March 26, 1940. M. KATZIN 2,194,554

DIRECTIVE ANTENNA SYSTEM

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Fig. 1

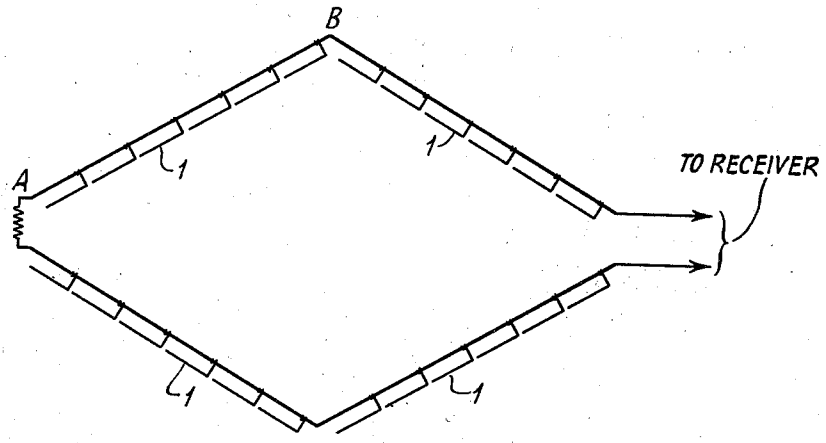



Fig. 2

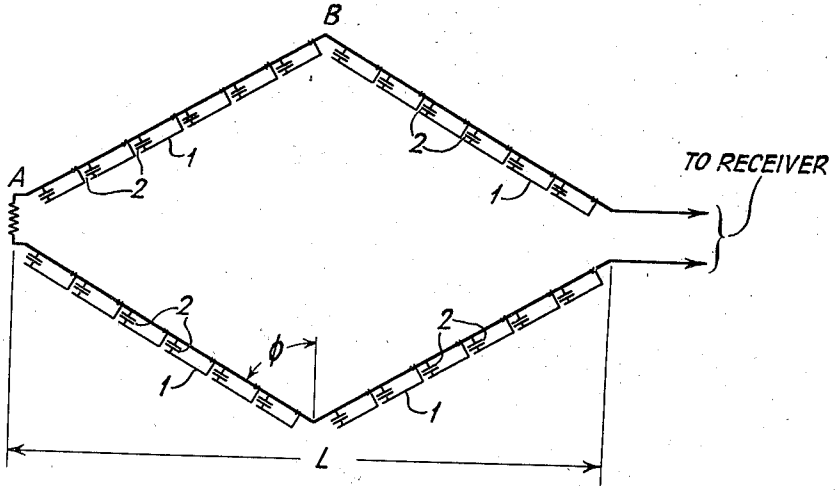
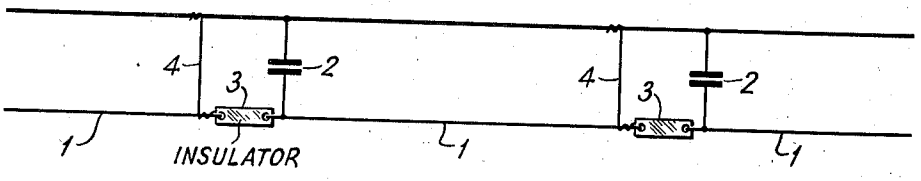



Fig. 3




INVENTOR.
MARTIN KATZIN

BY

ATTORNEY.

