Nov. 16, 1937. P. S. CARTER 2,099,296

APERIODIC ANTENNA

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Fig. 1

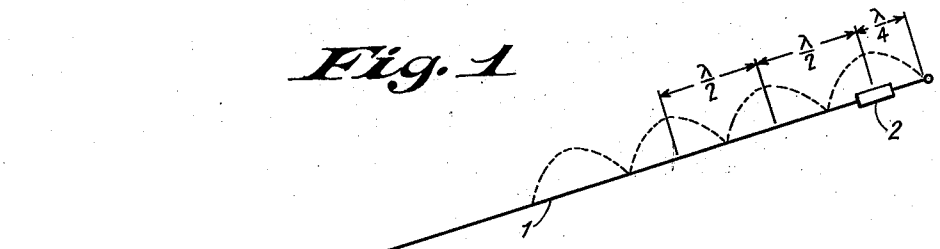


Fig. 2

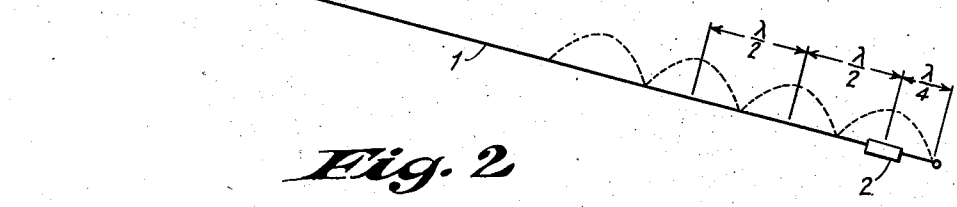


Fig. 3

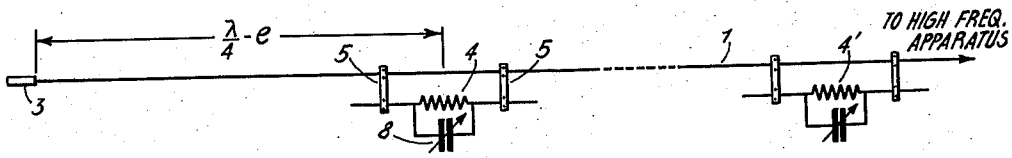


Fig. 4

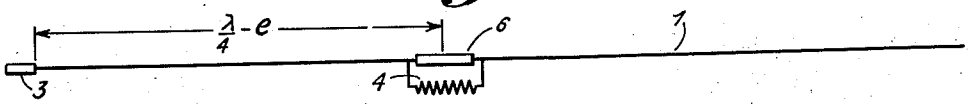


Fig. 5

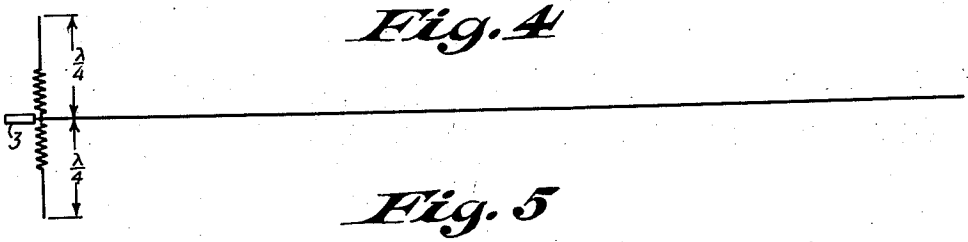
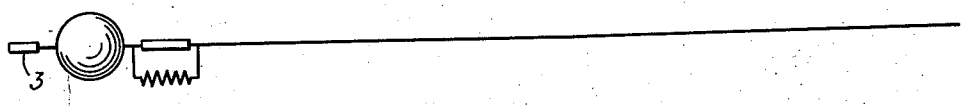
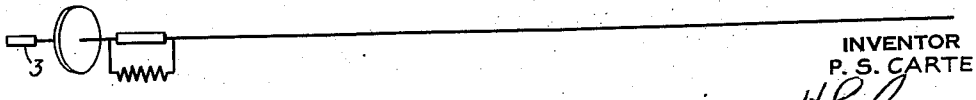


