Aug. 22, 1933. F. G. KEAR 1,923,934

RADIO BEACON COURSE SHIFTING METHOD

Filed Nov. 24, 1931 3 Sheets-Sheet 1

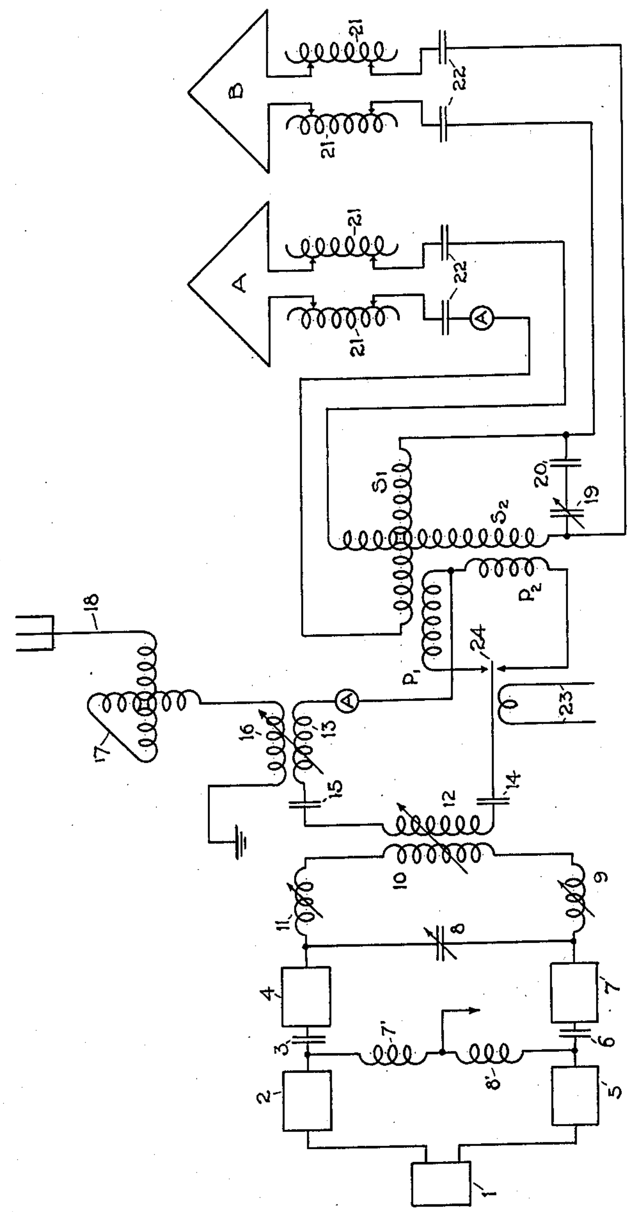


FIG. 1.

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RADIO BEACON COURSE SHIFTING METHOD