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Fig. 4

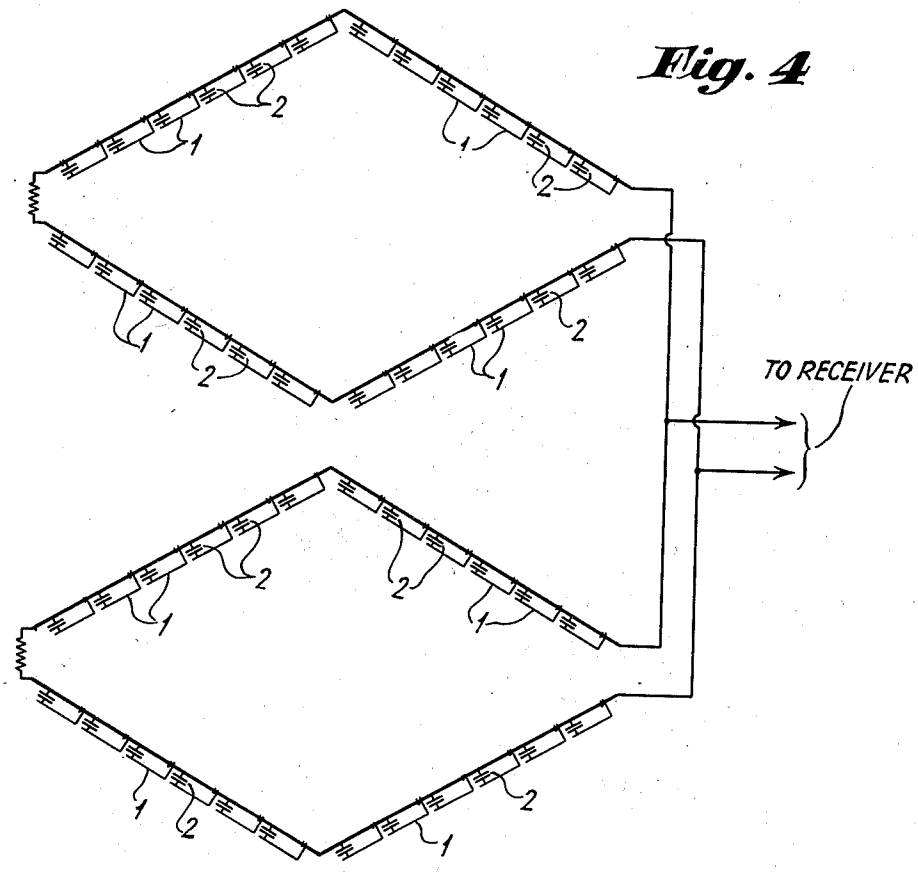
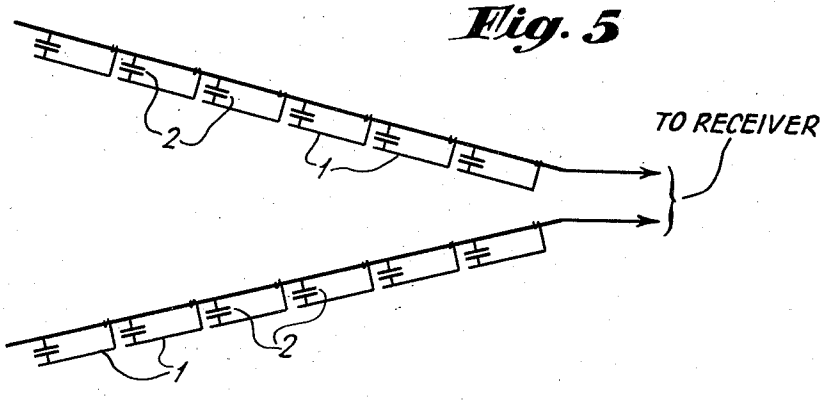



Fig. 5




INVENTOR.
MARTIN KATZIN

BY

ATTORNEY.