Fig. 6





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Fig. 7

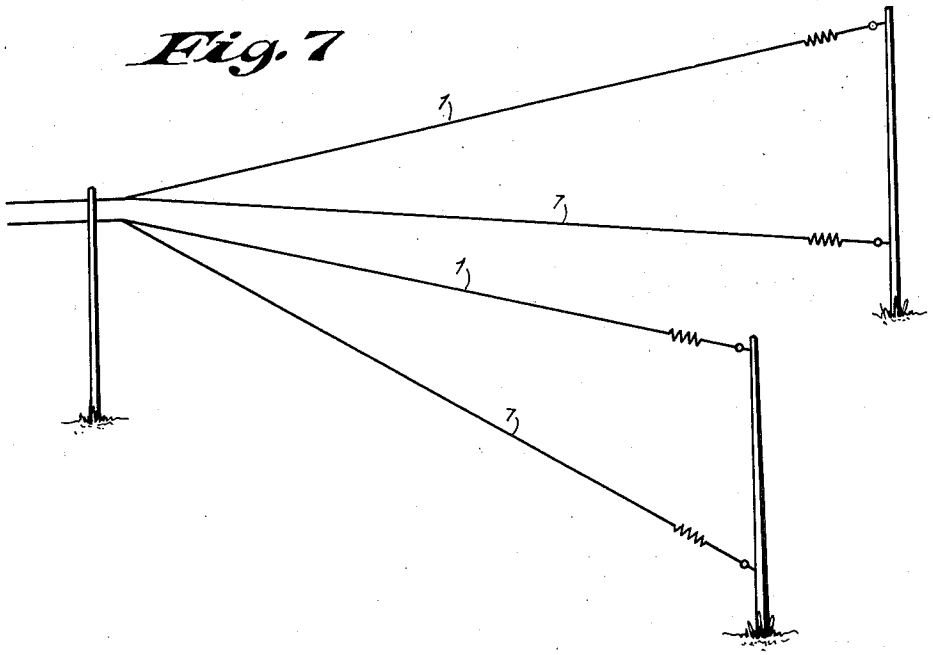
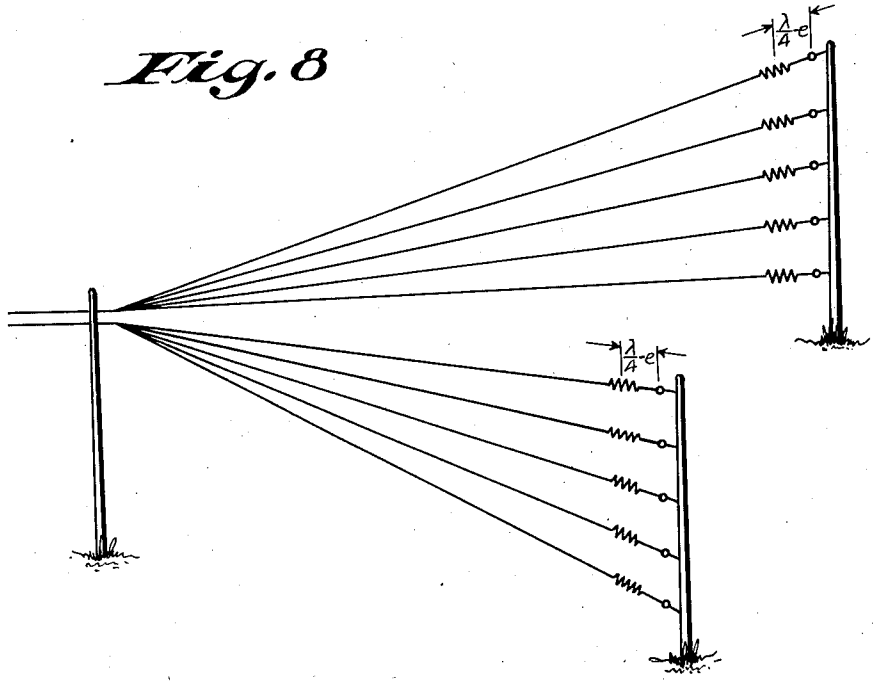


Fig. 8



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APERIODIC ANTENNA

Philip S. Carter, Rocky Point, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application December 23, 1933, Serial No. 703,801

10 Claims. (Cl. 250—33)

This invention relates to aperiodic antennae, and particularly to such of these which are of the open-ended type.

