United States Patent [19]

Hollingsworth

[11] **3,761,940**

[45] **Sept. 25, 1973**

[54] **MEANS FOR DIRECTING ELECTROMAGNETIC WAVE ENERGY AT A VERY LOW ANGLE ABOVE THE HORIZON**

[76] Inventor: **R. Lee Hollingsworth,** 186 Secatogue Ln., West, West Islip, N.Y. 11795

[22] Filed: **Dec. 10, 1969**

[21] Appl. No.: **870,607**

Related U.S. Application Data

[63] Continuation-in-part of Ser. Nos. 172,581, Feb. 12, 1962, Pat. No. 3,289,208, and Ser. No. 684,873, Nov. 21, 1967, abandoned.

[52] **U.S. Cl.** **343/826,** 343/830, 343/890

[51] **Int. Cl.** **H01q 21/00**

[58] **Field of Search** 343/825, 829, 830, 343/831, 886, 890, 731, 735, 736, 826, 845, 846

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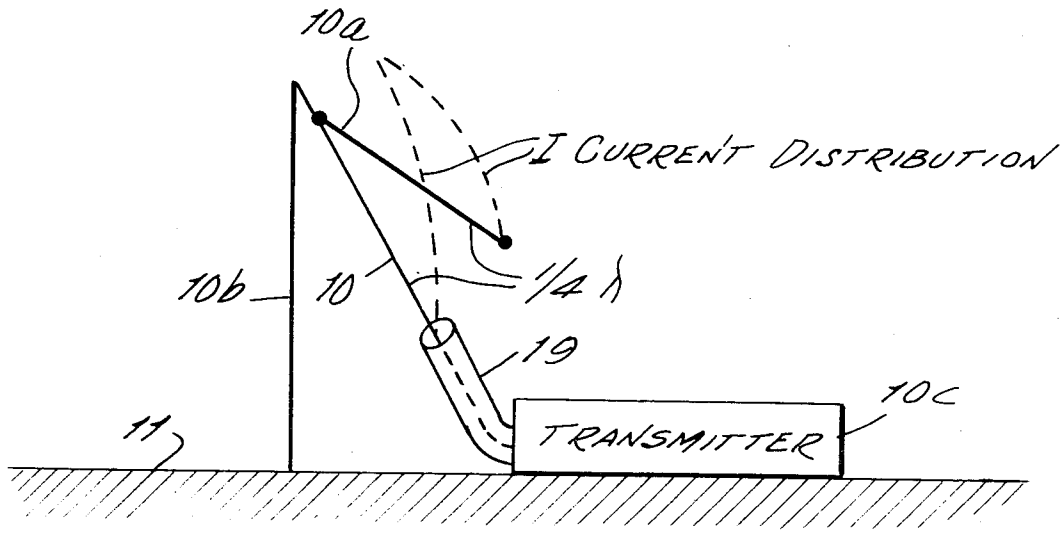
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Primary Examiner—Eli Lieberman

[57] **ABSTRACT**

The present invention comprises substantially vertical electromagnetic radiators which are arranged to have the maximum current mode at the top of one or more radiators to direct the wave energy along the ground plane without radiating energy directly towards the sky, which are . . . as well known . . . reflected back to Earth to cause interference. The invention also includes means comprising a single or multiple wavelength vertical antenna whereby the second 90 electrical degrees of each 180 electrical degrees is shielded from radiation to avoid high angle radiation. While the aforesaid means provides wave concentration along the ground towards the horizon, additional arrangement of radiators are associated to concentrate this ground wave energy in less than 360° from the point of transmission as desired.

