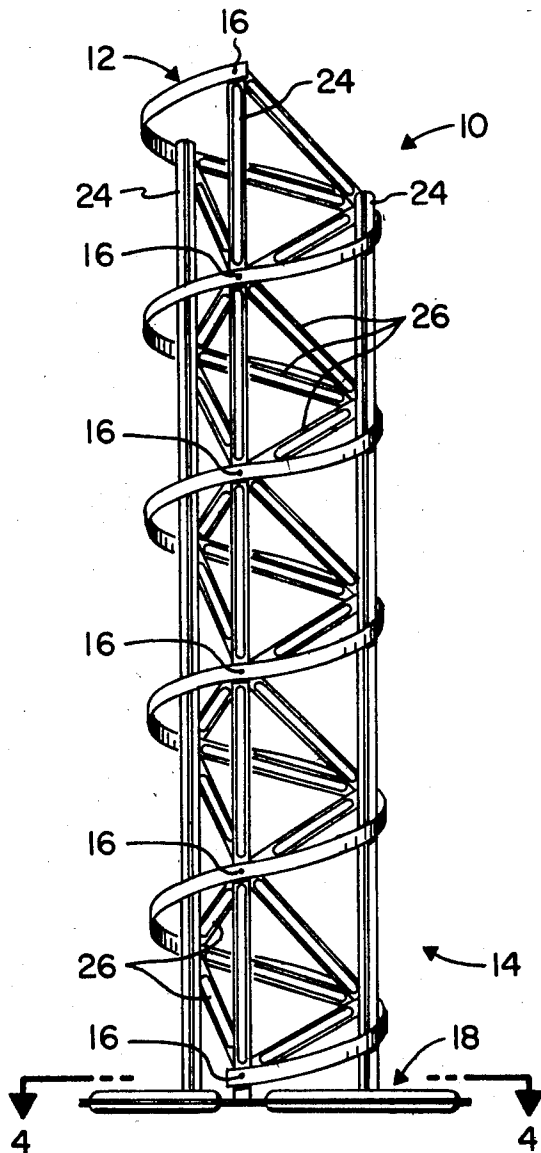


- [54] **LIGHTWEIGHT DEPLOYABLE HELICAL ANTENNA**
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- [73] Assignee: **TRW Inc.**, Redondo Beach, Calif.
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- [52] U.S. Cl. **343/881, 343/895**
- [51] Int. Cl. **H01q 1/36**
- [58] Field of Search..... **343/880, 881, 895**
- [56] **References Cited**
UNITED STATES PATENTS
3,699,585 10/1972 Morrison 343/895

Primary Examiner—Eli Lieberman
Attorney, Agent, or Firm—Daniel T. Anderson;
Donald R. Nyhagen; Jerry A. Dinardo

[57] **ABSTRACT**
A lightweight deployable helical antenna having a thin, flat electrically conductive radiator strip helically coiled about an axially extensible and contractable supporting structure and pivotally secured at intervals to the structure in a manner such that the antenna is longitudinally contractable to a collapsed configuration and extendible to a deployed configuration. In the preferred embodiment, the antenna supporting structure is a truss frame structure constructed of tubular, resiliently flexible elastic strain energy deployable beams which deform when the frame structure is contracted to store elastic strain energy for extending the antenna to its deployed configuration.

