

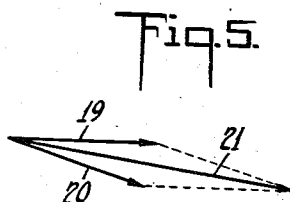
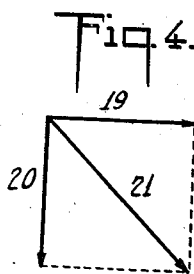
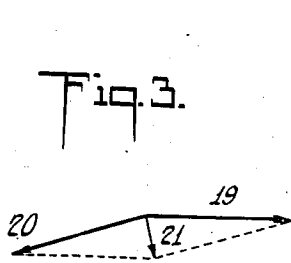
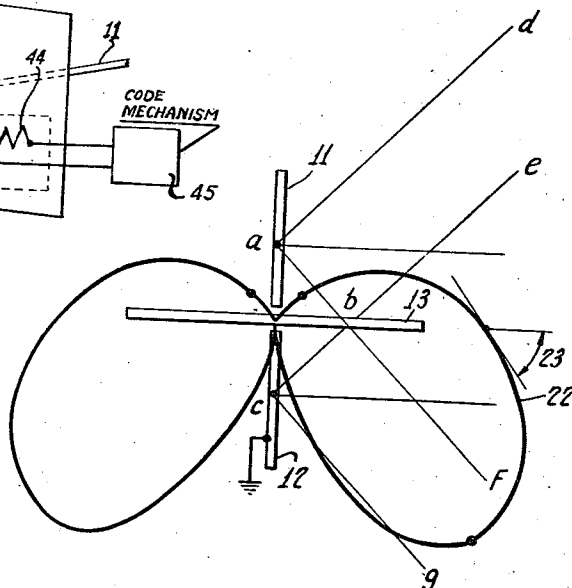
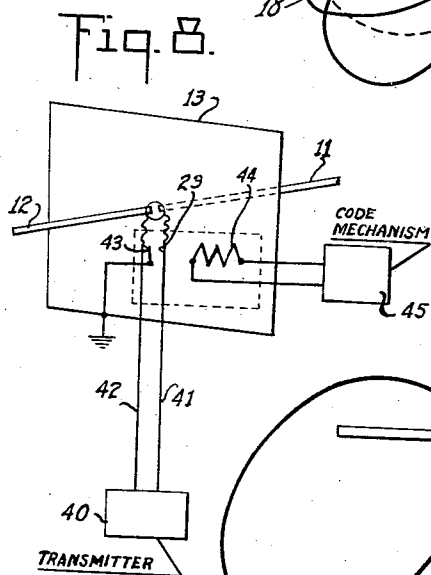
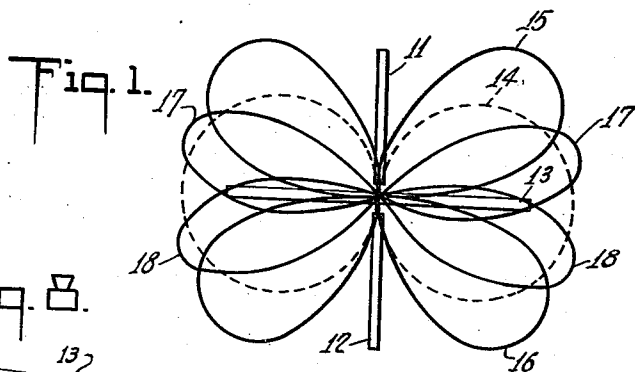
Dec. 21, 1943.

CARL-ERIK GRANQVIST
DIRECTIONAL RADIO BEACON

2,337,324

Filed Feb. 14, 1942

2 Sheets-Sheet 1



INVENTOR,
Carl-Erik Granqvist
BY
Jarvis C. Muehle
his ATTORNEY

Dec. 21, 1943.

CARL-ERIK GRANQVIST
DIRECTIONAL RADIO BEACON

2,337,324

Filed Feb. 14, 1942

2 Sheets-Sheet 2

Fig. 6.

