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ANTENNA

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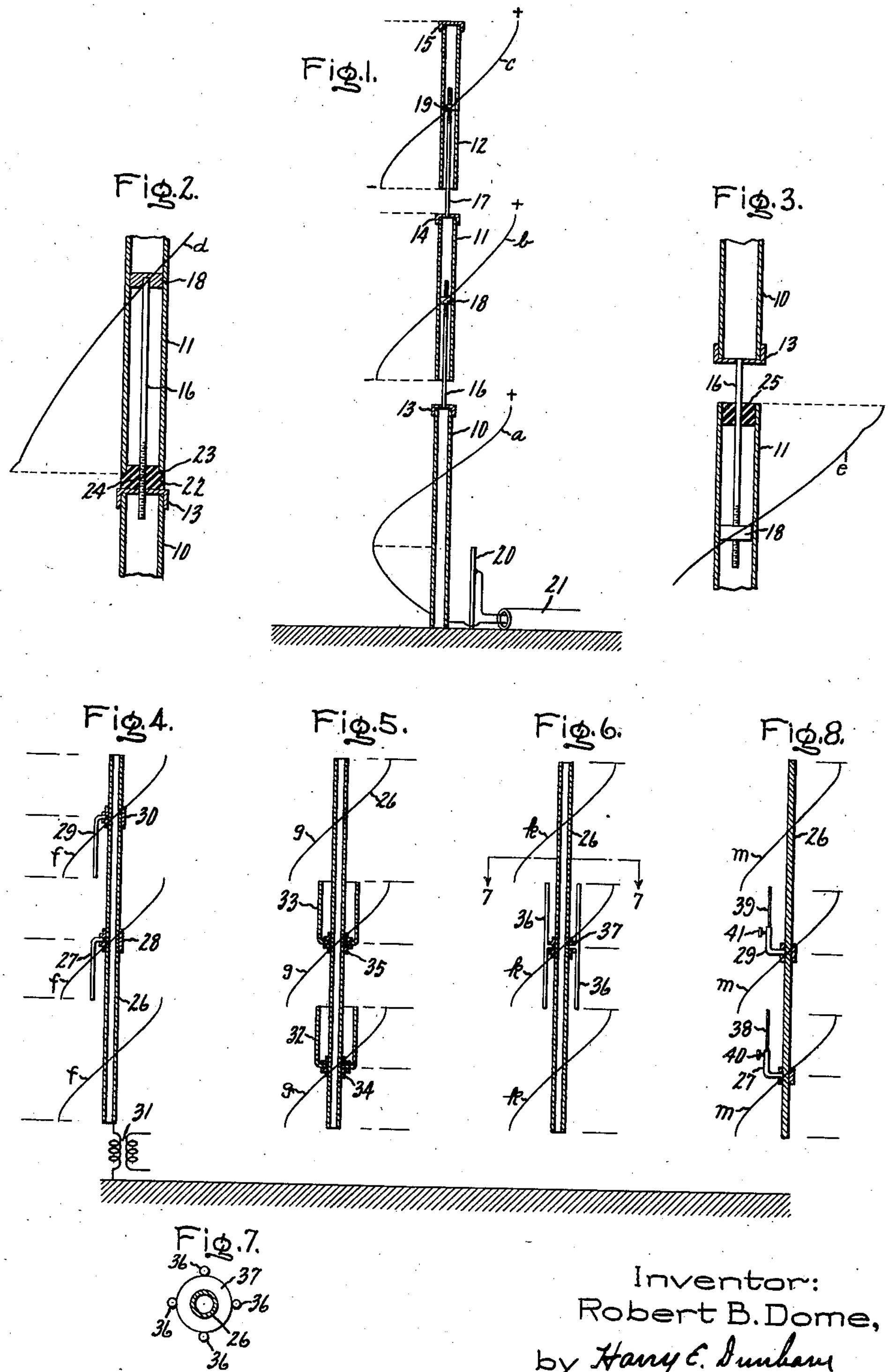


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## ANTENNA

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My invention relates to an improved antenna for a radio signaling system and more particularly to a high frequency antenna of the type having a plurality of half-wave sections oscillating in phase.

