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Esposito et al.

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[54] UNFURLABLE ISOTROPIC ANTENNA

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[73] Assignee: **The United States of America as represented by the Secretary of the Air Force**

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[21] Appl. No.: **24,412**

[52] **U.S. Cl.**.....**343/792.5**, 343/DIG. 2, 343/797, 343/872

[51] **Int. Cl.**.....**H01q 11/10**

[58] **Field of Search**.....343/700 A, 706, 705, 792.5, 343/797, 880, 100 DE

[56] **References Cited**

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[57] **ABSTRACT**

The invention is a broadband isotropic antenna of the tri-orthogonal type. It is a randomly polarized antenna system that has particular application in satellites. The antenna consists of three independent antenna elements arranged in a mutually orthogonal configuration. Each of the elements is mounted on unfurlable partitions contained within an inflatable spherical enclosure.

2 Claims, 5 Drawing Figures

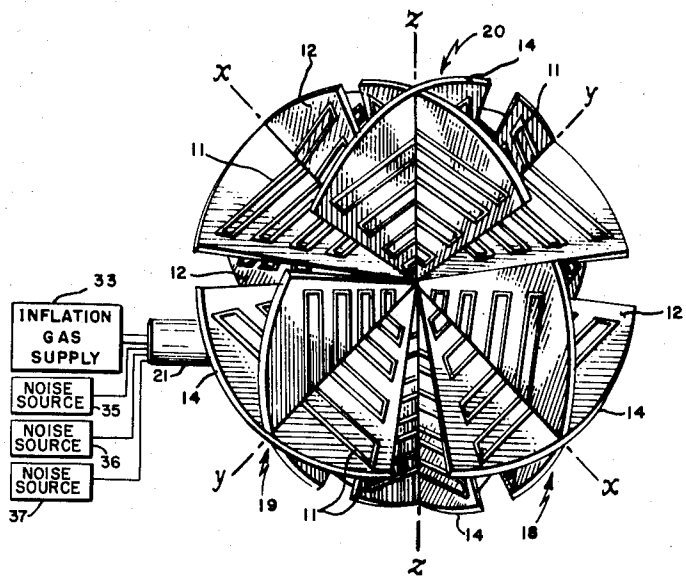
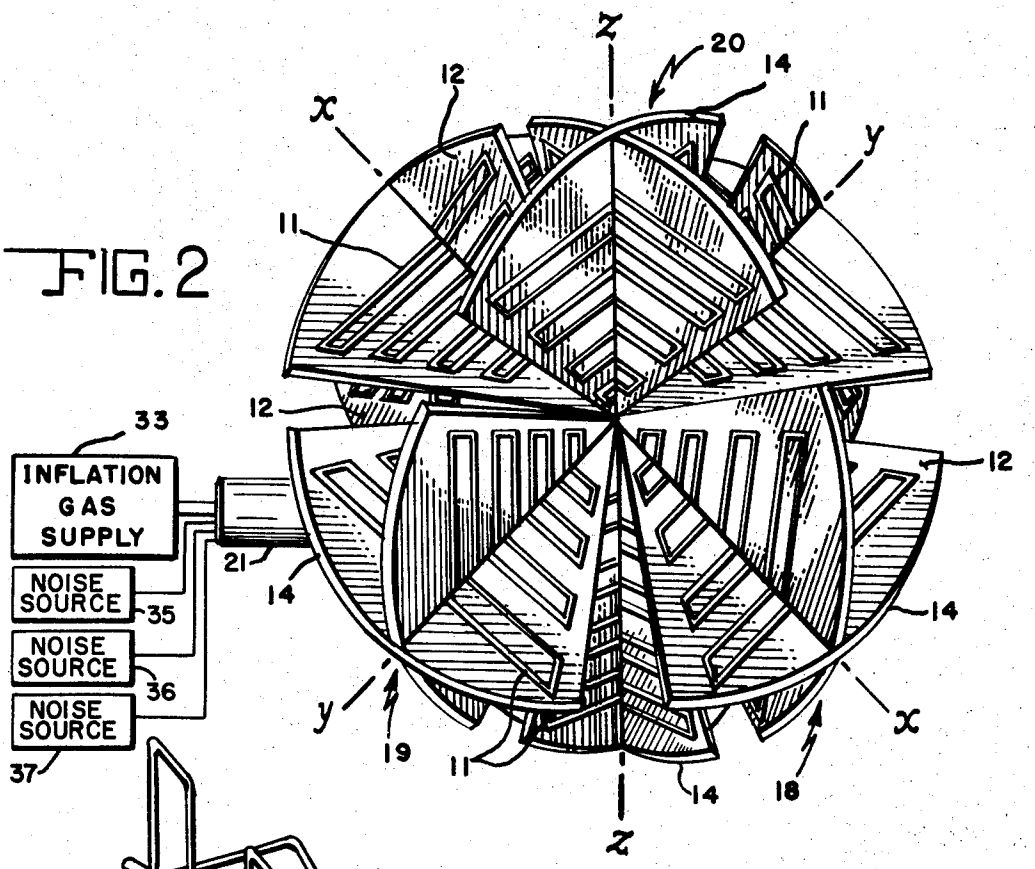