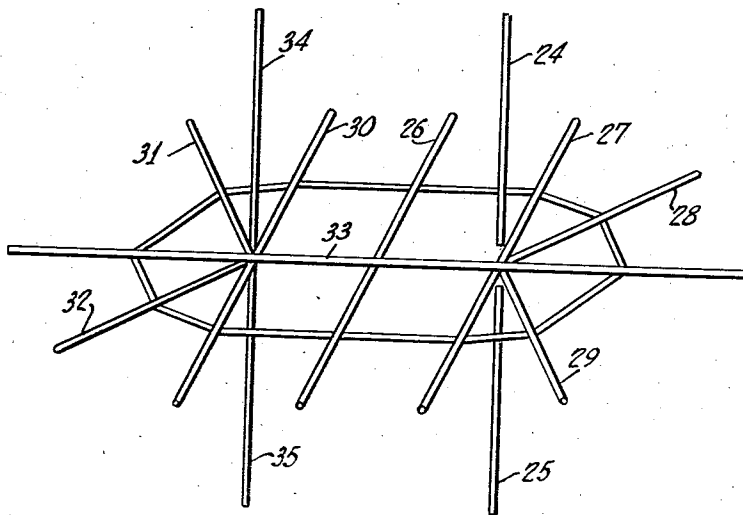
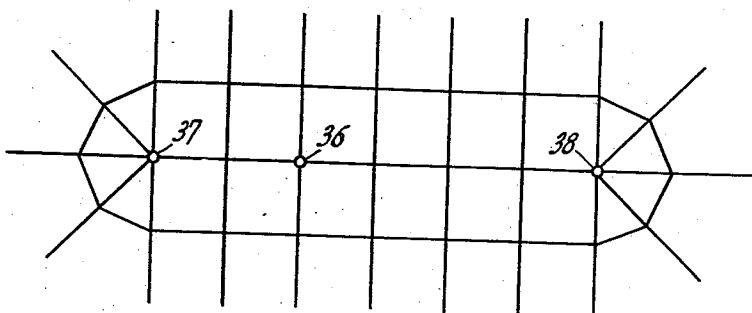


Fig. 7.



INVENTOR
Carl-Erik Granqvist
BY
James C. Marble
ATTORNEY

UNITED STATES PATENT OFFICE

2,337,324

DIRECTIONAL RADIO BEACON

Carl-Erik Granqvist, Stockholm, Sweden, assignor to Aga-Baltic Aktiebolag, Stockholm, Sweden, a corporation of Sweden

Application February 14, 1942, Serial No. 430,904
In Sweden January 13, 1941

10 Claims. (Cl. 250—11)

My invention relates to radio beacons.

In my U. S. patent application, Ser. No. 363,281, filed October 29, 1940, for Directional radio beacon, now Patent No. 2,309,063, granted January 19, 1943, a directional radio beacon is described having a high degree of directional sharpness. The radio transmitter described in the said patent comprises a pair of dipole antenna half parts, i. e., two bars extending in the same longitudinal direction and preferably having a length of about $\frac{1}{4}$ wave length. A grounded screen is interposed between the two half parts in a plane perpendicular thereto and an arrangement is provided for alternately connecting one or the other of the dipole antenna half parts with ground. In synchronism with the reversal of the ground connection between the two dipole antenna half parts two field patterns are radiated which are symmetrical about the screen, and are so related that the field intensity in the longitudinal direction of the screen is the same for both patterns and therefore remains constant regardless of which half part is grounded.

The present invention relates to radio beacons of the above described type in which a further increase in directional sharpness is obtained with a screen of smaller size.

The invention is further described in connection with the annexed drawings, in which Figs. 1 and 2 are polar diagrams illustrating the characteristics of the pattern, Figs. 3-5 are vector diagrams for explanation of the operations of the invention, Figs. 6 and 7 are perspective views and plan views respectively illustrating two different embodiments of the invention, and Fig. 8 is a perspective view illustrating a transmitter embodying the present invention.

Fig. 8 illustrates diagrammatically a transmitter of the type shown in the above mentioned Patent No. 2,309,063 which comprises a pair of oppositely extending dipoles 11 and 12, a grounded screen 13 connected therebetween, a transmitter 40 connected by lines 41 and 42 to the respective dipoles 11 and 12, a switch 43 actuated by a relay 44 to selectively connect the dipoles 11 and 12 to ground through the screen 13 and a code mechanism 45 which actuates the switch relay 44 in a timed sequence corresponding to the code signals to be transmitted.

In Fig. 1 two antenna half parts 11 and 12 of a pair of dipole antennas are shown with a screen 13 disposed therebetween as above described. The dipole antenna pair would, if the screen were not present, have the radiation characteristic indicated by the dotted line 14. If the screen had

infinite extension, on the other hand, a radiation characteristic indicated by lines 15 and 16, would be obtained. As, however, the screen has a limited extension, a radiation characteristic which is intermediate in form between the two characteristics 14 and 15-16 is obtained.

