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BROAD BAND ANTENNA
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Fig. 1.

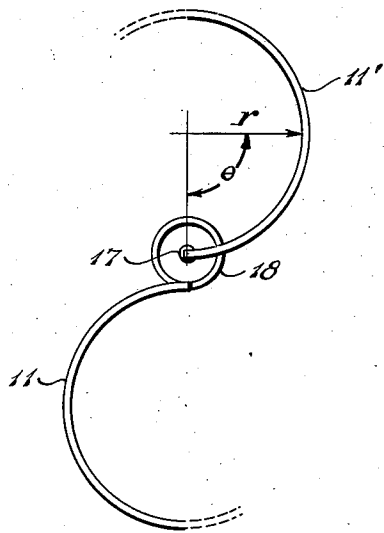
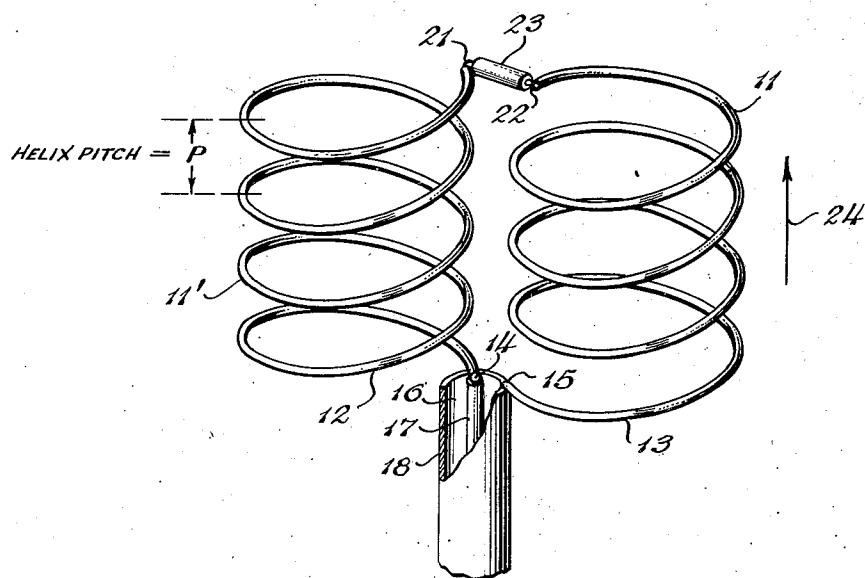


Fig. 2.



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BROAD BAND ANTENNA

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My invention relates to antennae or radiators for radio communication and signaling systems, and concerns particularly radiators suitable for use in high frequency radio systems such as may be used in connection with object detection.

An object of my invention is to provide an antenna having a pattern like an end-fire array of dipoles, but having a broader frequency band.

A further object of my invention is to provide a balanced double-ended antenna which is useful in pulse systems and in which sparking is prevented.

A further object of my invention is to provide an antenna giving circular polarization of radiation and reception.

Other and further objects and advantages will become apparent as the description proceeds.

In carrying out my invention in its preferred form, I utilize a rod or wire of suitable conducting material which is electrically continuous from one input terminal to the other, which is bent into helical form and has a diameter and pitch of the helix of such a value in relation to the desired wave-length that radiation from all elements of the antenna is in phase.

A better understanding of the invention will be afforded by the following detailed description considered in connection with the accompanying drawing, in which

Fig. 1 is a diagram representing a fragmentary end view of one embodiment of my invention, and

Fig. 2 is a perspective diagram of the embodiment of my invention represented in Fig. 1.

Like reference characters are utilized throughout the drawing to designate like parts.

The antenna illustrated in the drawing comprises a unitary length of wire 11 which is bent in the form of a helix. In order that running waves instead of a standing wave may be produced, and in order that a suitable termination may be conveniently connected to the antenna I prefer to provide a pair of helices 12 and 13 each formed of a length of wire represented by the separate symbols 11 and 11'.

For supplying input energy to the antenna at input terminals 14 and 15, a suitable transmission line, such as concentric line 16, may be provided comprising an inner rod conductor 17 connected to the antenna terminal 14 and an outer cylindrical conductor 18 connected to the antenna terminal 15.