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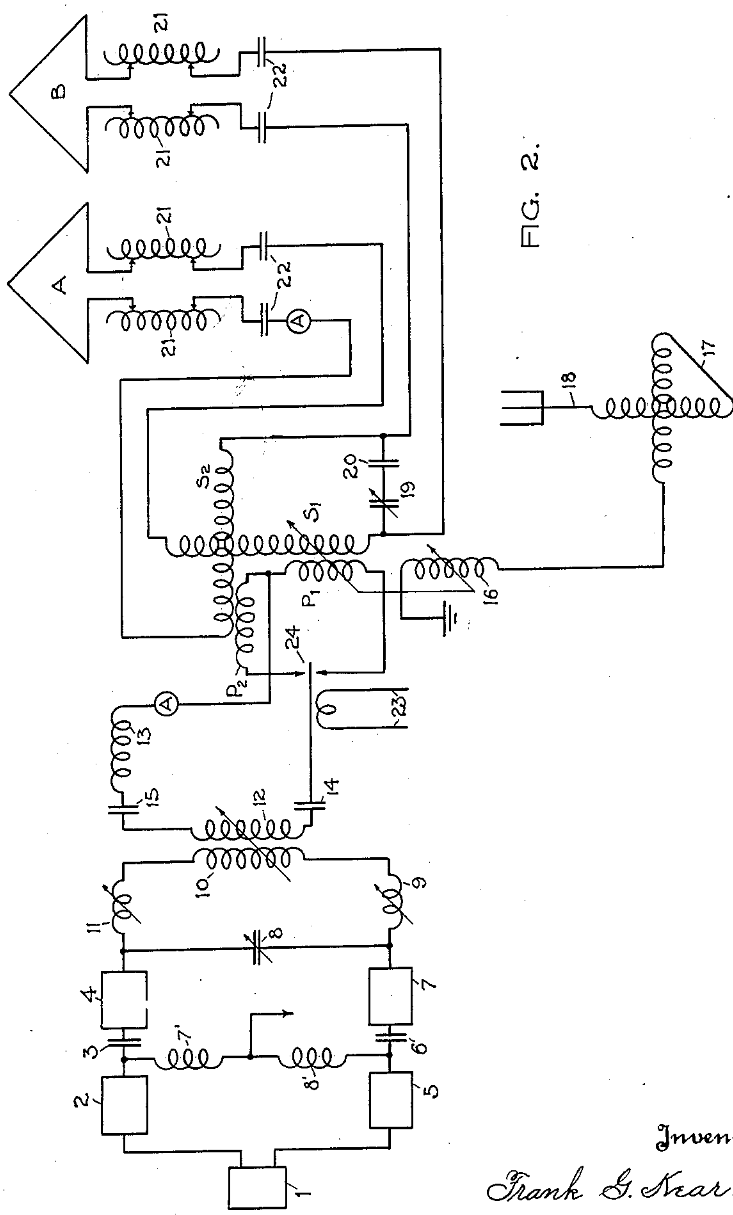


FIG. 2.

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RADIO BEACON COURSE SHIFTING METHOD

Filed Nov. 24, 1931 3 Sheets-Sheet 3

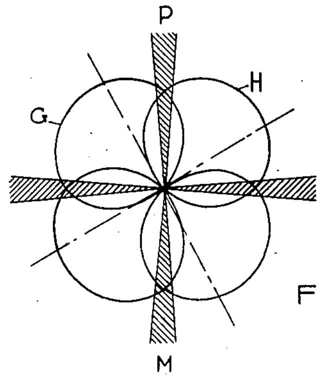
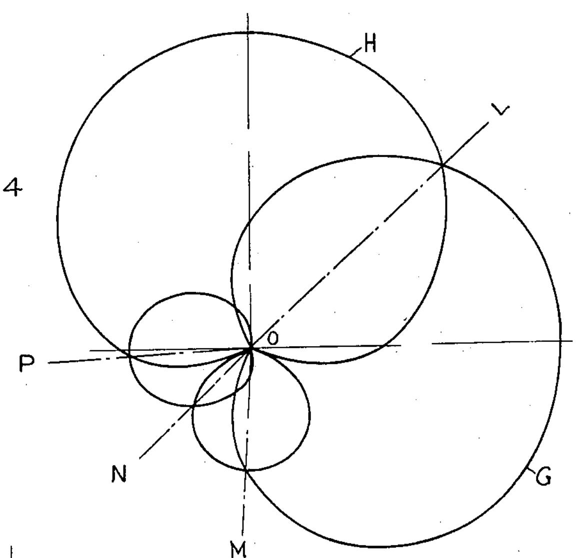



FIG. 3.

FIG. 4



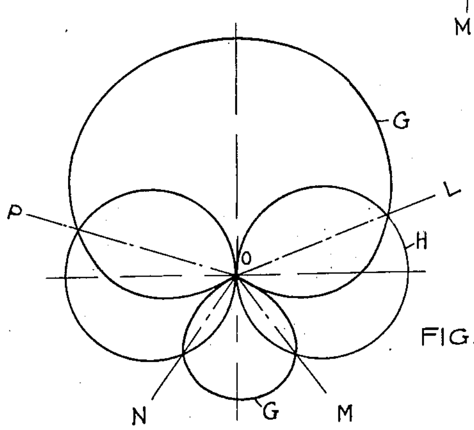




FIG. 5.

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# UNITED STATES PATENT OFFICE

1,923,934

## RADIO BEACON COURSE SHIFTING METHOD

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Application November 24, 1931
Serial No. 577,025

2 Claims. (Cl. 250—11)

(Granted under the Act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon.

This invention relates generally to radio beacons and has more particular reference to a novel method and apparatus for adjusting the direction of radio beacon courses.

