Sept. 16, 1930. S. P. NIXDORFF 1,775,826

RADIO SIGNALING SYSTEM

Filed Nov. 15, 1927 3 Sheets-Sheet 1

Fig. 1.

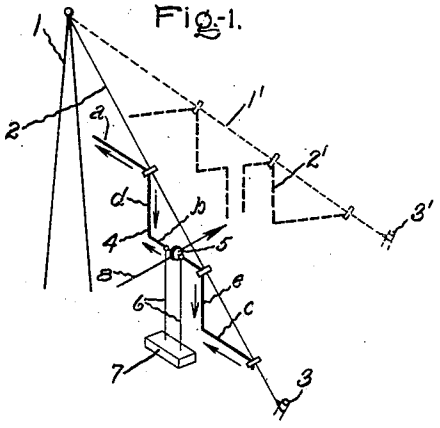



Fig. 2.

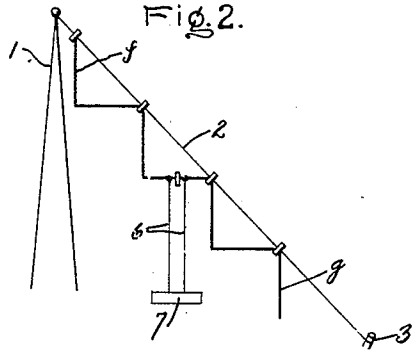



Fig. 4.

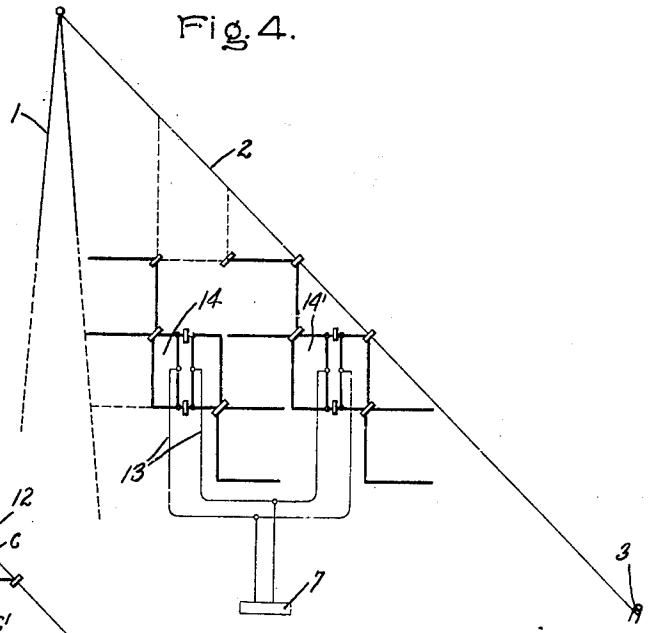
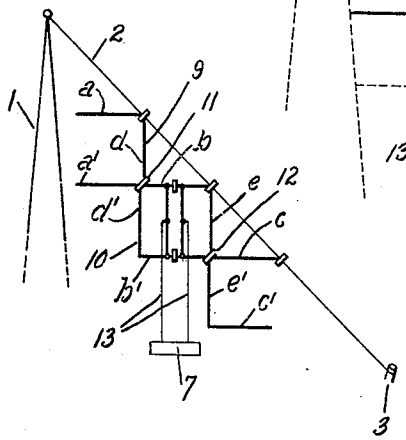



Fig. 3.




Inventor:
Samuel P. Nixdorff.
by Alexander S. Lamb
His Attorney.

Sept. 16, 1930. S. P. NIXDORFF 1,775,826

RADIO SIGNALING SYSTEM

Filed Nov. 15, 1927 3 Sheets-Sheet 2

Fig. 7.

