

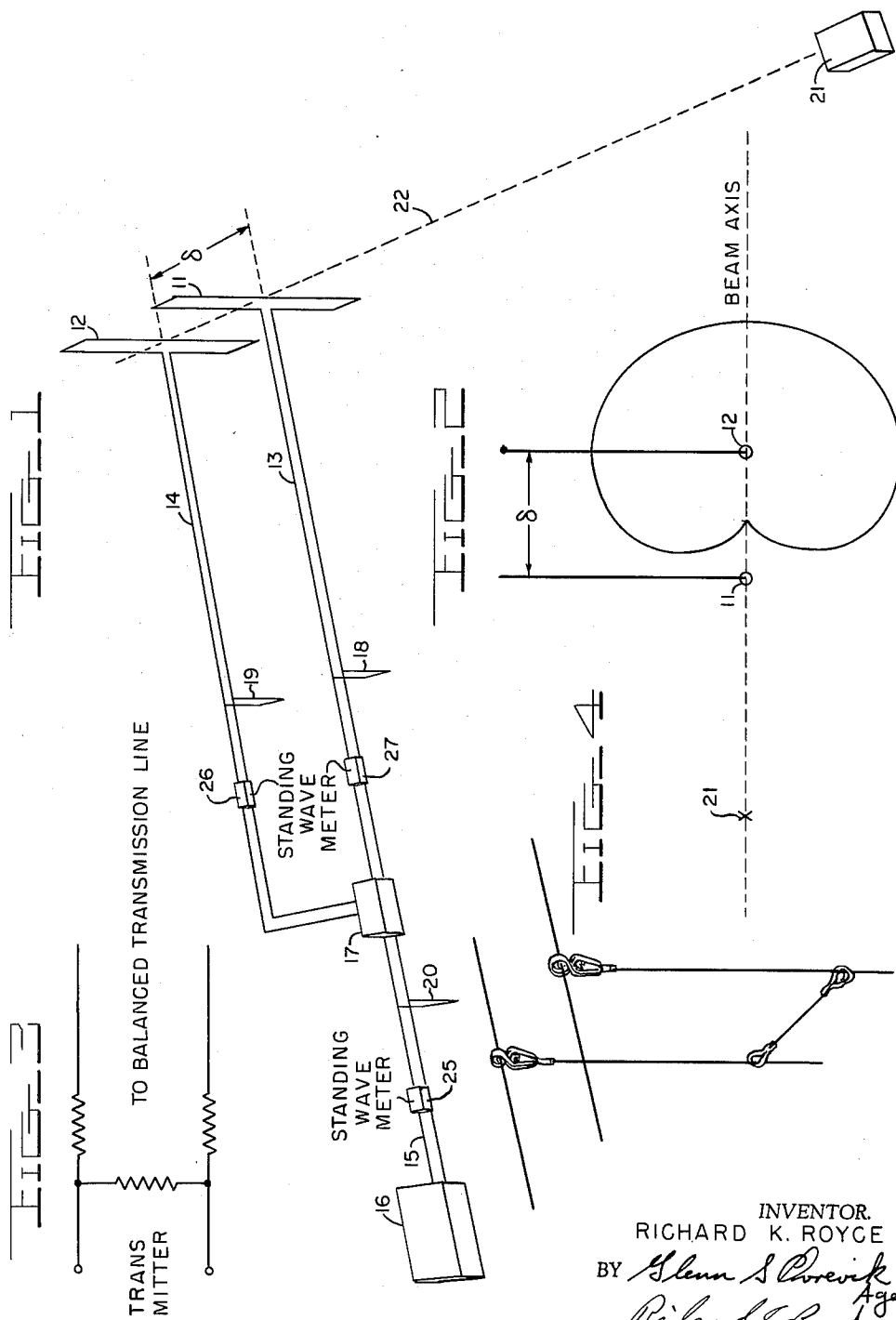
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METHOD FOR ANTENNA ARRAY TUNING

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METHOD FOR ANTENNA ARRAY TUNING

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4 Claims. (Cl. 343—100)

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

This invention relates in general to directional antenna tuning methods and in particular to a method of tuning at least two driven antenna to provide a selected radiation pattern.

