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H. A. WHEELER

2,432,057

WAVE-SIGNAL ANTENNA

Filed June 23, 1944

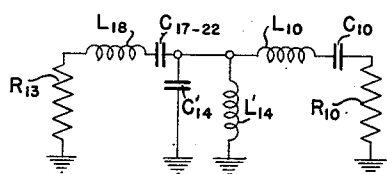
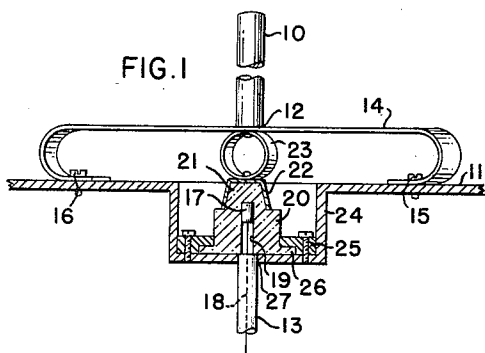


FIG. 3

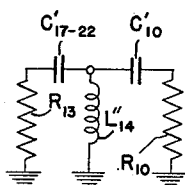


FIG. 4

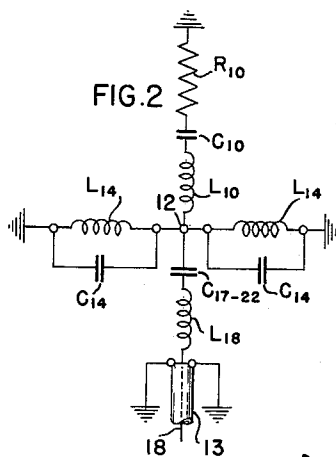


FIG. 2

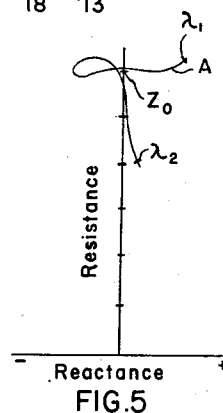


FIG. 5

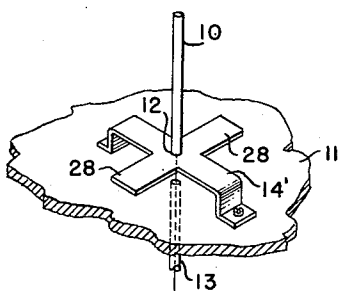


FIG. 6

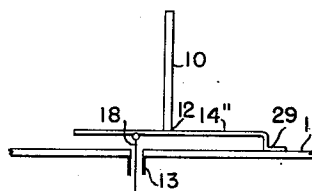


FIG. 7

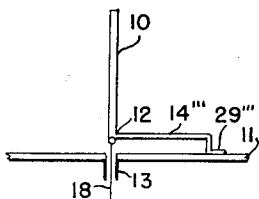


FIG. 8

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2,432,057

WAVE-SIGNAL ANTENNA

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12 Claims. (Cl. 250—33)

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The present invention relates to wave-signal antennas and, particularly, to such antennas either of the shunt-fed or series-fed quarter-wave type.

Wave-signal antennas having an effective electrical length of an odd number of quarter-wave lengths, usually one quarter-wave length, are conventionally coupled to a wave-signal translating apparatus through a feed transmission line which itself is coupled to the antenna by either a so-called series-feed or shunt-feed arrangement.

In the series-feed type of coupling, the antenna is usually supported with its base mounted on an insulator and thus in spaced relation to a conductive ground surface. The transmission line is connected directly or through a suitable impedance-matching transmission-line section across the insulator. The use of a base insulator has the disadvantages that the insulator is subject to electrical and mechanical failure and introduces substantial difficulties regarding the mechanical support of the antenna.

