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H. DE FRANCE
BEACON SYSTEMS
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429,583
2 Sheets-Sheet 1

Fig. 1

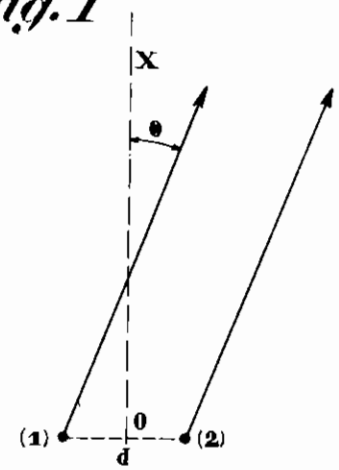

Fig. 2

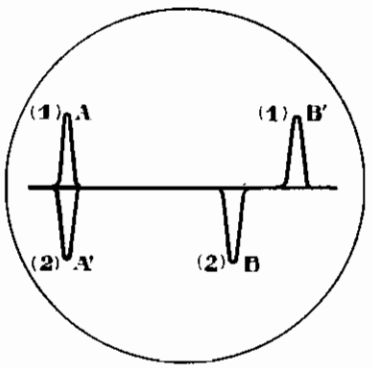

Fig. 3

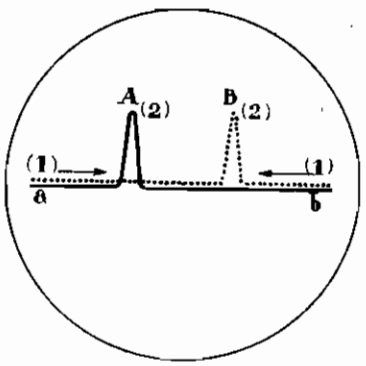

Fig. 4

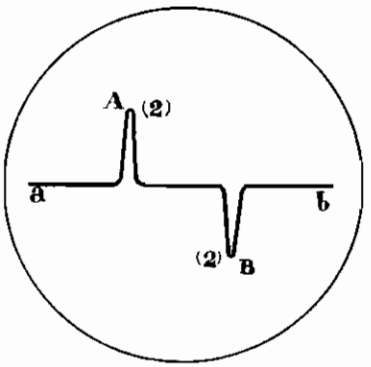

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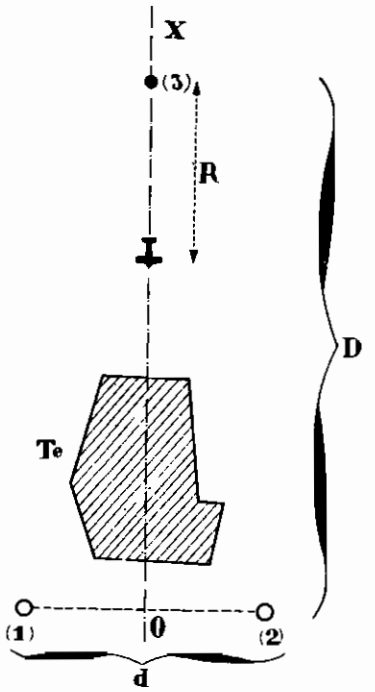
Fig. 5



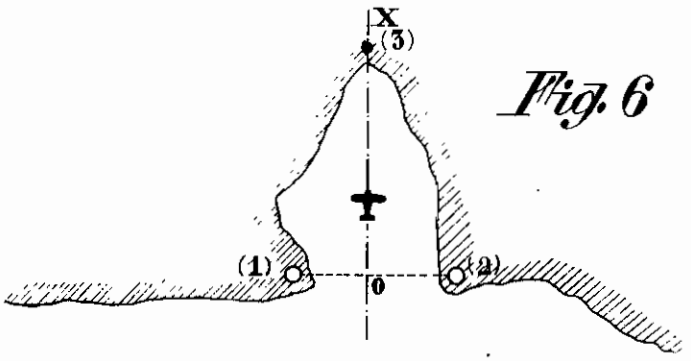


Fig. 6

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ALIEN PROPERTY CUSTODIAN

BEACON SYSTEMS

Henri de France, Lyon, France; vested in the Alien Property Custodian

Application filed February 4, 1942

The present invention relates to beacon systems of the type including radio-transmitters located on the ground and it is more especially although not exclusively concerned among these systems with those adapted to equip landing grounds, i. e. radio guides intended to permit the blind landing of air crafts.

The chief object of the present invention is to provide a system of this kind which is better adapted to meet the requirements of practise, and in particular which is more accurate, than those used for the same purpose up to the present time, while being extremely simple.

