March 14, 1933. C. S. FRANKLIN 1,901,025

AERIAL

Filed Aug. 17, 1927

Fig. 2

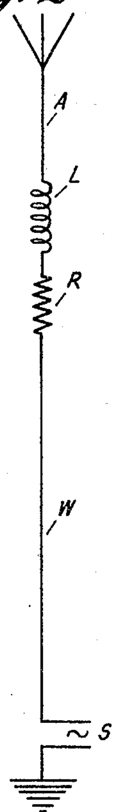


Fig. 3

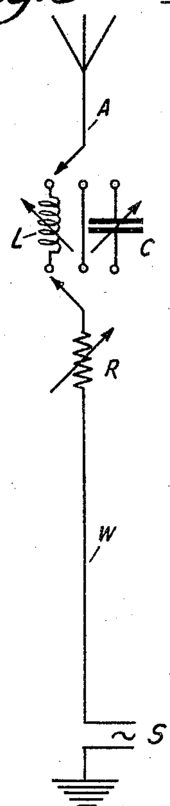


Fig. 4

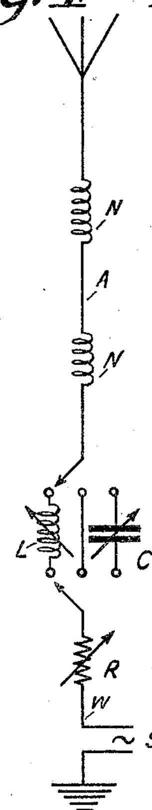


Fig. 5

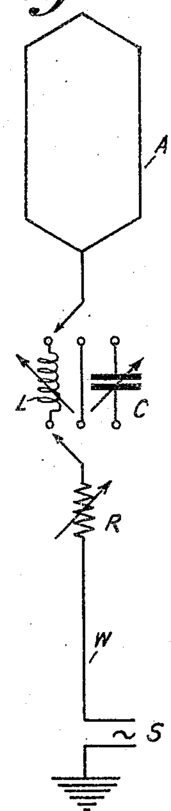
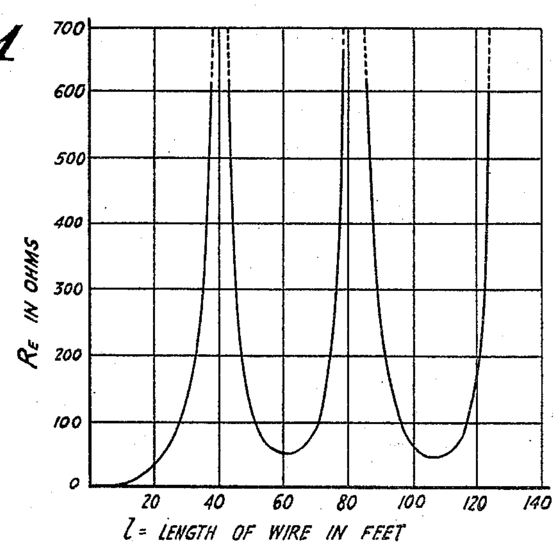


Fig. 1



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UNITED STATES PATENT OFFICE

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AERIAL

Application filed August 17, 1927, Serial No. 213,450, and in Great Britain September 8, 1926.

This invention relates to aerials for use in wireless telegraphy and telephony, and is particularly applicable to aerials intended to be operated on short wave lengths.

In order that the invention may be the more readily understood, there will now be explained certain of the phenomena which occur when an alternating potential, of simple harmonic form, is applied to one end of a wire, the other end of which is insulated or open ended.

It should be understood that the following description of phenomena is given purely by way of explanation, and that, while it is substantially accurate, the invention is not dependent upon the absolute accuracy or otherwise thereof.

When a wire of length less than a quarter wave length, insulated at one end, has applied to its other end an alternating potential of simple harmonic form, the said wire may be regarded as equivalent to a condenser in series with a resistance connected across the generator of the applied potential, the value of the condenser and resistance being a function of the actual length of the wire and its local surroundings. If the wire is substantially a quarter wave length long, it becomes equivalent to a pure resistance connected across the generator, and of value dependent inter alia upon the radiation resistance and the local surroundings. This value of resistance may easily be much lower than the surge impedance of the wire, as expressed by the form

$$\sqrt{\frac{L}{C}}$$

using the usual symbols.

If the length of wire be between a quarter and a half wave length, the wire may be regarded as equivalent to an inductance in series with a resistance connected across the generator, the value of the resistance increasing with the length. When the wire is substantially half a wave length, it is again equivalent to a pure resistance connected across the generator, the value of the said resistance being again determined by the radiation resistance of the wire and by its local surroundings. In this case the value of the resistance will generally be much higher than the surge impedance of the wire.

