

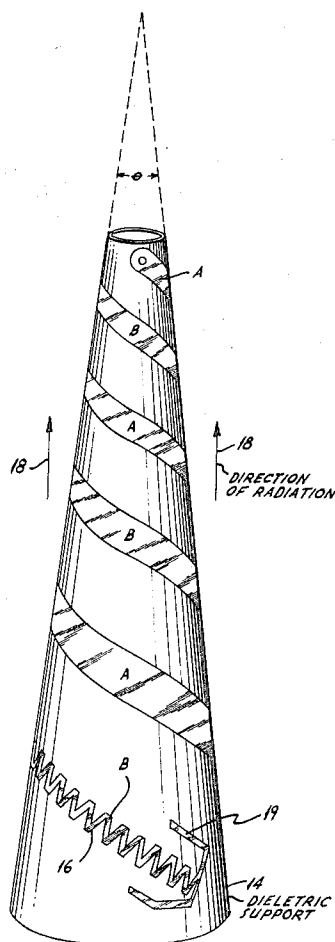
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 [21] Appl. No. **641,841**
 [22] Filed **May 26, 1967**
 [45] Patented **Jan. 4, 1972**
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[56] **References Cited**
UNITED STATES PATENTS
 2,958,081 10/1960 Dyson 343/895
 3,241,148 3/1966 Lechtreck 343/895
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[54] **UNBALANCED CONICAL SPIRAL ANTENNA**
 10 Claims, 6 Drawing Figs.

[52] U.S. Cl. 343/895
 [51] Int. Cl. H01q 1/36
 [50] Field of Search 343/895

ABSTRACT: A directional broadband antenna utilizing two dissimilar interleaved spiral radiators of conical configuration with radio equipment optionally housed in shield within dielectric conical support for radiators.



