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HELICALLY SLOTTED CYLINDRICAL ANTENNA

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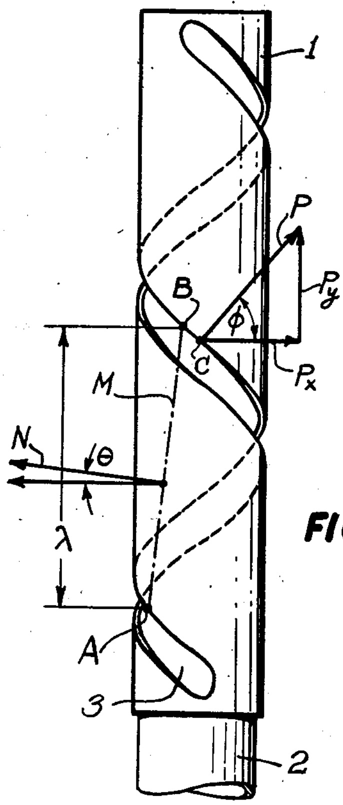

FIG. 1

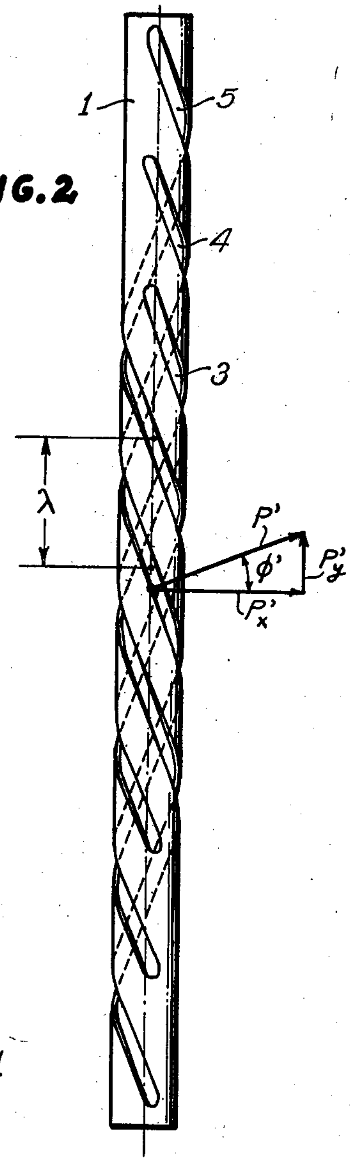

FIG. 2

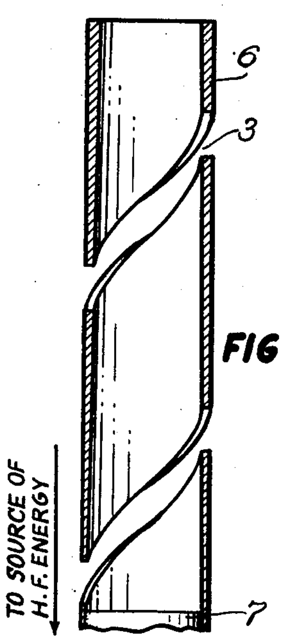

FIG. 3

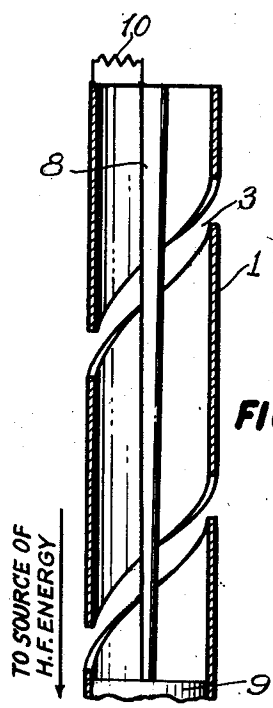

FIG. 4

INVENTOR.
WILLIAM SICHAK
BY Robert Harding Jr.
ATTORNEY

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HELICALLY SLOTTED CYLINDRICAL ANTENNA

William Sichak, Lyndhurst, N. J., assignor to International Standard Electric Corporation, New York, N. Y., a corporation of Delaware

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4 Claims. (Cl. 250—33.63)

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The present invention relates to radio antennae and, more particularly, to antennae used for the transmission of high frequency energy.

Generally, any discontinuity in a conductor carrying high frequency alternating current will radiate some power, and antennae radiating from slots which extend across current lines are known. In a single-slot antenna, however, the power radiated is limited by the width of the conductor, and it is therefore customary to provide a plurality of slots from which power may be abstracted at discrete points.

An object of the present invention is to provide an antenna in which the power radiated is not limited by the width of the conductor, yet is abstracted from the conductor in a continuous fashion.

Another object of the invention is to provide an antenna of the character described which is of simple design and convenient to manufacture.

A further object of the invention is to provide an antenna of the character described which has a circular pattern of radiation in a plane transverse to the radiating conductor and in which the direction of the beam and the plane of polarization are readily determinable.

Still another object of the invention is to provide an antenna of the character described in which the power abstracted at different points along the conductor is substantially the same.

In order to attain the above objects and others which will become apparent as the description proceeds, a tubular conductor is provided with a helical slot the pitch of which is determined by the wavelength to be radiated. The tubular conductor may be a wave guide or the outer conductor of a coaxial transmission line. The pitch of the helix is preferably an integral number of wavelengths; if more than one wavelength, a plurality of helical slots may be interleaved in the fashion of a multiple-thread screw.