An object of my invention is to provide an improved and greatly simplified antenna arrangement having a radiation directivity characteristic of the flattened or pancake type which may be symmetrical or non-symmetrical, as desired, in the horizontal plane.

A further object of my invention is to provide an antenna having two or more half-wave sections oscillating in phase and my invention contemplates that the several sections may be formed as a continuous metallic conductor unbroken at any point through its length by electrical insulators thereby to provide an antenna of the type named which has the advantages of simplicity of construction and erection, low cost, and great mechanical strength.

An additional object of my invention is to provide an improved and simplified phase-reversing arrangement to interconnect half-wave sections of an antenna and one which is especially suitable where mechanical and electrical symmetry of the antenna is desired.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 illustrates an elevational view in cross section of an embodiment thereof; Figures 2 and 3 show in cross section certain modified constructional details of this embodiment; Figures 4, 5, 6, and 8 illustrate additional modifications; and Figure 7 shows a cross section along the plane 7—7 of the Figure 6 modification.

Referring more particularly to Figure 1 of the drawing, my invention is illustrated as embodied in an antenna having a metallic section **10** having a length of three quarters of a wave length of the wave at which it operates and which supports two metallic half-wave sections **11** and **12**. Each section is preferably of circular cross section in the horizontal plane and may in practice conveniently be formed of lengths of pipe. Metallic caps **13**, **14** and **15** close the upper ends of the respective sections **10**, **11** and **12** to exclude moisture and foreign matter to which the antenna is exposed in service. The caps **13** and **14** additionally provide a support for the respective vertical current conducting rods **16** and **17** which likewise are preferably circular in cross section in the horizontal plane and may be solid or hollow as desired. Each rod is electrically connected through its supporting cap to the antenna section immediately below it and forms, in effect, a reduced extension of the section. The upper end of each rod is threaded for engagement with a respective metallic member **18**, **19**, which is mechanically and electrically connected midway between the ends of the respective sections **11** and **12**.

In operation, the antenna is excited by a short, or so-called stub antenna **20** having a length equal to a quarter of a wave length of the operating wave. This antenna is arranged in parallel spaced relation to the lower quarter-wave portion of the antenna section **10**. The lower end of the section **10** and the stub antenna **20** are connected in energy transfer relation to signaling apparatus, not shown, through a transmission line, represented diagrammatically at **21**. The potential distribution along the length of the section **10** is represented in magnitude and phase by the solid line *a*. The term "phase" as thus used is in accordance with standard engineering practice and indicates the polarity of the potential at a given instant at points along this length of the antenna section.

The rod **16** forms with the lower half of the antenna section **11** a concentric transmission line which, at the lower end of the section **11**, presents a high impedance to the potential existing at the upper end of the antenna section **10**. This impedance produces an abrupt change in the phase of the potential existing between the upper end of the antenna section **10** and the lower end of the section **11**, a diagrammatic illustration of the exact relation of the change being omitted from the drawing for purposes of simplicity. The member **18**, and with it the section **11**, is adjusted along the length of the rod **16** to a point at which the potential between the upper end of the section **10** and the lower end of the section **11** is reversed just 180° in phase. The potential distribution which now exists along the antenna section **11** is represented in magnitude and phase by the solid line *b*.

The rod **17** and the lower end of the section **12** likewise form a concentric transmission line having a high impedance to the potential existing at the upper end of the antenna section **11**. Here, again, the phase of the potential reverses abruptly between the upper end of the section 11 and the lower end of the section 12, the reversal being 180° in phase by suitable adjustment of the member 19 along the rod 17. The potential distribution along the section 12 is represented in magnitude and phase by the solid line *c*.

The potential distribution existing along the several sections of the antenna produces a flow of current in each section. The current which flows along the upper end of the rods 16 and 17 is neutralized, as far as the transfer of energy between the antenna and the surrounding space is concerned, by a similar flow of current along the inside surfaces of the lower end of the respective sections 11 and 12. That current which is effective in transferring energy between the antenna and the surrounding ether flows in each section in phase with that of the current existing in each of the other antenna sections. The graphical representation of the magnitude and phase of the current in the several sections is omitted from the drawing for purposes of simplicity since these are values which are determined by and vary in accordance with the potential distribution shown by the solid lines *a*, *b* and *c* in a manner well known to one skilled in the art.