9 Claims, 6 Drawing Figures



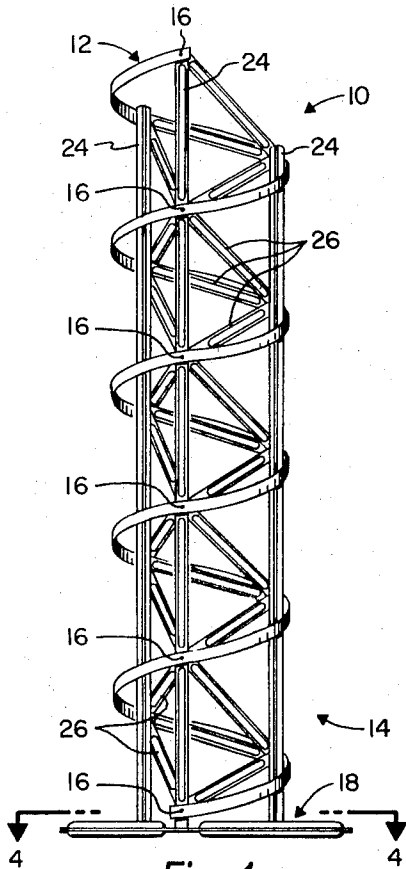


Fig. 1

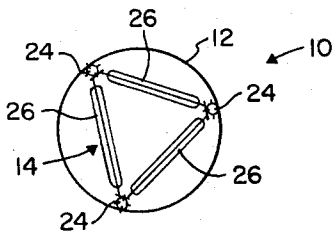


Fig. 2

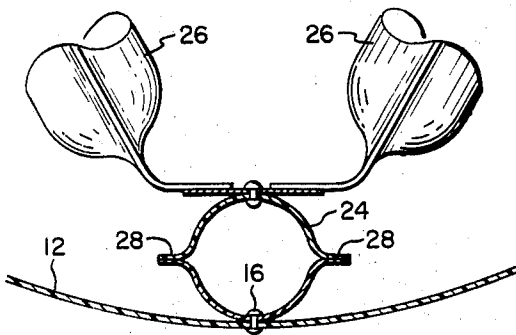


Fig. 3

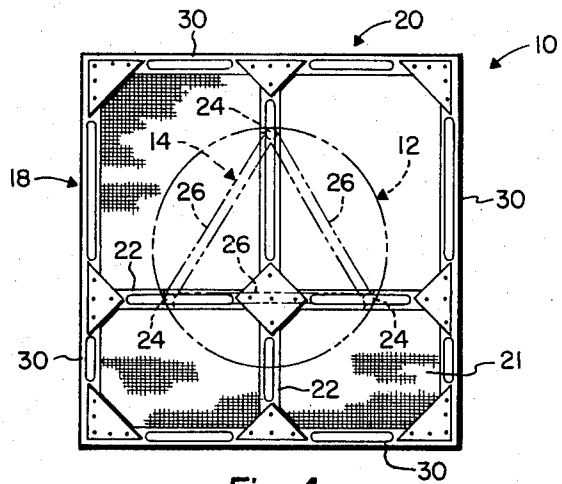


Fig. 4

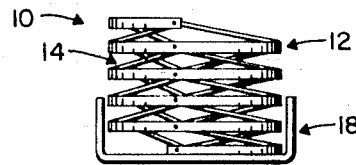


Fig. 5

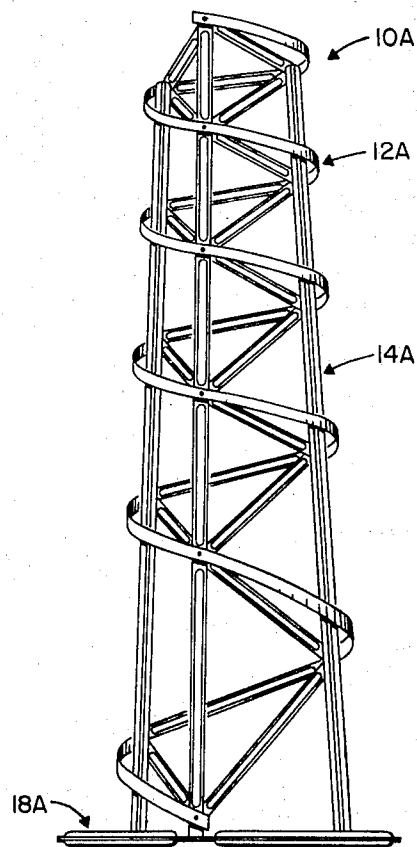


Fig. 6

LIGHTWEIGHT DEPLOYABLE HELICAL ANTENNA

This invention herein was made in the course of or under a contract or subcontract thereunder, (or grant), with the Department of the Air Force.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates generally to antennas and more particularly to a novel deployable helical antenna.