FIG. 2



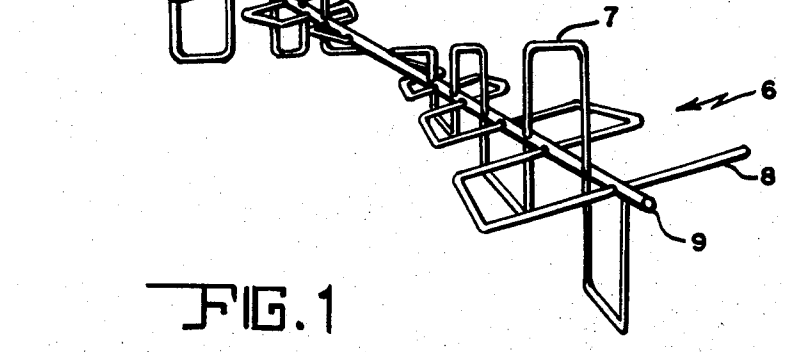
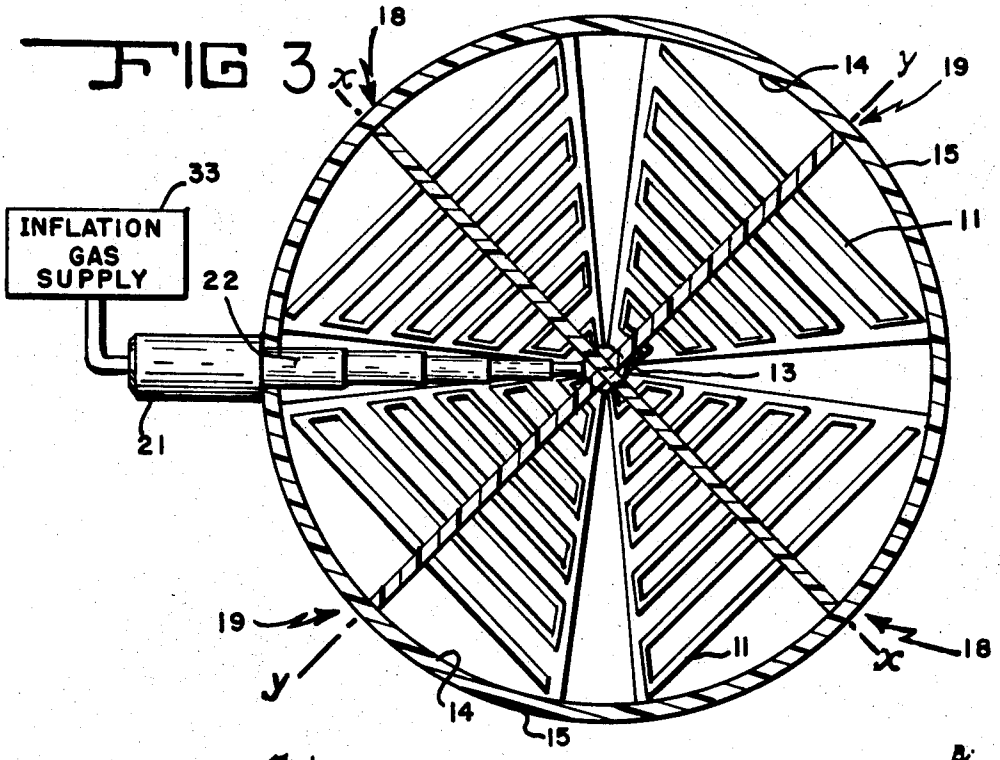


