

July 7, 1931.

E. BRUCE

1,813,143

AERIAL SYSTEM

Filed Nov. 25, 1927

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FIG. 1.

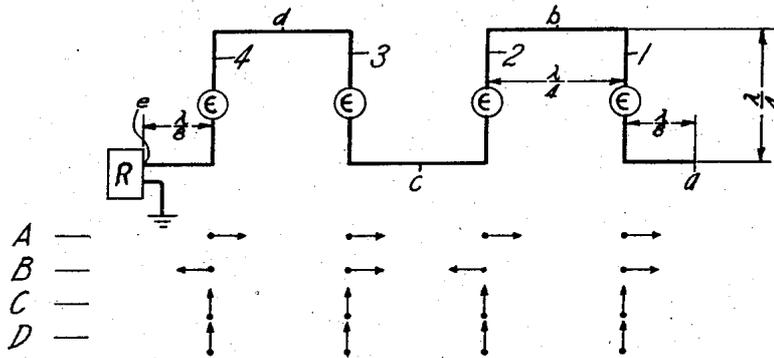


FIG. 2.

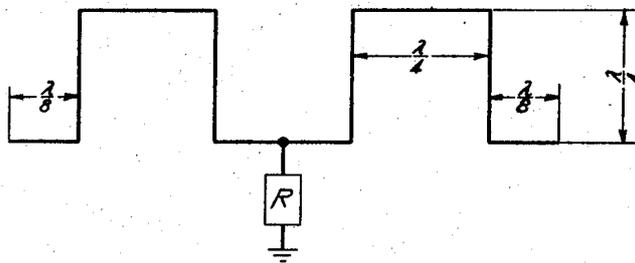
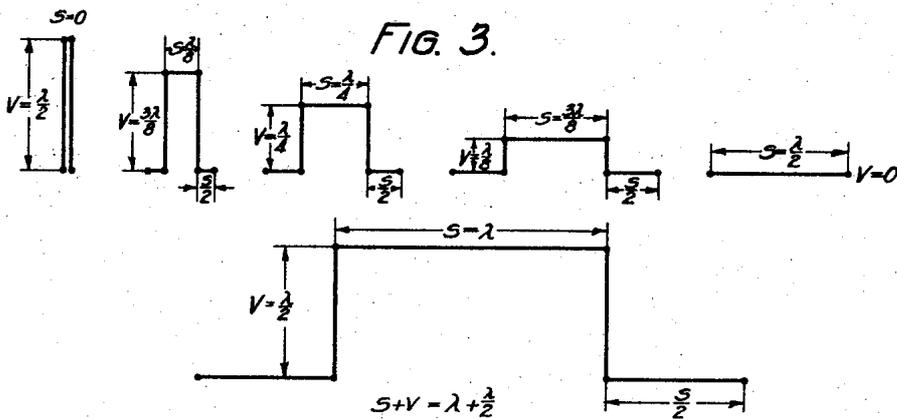


FIG. 3.



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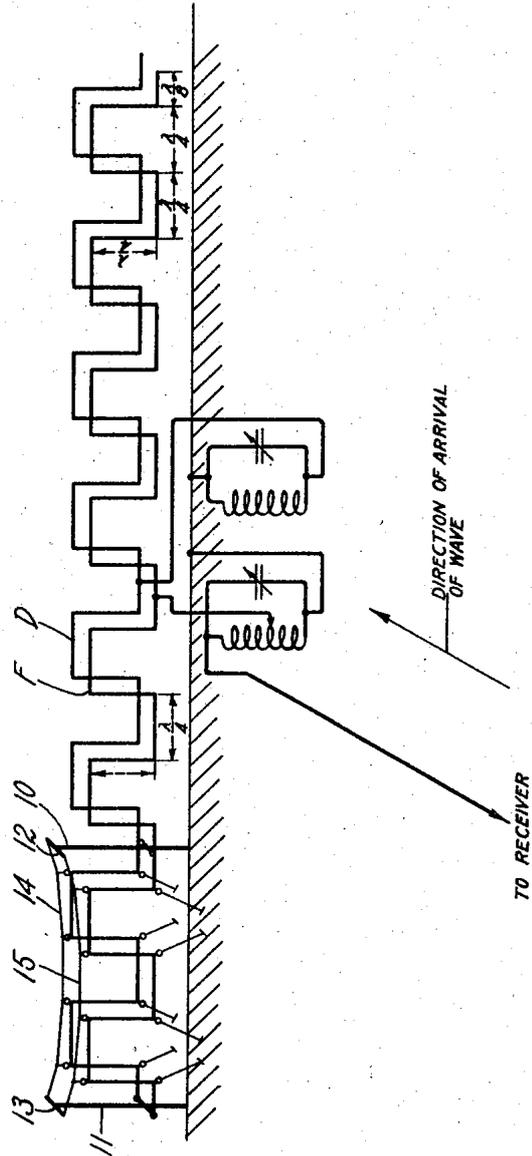
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FIG. 4.



