May 25, 1937. H. M. DOWSETT ET AL 2,081,530

WIRELESS DIRECTION FINDING SYSTEM

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Fig. 1

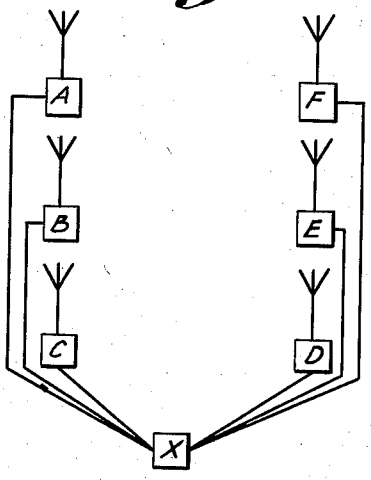


Fig. 2

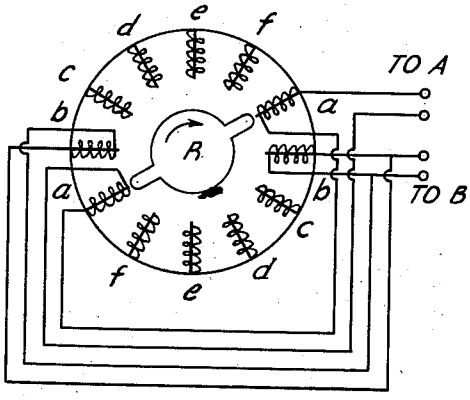


Fig. 4

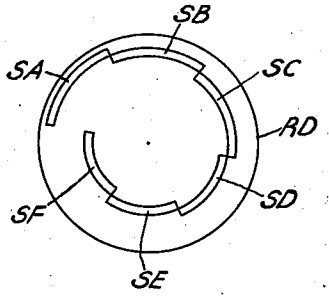


Fig. 3

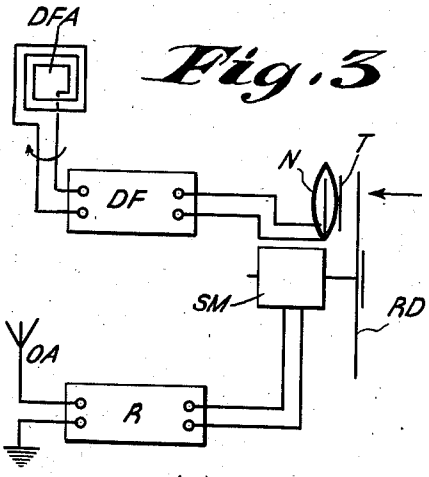
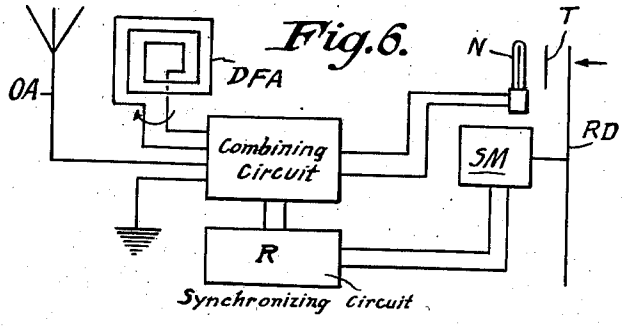


Fig. 5



Fig. 6.



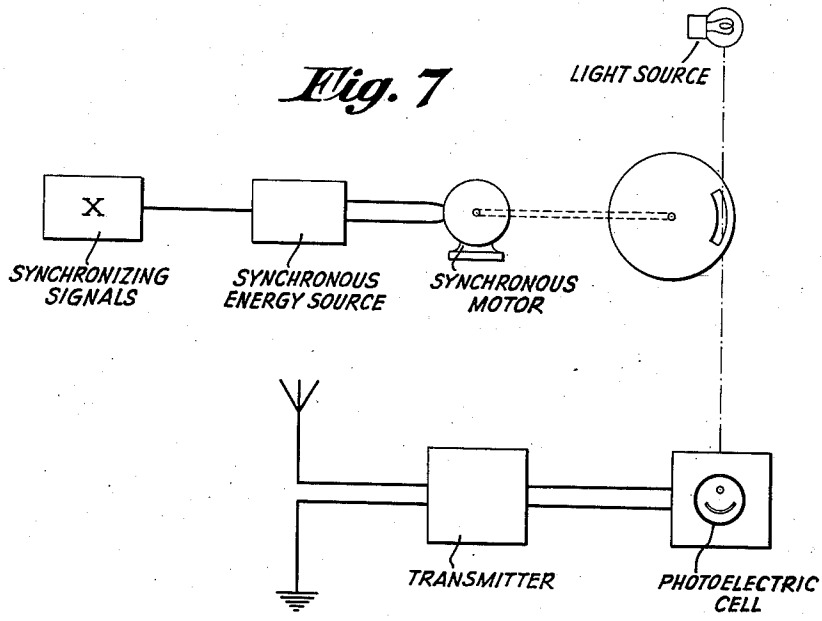
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Fig. 7



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WIRELESS DIRECTION FINDING SYSTEM

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11 Claims. (Cl. 250—11)

This invention relates to wireless direction finding systems and has for its object to provide a system whereby direction finding operations can be satisfactorily accomplished by relatively unskilled persons.

In wireless direction finding systems as at present in use, bearings are usually obtained by observing the direction from which signals from a known beacon station are received. The various beacon stations emit characteristic call signs or signals by which they can be identified and the direction of such a beacon station is ascertained at the receiving station by means including a rotatable frame aerial or a pair of fixed frames and a radiogoniometer, the operator moving the rotating frame or the radiogoniometer search coil until a maximum audible signal or a minimum audible signal, as the case may be, is received. In practice these operations call for a considerable amount of skill and judgment. Furthermore, wireless direction finding systems as at present known involve as a rule the employment by various stations of a substantial width of transmitting frequency band and in view of the present crowded state of the available wireless frequency band, it is highly desirable to provide a system wherein a wide transmission frequency band is unnecessary.