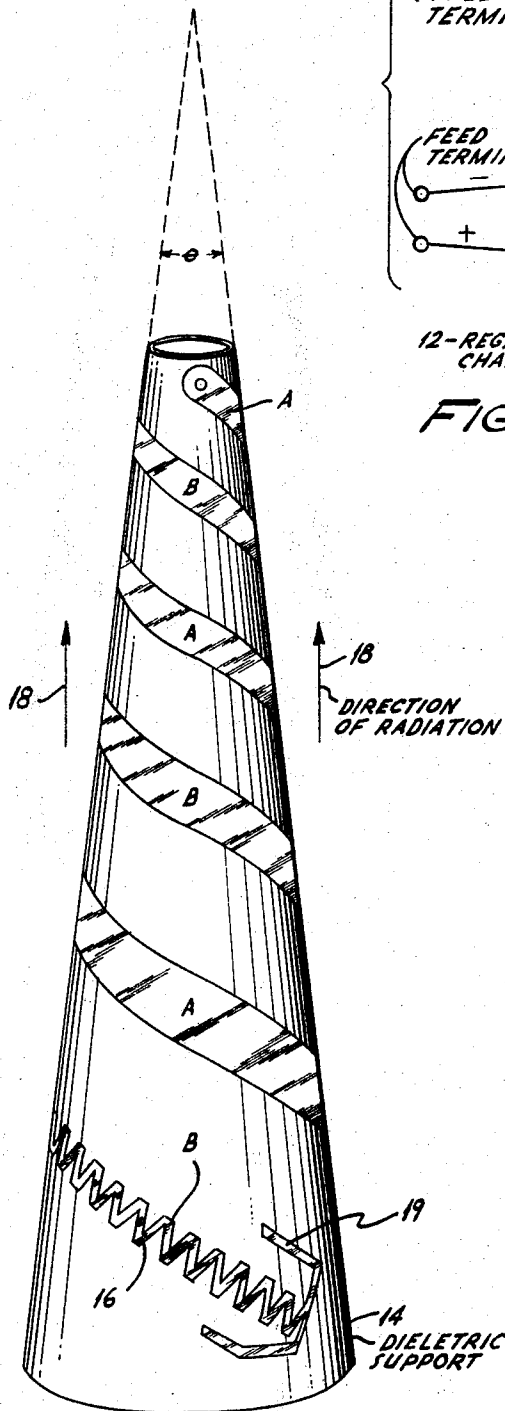


FIG. 2. SIDE ELEVATED VIEW

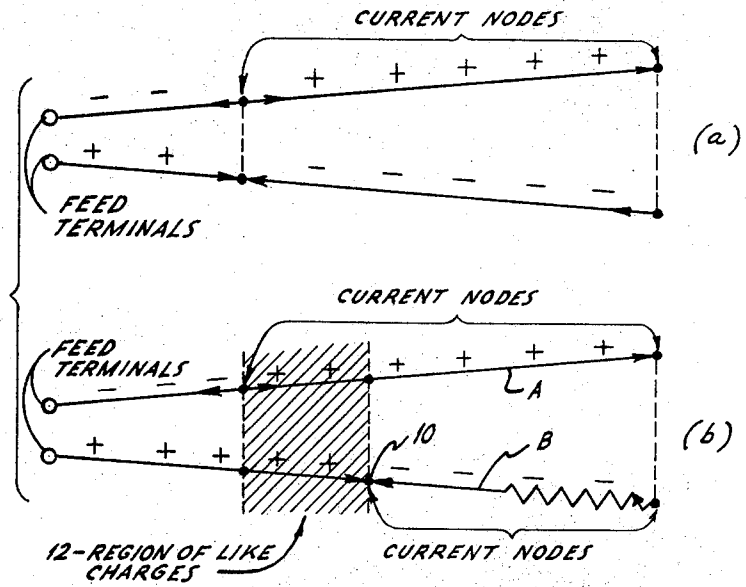


FIG. 1.-CHARGE DISTRIBUTION ON (a) BALANCED LINE AND (b) UNBALANCED LINE

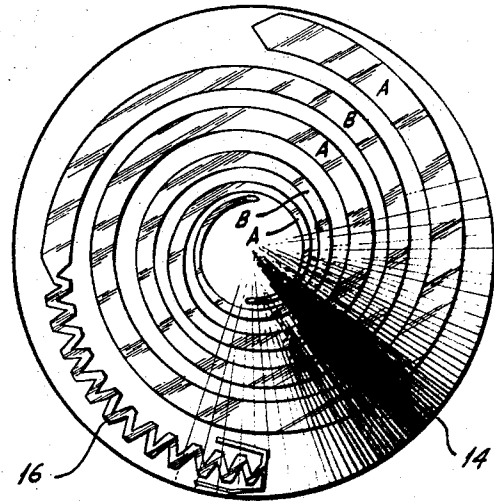


FIG. 3. TOP VIEW

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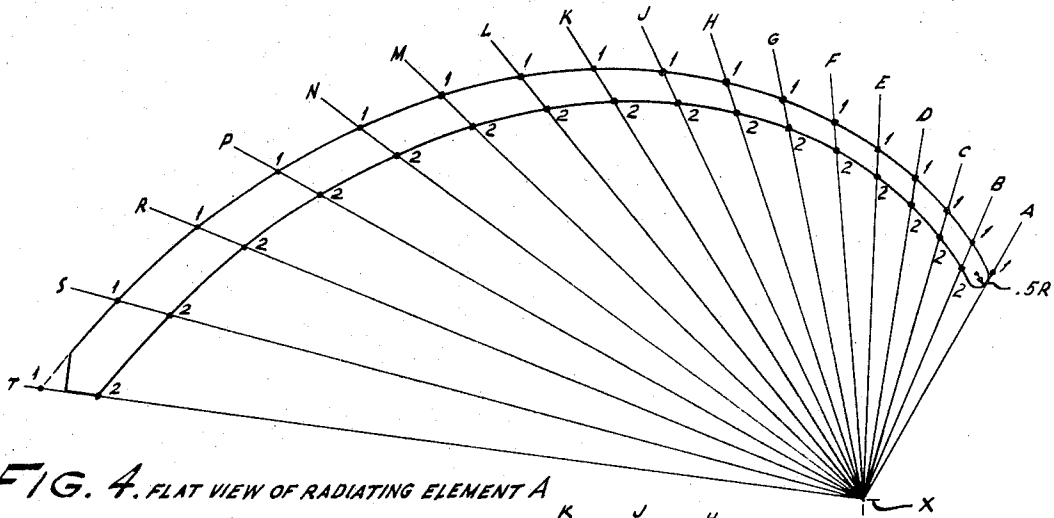


