NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3,546,705

Government or Corporate Employee : U.S. Government

Supplementary Corporate Source (if applicable) : N/A

NASA Patent Case No. : MSC-12209

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes ☐ No ☒

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

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Enclosure
Copy of Patent cited above

FACILITY FORM 602

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N71-24842

Dec. 8, 1970 P. H. LEMSON **3,546,705**

BROADBAND MODIFIED TURNSTILE ANTENNA

Filed Dec. 1, 1969

FIG. 1

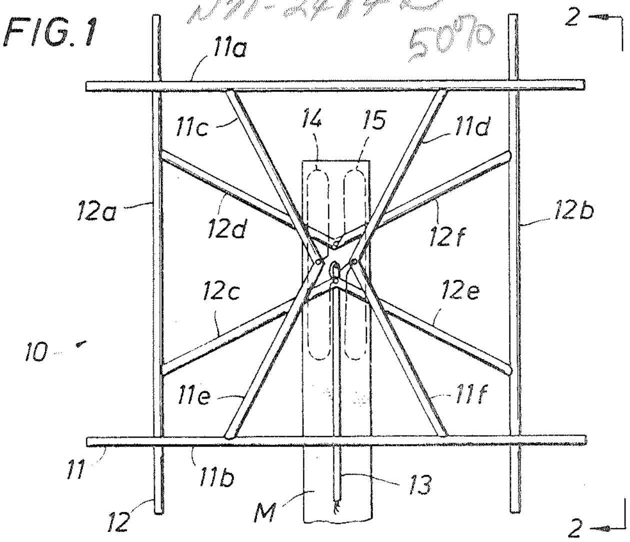


FIG. 2

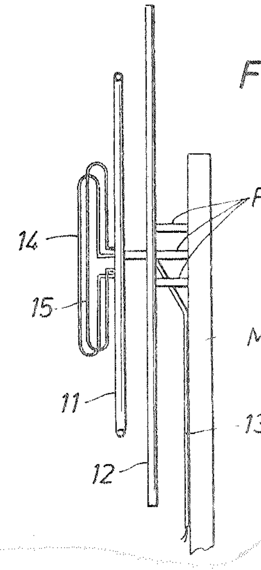


FIG. 3

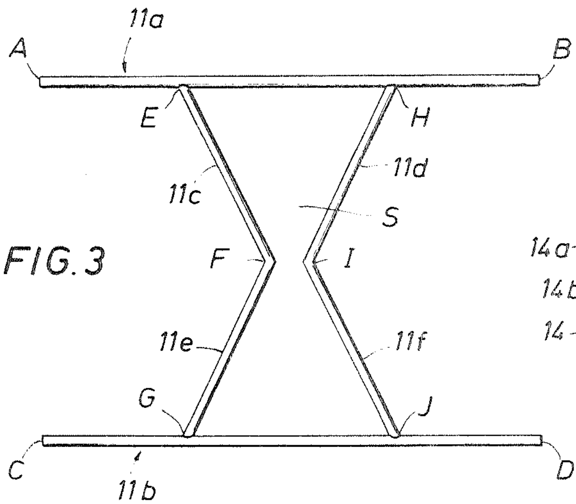
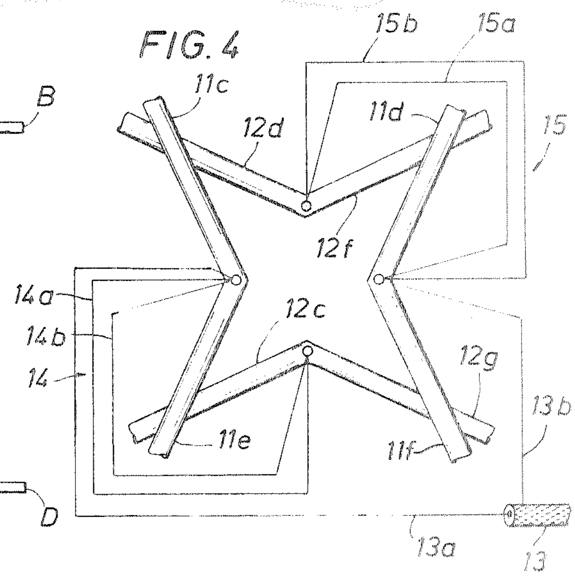