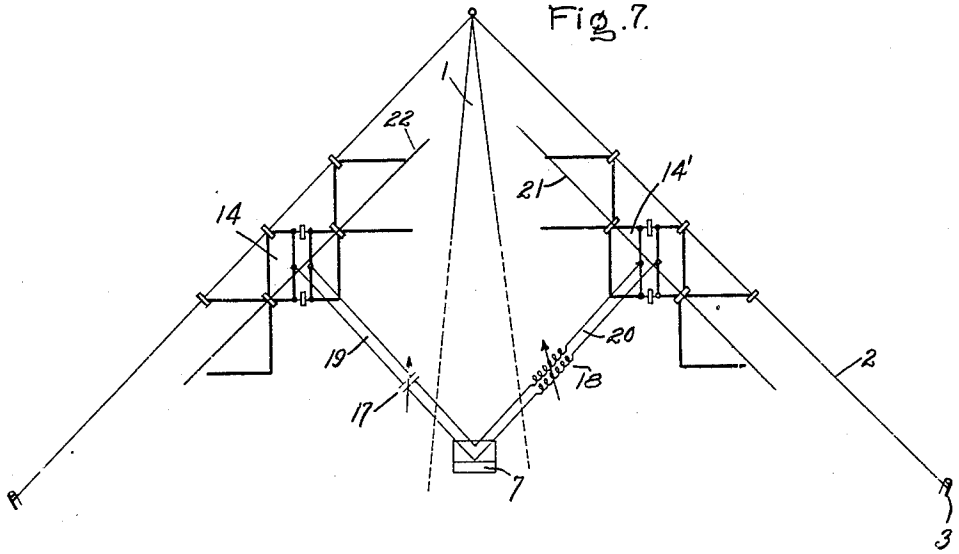



Fig. 5.

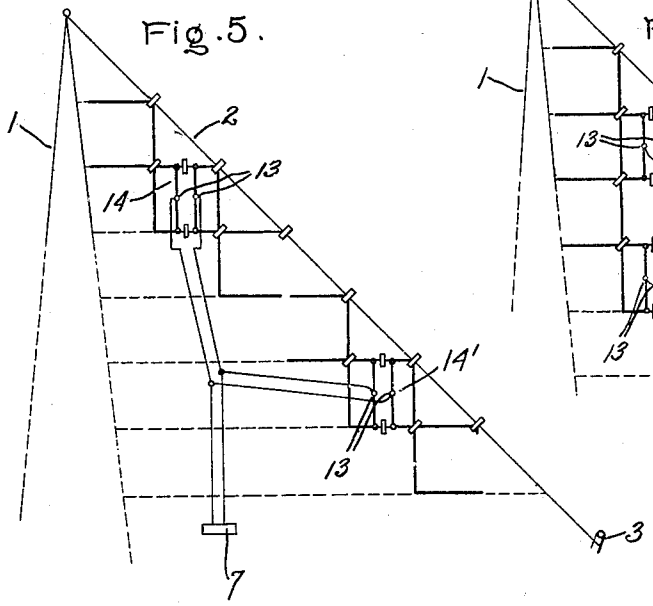
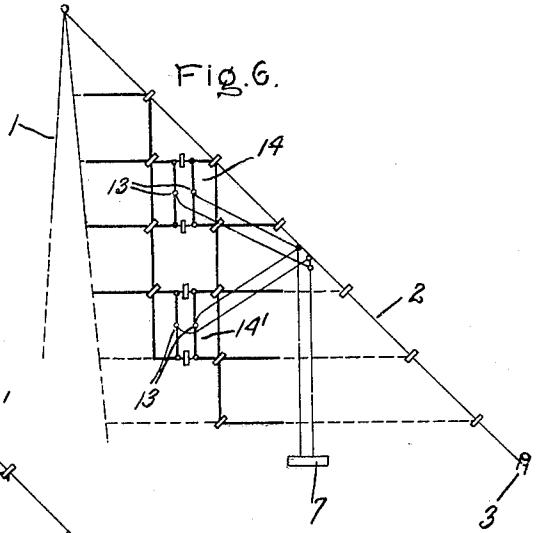



Fig. 6.




Inventor:
Samuel P. Nixdorff.
by Alexander S. Lamb
His Attorney.

Sept. 16, 1930. S. P. NIXDORFF 1,775,826

RADIO SIGNALING SYSTEM

Filed Nov. 15, 1927 3 Sheets-Sheet 3

Fig. 8.