2 Claims, 17 Drawing Figures



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4 Sheets-Sheet 1

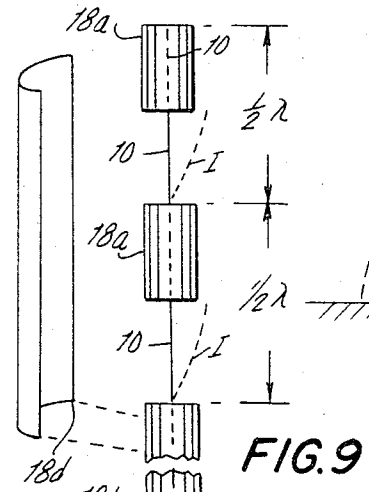


FIG. 9

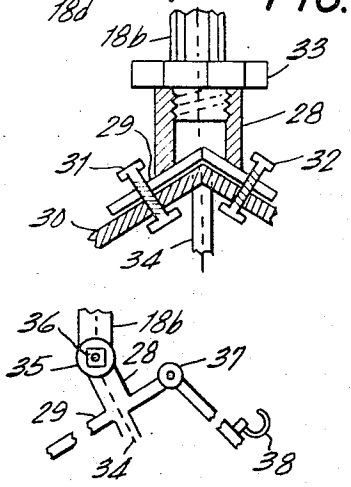


FIG. 9a

FIG. 1

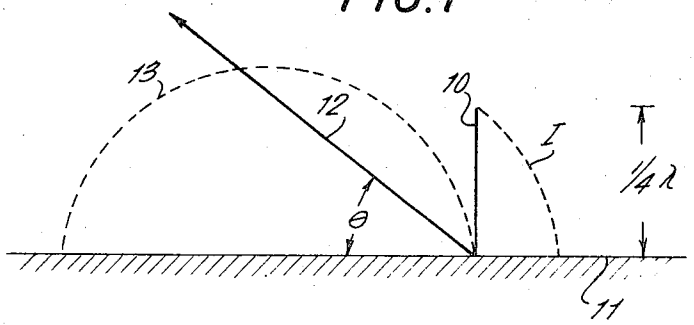


FIG. 2

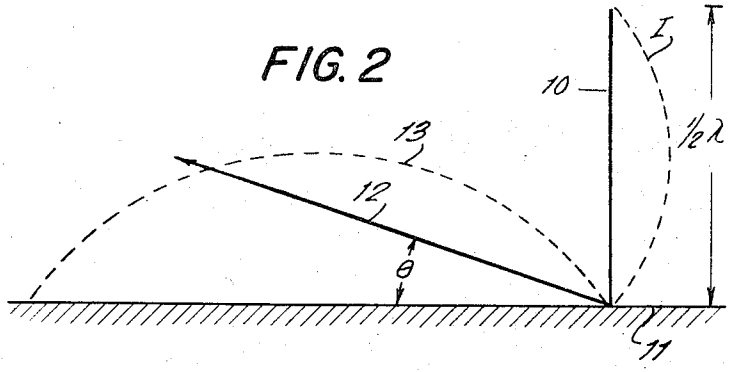
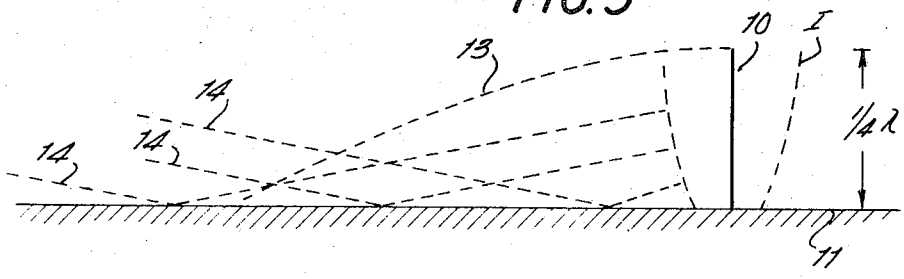


FIG. 3



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FIG. 4

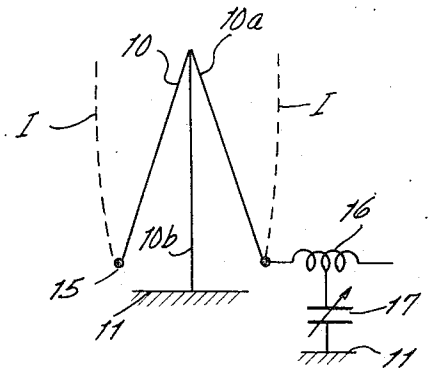
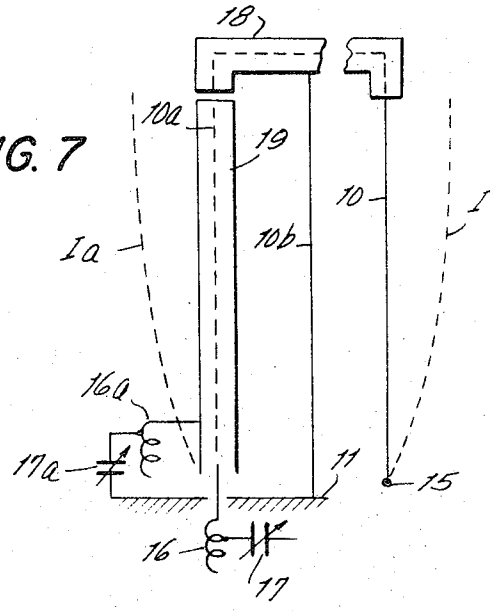


FIG. 7



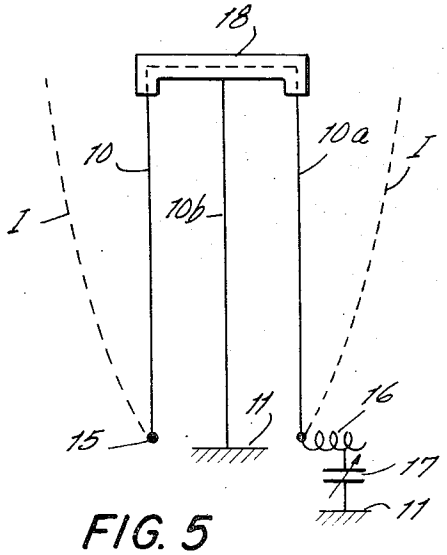
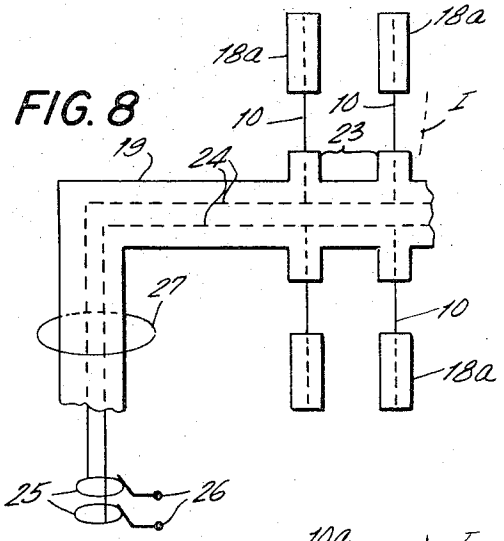


