separately connected electrically to said edges at the open end of said cylinder, and means tuning said slit-like opening to one-half of said wavelength, the last-named means comprising radio frequency short circuiting means engaging said edges at one point along their length.

3. An antenna adapted to operate over a predetermined wavelength range, comprising a tubular structure having an open end, said structure being conductive except for a relatively narrow strip extending longitudinally along said structure from said open end, the edges of said structure adjacent said strip being substantially coplanar with the axis of said tubular structure,

the effective length of said strip being equal to at least one-half of the longest wavelength in said range, the effective distance from one to the other of said edges around said structure by the shortest path being equal to substantially one wavelength, transmission line means having its conductors separately connected to said edges at one end of said strip, and means tuning said structure to one-half of said wavelength, the last named means comprising radio frequency short circuiting means connected across said edges at one point along said strip intermediate the ends thereof.

4. A broad band antenna with a substantially omnidirectional pattern in a given plane and polarized in the same plane, comprising: a conductive sheet in the form of a hollow metallic radiator having a slit along the length thereof, the ratio of the effective electrical length of the perimeter of said radiator to the length of said slit being not more than two to one, radio frequency transmission means connected to opposite edges of said slit at one end thereof, and means comprising a shorting element which slidably engages solely the edges of said slit at any point thereof for tuning said antenna.

5. An antenna for operation at a predetermined frequency with a substantially omnidirectional pattern in a given plane and polarized in the same plane, comprising: a conductive sheet in the form of a hollow metallic radiator closed at one end and having a slit along the entire length thereof, the effective electrical peripheral length of said hollow radiator at said frequency being substantially one wavelength, said slit having edges which are generally coplanar with the axis of said structure and having a length of at least an effective electrical half wavelength at said frequency, radio frequency transmission means connected to opposite edges of said slit at the open end of said radiator, and means for tuning said antenna comprising a shorting element which slidably engages solely the edges of said slit at any point thereof.

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