The invention will be better understood from the following description, taken in conjunction with the accompanying drawing in which:

Fig. 1 illustrates one embodiment of the invention;

Figs. 2, 3 and 4 are different modifications of the structure shown in Fig. 1.

In Fig. 1 there is shown a tubular conductor **1**, rising in a vertical direction and being suitably energized from a source of high frequency energy, as, for instance, the wave guide **2**. A helical slot **3** is milled into the conductor **1**, making two complete turns around the latter. The energy radiated by each turn will add vectorially so that, if the pitch of the helix is at least roughly equal to

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one wavelength, reinforcement will occur. Also, since the slot extends over an angle of 720°, the radiation pattern in a horizontal plane will be circular; in a vertical plane the pattern may have several lobes and will be dependent upon the number of turns.

In the example given in Fig. 1, the length of pitch has been chosen slightly greater than a wavelength λ, with the result that two co-phasal points such as A and B will be relatively displaced by a small angle. The line M, interconnecting the points A and B, indicates the direction of the wave front through these two points, and thus the beam will propagate itself in a direction N, normal to M, making an angle θ with the horizontal. It will be seen, therefore, that the direction of the beam depends on the ratio between the pitch and the wavelengh and will be horizonal if the length of pitch equals λ or a multiple thereof.

Another factor to be considered is the plane of polarization of the radiated beam. This plane of polarization will be normal to the slot and, for a point C, has been indicated at P in Fig. 1, enclosing an angle ϕ with the horizontal. The cotangent of this angle is given as the ratio between the pitch of the helix and the circumference of the conductor **1** and, therefore, the angle θ will be large if the wavelength is small relative to the conductor diameter, resulting in a small horizontal component Px and a large vertical component Py. If this is undesirable, the angle θ and, thereby, the vertical component of the radiated field may be reduced by making the pitch of the helix equal to several wavelengths, such an arrangement having been illustrated in Fig. 2.

The antenna shown in Fig. 2 comprises a tubular conductor **1** formed with three helical slots **3**, **4**, and **5**, the axial distance between slots being one wavelength and the pitch of each helix being, consequently, 3λ. While Fig. 2 has been drawn to a smaller scale than Fig. 1, it will be noted that the proportion between the wavelength λ and the diameter of conductor **1** has been left substantially unchanged. With the arrangement of Fig. 2, however, the plane of polarization P' encloses a much smaller angle θ' with the horizontal, resulting in a large horizontal component Px' and a small vertical component Py'.

For maximum efficiency, as well as for the purpose of obtaining a truly circular pattern of radiation, it is desirable that the slot radiate the same amount of power per unit length along the entire active surface of the antenna. This may be achieved in two ways: The coupling of the slot may be increased uniformly so as to compensate for the power radiated along its length, or the coupling may be held constant and special means may be provided for maintaining a uniform power density along the slot by supplying added power to the conductor progressively over its length. The first case is illustrated in Fig. 3 where a tubular conductor **6** is shown as gradually increasing in thickness, starting at its point of coupling to a source of high frequency energy, as, for instance, the wave guide **7**. The second case is illustrated in Fig. 4 wherein the tubular conductor **1** forms the outer conductor of a coaxial line having an inner conductor **8**. The inner conductor **8** is tapered so as to decrease the characteristic impedance of the line in a direction away from the source of energy, shown as a coaxial line **9**. A suitable termination, indicated at **10**, may be provided between the outer and inner conductors **1** and **8** of the line.

It may be noted that any reflection occurring at a particular point along the slot will be effectively canceled by an equal reflection occurring at another point a quarter wavelength removed, such cancellation occurring point by point if the slot extends over an integral number of half wavelengths. Thus, with proper adjustment of the power distribution along the radiating portion of the antenna, a good impedance match will be obtained.

It will be further understood that the slots **3**, **4** and **5** need not be air gaps but may represent any discontinuity in the conductor filled with dielectric material which latter may advantageously take the form of a solid insulator where it is desired to increase the mechanical rigidity of the structure.

While the invention has been described with reference to certain specific embodiments, it should be understood that the examples given are strictly illustrative and that various modifications and adaptations will be possible without departing from the spirit and scope of the invention as defined in the objects and in the appended claims.

What is claimed is:

1. A radio antenna adapted to radiate energy uniformly from end to end comprising a tubular conductor, means for applying high frequency energy to said conductor adjacent one end thereof, said conductor being provided with at least one helical slot extending from said one end toward the other and having a pitch which equals substantially an integral number of wavelengths of the said high frequency inside said conductor, and means operatively associated with said slotted conductor for compensating for power lost by radiation along the way from said one toward said other end.

2. An antenna according to claim 1 wherein said compensating means comprises an inner conductor coaxial with said tubular conductor, said inner conductor increasing in diameter from said one toward said other end.

3. A radio antenna comprising a tubular conductor and means for applying high frequency energy to said conductor adjacent one end thereof, said conductor being formed with at least one slot extending helically around the conductor from said one end toward the other and having a pitch which equals substantially an integral number of wave lengths of the said high frequency inside said conductor, said conductor having a thickness that increases gradually from said one end to the other end in such a manner that the coupling of the slot increases with growing distances from said one end whereby the loss of power occurring along the slot will be substantially compensated.

4. A radio antenna adapted to radiate energy uniformly from end to end comprising a tubular conductor, means for applying high frequency energy to said conductor adjacent one end thereof, said conductor being provided with at least one helical slot extending from said one end toward the other and having a pitch which equals substantially an integral number of wavelengths of the said high frequency inside said conductor, and means in said antenna for compensating for power lost by radiation along the way from said one toward said other end.

WILLIAM SICHAK.

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