FIG. 1

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FIG 3



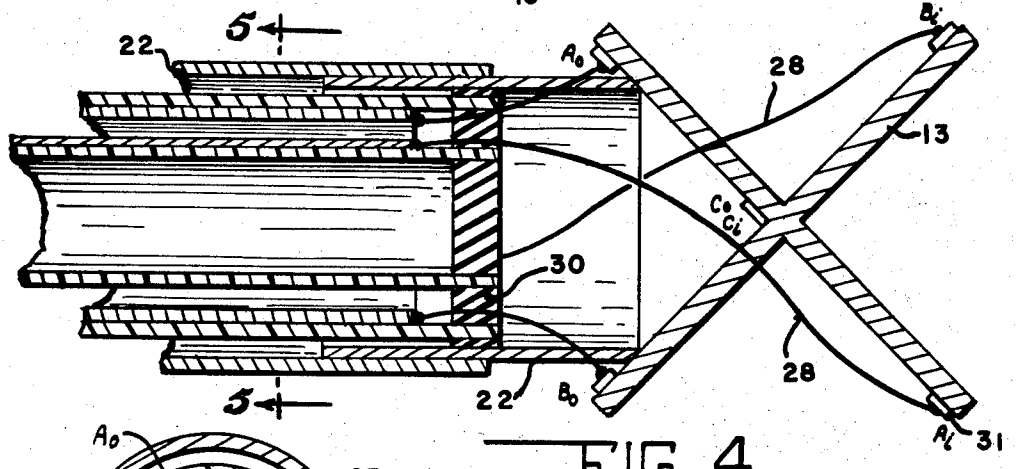


FIG 4

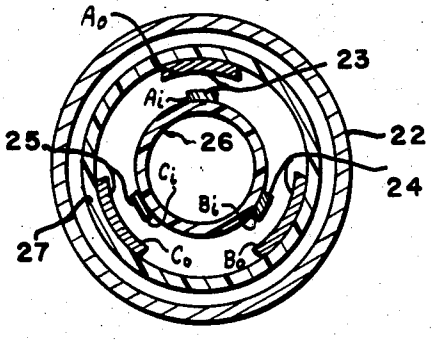


FIG 5

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UNFURLABLE ISOTROPIC ANTENNA

BACKGROUND OF THE INVENTION

This invention relates to unfurlable isotropic antennas and in particular to randomly polarized isotropic antennas adapted to use in exoatmospheric jamming systems.

Exoatmospheric jamming systems require antennas that radiate power equally in all directions. Furthermore, the polarization of the antenna's radiated energy in any direction throughout the spherical coverage must be varying randomly with time. With regard to the first criterion it has theoretically been shown that an isotropic radiation pattern having no zeroes or nulls in radiating power density over 4π steradians must contain elliptical polarization with all axial ratios of both senses. It is also known that a combination of spiral antenna elements which individually radiate circular and elliptical polarizations will add to give a varying polarization over all space when fed coherently. In such a case, however, the polarization is random only with pointing direction but not with time. No known antenna system excited from a single input can simultaneously provide both an isotropic radiation pattern and random polarization with time.

It is also desirable that such an antenna be light weight and unfurlable. The physical demands placed upon the antenna system by such a criterion make the use of separate balanced feeds particularly difficult.

SUMMARY OF THE INVENTION

The present invention comprehends the use of three antenna elements each positioned on the major axis of a rectangular coordinate system. Such an arrangement effects radiation of power equally in all directions. Each such antenna element comprises two planar logarithmetically periodic subelements. The subelements have a common major axis and are in orthogonal relationship to each other. Each antenna element is fed from a separate noise source and each feed includes an infinite balun. The antenna elements are fabricated of thin flexible metal and are laminated on to flexible sheets of dielectric material. The sheets comprise partitions located on the major planes of a rectangular coordinate system within an inflatable spherical enclosure. The feed system comprises two concentrically arranged inflatable tubes upon which the infinite baluns are disposed.