According to a feature of the present invention, a beacon system intended to mark out a straight line along the ground so as to permit of guiding an air craft along said line, includes at least two radio transmitters suitably located with respect to said line and combined in such manner that at least one of them can receive and retransmit the signals emitted by the other.

According to another feature of my invention, when it is desired to mark out a landing ground so as to permit or facilitate the blind landing of an air craft thereon, I make use of a first system for emitting radio signals and in particular a system including two transmitters for marking out an axis of the landing ground together with a second system for emitting radio signals conjugated in a suitable manner with the first signals, preferably in the way above-mentioned, whereby it is possible for the air craft's pilot to know when he is nearing the landing ground.

Other features of the present invention will result from the following detailed description of some specific embodiments thereof.

Preferred embodiments of the present invention will be hereinafter described with reference to the accompanying drawings given merely by way of example and in which:

Fig. 1 is a diagrammatical view showing the disposition on the ground of a system for marking out a certain line on said ground, such a system including two radio transmitters according to the principle of the invention;

Fig. 2 is a diagrammatical view of the screen of a cathode ray oscillograph included in a receiver system on board an aircraft or other movable engine with the indication of reception of the radio signals emitted by the beacon system of Fig. 1, according to the invention;

Figs. 3 and 4 are diagrammatical views analogous to that of Fig. 2 and corresponding to two other embodiments of the invention respectively;

Fig. 5 diagrammatically shows a landing ground and the beacon system used according to another feature of the present invention;

Fig. 6 shows an arrangement similar to that of Fig. 5, but corresponding to a landing area for seaplanes.

In the following description, it will be supposed, by way of example, that it is desired to establish a beacon system for marking out an axis such as OX (Fig. 1).

I make use of at least two radio transmitters 1 and 2, located symmetrically on either side of the axis OX in question and at a distance d from each other. These transmitters are adapted respectively to send two series short signals conjugated in a suitable manner, the whole being such that it is possible, on a machine, for instance an aircraft, fitted with suitable receiving apparatus, to ascertain the angular position of said aircraft with respect to axis OX from the measurement of the phase difference between the phenomena produced by the selected reception of said signal.

As for the manner in which the signals are emitted by the transmitters, according to one of the features of the present invention, at least one of the transmitters is fitted with means for receiving the signals transmitted by the other and causing the signals thus received to be retransmitted by the first mentioned transmitter. Such an arrangement permits, among other advantages, of increasing the precision with which axis OX is marked out.

Such a general principle may be applied in many different ways, some of which will be hereinafter described by way of example.

Concerning first the principle of the system relative to the transmission of the signals, this part may include transmitter stations 1 and 2, of any suitable type, at least one of which is fitted with a receiver device adapted to control its emission of signals in response to the reception of the signals transmitted by the other transmitter. Such a device can only be worked out by anyone skilled in the art.

Of course, in order to permit of selecting the two series of signals on the receiving apparatus existing on board the aircrafts, it will be advantageous to devise the two transmitters in such manner that the two corresponding series of signals are emitted with different characteristics respectively. In particular, these two series of signals may be emitted with different wavelengths.

It should be well undertsood that the signals may have the form of saw teeth different for

each series, as it has been explained in a French Patent application filed October 27, 1939, for "Improvements in Radio marking Methods for Maritime of Aerial Navigation and devices for carrying out."

Furthermore preferably and as it will be supposed to be the case in the following description, each transmitter is provided with a receiver device capable of receiving and retransmitting the signals transmitted from the other.

This last mentioned condition may be applied in different ways.

For instance, according to an embodiment of the invention, the transmission of the two series of signals by transmitters 1 and 2 may be effected independently of the means for retransmitting for each of them the signals received from the other, but preferably at the same rhythm.

According to another embodiment, the transmitters are mutually controlled by each other, transmitter 1 emitting a signal which is received by transmitter 2 and retransmitted by the latter with its own wave-length or in a general way with its own characteristics, after which transmitter 1 in turn receives the last mentioned signal and retransmits it, and so on.

I will now deseribe the receiving part of the system which is that to be provided on the aircrafts or other machines to be guided and which must be capable of indicating a value corresponding to the phase differences with which the two series of signals are received, whereby it is possible to determine the position of the aircraft, i. e. the angle θ made with the beacon line OX by a straight line extending from point O to point P designating the aircraft. Such a receiving apparatus is made of any suitable type, including means capable of selecting the signals coming from transmitter 1 from those coming from transmitter 2, i. e., in the case that has been considered, distinct received circuits respectively tuned to the two respective wave-lengths of the two transmitters.