A shunt-fed antenna has its base mechanically and electrically connected to the conductive ground surface, thereby avoiding the requirement of base insulators. One conductor of the transmission line is connected to the conductive ground surface at the base of the antenna, while the other conductor extends at an angle to the conductive surface and is connected to a point on the antenna usually located about one-fifth of the antenna height. The angle which the last-mentioned conductor makes with the grounded surface is usually about 45 degrees, although this angle and the height of the connection of the conductor to the antenna must usually be determined by trial. The inclined conductor forms with the lower portion of the antenna, below the point of its connection therewith and with the ground return path provided by the conductive surface, a closed conductive loop which matches the impedance of the antenna to the characteristic impedance of the transmission line. There is the disadvantage with this arrangement, however, that the feed transmission line must terminate at a substantial distance from the base of the antenna and the inclined conductor must then extend from there to a point on the antenna located a substantial distance from its grounded end. Frequently insufficient space is available around the base of the antenna for this purpose and an alternative form of antenna feed must be used generally at the expense of increasing the over-all antenna height, as in the J type of antenna where the antenna conductor has a J

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configuration grounded at its base, or by the provision of a well sunk below the ground surface to accommodate a quarter-wave length portion of the base of the antenna.

There is the additional disadvantage, with any of the antenna systems described, that while the antenna impedance can be matched to the characteristic impedance of the feed transmission line at a given frequency, it is difficult to provide any form of compensating network, of the type disclosed in United States Letters Patent No. 2,064 774, granted December 15, 1936, to Harold A. Wheeler for "Wave signal collecting system" and assigned to the same assignee as the present application, which enables the antenna to present to the feed transmission line substantially constant impedance over a predetermined range of operating frequencies.

It is an object of the present invention, therefore, to provide a new and improved wave-signal antenna which avoids one or more of the disadvantages and limitations of prior antennas of the type described.

It is a further object of the invention to provide, in a system for translating wave signals within a predetermined range of wave lengths, a new and improved antenna which is adapted to have substantially uniform impedance over such wave-length range and one in which uniformity of impedance is easily and readily effected by an antenna supporting structure involving a relatively simple, sturdy and inexpensive construction.

It is an additional object of the invention to provide a quarter-wave antenna of the shunt-fed type which requires a minimum amount of mounting space and which permits termination of a feed transmission line immediately adjacent the base of the antenna.

It is a further object of the invention to provide a new and improved unitary antenna structure which does not require any electrical insulation in its construction, one which may be directly supported from and in electrical engagement with a conductive ground surface, and yet one which may be either of the series-fed or shunt-fed type, as desired, with transmission-line termination directly at the base of the antenna.

In accordance with the invention there is provided, in a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with

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one end thereof spaced from the surface by a distance much less than one quarter-wave length at a predetermined wave length of the aforesaid range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from the surface in insulated relation therewith. The antenna includes a support conductor extending laterally from the aforesaid one end of the antenna conductor and having a length substantially greater than the aforesaid distance for mechanically and electrically connecting the said one end of the antenna conductor to the surface to support the antenna conductor thereon. The length of the antenna conductor is such as to provide by resonance at the aforesaid predetermined wave length approximately maximum current therein at the said one end and the cross-sectional dimension of the portion of the support conductor between the surface and the said one end of the antenna conductor is small enough to provide at least one-tenth of the total inductance of the antenna conductor and the said portion of the support conductor.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring now to the drawing, Fig. 1 illustrates a wave-signal antenna embodying the present invention in a particular form; Fig. 2 represents the equivalent circuit diagram of the Fig. 1 antenna arrangement and Figs. 3 and 4 represent simplified forms of equivalent circuit diagrams thereof, these circuit diagrams being used as an aid in explaining the operation of the invention; Fig. 5 represents a typical impedance characteristic of an antenna embodying the invention; and Figs. 6, 7 and 8 illustrate several antenna arrangements embodying the present invention in individual modified forms.

Referring more particularly to Fig. 1 of the drawing, there is illustrated a wave-signal antenna of the quarter-wave series-fed type embodying the present invention in a particular form. The antenna comprises an antenna conductor 10 having an effective electrical length of an odd number of quarter-wave lengths at a predetermined wave length in the range over which the antenna is to operate. The antenna conductor 10 preferably is a quarter-wave length long and is adapted to be mounted in extending relation from a conductive surface 11, which for example may be the surface of the ground or a conductive surface of a motor vehicle or naval vessel, with one end 12 of the antenna spaced from the surface 11 by a distance much less than one quarter-wave length at the aforesaid predetermined wave length. The antenna conductor 10 is adapted to be coupled to a wave-signal translating apparatus, not shown, by a coaxial transmission line 13 having a predetermined characteristic impedance Z_0 and having the inner conductor thereof extending from the surface 11 in insulated relation therewith.