It is a principal object of the invention to provide a new and improved broadband isotropic antenna.

It is another object of the invention to provide a broadband isotropic antenna where from the polarization of radiated energy varies randomly with time.

It is another object of the invention to provide a broadband isotropic antenna that is lightweight and unfurlable and adaptable to exoatmospheric uses.

These, together with other objects, advantages and features of the invention will become more apparent from the following detailed description taken in conjunction with the illustrative embodiments in the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric drawing of two orthogonal logarithmetically periodic antenna subelements of the type comprehended by the invention;

FIG. 2 is an isometric drawing of an isotropic antenna of the type comprehended by the invention (spherical enclosure not shown);

FIG. 3 is a plan view of the isotropic antenna of FIG. 2;

FIG. 4 illustrates, in sections, the feed structure of the isotropic antenna of FIG. 2; and,

FIG. 5 is a sectional view of the feed structures of FIG. 4 taken at 5—5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The basic component of the antennas of the present invention is a frequency independent dipole element. It has been discovered that a properly designed log periodic element will give essentially a dipole pattern over a broad frequency band. Such an element is composed of two orthogonal straight tooth log periodic structures fed 90° in phase. The resulting element configuration is essentially a broadband version of a turnstyle dipole array giving an omnidirectional pattern in a plane perpendicular to its axis. The two elements must be phased 90° to each other to obtain the omnidirectional pattern characteristics. The phase rotation phenomenon of log periodic elements is used to obtain this broadband 90° phasing. The phase of the radiated energy from the log periodic structure will go through 360° as the structure is scaled through one period. Hence to achieve the 90° phase required in the turnstyle array, one structure is scaled by a factor of one quarter period with respect to its orthogonal mate. Such an antenna element is illustrated in FIG. 1 by turnstyle antenna element **6** which consists of vertically disposed log periodic structure **7** and horizontally disposed log periodic structure **8**, both of which reside on the common major axis through connecting member **9**.

Referring now to FIGS. 2 and 3, there is illustrated an isotropic antenna of the type comprehended by the present invention. In the interest of clarity of illustration the inflatable enclosure member **15** is not shown in FIG. 2. The isotropic antenna comprises antenna elements **18**, **19**, and **20**, support cannister **21**, telescope tube support member **22**, and inflation gas supply **33**.

Antenna elements are formed by laminating aluminum or copper foil **11** to pie shaped flexible plastic sheets **12**. The metal foil is the conductor and is cut to the pattern shown in FIG. 3. A section size of ¼ inch in width and a thickness of 1 mil is adequate for electrical performance and power handling capability in most instances. The mechanical strength is supplied by the plastic sheet **12**, which can also be 1 mil thick. These thin sections are light in weight and easy to fold for packaging and have adequate strength to support all imposed loads.

Each half of the antenna element is made as a separate unit, and all elements are connected to a center block **13**. The center block **13** is a dielectric, such as a rigid foam that fastens to and supports the front edge of each element. This fastening can be made by bonding the plastic sheet **12** to the dielectric block **13**. The terminal feed point for each element is mounted in the block **13**. The connection from the terminal to the feed line on the element is made by bonding a terminal strip section to the aluminum foil and screwing it to the terminal.

The outer edge **14** of each sheet element **12** is fastened to the inner surface of inflatable spherical enclosure member **15**. This fastening can be accomplished by bonding the element sheets to ribs which have been bonded to the interim surface of the enclosure member. The diameter of enclosure member **15** is made slightly larger than the element sections so that when the enclosure member is inflated, the ribs exert a tension force on the element. The transfer of force is from the one side of the spherical enclosure member, through one side of an element, through the center block, to the outer side of the element, and to the opposite side of the spherical enclosure member. With this design, there is no net force tending to move the center block, and all sections are under light tension forces. The tension forces pull the element into shape during unfurling and hold the alignment and flatness under dynamic forces.