FIG. 5

FIG. 8



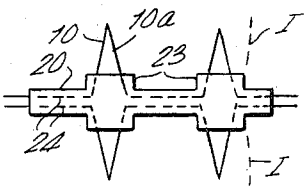


FIG. 10

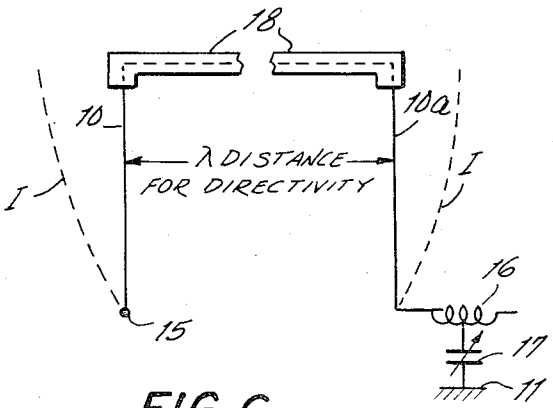


FIG. 6

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FIG. 4b

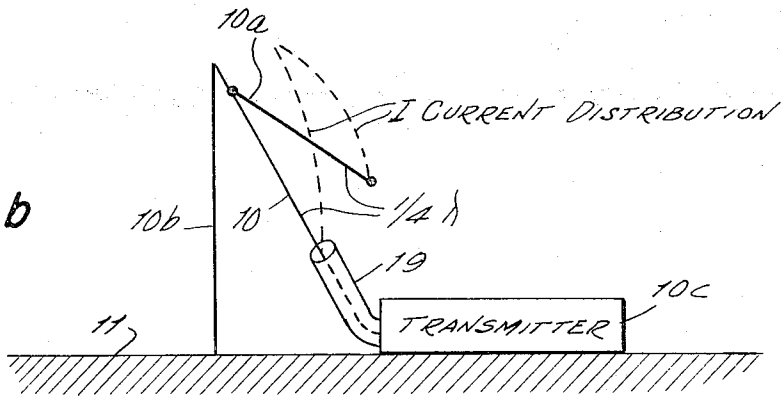


FIG. 4d

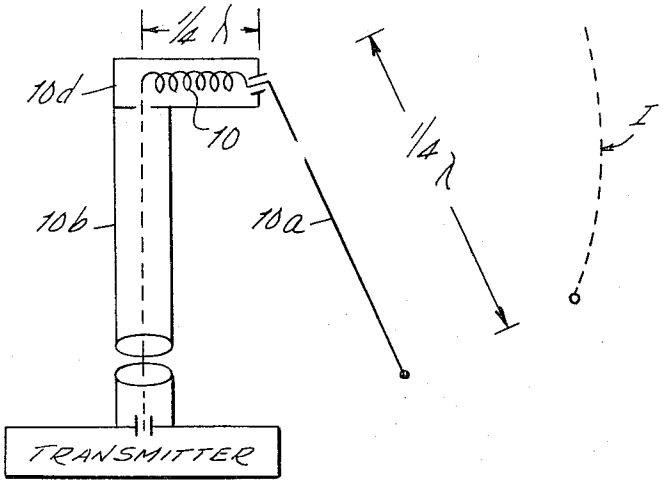
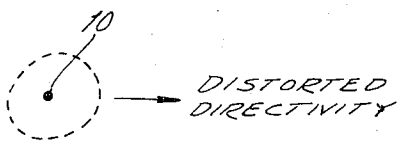


FIG. 4e



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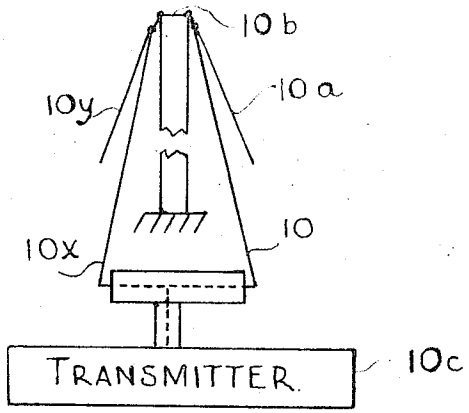


FIG. 4f

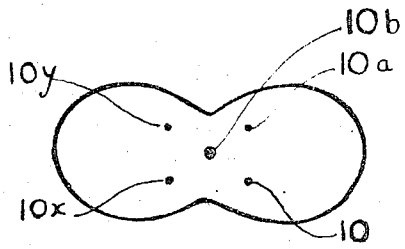
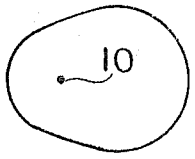


FIGURE EIGHT FIELD PATTERN

FIG. 4g



PROVED FIELD OF FIG. 4b

FIG. 4c

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MEANS FOR DIRECTING ELECTROMAGNETIC WAVE ENERGY AT A VERY LOW ANGLE ABOVE THE HORIZON

This is a continuation in part of my application Ser. No. 172,581, filed Feb. 12, 1962 from which U.S. Pat. No. 3,289,208 issued, and application Ser. No. 684,873, filed Nov. 21, 1967, now abandoned in favor of this continuation in part application.

The invention therefore includes means to concentrate along the Earth's surface most of the radiated energy from substantially a vertical type antenna, and including the radiator types for use in the standard radio broadcast band of frequencies from 535 to 1605 kilocycles, and the adjacent frequencies. Such radiators may be separated and distanced apart and phased to achieve field pattern directivity, yet radiate substantially no skywave energy according to the invention.

