May 23, 1939. A. ALFORD 2,159,646

ANTENNA

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FIG. 1

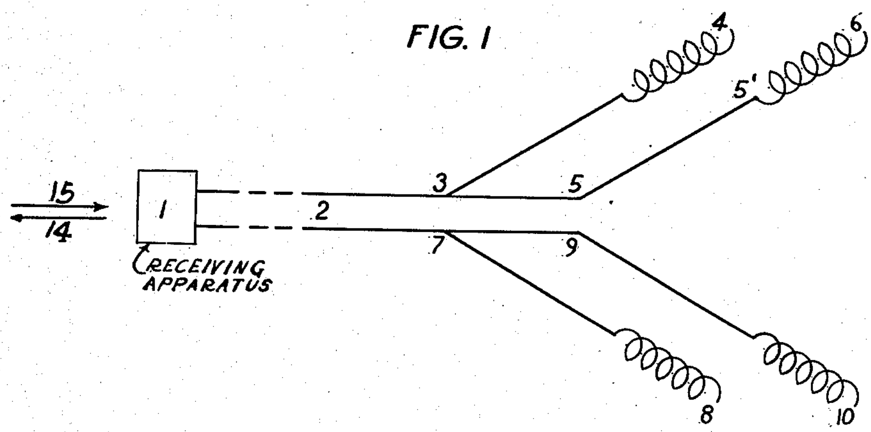
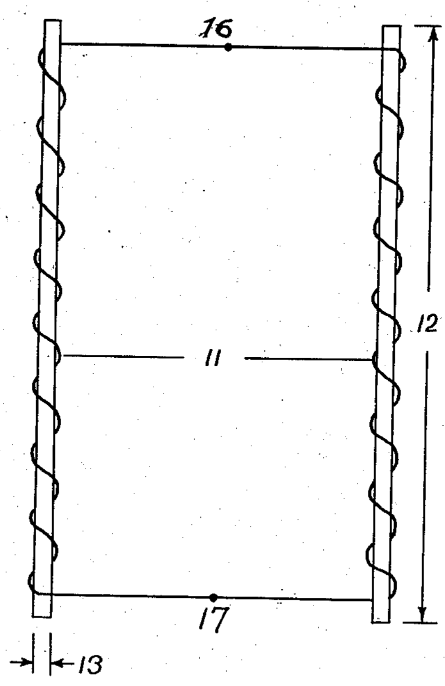


FIG. 2



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6 Claims. (Cl. 250—33)

This invention relates to new and useful improvements in antennae.

The object of the invention is to provide a directional antenna, particularly adapted for short wave radio reception and transmission, and more particularly the provision of an inexpensive and readily installed terminating reactance for minimizing the reflection of waves from the antenna ends.

These and other objects of the invention will more fully appear from the following specification and claims of a preferred embodiment.

In carrying my invention into effect I make use of electrically long conductors as collectors of electromagnetic energy. Such conductors when used for the transmission and reception of radiant energy are known to have marked directional characteristics which may be utilized to secure a co-operative result when two or more conductors are employed as a system. With open-ended conductors, which I prefer to use, the co-operative effect may result in sharp-cut bilateral directivity, i. e., in two directions diametrically opposed. I propose to convert such a system into one having unilateral directivity by the mere extension of the open ends for a short distance through an artificial line having a surge impedance substantially equal to that of the antenna. This artificial line should have a high attenuation per unit length. The desirability of unilateral directivity is well known to one skilled in the art.

My invention will be more fully understood by reference to the following description together with the accompanying drawing in which:

Fig. 1 shows one way in which my invention may be carried into effect by making use of electrically long conductors disposed at an angle to each other in pairs serving as collectors of radiant energy, and

Fig. 2 shows in detail one form which my concentrated attenuating conductor may take.

In the following description I have limited myself to systems adapted for the reception of radiant energy merely for the sake of illustration, but it is well known that the organization will serve equally well for the transmission of radiant energy.

Referring to Fig. 1, 1 is the receiving apparatus fed by the open-ended collectors 3—4, 5—6, 7—8, and 9—10 which are most receptive to radiant energy arriving in the direction of the arrow 14 and by virtue of my invention rejective to radiant energy arriving in the direction of the arrow 15.

The receiving apparatus 1 and the means for coupling it to the transmission line 2 may assume any of the arrangements known in the art, the particular form being unimportant.