March 26, 1940. M. KATZIN 2,194,554

DIRECTIVE ANTENNA SYSTEM

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Fig. 6

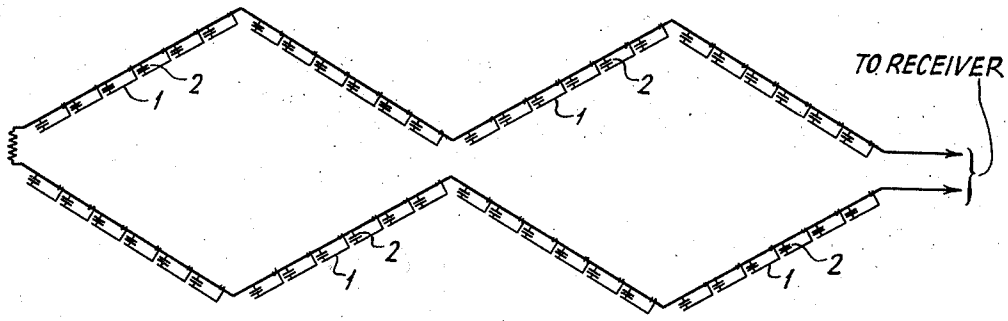
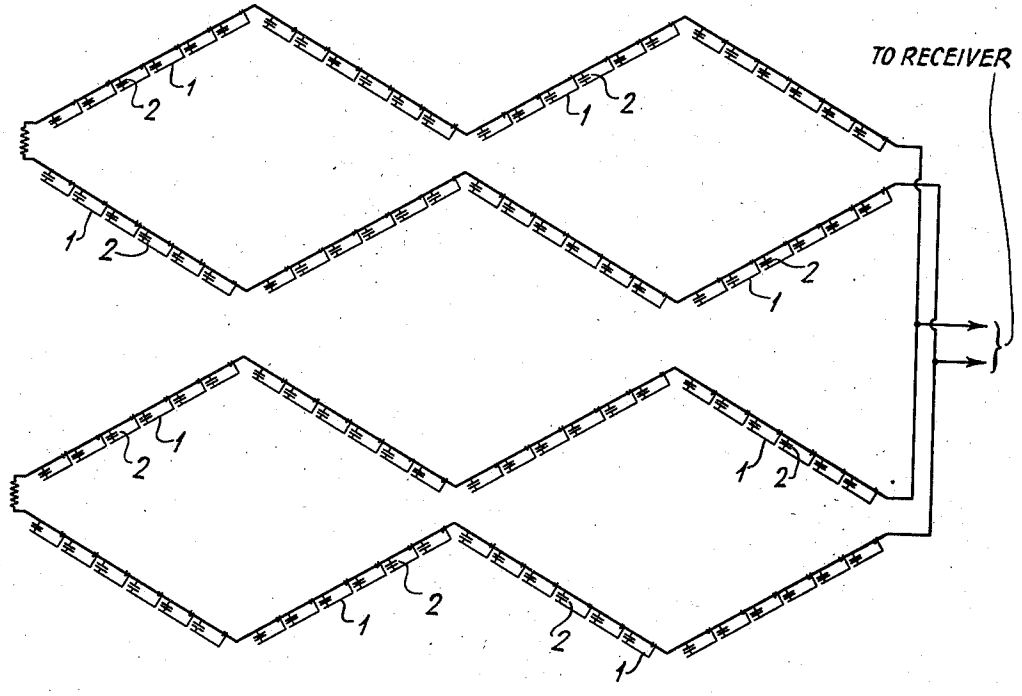



Fig. 7




INVENTOR.
MARTIN KATZIN

BY

ATTORNEY.

Patented Mar. 26, 1940 2,194,554

# UNITED STATES PATENT OFFICE

2,194,554

## DIRECTIVE ANTENNA SYSTEM

Martin Katzin, Riverhead, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application April 8, 1938, Serial No. 200,855

10 Claims. (Cl. 250—33)

This invention relates to a directive antenna system and, in particular, to directive antennae which comprise as constituent elements thereof one or more V type antennae.

An antenna to which my invention is particularly adapted is the rhombic or diamond antenna, one form of which is an arrangement with horizontal wires disposed in a diamond shaped plan. The principle involved in such an antenna is that the sides are of such length that the signal current will have to travel 180 degrees further in the wires than is traveled by the signal wave front which induces the increment of voltage in the wires. As antennae of this type are ordinarily constructed the electrical velocity in the wires is approximately that of the speed of light or the same as the speed of propagation of the electro-magnetic wave front of the signal. It is, therefore, necessary to either make the width of the structure great or the sides a number of wave lengths in length in order to obtain the desired phase relationship. It is often inconvenient to have the antenna structure occupy so much territory and, furthermore, if the distance between the wires is too great a random phase displacement between the voltages induced in the wires may reduce the gain from the anticipated value.