2. Prior Art:

The axial mode helix and conical log spiral are the most popular form of medium gain, circularly polarized antennas with a reasonably wide bandwidth. These antennas provide a nearly perfect circularly polarized signal over a 1.7 to 1 frequency bandwidth and can be designed to perform with some degradation, over a 2 to 1 bandwidth. The gain of the helical antenna is proportional to the third power of the signal frequency. Typical antenna gain ranges between 8 to 20 db for an axial antenna length of 0.7 to 10 times the wave length.

Some helical antennas are designed to remain permanently fixed in their normal operating configuration. On the other hand, many applications require a deployable helical antenna, that is, a helical antenna which may be contracted to a collapsed configuration and extended to a deployed operating configuration. Examples of such deployable helical antennas are shown in U.S. Pat. Nos. 3,192,529; 3,524,193 and 3,699,585.

Designing a helical antenna having the capability of contraction and deployment presents certain problems whose severity increases with wave length. These problems stem from the relationship between the overall helix diameter and cross-sectional diameter of the helical conductor or radiator and wave length. In this regard, it is known that the optimum overall diameter of a helical antenna radiator is on the order of 0.3 times the center frequency wave length. The optimum cross-sectional diameter of the helical conductor or radiator is on the order of 0.006 times this center frequency wave length. At longer wave lengths, the above relationships yield helix dimensions which are too large for utilization of conventional helical antenna designs and deployment techniques.

Consider, for example, a helical antenna designed for a frequency of 120 MHz., corresponding to a wave length of 8.5 feet. For this frequency and wave length, the antenna helix should have an overall diameter of 2.5 feet, a length of 14 feet, and a helix cross-sectional diameter of 0.6 inches. Needless to say, a helix with these dimensions is ill-suited to use in a conventional deployable helical antenna, due in large part to the extreme stiffness of the helix resulting from its relatively large cross-sectional diameter. As a consequence of the foregoing factors, the existing deployable helical antennas are limited to relatively small helix elements and hence to relatively high frequencies.

SUMMARY OF THE INVENTION

This invention provides an improved deployable helical antenna which avoids the above and other disadvantages of the existing deployable helical antennas. The improved antenna has a conductor or radiator element in the form of a thin flat strip coiled helically about a longitudinally extendible and contractable supporting structure. The helically coiled strip, or helix, is

arranged with its faces parallel to the axis of extension and contraction of the structure. The helix is pivotally attached at its ends to the ends of the supporting structure and at intervening points spread along the helix to the adjacent points of the structure. The axes of these pivot points intersect the axis of the supporting structure and are transverse to the faces of the helix strip in such a way that the structure and helix are axially contractable to a collapsed or compressed configuration and extendible to an extended or deployed configuration. During contraction and deployment of the antenna, the supporting structure and helix undergo relative rotation at the pivotal attachment points of the helix.

In the described preferred embodiments of the antenna, the supporting structure is a strain energy deployable truss frame constructed of tubular elastic strain energy deployable beams. During contraction of the structure, these beams deform and store elastic strain energy for deploying the structure. The helix is pivotally attached to the truss frame at junction points of the truss frame beams. One described embodiment is an axial mode helical antenna whose helix has a uniform diameter and pitch from end to end. The other described embodiment is a conical log spiral antenna whose helix has both a varying pitch and diameter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of an axial mode helical antenna according to the invention showing the antenna in its extended or deployed configuration;

FIG. 2 is an end view of the antenna;

FIG. 3 is an enlarged detail of one pivotal joint between the antenna helix and supporting structure;

FIG. 4 is a top plan view of the antenna ground plane taken on line 4—4 in FIG. 1;

FIG. 5 is a side elevation of the antenna in its contracted packaged configuration; and

FIG. 6 is a side elevation of a conical log spiral antenna according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The deployable helical antenna 10 illustrated in FIGS. 1—5 has a helical radiating element or helix 12 coiled helically about a longitudinally extendible and contractable supporting structure 14. Helix 12 is a thin flat metallic strip arranged with its face parallel to the axis of the supporting structure. The ends of the helix are attached by pivot means 16 to the ends of the supporting structure. Intervening points of the helix are attached to the structure by additional pivot means 16. The pivot axes of the pivot means are transverse to and intersect the longitudinal axis of the structure and the faces of the helix, such that the structure and helix, are contractable axially to their collapsed or packaged configuration of FIG. 5 and extendible axially to their deployed operating configuration of FIG. 1.