FIG. 4. FLAT VIEW OF RADIATING ELEMENT A

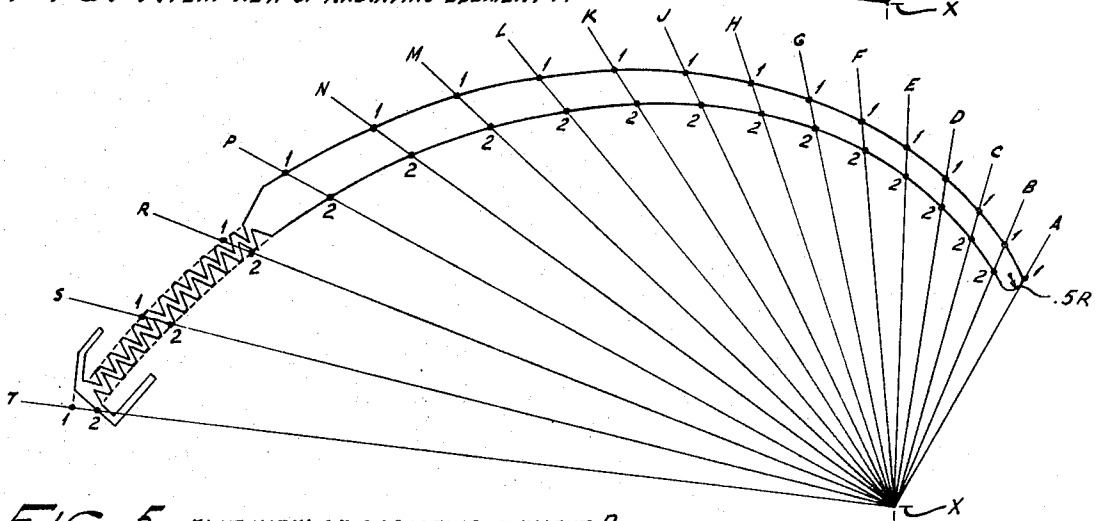


FIG. 5. FLAT VIEW OF RADIATING ELEMENT B

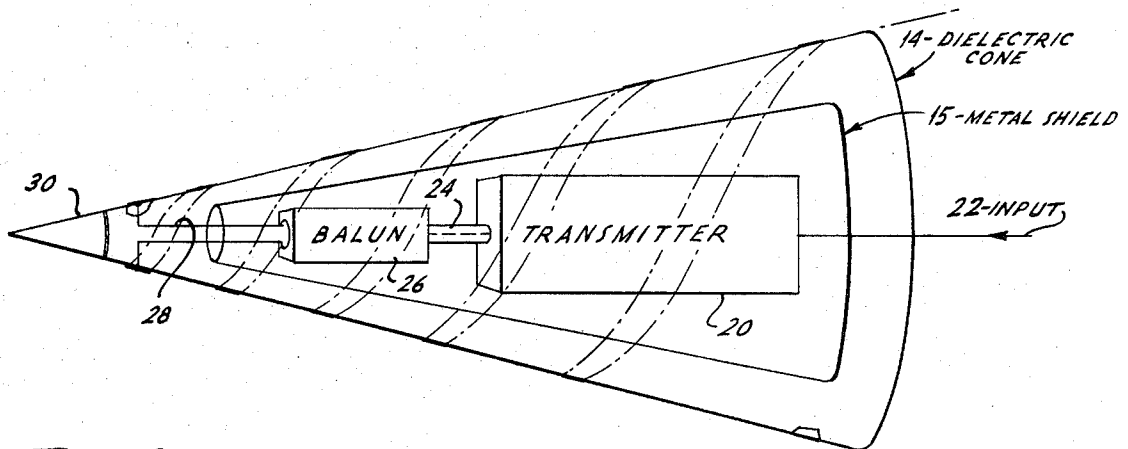


FIG. 6. SKELETON VIEW OF ANTENNA WITH RADIO EQUIPMENT

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UNBALANCED CONICAL SPIRAL ANTENNA

This invention relates generally to antennas and particularly to a broadband directionally radiating antenna of very small volume in relation to comparable counterparts thereof.

The prior art conical spiral antenna, typified in U.S. Pat. No. 2,958,081 to Dyson, granted Oct. 25, 1960, is capable of broadband directional-radiating characteristics. However this type of antenna must have a relatively large size in order to radiate efficiently. For example, the prior art conical spiral antenna normally occupies about 0.04 cubic wavelength of volume at the longest wavelength of its operating band. As will be recognized by those skilled in the art, this size is undesirably large and creates various difficulties in practical installations of the antenna. It would therefore be highly desirable to provide a wideband, directionally radiating antenna of greatly reduced size.

