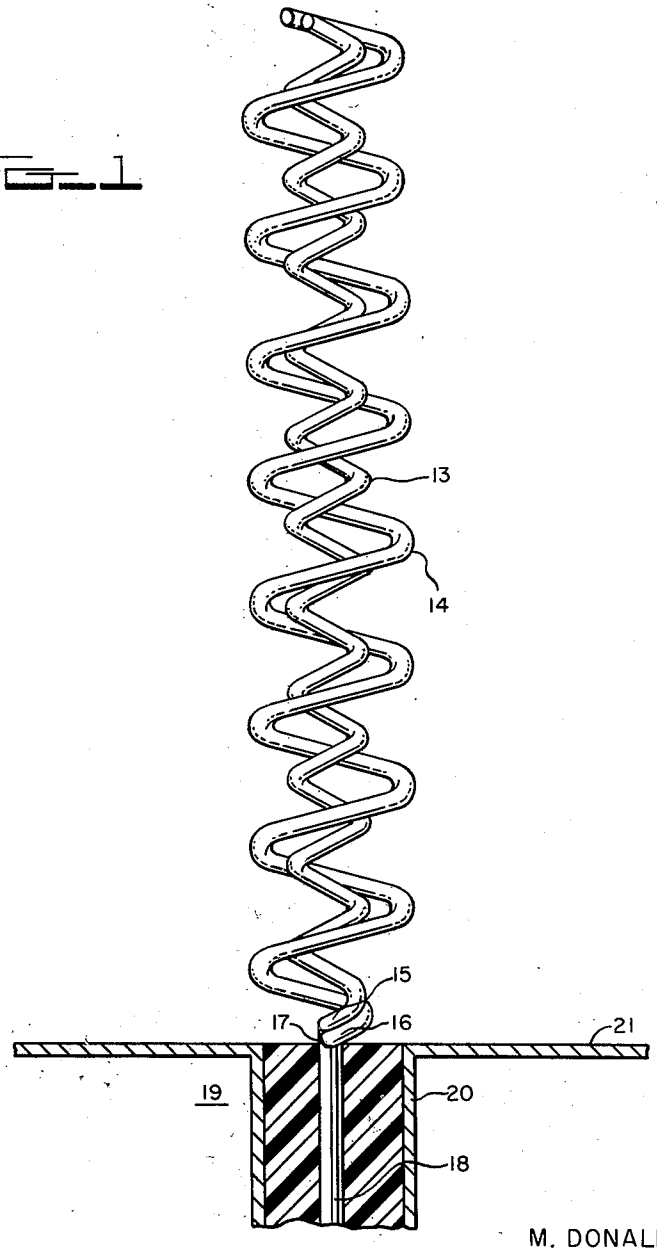
Sept. 23, 1952 A. E. MARSTON ET AL 2,611,868

BROADBAND HELICAL ANTENNA

Filed Nov. 15, 1949 2 SHEETS—SHEET 1

FIG. 1



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FIG. 2

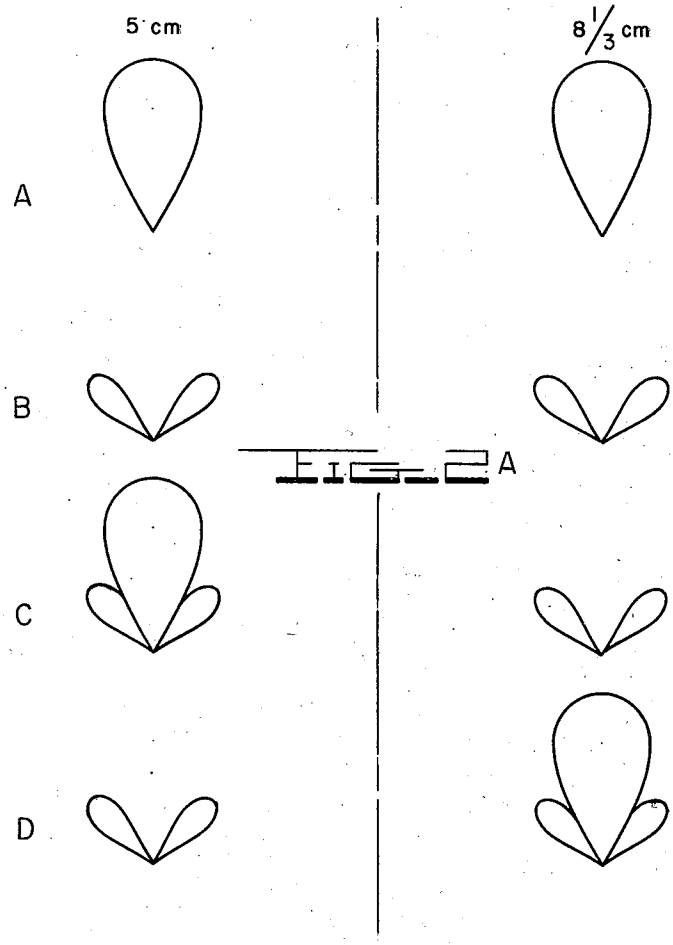


FIG. 2A

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BROADBAND HELICAL ANTENNA

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This invention relates in general to a broad band helical antenna and in particular to a broad banded multi-element helical antenna.