Each antenna section 10, 11 and 12 thus operates in the manner of an individual half-wave vertical dipole antenna and the effect obtained by the arrangement shown in Figure 1 is that of a plurality of vertical dipole antennas arranged end to end and oscillating in phase. If the antenna is used to transmit signal energy, the resulting radiation characteristic of the antenna is of the flattened pancake type symmetrical in the horizontal plane. The flattened pancake characteristic becomes more pronounced as the number of antenna sections is increased though the use of more than about three sections requires, for full effectiveness, that every fourth one of the added sections be directly supplied with energy from the signalling apparatus.

The mechanical rigidity and strength of the antenna shown in Figure 1 may be increased by the construction illustrated in Figure 2 which shows a partial view of the antenna sections 10 and 11 of the Figure 1 arrangement. A block of insulating material 22 is shouldered at 23 to receive the lower end of the section 11, is apertured at 24 to provide an opening through which the rod 16 extends, and fills the space between the antenna sections 10 and 11. The insulating material 22 may be resilient to a certain degree in order that the length of the rod between the cap 13 and the member 18 may be suitably adjusted. Since the insulating material has a higher dielectric constant than air, it will produce a discontinuity in the potential distribution along the antenna section in the manner illustrated by the solid line *d* which shows the potential distribution in magnitude and phase along the lower half of the antenna section 11. This will necessitate that the length of the rod 16 between the cap 13 and the member 18 be shortened somewhat more than would be the case were the insulating material 22 not used if the phase of the potential at the lower end of the antenna section 11 is to be 180° out of phase with that at the upper end of the section 10. The rod 16 is shown in this modification fixedly secured at one end to the member 18 and screw-threadedly engaging the cap 13.

It will be obvious that the antenna shown in Figure 1 may be turned end for end with the section 10 at the top and the section 12 at the bottom. In this event, the antenna section 10 is made one-half wave length long and the antenna section 12 is increased to a three-quarter wave length. The connection of the several antenna sections to each other is then made in the manner illustrated in Figure 3 which shows a portion of the sections 10 and 11. A block of insulating material 25 is provided to close the upper end of the antenna section 11 for the purpose of increasing the mechanical strength of the antenna and to exclude dirt and moisture from the upper half of this section. The potential distribution in magnitude and phase along the upper half of the antenna section 11 is illustrated by the solid line *e*.

Figure 4 illustrates a modification of my invention in which a continuous metallic pole 26, unbroken at any point throughout its length by electrical insulators, operates in a manner similar to the Figure 1 arrangement as a series of vertical dipole antennae arranged end to end and oscillating in phase. The pole 26 in practice may be formed of pipe having a length equal to any desired number of half-wave lengths. A metallic conducting member 27 is supported at one end from the pole 26 by a metallic collar 28 which is secured to the pole at a point three-fourths of a wave length from its lower end. The member 27 is thus mechanically supported from and electrically connected at its upper end to the pole 26 with the axes of the member in parallel spaced relation to the axes of the conductor. The spacing between the member 27 and the pole 26 is but a few inches or at most a small fraction of a wave length. The member has a length of approximately one-fourth wave length and the lower end of the member therefore falls at a point one-half wave length distant from the lower end of the pole 26. A similar member 29 is supported in like manner by a collar 30 with the lower end of the member distant one-fourth wave length from the upper end of the member 27.

In operation, the Figure 4 antenna arrangement is connected in energy transfer relation with a signaling apparatus, not shown, by a transformer 31. The antenna may be connected to the signaling apparatus in a manner similar to the Figure 1 arrangement by extending the lower end of the antenna one-fourth wave length and by providing in closely spaced parallel relation with the extended portion a one-quarter wave stub antenna similar to the stub antenna 20 of Figure 1, the connection of the antenna to the signaling apparatus then being the same as that of the Figure 1 arrangement. Each of the members 27 and 29 forms with that portion of the pole 26 immediately opposite a transmission line which presents a high impedance to the potential existing on the pole at points opposite the lower ends of each member. The potential thus abruptly reverses 180° in phase at these points and may be represented in magnitude and phase along the length of the pole by the solid lines *f*. It will be observed that this potential distribution is such as to cause the antenna to operate as a series of vertical dipoles arranged end to end and oscillating in phase. The radiation characteristic of the antenna, when the antenna is used as a radiator of signaling energy, is of the pancake type. However, the use of a single member 27, 29 at each elevation (whose several axes preferably coincide) renders the radiation characteristic non-uniform in the horizontal plane.

