Dec. 23, 1958

G. STAVIS ET AL

2,866,194

OMNIDIRECTIONAL BEACON ANTENNA

Filed Nov. 14, 1955

2 Sheets-Sheet 1

Fig. 1

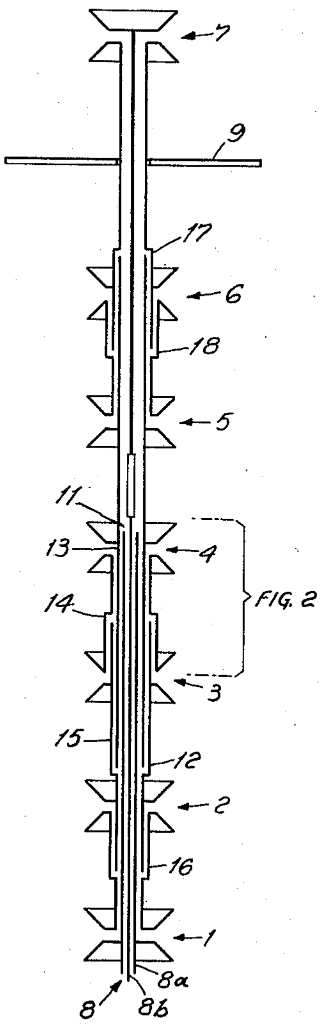
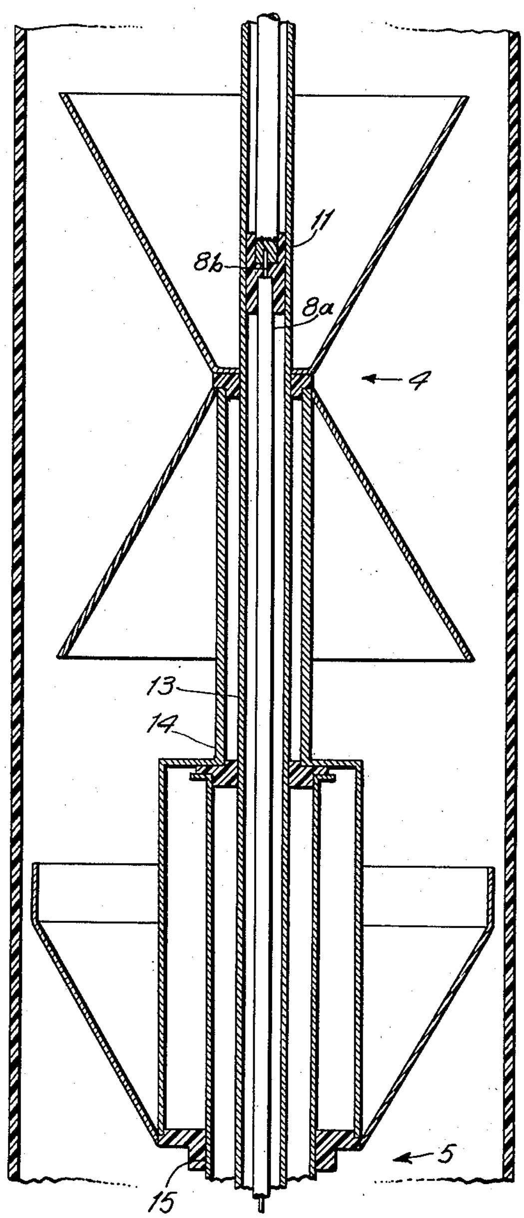