The antenna includes an elongated support conductor 14 positioned on the antenna side of the surface 11 in laterally or radially extending relation with the end 12 of the antenna conductor and approximately parallel with the conductive surface. The support conductor 14 has an effective electrical length of approximately an odd number of half-wave lengths, preferably a single

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half-wave length, and thus one substantially greater than the distance by which the end 12 of the antenna conductor is spaced from the conductive surface 11. It is the purpose of the support conductor mechanically and electrically to connect the end 12 of the antenna conductor to the conductive surface, to support the antenna conductor 10 thereon, while at the same time presenting to this end of the antenna conductor an impedance to ground as high as though a support of insulating material were used. The conductor 14 preferably has an approximate U-shaped configuration and is electrically and mechanically connected to the conductive surface 11 at its ends, as by machine screws 15, 16, with the center of the support conductor spaced from the surface 11 and supporting normal thereto and in electrical engagement therewith the antenna conductor 10. The length of the antenna conductor 10 is such as to provide by resonance at the predetermined wave length aforementioned approximately maximum current therein at its end 12. The cross-sectional dimension of the portions of the support conductor 14 between the surface 11 and the end 12 of the antenna conductor is sufficiently small as to provide at least one-tenth of the sum of the inductance of the antenna conductor and the parallel inductance of these portions of the support conductor.

As will be pointed out in greater detail hereinafter, the proportioning of the antenna conductor 10 and the support conductor 14 in the manner described causes the antenna conductor to have a predominantly capacitive reactance and the support conductor 14 a predominantly inductive reactance. There is provided a condenser connected in series with the transmission line 13 and having a value so related to the predominant capacitive reactance of the antenna 10 and the predominant inductive reactance of the support 14 as to provide by resonance an antenna impedance at the end 12 of the antenna conductor which is substantially constant over the range of operating wave lengths of the antenna. This condenser is provided by a conductive member 17 which is connected to the inner conductor 18 of the transmission line 13 and is secured in a central bore 19 of an insulator 20. The latter has a conical end portion 21 over which is secured a conductive cap member 22. The latter is electrically connected to the end 12 of the antenna conductor 10 and to the support conductor 14 at its center by a conductive flexible strap member 23. The insulator 20 is secured in a small well 24, provided in the conductive surface 11, by a ring member 25 which extends over a flanged base portion 26 of the insulator. The outer conductor of the transmission line 13 is electrically and mechanically secured to the edge of an aperture 27 provided centrally of the floor of the well 24. A suitable drain, not shown, may be provided in the well 24 by which to permit accumulated moisture to drain out of the well.

Considering now the operation of the antenna just described, Fig. 2 represents schematically the equivalent circuit diagram of the antenna with the distributed inductance and capacitance of the antenna conductor 10 represented as lumped inductors L_{10} and C_{10} , respectively, and the radiation resistance of the antenna conductor represented by a resistor R_{10} . In similar manner, the distributed inductance and capacitance of the arms of the support conductor 14 are represented as equal lumped inductors L_{14} , L_{14} and lumped parallel-connected condensers C_{14} , C_{14} .

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The outer conductor of the transmission line terminates and is grounded at the bottom of the well 24, whereas the inner conductor 18 of the transmission line extends on to the conductive member 17 positioned within and near the top of the insulator 20. As is well known, the unshielded portion of the transmission-line conductor 18 has distributed inductance which, with the distributed inductance of the conductive member 17 and the strap member 23, is represented in Fig. 2 by the lumped inductor L_{18} . The condenser, comprised by the member 17 and the cap 22 associated with the insulator 20, is represented in Fig. 2 by the condenser C_{17-22} . The end of the antenna conductor 10 is indicated in Fig. 2 as the junction point between the inductors L_{14} , L_{14} and L_{10} .

