March 31, 1964 J. VAN NUYS GRANGER 3,127,612

GROUND SCREEN FOR VERTICAL LOG PERIODIC ANTENNA

Filed April 2, 1962

FIG. 1

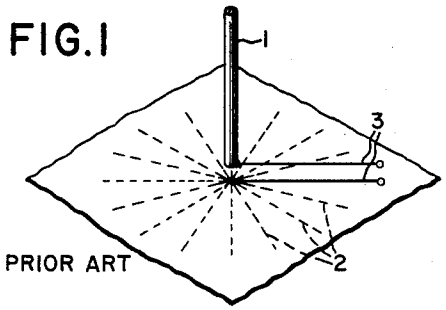


FIG. 2

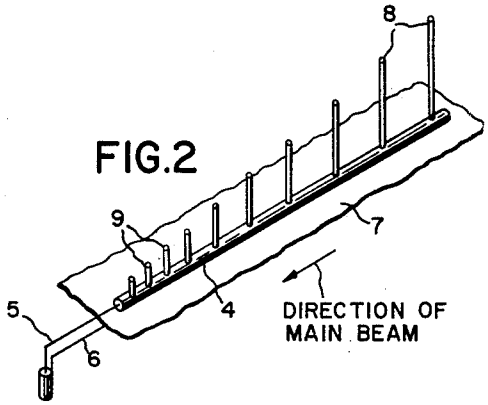


FIG. 3

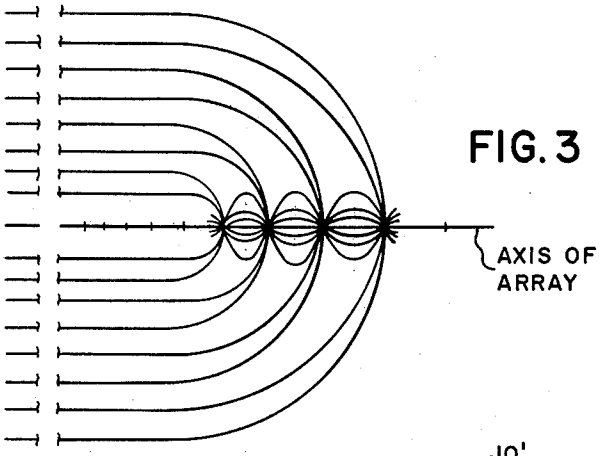
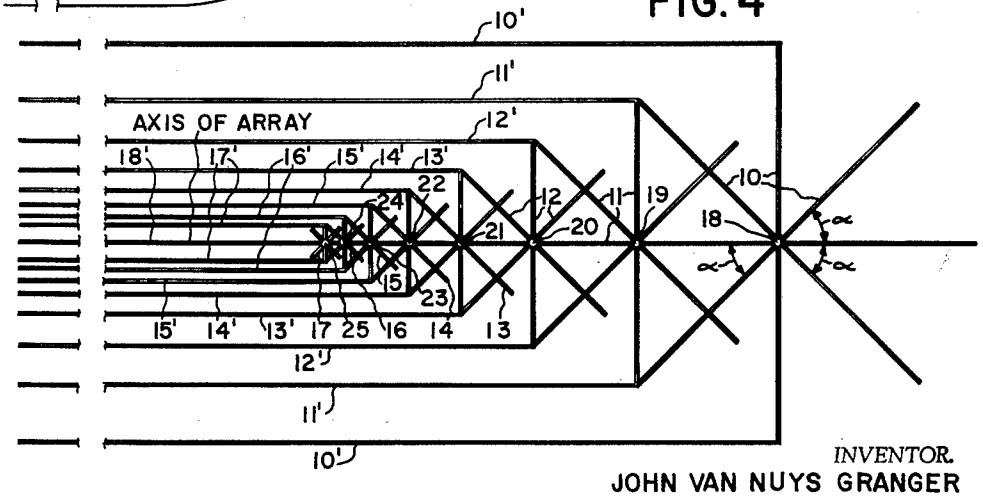


FIG. 4



INVENTOR.
JOHN VAN NUYS GRANGER
BY Paul B. Hunter
ATTORNEY

United States Patent Office 3,127,612 Patented Mar. 31, 1964

3,127,612

GROUND SCREEN FOR VERTICAL LOG PERIODIC ANTENNA

John Van Nuys Granger, Atherton, Calif., assignor to Granger Associates, Palo Alto, Calif., a corporation of California

Filed Apr. 2, 1962, Ser. No. 184,461
4 Claims. (Cl. 343—792.5)

This invention relates generally to antenna ground screen structures, and the invention relates more particularly to a novel ground screen or counterpoise structure of optimum design and especially suited for use with logarithmically periodic antenna systems.