For lengths between half and three quarters of a wave length, the wire is again equivalent to a condenser in series with a resistance across the generator, and for lengths between three quarters and one wave length, it becomes equivalent to an inductance in series with a resistance.

In general, at one quarter, three quarters, five quarters etc. wave lengths, the wire may be regarded as equivalent to a resistance less than the surge impedance of the wire, and at a half, one, one and a half etc. wave lengths, the wire becomes equivalent to a resistance higher than the surge impedance of the wire. As the wire is made longer and longer, the resistance values gradually approach the surge impedance of the wire. If the wire be earthed at the far end, it becomes equivalent to a series of high resistances at a quarter, three quarters, five quarters, etc. wave lengths, and as a series of low resistances at lengths of a half, one, one and a half waves.

According to this invention there is inserted in an aerial at any point where the apparent resistance is equal to or lower than the surge impedance, a resistance of such value as to make the total resistance equal to the surge impedance and an inductance or condenser of such value as to neutralize the effective capacitative or inductive reactance of the wire.

It has been found that when such a resistance and/or reactance is inserted in an aerial, however much the length of this aerial may be increased between the point of insertion and the generator, the said aerial appears equivalent at the generator to a resistance equal to the surge impedance, provided, of course, that the constants of the said aerial are not substantially affected by local surroundings.

In such an arrangement, energy flows along the wire from the generator to the point where the resistance and/or reactance are inserted, and is substantially completely absorbed by the resistance and by radiation from the part beyond, so that substantially no reflection occur back along the wire. It would appear, therefore, that the energy supplied is dissipated in three ways. First, a certain amount is radiated from the wire between the generator and the point of insertion of the reactance and/or resistance. Second, a certain amount is absorbed by the resistance. Third, the remaining amount is dissipated in radiation from the part beyond and in any resistance in this part. The relative proportions of the energy so dissipated may be varied between wide limits by the relative lengths of wire before and beyond the point where the compensating reactances and/or resistances are inserted.

If the point of insertion selected is such that the apparent equivalent resistance at this point is equal to the surge impedance of the wire, then it is necessary to insert only capacity or inductance so that there is no dissipation of energy in resistance beyond that due to the resistance of the wire itself.

The invention may be employed in two general ways.

First, the part beyond the point where compensation is inserted may be short and therefore possess only negligible radiative properties, whilst it ohmic resistance may be considerable. The part before this point may be any desired length. This form provides in effect a so-called "Beverage" or wave aerial but has the important advantage over known wave aerials that as no physical earth of the part beyond the point of compensation need be provided, it can be erected vertically or at any angle desired.

Second, the part beyond the point where compensation is inserted may be long and have large radiating power. In this form the energy dissipated by radiation from the part before the point of compensation need only be small compared with the energy radiated by the part beyond. The first mentioned part in effect is then simply a feeder of energy to the main radiating second mentioned part, and enables the second part to be erected at considerable heights above the earth, whereby improved efficiency and reduced earth losses may be obtained. Further, the part beyond the point of compensation need not be merely a plain wire, but may be of any desired form, and may also contain impedances adapted, for example, to give improved directional effects.

The part beyond the point of compensation may, if desired, be earthed, the compensation being adjusted to suit, as explained above.

Any combination of the above two general ways of using the invention may be employed.

Again, a number of such aerials may be employed in combination with or without reflecting systems to obtain directional effects.

A more complete understanding of the invention will be had from the following description when read in connection with the annexed drawing in which;

Fig. 1 is a curve showing the relation between the effective resistance of a wire and its length.

Fig. 2 shows the invention applied to an antenna of a quarter wave length or less.

Fig. 3 shows the invention applied to an antenna the length of which is between a quarter and a half wave length or between three quarters and one wave length and so on.

Fig. 4 shows the invention applied to an aerial of considerable length compared to the wave length, and

Fig. 5 shows the invention applied to an aerial a part of which is composed of a plurality of wires in parallel.

The changes in effective resistance are illustrated in the curve shown in Figure 1, the ordinates representing the measured effective resistance in ohms of a wire having a surge impedance approximately of 400 ohms and energized on a wave length of 86 feet.

The abscissæ represent lengths of wire in feet, and as will be seen the effective resistance varies from low values of the order of 50 ohms at a quarter, three quarters, five quarters . . . wave lengths to values of the order of 1000 ohms or more at half, one, one and a half, . . . wave lengths.