Accordingly, several objects of the present invention are: (1) to provide a directional broadband antenna of greatly reduced size, and (2) to provide an improved conical spiral antenna. Another object is to provide an antenna in which transmitting or other equipment can be housed conveniently within the antenna so as not to require additional space. Further objects and advantages of the present invention will become apparent from the ensuing description thereof.

SUMMARY

A directional broadband antenna of greatly reduced size is provided in the form of a two-arm conical spiral antenna in which the electrical characteristics of the arms are dissimilar so as to create different standing wave patterns on the respective arms. Thereby identical fields will exist over a corresponding portion of each arm so that the antenna will be able to radiate efficiently even though the spacing between the arms is reduced by reducing the size of the antenna. Also radio equipment may optionally be housed within a shielded enclosure positioned within a conical support for the antenna.

DRAWINGS

FIG. 1 is a diagram of charge distributions on balanced and unbalanced lines which aids in understanding the present invention,

FIG. 2 is a side elevational view of one form of the antenna of the invention,

FIG. 3 is an end view of the antenna of FIG. 2,

FIGS. 4 and 5 are flat developments of the respective radiating element of one form of the antenna of the invention,

FIG. 6 is a skeleton view of one practical installation of the antenna of the invention showing the placement of radio equipment within the antenna.

FIG. 1

A typical prior art conical spiral antenna (not shown) comprised a pair of identical (balanced) conductors formed on a dielectrical conical surface with one conductor displaced from the other by 180°. Thus a 180° of the two conductors on a planar surface perpendicular to the axis of the cone was a pair of interleaved spirals. As stated, this antenna had to be relatively large in order to radiate efficiently. The necessity for its relatively large size is due to the need for preventing the fields produced by each conductor, which are at all times equal and opposite at all corresponding portions of both conductors, from canceling each other.

FIG. 1A shows a diagram of the theoretical charge distribution on the unwrapped arms of a typical prior art balanced spiral antenna. It can be seen that the current nodes on each conductor are at corresponding points on each conductor and, as represented by the (+) and (-) signs, the instantaneous field produced by one conductor is opposite to that produced by the other conductor at all corresponding points. Since the fields produced by the separate conductors are equal and opposite, a large amount of mutual cancellation will occur unless the conductors are spaced apart by a substantial fraction of a wavelength. Thus in order to be able to radiate efficiently, the balanced conical spiral antenna had to be relatively large.

According to the invention, a conical spiral antenna is provided in which the respective arms thereof are electrically dissimilar so as to provide an unbalanced arrangement. Thereby the stand-wave patterns on the respective arms, and the fields created on the two arms will not be equal and opposite over corresponding portions of both arms but will actually be in phase over a large corresponding portion of both arms. No cancellation will occur over these in-phase portions so that efficient radiation will be provided even though the arms are closely spaced by a very small fraction of a wavelength.

FIG. 1B shows a diagram of the instantaneous charge distribution on the unwrapped arms of an unbalanced spiral antenna according to the invention. The lower arm B is made electrically dissimilar to the upper arm A by providing, in one preferred embodiment, a slow wave portion on arm B by shaping the right end thereof in the form of a zigzag. This slow wave portion will shift the current node 10 on arm B to the right, toward the slow wave portion. This will shift the entire field produced by arm B to the right so as to create a region 12 on both arms in which the charges produced by the respective arms are similar. It will be evident that the arms now will be able to radiate efficiently no matter how closely the arms are spaced since no opposite polarity, mutually cancelling fields will exist in region 12.

FIGS. 2 and 3

FIGS. 2 and 3 show side elevational and end views of an unbalanced conical spiral antenna according to the preferred embodiment of the invention in which unbalanced arms such as shown in FIG. 1B are formed on a conical dielectric support 14. As indicated by the end view of FIG. 3, which shows a projection of the arms on a planar surface perpendicular to the axis of the cone, the arms form a pair of interleaved equiangular spirals, with the envelope of the zigzag portion 16 forming part of the spiral shape of arm B.

The dielectric support 14 has no significant electrical function and may be omitted if the arms are made rigid enough to be self-supporting or are otherwise supported.

The arms are normally excited at the ends thereof closest to the narrower end of the conical support 14. As indicated by arrows 18, the antenna will radiate in the direction in which the cone points over the higher frequency portion of the operating band. Over the lower frequency portion of the operating band, the antenna will radiate with less intensity in the direction in which the cone points, but with increasing intensity in the directions normal to the cone's axis.