Helical antennas when designed to radiate as the filament or end-fire type, i. e., wherein the maximum radiation is in the direction of the helix axis, have inherent characteristics which in themselves tend to provide broad banded operation. It is also an inherent function, however, of the helical antenna that when not operating at the particular wavelength at which the element was designed, the pattern therefrom will shift its axis of maximum radiation and become conical or otherwise distorted. It follows, therefore, that there are practical working limits of frequency operation upon which a desired radiation pattern may be obtained from the conventional single helical antenna.

The present invention provides a multi-element helical antenna whose main axis of radiation is substantially unvaried over a broader band of frequencies hereinbefore achieved by the conventional single helical antenna.

It is accordingly an object of the present invention to provide a new and improved helical antenna operable over a broad band of frequencies.

It is a further object of the present invention to provide a new combination and arrangement of helical antennas operable to provide an essentially unitary radiation pattern over a broad band of frequencies.

Further objects and attainments of the present invention will become apparent from the following detailed description when taken in conjunction with the drawing in which:

Fig. 1 is a typical embodiment of the present invention illustrating a broad banded multi-element helical antenna constructed in accordance with the teachings of the present invention.

Fig. 2 shows several antenna patterns illustrative of the radiation field obtained from the individual helical antennas of Fig. 1 if they were to radiate alone.

Fig. 2*a* shows several antenna patterns illustrative of the radiation field obtained from the helical antenna as shown in Fig. 1.

The present invention is described hereinafter for the purposes of transmitting electromagnetic energy, it is to be understood, however, that it is not to be thusly limited and that the principles lend themselves equally well to the reception of electromagnetic energy.

In accordance with the teachings of the present invention, a plurality of helical antenna elements are employed and each is designed to be end-fire over a distinct frequency spectrum in the band to be covered. In particular, the entire frequency band to be covered by the array is divided into a minimum number of sub-bands and a different helix is used to cover each sub-band. Each helix is end-fire over its particular sub-band so that the range of frequencies of operation for which one helix is end-fire overlaps the range of frequencies of operation for which an adjacent helix is end-fire. Accordingly over an extended range of wavelength one helix is always radiating as an end-fire antenna.

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To illustrate this more specifically the broad banded multi-element helical antenna may be described, for simplicity only, as having two elements. One element is designed to provide end-fire radiation at a wavelength above the wavelength of the other element. In the transmission of electromagnetic energy both elements of the exemplary embodiment are fed from a single transmission line so that at a wavelength slightly above or below the exact resonant frequency of the first helical element, designed to radiate at the higher wavelength, the first helical antenna will, because of its natural resonance characteristic, be more strongly fed. The field radiation pattern obtainable from the multi-element helical antenna is essentially that which would be obtained from the first helical antenna if it were to radiate alone as a single antenna. Again, when there is transmission of electromagnetic energy at a wavelength slightly above or below the exact resonant frequency of the second helical element (the one designed to radiate at the lower wavelength), this second helical element will be more strongly fed. The field radiation pattern obtainable from the multi-element helical antenna is essentially that which would be obtained from the second helical antenna if it were to radiate alone as a single antenna.

Referring now in particular to Fig. 1 there is illustrated a practical working embodiment of the present invention wherein the multi-element helical antenna is operable as a single broad banded helical antenna. The two helical elements, as shown, are of electrical dimensions operable as end-fire antennas at distinct wavelengths. The frequency distinction therebetween is sufficiently narrow to cover the practical end-fire limits of each antenna but not to have an appreciable overlapping. As a typical example, the first helical antenna 13 is designed in this particular instance for 5 cm. operation to cover the lower wavelength and the second helical an-

tenna 14 is designed for 8⅓ cm. operation to cover the higher wavelength. Both antennas are wound in the same direction, with the higher frequency antenna 13, coaxially disposed within the lower frequency antenna 14. The inner element 13 having the smaller diameter and more turns per unit length than the lower frequency antenna 14. In determining the resonant frequency of the helical elements, the spacing between turns is calculated to be .24 of the wavelength and the diameter of the turns is .31 of the wavelength. The number of turns of each element is, of course, not a factor in determining the operating wavelength. The number of turns, however, does have a direct relationship to the width of the beam pattern; the more turns the more narrow the beam pattern. For the particular function of the multi-element helical antenna shown in Fig. 1 the 5 cm. antenna 13 has eleven full turns and the 8⅓ cm. antenna 14 has eight full turns.

The two helical antennas 13 and 14 are coaxially disposed above a central point on ground plane 21. The adjacent ends 15 and 16 are connected to a common point 17 and which common point is connected directly to the inner conductor 18 of coaxial transmission line 19. The manner of these connections are well known in the art and can be by soldering. The outer conductor 20 of coaxial transmission line 19 is terminated in the ground plane 21. The coaxial transmission line 19 serves to energize each of the elements with equal time phase voltages, this being possible since both elements are connected to the same point and the spacing of the elements is not a factor in the principle of the operation of the present invention.

