March 3, 1953 M. D. ADCOCK ET AL 2,630,530

HELICAL ANTENNA ARRAY

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FIG. 1

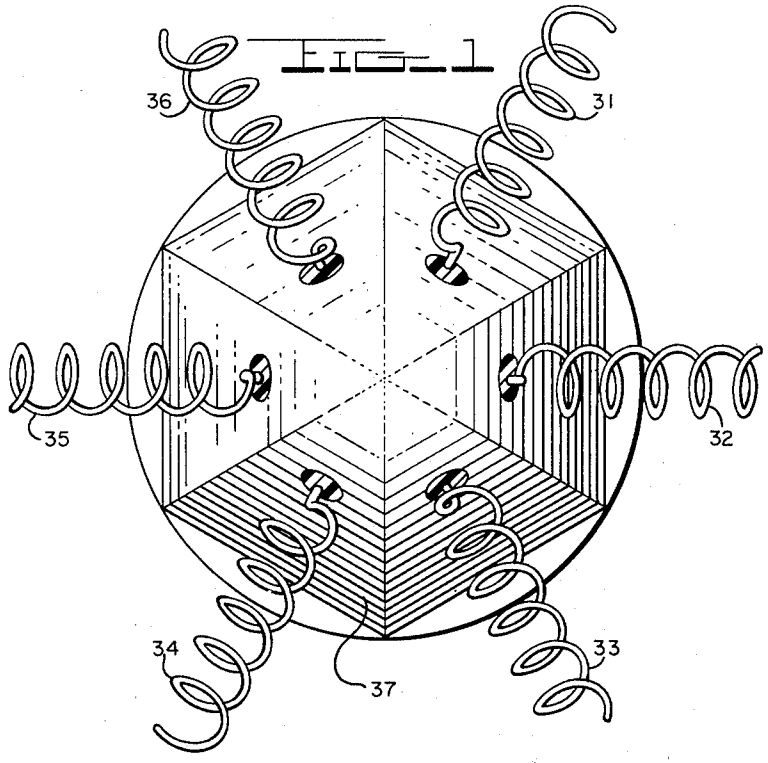
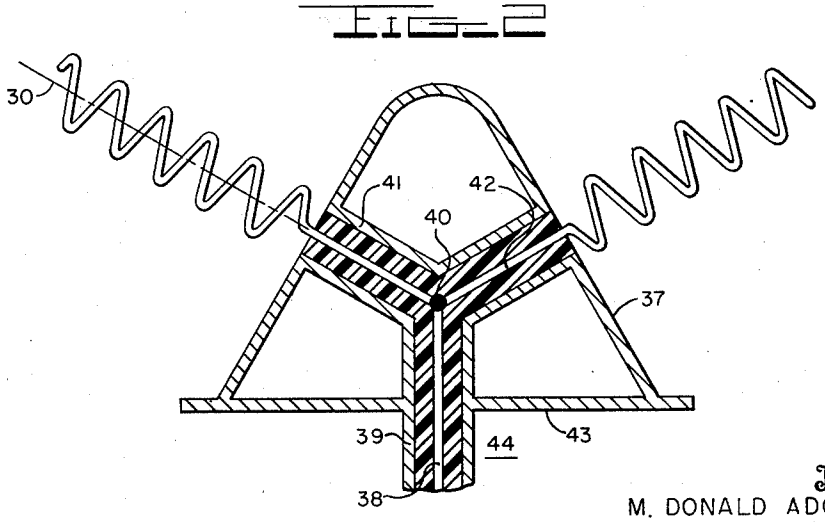