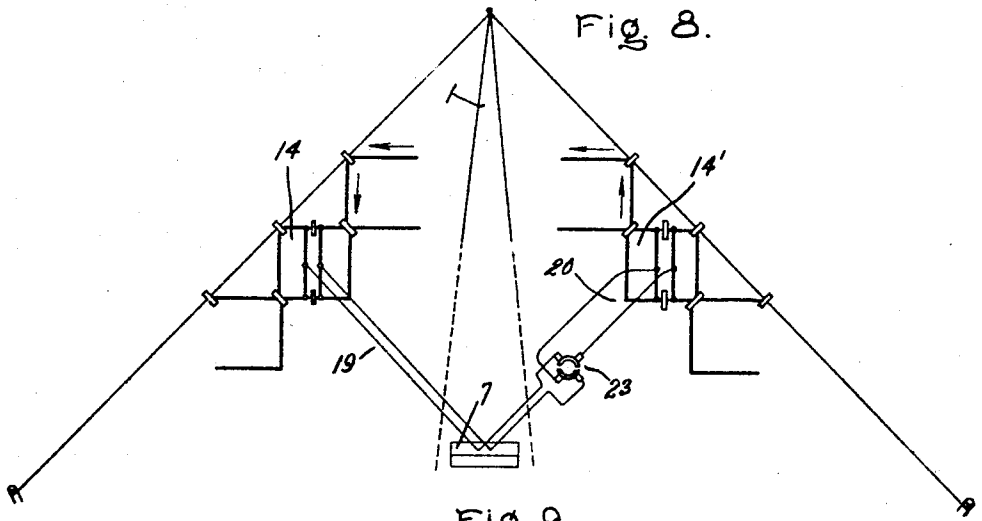



Fig. 9.

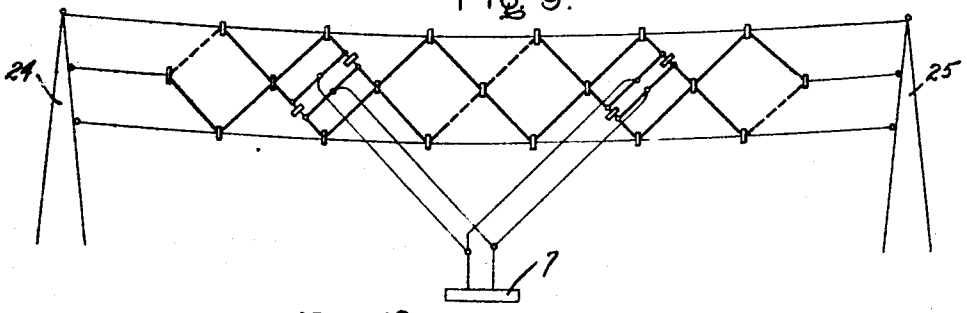



Fig. 10.

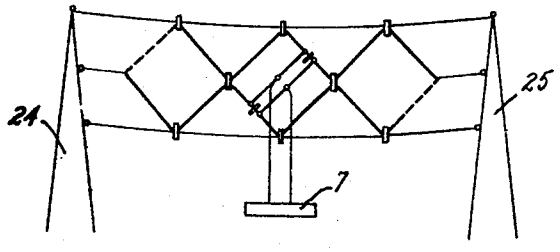
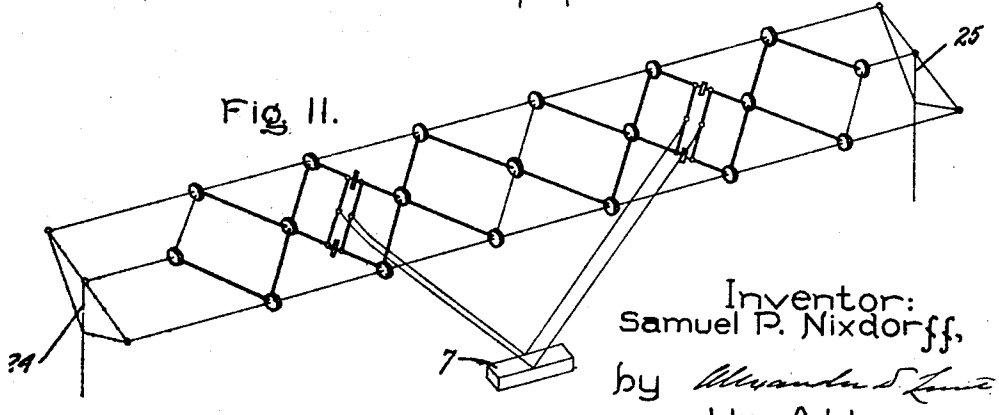



Fig. 11.