The present invention is based upon an investigation of the form of the characteristic with screens of different intermediate finite areas. Beginning with an infinite extension of the screen, corresponding to the characteristic 15 for the antenna half part 11 and the characteristic 16 for the antenna half part 12, if the dimensions of the screen 13 are progressively decreased, a correspondingly increasing capacitive coupling will occur between the two antenna half parts, causing one of the half parts, even if it is grounded, to radiate actively with a field intensity which is among other things dependent upon the degree of capacitive coupling between the two antenna half parts. The field diagrams will therefore change their character, the diagram 15 changing into the form 17, and the diagram 16 changing into the form 18.

The loop-shaped diagram thus formed will be positioned with a major part on that side of the screen where the fed antenna part is situated and with a minor part on that side of the screen where the grounded antenna half part is situated.

A continued decrease of the dimensions of the screen 13 will cause an increased coupling between the fed and the grounded antenna half parts, and consequently that part of the loop characteristic which is positioned on the side of the fed antenna half part will continuously decrease, whereas the part of the loop characteristic which is positioned on the side of the grounded antenna half part is increased to a corresponding degree. At a certain extension of the screen the characteristic will be substantially symmetrical about the plane of the screen and hence will intersect with the plane of the screen at a right angle. This dimension of the screen is herein called the critical magnitude of the screen.

If the dimensions of the screen are decreased below the critical magnitude, two different phenomena occur. First the loop-shaped characteristic will turn further into the side of the screen where the grounded antenna half part is situated, the angle of intersection between the plane of the screen and the characteristic decreasing to values below 90° as indicated at 23, Fig. 2. Secondly the grounding action of the screen will diminish, so that the angle between

the characteristics 15 and 16 will continuously decrease until it finally fully disappears. In the last named case obviously the two characteristics will coincide and form the substantially circular diagram 14. However, the upper half of the circle in Fig. 1 is derived from the characteristic 15 and the lower half of the circle in Fig. 1 is derived from the characteristic 15.

The successive conversion of the characteristic into circular form results in a tendency which opposes the above mentioned tendency of the intersecting angle between the characteristic and the plane of the screen to decrease below 90°. Hence at a certain dimension of the screen this angle attains a minimum value. This last dimension of the screen is herein called the optimal magnitude of the screen, which is, as will be obvious from the above, less than the critical magnitude of the screen.

It is assumed that in Fig. 2 the screen is of the optimal magnitude. The dipole antenna half parts, which are assumed to have a length of exactly a quarter of a wave length, may for simplicity be considered as concentrated radiation points situated at the mid-point of the dipole antenna half part, that is, at a distance of one eighth of a wave length from the screen. It is assumed in the following that the dipole antenna half part 12 is grounded, whereas the dipole antenna half part 11 is connected to the source of voltage. Due to the incompleteness of the screen 13 it is not possible to prevent capacitive transfer to and radiation from the dipole antenna half part 12. The radiation current from this dipole antenna half part will vary according to the capacity between the half parts and the inductance of the antenna half parts and their length as compared with the wavelength. Hence in certain instances the currents in both of the dipole antenna half parts may be equal. For simplicity it is assumed that this is the case. It should be noted, however, that in this the ideal shape of characteristic will not ordinarily be obtained.

The radiation from the dipole antenna half part 12 due to the capacitive voltage transfer is about 90° displaced in phase in relation to the radiation from the dipole antenna half part 11. To this, however, is added a further displacement in phase caused by the propagation time of the radiation, which on one side of the screen is added to the capacitive displacement in phase caused by the coupling between the dipole antenna half parts, but on the other side of the screen is opposed to the last named displacement in phase. For explanation of this we may consider the radiation at a 45° angle on one side of the screen, in the direction of the screen, and at a 45° angle on the other side of the screen.

The radiation can be considered to emanate from the electrostatical center of gravity of the dipole antenna half parts. The two centers are situated in a distance from each other of about one quarter of a wave length if the dipole antenna half parts are of the usual length of one quarter length each. The propagation time for one of the radiation waves, until it coincides with the other propagation wave may therefore be represented by a simple graphical construction. In the present case the hypotenuse ac of the triangle abc , Fig. 2, is a quarter of a wave length. Consequently the distance $ab=bc=0.13$ of a wave length, which corresponds to a displacement in phase due to the propagation time of 65°. The radiation in the direction ad thus will cooperate with a radiation from the dipole antenna half

part 12 in the direction ce , which is 90° displaced in phase due to the capacitive coupling and is 65° displaced in phase in the same direction due to the time of propagation of the wave, that is, it will have a total phase displacement of 155°.