FIG. 2



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FIG. 3

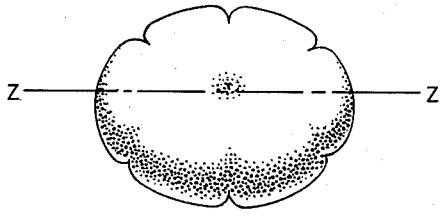
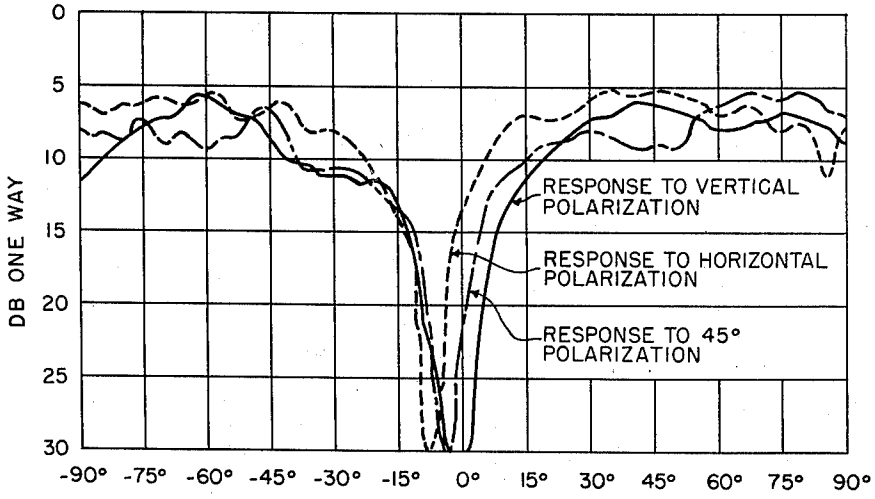


FIG. 4



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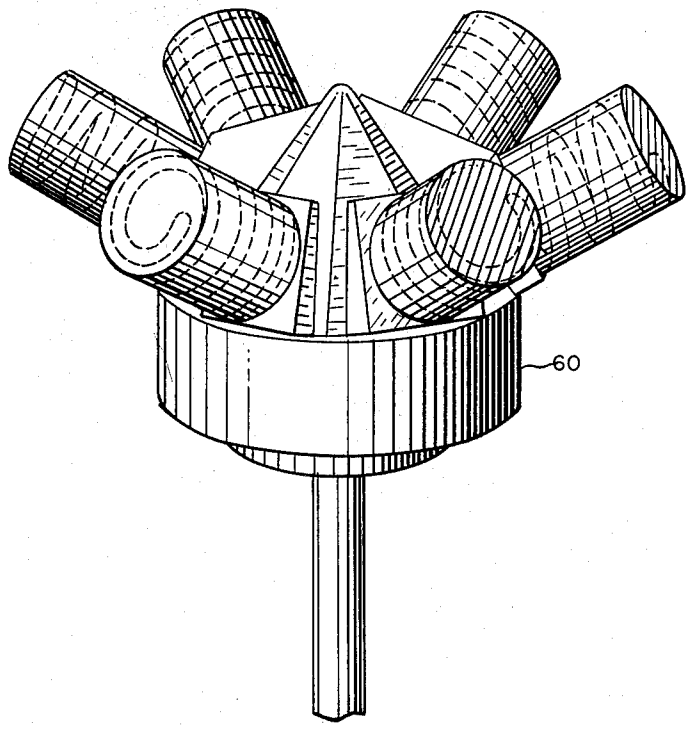
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FIG. 5



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HELICAL ANTENNA ARRAY

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8 Claims. (Cl. 250—33.57)

(Granted under Title 35, U. S. Code (1952), sec. 266)

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This invention relates in general to helical antenna arrays and is particularly directed to the problem of using helical elements to form an array offering a circularly polarized omnidirectional radiation pattern suitable for either transmission or reception purposes.

A frequently encountered difficulty in the transmission and/or reception of radiant energy is the choice of proper polarization. During the recent war the choice of proper polarization was a primary factor, especially in the jamming of enemy radar when it was not known what type of polarization was employed by the enemy. This problem is of essence today in the transmission and reception of radiant energy with respect to television.

Another vitally important factor, in the transmission and reception of television signals, as well as many other antenna applications, is to have a complete omnidirectional antenna field pattern. In certain other instances, however, such as for navigational purposes, it may be desired to have an omnidirectional pattern with a series of nulls interpersed therein.