In the co-pending application No. 63,483, filed February 12, 1936, by H. O. Peterson and assigned to the assignee of this application, there are shown methods whereby optimum signal build-up may be obtained in a rhombic or diamond antenna of reduced dimensions by loading the antenna conductors so that the velocity of current propagation along the antenna is reduced from the normal free space value. Above the optimum frequency of such an antenna the resultant voltage built up along the whole antenna decreases.

The present disclosure provides means for maintaining the antenna at high efficiency at frequencies above the optimum frequency as determined by the condition of 180 degrees phase lead of the voltage increment at the widest part of the antenna with respect to the increment transmitted to that point from the end of the antenna along the wires.

An object, therefore, of my invention is to provide a compact V type antenna having a wider frequency response than generally obtainable heretofore.

Another object is to increase the velocity of signal waves of higher frequency over that prevailing at the optimum frequency.

Still another object is to provide an antenna with a primary peak response for a particular vertical angle of incidence of the signal wave of one frequency and a secondary peak response to a different vertical angle of incidence of a second signal wave of a higher frequency.

A better understanding of my invention may be had by reference to the following detailed description which is accompanied by drawings wherein Figure 1 shows an arrangement, according to the application above referred to, and of which my arrangement is an improvement, while Figure 2 shows my improvement which provides for increased efficiency at higher frequencies. Figure 3 shows a practicable method of effecting the principles of this disclosure, being an enlarged view of a portion of Figure 2. Figures 4, 5, 6 and 7 show modifications of my invention.

It is well known that the velocity of propagation along any current-carrying conductor system in space is substantially that of light waves. This is true for a single wire system as well as a system comprising two or more wires in parallel. The arrangement shown in Figure 1 has a velocity lower than that of light by virtue of the fact that the loading members 1 carry substantially no current.

Figure 2 is similar to Figure 1 with the addition of condensers 2 at the free ends of loading members 1. The object of these condensers is to allow current to flow through loading members 1 at high frequencies, thus increasing the velocity of propagation of the system over that prevailing at the lower frequencies. Thus a new higher optimum frequency is provided. This frequency is determined by the dimensions of the antenna and the velocity of light, being that for which the voltage increment at A, traveling along the antenna to B at nearly the velocity of light, lags the voltage increment at B by 180 degrees.

Figure 3 shows in enlarged detail the construction of the antenna conductors. The loading members 1 are connected in series with a group of insulators 3 and one end of each conductor is attached to the main aerial conductor by means of members 4. At the other end of each of the conductors 1 a condenser 2 is bridged across to the main aerial conductor. It will be seen from this figure that the auxiliary conductors which are used to decrease the speed of the wave along the antenna wires may be conveniently supported from the main antenna

structure without the necessity of complicated supporting or guying structures.

Figure 4 shows a modification of my invention wherein two diamond shaped antennae are connected in parallel in order to increase the horizontal directivity of the antenna system.

Figure 6 shows another modification including two diamond shaped antennae which are, however, in this case connected in series.

Figure 7 shows a combination of the parallel connection of Figure 4 with the series connection of Figure 6, thereby increasing the signal response. The construction of the loading conductors in each of these modifications is the same as shown in Figure 3.

Figure 5 illustrates the application of my improvement to the V shaped antenna such as that shown by P. S. Carter in Patent No. 1,974,387, dated September 18, 1934.

It is possible to proportion an antenna according to the above principles so that for the lower optimum frequency maximum voltage build-up takes place for a particular vertical angle of the signal wave, while for the higher optimum frequency maximum voltage build-up occurs for a different vertical angle. Thus, for example, if desired, a low frequency vertical angle in the neighborhood of 20 degrees may be provided for, while for the high frequency response a vertical angle of 10 to 15 degrees may be chosen. This may be illustrated by an example, as presented below.