FIG. 4



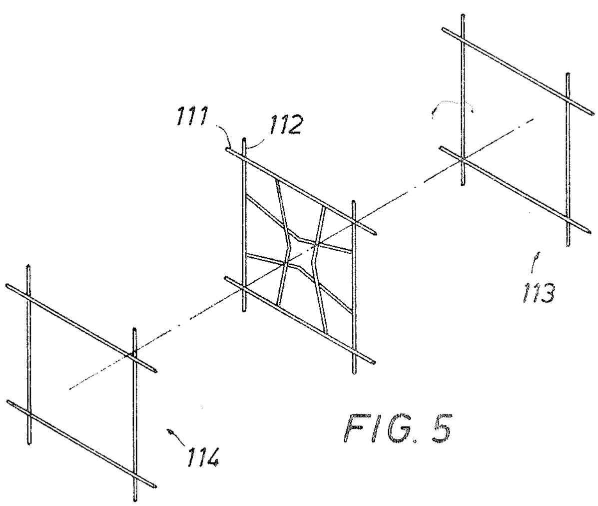


FIG. 5

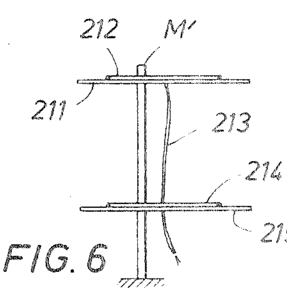


FIG. 6

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3,546,705
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BROADBAND MODIFIED TURNSTILE ANTENNA

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Int. Cl. H01q *21/26*
U.S. Cl. 343—797 7 Claims

ABSTRACT OF THE DISCLOSURE

An antenna element is provided with two resonant half-wave dipoles energized through feeders connected to the dipoles with a delta match. The feeders to each dipole co-operate with the dipoles and each other to form a half-wave wire slot. Two antenna elements may be combined and fed in phase quadrature to develop circular polarization.

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

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to antenna elements and configurations which may be employed in broadcasting, telemetry transmissions, experimentation, tracking, radar and other applications. More specifically, the present invention relates to a broadband modified, turnstile antenna which may be employed in space tracking and communications.

Brief description of the prior art

Original forms of turnstile antennas generally included two half-wave dipoles fed in phase quadrature. While the first turnstile antenna design had many desirable features and exhibited many improved operating characteristics, tuning of the antenna generally required the cutting of matched transmission lines to a predetermined length while the antenna was mounted in an operative position. Tuning after the antenna has been mounted is often difficult or impossible especially where the antenna is positioned atop a high structure such as a tall office building or tower. The original turnstile design was subsequently improved by pretuning it during its fabrication so that no tuning was required after the antenna had been mounted in its operative position.

Further modification of the basic turnstile antenna included the addition of radiating elements constructed from metal sheets and rod-like dipole elements connected together to form a wire slot. The latter antenna is generally referred to as a "Superturnstile" while the pretuned antenna described earlier is referred to as a modified turnstile antenna.

In general the turnstile and modified turnstile are relatively narrow band width antennas. Complex feed systems are often required for use with the turnstile and modified turnstile and both of the antenna configurations are difficult to match. The superturnstile exhibits broader band width characteristics than the turnstile or modified turnstile but required a complicated feed system and cannot be used in highly directional parasitic arrays. In addition, the broad surface areas of the superturnstile and the inherent structural weaknesses imposed by its large number of connections and elements also make the superturnstile undesirable for use where ice, snow and sleet may form. The large volume occupied by the superturnstile prevents it from being suitable for use in aircraft and spacecraft particularly in applications where two superturnstiles are

to be employed together as is required for circular polarization.

SUMMARY OF THE INVENTION

The present invention incorporates the desirable features of a turnstile, modified turnstile and superturnstile antennas, while avoiding or eliminating most of the shortcomings of these antennas. The structure of the antenna element of the present invention is extremely simple, occupies relatively little space, is durable and resists breakage. The antenna element is an essentially planar structure having a series of interconnected rod-like components which include two resonant half-wave dipole elements and four delta matching feeder elements. The feeder elements co-operate with the dipole elements in the antenna structure to form a half-wave wire slot which combines the reactive components of the slot and dipole to increase the broadband characteristic of the antenna element. The wire slot may be dimensioned to establish a desired input impedance to the antenna element which permits the use of economical, high impedance, low loss lines.

Where circular polarization is desired, two antenna elements of the invention are employed.

The two elements are positioned in overlapping non-touching relationship and since each is essentially planar, the total space occupied by the composite antenna is relatively small. Quarter-wavelength, balanced phasing lines connect the two elements to place the four dipole currents of the composite antenna in proper phase. In the preferred form of the circularly polarized antenna, two phasing lines are employed to increase the frequency range over which circular polarization may be obtained.