The non-uniform radiation characteristic in the horizontal plane of the Figure 4 antenna arrangement may be changed, where desired, to a uniform characteristic by the arrangements illustrated in Figures 5 and 6. Figure 5 shows a number of open ended sleeves **32** and **33** positioned at selected points along the length of the pole **26**. These sleeves are suitably supported on the pole by collars **34** and **35** and are electrically connected to the pole **26** at their lower ends. Since the free ends of the sleeves **32** and **33** extend upwardly, the electrical connection of the lower end of the sleeve **32** to the pole is made at a point one-quarter wave length from the lower end of the pole. The sleeve **33** is electrically connected to the pole at a point one-quarter wave length from the upper end of the sleeve **32**. The potential distribution along the length of an antenna constructed in accordance with this modification of my invention is in the manner illustrated by the solid lines *g*. Each sleeve **32**, **33** is preferably closed by a sheet of insulating material, not shown, as in the manner of the Figure 3 arrangement to prevent the accumulation of foreign matter in the upturned sleeve. The use of such insulation has the effect, as in Figure 3, of causing a slight discontinuity in the potential distribution. This requires a slight shortening of the sleeve to less than one-quarter wave length. The end of the shortened sleeve remains, however, at the point of potential phase reversal.

Figure 6 illustrates an additional modification in which a number of members **36**, having a length of one-half wave length, are mechanically supported in spaced relation from and are electrically connected at their center to the antenna pole **26** by a collar **37**. A plurality of such members are spaced equidistantly around the pole **26** in the manner shown in Figure 7 which illustrates a cross-sectional view of the antenna taken along the horizontal plane **7—7**. The lower end of each member is spaced one-half wave length from the bottom end of the pole **26** and the potential distribution along the length of the antenna is as indicated by the solid lines *k*.

The modification of Figure 8 is similar to that of Figure 4 except that the antenna pole **26** is here shown as a solid conductor and the members **27** and **29** are each provided with a telescopic section **38** and **39**, respectively, by which the length of the member may be accurately adjusted. Set screws **40** and **41** secure the respective telescopic sections **38** and **39** in adjusted position. Since the members **27**, **29** point upwardly, their electrical connection to the antenna pole **26** must be at the same points as the connection of the sleeves **32** and **33** of the Figure 5 modification in order that the potential distribution along the length from the antenna may be as indicated by the solid lines *m*.

It is to be understood that the antennae shown in Figures 5 and 8 may be inverted, if desired, to provide arrangements which do not require the use of insulating material to close the open ends of the sleeves **32** and **33** (Fig. 5) or waterproofing of the joint between the telescopic sections **27**, **38** and **29**, **39** (Fig. 8).

The manner of connecting the antennae shown in Figures 5, 6 and 8 to the signaling apparatus with which they are used is not shown on the drawing for purposes of simplicity, but it is understood that the connection will be in a manner similar to that illustrated in Figure 4.

While I have shown several embodiments of an antenna having a physical length of three one-half wave lengths, the length in practice need not be that shown but may be fewer or greater than three one-half wave lengths as will be obvious to one skilled in the art. Thus while I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since many modifications may be made in the elements of the antennae and their arrangement, and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is—

1. An antenna having a length equal to at least an integral multiple of a half-wave length of the wave at which said antenna operates, and being electrically continuous throughout its length, means to excite each section of the said antenna from an end of an adjacent section, and means to maintain the potentials in corresponding portions of each half-wave length section of said antenna in like phase, said means including means forming with a portion of one section adjacent to another section a transmission line having a high impedance to the potential existing at the point between said sections.

