April 25, 1939. H. O. PETERSON 2,155,955

DIRECTIVE ANTENNA SYSTEM

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Fig. 1

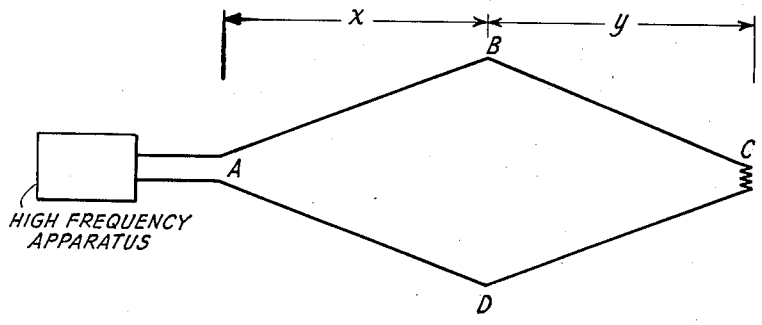


Fig. 2

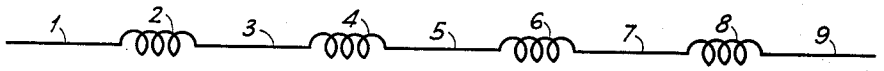


Fig. 3

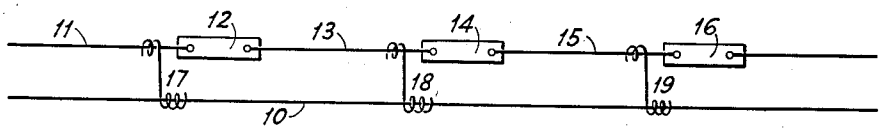
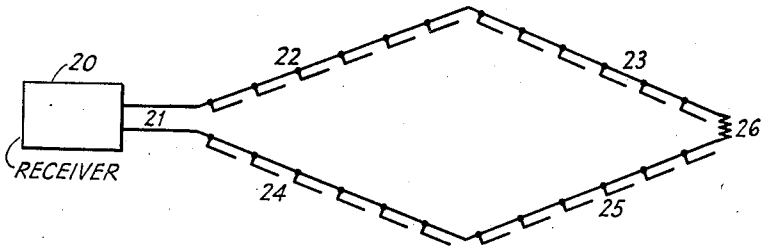