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## AERIAL SYSTEM

Application filed November 25, 1927. Serial No. 235,464.

This invention relates to wave transmission and more especially to aerial systems arranged broadside with respect to the direction of propagation of radiant energy waves.

It is an object of this invention to provide an aerial system for space propagated waves which will be simple and economical in construction, highly efficient in operation, and have a good directional characteristic.

It has heretofore been proposed to provide a uni-directional broadside aerial system as disclosed, for example, in British Patent 243,706, May 6, 1926. This aerial system comprises a reflector or reradiating unit and an antenna unit, each consisting of a series of vertical wires to constitute active elements which are connected together by a transmission line having an apparent infinite transmission velocity. Because the energy supplied to the antenna unit is propagated therein at an apparent infinite velocity, the currents in the active elements are in phase with each other.

According to the present invention, the aerial system consists of an antenna unit and a reflector or reradiator unit which are identical in form, are arranged in parallel planes, and are spaced from each other a definite fraction of a wave length. The units consist of a series of active elements whose length has a definite relation to the wave length to be received or propagated and have their corresponding ends alternately connected together by non-active leads, also having a length bearing a definite relation to the wave length, to constitute a zig-zag grid structure with 90° angles at the junction points of the active elements and non-active leads. The reflector or reradiator is spaced from the antenna an odd multiple of one quarter of a wave length.

Because of the physical dimensions of the antenna, energy supplied thereto by a local source for radiation, or derived from a wave incident thereupon, produces in the active elements currents which are in phase with each other.

The antenna and reflector cooperate to

give the aerial system a uni-directional characteristic.

An antenna having the same general form as the antenna of the present invention but having different dimensions is described in applicant's copending application, Serial No. 173,833, filed March 9, 1927.

The invention will be better understood from the following description taken in connection with the attached drawing forming a part thereof and in which:

Fig. 1 is a schematic illustrating one design of antenna (without a reflector) and vectors of the currents and voltages produced in the active elements by an incoming wave;

Fig. 2 is similar to Fig. 1, but with the transmitting or receiving set connected at the middle instead of at the end;

Fig. 3 shows other arrangements which will produce the same results; and

Fig. 4 shows schematically an aerial system comprising an antenna and reflector and a means of supporting the same.

Referring particularly to Fig. 1, there is shown, by way of example, an antenna consisting of a series of active and non-active elements connected to a receiver R. The corresponding ends of the active elements are connected together by the non-active elements. In this figure both the active and non-active elements are one quarter of a wave length long. An active element is one which serves to effect the translation of the energy of a wave, incident upon the antenna, into energy which is supplied to the receiver, whereas a non-active element does not operate to effect such translation, but merely functions to transfer energy from one active element to the other.

Below each active element is shown the vectors for voltages and currents at a given time  $t$ , for an ideal lossless line when the radiant wave is propagated in a direction perpendicular to the plane of the antenna. Row A represents the phases of the voltages induced by the wave. As is well known these voltages are all in the same direction. The wire voltage phases, however, which are

represented in row B are  $180^\circ$  apart in adjacent active elements.

The resultant voltages induced in each active element may be considered as concentrated at the middle of the vertical, since the resultant of the voltages in each elemental part of the active element has the same phase as the voltage in the middle element. Assume the voltage in each active element to be at  $\epsilon$ . The wire distance between points  $\epsilon$  in adjacent active elements is

$\frac{\lambda}{2}$  where  $\lambda$  is the wave length. Therefore,

when the current due to the voltage in active element 1 reaches  $\epsilon$  in active element 2 the current due to the voltage then impressed by the succeeding half space wave in active element 2 will be in phase with it. This condition is represented in row C which shows the currents at the receiving set R directly propagated by the active elements.

The currents due to free end reflection arriving at R will also be in phase as represented in row D. This will be apparent by considering point  $\epsilon$  in active element 1. The

wire length from  $\epsilon$  to the free end is  $\frac{\lambda}{4}$ .

Therefore, with the  $180^\circ$  phase change due to reflection, the reflected current will be in phase at  $\epsilon$  with that due to the next succeeding half space wave. For waves propagated in a direction other than perpendicular to the plane of the antenna, these conditions will not hold, and the strength of the currents arriving at R will decrease as the direction of the waves departs from the perpendicular.

Since standing waves ideally cause current nodes at wire distances which are integral multiples of one half the wave length

$\left(\frac{\lambda}{2}\right)$  measured from the open end, current

nodes in Fig. 1 occur at points  $a, b, c, d$  and  $e$ . It will at once be evident that the undesired reradiation from the non-active members will be annulled in all directions perpendicular to these members. The reradiation in all other directions will be negligible, because of the reduced effective length of a non-active member in these directions, as well as because the current magnitudes which exist in these members are low.