Vertically polarized antenna systems that are excited in such a way as to produce significant radio frequency currents at the base of the radiating element or elements require a ground screen or counterpoise structure for efficient operation. The function of the ground screen or counterpoise structure is to carry, preferably with minimum power loss, the pattern of radio frequency currents which are required by the laws of electrodynamics to support the desired electromagnetic fields on the surfaces of radiating elements themselves and in the space surrounding the antenna and extending outwardly to great distances in the directions in which radio signals are to be propagated. When the antenna is located on or near the surface of the earth, and in the absence of a ground screen or counterpoise structure, the ground currents produced by the antenna are conducted in the upper layers, i.e. within the skin depth, of the earth itself. For the type of soil conditions which usually prevail, this mode of operation is unsatisfactory because of the power losses which occur when R-F currents pass through a resistive medium such as soil, and the related distortion of the desired electromagnetic fields as well as the diminution thereof.

Ground screen or counterpoise structures, as heretofore generally constructed, have been more or less arbitrary and inefficient except as for the simple vertical monopole antenna using radiating wires, and this is particularly true in the case of vertical polarized directional antennae.

It is therefore the principal object of the present invention to provide a novel ground screen structure of optimum design, having conducting members so disposed as to obtain highly efficient operation while utilizing simultaneously a minimum amount of conductive material in the structure.

A feature of the present invention is to provide a ground screen structure that is effective over a wide band of operating frequencies and which is especially valuable for use with antenna arrays of the logarithmic periodic type.

Another feature of the present invention is the provision of a novel ground screen structure that is highly effiicient in use, having a high ratio of reflectivity to ground screen material used, and which in operation is substantially independent of the antenna operating frequency and of surrounding soil conditions, the said ground screen structure having a very low electrical loss.

Other objects and advantages of the present invention will become apparent from the following description taken in connection with the accompanying drawings, wherein:

FIG. 1 shows a fragmentary perspective view of a typical ground screen used heretofore in connection with a simple vertical monopole antenna.

FIG. 2 is a perspective view of a logarithmic periodic array of vertical monopoles in schematic form shown in relation to the adjacent ground or ground screen.

FIG. 3 is a schematic view showing the ground current pattern ideally present in connection with the operation of the logarithmic array shown in FIG. 2.

FIG. 4 is a view in plan of the preferred form of the novel antenna ground screen structure of the present invention.

Referring now to the drawings, it will be seen that FIG. 1 shows a typical ground screen **2** used heretofore in connection with a simple monopole antenna **1**. This screen **2** can take the form of a metal sheet or may consist of a plurality of radiating wires angularly spaced with each other and which are lying on or are buried near the surface of the earth beneath the antenna **1**. In this case, the antenna may be fed from terminals **3**, one of which is connected to the ground screen and another of which is connected to the antenna. Experience has shown that in the high frequency band, i.e. from roughly 1 to 40 megacycles, the radial wires should have a length of several wavelengths of the operating frequency and should be spaced not more than 10 to 30 degrees angularly apart for best antenna performance. Radiating efficiency is increased, of course, by employing longer wires **2** and arranging them closer together angularly. Thus while the use of a metal plane would produce a highly efficient ground screen, at the same time it would be very wasteful of conducting material.

There is shown in FIG. 2 a typical logarithmic periodic array **4** of vertical monopoles in schematic form, wherein the radiating elements are arrayed in a line and mutually spaced at progressively greater distances apart leading from the apex. Various methods may be used for exciting such an array such as the feed lines **5**, **6** connected to the array and to the ground screen **7**. When excited, such an array produces a beam of radio frequency energy traveling in a direction from the longer elements **8** of the array toward the shorter elements **9**, i.e. in the direction of the arrow shown in FIG. 2. In practice, when using such an array, only a portion of the radiating elements are excited at any given operating frequency, the shorter elements being excited at the higher frequencies and the longer elements at the lower frequencies.