Fig. 4



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Fig. 5

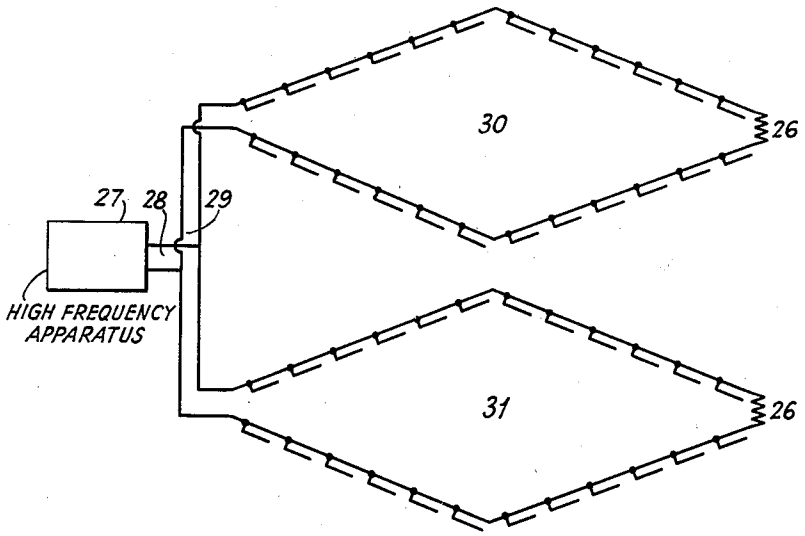


Fig. 6

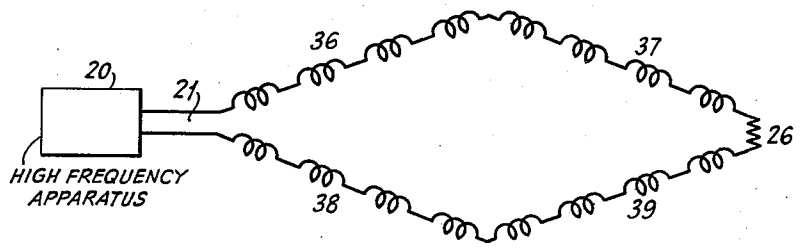
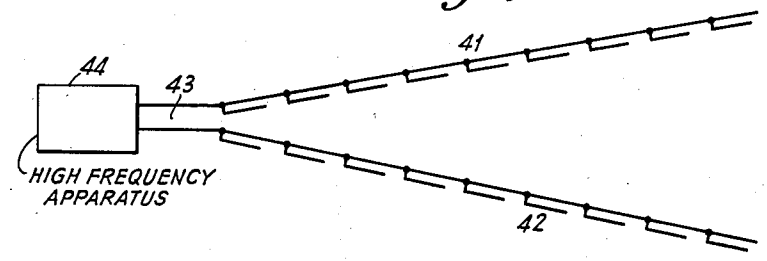


Fig. 7



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Fig. 8

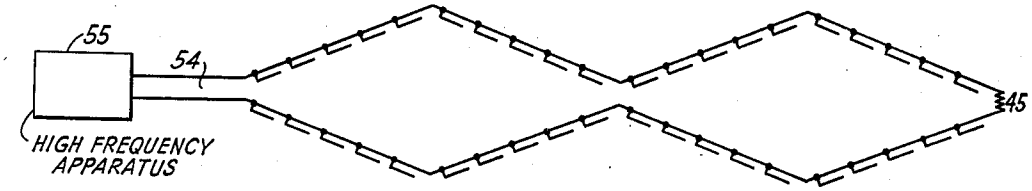


Fig. 9

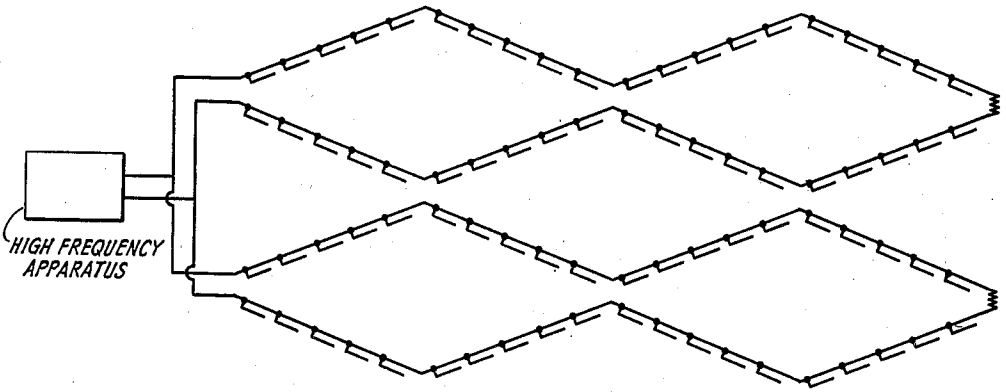
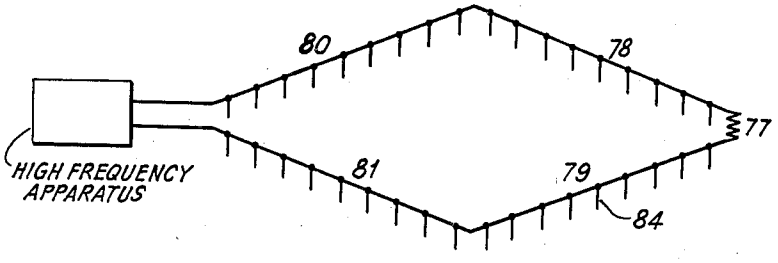


Fig. 10



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Patented Apr. 25, 1939

2,155,955

UNITED STATES PATENT OFFICE

2,155,955

DIRECTIVE ANTENNA SYSTEM

Harold O. Peterson, Riverhead, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application February 12, 1936, Serial No. 63,483

3 Claims. (Cl. 250—33)

This invention relates to directive antenna systems, and particularly to directive antennae which employ as constituent elements one or more V-type antennae.

An antenna to which the invention is particularly adapted is the diamond antenna which is arranged, in general, with horizontal wires disposed as shown in Fig. 1. The principle used in constructing such an antenna is to make the sides of such length that the signal current will have to travel 180° farther in the wire than is travelled by the signal wave front which induces the increments of voltage in said wire. Referring to Fig. 1, if we represent the distance travelled by the signal in space as X, the dimension AB will be made 180° or one-half wavelength longer than the distance X. The same applies to the relationship between Y and the distance BC. By observing such a relationship, we obtain the condition of a signal building up along a wire BC as the signal wave front advances from C toward A. This built-up resultant is approximately 90° out of phase with the increment induced at point B and consequently by turning the corner at B, the next increment just beyond B toward A is caused to add up in phase quadrature with the resultant, travelling on from the wire BC. Subsequently, increments along the wire BA add to this resultant until it is a maximum at point A.

As these antennas are ordinarily constructed, the electrical velocity in the wires AB, BC, AD and DC is approximately the same as the speed of light or the same as the velocity of propagation of the electromagnetic wave front. It is consequently necessary to either make the width BD great compared to the length AC, or else to make all of the dimensions AB, BC, CD, and AD quite large, i. e., several wavelengths in length. This follows from the fact that the antenna is built with each conductor disposed at an oblique angle relative to the direction of propagation of the electromagnetic wave front and that this oblique angle is made such that the electrical length of the conductor is approximately one-half wavelength longer than the projection of said conductor upon a line parallel to the direction of propagation of the electromagnetic wave. This means that as the conductor is made shorter, the angle between the conductor and the direction of propagation becomes greater and if the velocity of propagation in the conductor is nearly that of light, the angle between the conductor and the direction of propagation may be greater than 45°, in which case, generally, there will obtain the condition for an antenna which, if built according to Fig. 1, will have its dimension BD greater than its dimension AC. It is often inconvenient to have the structure occupy so much territory and there are, furthermore, electrical disadvantages in having the various wires too far apart, since a random phase relationship between the voltages in the various wires comes into effect and the anticipated gain of the antenna, due to its great size, is not realized in practice.

One of the objects of the present invention is to enable the usual functioning of such an antenna with a construction which is more compact and occupies much smaller space.

Another object is to provide a more compact V-type antenna than generally used in practice.

Since the criterion of design in the diamond type antenna is that the electrical length of the element BC be 180° greater than the distance travelled in space Y, it follows, and the present invention is based on an appreciation of the fact that the desired result can be achieved in a shorter section of wire if the velocity of propagation in the wire is made considerably less than the velocity of propagation of the signal. According to one embodiment, the invention comprises a compact type of diamond shaped directive antenna wherein the velocity of propagation in the wires thereof is decreased and made considerably less than the velocity of propagation of the signal in the ether. According to another embodiment, the invention comprises a compact type of V-shaped directive antenna.

A better understanding of the invention may be had by referring to the following detailed description which is accompanied by drawings wherein:

Fig. 1 is a known type of diamond antenna given for the purpose of illustrating the principles involved;

Figs. 2 and 3 illustrate two different arrangements for decreasing the velocity of propagation of a signal along a conductor; and

Figs. 4–10, inclusive, show various embodiments of the present invention.

Figs. 2 and 3 illustrate the manner in which the velocity of propagation along a conductor may be decreased by adding inductance, as shown in Fig. 2, or capacitance, as shown in Fig. 3. In Fig. 2 sections of wire 1, 3, 5 and 7 are connected together by serially placed inductance elements 2, 4, 6 and 8 for effecting the desired result. These inductance elements should appear at frequent

intervals along the conductor so that there are at least six or seven loadings per wavelength.

In Fig. 3 the inductance of the conductor 10 is practically the same as for a free wire in space, but the capacitance to surrounding space is increased by adding capacitor elements such as, for example, the parallel sections of wire 11, 13 and 15 which connect with conductor 10 through jumpers 17, 18 and 19. These sections of wire are separated by insulators 12, 14 and 16. It will be apparent, of course, that other suitable mechanical forms of capacitor elements may be connected to the conductor 10 to produce the effect of increasing its capacitance to a unit length. These loadings of capacitance should also be at frequent intervals as in Fig. 2, so that there are at least six or seven loadings per wave length, in order that the conductor 10 may constitute what is generally known as a "smooth line".

Fig. 4 illustrates one embodiment of the present invention, wherein a diamond shaped antenna employs capacitive loading of the kind illustrated in Fig. 3 to reduce the velocity of transmission of the signal wave along the conductors 22, 23, 24 and 25. This diamond shaped antenna is coupled to a receiver 20 through a transmission line 21, and is terminated in an impedance network 26 which is equal to the surge impedance of the antenna system so as to make the antenna unidirectional.

Fig. 5 illustrates two such antennas 30 and 31 as shown in Fig. 4 connected in parallel by transmission line 29 which couples to high frequency apparatus 27 through line 28 for broadside operation. The broadside arrangement of Fig. 5 serves to improve the directive characteristics of the antenna.

Fig. 6 illustrates another embodiment of the present invention, wherein the diamond shaped antenna employs series connected inductance loading elements, as shown in Fig. 2, for reducing the velocity of propagation of the signals in the antenna.

Fig. 7 represents a V-shaped antenna utilizing these principles in which 41 and 42 represent conductors which are loaded in this case by capacitor elements so as to have a velocity less than that of light and so disposed that the electrical length of each conductor will be approximately one-half wavelength longer than the length of its projection upon a line parallel to the direction of propagation of the electromagnetic wave. This antenna connects to the radio frequency apparatus situated at 44 by means of transmission line 43. This V, without applicant's improvement, is of the well known type, and is adequately described in Carter United States Patent No. 1,974,387, granted September 18, 1934, to which reference is herein made.

Fig. 8 represents a directive antenna system comprising two rhombic or diamond shaped antenna units connected in series, one end of the system being terminated in a network 45 of impedance equal to that of the antenna system and the other end of the system connected through transmission line 54 to the radio frequency apparatus situated at 55.

Fig. 9 represents two antennas built according to Fig. 8 connected in parallel with proper phase relationship so that the effects of the two antenna units will be cumulative for electromagnetic wave fronts having a desired direction of propagation.

Fig. 10 shows how a directive antenna built according to Fig. 1 may be loaded by means of short conductors disposed at approximately right angles to the main antenna conductors 78, 79, 80 and 81. These loading conductors indicated as 84 generally constitute capacity loading of the main antenna conductors in accordance with the teachings of this disclosure.

It will be understood that the invention is not limited to diamond shaped or V-type antennas in any one particular plane, since such directive antennas may be disposed in the vertical plane or at any angle to the horizontal without departing from the spirit and scope of the invention. Also, the antenna arrangements can be used equally well for transmitting as for reeciving, although it is believed that the advantages of applicant's invention of making a compact antenna construction which will fit into a smaller space geographically is of special importance for receiving work on account of the random phase relationship occurring in a receiving signal as received independently at geographically separated points. Similarly, any of the means shown throughout the figures for reducing the velocity of propagation along the wires, whether inductors, capacitors or short wires may be used one for the other.

The arrangements of the invention hereinabove discussed and illustrated are not to be construed as being limitative of the invention since various modifications may be made without departing from the principles of the invention which have been outlined.

What is claimed is:

1. A broadside antenna system comprising two diamond shaped antennas, each comprising four conductors of substantially similar length located in the same plane, high frequency apparatus coupled to a vertex of one of said antennas and in parallel relationship to the correspondingly located vertex of the other antenna, an impedance network connected to the opposite vertex of each antenna which is equal to the surge impedance of that antenna, and reactance elements, at least six to the wave length, coupled to each conductor of each antenna for decreasing the velocity of propagation of the waves along the conductor as compared with the velocity of propagation of waves in space, whereby there is obtained a compact antenna system of less lateral and longitudinal dimensions and of the same general configuration as the same type of antenna system without reactance elements.

2. A directive antenna system in the form of a rhombus having conductors disposed at oblique angles to the direction of propagation of electromagnetic waves, a surge impedance network, said conductors being loaded at regular intervals of less than one sixth wave length with reactance elements so that the electrical velocity of said conductors is appreciably less than the velocity of propagation of electromagnetic waves in free space, said conductors being of such length and so disposed in space that the electrical length of each conductor is approximately one-half wave length longer than the length of a conductor's projection upon the direction of propagation of the electromagnetic waves, one corner of said rhombus being connected to radio frequency apparatus and the opposite corner connected to said surge impedance network, said network having an impedance value equal to the surge impedance of the antenna system whereby a unilateral directional characteristic is obtained, whereby there is obtained a compact antenna system of less lateral and longitudinal dimen-

sions and of the same general configuration as the same type of antenna system without reactance elements.

3. A directional antenna comprising a pair of diverging radiating elements angularly disposed with respect to each other, high frequency apparatus coupled to the more closely adjacent ends of said elements, said conductors being loaded at regular intervals of less than one-sixth wave length with reactance elements so that the electrical velocity of said conductors is appreciably less than the velocity of propagation of electromagnetic waves in free space, said conductors being of such length and so disposed in space that the electrical length of each conductor is approximately one-half wave length longer than the length of a conductor's projection upon the direction of propagation of the electromagnetic waves, whereby there is obtained a compact antenna system of less lateral and longitudinal dimensions and of the same general configuration as the same type of antenna system without reactance elements.

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