It has long been appreciated that a limitation of the radio range-beacon in its early form has been the fact that the four courses emanating from a single radio range-beacon have been at fixed angles of 90° to each other. It is obvious that such an arrangement could serve only one course at a time when situated at an airport except whereby rare coincidence two courses extended at 90° or 180° from an airport. In order to make at least two of the four available courses useful the radio beacon installations could be situated halfway between points on the straight airways at distances of approximately 200 miles. This would make it possible to use two of the four courses and at the same time to reduce the angular width of the equisignal zone since the two courses were displaced 180°. This is accomplished by increasing the angle between the two primary coils of the goniometer to about 120° instead of 90°. Some installations of this type were made along the Transcontinental Airway.

Placing radio range-beacons in this manner has one particularly annoying feature in that the course is usually broadest where it should be narrowest. To make this statement clear, it should first be understood that an equisignal course is a true angular function; that is, directly over the center of the loop antenna the courses have an infinitesimal width, and gradually the width increases to approximately 6 miles at 100 miles distance from the radio range. When a pilot flies from a point at a distance from the radio range it is evident that his course gradually becomes sharper and narrower as he approaches the beacon installation, and if he keeps on his course it will take him directly over the radio tower. This feature alone is one of paramount importance and can not be neglected, since experience has shown that when the radio range is located adjacent to the terminal airport pilots are able to locate the airport and make safe landings when conditions are such that they would otherwise be unable to find the terminal airport. Hence, when a radio beacon is located at a terminal airport there are two very distinct advantages: First, the course becomes narrower as the pilot approached the beacon; second, the beacon informs the pilot definitely when he has passed over the tower. Therefore, it practically fixes a point in space directly over the antennas. It is apparent that such a point in space would be of unquestionable value if located adjacent to a terminal airport instead of halfway between two airports. It was with these particular features in mind that the problem of fitting radio ranges to the airways was attacked.

The main object of my present invention, therefore, is the provision of a radiobeacon system whereby radiobeacon courses can be shifted by the addition of circular radiation in time-phase with the normal figure-of-eight radiation from the loop antennas.

Another object of my invention is the provision of a vertical antenna, located at the intersection of the two loop antennas and in inductive relation with the radio transmitter so that its radiation is in time phase with the radiation from the phantom antennas.

Another object of my invention is the provision of a vertical antenna, at the intersection of the two loop antennas, in inductive relation with one of the primary coils of the goniometer, and radiating in time phase with the phantom antenna of the said primary.

Other objects as well as advantages of my system will be self-evident from the following description of my invention taken in connection with the accompanying drawings in which:

Figure 1 is a schematic diagram of a radiobeacon system embodying my invention;

Figure 2 is a schematic diagram of a radiobeacon system embodying a modification of my invention shown in Figure 1;

Figure 3 is a diagram showing the normal radiated space pattern of two loop antennas when the primary coils of the goniometers are at 90° with respect to each other.

Figure 4 is a diagram of a field intensity pattern obtained by permitting a vertical antenna, inductively coupled to both primary coils of the goniometer, to radiate in time phase with the radiation from the phantom loop antennas.

Figure 5 is a diagram of a field intensity pattern, obtained by permitting a vertical antenna inductively coupled to one of the goniometer primaries to radiate in time phase with the radiation from the phantom loop antenna corresponding to that goniometer primary winding.

Referring to the accompanying drawings in which like reference characters designate like parts and like space patterns, the numeral 1 (Figure 1) indicates a master oscillator which is connected for supplying radio-frequency currents in equal proportions to the control grids of the intermediate amplifiers 2 and 5 operating in a push-pull circuit and cross-neutralized. 7′ and 8′ denote radio-frequency chokes. The power output of 2 passes through the condenser 3 to the control grid of the power amplifier 4. Likewise, the power output of 5 passes through the condenser 6 to the control grid of the power amplifier 7. The power output of 4 and 7 is transferred to the tuned tank circuit, comprising the variable condenser 8 and the variable inductors 9, 10 and 11, from which it is transferred, through the medium of the inductive relation existing between the coils 10 and 12, to the untuned link circuit comprising the condensers 14 and 15, the coupling coils 12 and 13, the primary coils of the goniometer $P_1$ and $P_2$ and the relay 24. Some of the power is then transferred to the vertical antenna 18 by means of the inductive relation between 13 and 16. The numeral 17 denotes the antenna tuning inductor. The remainder of the power is then transferred to the loop antennas A and B by means of the inductive relations existing between the primary coils of the goniometer $P_1$ and $P_2$ and the secondary coils $S_1$ and $S_2$, respectively. 21 and 22 denote the tuning inductors and capacitances, respectively, of the loop antennas A and B. The power for operating the relay 24, which connects the primary coils of the goniometer $P_1$ and $P_2$ to the tank circuit alternately is supplied by the conductors 23.

