May 30, 1944. H. MATSUDAIRA 2,349,976

SYSTEM FOR DIRECTIVE RADIATION OF ELECTROMAGNETIC WAVES

Filed Jan. 14, 1941

Fig. 3

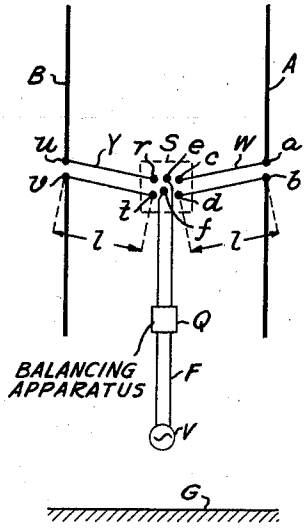


Fig. 1

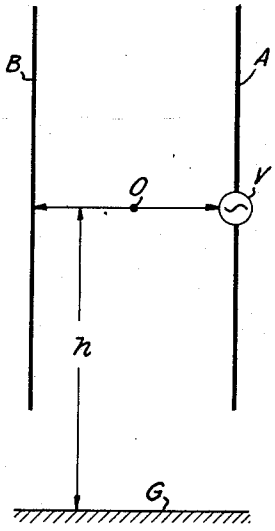


Fig. 4

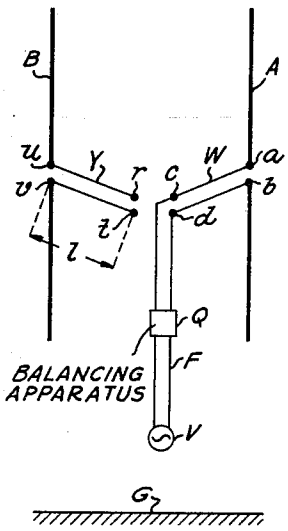


Fig. 5

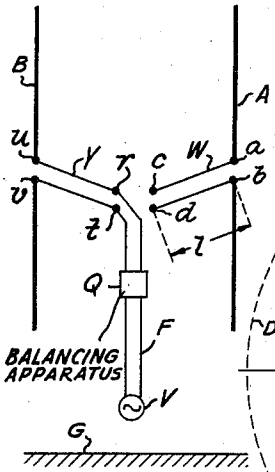


Fig. 2

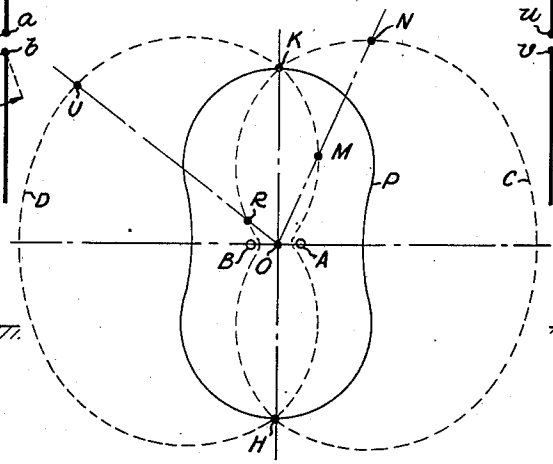
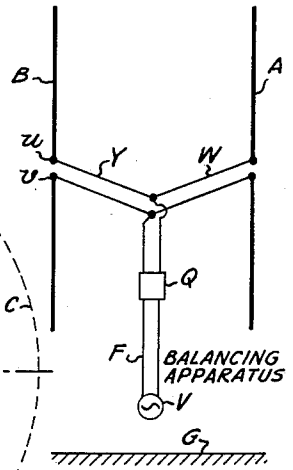


Fig. 6



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SYSTEM FOR DIRECTIVE RADIATION OF ELECTROMAGNETIC WAVES

Hatsutaro Matsudaira, Hsingking, Manchoukuo; vested in the Alien Property Custodian

Application January 14, 1941, Serial No. 374,322

1 Claim. (Cl. 250—11)

This invention relates to a system for directive radiation of electromagnetic waves for obtaining an equisignal intensity zone to meet a predetermined direction by the interlocking of different directive radiations from two dipole antennae of a half wavelength each.