It is obvious from the vector diagram, Fig. 3, that the resulting radiation resulting from the combined effect of the waves ad and ce will be only extremely small. The radiation vector in the direction ad in Fig. 3 is indicated by the arrow 19, the radiation vector in the direction ce by the arrow 20 and the resultant by the arrow 21.

If we now consider in a corresponding manner the radiation in the direction of the plane of the screen, we find that only the phase displacement of 90° due to the capacitive coupling between the antenna half parts is present, and that therefore the vector diagram in Fig. 3 is converted into the vector diagram shown in Fig. 4. Finally the radiation at an angle of 45° with the plane of the screen on the side where the grounded dipole antenna half part is situated, that is, in the direction af or cg , respectively, will be considered. In that case the vector diagrams of Figs. 3 and 4 are converted into the form of Fig. 5. If further radiation angles are plotted in the same manner a continuous diagram as indicated at 22 in Fig. 2 is obtained. As mentioned above the shape of the characteristic 22 is based on the assumption that the radiation from both of the antenna half parts are equal. However, this is usually not the case, and, by suitable dimensioning of the different parts of the antenna system an intersecting angle 23 between the characteristic 22 and the plane of the screen 13 may be obtained which, at the optimal magnitude of the screen, is substantially less than that shown in Fig. 2. The same angle may also be obtained with a magnitude of the screen 13 which is greater than the critical magnitude, although in this case the characteristics will have changed their places. However, in the last case the screen will be so large, that for purely practical reasons it could not be used. This is especially the case when the radio beacon is to be made portable.

If, on the other hand screens of practically usable magnitude are used which are dimensioned within the range of greater than critical magnitude, the intersecting angle 23 with the plane of the screen will be correspondingly greater and consequently the directional sharpness will be less.

When an antenna system of this kind is used for course beacons, the dipole antenna half parts are usually connected with the two leads to a radio frequency generator, the screen being connected with a contact spring which is oscillated between two counter-contacts, one of which is connected to one of the dipole antenna half parts and the other one to the other dipole antenna half part in time with a complement code such as the Morse letters E—T. Consequently the radiation from the antenna system will assume the character of a diagram alternating from the diagram 17 to the diagram 18, Fig. 1, and a listener in any direction except in the plane of the screen will always observe a change in the observed sound intensity of the two signals. The precision with which the correct direction can be determined will therefore be directly proportional to tangent of the angle 23 at which the diagram intersects the plane of the screen.

In radio beacons the purpose of which is to

show the course with great accuracy for instance for beacons in especially narrow waters, air landing beacons, etc., it often happens that immediately behind the beacon, that is, on that side of the beacon which is opposite to the direction of the course, there may be placed some geophysical or technical object, which may cause reflection of the radiation transmitted in that direction. This reflected radiation obtains on the one side the same wave length as the radiation directly transmitted in the direction of the course and will also be observed, but on the other side, due to the irregular character of the reflector, will have a directional characteristic which is not only very indistinct but will, as a rule, substantially diminish the direction sharpness as the angle of the directional characteristic of the combined signals is increased. Often, moreover, the symmetry between the diagrams 17 and 18, Fig. 1, necessary for correct direction finding will cease.

According to the invention this disadvantage is obviated by providing the antenna system with one or more effective reflectors on that side, where the disturbing radiation reflections are located, said reflectors being designed in such a manner that they do not perceptibly impair the radiation pattern, but preferably even sharpen the angle 23 of the radiation diagram. For this purpose it is especially desirable that the screen have an extension which is sufficient to screen the reflectors, which have the form of bars connected to the screen, in substantially the same manner as the two dipole antenna half parts are screened.

Further a substantial sharpening of the intersecting angle 23 may be obtained by providing, in addition to the said reflectors, further directors on that side of the dipole antenna half parts, in which radiation is desired.

Further details will be evident from the following description of two different embodiments of the invention.

Fig. 6 is a perspective view of an antenna system according to the invention, having one reflector. The two dipole antenna half parts are indicated at 24 and 25. It is assumed that they are the usual one quarter of a wave length long. The screen is composed of bars 26-33, welded together or joined together in some other way, and symmetrically arranged about the bar 26 which crosses the plane of the dipole antenna half part at a distance of about one eighth of a wave length from said half parts. At a point which is symmetrical to the intersection point of the dipole antenna with the screen, two bars 34 and 35 are arranged. These are also about one quarter of a wave length long and are, as will be evident from the above, situated at a distance from the dipole antenna of about one quarter of a wave length. The bars 34 and 35 are further metallically connected to the screen. In this case the best possible reflection is obtained. Consequently the diagram will be exactly equal to that according to Fig. 1, except in two respects, namely the all-over field intensity will be proportionally stronger, and the loop which is removed by the reflectors will be missing.