The enclosure member inflation gas can be an inert type such as nitrogen. The inflation gas also serves to provide a gaseous atmosphere for the antenna to reduce the possibility of break-down. The pressure level required for electrical break-down prevention may be greater than the pressure required for unfurling and tensioning the antenna sheets.

Referring now to FIGS. **4** and **5**, the three antenna elements **18**, **19**, and **20** are fed from a single feed assembly that incorporates three baluns **23**, **24** and **25**. Each of the baluns connects the input coaxial connector to the terminal feed points **31** on the center block of the antenna. The three baluns in one tube arrangement is accomplished by using concentric gas inflated tubes **26** and **27**. The outer conductor of each balun is formed by a shaped aluminum foil strip bonded to the inside of the outer tube. The inner conductor is formed by a shaped aluminum foil strip bonded to the outside of the inflated inner tube. Each pair of inner and outer conductors forms a balun for that feed line. The three baluns are equally spaced 120° apart on the tubes. The ground of the input connector is attached to the outer conductor of the balun and the inner conductor of the connector passes through a clearance hole in the outer strip conductor and connects to the inner strip conductor of the balun.

The input end of the balun is securely mounted to the canister through a flanged plate; this plate pilots the inner and outer conductor tubes, and supports the input connectors. The circularity of the inner and outer conductor tubes is maintained by the gas pressures in the tubes. The concentricity of the tubes is maintained by plastic spacer **30**. The feed lines **28** from the end of the balun to the feed point connections of the individual elements are twin lead lines. Each pair of lines connects to corresponding inner and outer balun conductors. The twin lead wires are supported and held in the required spacing by a dielectric sleeve not shown. The three feed lines are routed from the ends of the balun to the terminal block in a pattern that minimizes interaction. The end of the balun and the terminal block are mounted to the same tubular end of the telescoping support tube **22** as is the terminal block. This design permits the feed line end to be encapsulated in foam for maximum resistance to all loads. The inflation gas inlets are hose connections mounted in the base support flanged plate. The inner and outer conductor tubes may be fed individually to maintain the required pressure differential, the outer conductor sleeve pressure being less than the inner or they may be fed from the inner connector line through an orifice that provides the required pressure drop.

The unfurling cycle is initiated when a valve directs gas with the required pressure into the line that feeds the telescoping tube assembly. When the pressure in the tube assembly starts to build up, the tube pushes out popping off the antenna cover (not shown). The telescoping tube continues to extend to its final positions. After the telescoping tube is extended, gas under the required pressure is sent into the antenna enclosure to inflate it. This inflation does not start until the telescoping tube has brought the center and the front surface of the enclosure out and away from the canister. This is to minimize the possibility of interlocking and to minimize drag.

The balun conductor tubes are extended in a deflated condition along with the telescoping tubes by the support at the front of the tubes. The inflation gas is sent into the conductor tubes only after the telescoping tubes are extended. With this sequence, it is possible to avoid a problem caused by having the balun tubes inflate before the telescoping tubes with a resulting jam. The erection time span will be governed largely by the inflation time for the array enclosure.

It will be understood that various changes in the detailed materials and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention may be made by those skilled in the art with the principle and scope of the invention as expressed in the appended claims.

What is claimed is:

1. A broadband isotropic antenna comprising first, second and third antenna elements, each said antenna element comprising first and second planar logarithmically periodic antenna subelements, said subelements being in orthogonal relationship and having a common major axis, the major axis of said first antenna element being in coincidence with the X—X axis of a rectangular coordinate system, the major axis of said second antenna element being in coincidence with the Y—Y axis of said rectangular coordinate system and the major axis of said third antenna element being in coincidence with the Z—Z axis of said rectangular coordinate system, said first, second and third antenna elements being centered at the center of said rectangular coordinate system, an inflatable enclosure member having flexible partitions disposed therein, said enclosure and partitions having geometries and organization adapted to give said enclosure a substantially spherical form wherein the planes of a rectangular coordinate system are defined by said partitions during the inflated condition of said enclosure, said logarithmically periodic antenna subelements being flexible material and disposed on said partitions, and first, second and third noise sources, each said antenna element being fed from a separate noise source.

2. A broadband isotropic antenna as defined in claim **1** wherein the subelements of each said antenna elements are phased 90° to each other.

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