In operation, such an array produces a flow of R-F currents on or near the surfaces over which the array is located. For efficient operation, a ground screen has to be used to carry these currents, and thus it becomes important to know the paths over which these ground currents flow and the relative amplitude of the currents in different parts of the path in order to determine the optimum configuration of a ground screen.

If for the moment it is considered that only one of the elements of the antenna is excited, as in the case of an isolated single monopole antenna, the ground current would follow a radial path as shown in FIG. 1, and the intensity would drop off rapidly with distance from the common junction point. However, in the case where a number of adjacent elements are excited, as shown in FIG. 2, with comparable amplitudes but with a progressive phase variation, as in the case in an actual logarithmically periodic array, it has been found from tests that the distribution of ground currents is quite different. Close in to the base of individual antenna elements the current direction is substantially radial, but as distances from the base of the elements become greater, and comparable with the element-to-element spacing, the current paths are no longer purely radial, and components of significant amplitude appear in directions extending parallel to the axis of the array, i.e. in the direction of the arrow shown in FIG. 2. At still greater distances from the antenna elements, the only currents of significant amplitude are those flowing in a direction parallel to the axis of the array. In the region of the main beam of the array and a few wavelengths forward of the apex of

the array, these longitudinal currents are essentially identical to those associated with a vertically polarized wave propagated in the direction of the wave beam. This ground current pattern appears approximately as shown diagrammatically in FIG. 3.

As was pointed out in connection with the antenna of FIG. 1, it is generally known that it is not necessary to extend the ground radials indefinitely since the intensity of the ground current falls off rapidly with distance from the antenna. In the case of the logarithmic periodic array, radial currents fall off to a negligible value within a distance of one-quarter of the wavelength in those directions which lie outside of the main beam of the array. For ground screen paths which are within the main beam, however, the current intensity is appreciable out to distances of several wavelengths, as shown in FIG. 3. At each operating frequency a ground screen design for a logarithmically periodic array should provide good conducting paths, such as wires, for the current flow, as is shown schematically in FIG. 3. The ground screen conductor should extend in each direction far enough so that the equivalent ground current intensity is small at points where the ground screen terminates. This distance is of the order of one-quarter wavelength in directions at the side or to the rear of the array and increases to the order of several wavelengths in the region forward of the array. The spacing between adjacent ground screen conductors should be small compared with the wavelength.

Such an arrangement of ground screen conductors, which meets the requirements set forth heretofore, over the entire operating band of a logarithmically periodic array in accordance with the present invention is illustrated in the structure of FIG. 4. Thus, in this figure it will be noted that the radial conductors **10, 11, 12, 13, 14, 15, 16, 17**, associated with antenna elements such as **18, 19, 20, 21, 22, 23, 24, 25** extend radially from the respective antenna elements for distances of approximately one-quarter wavelength in directions to the side and to the rear of the array. Extending forwardly of the array, however, additional relatively long conductors **10′, 11′, 12′, 13′, 14′, 15′, 16′, 17′** are provided, extending parallel to the longitudinal axis of the array. Central conductor **18′** extends along the axis of the array and is continuous with central radial conductors **10, 11, 12, 13, 14, 15, 16,** and **17**. It will be noted that the leads **10′** are connected to the outer ends of those conductors **10** which extend at right angles to the longitudinal or central axis of the array from the vicinity of the lowest frequency antenna element **18**. Conductors **11′** connect with the outer ends of the leads **11** extending at right angles to the longitudinal axis of the array from the vicinity of the antenna element **19**, having a frequency somewhat higher than that of antenna **18**. It will be noted that leads **11′** also connect with conducting elements **10** extending forwardly at the angle α with the longitudinal axis of the array. Similarly conductors **12′, 13′, 14′, 15′, 16′, 17′** are connected to respective radial elements of conductors **12, 13, 14, 15, 16, 17**, and are also connected to associated adjacent radial conductor making the angle of α with the longitudinal axis of the array.