Fig. 2



INVENTORS
GUS STAVIS
JAMES S. ENGEL
BY Ernest Fanwick
ATTORNEY

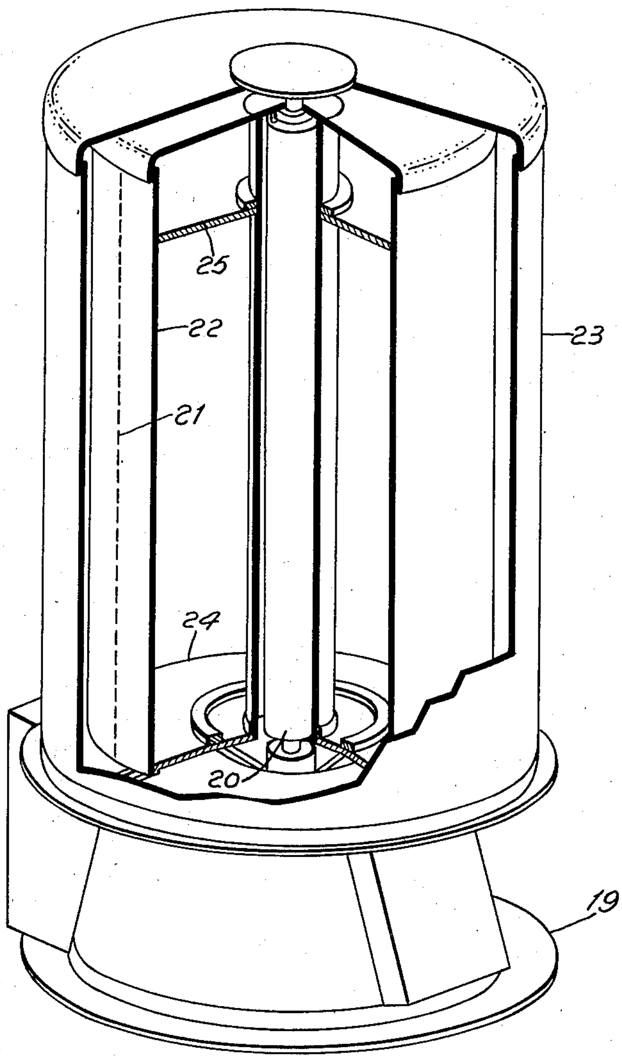
Dec. 23, 1958 G. STAVIS ET AL 2,866,194

OMNIDIRECTIONAL BEACON ANTENNA

Filed Nov. 14, 1955

2 Sheets-Sheet 2

Fig. 3



INVENTORS
GUS STAVIS
JAMES S. ENGEL
BY Ernest Fanwick
ATTORNEY

United States Patent Office

2,866,194

Patented Dec. 23, 1958

2,866,194

OMNIDIRECTIONAL BEACON ANTENNA

Gus Stavis, Ossining, N. Y., and James S. Engel, Tenafly, N. J., assignors to International Telephone and Telegraph Corporation, Nutley, N. J., a corporation of Maryland

Application November 14, 1955, Serial No. 546,617

7 Claims. (Cl. 343—725)

This invention relates to omnidirectional beacon antennas and, more particularly, to omnidirectional beacon antennas for use in producing a multiple-modulation radiation pattern having a fundamental modulation frequency and one or more additional harmonics of the fundamental modulation frequency for use in radio navigation systems commonly known as TACAN.

Omnidirectional beacon systems such as in TACAN have a high order of directional accuracy which is dependent upon the use of a directive antenna pattern rotated at a fundamental frequency and modulated by a harmonic of this fundamental frequency so as to produce a generally multilobed rotating directive radiation pattern. Due to the rotation of the multiple-modulation antenna pattern, a receiver located remotely from the transmitter receives energy which appears as an amplitude-modulated wave having a fundamental modulation component and a modulation component at a harmonic frequency of the fundamental. Both fundamental and harmonic frequency reference signals are transmitted omnidirectionally for comparison with the received components of the rotating pattern so that the receiver may determine its azimuth relative to the beacon's antenna system.

Previous antennas designed for use with such omnidirectional beacons have necessitated the use of rotating radio frequency (R. F.) joints and usually have been difficult to enclose for protection from the weather. Other antenna systems known to the prior art have disclosed the production of the modulation frequency by the rotation of a parasitic element about a vertical stack of equally spaced central radiators such as cones.