The ordinary type of antenna as known in the art presents an impedance to the load which varies widely as the frequency varies throughout a band. In communication with short waves around three meters, particularly in television where the frequency band width is of the order of 1,500,000 cycles, a variation in impedance with change in frequency results in picture distortion, as a consequence of which it has been found to be highly desirable to obtain an antenna whose impedance remains constant over a wide range of frequencies. An aperiodic antenna, it is known, possesses this desirable characteristic since it eliminates any distortion which may be due to antenna tuning.

It is therefore an object of the present invention to provide in a simple and convenient manner ways and means by which an open-ended antenna may be made to have a flat frequency band characteristic.

A further object is to provide an open-ended antenna which is both aperiodic and unidirectional in nature.

In general, these objects are attained by the provision of an energy or power absorbing device in the open-ended antenna, preferably in the form of a resistance.

A feature of the invention is a transmitting antenna which may be made to be unidirectional without the use of a reflecting system. This is effected by the dissipation of part of the power in the system in resistances which are connected near the end or ends of the transmitting antenna nearest the receiving station and/or by special design of the radiating arrangement whereby there is obtained high attenuation by radiation.

Other objects and features will appear in the subsequent detailed description which is accompanied by drawings wherein Figure 1 shows an antenna of the V type provided with an arrangement in accordance with the invention for making it aperiodic; Figures 2 to 6 show various structures for accomplishing the invention; and Figures 7 and 8 show means for increasing the efficiency of systems constructed in accordance with the invention whereby the amount of power dissipation in the aperiodic antenna system is reduced.

Although the invention will be described with particular reference to a V type antenna structure it is to be understood, of course, that it is not limited thereto, since it is applicable to all types of transmitting and receiving antenna structures.

Referring to Figure 1, there is shown, by way of example only, an antenna of the V type comprising essentially a pair of wires 1, 1 which are a plurality of half wave lengths long and angularly disposed with respect to each other. These wires in the ordinary V structures are so energized that standing waves are caused to exist on the wires in phase opposition whereby there is obtained a radiation characteristic predominantly along the direction of the plane of the bisector of the angle of the conductors. For unidirectional radiation it has been customary to provide a similar structure composed of wires parallel to the wires in the first structure and spaced away an odd number of quarter wave lengths measured in a direction along the bisector of the angle along the conductors. Such an arrangement is adequately described in my United States Patent No. 1,974,387, granted September 18, 1934.

Various methods have been proposed in the past for reducing the reflection of the waves on the antenna wires which cause the presence of standing waves, such as by the use of a resistance between the antenna wires and ground. However, in the case of a short wave transmitting antenna it is not feasible to avoid standing waves by closing the open ends of the antenna wires with resistances because of the excessive losses which result. Another method of reducing the standing waves by radiating as much as possible the energy fed to the antenna is described in United States Patent 1,927,522, granted September 19, 1933 to N. E. Lindenblad, wherein there is described a system comprising a plurality of pairs of diverging conductors arranged end to end so as to radiate accumulatively.

According to the present invention, traveling waves are achieved and the antenna is made substantially aperiodic over a wide range of frequencies and unidirectional in character by providing, at or near the far end of the antenna wire or wires, one or more power absorbing circuit means for dissipating power. These circuit means, indicated as 2 in Figure 1, may take any of the forms illustrated in Figures 2 and 3, or, if located substantialy at the open end of the antenna, may take any of the forms illustrated in Figures 4, 5 and 6, although it is preferred to employ the method of power dissipation shown in Figure 2.