Preferably, the phase difference in question is indicated visually, as also suggested in the prior Patent Application above mentioned. I may for instance make use of a cathode ray oscillograph, the control and deviating means of which are adapted to be suitably influenced by the radio signals received from the two transmitters above described.

Of course, I do not wish to be limited to such an arrangement and I might proceed in any other suitable way. For instance, I might make use of recording devices, in combination with a band or strip unwinding from a drum or I might merely make use of devices such as phasemeters tuned to the frequency of the signals.

In order to give a better understanding of the principle of my invention, I will now give some specific examples thereof.

First, it will be supposed that according to an advantageous embodiment of the receiver apparatus, the oscillograph is arranged in such manner that, through controlling devices which will be easy to provide, the reception of a signal transmitted by 1 or by 2 causes the horizontal scanning to be started in the oscillograph while producing a deviation the latter taking place for instance in one direction for the signals transmitted by 1 and in the opposed direction for the signals transmitted by 2.

On the other hand, it will be supposed that both transmitters send their signals independently and at the same rhythm.

The phenomenons occurring in the receiving apparatus are as follows:

When transmitter 1 sends a signal, the latter reaches transmitter 2 after a time interval equal to

$$\frac{d}{c}$$

seconds, c being the velocity of light. This signal is then retransmitted by transmitter 2, on the wave-length thereof and with a delay equal to t corresponding to the time constant of the system of circuits of said transmitter.

It follows that at a great distance and at a point P and the angular coordinate of which is θ, signal (1) is first received, then signal (2) after a time interval which is:

$$T=\frac{d}{c}(1-\sin\theta)+t$$

In the oscillograph, signal (1) produced at A the starting of the horizontal scanning and also a positive deviation (i. e. deviation above the horizontal line). Signal (2) produces at a point B a negative deviation, i. e. a deviation below said horizontal line.

Distance AB therefore gives a measurement of the phase difference

$$\frac{d}{c}(1-\sin\theta)+t$$

If now a short time after this (i. e. after a time sufficiently short for ensuring the persistency of the luminous impressions on the oscillograph), transmitter 2 in turn sends a signal, the latter is received and retransmitted by transmitter 1. At the receiving point P, the reception of these two successive signals takes place with the following time interval:

$$T'=\frac{d}{c}(1-\sin\theta)+t$$

Thus the oscillograph gives two new images or deviations A' and B', the horizontal scanning of the spot now starting with the reception of signal (2) which has been the first to be received.

It follows that on the oscillograph distance B—B' corresponds to the following time interval:

$$T'-T=\frac{2d}{c}\sin\theta$$

This shows that the invention permits a precision which is twice that obtained by the known methods used prior to this invention; these known methods merely involve the emission of synchronous signals by the transmitters and the phase difference is then equal to

$$\frac{d}{c}\sin\theta$$

According to the present invention, I obtain the following value of θ:

$$\sin\theta=\frac{BB'\times c}{2d}$$

and the presence of factor 2 in this formulae shows that the accuracy with which small angles are obtained is doubled for an absolute value of the reading of BB'.

If now, according to another embodiment already referred to, it is supposed that transmitters 1 and 2 are dependent upon one another, i. e. are controlled by one another, the reception may be effected in such manner that the signals

from transmitter 1 alternately start the scanning in the oscillograph in one direction (from a to b). Then, for the next signal from transmitter 1 in the opposed direction (from b to a), and so on while the signal transmitted by 2 produces deviation of the spot, as shown by Fig. 3.

This device will work in the following manner:

Segment a—b is the total segment horizontally scanned by the spot of the oscillograph. Point a corresponds to a signal from 1, point b to the next signal from 1, point a to the first signal from 1 and so on.

On the other hand, to a signal (1) corresponding to a; there corresponds a signal (2) transmitted after a time T above defined and this signal 2 is marked at A.

Likewise, to a signal (1) corresponding to point b, there corresponds a signal (2) sent after a time interval equal to T', and this signal (2) is marked at B.

Therefore:

$$aA = \frac{d}{c}(1 - \sin\theta) + t$$

$$bB = \frac{d}{c}(1 + \sin\theta) + t$$

so that it is clear that:

$$AB = \frac{2d}{c}\sin\theta$$

as in the first embodiment above described.