At the lower or base end of the antenna 10 is a ground plane 18. This ground plane has a rectangular frame 20 and a wire mesh screen 21 secured about its edges to and extending across the opening through the frame. Also secured to and extending across the frame 20 are a pair of intersecting frame members 22 to which the base of the supporting structure 14 is attached. The ground plane is foldable to its packaged configuration of FIG. 5.

Referring in greater detail to the preferred antenna embodiment of FIGS. 1-5, the supporting structure 14 is a strain energy deployable truss frame of generally triangular cross-section, as shown in FIG. 2. The truss frame is constructed of resiliently flexible beams 24, 26 joined to one another in the illustrated truss frame configuration. Each beam is similar in shape to the beam described in U.S. Pat. No. 3,749,133 and like the latter beam has a thin-walled tubular configuration with diametrically opposed coplanar flanges 28. The beams are constructed of thin plastic or metallic spring material whose physical characteristics are such that the beams may be flattened and folded without exceeding the yield strength of the material, such that when thus folded the beams store elastic strain energy for returning the beams to their normal tubular shape when released. The preferred beam material is a thin polymer film, such as Mylar or Kapton, or fiberglass which is thermally preformed to the illustrated tubular beam configuration.

As noted above and shown in the drawings, the truss frame 14 is generally triangular in cross-section. The beams 24 extend longitudinally of the frame and form its apices. Helix 12 encircles these longitudinal beams in such a way that the inner face of the helix contacts or is located in close proximity to each beam at the crossing points of the helix and beam. The helix is pivotally attached to the longitudinal beams at these crossing points by the pivot means 16. Beams 26 are cross beams which extend diagonally between the longitudinal beams 24 and are attached to the latter beams opposite their points of pivotal attachment to the helix 12 by means of gusset plates 29, as shown in FIG. 3. As shown in FIG. 3, the longitudinal beams 24 are oriented with their flanges 28 parallel to the helix 12 at its crossing points with the beams.

The sides 30 of the ground plane frame 20 and the intersecting frame members 22 comprise tubular strain energy beams similar to the beams 24, 26 of the truss frame 14. The frame beams 30 are arranged with their flanges in a common plane parallel to the ground plane frame 20. The ground plane screen 21 is secured to the inner flanges of the frame 20.

Helix 12 and truss frame 14 are preformed to assume their extended or deployed configuration of FIG. 1. The ground plane frame 20 is preformed to assume its flat configuration of FIG. 1. In this deployed configuration of the antenna 10, the helix 12 is conditioned to radiate electromagnetic waves in a manner similar to a conventional helical antenna. The helix and truss frame are axially contractable to their collapsed or packaged configuration of FIG. 5. During this contraction, the helix compresses axially and the beams 24, 26 of the truss frame are flattened and folded within the helix. The ground plane 18 is folded, as shown. When the antenna 10 is thus contracted or collapsed, it is quite compact and may be stowed or packaged in a relatively small volume. In this collapsed configuration, the folded beams 24, 26 of the truss frame 14 store elastic strain energy which erects the antenna to its deployed configuration of FIG. 1 when the antenna is released. The folded beams of the ground plane 18 store strain energy for returning the plane to its flat configuration of FIG. 1.

The advantages of the deployable antenna 10 are obvious. Thus, the antenna is relatively simple and lightweight, the antenna is collapsible to a relatively com-

pact configuration for stowage and erects automatically, when released, under the force of the strain energy stored in the antenna beams. These advantages result from the utilization of the lightweight, strain energy erectile truss frame 14. Utilization of such a truss frame is permitted, in turn, by the use of a helix 12 in the form of a flat strip conductor rather than a conventional cylindrical conductor. In this regard, it will be recalled from the earlier discussion that a helical conductor of circular cross-section for a frequency of 120 MHz, would be far too stiff to enable its contraction and deployment, at least by a simple, lightweight, strain energy erectile truss frame of the kind employed in this invention. The present flat strip helix, on the other hand, may be compressed with relatively small force.