It is common practice in radio communication systems to employ a directional antenna array consisting of two omnidirectional antenna, for example, vertical folded dipoles, spaced $\frac{1}{4}$ wavelength apart, which are driven to produce a cardioid-shaped radiation pattern. This type of antenna array is particularly useful in ship to shore applications where a shore station is expected to cover ships within a wide area.

As is recognized by those skilled in the art, the operational tuning of the directional antenna array is extremely complex in that any adjustment of transmitter, transmission line, antennae or surroundings, disturbs the resultant radiation pattern and thus necessitates further adjustment until a reasonable compromise is reached.

Consequently, the turning of directional antenna arrays by present known methods necessitates the services of highly qualified personnel able to predict the effect of various adjustments. Obviously, such qualified personnel are not always available and less qualified personnel may be called upon "to do the best they can" under quasi-emergency circumstances, and the antenna array may have poor radiation, or poor directivity, or both, as a result. Thus a simplified quick method for the accurate tuning of directional antenna arrays is needed and would be welcomed as a substantial advancement of the art.

Accordingly:

It is an object of this invention to provide a method of tuning directional antenna arrays wherein variable factors are minimized.

It is also an object of this invention to provide a method of tuning directional antenna arrays whereby relatively inexperienced personnel can satisfactorily perform the tuning operation.

It is another object of this invention to provide a method of tuning directional antenna arrays which is relatively simple, quick and reliable.

It is still another object of this invention to provide a method of tuning directional antenna during the energization thereof without serious personnel hazard.

Other objects of this invention will become apparent upon a more comprehensive understanding of the invention for which reference is had to the following description and drawings, wherein:

FIG. 1 depicts an exemplary directional antenna array which may be tuned by the method of this invention.

FIG. 2 is the desired radiation pattern provided by the antenna array depicted in FIG. 1.

FIG. 3 is a schematic showing of an impedance network suitable for use in accordance with the method of this invention.

FIG. 4 is a pictorial showing of a means for loading balanced transmission lines suitable for use in accordance with the method of this invention.

Briefly, the method of this invention provides for tuning the antenna array under simulated operating conditions

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which closely approximate actual conditions such that the radiation pattern under actual operating conditions is substantially as desired.

The antenna array depicted in FIGURE 1 embodies two driven half wavelength folded dipole elements spaced approximately one quarter wavelength apart which is relatively basic in design and mode of operation. This basic antenna array has been selected merely to simplify the disclosure of the invention and thus to facilitate a clearer understanding thereof.

In FIGURE 1, two physically equal dipoles, 11 and 12, are shown with a spacing δ therebetween which is substantially $\frac{1}{4}$ wavelength at the operating frequency f of the system. Two branch feeder transmission lines, 13 and 14, are interconnected with main feeder transmission line 15 via coupler 17 with the main section connected to the transmitter 16. In accordance with standard practice, one of the feeder transmission lines, 14, is longer than the other by approximately $\frac{1}{4}$ wavelength at the opening frequency f . Tuning stubs 18 and 19 are associated with branch feeder transmission lines 13 and 14, respectively, and tuning stub 20 is associated with main feeder transmission line 15. Each tuning stud is adapted, by means not shown, for movement along each respective feeder transmission line in accordance with the method of this invention. Tuning stubs 18, 19 and 20 are also adapted, of course, for adjustment of the respective lengths thereof in accordance with the teaching of this invention. During the tuning operation, standing wave meters 25, 26, and 27 are respectively coupled to the main transmission line 15 and the branch feeder lines 13 and 14 to provide a way to determine when there is minimum reflected energy in each of the lines for purposes that will become clear hereinafter. In addition, a field strength measuring means, 21, is disposed at a null point, in this application on the beam axis of the array, indicated at 22, substantially remote from the antenna array for reasons which will become apparent hereinafter.

It will be appreciated that by proper feeding of this antenna array, a cardioid shaped radiation pattern such as shown in FIG. 2, may be obtained. Ordinarily, proper feeding, which is the crux of the matter, of course, is difficult to obtain by prior art methods. Indeed, frequently it is considered inadvisable to employ tuning devices of the adjustable stub variety where an optimum feeding arrangement is sought because the stubs themselves generally act as auxiliary antenna and further complicate the adjustment problem.