The transmission line 2 may be similar in construction to the ordinary telephone line. Since the function of the transmission line is to convey the electrical energy picked up by the collectors to the receiving apparatus, it is desirable that the function be performed with reasonable efficiency. This is a matter only of engineering expediency, the design factors being well known to one skilled in the art.

The collectors 3—4, 5—6, 7—8 and 9—10 are conductively connected in pairs to the transmission line, the connections 5 and 9 being made at the last pole of the transmission line, 3 and 7 at the next to the last pole, and so on for additional pairs. They are all of substantially equal length and arranged to make equal angles with the axis of the collector system, the angles being such that they co-operate in collecting radiant energy most efficiently mainly along the vertical plane of the bisector of the angle between the sides of each pair. Obviously, this angle would be the same, if the collectors are considered for the moment as radiators, as that between the radiators when radiation from one side of a pair is arranged to reinforce that from the other side of a pair. A collector system of this kind, unless special devices are provided, is strongly responsive to radiant energy arriving substantially in directions 14 and 15 and practically non-responsive to that arriving from other directions. This is the same as saying that the system is bilaterally directive.

My invention renders such a system unilaterally directive or, more specifically, it operates to accept radiant energy arriving in direction 14 (front) and reject that arriving in direction 15 (back). I accomplish this result by taking advantage of the fact that the energy picked up by each collector in front reception flows directly to the transmission line, while in the back reception, it is naturally constrained to flow first to the outer end and thence by reflection back over the collector toward the transmission line. I do so by interposing an artificial line of high attenuation in the path of the energy collected by each collector in back reception on its way to be delivered to the transmission line whereby it is greatly weakened in such a way that the energy collected in front reception is free from the necessity of traversing the conductor of high attenuation on its way to the transmission line.

Furthermore, the artificial lines of high attenuation are in concentrated form, i. e., of physical dimensions very small as compared with the overall physical dimensions of the collector system.

First, consider a typical collector such as 5—6. It is seen to consist of two parts, 5—5′ and 5′—6. The part 5—5′ may consist of a wire of the order of several wavelengths long of reasonably high conductivity such as is usually employed in antenna construction. A wire of this kind offers relatively little attenuation to the radiant energy it intercepts. The part 5′—6 is an extension of 5—5′ at the otherwise open end 5′ and is purposely designed to have high attenuation per unit length as will be explained later. Moreover, 5′—6 is made to have substantially the same surge impedance as 5—5′.

The functioning of the typical collector will now be explained. Consider first the reception of radiation from the front. Oncoming waves from this direction first encounter 5′—6 which, being of small dimensions and high attenuation, contributes a negligible proportion of the sum total of the energy picked up and delivered to the transmission line and so far is inoperative. They next encounter 5—5′ which, being long and of low attenuation, contributes substantially all of the energy picked up and delivered to the transmission line by the collector 5—6 as a whole. Furthermore, the picked up energy flows directly to the transmission line in the general direction of arrow 14.

Next consider the reception of radiation from the back. Since 5′—6 is practically inactive, as far as picking up energy is concerned, it is necessary to attend only to what happens to the energy picked up by 5—5′ which is substantially of the same magnitude as in the case of front reception. There is an important difference, however, in that with back reception the energy picked up flows away from the transmission line in the general direction of arrow 15 and can be delivered eventually to the transmission line only by reflection at the outer end or at any point of discontinuity in the conducting medium on the way to the outer end. Since the wire 5—5′ is uniform throughout its length there is no point of discontinuity in it. There may, however, be such a point at the junction 5′ but I make the surge impedance of 5′—6 substantially the same as 5—5′ so that reflection at the junction is practically avoided. Part 5′—6 is also of uniform construction so there is no point of discontinuity along it. The consequence is that the energy picked up in back reception by 5—5′ must first travel to the outer end 6 and then after reflection traverse 5′—6 a second time before reaching 5—5′ over which it is delivered to the transmission line. On account of the high attenuation to which it is twice subjected, it is negligibly small in comparison with the energy picked up in front reception and delivered to the transmission line. The net result is that the collector system of my invention provides a front to back discrimination equal in magnitude approximately to twice the attenuation of 5′—6.

An essential feature of my invention is the concentrated form of 5′—6. In Fig. 2 I have shown diagrammatically a construction which I have used in practice. It consists of two substantially equal solenoids, each with the length 12 very great in comparison with the diameter 13 wound with high resistance wire, adjacent turns being separated by a distance comparable with dimension 13. Points 16 and 17 correspond with points 5′ and 6, respectively, of Fig. 1.