By means of the antenna element of the present invention, broadband antenna characteristics are achieved without any loss of gain. Two elements may be combined whereby circular wave polarization is achieved without the use of complex coaxial phasing lines or networks. In addition, the antenna element of the present invention may be employed in highly directive configurations even at the lower frequencies where other antenna forms are not useable.

These and other features and advantages of the present invention will be more fully evident from the following specification, drawings and related claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of a broadband modified turnstile antenna constructed in accordance with the teachings of the present invention designed for circular polarization;

FIG. 2 is a side view of the antenna of the present invention taken along the line **2—2** of FIG. 1;

FIG. 3 is an elevation illustrating the antenna element of the present invention;

FIG. 4 is a schematic diagram illustrating the phasing and feed connections of the antenna illustrated in FIGS. 1 and 2;

FIG. 5 is a schematic representation of a directive antenna array constructed in accordance with teachings of the present invention for providing unidirectional coverage in a single plane; and

FIG. 6 is a schematic representation of a directive antenna array for omnidirectional coverage in the horizontal plane.

PREFERRED EMBODIMENTS OF THE INVENTION

With reference to FIG. 1 of the drawings, a broadband modified turnstile antenna of the present invention designed for circular polarization is indicated generally at **10**. The antenna **10** which may be mounted on any suitable means such as a mast M includes two antenna elements **11** and **12** each of which has a pair of rod-like dipole segments **11***a*, **11***b*, and **12***a*, **12***b* respectively. The dipole segments **11***a* and **11***b* of element **11** are fed by four rod-like feeder elements **11***c*, **11***d*, **11***e* and **11***f* which form a delta match with their respective dipoles. Similarly, the dipoles of the second antenna element **12** are fed by feeder elements **12***c*, **12***d*, **12***e* and **12***f* which also form a delta match with their respective dipole radiating elements.

The elements **11** and **12** of the antenna **10** are electrically connected to a coaxial feed cable **13** having inner and outer conductors **13***a* and **13***b* respectively. The connection of the conductors **13***a* and **13***b* to the antenna elements is represented schematically in FIG. 4. The inner conductor **13***a* is connected to the junction of feeder elements **11***c* and **11***e* and the outer conductor **13***b* is connected to the junction of feeder elements **11***d* and **11***f*.

For circular polarization, the antenna element **12** is rotated approximately 90° with respect to element **11** and is held in this position by any suitable means such as the mounts F which secure the elements to the mast M. Phasing lines **14** and **15** are then employed to appropriately connect the two elements **11** and **12** to provide the desired electrical phasing relationship for the antenna signal. Each of the lines **14** and **15** is a quarter-wave length balanced transmission line. Each of the lines **14** and **15** also include two conductors **14***a*, **14***b* and **15***a*, **15***b* respectively. Conductors **14***a* and **15***a* are connected to form a first phasing line and conductors **14***b* and **15***b* are connected to form a second phasing line. If desired, single conductors may be employed for the phasing lines, however plural lines of slightly varied length increase the frequency range within which circular polarization may be effected.

With reference to FIG. 3, the antenna element **11** of the present invention is illustrated in greater detail and is seen to include a first dipole **11***a* extending between the points designated as A and B and a second, parallel dipole **11***b* extending between the points C and D. The dipole elements **11***a* and **11***b* are fed using a delta match by feeder elements **11***c*, **11***d*, **11***e* and **11***f* which extend respectively between the points EF, HI, FG and IJ. The construction illustrated in FIG. 3 also forms a half-wave wire slot S defined by the "keyhole" configuration EFGJIH. By this construction, the reactive components of the wire slot S are combined with the reactive components of the dipoles **11***a* and **11***b* to provide broadband antenna characteristics for the composite antenna element. In designing the slot S, it is dimensioned to be a resonant half-wave slot and to provide the desired input impedance of the element **11** which should be approximately equal to the impedance of the transmission line to be employed with the element.

The length of the intercepted segmnts EH and GJ largely determine the input impedance of the element **11**, with impedance increasing as the length of the intercepted segments increases. In constructing the antenna element **11**, it is desirable to maintain the length of the intercepted segments EH and GJ in the range between 0.1 and 0.25 wave length. With smaller lengths, improper matching occurs which causes loss of some of the antenna's broadband characteristics, while larger lengths prevent the wire slot S from operating as a slot and cause the element to operate as two folded dipoles. The separation between the two dipoles **11***a* and **11***b* is dependent upon the desired resonant slot frequency and the element input impedance. For optimum performance characteristics, it is preferable that the resonant frequency of the slot and dipole be within approximately 25% of each other.