In many antenna systems for use with TACAN, it is desirable to utilize a vertical array comprising a stack of dipoles, disc cones, biconical radiators or a single vertical radiation element. Assuming each of the radiating elements has an equal impedance, it is desirable that each of the elements in a stacked vertical array be fed with currents substantially of predetermined phase. In the past, it has been found that the difference in the lengths of line necessary to couple the first or topmost radiating element and the last or bottom element to the source of energy has caused such vertically stacked arrays to be highly frequency sensitive, i. e., the radiation from the topmost element would be altered in phase with respect to that from the lower elements as the frequency has changed due to the longer length of feedline necessary to couple the energy to the topmost antenna. It has also been found desirable to feed such an antenna system without having the transmission line lie in the radiation field of the antenna system in order to prevent unwanted distortions of the antenna pattern.

However, it has been found that the mere excitation of a vertical stack of equally spaced central radiators such as cones produces a radiation pattern having a poor vertical-angle coverage characteristic resulting in a substantial "cone of silence" being present over the site of the navigation beacon.

One of the objects of this invention, therefore, is to provide an improved omnidirectional beacon antenna system especially suited for use in the TACAN navigation system.

Another object of this invention is to provide an antenna system for producing a multilobed azimuthal directive pattern having improved vertical-angle coverage.

Still another object of this invention is to provide means for feeding an antenna system comprising a vertical stack of radiating elements, in such a manner as to provide proper phasing and pattern characteristics with a minimum of radiation interference.

The above-mentioned and other features and objects of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagrammatic illustration in schematic form of one embodiment of the omnidirectional antenna system of this invention;

Fig. 2 is a partial elevational view in cross section of a portion of the embodiment of the TACAN antenna system shown in Fig. 1; and

Fig. 3 is a perspective view partly broken away of the antenna system and modulation or parasitic reflectors in accordance with the principles of this invention for use in the TACAN aerial navigation system.

There is presently known in the art of aerial navigation a system of radio navigation called TACAN in which a ground beacon transmitter generates a constant amplitude train of pulses, including at appropriate times random noise pulses to maintain a constant duty cycle, and specially coded bursts of pulses for azimuth reference service, as well as accurately timed pulsed responses to distant measurement interrogations. This train of fixed-amplitude pulses constitutes the input to the ground beacon antenna which has for one of its main purposes the imposition of a certain amplitude modulation upon the pulse train in order to enable the airborne equipment to yield azimuth information. This system utilizes an antenna which is capable of imposing a fundamental frequency amplitude modulation on the pulse train for a coarse azimuth indication, as well as transmitting a synchronous 15-cycle reference trigger pulse in synchronism with the fundamental amplitude modulation. In addition, transmission must be amplitude modulated at a harmonic frequency, and a harmonic frequency trigger pulse must be radiated by the antenna in synchronism with the harmonic frequency modulation. Important radiation characteristics of such an antenna system must be the provision for vertical directivity in the radiation pattern to provide maximum range capabilities as well as a vertical pattern uptilt to improve sight freedom. The modulating mechanism for use in the TACAN system is completely contained in the antenna of this invention and is pursely mechanical in nature, comprising basically parasitically excited wires which are rotated around a stationary central radiating array to obtain the desired radiation pattern.

Referring to Figs. 1 and 2 of the drawings, it is seen that an omnidirectional beacon antenna in accordance with the principles of this invention consists of a plurality of biconical dipole elements 1–7 stacked in vertical alignment. Fig. 2 is a schematic illustration of a portion of the schematic diagram shown in Fig. 1 which is indicated by the brackets labeled Fig. 2. This portion contains a main or central feedpoint 11. The same reference characters are used in Fig. 1 as in Fig. 2 to illustrate the identical parts. The distribution or feed system is contained in the central portion or mast 8 of the array and consists of a number of coaxial alternately fed transmission lines, as hereinafter explained. This feed arrangement minimizes relative phase shifts between antenna elements, thus maintaining a more constant vertical pattern over the frequency range utilized. It should, of course, be understood that impedance transformers may be included at all feedpoint junctions to maintain the desired impedance.