In an antenna array constructed in accordance with the present invention, a plurality of circularly polarized helical antenna elements comprise the array. The helices are equally spaced radially around a common ground plane, to give a complete omidirectional radiation or reception pattern, or as hereinafter described, to give an antenna pattern having a number of nulls in accordance with the number of helical antenna elements employed.

It is accordingly an object of the present invention to provide a new and improved circularly polarized antenna array comprising a plurality of helical antenna elements.

Another object of the present invention is to provide a helical antenna array wherein the radiation fields of the individual helical antenna elements are added to give a complete omnidirectional pattern.

Another object of the present invention is to provide a helical antenna array wherein the relative phases of the individual helical antenna elements may be varied without affecting the phase of the currents feeding the individual helical elements to give an antenna pattern having a number of nulls therebetween in accordance with the number of elements employed.

Still another object of the present invention is to provide a new and improved antenna array wherein the angle of the helices with respect to the longitudinal axis of the array is varied

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to vary the degree of overlapping of patterns derived therefrom.

Further objects and attainments of the present invention will become apparent upon a careful consideration of the following detailed description when taken in conjunction with the drawings in which:

Fig. 1 is a top view of a typical embodiment of the present invention wherein all the helical elements are equally radially spaced around a common ground plane.

Fig. 2 is a cross sectional view of Fig. 1.

Fig. 3 is a perspective view of one typical radiation or reception field pattern obtainable with the array illustrated in Fig. 2.

Fig. 4 is a graphical representation of the reception pattern obtainable with the array illustrated in Fig. 1 wherein horizontal, vertical and 45° polarization is employed in transmission.

Fig. 5 is an illustration of the helical antenna array of Fig. 2 with a plastic embedment molded thereon.

The antenna array constructed in accordance with the teachings of the present invention employs a plurality of similar helical antenna elements. The helical elements in the preferred embodiment are of the filament (end-fire) type at the particular frequency at which they are designed for operation; that is, the radiation is maximum in the direction along the longitudinal axis of the helices. The polarization of the antennas comprising the array, when used for reception as well as transmission, is substantially circular. The helical antennas are symmetrically disposed around a common ground plane and are connected together to a common transmission line. This being possible in the transmission of radiant energy since all the radiators are energized in phase.

Referring now in particular to Fig. 1, there is illustrated an antenna array, composed of a plurality of helical elements having circular polarization and operable to give hemispheric coverage or to have a number of nulls in accordance with the number of elements employed. More particularly there is shown, in Fig. 1, a top side view of a practical embodiment of the present invention comprising six helical elements **31**, **32**, **33**, **34**, **35** and **36**. The helices are symmetrically disposed in azimuth and each of the elements is centrally positioned at right angle to one side of a six sided pyramid **37** which serves as the ground plane for the helices. The number of helices shown is, of course, only by way of illustration.

It was stated above that each helix has one end connected to a common point from which common point the plurality of helices are energized in phase. The antennas are also equally spaced around the common ground plane. It remains then that the phasing of the elements is completely independent of the phase of the energizing voltage and also of the spacing. The phasing of the individual helices with respect to each other is controlled by the angular orientation of the helix about its longitudinal axis. By varying the orientation of each of the respective helices, there occurs a phase change directly proportional to the angular orientation between helices. As an example, if it were desired to have a phase difference of 60° between the helices shown in Fig. 1, the first of the six helical antennas would be oriented at 0°, the second antenna would be oriented so that the first turn subtends at a 60° angle with respect to that of the first helix, the third at 120°, the fourth at 180°, the fifth at 240° and the sixth at 300°.

In the conventional type of transmitting antenna array, wherein the frequency of the energizing voltage is changed, there necessarily occurred also a change in phase of the energizing voltages feeding each antenna. This is especially annoying wherein the field radiation pattern is desired to be changed after the antenna array has been constructed. A change in phase of the energizing voltage accordingly is accompanied by a change in the impedance of the array. In an array constructed in accordance with the present invention the phase of the energizing voltage is unaffected since the phase displacement of the elements is entirely dependent on their orientation. It thereby, necessarily follows, that the impedance of any one element or of the entire array is also unaffected.