The length of the unbalancing zigzag portion 16 of arm B is not critical and desirably extends up from the end of the arm from one-eighth to one-fourth wavelength at the lowest wavelength of the radiated band as measured along the centerline of the arm. The "U"-shaped portion 19 at the end of the zigzag is an end loading element for fine tuning; this element has been found to increase the operating bandwidth by reducing the lowest operating frequency by 20 percent.

The use of a zigzag portion 16 is only one way of unbalancing the arms so that the standing-wave patterns thereof are not opposite in the two arms. The arms can be unbalanced in other ways such as: (1) terminating one arm in a capacitor and the other arm in an inductor, (2) adding a fast wave structure such as a series of ungrounded capacitor elements in series to one arm, (3) replacing the zigzag structure with any slow wave structure such as (a) a group of ungrounded inductive elements in series, (b) a toothed structure, and (c) different dielectric loading than the other arm, or (4) lengthening one arm (the additional arm length may be coiled or spiraled inside the antenna cone). It has been found that unbalancing by lengthening one arm produces matched input impedances at frequencies lower than those obtainable with the use of the zigzag portion. Other suitable ways of unbalancing the two arms of the antenna will be visualized by those skilled in the art and accordingly the invention is not limited to the specific embodiment shown or the other examples given but contemplates all unbalanced structures within the scope of the appended claims.

In one operational embodiment of the invention the antenna was designated to radiate efficiently over the band from 200 to 600 MHz by making the cone angle $\theta 13.2^\circ$, the height of the cone 26 inches, the diameter of the base thereof 8 $\frac{3}{4}$ inches, and the diameter of the truncated upper base thereof 2 $\frac{3}{4}$ inch. The input voltage standing wave ratio was less than 2 to 1 relative to 50 ohms over the entire band. The volume of the antenna cone was 0.003 cubic wavelength at the longest wavelength of the band, a reduction to less than 8 percent of the volume of a corresponding balanced arm conical spiral antenna. This dramatic reduction in size is possible because of the unbalancing slow wave zigzag portion 16.

FIGS. 4 and 5

FIGS. 4 and 5 show flat layout views of the individual radiating arms A and B and the tables below give dimensions in inches from the reference points X to the other lettered reference points A to T. On a flat pattern, the angle between adjacent reference lines in the group XA to XT in FIGS. 4 and 5 was $6^\circ 57.5'$. The actual dimensions of the radiating elements and the details of the zigzag portion are not critical and the diagrams of FIGS. 4 and 5 and the tables below are given as an example of one optimized design of a preferred embodiment of the antenna.

FIG. 4				FIG. 5			
A1	10.75	A2	—	A1	10.75	A2	—
B1	11.60	B2	10.42	B1	11.60	B2	10.42
C1	12.50	C2	11.32	C1	12.50	C2	11.32
D1	13.50	D2	12.32	D1	13.50	D2	12.32
E1	14.58	E2	13.40	E1	14.58	E2	13.40
F1	15.72	F2	14.54	F1	15.72	F2	14.54
G1	16.96	G2	15.72	G1	16.96	G2	15.72
H1	18.30	H2	16.96	H1	18.30	H2	16.96
J1	19.75	J2	18.30	J1	19.75	J2	18.30
K1	21.30	K2	19.75	K1	21.30	K2	19.75
L1	23.00	L2	21.30	L1	23.00	L2	21.30
M1	24.85	M2	23.00	M1	24.85	M2	23.00
N1	26.80	N2	24.85	N1	26.80	N2	24.85
P1	28.90	P2	26.80	P1	28.90	P2	26.80
R1	31.10	R2	28.80	R1	30.08	R2	28.90
S1	33.50	S2	31.10	S1	32.28	S2	31.10
T1	36.10	T2	33.50	T1	34.50	T2	33.50

Table of distances in inches from reference point X to reference points A1 to T2 in FIGS. 4 and 5.

FIG. 6

According to the invention, radio equipment may be placed within the dielectric support 14 if a suitable isolating metal shield 15, smaller than the dielectric support 14, but corresponding in configuration thereto, is provided within support 14. The metal shield 15 has no significant electrical function in the operation of the antenna; however it should not be spaced close to the radiating arms in order to minimize loading. Within the metal shield 15 can be placed a transmitter 20 which is excited by an input 22.