The diagram shown in Figure 2 is identical to Figure 1 with the exception of the method for transferring power to the vertical antenna. In Figure 2, the coupling coil 16 of the vertical antenna 18 is coupled inductively to the primary coil $P_1$ of the goniometer and is energized only when the goniometer primary $P_1$ is connected to the link circuit, while in Figure 1 the vertical antenna is energized regardless of whether $P_1$ or $P_2$ is in circuit.

The principle of operation of my invention is best understood by referring to the accompanying radiated space patterns. Figure 3 is the radiated space pattern of a typical radio range when the goniometer primary coils are set at 90° with respect to each other (i. e., the space patterns obtained with the circuits shown in Figures 1 and 2 when the vertical antenna is disconnected).

G and H denote the figure-of-eight radiated space patterns of the two phantom loop antennas. Each primary winding of the goniometer, acting in conjunction with the crossed secondary coils and the two crossed-loop antennas, sets up a system (a phantom loop antenna) which is electrically equivalent to a single loop antenna. The plane of this phantom antenna is dependent upon the relative coupling of the secondary coils to the primary coils under consideration.

Since there are two primary windings, two such phantom antennas exist, the angle between their planes being equal to the angle between the primary windings of the goniometer. The two phantom antennas may be rotated in space (thus changing the position of the equisignal zones or courses formed by their space patterns) by changing the relative position of the primary windings with respect to the secondaries. This may be accomplished by rotating either the primary or the secondary coils. The four equisignal courses indicated by the cross-hatched areas L, M, N and P maintain fixed angles of 90° to each other when the goniometer primaries remain fixed at 90°. It is understood that the goniometer secondary coils are always maintained at 90°.

The preferred system shown in Figure 1, including the vertical antenna by means of which circular radiation is added in time phase to the normal figure-of-eight radiation from the phantom antennas yields the radiation space pattern shown in Figure 4. It will be noted that one lobe of each of the normal figure-of-eight patterns G and H is increased and the other decreased correspondingly, producing a shift of two of the courses MO and PO, in the direction of the smaller lobes. The amount of this shift may be controlled by adjusting the magnitude of the current in the vertical wire. This shift is limited only by the disappearance of the two smaller lobes. The courses OL and ON retain their normal 180° relationship.

When the vertical antenna 16 is coupled to only one primary coil of the goniometer $P_1$ as shown in Figure 2, only one figure-of-eight radiated space pattern G will be distorted as shown in Figure 5. It will be noted that the addition of the circular radiation to the figure-of-eight space pattern produces a shift in the four beacon courses; i. e., it increases the angle between the courses OL and OP and decreases the angle between OM and ON correspondingly.

The amount of shift attainable with either arrangement (Figures 1 or 2) depends, within certain limits, upon the magnitude of the circular radiation and the power output of the transmitters and their ratio with respect to each other.

In practical tests of this system conducted at Bellefonte, Pennsylvania, excellent control of the amount of shift was obtained by inserting a coupling coil in the common goniometer primary circuit and coupling thereto the vertical antenna installed on the radio range tower. Displacements as large as 30° were readily obtainable.

The embodiment of the invention illustrated and described herein has been selected for the purpose of clearly setting forth the principles involved. It will be apparent, however, that the invention is susceptible of being modified to meet the different conditions encountered in its use, and I, therefore, aim to cover by the appended claims all modifications within the true spirit and scope of my invention.

What I claim is:

1. A method of shifting two radio beacon courses from their normal 180 degrees displacement to align them with two airways intersecting at a radio beacon at an angle other than 180 degrees which consists in introducing circular radiation into the normal figure-of-eight radiations from the beacon.

2. A method of changing the angular displacement between two of a plurality of equisignal courses from a radio beacon which consists in introducing circular radiation into the normal figure-of-eight radiations from the beacon.

FRANK G. KEAR.