The preceding description applies in a similar manner to an antenna of this form, used for transmission instead of reception. In this case the receiver R is replaced by a suitable transmitter apparatus and the active elements serve to translate the locally supplied energy into radiant wave energy. The non-active elements function to conduct locally supplied energy to the different active elements and no appreciable power will

be consumed in horizontally polarized radiations.

Obviously, the antenna system shown to the right of R in Fig. 1 may be duplicated at the left with an improvement in the directional characteristic. Such an arrangement is illustrated in Fig. 2. The voltage and current conditions illustrated and explained in connection with Fig. 1 hold for the antenna of Fig. 2. The improved directional characteristic is due to the symmetry of the system. As pointed out above in connection with Fig. 1, the undesired reradiation from the non-active elements is negligible. In the form shown in Fig. 2 this reradiation is nullified, since that occurring to the left of the set is opposed to that occurring to the right of the set.

Other lengths of the active elements and spacings therebetween, than those indicated in Figs. 1 and 2, may be used to obtain the proper phase relationship required for broadside reception and propagation. Dimensions for the heights of active elements and spacing between them may be chosen within a wide range, as long as they satisfy the equations

$$\frac{\lambda}{2} = S + V \text{ and } n\lambda + \frac{\lambda}{2} = S + V$$

where  $\lambda$  is the wave length, S the spacing between active members, V is the height of an active member, which should not exceed  $\frac{\lambda}{2}$  and where  $n$  is any integer. Examples of aerial systems conforming with the above principles are illustrated in Fig. 3.

The aerial systems described above are bi-directional and to obtain an aerial system having a uni-directional characteristic, a reflector or reradiator is used.

A uni-directional aerial system is shown in Fig. 4 in which an antenna F and a reflector or reradiator D are shown. The reflector has the same form and dimensions as the antenna and is spaced back of it, with reference to the direction of wave propagation, an odd multiple of one quarter of a wave length. It is to be understood that the integer "one" is considered an odd multiple. The reflector is equally efficient in either transmitting or receiving.

The mid-point of the antenna is connected to ground through a resonant circuit which may be tuned and the signal wave is conducted to or from the antenna by means of a one wire transmission line. The reflector is connected to ground through a similar resonant circuit which may also be tuned. The reflector, however, is not connected to the receiving or transmitting set.

The resonant circuit connected to the reflector has been found effective in making adjustments to minimize back end effects,

especially those due to atmospheric disturbances.

Various methods may be used for supporting the aerial system, one of which is shown in connection with a part of the system of Fig. 4. As illustrated two vertical poles 10 and 11 of sufficient height to support the antenna above ground, have cross arms 12 and 13 at least one quarter of a wave length long to give the proper spacing between the antenna and reflector. Ropes or cables 14 and 15 extend between corresponding points of the cross arms, and the antenna and reflector are supported therefrom by means of short lengths of rope or cable and strain insulators in any well known manner.

The lower part of the system is maintained in position and prevented from swaying by means of ropes or cables properly insulated therefrom and anchored in the ground substantially as shown. Other means, such as a fixed framework may also be used to support the aerial system.

It is to be understood that, whereas in the above description the aerial system is described as lying in a vertical plane with its major axis horizontal, the system may be mounted with its major axis vertical.

What is claimed is:

1. A uni-directional broadside aerial system comprising an antenna and a reflector, identical in form, mounted in parallel planes separated by an odd multiple of a quarter wave length, said antenna and said reflector comprising a series of active elements having corresponding terminals of adjacent elements alternately connected by non-active elements, the sum of the length of each active element and the spacing between adjacent active elements being an odd multiple of half a wave length.

2. A broadside aerial system in accordance with claim 1 characterized in this, that the free non-active elements have a length equal to one half the wave distance between the mean points of the active elements.

3. A broadside aerial system in accordance with claim 1 characterized in this, that the wire distance between a point on one active element and the corresponding point on another active element in the system is an odd multiple of half a wave length.

4. An antenna comprising a coplanar series of substantially vertical linear conductors and substantially horizontal linear conductors alternately connecting corresponding terminals of the vertical conductors, so as to constitute the whole, a single series circuit of generally zigzag form, the lengths of the respective vertical and horizontal conductors being such that the sum of each adjacent pair of them is an odd multiple of a half wave length of the wave operated on.

5. The antenna in accordance with claim 4 characterized in this, that the vertical and horizontal conductors have equal lengths.

In witness whereof, I hereunto subscribe my name this 23 day of November A. D., 1927.

EDMOND BRUCE.

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