The basic principle of the invention and discovery may also be explained by visualizing a fed concentric transmission line suspended substantially vertical which has alternated quarter wave or 90° of the outer conductor cut away to allow radiation to take place during the first 50 percent of the time of each half wave of supplied wave energy, or a desired portion of the 180° length of each one half wave section. This reduces to a degree the apparent present standards of radiation efficiency, however the energy so radiated and received along the ground plane towards the horizon appears to have the same or higher efficiency.

To obtain the desired result in one embodiment of the invention, this is achieved by connecting one vertical 90° antenna at its top to another close by vertical 90° antenna extending downward substantially to establish ground level, both antennae being preferably lightly lump tuned at the feed end and at the far terminating end to provide substantially equal high voltages at the feed end and at the terminating end, with a half wave or 180° current distribution from the feed end up one quarter wave or 80° and down the next to the end or terminating end, comprising a partial radiating loop circuit wherein maximum current is at the top of the two one quarter wave sections. Such antenna can be omni-directional for transmission, but would be bi-directional for receiving, due to the wave travel in space cutting both sections at or near simultaneously to set up opposing currents, as in a radio navigation compass loop. Both the feed end and the downward extending section may be shielded by a concentric transmission line or other shielding means near the earth or termination to prevent radiation for about the first 30° of the radiators above real or established ground. This is desirable only to avoid excessive absorption at or near the ground level, and therefore reduce the energy instantly reflected from the earth near the installation. In the higher frequencies where the radiators are mounted many wavelengths above the earth, reflection skyward from the earth is greatly reduced since radiation decreases by the square of the distance from a non-directional antenna. This invention therefore, in one embodiment resides in a sharply folded over antenna radiating means, comprising at least two one-quarter wave or 90° antennae, which are fed to utilize the first half of the full energy wave to cause the maximum of the current lobe to be full at the top or extreme high point of the radiating means. The current therefore ascends to maximum as it passes through the substantially sharp pointed top to return to the ground terminating

end, or the unterminated end of the second 90° length while descending in current value towards the current zero mode. The metallic ground portion between the feed end and terminating end is shaped to be non-inductive in so far as possible, namely flat in construction. The current angle of direct radiation from the radiators never effectively radiate but little above the horizon, and a current distribution effect is had that is the equivalent of, or perhaps better than, a flat topped vertical antenna, on which the flat top section would be infinitely large in diameter. This is impossible to effectively obtain at lower operating frequencies, but this can be obtained effectively in the high frequency ranges of the spectrum. This states the basic invention and discovery rather precisely. A simplified version of the invention for less efficiency, provides that a one-quarter wave or 90° antenna section be condensed within a shielding means such as a box at the top of the tower, or placed in a concentric tower, and at least a second one-quarter wave section be exposed and extended downward vertically or at an angle as set forth hereinafter. Two or more downward extended sections may be slanted and positioned to produce directivity, yet concentrate the energy toward the horizon.

The invention is therefore applicable for every application where maximum current is desired at or near the radiator tops or extremity from the point where radiation begins, in the applications of this new method of obtaining horizontally directive radiation. This is a new, and perhaps far reaching discovery, which will reduce tower heights; eleminate the need for tower base insulators, and reduce obstruction tower lighting requirements in some of the frequencies within the standard broadcast band. With proper directivity in the horizontal plane, this type of radiation may allow thousands of radio frequencies to be duplicated for local ground wave communications and broadcast uses, which may also be utilized for long distance intercontinental communication purposes, when the frequencies used for local communication distances are carefully installed with proper safeguards against skyward radiation, according to the present invention.

The invention provides new means for obtaining directional radiation using only one tower support when the slanted or vertical one-quarter wave sections are arranged to provide desired field distortion or directivity of propogation within the limits available. To achieve the ultimate in field pattern directivity two or more phased units are required, some of which may be parasitic radiator units. They may be supported by one tower, even on the low and intermediate frequencies. The invention is adaptable also for frequencies in the VHF and UHF bands, and in some of the lower microwave ranges of the electromagnetic wave spectrum, and may be used in providing directive phased wave energy concentrations of a high order, which greatly reduces weight and bulk, and in this respect, the ways of application are numerous, including high speed mechanical scanning antennae. It is to be understood that in the use of these antennae, the lower portion of the current lobe is preferably shielded from radiation including its use in the standard and medium frequency broadcast bands, therefore this lower portion of the low angle radiated wave is also intended to be kept preferably at a minimum allowing radiation to take place below the maximum current lobe point down to about thirty degrees above the feed or terminating end. In uti-

lizing the invention for microwave radiation escape apertures allow the portions of the wave energy to escape in the plane substantially perpendicular to the direction of wave travel within a microwave generating cavity or from a wave guide through an aperture from substantially the center of the current mode, thus allowing radiation to take place only in the direction desired. The cavity generator-radiator may be suitably elevated.

The objects and purposes of the present invention become clear and understandable to those schooled in the art to which the invention pertains, as the application is read and studied.

A detailed description of the invention follows the preleminary description with reference to the drawings wherein:

FIG. **1** shows the ground wave coverage and optimum angle of skywave radiation according to the prior art, for a one-quarter wave vertical radiator or 90° antenna.

FIG. **2** shows the ground wave coverage and optimum angle of skywave radiation according to the prior art, for a one-half wave vertical radiator or 180° antenna.

FIG. **3** illustrates the ground wave pattern radiated from a one-quarter wave or 90° antenna according to the present invention.

FIG. **4** shows a preferred form of the invention for non-directional transmission, except in the horizontal plane around the system towards the horizon, for the most part.

FIG. **4***b* shows an antenna designed to give a distorted pattern.