The object of this invention is to provide a directive radiating system of a simple construction, having high efficiency in feeding the antennae, and without the trouble of so-called "key-clicks" when detecting a continuous equisignal zone of radiations.

Among many applications, the invention may be particularly employed for finding the runway of an aerodrome by detecting, on aircraft intended to be guided, the equisignal zone of radiation, which direction is predetermined to the runway, when the visibility is obscured by clouds, fogs and at night, or during blind flight.

The invention will now be described in detail with reference to the accompanying drawing, in which:

Figure 1 shows an arrangement of a vertical half wave antenna and a reflector,

Figure 2 shows directive characteristics of radiation of the antenna system when a method of feeding the antenna and the length of a reflector have been changed,

Figure 3 shows two vertical antennae of a half wavelength each and their feeding system,

Figure 4 shows two antennae, one acting as a radiator and the other as a reflector,

Figure 5 shows the same antennae, but with their relation reversed, and

Figure 6 shows a connection of said two antennae at the instant they are simultaneously fed together.

When we set vertically a metal rod A of a half wavelength excited from an energy source V with a tuned frequency, with a height h above the ground G, and another metal rod B slightly longer than a half wavelength, said two rods A and B being arranged parallel and apart a quarter wavelength from each other, it is well known that the rod A acts as a vertical antenna and the rod B as a reflector by induced electric current from the rod A, and we get a radiating field of a directive characteristic shown as a polar curve C as shown in Fig. 2, which pattern of radiation will hereinafter be referred to as "the first case" for the sake of convenience in explanation.

Now, assume the case in which the metal rods A and B are put in inverse arrangement, that is to say, the length of the rod B is made equal to a half wavelength energized with the same source V, and the rod A is made slightly longer than a half wavelength. Then the rod B acts as a radiator and the rod A as a reflector, and the pattern of the field radiating from this arrangement must be represented by a polar curve D which is perfectly symmetrical to the curve C of "the first case." Said pattern D will hereinafter be referred to as "the second case."

In both cases, the height h of the metal rods A and B above the ground may influence the directive characteristic in zenithal planes, but not any characteristics in horizontal planes. From the above mentioned patterns of Fig. 2, it is obvious that points of intersection K and H of the curves C and D and a center o of the arrangement of the rods A and B must be on a straight line which is at a right angle to a plane containing the rods A and B, because of the symmetry of the curves C and D. It is to be understood that, in order to obtain a radiation field having such a directive characteristic shown as polar curves C and D, the impedance of the rod acting as a reflector must always be suitably inductive.

According to this invention, for making the impedance of the reflector inductive, I employ a method which will be described with reference to Fig. 3. In Fig. 3, the length of the metal rods A and B is made equal to a half wavelength and divided into two parts at the mid points, where two parallel-wire-feeders W and Y are connected, the length of the same being preadjusted to have a reasonable reactance for any rod acting as a reflector.

When a couple of contact points e and f of a change-over relay S, to which is connected a main feeder line from the energy source V, are brought into contact with a couple of contacts c and d of the feeder W, the overall connection will be as shown in Fig. 4. Then, the metal rod A, excited from the source V through the main feeder F and a balancing apparatus Q, acts as a vertical antenna, and the rod B has an open-ended feeder Y connected at its center portion, being the current loop of the rod.

From a theoretical basis, it is understood that an equivalent reactance X of an open-ended feeder line is expressed as

$$X = Z \cot \frac{2\pi}{\lambda} l \qquad (1)$$

where

Z: surge impedance of a feeder line,

λ: wavelength, standing on a feeder line,

l: length of a feeder line.

The end points u and v of feeder Y form a current-loop of the rod B, and the equivalent reactance at points u and v must be inductive, when the length l of the feeder Y satisfies the following equation:

$$\frac{\lambda}{4}n<l<\frac{\lambda}{4}(n+1) \qquad (2)$$

where

λ: wavelength standing on a feeder line, with

n: odd integer.