Inventor:
Samuel P. Nixdorff,
by Alexander S. Lamb
His Attorney.

Patented Sept. 16, 1930

1,775,826

# UNITED STATES PATENT OFFICE

SAMUEL P. NIXDORFF, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

## RADIO SIGNALING SYSTEM

Application filed November 15, 1927. Serial No. 233,491.

My invention relates to radio signaling systems and more particularly to radio signaling systems adapted for operation at short waves.

In a copending application of Ernst F. W. Alexanderson, filed November 15, 1927, Serial No. 233,509 entitled Radio signaling systems and which is assigned to the same assignee as my present application there are disclosed antennæ systems which are particularly adapted for radio signaling at short waves of one or more frequencies. Antennæ constructed in accordance with the invention of the mentioned application comprise a plurality of conductors each of which includes a number of sections which are alternately arranged to form continuous parallel lines including sections of each conductor. The arrangement is such that each of the sections in each line constitute individual oscillating units all of which oscillate in phase and cooperate to project a wave in a certain direction. As thus arranged the antenna possesses efficient radiating properties and it is highly directive in both the horizontal and vertical planes.

My present invention has for its purpose to effect certain improvements in antennæ of the type mentioned and to provide antennæ which have certain advantages over those of the prior art both in structural arrangement and in operation. More particularly my invention has for its purpose to provide antennæ systems which embody certain features of the antennæ mentioned and in which all of the different sections of the conducting members of the antenna cooperate to project or to respond to waves having a common direction of propagation. Still another purpose of my invention is to provide a directive antenna in which the direction in which the projected waves are propagated may be readily changed.

The novel features which I believe to be characteristic of my invention will be set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which the various figures represent diagrammatically different embodiments of my invention.

In each of the figures the conducting members of the antenna are represented by heavy lines and the suspension cables and feeder conductors are represented by light lines. The necessary insulating members are represented as small rectangles except where perspective is employed in which case they are represented as circular disks.

Referring to the drawing Fig. 1 represents a simple form of antenna embodying my invention. In this figure, 1 represents the usual tower or mast which is utilized for supporting the antenna. 2 represents a suspension cable extending from the top of the tower 1 obliquely toward the earth the lower portion of which may be suitably secured as, for example, by means of a plurality of anchors 3, 3′ driven into the ground and arranged in circular relation about the support 1. The antenna comprises a conducting member 4 which is arranged in zigzag or staircase formation extending from the top of the tower 1 parallel with the suspension member 2. This conducting member comprises two sets of sections, one of them comprising the sections $a$, $b$, $c$ which are arranged, for example, in a horizontal plane and the other comprises the sections $d$, $e$ which are arranged in a vertical plane. These sections are of equal length and the sections of each set are alternately arranged along the length of the conductor, the successive sections of one set $a$, $b$, $c$ extending in different directions from the intermediate section of the other set $d$, $e$. A suitable

section of the antenna as, for example, the mid-section $b$ is interrupted at the point 5 and at this point is connected by means of feeder line 6 to a suitable high frequency apparatus 7 which may be a transmitter, a receiver or both. When energized with high frequency currents having a wave length equal to twice the length of the equal sections of the antenna, the relative direction of the currents in the different sections of the antenna will be that indicated by the arrows. It will be seen that the horizontal sections $a$, $b$, $c$ are energized in phase and are adapted in themselves to project or to respond to waves having a horizontal polarization and propagated in a direction at right angles to the plane of the antenna. Likewise the sections $d$, $e$ are adapted in themselves to project or to respond to vertically polarized waves propagated at right angles to the plane of the antenna. The combined effect of the different sections is to project a wave at right angles to the plane of the antenna having a polarization at 45 degrees upward as is indicated by the arrow 8, and similarly if used as a receiver to produce a maximum response to waves having such polarization.