FIG. **4C** shows the pattern of the the FIG. **4***b* antenna.

FIG. **4***d* shows an alternative but less efficient embodiment of the antenna.

FIG. **4***e* shows the directivity pattern of the FIG. **4***d* antenna.

FIGS. **4***f* and **4***g* show additional means to increase the directivity of the generic invention.

FIG. **5** shows an alternative form of the invention upon without the top shielding unit.

FIG. **6** shows a representative directive antenna according to the generic invention.

FIG. **7** shows another version of the generic invention.

FIG. **8** shows an alternative means of suppressing the upper or outer current lobe of a directive antenna means according to the generic invention.

FIG. **9** shows an alternative antenna according to the generic invention.

FIG. **9***a* shows novel antenna mounting means.

FIG. **10** shows further adaptation of the generic invention.

The generic aspects of the invention are found in all of the drawings illustrated and described in the specification, namely means for producing radiation from substantially a vertical radiator where the current is maximum at the top of each radiator, or at the outer point of radiation.

In describing my invention in detail, reference is first made to FIG.**1**. Similar parts are identified by the same numerals throughout the specification and drawings. A one-quarter wave or 90° vertical radiator is shown at **10**. The current distribution is shown by the dotted curve indicated by I the term representing current. The ground system is indicated at **11**. For directional use, this ground system may have radiators above and below the earth. For high frequencies, the antenna and established ground is metal, and dimensioned to be capable of being rotated or scanned as desired when the system is used in the VHF and UHF bands. The optimum angle of radiation in FIG. **1** is shown by the arrow line **12**, which represents the resultant angle of all of the directly radiated and ground reflected sykwave energy components. This total number of radiated angled components is almost infinite in number, each taking or being radiated at separate and different angles. The graph showing the radiated characteristics, and the extent of the effective ground wave coverage is shown at **13**, and it is to be assumed that this represents a circle extending 360° around the vertical radiator **10**.

FIG. **2** is identical to FIG. **1** except that radiator **10** is extended to a height of one-half wavelength or 180 electrical degrees in length, with the current distribution shown by the dotted curvature line represented also by I. FIGS. **1** and **2** are presented to show the prior art in the field.

FIG. **3** shows substantially the results obtained by the use of the present generic invention and discovery. It may be assumed that radiator elements **10** and **10***a* in the various drawings may tend to show a slight bit of figure-eight type of directivity, however the radiators are located so close together that this directivity can be discounted in transmission, but would be present in a radio receiver if connected to the antenna. Non-directive transmission along the ground plane was confirmed by proof of performance measurements. The current I curve shows that the current distribution is such as to avoid direct skywave radiation from a slanted, or vertical radiator. The current curve I is the equivalent of FIGS. **27***b*, Page 794 of Terman's Engineering Handbook, (McGraw Hill), if the flat top section was enlarged sufficiently to fold the current over at right angles a full one-quarter wavelength from the top as shown partially by the Terman reference, except that the flat top section would itself direct energy in many directions including skyward.

FIG. **4** shows a preferred embodiment of the invention to provide non-directional transmission in the ground plane. (This embodiment of the invention is claimed in U.S. Pat. No. 3,289,208, and the description is here repeated for descriptive information only). The current may first ascend up the feed radiator **10**, and continues to descend towards the ground in radiator **10***a* from the summit or top of the highest point of radiation supported by tower **10***b*. Both antenna sections **10** and **10***a* may connect directly to the top of tower means **10***b* which may be grounded or ungrounded at **11**, since the tower radiates little if any unless resonated to the frequency of the applied radio frequency energy. The current distribution is indicated by the dotted lines represented by I. Radiators **10** and **10***a* represent a full one-half wave or 180° antenna in length from the feed point **15** through the complex tuned fircuit composed of inductance **16** and tuning condenser **17**, which may be substituted for a full one-half wave dimension in length. The tuning of inductance **16** and condenser **17** were used in the first installation as a convenience of resonant adjustments, and their values were rather small. It is to be appreciated that a portion of the effective height of antenna **10** and **10**a may not be allowed to radiate due to the elements of the complex tuning circuits being shielded, or concentrated in

shielding near the established ground level particularly on the low and medium wave lengths where it is impractical to have a full one-quarter wavelength vertical tower supporting means. The invention therefore provides that the radiation pattern area from radiators **10** and **10***a*, and of FIGS. **4,5,6,7** and **4***f* is substantially vertical, and fully representative of the generic concept of the invention. It is to be also appreciated that the leaning angle of antenna **10** and **10***a* causes the vertical radiated wave energy to be projected horizontally, substantially from the bottom to the top of the antenna. In operation, the energy flows alternately up to the top of **10** and **10***a* during the first 90° of each supplied alternation or 180° of energy, and down the second 90° section to provide omni-directional radiation in the direction of the horizon in 360°. The action is reversed in the system on the next one-half cycle of applied energy. It must be kept in mind, that the downward flow of current through **10** and **10***a* is not a directional change of current through **10** and **10***a* during the full one-half wave current, however the field does reverse, and this field reversal is such as to regeneratively increase the current in the opposite radiator. Since this regenerative effect takes place within the time of 180 electrical degrees of time at the applied frequency, it can be assumed that the radiation field is bulged in the direction of the horizon.

FIG. **4***b* shows the arrangement of at least two angled radiators **10** and **10***a* supported by **10***b* to provide distortion and directivity according to FIG. **4***c*. The low angle radiated energy towards earth **11** from radiators **10** and **10***a* is largely absorbed and re-radiated or reflected at a high angle as explained in the description of FIG. **4**, whereas the radiation to the right of the radiator support in FIG. **4***c* indicates distortion of the radiation towards the horizon to the right of the tower **10***b*.

FIG. **4***d* illustrates another adaptation of the invention wherein the transmitter **10***c* supplies energy by transmission line **10***b* and supporting means, to the concentrated and shielded first one-quarter wavelength of the one-half wave antenna, the second one-quarter wave section indicated at **10***a*. The shield and support **10***b* and **10***d* is preferably connected together and to ground **11**, which is normally the transmitter cabinet. The current curve I which shows the current distribution in the radiating sections is indicated by the dotted line I to the right of radiator **10***a*, and it is to be appreciated that this pattern extends around radiator **10***a* 360°, and the radiated energy to the left of **10***a* is reduced in that it is largely directed towards the earth, resulting in a distorted field pattern as indicated in FIG. **4***c* with the field pattern shown by the dotted line distorted to the right of radiator **10***a*. It is to be understood that the embodiment of the invention shown by FIGS. **4**, **4***d*,**4***f*, **5** and **7** may be distanced apart and fed in such time and phase relationship to produce substantially all field patterns obtainable by distanced apart and phased insulated vertical radiators as used and well known in the prior art, however, all of the prior art installations radiated the usual skywave energy as illustrated in FIGS. **1** and **2.** It is to be understood that more **10***a* radiators may be connected to shield **10** and differently angled downward to vary the directive pattern or to provide non-directional radiation towards the horizon, and in this adaptation of the invention, a substitute is had for an extremely large and costly flat topped tower such that would be completely uneconomical and would not provide the same good quality of anti-skywave features as provided by FIG. **4***d* of the invention. Here then, the present invention comprises all means adaptable for exciting an antenna, and having only the second half or halves of the radiators downward from a point of elevation above the earth to avoid skywave radiation by having the current maximum at the top of each one-quarter wave radiator.

FIG. **4***f* in conjunction with FIG. **4***g* illustrates that the geometrics of the invention can be utilized in a versatile manner to achieve suitable directivity to satisfy many needs and requirements in the field of electromagnetic field transmission, yet only one radio tower is required, and without radiating skywave energy. In FIG. **4**f transmitter **10***c* connects to branched transmission line **19,** which comprises a precision common point feed, to supply electromagnetic wave energy to one-quarter wave radiators **10** and **10***a* to the right of tower **10***b* and exactly the same instant that the energy is fed to one-quarter wave radiators **10***x* and **10***y* on the opposite side of tower **10***b* in equal amounts of power. This has the effect of feeding two spaced apart one-half wave radiators in parallel, therefore the total currents flowing into both radiator sections would be considerably increased because the radiation resistance would be substantially altered, and the field reactions between all radiating elements is increased, therefore the field distortion or directivity is increased substantially as indicated by the estimated pattern of FIG. **4***g* which is derived from FIG. **4***c*, the pattern of a proof of performance made on an installation representative of FIG. **4***b*. It is to be understood that radiator **10** and **10***y* may be commonly connected to equalize the total field reactions. Radiators **10** and **10***a* of FIG. **4***b* were separated 45° for the proof of performance pattern of FIG. **4***c*, therefore to produce the Figure-eight it can be assumed that radiators **10***x* and **10***y* are also separated 45°. By varying the angle of separation of **10** and **10***a*, and **10***x* and **10***y*, it is possible to obtain almost any pattern of directivity desired with one supporting tower by positioning each pair of radiators at different positions relative to each other around the tower. FIGS. **4***d* and **4***f* and all possible geometric variations described or alluded to comprises means to fully accomplish the generic purposes and accomplishments of the invention, namely, that of operating with currents at the maximum heights of a plurality of one-quarter wave radiators to provide concentration of wave energy along the earth toward the horizon without radiating little, if any, skywave energy.

FIG. **5** shows antenna elements **10** and **10***a* to be substantially vertical, and connected across the top of **10***b* supporting means, through a non-radiating shield means **18** which could take other forms such as a balanced five wire line. It is intended that shielding means **18** averages up to 10° of a wavelength in the "AM" broadcast band (535 – 1605 kilocycles), to provide a reasonable separation between **10** and **10***a*. Radiators **10** and **10***a* may be two insulated radio towers built close together with a non-radiating connecting means **18** connecting the tops of the towers so that the dimension of the system invention may be met, but with a light apparent loss due to the non-radiation through connection **18.** The operation of this embodiment of the invention is substantially as described in FIG. **4.** Sections **10** and **10***a* may indeed be leaned in accordance with FIG. **4** if desired so long as the connection

18 across the top is present. In this adaptation of the generic invention, less ground reflected energy towards the sky is accomplished if the lower 30° be shielded from radiation as illustrated.

FIG. 6 shows two elements of a directive antenna system which is excited as heretofore described except that radiators 10 and 10*a* are separated a desired distance apart and connected at the tops by a non-radiating transmission line 18, in such phase and distance of physical separation relationship as to cause radiation to take place in time and inductive relationship to produce directivity as desired utilizing the known methods and techniques that are applicable to produce directivity. In this embodiment of the generic invention two directional factors are present and involved, namely, the fact that each one-quarter wave radiator 10 and 10*a* have maximum current at their tops to avoid radiation skyward, so by the phasing of the radiators by separation governs the amount of energy directed in one or more directions toward the horizon along the ground plane only, without skywave radiation in the direct manner as in the prior art as shown and described in FIGS. 1 and 2.