Assume that it is desired to receive a signal frequency of 20 Mc/s., arriving at an angle to the ground of 10°, and also to receive a signal frequency of 10 Mc/s., arriving at an angle of 15° to the ground and from the same horizontal direction; also assume the maximum available space in the direction of the arriving signal is 200 meters, shown as L in Figure 2. At 20 Mc/s. the antenna may be proportioned on the basis of velocity of signal travel in the wires being substantially the velocity of light, so that one-half wavelength difference exists between the travel of the waves in the sides of the antenna and in space, or

$$\frac{100}{\sin\phi}-100\times\cos 10°=7.5 \text{ meters } \frac{1}{\sin\phi}=\frac{7.5}{100}\times\cos 10°=1.05981$$

from which

$$\phi=70.°7 \ (\phi \text{ in Figure 2})$$

The velocity of propagation in the antenna wires necessary to give optimum signal build-up for the 10 Mc/s. signal is then found as follows:

Let $v$ denote the ratio of velocity of propagation in the antenna to that in free space. Then for optimum signal,

$$\frac{100}{v\times\sin\phi}-100\times\cos 15°=15 \text{ meters}$$

but since

$$\frac{1}{\sin\phi}=1.05981$$

we have

$$\frac{105.981}{v}-100\times\cos 15°=15 \text{ meters}$$

$$\frac{1}{v}=\frac{15+96.593}{105.981}=\frac{111.593}{105.981}$$

$$v=\frac{105.981}{111.593}=.9497$$

That is, a velocity in the wires of approximately 95% that in free space is required. This will enable the proper design of the loading sections to be determined.

In a like manner, the proper design for any desired operating conditions may be determined.

While I have indicated and described particular arrangements for carrying my invention into effect, my invention is by no means limited to the particular arrangement shown and described and modifications may be made without departing from the scope and the spirit of the invention.

I claim:

1. In an aerial system, an antenna conductor, radio apparatus coupled to one end of said antenna conductor, reactance elements coupled at spaced points along said conductor for decreasing the velocity of propagation of a signal wave of an optimum frequency along the conductor as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor disposed parallel to said antenna conductor and having one end connected to said aerial conductor and having a condenser connected between the other end and said aerial conductor whereby the velocity of propagation of waves having a frequency higher than the said optimum is increased.

2. An aerial comprising a plurality of conductors disposed in a generally V shaped plan, a receiver coupled to the vertex of said aerial and reactance elements coupled at spaced points along each conductor of said aerial for decreasing the velocity of propagation of a signal wave of an optimum frequency along the conductor as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor having one end connected to said aerial conductor and having a condenser connected between the other end and said aerial conductor whereby the velocity of propagation of waves having a frequency higher than said optimum is increased.

3. An antenna system in the form of a rhombus and comprising four conductors of substantially similar length located in the same plane, a receiver coupled to one vertex of said antenna, an impedance network connected to the opposite vertex of said antenna which is equal to the surge impedance of said antenna, and reactance elements connected at spaced points along each conductor of said antenna for decreasing the velocity of propagation of a signal wave of an optimum frequency along the conductor as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor having one end connected to said antenna conductors and having a condenser connected between the other end and said antenna conductor whereby the velocity of propagation of waves having a frequency higher than said optimum is increased.

4. An antenna system comprising a pair of diamond shaped antennae, each antenna comprising four conductors of substantially similar length located in the same plane, means for connecting the conductors at one vertex of each of said antennas together, a receiver coupled to said means, an impedance network connected to the opposite vertex of each of said antennae which is equal to the surge impedance of the antenna associated therewith and reactance elements coupled at spaced points along each conductor of each of said antenna for increasing the velocity of propagation of a signal wave of an

optimum frequency along the conductors as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor having one end connected to said antenna conductors and having a condenser connected between the other end and said antenna conductor whereby the velocity of propagation of waves having a frequency higher than said optimum is increased.