The unbalanced (coaxial) output 24 of transmitter 20 is converted to a balanced output by a balun 26. Balun 26 can be formed from a coaxial cable in which a slot in the outer conductor thereof widens gradually until the inner and outer conductors form a balanced two-wire line such as shown at 28.

The dielectric cone 14 may be made of any material which has a low dielectric loss, such as fiber glass. A streamlining apex portion 30 for the dielectric support 14 is shown in FIG. 6. Portion 30 has no electrical function and can be formed of the same material as support 14 or can be metallic, if desired.

Obviously the antenna of the invention can be formed as part of the nose of any airborne, surface, or undersea vehicle.

While there has been described what is at present considered to be the preferred embodiment of the invention it will be apparent that various modifications and other embodiments thereof will occur to those skilled in the art within the

scope of the invention. Accordingly, it is desired that the scope of the invention be limited by the appended claims only.

We claim:

1. A directional broadband antenna comprising two elongated electrical conductors shaped in a three-dimensional configuration such that (1) the projection thereof on a planar surface is a pair of separated interleaved spirals and (2) no two separate points on the axis of either of said conductors lie in any one plane parallel to said planar surface, said conductors being electrically dissimilar such that if two respective points on said conductors which lie in a plane parallel to said planar surface are excited by a radiofrequency voltage source, the resultant standing-wave current pattern in said conductors, and hence the resultant fields produced thereby, will be in phase over a corresponding portion of each of said conductors with respect to said coplanar points, whereby said antenna will be able to radiate efficiently even though said conductors are closely spaced.

2. The antenna of claim 1 wherein a portion of only one of said conductors has a zigzag configuration, the projection of the envelope of said zigzag portion conforming to part of one of said spirals.

3. The antenna of claim 1 further including a dielectric cone, said conductors being formed on the tapered surface of said dielectric cone.

4. The antenna of claim 1 further including a dielectric cone, said conductors being formed on the tapered surface of said dielectric cone, and further including a conductive enclosure positioned within said cone, said enclosure containing electronic means for supplying radiofrequency energy to said antenna, and means for coupling radiofrequency energy from said electronic means to a pair of coplanar points on said respective conductors.

5. The antenna of claim 4 in which said conductors are excited at the ends thereof at the narrower portion of said cone.

6. A broadband directional antenna comprising a conical dielectric support, a pair of conductors positioned on said support, said conductors having a configuration such that the projection thereof on a plane perpendicular to the axis of said cone is a pair of interleaved spirals, the end of one of said conductors being coplanar with and displaced from the end of the other by an angle of about 180° , said conductors being electrically dissimilar such that if said ends thereof are excited by a radiofrequency voltage source, the standing-wave current patterns in said conductors, and hence the resultant fields produced thereby, will be in phase over a corresponding portion of each of said conductors.

7. The antenna of claim 6 wherein one only of said conductors has a zigzag configuration over a portion of its length, the projection of the envelope of said zigzag forming part of one of said spirals.

8. The antenna of claim 6 further including a conductive enclosure positioned within said conical support, and also including a source of radiofrequency energy within said enclosure.

9. The antenna of claim 8 wherein said enclosure is cone shaped.

10. The antenna of claim 8 wherein said conductors are flat strips formed on said conical support, the width of said strips increasing toward the wider part of said support, one of said strips having a zigzag portion near the end thereof at the base of said support, the envelope of said zigzag portion forming part of one of said spirals, the end of said one strip having a U-shaped loading element connected thereto, a conical conductive enclosure having substantially the same taper angle as said conical support positioned within said support, said enclosure including a source of radiofrequency energy for exciting said antenna, and means coupling said source to the ends of said strips at the narrower end of said conical support.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,633,210 Dated January 4, 1972

Inventor(s) Charles W. Westerman, William G. Scott, William S. Wales

It is certified that error appears in the above-identified patent
and that said Letters Patent are hereby corrected as shown below:

Column 1, in paragraph beginning "FIGS. 4 and 5", second
line (line 44): "element" should be --elements--.

Column 1, in penultimate paragraph, fourth line (line 52):
"1800" should be --projection--.

Column 2, line 4: "stand-" should be --standing--.

Column 3, line 2: "designated" should be --designed--.

Column 3, line 5: after "8-3/8", --inches-- should be inserted.

Signed and sealed this 6th day of . June 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents