Nov. 29, 1966 R. L. HOLLINGSWORTH 3,289,208

ANTI-SKY WAVE RADIATING SYSTEM

Filed Feb. 12, 1962 2 Sheets-Sheet 1

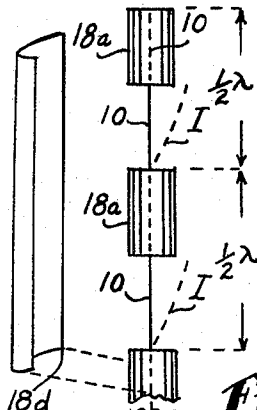

FIG. 9

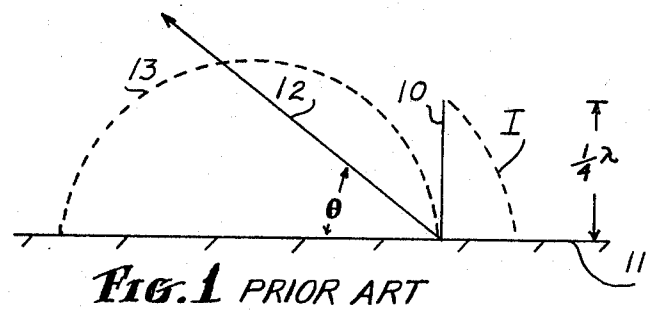

FIG. 1 PRIOR ART

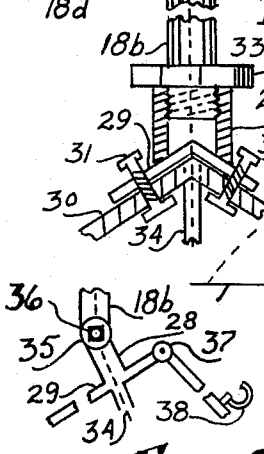

FIG. 9a

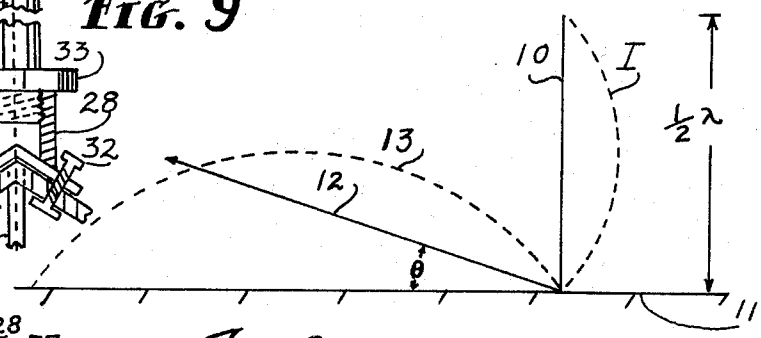

FIG. 2 PRIOR ART

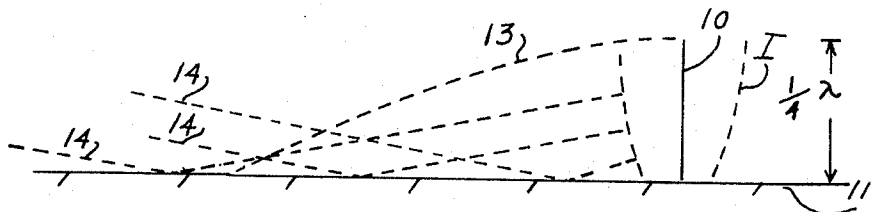

FIG. 3

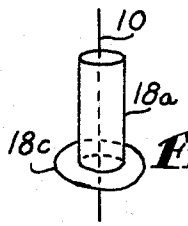

FIG. 9b

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ANTI-SKY WAVE RADIATING SYSTEM

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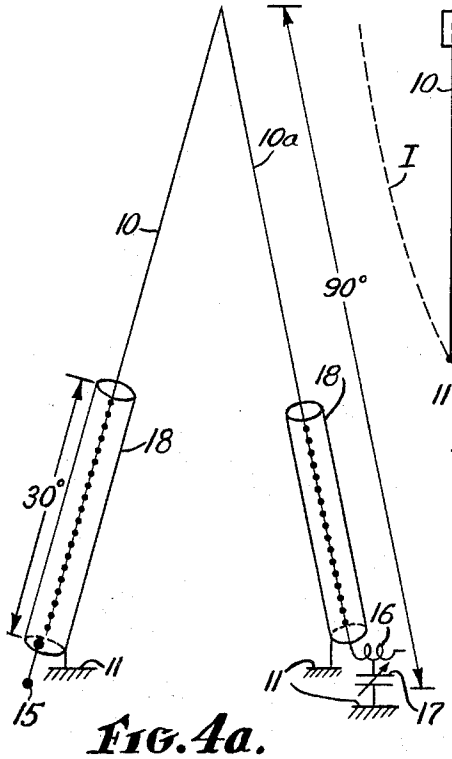

FIG. 4a.

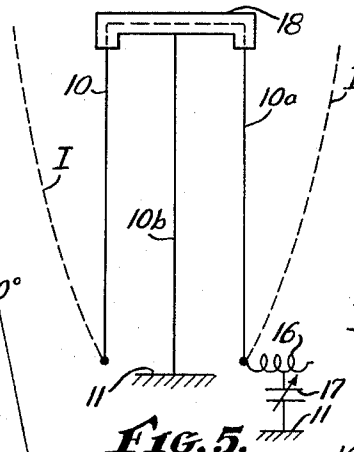

FIG. 5.

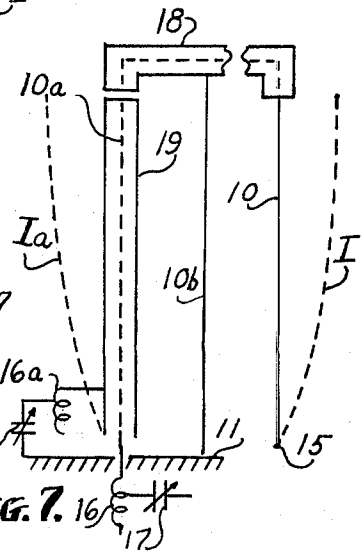

FIG. 7.

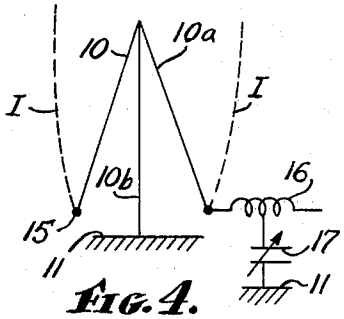

FIG. 4.

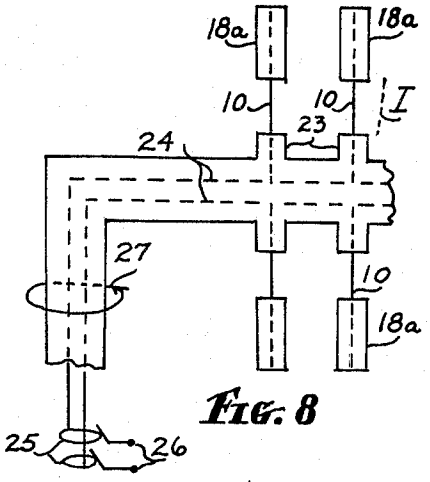

FIG. 8

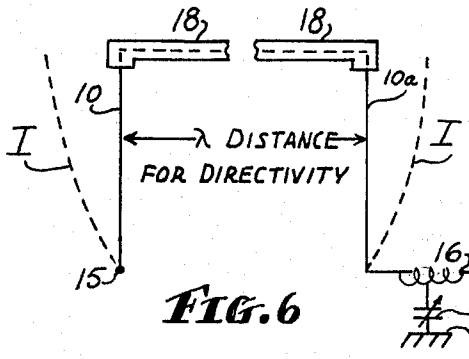

FIG. 6

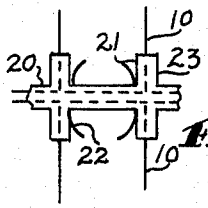

FIG8a

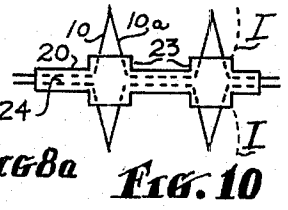

FIG. 10

R. Lee Hollingsworth INVENTOR.

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3,289,208

ANTI-SKY WAVE RADIATING SYSTEM

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Filed Feb. 12, 1962, Ser. No. 172,581
4 Claims. (Cl. 343—752)

The present invention relates to radio antennae which radiate a minimum amount of sky wave energy, that is, wave energy that radiates at angles above the horizon which are capable of being reflected from the ionospheric layers above the earth, and which are again received on the earth's surface remote from the point of transmission. The present invention provides means to concentrate along the earth's surface, most of the radiated energy from a vertical type antenna, and including the radiator types used in the standard radio broadcast band of frequencies from 535 to 1605 kilocycles. Such radiators may be separated and phased in the usual manner to achieve field pattern directivity yet radiate according to the invention.

The desired result may be achieved by connecting one vertical one-quarter wave or 90-degree antenna at its top, to another close by vertical one-quarter wave or 90-degree antenna extending downward substantially to ground level, both antennae being tuned at the feed end and at the ground terminating end to provide substantially equal high voltages at the feed end and at the ground terminating end, with a half wave or 180-degree current distribution from the feed end up one-quarter wave unit and down the next to the ground terminating end comprising a radiating loop circuit. Both the feed and/or the downward extending section may be shielded by a concentric transmission line near the earth to prevent radiation from approximately 30 degrees of the length of the radiators immediately above established ground level.

The invention then resides, in a sharply folded over antennae radiating means, comprising two quarter wave or 90-degree antennae, which are fed to utilize the first half of the half wave fed energy to cause the maximum current lobe to be at the top or extreme high point of the vertical radiator. The current therefore ascends to maximum as it passes through the sharp pointed top to return to the ground terminating end while descending in current value towards zero. The ground portion between the feed and terminating end is shaped to be non-inductive. Therefore the current angle of direct radiation from the radiators never effectively radiates above the horizon, and a current distribution effect is had that is the equivalent of, or perehaps better than, a flat topped vertical antenna, on which the flat top section would be infinitely large in size. This states the basic discovery precisely. This is a new, and perhaps far reaching discovery, which will reduce tower heights; eleminate the need for tower base insulators, and reduce or eleminate tower lighting requirements on 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 communication and broadcast uses, which may also be utilized for long distance inter-continental communication purposes, when the frequencies used for local communication ranges are carefully installed with proper safeguards against skywave radiation according to the present invention.

This invention is adaptable also for frequencies in the VHF, UHF and microwave ranges of the electromagnetic wave spectrum, and may be used in providing directive phased wave energy concentrations of a high order, with greatly reduced weight and bulk, and in this respect, the ways of application are numerous, including high speed mechanical scanning antenna. It is to be understood, that

in the use of these antennae, the lower portion of the current lobe is preferably shielded including its use in the standard and medium frequency broadcast bands, or they may be tuned in a manner to reduce the radiation towards the earth, therefore this lower portion of the low angle radiated wave is also intended to be kept at a minimum. Utilizing the invention for microwave radiation, escape apertures or windows allow the portions of the wave energy to escape in the plane perpendicular to the direction of wave travel within the microwave conducting means or wave guide. Furthermore, for high frequencies, using radiators, each of the radiators may be leaned to a center point to join at the tops of the radiators, providing another means to direct the wave energy towards but not appreciably above the horizon. In practice, the antenna ran true vertical for a short distance before leaning approximately fifteen degrees as it extended to the top of a supporting means.

One object of the present invention is to reduce skywave radiation from a vertical antenna, and to concentrate the radiated energy along the earth's surface into the horizon area.

Another object of the invention is to provide maximum current at the top of an antenna with the current value substantially constant in value from the point where radiation begins to the point of termination.

Another object of the invention is to provide a directive antenna means in which the skywave radiation components are substantially eliminated.

Still another purpose of the invention is to provide a VHF and UHF antenna that is highly directive, having a weight and bulk such as to allow the antenna to be physically scanned at high speed such as in radar, navigation, and limited distance communication which utilizes defined impulse passive bandwidths as set forth in my pending patent application Serial No. 680,884 filed August 28, 1957, entiled, Radio Navigation Aids, now abandoned.

Still another purpose of the invention is to provide antenna means to reduce skywave interference between domestic radio stations within a country, and between nations, and prevent the presently established stations operating on the same or adjacent frequencies from interfering with each other by skywave transmission routes.

The preliminary description of the present invention follows, and reference is made to the drawings wherein,

FIGURE 1 shows the current distribution; the optimum angle of skywave radiation, and the relative ground wave transmission distance of a one-quarter wave or 90-degree vertical radiator of common usage.

FIGURE 2 shows the same elements of FIGURE 1 but for a one-half wave vertical 180-degree radiator of common usage.

FIGURE 3 illustrates the ground wave pattern of a radiator according to the present invention showing the directly radiated skywave to have been eliminated, and also shows the remaining wave energy as being reflected skyward from the area of the radiator nearer to the ground.

FIGURE 4 shows a preferred form of the invention, particularly for medium low frequency transmission. In practice, the sloping angle of the radiators is smaller than indicated.

FIGURE 4*a* shows the antenna of FIGURE 4 to be self-supporting and shielded from radiation during the first and last 30 degrees of the total 180 degrees.

FIGURE 5 shows an alternative form of the invention of FIG. 4.

FIGURE 6 shows a representative directive antenna according to the present invention.

FIGURE 7 shows a representative directive antenna utilizing a parasitic or excited radiating element and other features.

FIGURE 8 shows an alternative means of suppressing the upper current lobes of a directive series of radiators, and capable of scansion movement.

FIGURE 8*a* shows an improved shield means for FIGURE 8.

FIGURE 9 shows an alternative antenna arrangement according to the invention.

FIGURE 9*a* shows novel antenna mounting means.

FIGURE 9*b* shows a modification for a part of FIGURE 9.

FIGURE 10 shows further adaptation of the principle of the invention to include a directive radiating means.

In describing my invention in detail, reference is first made to FIGURE 1, wherein similar parts are identified by the same numerals throughout the specification. A one-quarter wave or 90-degree vertical radiator is shown at **10**. The current distribution is shown by the dotted curve indicated by I. The ground system of usual characteristics is indicated at **11**. For directional use, this ground or common point base may have radiators above and below the established ground plane, which is metal and capable of being rotated or scanned as desired. The optimum angle of radiation is shown by the arrow line **12**, which represents the resultant angle of all of the direct and ground reflected sky wave energy components. The graph showing the radiation characteristics or 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 degrees around the vertical radiator **10**.

FIGURE 2 is identical to FIGURE 1, except that radiator **10** is extended to a height of one-half wavelength or 180 degrees, with the current distribution shown by the dotted curvature line represented by I. FIGURES 1 and 2 are presented to show the prior art. These representations are found in many text books on radio wave propagation, and applicant begs to refer to page 792 of Radio Engineer's Handbook by Terman. Pages 793, 794, 795 and 796 are of particular interest relative to this invention and this patent application. Figures 27b of page 794 and Figure 28 of page 795 are also of interest in that they indicate the need for the accomplishment according to the present invention namely, the providing of means to give the effects of an infinitely large flat top section on a vertical antenna.

FIGURE 3 shows substantially the expected results obtained from the antennae of FIGURES 4, 5 and 6, it being assumed that radiator elements **10** and **10***a* may tend to show a slight bit of figure-eight type of directivity, however the radiators are located so close together that this degree of directivity can be discounted. The current I curve shows that the current distribution is such as to avoid direct skywave radiation. The leaning angle is so small in FIGURE 4 that any skywave along the plane perpendicular to the leaning plane, can be ignored. The resultant radiation skyward is the sum total of the ground reflected signal emanating from the radiator at a low current value as indicated by reflected paths of energy shown at **14**. The current curve is the equivalent of Figure 27b, page 794, of Terman's Engineering Handbook, if the flat top section was enlarged sufficiently to fold the current over a full one-quarter wave from the top, as shown partially eliminated by the Terman reference. The lower 30-degrees of each radiator may be shielded by a concentric line's outer connection as shown in FIGURE 4*a*.

FIGURE 4 shows a preferred way of accomplishing the purpose of the invention for a non-directional antenna system. The current ascending up the fed radiator **10** connects to the descending current radiator **10***a* at the summit or top of the supporting radiator **10***b*. Both antenna sections **10** and **10***a* may connect directly to the top of tower supporting means **10***b* which may be grounded or ungrounded at **11**. The current distribution is indicated by the dotted lines represented by I, assuming that approximately the lower 30 degrees of the 90-degree radiators are concentrically shielded as shown in FIGURE 4*a* or contained in the complex tuning circuit **16** and **17**. Radiators **10** and **10***a* represent a full half wave antenna in length from the feed point **15** through the complex tuned circuit composed of inductance **16** and tuning condenser **17**. It is to be appreciated that a portion of the effective height or length of antenna **10** and **10***a* may not be allowed to radiate due to the elements of the complex tuning circuit being shielded, and/or by concentric shielding near the ground. This causes the radiating pattern area of the radiators **10** and **10***a*, represented by current curve I, of FIGURES 4, 5, 6 and 7 to be substantially vertical. It is to be also appreciated that the leaning angle of antennae **10** and **10***a* of FIGURE 4, causes the vertical radiated wave fronts to be projected horizontally, substantially from the bottom to the top of the antenna, however, better efficiency is had if the current reaches maximum early and remains at maximum from approximately 30 degrees of the total 90 degrees of each radiator above ground at the feed and terminating points to avoid low angle radiation and to avoid high absorption if there be excessive absorption structures in the immediate vicinity of the antennae. In operation, as one-half cycle of energy begins to flow up antenna **10**, a current is induced in the tower **10***b* and antenna **10***a* that is flowing downward producing radiated fields which complement the first radiated energy from radiator **10**, and acts as an added source of energy applied in the antenna loop circuit flowing in the same direction within the said loop circuit. The loop circuit comprises the feed source that normally has one side of the feed circuit (not shown) grounded; the other side of the feed circuit connected to and through antenna **10**, **10***a* and tower **10***b*, to common ground **11**. Also, when the current begins to flow up radiator **10**, there suddenly becomes a multiplicity of induced counter electromotive forces which tend to oppose mutually induced currents in adjacent elements where the current is flowing in the same direction as between **10***a* and **10***b* having been induced by the energy flowing in radiator **10**, however, their energy re-induced back into radiator **10** is in a complementary direction to the direction of the original applied current flow. Antenna **10** and **10***a* being slanted towards each other, the radiated energy from each is partially absorbed and re-radiated in the horizontal plane. The energy reflected from the ground to the right of radiator **10** and to the left of radiator **10***a*, is reflected from the ground at such a high angle that it apparently returns to earth if reflected by the ionosphere and is scattered to points well within the ground wave effective area coverage of the transmission, that is, these elements of ground reflected energies bounce from the earth substantially straight up from the earth. Such vertical radiation from the earth however is believed to be mostly absorbed in the earth since the energy at such close range to the antenna is heavily inductive in nature. Furthermore, wave energy radiated at an angle substantially perpendicular to the ionosphere usually penetrates the layers and never returns to earth. During the second half of the cycle, when the direction of the feed current back to the earth is reversed, current flows up through both the tower **10***b*, if grounded, and through radiator **10***a*, the fields of which conflict to a degree with each other, but both induce complementary energy into radiator **10**. In practice, this conflict between the currents in **10***a* and **10***b* was not noticeable, **10***b* being non-resonant. Tower **10***b*, if insulated from **10** and **10***a*, would radiate only a small amount from induced energy **10** and **10***a*. It is to be understood that harmonic trap circuits may be connected in series, or in parallel to each radiator at any point along the radiator, or in a box (not shown) at the top of FIGURE 4, and at the entrance to concentric lines of FIGURES 5, 6, 7, 8, 9 and 10 since the sharp and distinct reversal of the current generates strong second harmonic energy. The antennae of FIGURES 4, 5, 6, 7, 8, 9 and 10 may be

dimensioned to operate at above and below the fundamental frequency when desired.

FIGURE 4*a* shows radiators **10** and **10***a* to be self supporting and concentrically shielded by shield **18** through the first and last 30 degrees of radiation area leaving a total of 120 degrees as the total length for radiating energy into space.

FIGURE 5 shows antenna elements **10** and **10***a* to be substantially vertical, and connected across the top of **10***b* through a concentric line section **18** that does not purposefully radiate. The horizontal connection **18** of FIGURE 5 facilitates the uniform inductive relationship between **10**, **10***a* and **10***b*. It is to be appreciated that **10** and **10***a* may be two insulated radio towers built as close together as possible, and having a connection between the tops such as a concentric line, or a nonradiation 5-wire line type, where four of the wires form a balanced non-radiating shield for the center connection which carries the current.

In operation of FIGURE 5, the current flows up radiator **10**, and induces complementary wave energy into **10***a* and **10***b* and passes through concentric connection **18** which is supported by **10***b*, and continues through **10***a*, through the remainder of the loop circuit as heretofore set forth. The action of the radiation according to FIGURE 5 is substantially that of FIGURE 4, except that the leaning effects are not present in the radiation from the antennae of FIGURE 5. It is intended however, that radiators **10** and **10***a* may be angled as in FIGURE 4, and the separated distance at the top as they pass through concentric line **18** reduces the inductive skyward radiation effects near the top of the radiators.

FIGURE 6 shows a two element 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 a phase relationship, that one-half of a half wave of current value radiates from antenna **10** before entering the non-radiating transmission line **18**, which is dimensioned to exactly connect to radiator **10***a* as the last half of a half-wave of current flows in descending fashion down radiator **10***a*. The separation of **10** and **10***a* determines the phase relationship that produces the desired directivity by radiating substantially all of the wave energy in the desired direction, however the energy is directed along the surface of the earth or horizontal plane. It is to be understood, that it is impossible to prevent all radiated energy from being reflected from the ionosphere and/or the troposphere, however, when they travel as substantially surface waves, the great distance at which they travel to and from the point of reflection, determines to a large degree, the strength at which the signals are received back on the earth far removed from the point of transmission. Therefore, transmissions that do not exceed a certain limited power, such as class IV 250-watt transmissions in the standard broadcast band, may have their night time interference range of transmission greatly extended to substantially their ground wave range due to lack of interference from other class IV stations by the reduction of skywave radiation resulting from the use of the present invention by all class IV stations. The 50,000 watt standard broadcast stations may avoid the radiation of an effective skywave, when desired or required, and confine their radiation to substantially the ground plane area both day and night. This would provide many additional daytime and night time stations, particularly directive stations, to also use the frequencies of the high power stations set aside for this use. Furthermore regional class III stations may have their interference problems solved by the use of antenna means according to the present invention.

FIGURE 7 shows another embodiment of the invention wherein antenna **10** is fed with current and is shielded beyond the mid-point of the first current lobe's maximum value, as illustrated by the current distribution curve I. The current passes through non-radiating line **18**, which may be joined to non-radiating outer coaxial line **19**, and pass down through the complex tuning circuit **16** and **17** completing the loop circuit through ground **11**. This outer conductor of line **19**, when separated from **18**, will radiate when grounded, and this unit may be connected through complex circuit **16***a* and **17***a* to be accurately tuned as a closely associated parasitic one-quarter wave radiator, to produce a degree of directivity depending on the length of the separation from **10**. It is to be understood, that **19** may be all, or a part of, a supporting tower; be fed through complex tuning circuit **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 used for a non-directional radiating system, yet having maximum current at the top of shield **19**, in accordance with the present invention. If the impedance value of the antenna system is desired to be lowered, in FIGURES 4, 5 and 7, radiators **10** and **10***a* may have their number increased and be fed through radiator **10**, or fed commonly through other elements of the group. The added radiators may be equi-distantly or irregularly spaced around a circle area to equalize to a degree the field when absorption prevails in one or more close by sections of the antenna. Radiator **10***a* may comprise two balanced conductors supplied with one-half wave energy at their bottom near the ground, and connected at the top to at least one, and preferably two or more one-quarter wave radiators that extend downward substantially to the established end near the earth, each of which may terminate in a matching impedance at the established ground potential. This arrangement provides a shielded one-quarter wave feed to the top of the tower so that the radiating current is maximum at the top and decreases sinuously to the earth, thus placing the highly inductive field as far as possible above ground and usually above close by wave energy absorbing structures, without any direct radiation above the horizon. One of the downwardly extended quarter wave length radiators may be the supporting section **19**, which may also comprise a hollow tower, or a part of a cross sectional self supporting tower.

For frequency modulation broadcast transmission and television transmission in the VHF and UHF frequency bands, the present invention may be adapted according to FIGURES 8, 9 and 10, and other possible configurations not shown, where the radiator **10** comprises the center conductor or conductors attached to the transmission line. The shielding lengths **18***a* are spaced to shield the upper half of the one-half wave current lobes from radiating. The placement of shields **18***a* to cut off the current from radiating, utilizing the lower half of the current lobe for radiation, maintains the condition according to the present invention of providing the equivalent of a simulated infinitely large flat top section atop of the antennae.

FIGURE 8 shows a radiating vertical plan area view of a system which also provides a wave concentration plane generic to and in accordance with the present invention, which is formed into a rigid support for the directive array comprising a system of directive transmission. Reflecting parabolic shapes **21** and **22** of FIGURE 8*a*, are positioned to trap, contain and dissipate low angle radiation from each of the radiators **10**. Although not shown, these reflectors may also be fitted around each stub **23** to re-direct low angle radiation skyward directly, or indirectly from the earth at a steep angle that would never return to earth. Radiators **10** are cut to near one-half wave length of the frequency to be used, however non-radiating concentric line shields or stubs **23** prevent a great deal of the low angle radiation up to 30-degree point from being radiated. Stubs **23** may be flared as desired. The current that is radiated, is between the 30-degree point up to about the 100-degree point of each one-half cycle of energy. The remaining 80 degrees of the radiators **10** are shielded from radiation by concentric shields **18***a*. The two transmission lines **24** connect to radiators **10** from the slip rings **25**. Slip

rings 25 and connection 26 are representative of stationary electric feed connections when the antenna supporting means 20 is not scanned. The movement of the supporting means 20 may be in any direction desired when used for scanning or searching as in radar and navigation transmissions. Arrow 27 is indicative of desired scansion capability, both in azimuth and elevation for the directive antenna system of FIGURE 8. The distance between the radiators 10 determines the degree and efficiency of directivity. Supporting means 20 may be rotated 90 degrees to provide horizontal or vertical polarization. A flat shielding plate, not shown, may extend along and outward from pipe 20, 90 degrees from radiators 10 in rotation. There may also be added radiators 90 degrees apart, as example, around pipe 20 to give simultaneous horizontal and vertical polarization and shielded from each other by the above said flat shielding plate. With such accurate polarization separate intelligence transmission may take place simultaneously on the same frequency without mutual interference between the two polarized transmissions. Diversity transmission of the same intelligence via the horizontal and vertical modes is achieved with excellent results. The current distribution curves of FIGURE 8 indicate that the energy radiated from both sets of doublets or radiators 10, is substantially at right angles to the radiators 10, and very little skywave or off-direction transmission may be expected. Circular parabolic-like disks 21 and 22 fit around supporting pipe means 20 as shown in FIG. 8*a*, traps escaping low angle radiation. The transmission line 24 may be transposed as required to provide phase reversals along the line and to balance out unwanted inductive effects.

FIGURE 9 shows a self-supporting radiator 10 which comprises a rod member, that passes up through an outer concentric shielding pipe 18*b*. The bottom of pipe 18*b* is threaded and screwed into fitting 28, which is welded to antenna mounting means 29, which is made to fit the roof line of a house and a flat roof, 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 31 and 32. Lock nut 33 locks and waterproofs the threaded fitting 28. Transmission line 34 connects to 10 and to a receiver and/or transmitter in the building. This type of mounting is intended for use instead of the "strapped to the chimney" method of mounting and supporting television antennae, commercial communication antennae and citizen band communication antennae. This antenna mounting means 29 may be made of a hinge means to fit the straight line peak of any roof as shown in FIGURE 9*a*, or that of a flat roof, or of any elevated mounting area. A pipe 28 welded around an opening to pass transmission line 34 through a ball-like clamping means 35 and into 18*b* is fitted into clamping means 35. Locking nut and bolt 36 extending through the ball like clamping means 35, locks and holds 18*b* vertical or as adjusted. Before locking however, 18*b* is adjusted to allow the correct orientation of an antenna mounted thereon. Hinge fastening means 37 is strong, tight, and is waterproofed by usual treatment. A hook means 38 allows a ladder to be attached to hinge means 37. Further describing the antenna of FIGURE 9, shields 18*a* are substantially one-quarter wavelength long. If the lower portion of the current I from zero to 30 degrees is not to be radiated, then the shields 18*a* may be slightly longer than one-quarter wavelength, which reduces the one-quarater wave area for radiation from section 10 at the bottom by the same amount. In the prior art, shields 18*a* have been variously adjusted for matching reasons, and applicant has never been able to find a record of where these adjustments have been made to shield and conduct the current in a manner to effectively eliminate the upper portion of the descending current lobe in the 90 to 180-degree area of the radiator to eliminate directly radiated energy above the horizon

from a vertical position. The prior art does not appear to show an antenna where the upper portion is shielded from radiation, it apparently having been assumed that the upper portion of the radiator must be exposed. Directivity when desired is provided by reflector 18*d* which is attached to pipe 18*b*.

FIGURE 9*b* shows a bottom hat brim-like shield 18*c* which has the effect of sharply confining the radiation as the current begins to flow through the shield 18*c*. Although not shown, the same type of shield may be used at the tops of each shield 18*a* to direct the energy specifically at right angles to radiator 10.

In FIGURE 10, transmission line 24 connects with radiators 10 and 10*a* which have the slant angle effect of FIGURE 4. The current distribution is indicated by I. Stub shields or short concentric outer conductors 23 are projected from pipe 20, and shield from radiation the lower portion of the total one-half wave energy comprised of approximately the first and last 30 degrees, leaving the remaining 120 degrees to radiate almost wholly in the plane parallel to the pipe surface. When transmission line 24 is strong and rigid and capable of self support, and the line 24 is transposed for proper balancing, shielding pipe 20 may not be a requirement for certain uses, including scansion movement of the antenna. When this antenna is used for shipboard, it may be stabilized in known ways.

In utilizing the present invention for high frequency use, slightly better efficiency is had by adding current area to allow radiation to take place slightly above the horizon and reducing the low angle of radiation up to say 40 degrees to exclude the lower angle of radiation, which is reflected from the ground, and adds interference to a television signal in the form of short echoes to each picture modulation element due to the late arrival of the ground reflected signals. This is not as serious as off-side reflections, or buildings, water towers, etc. reflections from airplanes, but in some instances it disturbs clarity of a picture. The fact that serious reflections from airplanes several thousand feet in the air between the television transmitting station and receiving antennae, speaks loudly for the need for more concentration of transmitted energy in the horizontal plane parallel with the earth's surface, discounting the earth curvature up to 20–30 miles from the television transmitter when the antenna is sufficiently elevated above the earth.

It is to be appreciated that hat brim-type shields 18*c* of FIGURE 9*b* may extend as far as desired to further concentrate the energy in a plane perpendicular to the radiators.

There is also a 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 as described in FIGURES 8, 9 and 10 meets these requirements at least in part.

While I have described the invention in considerable detail, it includes means for phasing antennae dimensioned and partly shielded to provide directivity, however when the antennae according to the invention are placed in reflectors for further concentration, more defined patterns are provided without bulkiness. The antenna of FIGURE 9, as heretofore explained with the reflector 18*d*, provides directivity to concentrate the energy forward, cutting the radiation to substantially zero to the back area, but keeping the energy broadly projected at slightly above the horizon. When concentration of wave energy according to the present inpention, when a reflector is added, the efficiencies of the directivity factors of the two means are additive for greater wave concentration, with less weight and bulkiness. FIGURES 8, 8*a* and 10 may have a formed reflector rearward to provide increased power in the beam and to produce the addition of the directive features as stated above.

The principles of the present invention as set forth herein, are applicable to exciting and transmitting energy through wave guides, where the excitation is accomplished by an angled shielded probe radiator according to one radiator of FIGURE 8, and by a dimensioned aperture from a dimensioned wave generating cavity means, wherein energy wave fronts enter the said waveguide substantially at right angles and travel along the guide at different modes with less attenuation, than when excited by means of the prior art.

This discovery is compatible for both transmission and reception to utilize the full benefits involved. It is intended that all known techniques of obtaining desired directivity, and of utilization of the horizontal and vertical components of the radiated wave energy according to the present invention to provide improved transmission and reception, are anticipated.

I claim:

1. A radio wave transmitting antenna comprising an input terminal at substantially earth level and connectable to radio wave energy to be radiated, a radiator having a slope in degrees from true vertical and substantially one-quarter wavelength long connected from said terminal to the top of a vertical supporting means, at least one second radiator one-quarter wavelength long connected to the first said one-quarter wave radiator and sloped downward and equally angled opposite of the first said radiator and connected to a complex tuning means, said antenna comprising one-half wavelength from the input terminal through first and second said radiators and through said complex tuning means, the current fed to said antenna being zero at said input and rising sinusoidally to maximum at the top of said radiators, said current descending with radiation field reversal sinusoidally through the said second radiator and the said complex tuning means through zero.

2. The invention according to claim 1, wherein shielding means are provided to prevent radiation from near the bottoms and low current sections of the antenna.

3. The invention according to claim 1, wherein the antenna is dimensioned, tuned and shielded to radiate substantially between 30-electrical degrees and 150-electrical degrees during each 180-electrical degrees of applied electric energy.

4. The invention according to claim 1, wherein the two slanted radiators have a maximum physical length of 180-electrical degrees to provide maximum unshielded radiation current at the fundamental operating frequency of energy to be radiated.

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