It will be apparent that the inductors L_{14} , L_{14} are connected between the point 12 and ground so that they may be represented by a single lumped inductor L'_{14} as in Fig. 3, having a value of inductance one-half that of either of the inductors L_{14} , L_{14} . Similarly, the condensers C_{14} , C_{14} are connected in parallel between the point 12 and ground so that they may be replaced by a single condenser C'_{14} , as represented in Fig. 3, having a value twice that of either of the condensers C_{14} , C_{14} . The schematic circuit of Fig. 3 may thus be considered a somewhat simplified form of equivalent circuit diagram of the Fig. 1 antenna. Additionally there is included in the Fig. 3 circuit diagram, a resistor R_{13} which represents the characteristic impedance Z_0 of the coaxial transmission line 13.

It will be apparent from Fig. 3 that the antenna essentially comprises two series-resonant circuits coupled by a shunt-resonant third circuit. The constants of these resonant circuits are proportioned in accordance with the teachings of the aforesaid Wheeler patent to provide a value of antenna impedance equal to the characteristic impedance Z_0 of the transmission line 13 and one which remains substantially constant over the range of operating wave lengths of the antenna. This is accomplished, of course, by adjustment of the length of the antenna conductor 10, by adjustment of the length and cross-sectional configurations of the support conductor 14, by the selection of the length of the inner conductor 18 of the transmission line 13 which extends beyond the outer conductor thereof, and by the selection of the size and spacing of the condenser elements 17 and 22. The method by which this proportioning may be carried out will be readily apparent to one skilled in the art.

As previously mentioned, the antenna conductor 10 is proportioned to have a predominant capacitive reactance, while the support conductor 14 is proportioned to have a predominant inductive reactance. Fig. 4 represents an even more simplified equivalent circuit diagram of the antenna wherein only the predominant capacitive reactance of the antenna conductor 10 is represented as an equivalent condenser C'_{10} and the predominant inductive reactance of the support conductor is represented as an equivalent inductor L'_{14} . The size and spacing of the conductive cap 22 and conductive member 17 associated with the insulator 20 are so selected that the condenser provided thereby has a capacitive reactance slightly larger than the sum of the inductive reactances of the extended portion of the inner conductor 18 of the transmission line 13, the member 17, and the strap member 23. The net capacitance provided by the elements 17 and

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22 is represented in Fig. 4 by a condenser C'_{17-22} . The values of capacitance of the condensers C'_{17-22} and C'_{10} are so selected as to resonate with the inductor L'_{14} at the aforementioned predetermined wave length, which preferably is a wave length corresponding to the mean frequency of the frequency range over which the antenna is to operate.

Fig. 5 represents the impedance characteristic of an antenna when the elements thereof are proportioned in the manner last described. As there indicated, the impedance of the antenna at any wave length λ may have a reactive and resistive component. The coaxial transmission line 13, which is connected to the antenna, has a characteristic impedance Z_0 which is resistive and is plotted on the axis of ordinates in Fig. 5. Curve A represents the impedance of the antenna as seen by the coaxial transmission line. It will be seen from curve A that the antenna impedance, over the range from a first wave length λ_1 to a second wave length λ_2 , is substantially equal to the characteristic impedance Z_0 of the transmission line. This ensures maximum transfer of power between the transmission line 13 and the antenna over the wave-length range λ_1 to λ_2 .

In certain applications, it may be necessary to shorten somewhat the length of the support conductor 14 to minimize the mounting space required by the antenna. Fig. 6 schematically illustrates an antenna embodying a modified form of the invention which permits this while, at the same time, maintaining the antenna characteristics and its mode of operation substantially that described in connection with the Fig. 1 antenna. In Fig. 6, elements corresponding to similar elements of Fig. 1 are designated by similar reference numerals and analogous elements by similar reference numerals primed. While no attempt is made in Fig. 6 for purposes of simplicity to show the detailed construction of the antenna aside from the main constructional features, it will be understood that the detailed construction may follow along lines similar to those of the Fig. 1 antenna. In the present embodiment, the support conductor 14' is somewhat shortened physically, but its effective electrical length is maintained at the desired value by the provision of a capacitor member 28 which is electrically and mechanically secured to the support 14' and extends laterally from the end 12 of the antenna conductor 10 in approximately parallel spaced relation to the conductive surface 11. The capacitor member 28 effectively comprises a lumped capacitance positioned at the center of the support conductor 14' and thus has the effect of increasing the effective electrical length of the latter. Consequently, it will be apparent that the length of the capacitor member 28 varies inversely with that of the support conductor 14' and has a value such that the effective electrical length of the support conductor 14' is the same as though its physical length were increased to the desired value described above in connection with the Fig. 1 antenna construction. The operation of this modified form of the invention is otherwise essentially similar to that of the Fig. 1 antenna arrangement and will not be repeated.