The helices 12 and 13 may have end terminals 21 and 22, respectively, between which a suitable terminating impedance 23 is connected. Preferably the impedance 23 comprises a high frequency

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resistor having a resistance such as to suppress any reflected current waves. In other words, the unit 23 has an impedance matched to the antenna or equalling the characteristic impedance thereof.

Although the value of this resistance may be determined by calculation, I consider it preferable to determine the best value of terminating impedance by trial and error.

The form of antenna illustrated is advantageous when double-ended input is required and is useful for producing circular polarization. The direction of propagation of the radiated energy is along the arrow 24. In order that the phase relationship between the radiation and successive elements will be in the same phase, the dimensions of the antenna should be so chosen that variation in phase due to the lead or pitch of the helix compensates for the variation in phase due to the difference in position of said elements along the wire in any turn or portion of a turn of the wire forming the antenna. Thus, the effect of change in direction of the wire caused by bending it around an axis is overcome by also warping it to a pitch or advance along the direction of wave propagation.

It will be understood that an antenna of this type is particularly useful for high frequency radiation or radiation at frequencies such that the wavelength is comparable with the physical dimensions of the antenna. Consequently, the length of the wire is of the order of magnitude of a number of wavelengths, and the currents in the successive portions of the wire produce radiation at successively later periods of time. Consequently the radiation from successive elements of the wire would tend to vary progressively in phase relationship if the turns of wire all lay in the same plane.

Since the direction of propagation is along a line parallel to the helix axes, the change in phase due to progress of the phase along the wire in any one turn is compensated by the pitch of the wire causing successive portions of the wire to have different positions with respect to the direction of propagation. The radiation pattern resembles that of an end-fire array of dipoles.

The preferred dimensions of the antenna are therefore determined from the phase relationships of the radiation from various elements of the antenna. It may be shown that the phase of the radiation from any element is expressed by the equation

$$\phi = e^{jkr\theta - jk\frac{P\theta}{2\pi}} \cos \theta$$

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In this equation the symbol j stands for $\sqrt{-1}$, k is a constant $=2\pi/\lambda$, r is the radius of the curved portion of the antenna as shown in Fig. 1, θ is the angle between the element in question and the starting point of the wire, and the P is the pitch of the helix. The expression $e^{jkP\theta}$ determines the phase dependent upon the length of the wire, and the expression

$$\frac{jkP\theta}{2\pi}$$

the phase depending on the advance of the helix. The phase of waves running down the wires depends on $kr\theta$ for the distance along the wire and on $kP\theta/2\pi$ for the advance of the helix. When $\theta=\pi$, the direction of the wire has reversed. The waves will add in front if

$$r\pi - P/2 = \lambda/2$$

$$r - \frac{P}{2\pi} = \frac{\lambda}{2\pi}$$

In order to make the radiation from all elements of the same phase, dimensions should be chosen to satisfy the equation

$$r - \frac{\lambda}{2\pi} = \frac{P}{2\pi}$$

where λ is the electrical wavelength of the desired radiation. Suitable dimensions, for example, are

$$\pm \frac{\lambda}{4}$$

for the pitch P and the radius

$$r = \frac{5\lambda}{8\pi} \text{ or } \frac{3\lambda}{8\pi}$$

It will be apparent that the required phase relationships may be obtained by using a single helix, such as the helix 12 or 13 provided, however that the waves on the wire are running waves. To insure this, some form of termination is needed and the simplest way of providing for making connections to a termination is to employ a plurality of helices, in an even number, such as 2 or a multiple thereof.

Since rotational symmetry exists with respect to the helix axes parallel to the direction of propagation 24, the radiated wave is circularly polarized.

In accordance with the provisions of the patent statutes I have described the principle of operation of my invention, together with the apparatus which I now believe to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown and described is only illustrative and that my invention may be carried out by other arrangements.

What is claimed is:

1. An antenna composed of a length of conductor material curved to form successive elements with progressively different directions and in different planes with successive elements bent along a circle with a radius r and successive elements also warped into different planes with a pitch P satisfying the equation

$$r - \frac{\lambda}{2\pi} = \frac{P}{2\pi}$$

where λ is the electrical wave length of oscillations to be transmitted or received by the antenna.

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2. An antenna comprising a length of conductor material bent to a radius equal to

$$\frac{5\lambda}{8\pi}$$

and warped to give a pitch or advance equal to

$$\frac{\lambda}{4}$$

where λ is the electrical wave length of oscillations to be transmitted or received by the antenna.