The method of the prior art starts with the presumption of an ideal situation not involving discontinuities and an exact placement and sizing of radiator and transmission line elements in accordance with theoretical determinations for proper impedance match and phasing at the center operating frequency. The actual tuning operation consists of (1) field strength measurements under full power at selected points substantially remote from the antenna array, (2) transmitter shutdown, (3) length and/or placement adjustment of the several stubs, (4) field strength measurement under full power, (5) transmitter shutdown, (6) further adjustment of the several stubs, and (7) field strength measurement under full power, and infinitum. It will be appreciated that due to the numerous interrelated variables involved, the tuning of directional antenna arrays by the prior art method described above has been strictly a cut and try proposition. A considerable amount of delay is experienced in the course of the remote field strength measurements, of course, and also in the necessity for a permanent type stub adjustment to permit full power energization in each test instance. In addition, the method of the prior art

obviously does not permit the undetected installation of directional antenna arrays nor does it permit practical adjustment during energization of the array.

The method of the present invention starts with a similar presumption of an ideal situation not involving discontinuities but the placement and sizing of radiator elements and transmission line elements need not be so exacting as in the prior art method. For example, the substantially identical radiator elements in the antenna array should be spaced approximately $\frac{1}{4}$ wave-length apart at the center operating frequency, one transmission line should be approximately $\frac{1}{4}$ wavelength longer than the other and the stubs should be of a length sufficient to permit adjustment as required, that is, the case of a closed stub adjustment would be in the 0 to $\frac{1}{4}$ wave-length region and the stub should be at least .2 wave-length in practical application. It will be appreciated that open stubs could be employed but that closed stubs are generally preferred because of ease of adjustment and adaptability to lightning protection grounding arrangements.

The actual tuning operation of the present invention consists of (1) effective disablement of one or the other antenna and its associated transmission line segment, (2) conversion of transmitter from normal power to relatively low power constant current source, (3) energize transmitter, (4) adjust stub on transmission line associated with active antenna for minimum reflected power, (5) restore other antenna and its associated line to able condition, (6) install comparable stub (identical in position and size) on line associated with other antenna, (7) adjust stubs for minimum field strength indication at selected null point along beam axis, (8) stub main transmission line at point substantially .4 wavelength from junction, (9) adjust stub for minimum reflected power, and (10) reconvert antenna array and transmission line to normal power operation.

The first and second steps of the method as outlined above are preliminary in nature and may be taken in reverse order, of course, if desired. Disablement of an antenna and its associated branch feeder transmission line may be accomplished in quick, easy and temporary fashion by simple disconnection at the junction of the branch feeder transmission lines with the main feeder transmission line and the insertion of shorting bars at various points along the balanced transmission line and, in the case of a folded dipole, at various points thereon.

Conversion of the transmitter to act as a low power constant current source may be accomplished by any suitable impedance network. For example, the impedance network as shown in FIG. 3 may be employed. In such a network, a resistance of 600 ohms may be connected directly across the output of the transmitter and the two balanced lines of the main feeder may be connected via 2 series resistances of 3000 ohms each to afford a 10 to 1 power reduction. It is understood, of course, that a greater or lesser impedance ratio may be involved depending upon the particular circumstances of each individual case. In general, the power reduction should be sufficient to permit personnel handling of the transmission line and antenna during the energization thereof with relative safety utilizing standard protective gear such as leather covered rubber gloves.

The fourth step, stub adjustment, may be simplified by the use of temporary clasp means of the battery clip variety, as shown in FIG. 4, which permit quick and easy position and length adjustment by temporary release of the battery clips. It has been found that such temporary clasp means are entirely satisfactory for low power tuning purposes. In accordance with standard practice, of course, permanent clasp means should be utilized under full power operation to minimize arcing and other temporary contact complications. It will be appreciated that a wide variety of clamping means, including tem-

porary devices which can be made permanent, are permissible in the method of this invention. It is desirable, however, to use the same type of device in each adjustable stub assembly to maintain a degree of identity in the transmission line.

Adjustment for minimum reflected power may be accomplished by hanging a balanced line directional coupler of the type described in my copending application Serial No. 120,801, filed June 29, 1961 entitled, Open Wire Directional Electromagnetic Coupler, now Patent No. 3,169,219, for example, at a point intermediate the stub and the junction point.

Step 5—restoration of the other antenna and its associated line to able condition—merely involves an undoing of Step 1, and may be simplified by discrete, non-destructive disablement. For example, plug connection junction means and battery clip shorting means will permit a quick and easy disablement and restoration.