The lower six elements **1–6** of the antenna array are equally spaced and constitute the main array. To obtain an uptilt in the vertical pattern, the elements **1–6** are phased in such a manner that the lower two elements **1** and **2** lead in current and the upper two elements **5** and **6** lag in current with respect to the two central elements **3** and **4**. Such current phasing causes the maximum of the major lobe of the vertical pattern to occur somewhat above the horizon, and this effect is known to those skilled in the art as an "uptilt" of the pattern. The upper element **7** is spaced a distance different from the spacing of elements **1–6** and is utilized in order to improve the vertical-angle coverage of the antenna system. The element **1** operates in conjunction with a counterpoise **9** which is placed between elements **6** and **7**. The element **7** is fed the same quantity of power as the central elements **3** and **4** and contributes to the uptilt of the vertical pattern because of the virtue of a lagging current.

In order to couple energy to the radiation elements, the main transmission line **8** comprising an inner conductor **8*a*** and outer conductor **8*b*** proceeds to a central feedpoint **11** at which point the transmission line divides into a distribution network. The distribution network contains matching transformers at all positions in order to maintain an acceptable match at all points; however, for clarity in the illustration, the transformers are not shown.

At the main feedpoint **11**, the energy input is divided into two portions. The first portion comprising approximately twenty-three units of power is coupled to a feedpoint **12** by conductor **8** functioning as an inner conductor in conjunction with conductor **13** functioning as an outer conductor. The energy of approximately twenty-three units of power at feed-point **12** is divided into two portions of eighteen and five units of power each. The eighteen units of power are coupled to feedpoint **14** by means of conductor **13** and conductor **15** functioning as inner and outer conductors of a transmission line. The power at point **14** is evenly divided, and nine units of energy are fed to antenna elements **3** and **4**, respectively. The remaining five units of power appearing at feedpoint **12** are coupled to point **16** where the power is divided so as to feed bicone **1** with one unit and bicone **2** with four units of power.

The remaining fourteen units of power are coupled from central feedpoint **11** to feedpoint **17** where nine units of power are coupled to the bicone **7**, and the remaining five units are coupled to feedpoint **18** where it is split so that four units are fed to element **5** and one unit to element **6**. This distribution of 1—4—9—9—4—1 units of power can be recognized as one tending to suppress minor lobes. In order to obtain uptilt, elements **1** and **2** lead and elements **5**, **6** and **7** lag in current with respect to elements **3** and **4**.

Element **7** is introduced to improve the vertical-angle coverage of the antenna array. Unit **7** functions in conjunction with counterpoise **9** which is located between elements **6** and **7**. Element **7** is fed nine units of power and contributes to the uptilt by virtue of its lagging current. At high vertical angles, the counterpoise **9** tends to mask the radiation emitted from elements **1–6**; and therefore, at these angles, energy is received predominantly from the top element.

The gain of such an antenna array is approximately 5 db over a dipole; and one desirable uptilt places the maximum lobe at a vertical angle of approximately 5 degrees above the horizon, thus appreciably assisting in the reduction of siting effects. Due to the vertical distribution of the elements **1–6** constituting the main array and the greater spacing between the upper bicone **6** of the main array and the upper element **7** than is present between other adjacent bicones, the vertical distribution of the radiation pattern is appreciably greater than that due to a simple equispaced stacking of bicone antennas, thus reducing the "cone of silence" area enabling an aircraft flying over the beacon to receive signal during a greater period of time.

Referring to Fig. 3, one embodiment of a TACAN antenna system is shown in perspective to comprise a base **19** which may contain the various reference-pulse generators and mechanical movement systems used in the TACAN antenna system. The stack of biconical radiating elements are housed in a tube of fiberglass or other insulating material. In order to produce the fundamental signal modulation, a parasitic element **21** comprising a high-resistance metallic wire is mounted upon a cylinder made of nonconductive material **22** which is then rotated about the central array **20**. To produce the harmonic frequency modulation, a plurality of parasitic elements (not shown) are equally spaced on a second cylinder made of a nonconductive material **23** at a greater distance from the array **20** than the fundamental parasitic element, and both cylinders **22** and **23** are rotated in synchronism about the array **20**. In order to provide for desirable radiation pattern characteristics, counterpoise plates **24** and **25** are provided. Counterpoise **25** in Fig. 3 functions in a manner similar to the counterpoise **9** shown in the schematic drawing of Fig. 1.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of our invention as set forth in the objects thereof and in the accompanying claims.