The spacing and the length of the reflectors may be varied to control the shape of the characteristic. Thus it has been proved by tests and by calculations, that to a certain degree it is possible to deviate from the shape and the dimensions, which should theoretically give the optimum of reflection without producing noticeable

disturbances, but it is also possible by means of such smaller deviations to control the shape of the characteristic to obtain even a smaller sharpening of its intersection angle 23. The rules for the deviation in form and position, which should be made, are, however, individual for each case and may suitably be determined empirically. As a rule the reflector bars 34 and 35 should be somewhat longer than the dipole antenna bars 24 and 25.

With an antenna system of this kind a sharpness in the plane of the screen of 15 db. per degree has been obtained. For comparison reference may be made to an article of Henry I. Metz in Journal of the Aeronautic Sciences, July 1940, where normal directional sharpness with older antenna systems was indicated as 0.5 db. per degree and the highest optimum hitherto obtained was indicated as 2.3 db. per 1.5.

For many purposes the above directional sharpness was fully sufficient. In cases requiring greater directional sharpness, however, the directors may be arranged as shown in Fig. 7. In this figure the screen is shown in plan view in the plane of the paper, the dipole antennas, the reflectors and the directors thus having a direction perpendicular to the plane of the paper. The dipoles are arranged at the point 36 and the reflectors at the point 37 as shown in Fig. 6. The distance between the points 36 and 37, as in the arrangement according to Fig. 6, is substantially a quarter of a wave length. At the point 38, situated at a distance of substantially a half wave-length distance from the dipole antennas, however, a further pair of bars is arranged. These have the length of a quarter of a wave-length each and also are also metallically connected to the screen. Due to the deviation phase of the radiated wave when passing the plane of these bars, they will have a direction influence on the radiated wave. Hence they are called directors. The highest sharpness is obtained when the directors are somewhat shorter than the dipole antennas.

By experiments it has been proved that a pair of directors arranged in the manner shown in Fig. 7, improve the directional sharpness to a high degree. A greater directional sharpness may be obtained by a series of one or more additional pairs of directors each spaced a half of a wave-length apart.

Of course, the invention is not limited to the above shown embodiments but substantial modifications thereof may be made.

What is claimed:

1. A directional radio beacon comprising a dipole antenna having a pair of longitudinal half-parts extending in opposite directions, a screen interposed between said half-parts in a plane normal thereto, a transmitter feeding said antenna and timed mechanism to alternately ground said half-parts, said screen having an extension less than the critical magnitude at which the radiation characteristic of each half-part, when the other half-part is grounded, intersects the plane of the screen at substantially a right angle.

2. A directional radio beacon as set forth in claim 1 in which the screen is of the optimum magnitude at which said characteristic intersects the plane of the screen at the minimum angle.

3. A directional radio beacon according to claim 1 in which the screen is made in the form of a net-work of metallic bars.

4. A directional radio beacon according to

claim 1 in which the screen is metallica-
ly connected with two reflector bars which extend par-
allel to the dipole antenna half-parts.

5. A directional radio beacon according to
claim 1 in which the screen is metallica-
ly connected with two reflector bars which extend par-
allel to the dipole antenna half-parts, and is ar-
ranged symmetrically about a line which forms
a center line joining the points of intersection of
the screen with the antennas and the reflector
bars.

6. A directional radio beacon according to
claim 1 in which the screen is metallica-
ly connected with two reflector bars which extend par-
allel to the dipole antenna half-parts, the dis-
tance between the dipole antenna half-parts and
the reflector bars being substantially one-quar-
ter of the wave-length for which the radio beacon
is designed.

7. A directional radio beacon according to
claim 1 in which the screen is metallica-
ly connected with two reflector bars which extend par-

allel to the dipole antenna half-parts, the re-
flector bars being somewhat longer than the di-
pole antenna half-parts.

8. A directional radio beacon according to
claim 1 in which the screen is metallica-
ly connected to at least one pair of director bars which
extend parallel to the dipole antenna half-parts.

9. A directional radio beacon according to
claim 1 in which the screen is metallica-
ly connected to at least one pair of director bars which
extend parallel to the dipole antenna half-parts,
the distance between the dipole antenna half-
parts and the director bars being substantially a
half of the wave-length for which the directed
radio beacon is designed.

10. A directional radio beacon according to
claim 1 in which the screen is metallica-
ly connected to at least one pair of director bars which
extend parallel to the dipole antenna half-parts,
the director bars being somewhat shorter than
the dipole antenna half-parts.

CARL-ERIK GRANQVIST.