Step 6 pertains to the establishment of a stub means on the line associated with the other antenna. It is particularly advisable to employ a stub of similar length at a similar point on the line relative to the respective antenna.

At this point the antenna array has been roughly tuned in its peculiar environment. That is, irrespective of the degree of disturbance attributable to the antennae environment, the two antennae are approximately equally affected and reflected energy in the branch transmission lines has been minimized.

Step 7 makes use of a null indicating field intensity meter disposed substantially in line with the two antennae at a point at least 2 wavelengths therefrom and preferably at a much greater distance therefrom. In accordance with the method, the stubbing means are adjusted in length and/or position to obtain a minimum indication at the field intensity meter by use of any suitable information relay means, generally by use of portable radio equipment.

It will be appreciated that portability is not critical to the method of this invention since the field intensity meter is relatively stationary, and the stubs are effectively confined to a general area on the branch transmission lines.

Once a minimum field strength has been reached, a main feeder transmission line reflected power correction is generally needed to balance the impedance at the transmission line junction to the transmitter output impedance. This is readily accomplished by means of an adjustable stub disposed at a point substantially .4 wavelength from the junction by use of a directional coupler of the type described in the aforementioned copending application.

Step 10, of course, represents a completion of the method and constitutes the making of permanent connection at all points of temporary connection and the removal of the impedance network introduced in Step 2.

The method of the invention as described above is notably free of the countless complex procedures normally involved in the idealized directional antenna tuning methods of the prior art. In particular, exacting determinations of antenna to antenna, and antenna to transmission line relations are avoided by a progressive reduction of interrelated variable factors to single considerations of minimum wave energy reflection and minimum field intensity. Moreover, the method of the present invention permits on site adjustment of the directional antenna array while operating at relatively low power and with short term energization of the antenna. Thus, tuning of the directional antenna array may be accomplished by the method of this invention with a minimum number of personnel, with minimum energy dissipation, and as a relatively secretive operation if necessary. It will be appreciated that the method of the invention is especially useful in emergency operations, for example, in emergency operations involving relatively unskilled military personnel stranded in enemy territory.

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It is understood, of course, that it is within the purview of this disclosure to alter or adapt the method of this invention to the peculiarities of each individual situation. For example, where more than two antennae are employed and something other than a cardioid pattern is desired, it is permissive to employ a sufficient number of field intensity meters to observe all or a lesser number of anticipated null points at selected azimuth points about the antenna array.

Finally, it is understood that the method of this invention is only to be limited by the scope of the claims appended hereto.

What is claimed is:

1. The method of tuning a directional antenna array including at least two substantially identical omnidirectional radiation elements disposed in selected relation to provide a prescribed radiation pattern having at least one null area, a high energy source and transmission line means with a main section connected to said high energy source and branch sections interconnecting said main section and each of said radiation elements comprising the steps of

- (1) disabling all but one of said radiation elements and their respective branch sections of said transmission line means;
- (2) converting said high energy source into a relatively low energy constant current source;
- (3) energizing said source;
- (4) loading the branch section associated with said one of said radiation elements and adjusting said load for minimum reflected power in said branch section;
- (5) restoring the other radiation elements and their respective branch sections of said transmission line means to able condition;
- (6) loading the branch sections associated with said other radiation elements to the same extent and at the same point as the branch section associated with said one radiation element is loaded whereby all

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branch sections are similarly loaded at substantially the same point relative to their respective radiation elements;

(7) adjusting the loading on each branch section for minimum field strength indication at said null area of said prescribed radiation pattern;

(8) loading said main section of said transmission line and adjusting said load for minimum reflected power; and

(9) restoring said source to high energy operation.

2. The method of tuning directional antenna arrays as described in claim 1 wherein, steps (1) and (2) are reversed.

3. The method of tuning balanced directional antenna arrays as described in claim 1 wherein the loading of transmission line sections in steps (4), (6), (7) and (8) is accomplished by the use of adjustable stubs.

4. The method of tuning directional antenna arrays as described in claim 3 wherein the array consists of two substantially identical omnidirectional radiation elements disposed in selected relation to provide a cardioid shaped radiation pattern and step (2) is accomplished by the insertion of an impedance network in said main section of said transmission line means at its point of connection to said high energy source such that the majority of the energy output thereof is dissipated in said impedance network.

References Cited by the Examiner

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