Referring to Figure 2, A is a wire of a quarter wave length or less and L an inductive reactance of such value as to compensate for the effective capacitative reactance of the wire A. If the said wire be of effectively a quarter wave length, the inductance L will be of course of zero inductive reactance. R is a resistance of such value as to make the effective total impedance of inductance L and wire A equal to the surge impedance of the wire W, which may be of any desired length and which is connected at its base to a source S of high frequency energy.

If desired, the component impedances L and R may be combined together in a single coil.

In the modification shown in Figure 3, C is a condenser which may be connected in circuit in place of the inductance L to balance the reactance of the wire A when the said reactance is inductive i. e. the length of the wire A is between a quarter and a half wave length or between three quarters and one wave length . . . and so on.

In the modification shown in Figure 4, the aerial A is of considerable length compared to the wave length, radiation being suppressed or reduced from alternate half wave lengths thereof by forming the said half wave lengths or parts thereof by inductance coils N.

In the modification shown in Figure 5, the part A of the aerial is constituted by a plurality of wires in parallel. As has been hereinbefore stated, the effective resistance of a wire half, one, and one and a half . . . wave lengths long will generally be a resistance much higher in value than the surge impedance of the wire. By employing a number of wires in parallel the surge impedance can be considerably reduced as also can be the effective resistance of half, one, one and a half . . . wave lengths of the wire. A special case, therefore, arises, in which, by employing as the wire W a thin wire having a high surge impedance, and by utilizing for the part A a plurality of wires sufficiently spaced, the effective resistance of the part A for half, one, one and a half . . . wave lengths may be made equal to the surge impedance of the wire W without providing separate compensating resistances or reactances, i. e. the parts L, C, R, may be dispensed with as separate entities.

In carrying out the invention in practice, rigidly exact compensation is not necessary, and it has been found that compensation sufficiently exact to permit about, say, 10% of the wave to be reflected, is accurate enough for most practical purposes.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In a system for transmitting intelligence from one geographically situated point to another by propagated electromagnetic waves derived from the flow of high frequency undulatory electrical currents acted upon in accordance with the intelligence to be transmitted, an antenna system grounded at only one end comprising a radiator element less than one-quarter wave length long, a single wire for connecting high frequency apparatus thereto, and, the series combination of an inductance and a resistance between the wire and element, the inductance having a value such as to neutralize the capacitive reactance of the radiator element, and the resistance having a value such that it together with the inductance and radiator element terminates the wire by an impedance equal in value to the surge impedance of the wire.

2. In a system for transmitting intelligence from one geographically situated point to another by propagated electromagnetic waves derived from the flow of high frequency undulatory electrical currents acted upon in accordance with the intelligence to be transmitted, an antenna system grounded at one end only comprising a linear radiator of a length lying between an odd number and the next higher even number of quarter wave lengths, a single wire for connecting the radiator to high frequency apparatus, and, a resistance and a condenser connected between the wire and radiator, the condenser having a value sufficient to neutralize the inductive reactance of the radiator, and the resistance having a value such that it together with the condenser and radiator terminates the wire by an impedance equal in value to the surge impedance of the wire.

3. In a system for transmitting intelligence from one geographically situated point to another by propagated electromagnetic waves derived from the flow of high frequency undulatory electrical currents acted upon in accordance with the intelligence to be transmitted, an antenna system grounded at one end only comprising a radiator greater than one-quarter wave length in length, a single feed wire, a reactor and a resistance in series connecting said radiator to said feed wire, said reactor being of a value such as to neutralize the reactance of said radiator, and said resistance being of a value such that it together with the reactor and radiator terminates the wire by a resistance equivalent in resistance to the surge resistance of the wire.

4. An aerial system for wireless communication comprising an antenna connected to ground at one end only, said antenna comprising a first portion and a second portion connected together, one of said portions consisting of a single wire having a surge impedance equivalent to the effective resistance of said other portion to which it is connected, said single wire portion being adapted to supply high frequency energy to said other portion.

5. An aerial system for wireless communication comprising an antenna connected to ground at one end only, said antenna comprising a single wire feeder connected to an absorbing arrangement, said arrangement including a radiating element and a resistance element, both said elements having a combined effective resistance equivalent to the surge impedance of said single wire feeder.

6. An aerial system for wireless communication comprising an open ended radiating element and a single feeder wire of any length connected thereto, in which the effective resistance of the radiating element is made substantially equal to the surge impedance of the wire, and compensating arrangements including a reactance inserted intermediate said single feeder wire and said radiating element of such a value as to counteract the effective reactance of said element.

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