We claim:

1. An antenna array comprising a plurality of radiation elements disposed in a given vertical alignment, the spacing between each radiation element of said plurality of radiation elements being a given amount, an additional radiation element disposed in alignment with respect to said plurality of elements and spaced therefrom at a distance different than said given amount, a counterpoise disposed between said plurality of radiation elements and said additional radiation element, a source of input energy, a transmission line coupled to said source, means to couple said energy from said transmission line to said plurality of said radiation elements including means to divide said energy at a feedpoint and a plurality of branch transmission lines coupling energy from said feedpoint to each of said plurality of radiation elements, and means to couple energy from said transmission line to said additional radiation element.

2. An antenna array comprising a plurality of equally spaced radiation elements disposed in a vertical alignment, an additional radiation element disposed in said vertical alignment with respect to said plurality of radiation elements and spaced at a distance greater than said equal spacing, a counterpoise disposed between said plurality of radiation elements and said additional element, a source of input energy, a transmission line coupled to said source, means to couple said energy from said transmission line to said plurality of elements including means to divide said energy at a feedpoint and a plurality of branch transmission lines coupling energy from said feedpoint to each of said plurality of radiation elements, and means to couple energy from said transmission line to said additional radiation element.

3. An antenna array comprising a plurality of equally spaced radiation elements disposed in a vertical align-

ment, an additional radiation element disposed in said vertical alignment with respect to said plurality of radiation elements and spaced at a distance greater than said equal spacing, a counterpoise disposed between said plurality of radiation elements and said additional element, a source of input energy, a transmission line centrally disposed with respect to said vertical alignment and coupled to said source, means to couple said energy from said transmission line to said plurality of elements including means to divide said energy at a feedpoint and a plurality of branch transmission lines coaxially disposed with respect to said transmission line and coupling energy from said feedpoint to each of said plurality of radiation elements, and means to couple energy from said transmission line to said additional radiation element.

4. An antenna array comprising a plurality of equally spaced biconical radiation elements disposed in a given vertical alignment and an additional biconical radiation element disposed in said vertical alignment with respect to said plurality of biconical elements and spaced at a distance greater than said equal spacing, a conductive surface disposed between said plurality of radiation elements and said additional element, a source of input energy, and a plurality of concentric transmission lines disposed axially of said biconical elements to couple said input energy to said radiation elements.

5. An antenna system comprising a plurality of equally spaced radiation elements disposed in a given vertical alignment and an additional radiation element disposed in said vertical alignment and spaced at a distance greater than said equal spacing from the nearest of said plurality of radiation elements, a conductive surface disposed between said plurality of radiation elements and said additional radiation element, a source of input energy, a plurality of concentric coaxial transmission lines disposed axially of said biconical elements to couple input energy to all of said radiation elements, and at least one parasitic element associated with said antenna array disposed for rotation about said vertical alignment.

6. An antenna system comprising a first group of radiation elements equally spaced and disposed in vertical alignment, at least one other radiation element disposed above said plurality of radiators, a conductive surface disposed between said plurality and said other radiation element, a first group of parasitic elements at a given distance from said vertical alignment of said radiation elements disposed for rotation about said radiation elements, and a second group of parasitic elements associated with said radiation elements and disposed for rotation about said vertical alignment at a distance greater than said given distance from said vertical alignment.

7. An antenna system according to claim 6 which further includes a first cylinder composed of nonconductive material surrounding said plurality of radiation elements, said first group of parasitic elements being carried by said first cylinder, a second cylinder composed of nonconductive material surrounding said first cylinder, said second group of parasitic elements being carried by said second cylinder, and means to rotate in synchronism said first and second cylinders about said radiation elements.

References Cited in the file of this patent

UNITED STATES PATENTS

2,631,237 Sichak --------------- Mar. 10, 1953