In Figure 2 there is illustrated an antenna wire 1 whose open end is connected to the usual suspension support, not shown, through an insulator 3. A power absorbing resistance 4 of any

convenient form shunts out a portion of the antenna wire at a point where the current is a maximum in the wire which is at a distance equal to

$$\frac{\lambda}{4}-e$$

from the end of the wire, where λ is the length of the communication wave for the mean frequency of the band over which the antenna is adapted to function and e an end correction for a particular condition. The end effect is usually caused by the capacity of the insulator **3** and the ordinary end condition of the antenna which makes the current maximum point somewhat less than a quarter wave length from the open end of the wire. Since the current maximum points occur at distances which are an odd multiple of a qarter wave length from the open end of the wire, as shown in Figure 1, it is desirable, in order to absorb as much as possible of the power, to place at least one other absorbing resistance in the wire, and these may be located at substantially any odd multiple of a quarter wave length of the mean frequency from the open end, as indicated in Figure 2 by the resistance **4'**. The length of the portion of the antenna shunted by the resistance **4** may be adjusted by varying the distances between the two vertical clamping strips **5** which are in contact both with the antenna and the resistance. This shunted portion of the antenna forms part of a closed circuit including vertical strips **5** and horizontal resistance **4** and associated terminal connections. For a given frequency, the total voltage induced in this closed circuit is proportional to the area enclosed by the closed circuit, and the amount of current flowing through resistance **4** depends upon the voltage and the effective impedance of the closed path. The value of resistance **4** may vary within wide limits depending upon the type of antenna and the frequency of the working wave. A small variable condenser **8** serves to compensate for the inductance formed by the loop comprised of the resistance, the metallic strips and the shunted portion of the antenna.

The principles underlying the invention will be readily understood from a knowledge of transmission line theory, it being well known that the impedance of a wire having an effective length of

$$\frac{\lambda}{4}$$

is very nearly zero. Since the larger portion of the total energy is associated with the primary wave which follows transmission line laws, it will be appreciated that the quarter wave section of wire beyond the loading resistance acts like a short circuit just beyond the resistance and makes possible the absorption of nearly all of the energy associated with the primary wave in the resistance. With proper adjustment little or no reflection will take place at the far end and the antenna will become aperiodic and unidirectional.

Figure 3 shows another method of loading. Here a variable resistance of convenient form shunts an insulator **6** placed at a distance of

$$\frac{\lambda}{4}-e$$

from the far end.

In Figure 4 two resistances are placed in series with two quarter wave wires pointing in opposite directions and perpendicular to the antenna wire. This arrangement causes the radiation from the quarter wave segments to be negligible inasmuch as the currents flow in opposite directions in the two branches.

Figure 5 shows the antenna wire terminated through a resistance to a sphere, and Figure 6 through a resistance to a disc. Both disc and sphere form low capacity reactances. The arrangements of these two figures are for the purpose of obtaining as high a capacity as possible in order that the current at the end of the antenna be high. In such case the resistance will absorb power. The distance of the sphere or disc and resistance from the open end of the antenna and the insulator **3** is not important in this case, but ordinarily this distance will be very short.

As set forth above, the larger portion of the field energy may be considered as associated with a primary wave following ordinary transmission line laws. The remaining energy, which is responsible for radiation, is associated with a number of secondary waves. If the ratio between the energies of the primary and the secondary waves can be decreased, the amount of power dissipation necessary to give an aperiodic antenna system will be reduced. This may be accomplished by fanning the wires **1**, **1** by a number of other wires **7**, **7** as shown in Figure 7, as a consequence of which there is obtained a decreasing characteristic impedance to the primary wave as the latter approaches the far end of the antenna. The radiation resistance undergoes little change over that for a single pair so that the ratio of power radiated to power dissipated is greatly increased.

Figure 8 shows an arrangement similar to Figure 7 with the addition of a greater number of fanning wires.

Although the systems herein described in connection with the present invention are inherently unidirectional, it may be advantageous in many cases to employ energized or floating reflectors which when used increase the concentration of radiation and decrease the amount of power dissipation.

By the term "odd multiple of a quarter wavelength" as used in the appended claims is meant any odd multiple including one-quarter of a wavelength.