3. An antenna comprising a length of wire in the form of a helix having a radius r and having a helix pitch P satisfying the equation

$$r - \frac{\lambda}{2\pi} = \frac{P}{2\pi}$$

where λ is the electrical wavelength of oscillations to be transmitted or received by the antenna.

4. An antenna comprising a length of conductor material bent into the form of a helix having a radius equal to

$$\frac{5\lambda}{8\pi}$$

and a helix advance or pitch equal to

$$\frac{\lambda}{4}$$

where λ is the electrical wavelength of oscillations to be transmitted or received by the antenna.

5. An antenna system for use with ultra short waves, comprising a length of conductor in the form of a helix having a diameter of the same order of magnitude as the length of said waves, and means supplying radio frequency energy to said helix, said helix having a pitch in relation to the diameter of said helix as to cause the same variation in phase due to the pitch of said helix as is due to the length of the conductor, whereby a unidirectional radiation pattern having a maximum directivity in the axis of the helix is formed.

6. An antenna system for producing circularly polarized ultra short waves, comprising a pair of conductors bent in the form of a pair of helices each helix having an input terminal and an end terminal connected to the other end terminal of said other helix of said pair of helices by a terminating matched impedance placed therebetween, and each of said helices further comprising a plurality of successive loops having diameters of the same order of magnitude as the length of said waves at the operating frequency, said loops of said helices being spaced from each other by a distance sufficient for radiation from each of said loops to arrive in phase at the next successive loop, whereby a radiation pattern having a maximum directivity along the axes of the helices is formed.

7. An antenna system for use with ultra short waves, comprising an even number of helices connected in series, a pair of input terminals each connected at one end of one of the helices, a terminating impedance connected in series with said helices and being matched thereto, and each of said helices further comprising a plurality of successive loops having diameters of the same order of magnitude as the length of said waves at the operating frequency, said loops of said helices being spaced from each other by a distance sufficient for radiation from each of said loops to arrive in phase at the next successive loop, whereby a unidirectional radiation pattern having a maximum directivity along the axes of the helices is formed.

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8. An ultra high frequency antenna system for use with ultra short waves comprising a plurality of radiating loops, means connecting each of said loops in electrical series with respect to one another, each of said loops being pitched from each other at a distance of the same order of magnitude as the length of said waves and having a suitable diameter so that the difference between the electrical phase displacement due to the length of conductor and the space phase displacement due to pitch is substantially a half-wavelength whereby radiation from each of said loops arrives in phase reinforcement at the next successive loop to form a radiation pattern having a maximum directivity in a plane perpendicular to the plane of said loops.

9. An antenna system for use with ultra short waves comprising a plurality of parallel displaced helices connected in series, each of said helices having a plurality of loops pitched in the same direction from each other by a distance in the same order of magnitude as said waves, a plurality of input terminals connected at one end of said helices and a terminating matched impedance connected in series with each of said helices so as to define a maximum radiation directivity characteristic for said waves along the axes of said helices.

10. In an antenna system for use with ultra short waves means for producing circular polarization comprising a pair of parallel displaced helices connected in series, each of said helices having a plurality of loops pitched in the same direction from each other by a distance in the same order of magnitude as said waves, a pair of input terminals connected at one end of said helices and a matched terminating impedance connected in series between said helices so as to define a maximum radiation characteristic for said waves along the axes of said helices.

11. A circularly polarized antenna system for use with ultra short waves comprising a pair of conductors having the shape of parallel displaced

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helices connected in series, each of said helices having a plurality of loops pitched in the same direction from each other by a distance in the same order of magnitude as said waves, and a terminating matched impedance connected between said conductors so as to define a maximum radiation directivity characteristic for said waves along the axis of said helices.

12. An ultra high frequency antenna system for use with ultra short waves comprising a pair of adjacent helices each having a plurality of radiating loops, said loops being connected in electrical series with respect to one another, each of said loops having a diameter of the same order of magnitude as the length of said waves, a terminating impedance interconnecting said adjacent helices for cancelling standing waves in said loops, said loops further being pitched from each other by a distance such that radiation from each of said loops will arrive in phase reinforcement at the next successive loop so as to form a radiation pattern of circular polarization having a maximum directivity parallel to the axes of said helices.

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