With reference to Fig. 2 there is shown a series of antenna patterns for purposes of illustrating the manner of operation of the helical antennas when radiating alone. In general the left hand column illustrates the patterns obtainable from the helical antenna designed to radiate at 5 cm. wavelength and the right hand column illustrates the patterns obtainable from the helical antenna designed to radiate at 8⅓ cm. wavelength. The two top patterns, characterized as A, show the field pattern obtainable from the 5 cm. antenna and the 8⅓ cm. antenna, if they were to radiate alone, at the frequencies at which they are end-fire. B illustrates the field pattern obtainable from the 5 cm. and 8⅓ cm. antennas, when they are radiating alone, at a frequency substantially above or below the wavelength at which they were designed to be end-fire.

With reference to Fig. 2*a* there is shown a series of antenna patterns for purposes of illustrating the manner of operation of the multi-element helical array. The left hand column of C and the right hand column of D illustrate the manner of radiation when the two antennas are grouped in accordance with the present invention as a multi-element helical antenna. The pattern in the left hand column of C is illustrative of the overall pattern of the multi-element helical antenna when operating at a wavelength in the order of 5 cm. The pattern in the right hand column of C is similar to that of B and is shown here to illustrate that the helical antenna designed to radiate as end-fire at 8⅓ cm. does radiate at 5 cm. even though the radiation is not end-fire. In brief then, when the 5 cm. and the 8⅓ cm. helical antennas are operating as a multi-element antenna their combined individual patterns, as illustrated in the right hand column of A and the left hand column of B of Fig. 2, will be as shown in C of Fig. 2*a*. The radiation pattern of the 8⅓ cm. antenna in this instance is in the conical mode. As shown by the overall pattern of the multi-element helical antenna in the left hand column of C, the conical radiation from the 8⅓ cm. antenna presents a null at the longitudinal axis of the main beam of the 5 cm. antenna radiating as end-fire. It is seen, therefore, that the radiation from the 8⅓ cm. antenna does not interfere with the end-fire radiation of the 5 cm. antenna when radiating as an end-fire antenna slightly above or below 5 cm. wavelength.

With reference to D of Fig. 2*a* there is shown in the right hand column the overall antenna pattern of the multi-element helical antenna when operating at a frequency having a wavelength slightly above or below 8⅓ cm. The antenna designed to radiate as an end-fire antenna at 8⅓ cm. has a beam pattern as shown in A of Fig. 2 whereas the 5 cm. antenna in this instance has conical beam pattern as shown in B of Fig. 2. Again the conical beam pattern, of the 5 cm. antenna in this instance, is similar to B and is shown in D to illustrate that it will also radiate at 8⅓ cm. although not as an end-fire antenna. When the two antennas are combined as in Fig. 1 their combined patterns will be as shown in the right hand column of D. The conical beam pattern of the 5 cm. antenna when operating at a frequency in the order of 8⅓ cm. wavelength also presents a null on the longitudinal axis of the main beam of the 8⅓ cm. antenna radiating as end-fire.

It is seen by these patterns that the helical antennas in combination have maintained the main axis of radiation unchanged over a wavelength almost twice as great as the wavelength of a single antenna. It is not quite twice as great due to the overlapping of the frequencies covered by the two antennas. An overlapping of course is necessary since the exact band-width limitations cannot be exactly determined for practical purposes. However the area of overlap can be kept to a minimum.

A broad band helical antenna having circular polarization readily finds utility in many antenna applications as well known to those skilled in the art, but the advantages offered, especially that of circular polarization, is of special importance to television both with respect to transmission and reception.

Although we have shown and described one preferred embodiment of this invention, it is to be understood that it is merely illustrative 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 plurality of coaxially disposed interwound helical antenna elements, each of said helical elements having different dimensions to provide distinct resonant frequencies and each radiating end-fire independently of the other, a connection from one end of each of said antennas to a single common point isolated from ground, and a transmission line connecting said helical antennas in phase at said common point.

2. An antenna comprising a ground plane, a plurality of coaxially interwound helical antenna elements disposed above a central point on said ground plane, each of said helical antennas having different dimensions to provide distinct resonant frequencies, a connection from one end of each of said antennas to a single common point, means connecting said helical antennas in phase which includes a transmission line having an inner conductor connected to said common point and an outer conductor connected to said ground plane.

3. A high frequency circularly polarized antenna comprising a ground plane, a plurality of end-fire helical elements coaxially interwound in the same direction and disposed above a central point on said ground plane, each of said elements radiating independently of the other and each having different dimensions to provide distinct resonant frequencies, a connection from one end of each of said elements to a single common point, concentric transmission line means connecting said helical elements in phase including an inner conductor connected to said common point and an outer conductor connected to said ground plane.

4. An antenna comprising a plurality of coaxially disposed, interwound, helical antenna elements connected together at a single common point of origin only, each of said elements having different dimensions to provide distinct resonant frequencies.

5. An end-fire antenna comprising a plurality of coaxially disposed, interwound, helical, end-fire antenna elements connected together at a single common point of origin only, each of said elements having different pitch and diameter to provide distinct resonant frequencies.

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