The use of high resistance wire provides the high attenuation per unit length. This will be readily apparent when one considers that at high frequencies the attenuation constant of a wire line is given very closely by the expression

$$R/2\sqrt{\frac{C}{L}}$$

where R, L, and C are the resistance, inductance and capacitance, respectively, all per unit length.

The solenoidal form is used to concentrate still more the attenuation per unit length. This, however, has a tendency to increase L which offsets to a slight extent the amount of attenuation per unit length. It is to minimize this effect that I specify that the length 12 shall be very great in comparison with the diameter 13 and also that adjacent turns be separated by a distance of the order of magnitude of dimension 13.

I use two solenoids as shown in Fig. 2 with the distance 11 between them adjustable. I do this in order to provide an independent adjustment of the surge impedance which I make equal to the surge impedance of part 5—5′ of Fig. 1. It is, of course, possible to design a single solenoid which will have sufficiently high attenuation and the proper value of surge impedance, but I find in practice that it is more convenient to leave the surge impedance to a separate and independent adjustment.

As a practical consideration it is not necessary that 5′—6 of Fig. 1 be extended horizontally at the end of 5—5′ but may be conveniently mounted on the supporting wooden pole or tower and parallel thereto. The terminating artificial lines are always insulated from ground.

What is claimed is:

1. In an antenna system, a transmission line, a pair of antenna wires forming a V with respect to the longitudinal axis of the line connected with the latter, and connected to the free end of each antenna wire two interconnected substantially equal solenoids of high resistance wire insulated from ground, each of great length with respect to its diameter and having turns separated by a distance substantially equal to the diameter, whereby currents reaching the free ends of the antenna wires are highly attenuated, the spacing between the two solenoids being adjusted to equal the surge impedance of the antenna wire, said inter-connected solenoids constituting the non-radiating terminating impedance device for the connected antenna wire.

2. In an antenna system, a transmission line, an antenna wire a plurality of wavelengths long connected therewith, and an artificial line insulated from ground and having a surge impedance substantially equal to the surge impedance of said antenna wire connected to the free end of the wire and constituting a non-radiating, non-reflecting terminating impedance device for said antenna wire said artificial line being formed of resistance wire and having an electrical length so related to its attenuation per unit length that wave energy traveling from said wire over said artificial line and then after reflection back over said artificial line to said wire is attenuated to a negligibly small value, and having small physical length with respect to its electrical length whereby the radiant action of such wave energy is negligibly small.

3. In an antenna system, a transmission line,

an antenna wire a plurality of wavelengths long connected therewith, and an artificial line having high attenuation per unit length insulated from ground and having a surge impedance substantially equal to the surge impedance of said antenna wire connected to the free end of the wire and said artificial line being formed of resistance wire and having an electrical length so related to its attenuation per unit length that wave energy traveling from said wire over said artificial line and then after reflection back over said artificial line to said wire is attenuated to a negligibly small value, and having small physical length with respect to its electrical length whereby the radiant action of such wave energy is negligibly small.

4. In an antenna system, a transmission line, a pair of antenna wires connected thereto and forming a V, and connected to the free end of each antenna wire an artificial line having high attenuation per unit length insulated from ground and having a surge impedance substantially equal to the surge impedance of said antenna wire, and constituting a non-radiating, non-reflecting terminating impedance device for said antenna wire said artificial line being formed of resistance wire and having small physical length with respect to its electrical length.

5. In an antenna system, a transmission line, antenna wires each a plurality of wavelengths long connected thereto and forming a V, and connected to the free end of each antenna wire an artificial line having high attenuation per unit length insulated from ground, and constituting a non-radiating, non-reflecting terminating impedance device for said antenna wire said artificial line being formed of resistance wire and having an electrical length so related to its attenuation per unit length that wave energy traveling from said wire over said artificial line and then after reflection back over said artificial line to said wire is attenuated to a negligibly small value, and having small physical length with respect to its electrical length whereby the radiant action of such wave energy is negligibly small.

6. In an antenna system, a transmission line, two pairs of antenna wires connected therewith, each pair forming a V, each of said wires being a plurality of wavelengths long and having connected at its free end an artificial line having high attenuation per unit length insulated from ground and constituting a non-radiating, non-reflecting terminating impedance device for said antenna wire said artificial line being formed of resistance wire and having an electrical length so related to its attenuation per unit length that wave energy traveling from said wire over said artificial line and then after reflection back over said artificial line to said wire is attenuated to a negligibly small value, and having small physical length with respect to its electrical length whereby the radiant action of such wave energy is negligibly small.

ANDREW ALFORD.