It will be seen that an antenna having the arrangement set out has very decided structural advantages. It comprises a directional antenna which may be supported by a single tower 1 and suspension cable 2 plus additional stay wires, not shown, as may be required. At the same time the zigzag or staircase arrangement facilitates the matter of obtaining a high effective elevation of the antenna above the earth. If it be desired to change the direction of propagation of the waves projected from the antenna, or to which the antenna respond, this may be effected by moving the suspension cable 2 about the support 1 to the desired position such, for example, as that represented by the dotted lines 1′, 2′, 3′ in the drawing. Thus by the simple operation of removing the cable 2 from one anchor 3 to another anchor 3′ and thereby rotating the antenna about the support 1 the direction of propagation of the radiated waves may be changed to any point in the compass.

Fig. 2 shows an antenna of the form shown in Fig. 1 with the exception that the end sections $f$ and $g$ of the conducting member are vertical rather than horizontal and the conducting member is a wave length longer than that shown in the former figure. This antenna will operate in the manner set forth in Fig. 1 but will be more directive in a vertical plane. The length of the antenna may be, of course, extended as desired with the limitation that the more remote sections should preferably be substantially equally energized with the sections proximate to the feeder conductors. Likewise an even number of sections may be employed.

In Fig. 3 another form of my invention is shown employing two conductors 9 and 10 which are suspended between the supporting cable 2 and the tower 1 in a suitable manner. The conductor 9 is formed of the horizontal sections $a$, $b$, $c$ and the vertical sections $d$, $e$ and the conductor 10 is similarly formed of the sections $a'$, $b'$, $c'$, $d'$, $e'$, the sections $e\ e'$, $d'\ c$, $d\ d'$, $a'\ b$ being arranged in continuous lines and conductors 9 and 10 being insulated from each other at the points 11 and 12. A suitable section of each conductor, such as the mid-sections, $b$ and $b'$ are each interrupted and the two sections are there connected together by means of feed lines 13, the midpoint of which is connected to the high frequency apparatus 7 such that the conductors 9 and 10 are electrically equidistant from the high frequency apparatus. Thus it will be seen that the sections of both of these conductors, which form parallel lines, will be energized in phase and will cooperate to project or to respond to waves propagated at a right angle to the plane of the antenna and having a plane of polarization at 45 degrees to the vertical.

Fig. 4, Fig. 5 and Fig. 6 represent further embodiments of my invention in which a group arrangement of the conductors is employed. In each of these figures, a group of conductors 14, 14′ are each constructed in a manner set forth in connection with Fig. 3 but are employed for the purpose of securing greater radiation and at the same time greater directivity. It will be seen that in Fig. 4 the groups are arranged in a horizontal direction with respect to each other, in Fig. 5 they are arranged in a 45 degree relation to each other, and in Fig. 6 they are arranged in a vertical direction. Thus variations in the directive properties of the antenna may be had. For example, the arrangement shown in Fig. 6 will project a wave having greater directivity in the vertical plane than that shown in Fig. 4, whereas the antenna shown in Fig. 4 will be more directive in the horizontal plane than that shown in Fig. 6. By the arrangement shown in Fig. 5 equal directivity in both planes may be expected. In each of the Figs. 4, 5 and 6 the midpoints of the feeder lines 13 are connected through lines of equal electrical length to the high frequency apparatus 7 or through lines so arranged that proper phase relations in the different conductors is had. This may be secured by adjusting the length of the conductors or by the insertion of artificial means such as concentrated inductance or capacity.

In Fig. 7 I have shown another form of my invention in which one group of conductors 14, such as represented in Fig. 3, is suspended from one side of the tower 1 and