FIG. 7 shows another generic embodiment of the invention wherein radiator element 10 is fed with current and is shielded beyond the midpoint of the first current lobe's maximum value, as illustrated by the current distribution curve I shown at the right. The current fed from terminal 15 passes up through non-radiating line 18 and along through shielded support means 19 via 10*a* finally reaching complex tuning means 16 and 17, which may or may not be connected to ground. Also the outer circuit 19 may be excited through the tuning circuit means 16 and 17 instead of through terminal 15; not radiate from 10*a* which is shorted (not shown) to 19 at the top of 19. Here unit 19 is tuned by 16*a* and 17*a* to cause the outside circuit to radiate according to the invention namely, that of having the radiating current maximum at the top of the radiator 19. It is a part of the invention, that 19 be all, or a part of a supporting tower; be fed through complex tuning circuits 16 and 17, assuming that 10, 10*b* and 18 are not present in the radiating system, therefore center conductor 10*a* and shield 19 are connected at the top (not shown) and used for a non-directional anti-skywave system having maximum current at the top of shield 19 in accordance with the generically related system invention.

For frequency modulation broadcast transmission and television transmission, and other forms of communication in the VHF and UHF and adjacent frequency bands, the present invention may be more readily adapted according to FIGS. 8,9 and 10, and other possible configurations not shown, where radiator 10 in part comprises the center conductors attached to the transmission line. Shielding lengths 18*a* are spaced to shield the upper half of the one-half wave energy from radiating skyward when positioned vertically as in FIGS. 8 and 9 hereinafter described.

FIG. 8 shows a vertical, (or flat if horizontal) area view of a radiating system and supporting plate and pipe means through which the feed lines pass from slip ring contacts 25 and 26 providing a concentrated radiation that is generic to and in accordance with the present invention, because of concentric shield means 18*a*. The transmission line 24 is formed into a rigid support for the directive array. Radiators 10 are cut to one-half wavelength of the frequency to be used, however non-radiating concentric line shields or studs 23 prevent a great deal of the low angle radiation up to approximately 30° on each radiator from being radiated. The current that is radiated, is between the 30° point up to about the 100° point of each one-half cycle or 180° of energy fed to provide directivity looking down the plane of the array to the right. The remaining approximately 80° of the one-half wave radiators 10 are shielded from radiation by concentric shielding means 18*a*. The two transmission lines 24 connect to radiators 10 from the slip rings 25.Slip Rings 25 and brush connectors 26 are representative of stationary electric feed connections when the antenna pipe supporting means 19 is not to be scanned. Scanning movement of the supporting means 19 may be in any direction desired, as when scanning or searching in radar and navigation purposes. Arrow 27 is indicative of desired scanning capability, both in Azimuth and elevation for directive systems of FIGS. 8,9 and 10. The distance between the radiators 10 and the far end terminating resistance (not shown to right) determines the degree and efficiency of directivity. Supporting means 20 may be rotated 90° to provide horizontal, or vertical polarization. A flat shield plate, not shown, may extend along and outward from pipe 20, 90° from either line or radiators 10, and this shield arrangement may be equally spaced between both horizontal and vertical radiators along an array to facilitate both vertical and horizontal component transmission, and to provide improved multiplexing, and diversity transmission effects with properly oriented receiving antenna means. The current I distribution curve of FIG. 8 indicates that the energy radiated from both sets of doublets or radiators 10, is not seriously off direction along the plane or projection of the radiated waves. The transmission line 24 may be transposed as required to provide phase reversals along the line and to balance out unwanted inductive effects. With the array of radiators positioned in the vertical plane as illustrated, the energy is not radiated skyward but is concentrated toward the horizon. With the array rotated 90° the energy is concentrated into a cheese slice-like wave pattern extended from a position on the horizon upwards into the sky depending on the sharpness of the beam of energy radiated. This provides a beam suitable for radar navigation scanning.

FIG. 9 shows a self supporting radiator 10 which comprises a rod member usually several wavelengths long, that passes up through an outer concentric shielding pipe means 18*b*. As support for this vertical antenna, and other types of small antenna, the bottom of pipe 18*b* is threaded and screwed into fitting 28, which is welded to the antenna mounting means 29, and is made to fit the roof line of a house as well as a flat roof or surface area, when mounting means 29 is made to conform to a flat surface. This mounting means 29 covers a substantial area of the roof, and is fastened securely through the roof structure 30 by large bolts or wood screws 31 and 32. Lock nut 33 locks the threaded fitting 28 making it water proof. Transmission line 34 connects to 10 and to a radio receiver or transmitter in the building or mobile craft. This type of mounting is intended for use in place of "the strapped to the chimney" method of mounting and supporting television antennae, commercial communication antennae and citizen band communication systems. Antenna mounting means 19 may be made as a hinge means to fit the straight line of any roof as shown in FIG. 9*a*, or of a flat