Another feature of the present invention is that the elevation angle of the helices, i. e., the angle between the longitudinal axis of the individual helices and the axis of the array, may be varied without departing from the phasing principle as taught above. This is possible without affecting the polarization of the antennas, since they are circularly polarized. The variation of this angle controls the degree of overlapping, etc. of the individual lobes of each helical antenna. A variation in the elevation angle of the helices with respect to the axis of the array or to the ground plane has proven to yield various types of field patterns, making it possible to have a complete omnidirectional pattern or again to permit a pattern having a number of nulls in accordance with the number of helical antennas employed. In other words the phasing of the helical antennas with respect to each other is substantially proportional to the orientation thereof, however, the field pattern derived therefrom may further be controlled by varying the above mentioned angle.

The helical antenna array as illustrated in Fig. 1, constructed in conformance with the principles of the present invention, was designed for 10 cm. operation, each helix having 5 turns with a spacing of .24 of the wavelength between any two turns; the diameter of each turn is .31 of the wavelength. The spacing and the diameter of the turns may be varied in the order of ±10% without appreciably affecting a change in the resonant frequency at which they are end-fire. The size of wire used in the preferred embodiment was $\frac{1}{16}$'' outside diameter, however it may

be varied considerably without appreciably affecting the resonant frequency of the helices. The number of turns per helix, of course, is not determinative of the resonant frequency but only as to the particular radiation pattern obtainable therefrom and each helix may have a different number of turns.

The helices are symmetrically disposed in azimuth and the helical antennas are centrally positioned on and at right angles to a six sided pyramid **37** which serves as the ground plane for the helices. The angle of elevation of each helix, that is the angle between the longitudinal axis of the helix, indicated by dotted line **30** of Fig. 2, and the base plate **43** for the pyramid **37**, is 30°.

The particular elevation angle of 30° of the helices with respect to the base plate **43** was found to be the optimum angle to give hemispheric coverage without loss of power due to overlapping at these frequencies with the particular design of helices. It will be noted upon observation of Fig. 1 that each helical antenna has an orientation distinction of −60°, thusly having a −60° phase difference between helices as taught above.

Fig. 2 is a cross sectional view of Fig. 1 to illustrate the manner in which the single coaxial transmission line is connected to the helical antennas. The coaxial transmission line **44**, composed of inner conductor **38** and outer conductor **39**, extends upward through the vertical axis of the six sided pyramid **37** to point **40** which is the converging point of the longitudinal axes of the six helical antennas. At this converging or common point **40** the coaxial line extends into a sexpartite coaxial line to each of the six helical antennas. The outer conductor **41** of the sexpartite coaxial line is terminated in the ground plane **37** at the base of the helices. The inner conductor **42** of each arm of the sexpartite coaxial line is connected directly to each helix as shown.

The antenna array, in which the dimensions were given above, gives a complete omnidirectional pattern, as illustrated in perspective in Fig. 3, when the helices are all oriented in the same manner, i. e., having a zero phase difference. It was also found that substantially the same pattern is obtained when the helices are oriented −60° apart, i. e., having a 60° phase difference, as shown in Fig. 1. The particular angle of elevation of 30°, as stated above, permits an omnidirectional pattern to be obtained and serves to eliminate the loss of gain due to overlapping. This elevation angle further serves to minimize the zone of silence directly above the antenna.

It was further determined that an antenna pattern having six nulls, a null between any two fields, can be obtained when the helices are oriented apart at an angle of 180°, which would give an 180° phase difference between helices. A pattern of this type readily finds utility in homing devices.

An antenna array constructed in accordance with Fig. 1 has proven to overcome the hereintofore mentioned difficulty wherein different types of polarization is employed. With reference to Fig. 4 there is shown a graphical representation of a typical reception pattern for any vertical plane through the axis of the helical antenna array wherein the transmission employed was vertical, horizontal and 45° polarization. In this figure the abscissa represents the angle with respect to the true vertical through the axis of the pattern of Fig. 3, such as shown by dotted line ZZ. It is readily seen upon observation of the graph

of Fig. 4 that the helical antenna array is equally as well operable regardless of the type of polarization employed at the opposite end.