Fig. 7 represents schematically an antenna embodying a modified form of the invention, which is essentially similar to the antenna of Figs. 1 and 6 and similar elements are designated by similar reference numerals and analogous elements by similar reference numerals double primed. The present antenna, which also may have construc-

tional details of the type indicated in Fig. 1, involves a somewhat simplified construction in that the support conductor 14'' has an L-shaped configuration and is mechanically and electrically connected to the conductive surface 11 only at one of its ends 29. The points along the support conductor 14'' at which the end 12 of the antenna conductor 10 and the inner conductor 18 of the transmission line 13 are connected thereto depend upon the effective electrical length of the antenna conductor 10 and the characteristic impedance of the transmission line 13. In greater detail, the support conductor 14'' has a physical length such that its effective electrical length is one quarter-wave length at a wave length in the range over which the antenna is to operate, preferably the mean wave length of such range. The antenna conductor 10 is connected to the support 14'' at a point such that the conductive path from the free end of the antenna conductor 10 through the support conductor 14'' to the conductive surface 11 has an effective electrical length of approximately an odd number of quarter-wave lengths at the predetermined wave length last mentioned. In practice, the length of this conductive path preferably is one quarter-wave length. At the same time, the cross-sectional dimensions of the support conductor 14'' are so proportioned that the portion of the support conductor between the conductive surface 11 and the end 12 of the antenna conductor 10 is small enough to provide at least one-tenth of the total inductance of the antenna conductor and this portion of the support conductor. In particular, the dimensions of this portion of the support conductor are selected to provide the desired uniformity of antenna impedance over the band of operating wave lengths of the antenna. The inner conductor 18 of the transmission line 13 is coupled to a point along the length of the support conductor 14'' such that the impedance between this point and the conductive surface 11 properly terminates the transmission line 13 in its characteristic impedance Z_0 . The constants of the antenna are proportioned in the manner described in connection with the antenna of Fig. 1 so that it presents to the transmission line 13 a substantially constant value of impedance over the range of operating wave lengths of the antenna. The operation of the antenna is otherwise similar to that of the Fig. 1 antenna and will not be repeated.

An even more simplified form of antenna is schematically represented in the modified form of the invention of Fig. 8 which is essentially similar to the antenna constructions heretofore described, similar elements being designated by similar reference numerals and analogous elements by similar reference numerals triple primed. The present antenna construction is quite similar to that of Fig. 7 except that the L-shaped support conductor 14''' is connected at one end to the conductive surface 11 and is connected at its other end to the end 12 of the antenna conductor 10. In the present arrangement, the cross-sectional dimensions of the support conductor 14''', its length, and its spacing from the conductive surface 11 are so proportioned that the effective electrical length of the conductive path from the free end of the antenna conductor 10 over the support conductor 14''' to the conductive surface 11 is an odd number of quarter-wave lengths, preferably one quarter-wave length, and at the same time the impedance of the support conductor 14''' is such as properly to termi-

nate the transmission line 13 in its characteristic impedance Z_0 .

From the above description of the invention, it will be apparent that an antenna embodying the invention has substantially uniform impedance over a predetermined range of operating wave lengths and is one in which uniformity of its impedance is easily and readily effected by an antenna and a supporting structure therefor of relatively simple, sturdy and inexpensive construction. Additionally, an antenna embodying the invention has the important advantages that it avoids the use of any insulating material in its construction, yet may be operated as a shunt-fed or series-fed antenna as desired. Further, the antenna requires a minimum amount of mounting space and permits the termination of a transmission line at a point immediately adjacent the base of the antenna, when operated as a shunt-fed antenna, rather than at a substantial distance to one side thereof as has heretofore been required in prior shunt-fed antennas.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and a support conductor extending laterally from said one end of said antenna conductor and having a length substantially greater than said distance for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portion of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the total inductance of said antenna conductor and said portion of said support conductor.

2. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and a support conductor positioned on the antenna side of said surface in laterally extending relation to said one end of said antenna conductor and having a length substantially greater than said distance for mechanically

and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portion of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the total inductance of said antenna conductor and said portion of said support conductor.

3. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and a support conductor extending laterally from said one end of said antenna conductor and having a length substantially greater than said distance for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the conductive path from the other end of said antenna conductor to said surface traced through said support conductor having an effective electrical length of approximately an odd number of quarter-wave lengths at said predetermined wave length and the cross-sectional dimensions of the portion of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the total inductance of said antenna conductor and said portion of said support conductor.

4. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and a support conductor extending radially from said one end of said antenna conductor approximately parallel to said surface and having a length substantially greater than said distance for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portion of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the total inductance of said antenna conductor and said portion of said support conductor.

5. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with

one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and an approximately L-shaped support conductor extending laterally from said one end of said antenna conductor and having a length substantially greater than said distance for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portion of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the total inductance of said antenna conductor and said portion of said support conductor.

6. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and an approximately L-shaped support conductor extending laterally from said one end of said antenna conductor and having an over-all length equal substantially to an odd number of quarter-wave lengths at said predetermined wave length for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portion of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the total inductance of said antenna conductor and said portion of said support conductor.

7. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and a support conductor extending in a plurality of directions laterally from said one end of said antenna conductor and having in each of said directions a length substantially greater than said distance for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portions of said

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support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the sum of the inductance of said antenna conductor and the inductance of said portions of said support conductor in parallel.

8. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and an elongated support conductor mechanically and electrically connected to said surface at each of its ends with the center thereof spaced from said surface by said distance and supporting normal thereto and in electrical engagement therewith said antenna conductor, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portions of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the sum of the inductance of said antenna conductor and the inductance of said portions of said support conductor in parallel.

9. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and an approximately U-shaped support conductor extending symmetrically in lateral directions from said one end of said antenna conductor and having an effective electrical length equal approximately to an even number of half-wave lengths at said predetermined wave length for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portions of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the sum of the inductance of said antenna conductor and the inductance of said portions of said support conductor in parallel.

10. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor having an effective electrical length of an odd number of quarter-wave lengths at a predetermined wave length in said range and adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at said predetermined

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wave length and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, and an elongated support conductor having an effective electrical length of an even number of half-wave lengths at said predetermined wave length and being mechanically and electrically connected to said surface at each of its ends with the center thereof spaced from said surface by said distance and supporting normal thereto and in electrical engagement therewith said antenna conductor, the cross-sectional dimensions of the portions of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the sum of the inductance of said antenna conductor and the inductance of said portions of said support conductor in parallel.

11. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a transmission line having a predetermined characteristic impedance and having a conductor thereof extending from said surface in insulated relation therewith, a support conductor extending laterally from said one end of said antenna conductor and having a length substantially greater than said distance for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portion of said support conductor between said surface and said one end of said antenna conductor being small enough to provide at least one-tenth of the total inductance of said antenna conductor and said portion of said support conductor, and means for connecting said conductor of said transmission line to a point on said support conductor having a value of impedance equal to said characteristic impedance.

12. In a system for translating wave signals within a predetermined range of wave lengths, an antenna comprising, an antenna conductor adapted to be so mounted as to extend in a direction away from a conductive surface with one end thereof spaced from said surface by a distance much less than one quarter-wave length at a predetermined wave length in said range and adapted to be coupled to a wave-signal translating apparatus by a lead-in conductor which extends from said surface in insulated relation therewith, a support conductor extending laterally from said one end of said antenna conductor and having a length substantially greater than said distance for mechanically and electrically connecting said one end of said antenna conductor to said surface to support said antenna conductor thereon, the length of said antenna conductor being such as to provide by resonance at said predetermined wave length approximately maximum current therein at said one end and the cross-sectional dimensions of the portion of said support conductor between said surface and said one end of said antenna conductor being small

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enough to provide at least one-tenth of the total inductance of said antenna conductor and said portion of said support conductor, whereby said antenna conductor has a predominant capacitive reactance and said portion of said support conductor a predominant inductive reactance, and a condenser connected in series with said lead-in

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conductor and having a value so related to said capacitive and inductive reactances as to provide by resonance an antenna impedance at said one end which is substantially constant over said predetermined range of wave lengths.

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