I claim:

1. The combination with an open ended antenna adapted to function over a range of frequencies which is long relative to the wave length and whose radiating structure is devoid of concentrated reactance, of a power absorbing device in the form of a resistance shunting a portion of said antenna, said resistance being located at or near a point substantially an odd multiple of a quarter wave length of the mean frequency of said range from the open end, whereby said antenna is rendered substantially aperiodic over said range and substantially unidirectional in character.

2. The combination with an open ended antenna adapted to function over a relatively wide range of frequencies which is long relative to the working wave length, of a plurality of power absorbing devices in the form of resistances in circuit with said antenna, each of said resistances being located at different points substantially an odd multiple of a quarter wave length of the mean frequency of said range from the open end,

whereby said antenna is rendered substantially aperiodic over said range.

3. In combination with an open ended antenna adapted to function over a range of frequencies which is long relative to the wave length, of a power absorbing device in the form of a resistance shunting a portion of said antenna, said resistance being located at or near a point substantially an odd multiple of a quarter wave length of the mean frequency of said range from the open end, and a small compensating condenser connected in parallel to said resistance, whereby said antenna is rendered substantially aperiodic over said range.

4. In combination with an open ended antenna adapted to function over a range of frequencies which is long relative to the working wave length, of a power absorbing device in the form of a resistance located at or near a point substantially an odd multiple of a quarter wave length of the mean frequency of said range from the open end, said resistance being arranged to serially connect, electrically, different sections of said antenna, and an insulator in shunt of said resistance, whereby said antenna is rendered substantially aperiodic over said range of frequencies.

5. The combination with an open ended antenna adapted to function over a range of frequencies comprising a pair of wires which are long relative to the working wave length and angularly disposed with respect to each other, said wires being open at one of their adjacent ends, of a power absorbing device in the form of a resistance serially arranged in each of said wires and located substantially a quarter of the wavelength of the mean frequency of said range from the open end thereof, whereby said antenna is rendered substantially aperiodic over said range of frequencies.

6. The combination with an open ended antenna adapted to function over a range of frequencies comprising a pair of wires which are long relative to the working wavelength and angularly disposed with respect to each other, said wires being open at one of their adjacent ends, of a power absorbing device in the form of a resistance serially arranged in each of said wires and located substantially an odd multiple of a quarter of the wavelength of the mean frequency of said range from the open end thereof, whereby said antenna is rendered substantially aperiodic over said range of frequencies.

7. The combination with an open ended antenna adapted to function over a range of frequencies comprising a pair of wires which are long relative to the working wave length and angularly disposed with respect to each other, said wires being open at one of their adjacent ends, of a power absorbing device in each of said wires located substantially a quarter of the wavelength of the mean frequency of said range from the open end thereof, said device being in the form of a resistance arranged in series with its associated wire, and another similar pair of angularly disposed open ended antenna wires extending in the same general direction as said first pair, each wire of said last pair being in the same vertical plane with one of the wires of said first pair, the ends of said wires of both pairs in the same plane remote from said open ends converging and being directly connected together, whereby said antenna is rendered substantially aperiodic over said range of frequencies.

8. The combination with an open-ended antenna adapted to function over a range of frequencies which is long relative to the working wave length, of a plurality of power absorbing devices in the form of resistances each in shunt with a different portion of said antenna, each of said resistances being located at different points substantially an odd multiple of a quarter wave length of the mean frequency of said range from the open end, whereby said antenna is rendered substantially aperiodic over said range.

9. The combination with an open-ended antenna adapted to function over a relatively wide range of frequencies comprising a pair of wires which are long relative to the working wave length and angularly disposed with respect to each other, of a power absorbing device in each of said wires located substantially near the open end thereof, said device being in the form of a resistance arranged in shunt with a portion of said wires, said resistances being located at points substantially an odd multiple of a quarter wave length of the mean frequency of said range from the open ends of said wires.

10. The combination with an open ended antenna adapted to function over a relatively wide range of frequencies, said antenna being long relative to the working wavelength, of a power absorbing device in the form of a resistance in circuit with said antenna, said resistance being located at a point an odd multiple of a quarter wavelength of the mean frequency of said range from the open end, whereby said antenna is rendered substantially aperiodic over said range.

PHILIP S. CARTER.