In many installations of an antenna, such as on an aircraft, ship or submarine, it is necessary that the antenna be protected from shock, vibration, corrosion, etc. This is further necessary in the use of a helical antenna since the spacing of the turns, etc. is a principal factor in the proper operation of the antenna. If the antennas were allowed to vibrate from even a mild wind the entire manner of operability would be disturbed. With very small antennas not subject to vibration, such as probes or small dipoles, etc., a nonconducting casing has been sufficient as protection from corrosion and other weathering. A casing over the preferred embodiment of course would be no protection against shock or vibration.

We have found that by molding a plastic, such as polystyrene, over the entire array as illustrated at **60** in Fig. 5 the helical antenna array is entirely free from the effects of shock, vibration or weather. With a plastic embedment as a replacement for free space the antenna dimensions must accordingly be reduced to permit the antenna array to operate at the desired frequency. These changes may be computed from given formulas known to those skilled in the art.

Other means of protecting the antenna array may also be used such as a plastic foam, a dielectric hollow cylinder or rod and strip supports as an example of a few of which have been used successfully. The advantages of the form of embedment shown in Fig. 5 is that the overall size of the array is further reduced, the embedment permits pressurization and is very easily constructed.

Although certain specific embodiments of this invention have been herein disclosed and described, it is to be understood that they are merely illustrative of this invention and modifications may, of course, be made without departing from the spirit and scope of the invention as defined in the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. An antenna comprising: a polyhedral ground structure, a radiating helix disposed perpendicularly to each side of said ground structure, the angular orientation of the starting point of the initial turn relative to the respective longitudinal axes of the helices on adjacent sides of said polyhedron being different, and an in phase feed connection between said helices.

2. An antenna comprising: a polyhedral ground structure, a circularly polarized radiating helix disposed perpendicularly to each side of said ground structure, the angular orientation of the starting point of the initial turn relative to the respective longitudinal axes of the helices on adjacent sides of said polyhedron being different, and a common feed line connected to all said radiating helices in parallel.

3. An antenna comprising: a polyhedral ground structure, a circularly polarized radiating helix disposed perpendicularly to each side of said ground structure, the angular orientation of the starting point of the initial turn relative to the respective longitudinal axes of the helices on adjacent sides of said polyhedron being different and at least one of said helices having a relative angular orientation difference of 180° with at least one other of said helices, and an in phase feed connection between said helices.

4. An antenna comprising: a polyhedral ground structure, a circularly polarized radiating helix disposed perpendicularly to each side of said ground structure, the relative angular orientation of the starting point of the initial turn relative to the respective longitudinal axes of the helices on adjacent sides of said polyhedron being substantially 180°, and an in phase feed connection between said helices.

5. An antenna comprising: a pyramidal ground structure, a circularly polarized radiating helix disposed perpendicularly to each side of said ground structure, the angular orientation of the starting point of the initial turn relative to the respective longitudinal axes of the helices on adjacent sides of said pyramid being different, and a common feed line connected to all said radiating helices in parallel.

6. An antenna comprising: a pyramidal ground structure, a circularly polarized radiating helix disposed perpendicularly to each side of said ground structure, the angular orientation of the starting point of the initial turn relative to the respective longitudinal axes of the helices on adjacent sides of said pyramid being different and at least one of said helices having a relative angular orientation difference of 180° with at least one other of said helices, and a common feed line connected to all said radiating helices in parallel.

7. An antenna comprising: a pyramidal ground structure, a circularly polarized radiating helix disposed perpendicularly to each side of said ground structure, the relative angular orientation of the starting point of the initial turn relative to the respective longitudinal axes of the helices on adjacent sides of said pyramid being substantially 180°, and a common feed line connected to all said radiating helices in parallel.

8. An antenna comprising: a pyramidal ground structure, a radiating helix disposed perpendicularly to each side of said ground structure, the angular orientation of the starting point of the initial turn relative to the respective longitudinal axes of the helices on adjacent sides of said pyramid being different, an in phase feed connection between said helices, and a protective solid dielectric mass formed about said helices and rigidly supporting same.

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