The leads **10′ . . . 18′** extend for several wavelengths in the direction of the propagation of the antenna. The angle α is shown in FIG. 4 as constituting an angle of 45 degrees. However, this angle can be made of any value commensurable with 360 degrees. Angles of 10, 15, 30, or 60 degrees could be used with a corresponding increase or decrease in the density of the resulting ground screen structure, if desired. In FIG. 4 the length of the conductors **10′ . . . 17′** extending parallel to the axis of the array are arbitrarily chosen to place their ends on a common or imaginary line perpendicular to the axis of the array, but this is not necessary. For example, leads starting with **11′** could be made progressively shorter, if desired, corresponding to higher wavelengths. However, it is essential that these conductors have lengths of several wavelengths at the operating frequency at which the corresponding antenna element or radiator is strongly excited. The wires emanating from the shorter radiating elements could, therefore, be correspondingly shorter, if desired. The spacing between the conductors **10′ . . . 17′** measured in the direction at right angles to the longitudinal axis of the array could be made progressively smaller as you approach the axis of the array. Also, note that central conductor **18′** extends along the axis of the array. All these conductors are interconnected by the lead **18′**, as will be seen from a study of FIG. 4, and this lead in turn would ordinarily be connected to one side of the carrier supply, the other side being connected to the antenna elements **18 . . . 25**. Experience has shown that there is an inverse relationship between the lengths of the ground conductors in the region forward of the antenna and the angle of elevation of the maximum of radiation pattern of the array. In many applications it is desirable that this elevation angle decrease with increasing frequency. This is automatically achieved in the arrangement as shown in FIG. 4.

Thus, it will be seen that the novel ground screen structure of this invention as embodied in FIG. 4 provides for effective operation of the array over a wide band of frequency with a minimum of ground screen material as can be observed by comparing FIG. 4 with FIG. 3. Furthermore, the ground screen structure of FIG. 4 is essentially independent of operating frequency and of surrounding soil conditions. Furthermore, the structure of FIG. 4 obviously has a very low electrical loss in use.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An antenna ground screen structure for a directional array of the log periodic type employing a succession of mutually spaced vertical electromagnetic radiating elements extending upwardly from a common ground screen axis and adaped to be excited in progressively varying phase relationship comprising, radially extending mutually angularly spaced conductors projecting from the proximity of the base of successive antenna radiating elements, the group of radial conductors extending from the proximity of the base of each such antenna radiating element being electrically connected together at their common center and additional conductors connected to the ends of certain of said radial conductors and extending substantially parallel to the common ground screen axis of said array and to the direction of propagation of the said array, certain of said radial conductors associated with one antenna element intersecting and being electrically connected to certain of the radial conductors associated with an adjacent antenna element to produce a highly effective ground screen with the use of but a minimum conductor material.

2. An antenna ground screen structure as defined in claim 1 wherein a central conductor extends along the common ground screen axis of said radiating elements, said mutually spaced groups of radial conductors being connected to and extending from said central conductor, each of said additional conductors being connected to radial conductors of two adjacent antenna element radial conductor groups.

3. An antenna ground screen structure as defined in claim 2 wherein said radial conductors extending from any particular point on said central conductor are all of substantially the same length, the lengths of the radial conductors extending from successive points along the said central conductor taken in the direction of propagation of the antenna decreasing progressively with distance.

4. An antenna ground screen structure as defined in

claim 2 wherein the lengths of said radial conductors are of the order of a quarter wavelength of the operating frequency of the directional antenna elements associated therewith in use, said central conductor and said additional conductors having lengths equal to several wavelengths of such operating frequencies.

References Cited in the file of this patent

UNITED STATES PATENTS

802,424	Stone	Oct. 24, 1905
1,360,168	Alexanderson	Nov. 23, 1920
2,200,249	Hahnemann	May 14, 1940
2,292,342	Schelkunoff	Aug. 4, 1942
2,419,672	Busignies	Apr. 29, 1947
2,473,377	Koch	June 14, 1949
3,101,474	Wickersham et al.	Aug. 20, 1963

FOREIGN PATENTS

20,230	Great Britain	Sept. 3, 1909