According to another embodiment which is a modification of the preceding one, the direction of the signal (2) may take place on the opposite side of the horizontal line a—b when the light spot of the oscillograph moves from b to a.

In this case, I obtain on this oscillograph screen an image such as shown by Fig. 4, with which it is possible to read in a very accurate manner the value of distance A—B even when it is tending toward zero. Furthermore, the sign of angle θ can be appreciated, according as the upper signal is on the right hand side or on the left hand side of the lower signal, since it is thus possible to know which of the two signals corresponds to a or to b.

Whatever be the specific embodiment that is chosen, I obtain a system the operation of which results sufficiently clearly from the preceding description for making unnecessary to enter into further explanations.

This system has, over systems used prior to my invention, many advantages, among which the following may be cited:

(a) The indications are read directly on the oscillograph screen;

(b) It is possible to obtain a very high accuracy;

(c) It is possible to determine the sign of angle θ;

Of course, it should be well understood that this beacon system can be used in all kinds of applications.

For instance, as above stated, it may be used for marking out the axis of a landing ground so as to permit blind landing.

An examination of the oscillograph then permits of determining axis OX and of bringing the course of an aircraft into coincidence with this axis in such manner that the air craft will land in the vertical plane passing through said axis.

In this case, it is necessary to provide supplementary means for enabling the pilot exactly to appreciate the position of landing ground with respect to said vertical plane.

The present invention therefore includes for this purpose, some supplementary features such as will be hereinafter described and which can be used separately (i. e. whatever be the manner in which axis OX is marked out).

According to one of these features I combine with a first transmitter system capable of marking line OX, a second transmitter system located at a distance D from the first along said line and conjugated with said first transmitter system in any suitable manner owing to which it is possible to deduce from the phase difference between the two series of signals received, the position of the aircraft along line OX, i. e. to know when it is nearing the landing ground OTe.

For this purpose, for instance, such a system includes the following elements:

(a) On the one hand (Fig. 5) at least two radio transmitters 1 and 2 serving to mark out line OX. This transmitter may be of the type emitting synchronous signals, of the above described type, or of any other suitable type;

(b) On the other hand, at least one transmitter 3 located along line OX, either ahead of the landing ground, as shown, or behind said landing ground, this first transmitter being capable of sending signals suitably conjugated with those transmitted by 1 and 2.

Advantageously, and according to a feature of the invention, this conjugation may be performed in such manner that the signals of transmitter 3 are received and retransmitted by transmitters 1 and 2, or vice versa.

For instance, supposing that transmitter 3 is located as shown by the drawing, and supposing also that transmitters 1 and 2 receive the signals from 3 and retransmit them, the whole system works as follows:

If the airplane is beyond transmitter 3 the time interval between the reception of the signals from 1 and 2, on the one hand, and the signals from 3, on the other hand, is substantially:

$$\frac{2D}{c} + t$$

c being the velocity of light and t the time constant of circuits 1 and 2. In this case, the aircraft cannot appreciate its distance from the landing ground.

But, when said aircraft has moved past transmitter 3, the time interval in question becomes:

$$\frac{2D}{c} + t - \frac{2R}{c}$$

R being the horizontal distance form the aircraft to transmitter 3.

It follows that if it is possible to distinguish, on the aircraft, for instance by means of an oscillograph, the signals from 1, from 2 and from 3, the pilot will be enabled first to keep its aircraft in the vertical plan passing through OX and also to appreciate exactly its horizontal distance from the landing ground.

In order to permit a good selection of the various signals that are received, transmitter 3 may emit signals having characteristics different from those of transmitters 2 and 3, for instance it may send its signals on a valve-length different from those of the other signals.

From practical purposes, I may advantageously choose for d the distance ranging from 1 to 2 kilometers and for D a distance averaging 15 kilometers.

Of course, the embodiment above described constitutes only one example of my invention. It

may be modified without departing from the principle of said invention. For instance, transmitter 3 must not necessarily be located on the perpendicular passing through the middle point of line 1, 2 and the beaconing OX might be oblique with respect to said line 1, 2.

Any way, I may obtain, according to the invention, a system which enables the pilot to land very safely along an axis marked by the beacon system, with the help of his altimeter or any other equivalent means, since the pilot knows at any time the exact horizontal distance between his aircraft and the landing ground.

Of course, a system according to my invention might be adapted to different places or geographic arrangements as may exist.

For instance, I have shown in Fig. 6 the equipment of a base for seaplanes.

In this case, transmitters 1, 2 and 3 might eventually be disposed on floats.

HENRI DE FRANCE.