roof, or of any elevated mounting area. It may be a plate formed to fit each rooftop or area on which it is to be mounted. In FIG. 9*a* pipe **28** is welded around an opening to pass transmission line **34** through or around a ball-like fitting or clamping means **35** and into pipe means **18***b*. Locking nut and bolt means **36** extending through the clamping means **35,** locks and holds **18***b* in a vertical position as adjusted. Before locking however, **18***b* is adjusted to provide the correct orientation of the antenna for best directive transmission or reception. If a motorized rotor mechanism is to be used the base of **18***b* is secured, and the motor gear control unit is mounted above the roof or mounting elevation in series with supporting pipe means **18***b*. Hinge fastening means **37** is strong; is made of the lightest metal having good strength, and where maximum strength is required, the hinge or plate means is made of strong durable dipped steel plating. The roof installation is water proofed in the usual manner with suitable sealing compounds when necessary. The plate supporting means may be other than a solid plate or hinge means. It may be a squared-up steel frams means with a relatively small area along the roof line, but fastened to cover a rather wide area of the roof so that hook means **38** can be attached to receive hooks on a serviceman's ladder, and to attach guy wires to give further support to **18**b when higher than usual antenna elevations are required. Here the guy wires are fastened to the metal plate or frame and are not connected to a number of places on the roof as in the case of normally guyed installations which causes roof damage. On the larger installations on building tops, this is a major factor, and the mounting means made and constructed, and installed according to the present invention precludes such roof damage, and eliminates the possibility of falling parts.

In describing the antenna of FIG. **9,** shields **18**a are substantially one-quarter wavelength long. If lower portion of the current I from zero to 30° is not to be radiated, then shields **18***a* may be slightly longer than one-quarter wavelength, which reduces the one-quarter wave area for radiation from sections **10** at the bottom of each 90° radiating section, however the one-half wave dimension indicated to the right in the drawing remains the same. In the prior art, shields **18**a have been variously used for matching uses (impedance matching), or to allow the escape of a full one-half wave or radiation, however applicant has never been able to find a record of where these adjustments have been made to shield the radiation in a manner to effectively eliminate the upper half portion of each one-half wave of radiation, and when vertically erected avoid radiation directly towards the sky. In the prior art it apparently has been assumed that the upper portion of the radiating element, that is, the upper portion of each one-half wavelength are required to radiate for full efficiency. Specific directivity within the 360° of horizon, when desired, is provided by reflector means **18***d* which is attached to pipe **18***b*. This reflector **18***d* may be scanned around the antenna to produce a rotating beam as in radar and navigation systems. For this use, shields **18***a* may be removed to allow the usual skywave radiation to take place. Presently known and used high gain multiple wave stacked antenna all radiate strong skywave energy angled well above the horizon as indicated by serious intermittent interference in the VHF and UHF frequency bands. The generic ambodiment of FIG. **9** reduces skywave transmission to a minimum.

In FIG. **10** the two wire transmission line **24** connects with radiators **10** and **10***a* which have the slant angle effect of FIG. **4.** The current distribution for each radiating unit in the array, is indicated by the upper and lower cirrent I curves. Stub shields, or short concentric outer conductors **23** are projected from pipe **20** and prevent radiation in the lower portion of the total one-half wave area comprised of approximately the first 30° and the last 30° of radiators **10** and **10***a*, leaving the remaining 120° of the total 180° of energy to radiate almost wholly in the plane parallel to the pipe surface **20.** When transmission line **24** is strong and rigid and capable of self support, it may be scanned for the uses heretofore set forth in the description of FIG. **8.** When the antennae described herein are used for shipboard use, they may be stabilized in known ways.

The present invention can be used to improve television, high speed facsimile, computer signalling and tele-printer transmission, to reduce short time echoes to the elements of received signals. This type of short time echo interference is disasterous to color television reception in cities such as New York and other large cities where short time signal delays due to reflections from buildings and airplanes, particularly when the color signals are transmitted and received according to NTSC standards using the shadow masked tubes with three beams. Where the single beam color transmission and reception is used, utilizing the raster grid control means in the reproducing tubes, the condition is greatly improved in that some delayed signal elements are locked out from being reproduced. The fact that very serious reflections occur from airplanes several thousand feet in the sky speaks loudly for the need for more concentration of transmitted energy in the horizontal plane parallel to the earth's surface, discounting the earth's curvature up to 20–30 miles from the point of transmission.

There is also great need for increased directivity in high gain communication and radar antennae on the lower radar frequencies, without excessive bulkiness, weight and wind resistance. The present invention meets these requirements at least in part.

It is impossible to prevent all radiated energy from being reflected back from the ionosphere and/or the troposphere, however when the electromagnetic waves travel as substantially surface waves leaving the transmitting antenna, the great distance they must travel to and from the point of reflection, determines to a large degree the strength the signals are received back on earth far removed from the point of transmission, consequently they are weak or undetectable, except for sporadic bursts of multi-reflections which by chance concentrate simultaneously on the far distant receiving antenna.

The various illustrated versions within this application point to the single generic aspect of the invention, namely, antenna radiating means connected, arranged and utilized to avoid high angle radiation above the horizon from the point of transmission, and converged into less than 360° around the point of transmission.

I claim:

1. In the field of electromagnetic wave radiation, a wave antenna having a physical length of substantially one-half wavelength at the resonant operating frequency and connectable to a source of electromagnetic wave energy to be radiated into space, said antenna extending upwardly at an angle from the vertical to a sup-

porting means with respect to the existing ground one-quarter wavelength, then extended downwardly one-quarter wavelength, said two one-quarter wavelength sections separated at ground level less than **180**-degrees of a circle with the supporting means within the circle to increase the field strength of the electromagnetic wave transmission within the area encompassed by the said less than **180**-degrees, each of said one-quarter wavelength section of said antenna having maximum current at their tops to avoid radiating energy except in the vicinity of the horizon.

2. An antenna according to claim **1**, wherein the radiation is the product of phased energies from two or more pairs of radiators to produce wave propogation along the ground plane and concentrated at least in one direction and substantially at the horizon area.

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