another group 14′ is suspended upon diametrically opposite sides of the tower 1, these groups being electrically equidistant from the high frequency apparatus 7. The general direction of these antennæ as indicated by the lines 21, 22 is at right angles to each other, consequently if these be energized with currents having a 90 degree phase relation between the two a circularly or elliptically polarized wave will be projected at right angles to the plane of the antenna. This phase relation may be effected by connecting suitable phase adjusting means 17, 18 in the feeder leads 19 and 20 or by adjusting the length of the feeder wires as desired. With an arrangement of antenna such as that shown in Figs. 7 and 8 horizontally and vertically polarized waves may be projected alternately. Thus, for example, if the two groups of antennæ 14 and 14′ are energized in phase the horizontal members will cooperate to project a horizontally polarized wave at right angles to the plane of the antenna, whereas the vertical members of the group 14 will be opposed to the vertical members of the group 14′ with the result that their effects will be neutralized in a direction at right angles to the plane of the antenna. If the phase relation of the currents in the group 14′ now be reversed the vertical members will cooperate to project a vertically polarized wave in a direction at right angles to the plane of the antenna, whereas the horizontal members will be opposed in this direction. This phase reversal between the currents in the groups 14 and 14′ may be suitably effected by electrical means if desired or by a mechanical device, such as a reversing switch 23 connected in the leads to one of the groups. The type of antenna shown in Figs. 7 and 8 may be of particular utility in connection with the reduction of fading, as has been pointed out in a copending application of Ernst F. W. Alexanderson, filed November 15, 1927, Serial No. 233,508 and which is assigned to the same assignee as my present invention.

Figs. 9 and 10 show additional modifications of my invention in which the antenna are suspended in a vertical plane between the towers 24 and 25, the different sections of each conducting member being disposed at 45 degrees, or other suitable angle, to the vertical and one conducting member being arranged directly above the other to form continuous parallel lines in the manner set out in connection with the other figures. These antennæ will project a vertically polarized wave propagated at right angles to the plane of the antenna.

Fig. 11 shows a still different embodiment in which the groups of antennæ are suspended in a horizontal plane between supporting members 24 and 25. This antenna will project a horizontally polarized wave vertically upward and should therefore have particular utility in connection with the direction of airplanes.

Thus with an arrangement of conductors such as those described an antenna is formed in which all of the conducting sections of the antenna cooperate to project or to respond to waves of a desired character. The different parallel sections are operable in phase and this is effected without the use of concentrated inductance, capacity or tuning means of any kind which will interfere with the operation of the antenna at a plurality of frequencies. Any suitable length of conductor may be employed but where long antennæ are desired it is preferable to employ those of the type shown in Figs. 4, 5, 6, 9 and 11 since in these antennæ all sections may be substantially equally energized.

If desired suitable reflectors constructed in a manner similar to the construction of the antenna may be arranged in proximity to the antenna as set out in the above application Serial No. 233,509 of Ernst F. W. Alexanderson.

While I have shown particular embodiments of my invention it will, of course, be understood that I do not wish to be limited thereto since many modifications of the arrangements shown and described may be made without departing from the spirit and scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, an antenna comprising a conductor formed of two sets of alternately arranged sections, each of said sets comprising a plurality of substantially equal parallel sections separated by intermediate sections, the sections of one set being at an angle to the sections of the other set and adjacent sections of both sets extending in opposite directions from the intermediate section of the other set, a second similar conductor arranged in space relation with said first conductor to form a substantially continuous line comprising sections of both conductors, high frequency apparatus adapted for operation at a wave length approximately equal to twice the length of said substantially equal sections and lines connecting said apparatus and each of said conductors whereby all of the sections in each line cooperate in phase.

2. In combination, an antenna comprising a conductor formed of two sets of alternately arranged sections, each of said sets comprising a plurality of substantially equal parallel sections separated by intermediate sections, the sections of one set being at an angle to the sections of the other set and adjacent sections of both sets extending in opposite directions from the intermediate section of the other set, a second similar conductor arranged

in space relation with said first conductor to form substantially continuous parallel lines extending in different directions, each of said lines comprising sections of both conductors, high frequency apparatus adapted for operation at a wave length approximately equal to twice the length of said substantially equal sections and lines connecting said apparatus and said conductors whereby all of the sections in said parallel lines cooperate in phase.

In witness whereof, I have hereunto set my hand this 14th day of November, 1927.

SAMUEL P. NIXDORFF.

## CERTIFICATE OF CORRECTION.

Patent No. 1,775,826. Granted September 16, 1930, to

SAMUEL P. NIXDORFF.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, line 76, for "d'c" read b'c; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of October, A. D. 1930.

(Seal)

M. J. Moore,
Acting Commissioner of Patents.