2. An antenna having a length equal to at least an integral multiple of a half-wave length of the wave at which said antenna operates, and being electrically continuous throughout its length, means forming with a portion of one half-wave section adjacent to another half-wave section a transmission line having a high impedance to the potential existing at the point between said sections, and means for adjusting the impedance of said transmission line to maintain the potentials in corresponding portions of each half-wave section of said antenna in like phase.

3. An antenna having a length equal to at least an integral multiple of a half-wave length of the wave at which said antenna operates, said antenna being electrically continuous throughout its length and having along its length a potential distribution which includes potential nodes and antinodes, and means to maintain the potentials in corresponding portions of each half-wave length section of said antenna in like phase, said means including electrically conductive means electrically connected to said antenna at a potential node and extending in insulated spaced relation with said antenna to a point thereon at which a potential antinode occurs.

4. In an antenna, a plurality of conductive antenna sections each having an effective length of one-half wave length of the wave at which said antenna operates, means for supporting said sections in end to end relation, and means electrically connecting an end of one of said sections to substantially the midpoint of an adjacent section to maintain the currents in corresponding positions of said antenna sections of like phase.

5. In an antenna, a plurality of conductive antenna sections arranged end to end, each of said sections being substantially one-half wave length long, and means for electrically connecting an end of one of said sections to substantially the midpoint of an adjacent section, said last named means being effectively shielded with respect to space waves whereby said one section and said adjacent section operate in phase.

6. In an antenna, a plurality of conductive antenna sections, one of said sections being sub-

stantially three-fourths wave length long and a second of said sections being substantially one-half wave length long, means for supporting said sections in end to end relation, with substantially one-half of said second named section telescoping with one end of said first named section, and means for electrically connecting the aforesaid end of said first named section to substantially the midpoint of said second named section.

7. In an antenna, a plurality of conductive antenna sections, one of said sections being substantially three-fourths wave length long and a second of said sections being substantially one-half wave length long, means for supporting said sections in end to end relation with substantially one-half of said second named section telescoping in spaced relation with one end of said first named section, means for electrically connecting the aforesaid end of said first named section to substantially the midpoint of said second named section, and means for varying the length of said second named section with which said first named section telescopes with whereby the end of said second named section is positioned at a point on said first named section of maximum potential.

8. An antenna having a length equal substantially to an integral multiple of a half-wave length of the wave at which said antenna operates, and means for reversing at a point adjacent the end of a half-wave section of said antenna the phase of the potential existing at said point, said last named means including a current conducting member supported in insulated spaced relation to said antenna, a free end of said member lying opposite said point of phase reversal, and means for electrically connecting together said member and said antenna at a point distant substantially one-quarter wave length from said point of phase reversal.

9. In combination, an antenna comprising a conductor, having standing waves impressed thereon, a conducting member having a length equal to a quarter of a wave length of said wave, said member having one end thereof connected to a nodal point of said first conductor and extending along said first conductor in parallel spaced relation thereto to form therewith a quarter wave transmission line section, whereby the voltage on the opposite end of said member is in opposite phase to the voltage on said conductor at a point near said opposite end, and the half wave length sections of said antenna adjacent said opposite end oscillate in like phase.

10. An antenna comprising a continuous electrical conductor, said conductor having individual conductors electrically connected thereto at intervals spaced apart by one half of a wave length of the wave at which said antenna operates, each individual conductor being substantially one quarter of a wave in length and extending from its point of electrical connection to said first conductor along said conductor in substantially parallel spaced relationship thereto to form a quarter wave length transmission line section.

11. In an antenna, the combination of a plurality of conductors positioned end to end, and each having a length substantially a half of the wave length of the wave at which said antenna operates, a connector connecting the midpoint of one of said first conductors to the adjacent end of the next adjacent of said first conductors, said connector extending along the intermediate portion of said first conductor to form therewith a quarter wave transmission line section.

12. An antenna, comprising a conductor having a length substantially equal to three halves of a wave length of the wave at which said antenna operates, a second conductor having a length equal to one half of a wave length of said wave positioned parallel thereto adjacent its middle portion, and means electrically connecting the middle portion of said conductors together.

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