Concerning its electrical requirements, the thickness of the helix strip 12 should be at least one skin depth which, at a frequency of 120 MHz, is approximately 1 mil. However, structural stiffness requirements necessitate a somewhat thicker strip which may be on the order of 5 mils. The maximum thickness, of course, is dictated by the strip flexibility required for contraction and deployment of the antenna in the manner described. It will be obvious to those versed in the art that the width of the helix strip for a given frequency must be substantially greater than the diameter of helix conductor of circular cross-section. As a rule of thumb, the width of the helix strip is approximately 0.01 times the wave length. For a frequency of 120 MHz, the helix strip width is about 1 inch. While a flat strip helix may cause some degradation of antenna performance compared to a helix of circular cross-section, any degradation which does occur may be closely compensated by merely increasing the antenna length. The increase in length necessary to compensate for such degradation is relatively small and will not interfere with contraction and deployment of the antenna.

The antenna 10 illustrated in FIGS. 1-5 is a so-called axial mode helical antenna wherein the helix 12 has a uniform diameter and pitch from end to end. The modified antenna 10a of FIG. 6 is a conical log spiral antenna whose helix 12a has a diameter and a pitch which varies logarithmically. The antenna supporting structure or truss frame 14a is tapered at the same angle as the helix. Antenna 10a is otherwise identical to antenna 10.

We claim:

1. A deployable helical antenna comprising:

a longitudinally extendible and contractable supporting structure;

a relatively thin and flat electrically conductive radiator strip coiled helically about said structure with the faces of the strip generally parallel to the longitudinal axis of the structure;

pivot means securing the ends of said strip to the ends of said structure;

additional pivot means securing said strip to said structure at points spaced along the strip; and

the pivot axes of said pivot means being transverse to the axis of said structure and the faces of said strip, whereby said antenna is contractable to a collapsed configuration wherein said structure and radiator strip are axially contracted and the antenna is extendible to a deployed configuration wherein said structure and radiator strip are axially extended.

2. A deployable antenna according to claim 1 wherein:

said supporting structure comprises a truss frame structure constructed of resiliently flexible strain energy beams which deform upon contraction of the antenna to its collapsed configuration to store elastic strain energy for extending the antenna to its deployed configuration.

3. A deployable antenna according to claim 2 wherein:

said beams comprise resiliently flexible tubular beams with coplanar diametrically opposed flanges, and said beams flatten and fold during contraction of the antenna to its collapsed configuration.

4. A deployable antenna according to claim 3 wherein:

said truss frame structure has a generally triangular cross-section and includes three longitudinal beams extending lengthwise of the structure and cross beams joining the longitudinal beams; and said helically coiled radiator strip is pivotally attached to said longitudinal beams at the points of attachment of the latter beams and cross beams.

5. A deployable antenna according to claim 4 wherein:

said antenna is an axial mode helical antenna and said helically coiled radiator strip has a substantially constant diameter and pitch.

6. A deployable antenna according to claim 4

wherein:

said antenna is a conical log spiral antenna and said helically coiled radiator strip has a diameter and pitch which vary logarithmically.

7. A deployable antenna according to claim 1 wherein:

said antenna is an axial mode helical antenna and said helically coiled radiator strip has a substantially constant diameter and pitch.

8. A deployable antenna according to claim 1 wherein:

said antenna is a conical log spiral antenna and said helically coiled radiator strip has a diameter and pitch which vary logarithmically.

9. A deployable antenna according to claim 1 including:

a ground plane at one end of said antenna including a rectangular frame comprising resiliently flexible strain energy frame members about the perimeter of the frame, a wire mesh screen secured to said frame members and extending across the frame, resiliently flexible strain energy cross beams secured to said perimeter frame members and extending across said screen in crossing relation to one another and joined to one another at their crossing point, and means joining said cross beams to said structure.

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