In the preferred form of the invention, the lengths EH and GJ intercepted by the feeders **11***c*, **11***d* and **11***e*, **11***f* respectively plus the sum of the lengths of the feeder elements themselves is equal to approximately one wave length.

In the way of example, an antenna having the construction illustrated in FIGS. 1 and 2 was built with the dipoles of elements **11** and **12** designed to be resonant at 330 mHz., the slots S designed to be resonant at 440 mHz., the two phasing lines being 300 ohm lines with one line being resonant at 320 mHz. and the other being resonant at 360 mHz. In this test model, the voltage standing wave ratio (VSWR) was less than 2:1 across the entire range from 225 to 380 mHz. and the resultant characteristic impedance of the transmission line **13** was approximately 150 ohms. The antenna covered a frequency range of 1.7 to 1 for a VSWR of less than 2:1 without the use of special matching devices. The gain of the antenna over an isotropic source was found to be equivalent to or slightly greater than that of a conventional turnstile antenna and circular polarization was achieved over a 1.3 to 1 frequency range.

FIG. 5 of the drawings illustrates the antenna element of the present invention employed in a highly directive array. Two driven antenna elements **111** and **112** which are rotated 90° with respect to each other are illustrated in coaxial alignment with two parasitic arrays of directors and reflectors indicated generally at **113** and **114**, with the driven antenna elements **111** and **112** being axially spaced from the two parasitic arrays **113** and **114**. The parasitic elements in each array may be formed of four crossed, connected dipoles having the illustrated configuration. The driven elements **111** and **112** have the same form as illustrated in FIG. 3. By means of the illustrated antenna construction, a highly directional signal of the type required for space communications and tracking may be obtained. It will also be understood that other configurations may also be employed with the antenna element of the present invention for achieving a directive or an omnidirectional array. Thus, by way of example rather than limitation, a conical horn reflector or parabolic dish reflector located approximately a quarter-wave length behind the driven antenna elements could be employed for producing a highly directive array. Where omnidirectional coverage is desired, two antenna elements such as the element illustrated in FIG. 3 may be spaced a full wave length apart, fed in parallel and mounted on a vertical mast in either the vertical or horizontal plane.

With reference to FIG. 6, a modified form of the invention is illustrated for producing omnidirectional coverage in the horizontal plane. In the form of the invention illustrated in FIG. 6, two sets of antenna elements **211**, **212** and **214**, **215** are horizontally mounted on a vertical mast M′ and are interconnected by one or more transmission lines **213** of approximately one wavelength. The two antenna elements in each set are rotated 90° with respect to each other in the manner previously described with reference to FIG. 1. It should be noted that if desired, more than two antenna elements of the present invention may be included in any group.

While the antenna of the present invention has been described as having rod-like dipoles and feeders, it will be understood that the antenna elements may be formed by printed circuit technique or may take on any other physical configuration which provides the desired results.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. An antenna comprising:

a first antenna element having first and second dipole elements fed in a delta match by a plurality of first feeder elements with said first feeder elements and said first and second dipoles cooperating to form a first half-wave wire slot;

a second antenna element having third and fourth dipole elements fed in a delta match by a plurality of second feeder elements with said second feeder elements and said third and fourth dipoles cooperating to form a second half-wave wire slot, said first and second antenna elements being disposed with the dipole elements of the first antenna element in spaced orthogonal relationship to the dipole elements of the second antenna element; and

a plurality of quarter-wave length phasing lines connecting said first and second antenna elements for developing circular wave polarization.

2. The antenna as defined in claim 1 further including directive means associated with said first and second antenna elements for forming a directive antenna array.

3. The antenna as defined in claim 1 wherein said first feeder elements intersect and connect to said first and second dipole elements to intercept first and second lengths along each of said dipole elements respectively with the sum of said first and second lengths combined with the total lengths of said first feeder elements being approximately equal to one wave lengtth.

4. The antenna as defined in claim 1 wherein said second feeder elements intersect and connect to said third and fourth dipole elements to intercept third and fourth lengths along each of said dipole elements respectively with the sum of said third and fourth lengths combined

with the total lengths of said second feeder elements being approximately equal to one wave length.

5. The antenna as defined in claim 4 further including directive means associated with said first and second antenna elements for forming a directive antenna array.

6. The antenna as defined in claim 1 wherein said first and second dipole elements are spaced from each other in an approximately parallel disposition and lie in approximately the same plane.

7. The antenna as defined in claim 1 wherein said third and fourth dipole elements are spaced from each other in an approximately parallel disposition and lie in the same plane.

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ELI LIEBERMAN, Primary Examiner

U.S. Cl. X.R.

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