If we take appropriately the length l within a scope of satisfying the Equation 2 and without a considerable loss resistance, the metal rod B has an inductive reactance and acts as a reflector, in which condition all particulars are the same as "the first case" already mentioned, and this enables obtaining a radiating field of polar curve C shown in Fig. 2.

When the couple of contact points e, f of the relay S come in contact with a couple of contact points r, t, the overall connection of the system will be as shown in Fig. 5, which is quite opposite and symmetrical to that of Fig. 4, when a radiating field of this connection will have the polar curve D shown in Fig. 2. In both cases, the balancing apparatus Q of the main feeder F must be adjusted to obtain the maximum efficiency of feeding from the energy source V.

Now, if the change-over relay S is so designed that the couple of contact points e and f moves together according to predetermined signals, for example, Morse signals E(dot) for Fig. 4, and T(dash) for Fig. 5, then radiating fields of polar curves C and D will be alternately radiated by keying the relay S following the above signals, which will be detected with a suitable receiving apparatus. For example, in a direction O—M—N of Fig. 2, stronger E(dot)-signals proportional to O—N will be repeatedly detected and weaker T(dash)-signals proportional to O—M in intervals of E(dot)'s, and, in another direction O—R—U, stronger T(dash)-signals and weaker E(dot)-signals, proportional to O—U and O—R will alternately be detected. On a straight line, in the direction of intersection of polar curves C and D, both signals are superposed with equal intensity, causing a continuous signal. Thus, in an aerodrome, when we assign the direction of equisignal intensity KOH to the runway, the pilot during blind flight may find the runway by employing suitable detecting apparatus.

However, the method of interlocking two signals E and T is very important. The shortest interruptions of equisignal radiation, if any, cause "key-clicks" which destroy the continuous equisignal, and make it difficult to detect the runway, especially in aural detection. To overcome this difficulty, according to this invention, the change-over relay S is designed in the following manner. Two couples of contact points c, d, and r, t are made of adjustable spring metal and the distances between the same and the couple of contacts e, f are so adjusted that there will be an extremely short interval of time of simultaneous contacting with both couples of c, d and r, t during the movement of the contacts e, f from c, d to r, t and vice versa. Therefore, in this invention, there is not any instant of interruption of antenna excitation from energy source V, but both antennae are simultaneously excited for a very short interval of time, as they will be with the connection shown in Fig. 6. In said connection of Fig. 6, both antennae A and B are excited in the same phase and magnitude, and of which the directive characteristic of radiation must be such a polar curve P as shown in Fig. 2, so that the direction of maximum intensity coincides with the equisignal intensity KOH. It will be necessary to equalize the field intensity of the polar curve P to that of polar curves C and D in the direction of KOH to completely avoid "key-click." If an antenna input of Fig. 6 is equal to that of Figs. 4 and 5, the field intensity of polar curve P may always be stronger than that of polar curves C and D in the direction of equisignal KOH, but the main feeder F is so adjusted as to balance the antenna system in the connections of Figs. 4 and 5 to obtain the maximum efficiency of feeding energy. Therefore, in the connection of Fig. 6, there will be an unbalancing of feeder F and decrease of the input of antenna, which causes the field intensity of polar curve P to diminish to substantially equal value with the intensity of the polar curves C and D in the direction of equisignal KOH, and the trouble due to "key-clicks" is practically removed.

What I claim is:

A system for directive radiation of electromagnetic waves, comprising a current source, a double pole change over means connected to said source, two doublet antennae each of which is tuned to a predetermined wave length, a pair of feeders connected to each of said antennae and having end contacts adapted to be engaged by said change over means, said feeders having an inductive reactance at the frequency to which said antennaes are tuned when said end contacts are opened by said change over means so as to cause the antennae respectively connected to the feeder involved to act as a reflector and allowing two fields to be radiated by the operation of said change over means, said fields having different directional characteristics of symmetrical pattern and said change over means comprising means for connecting both feeders simultaneously to the current source during the change over period so as to cause excitation of both antennae in the same phase and magnitude and radiate a third field of different directional characteristics than the first two and thereby avoid any interruption of radiation from the system during said change over period.

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