5. An antenna system comprising a pair of diamond shaped antenna, each antenna comprising four conductors of substantially similar length located in the same plane, means for connecting one vertex of one antenna to one vertex of the other antenna, a receiver coupled to the other vertex of one of said antenna, an impedance network connected to the remaining vertex which is equal to the surge impedance of said antennae and reactance elements coupled at spaced points along each conductor of each of said antenna for decreasing the velocity of propagation of a signal wave of a predetermined optimum frequency along each conductor as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor having one end connected to said antenna conductor and having a condenser connected between the other end and said antenna conductor whereby the velocity of propagation of waves having a frequency higher than said optimum is increased.

6. In an aerial system, an antenna conductor, radio apparatus coupled to one end of said antenna conductor, reactance elements coupled at spaced points along said conductor for decreasing the velocity of propagation of a signal wave of optimum frequency along the conductor as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor disposed parallel to said antenna conductor and having its end nearest said radio apparatus connected to said aerial conductor and having a condenser connected between the end remote from said radio apparatus and said aerial conductor whereby the velocity of the propagation of waves having a frequency higher than the said optimum is increased.

7. An aerial comprising a plurality of conductors disposed in a generally V-shaped plan, a receiver coupled to the vertex of said aerial, and reactance elements coupled at spaced points along each conductor of said aerial for decreasing the velocity of propagation of a signal wave of an optimum frequency along the conductor as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor disposed parallel to said antenna conductors and having its end nearest said receiver connected to said aerial conductor and having a condenser connected between its end remote from said receiver and said aerial conductor whereby the velocity of propagation of waves having a frequency higher than said optimum is increased.

8. An antenna system in the form of a rhombus and comprising four conductors of substantially similar length located in the same plane, a receiver coupled to one vertex of said antenna, an impedance network connected to the opposite vertex of said antenna which is equal to the surge impedance of said antenna, and reactance elements connected at spaced points along each conductor of said antenna for decreasing the velocity of propagation of a signal wave of an optimum frequency along the conductor as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor disposed parallel to said antenna conductor and having its end nearest said receiver connected to said aerial conductor and having a condenser connected between the end remote from said receiver and said aerial conductor whereby the velocity of the propagation of waves having a frequency higher than the said optimum is increased.

9. An antenna system comprising a pair of diamond shaped antennae, each antenna comprising four conductors of substantially similar length located in the same plane, means for connecting the conductors at one vertex of each of said antennas together, a receiver coupled to said means, an impedance network connected to the opposite vertex of each of said antennae which is equal to the surge impedance of the antenna associated therewith and reactance elements coupled at spaced points along each conductor of each of said antenna for increasing the velocity of propagation of a signal wave of an optimum frequency along the conductors as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor disposed parallel to said antenna conductor and having its end nearest said receiver connected to said aerial conductor and having a condenser connected between the end remote from said receiver and said aerial conductor whereby the velocity of the propagation of waves having a frequency higher than the said optimum is increased.

10. An antenna system comprising a pair of diamond shaped antenna, each antenna comprising four conductors of substantially similar length located in the same plane, means for connecting one vertex of one antenna to one vertex of the other antenna, a receiver coupled to the other vertex of one of said antenna, an impedance network connected to the remaining vertex which is equal to the surge impedance of said antennae and reactance elements coupled at spaced points along each conductor of each of said antenna for decreasing the velocity of propagation of a signal wave of a predetermined optimum frequency along each conductor as compared with the velocity of propagation of said wave in space, said reactance elements each comprising a relatively short conductor disposed parallel to said antenna conductor and having its end nearest said receiver connected to said aerial conductor and having a condenser connected between the end remote from said receiver and said aerial conductor whereby the velocity of the propagation of waves having a frequency higher than the said optimum is increased.

MARTIN KATZIN.