The principal object of the present invention is to provide a simple and efficient system whereby the operator at a receiving station, who may be a comparatively unskilled person, may easily identify a radio transmitting station being received and which shall be such that the frequency band occupied is comparatively small.

The novel features of my invention have been pointed out with particularity in the claims appended hereto. The nature of my invention and the manner of operation of the same will be better understood from the following detailed description thereof when read in connection with the attached drawings in which Figures 1 and 2 illustrate diagrammatically the essential elements of a transmitting system arranged in accordance with my invention; Figures 3, 4, 5 and 6 illustrate the essential features of a receiver arranged in accordance with my invention; and Fig. 7 illustrates certain features of the transmitter arrangements preferably employed at any one of the stations A, B, C, D, E or F as shown in Fig. 1.

In carrying the invention into practice the means provided at the receiver for enabling the operator to identify a station being received, are such as to cause the name of the station being received, to be indicated preferably by illuminating that name on a screen or chart.

According to this invention a wireless direction finding system comprises a plurality of transmitting stations A, B, C, D, E and F (Fig. 1) adapted to transmit signals in turn at a definite time or for predetermined periods and at predetermined intervals, and at least one receiver adapted directionally to receive said transmitted signals, said receiver including a member running synchronously at a speed determined by the frequency of transmission of signals from the transmitting stations and means actuated in dependence upon the times of transmission of the signals from the various transmitting stations with relation to the movement of the synchronous member, for indicating to which of the transmitting stations in the system the directional receiving means are adjusted. Thus the receiver may incorporate a chart marked out with the names of a plurality of beacon stations and may be provided with means for picking out from that chart the name of a station to which the receiving directional aerial is adjusted.

In one way of carrying out the invention the transmitting portion of the system consists of a number of transmitting stations, each being provided with apparatus such as shown in more detail in Fig. 7. Such apparatus preferably includes a synchronous motor driving a disk which is provided with a slot adjacent to and parallel to the periphery thereof, said slot embracing a fraction of a circle. For example, supposing there are six transmitting stations in the system, then the slot would extend through 1/6th of the circle. Behind the disk is arranged a suitable projection lamp arrangement whereby light is projected on to the disk, there being on the other side of said disk a photoelectric cell or equivalent means, the whole arrangement being such that during 1/6th of each revolution of the disk, light will pass through the slot therein to fall upon a photoelectric cell. The motors and disks at the various transmitting stations are maintained in synchronism preferably by signals initiated at a central station X so that they all run together at the same speed and in fixed relationship with one another. This may otherwise be accomplished in any convenient manner, and may be accomplished by arranging one of the different transmitting stations to transmit a synchronizing frequency which is employed not only, in a manner to be described later, in connection with reception, but also for synchronizing purposes, as between the transmitters. The slots

in the disks at the various transmitting stations are in different positions relative to one another so that during ⅙th of a revolution of a disk, light will be transmitted through the slot in the disk at one of the transmitting stations, during the next ⅙th of a revolution light will be transmitted through a slot in another, during the next ⅙th of a revolution light will be transmitted through a third, and so on.

Accordingly, whenever light falls on the photoelectric cell at a transmitting station, an impulse will be transmitted and this impulse will not occur at the same time at any two stations. The motors are so arranged that the impulses, to be hereinafter referred to as "picture impulses" and caused by illumination of the photoelectric cells at the transmitters, are of substantially greater amplitude than the synchronizing signals. These details are clearly shown in Fig. 7, where the elements in combination are suitably designated by explanatory legends.

Figures 1 and 2 of the accompanying drawings illustrate an alternative form of transmitting portion of a system in accordance with this invention. Figure 1 illustrates six radio transmitters A B C D E F, suitably positioned geographically and connected by land lines to a central control station indicated at X. The station X is provided with a motor driven impulse distributor which may consist as illustrated in the accompanying Figure 2 of a small alternating current generator which, in the case considered where there are six transmitting stations, may have a 12 pole stator and a two pole rotor. The windings appropriate to each pair of stator poles, these windings are indicated by the letters *a a b b c c* etc., in Figure 2, are connected by land lines as indicated to the appropriate station A B C D E or F. For the sake of simplicity the connections for the windings *a a* and *b b* only are shown in Figure 2, but, of course, the other windings are similarly connected each to its appropriate station. The rotor R may consist of a permanent magnet having two poles, or it may be a two pole armature electro-magnetically energized from a source of direct current. As will be apparent rotation of the rotor R will result in the generation and distribution of impulses to the stations A B C D E and F in succession and these impulses are radiated by the said stations. The rotor R is preferably driven by a synchronous motor. To take a practical numerical example, the driving motor may run at 300 revolutions per minute and the pole pieces of the armature may be caused to pass the field poles at the rate of 60 per second. Thus each impulse generated may be $\frac{1}{60}$th of a second in duration, each transmitting station radiating 10 impulses per second, since the distributor will generate 6 impulses in $\frac{1}{10}$th of a second.

We shall now describe an embodiment of receiving apparatus suitable for use in a system which employs transmitters of the type hereinbefore mentioned. This embodiment of receiving apparatus is illustrated in Figs. 3, 4, and 5.

Each receiving station in the receiving portion incorporates a synchronous motor running in synchronism with the motors at the transmitters, or at the station X as the case may be. The motor at each receiver is employed to drive a disk having not merely one slot but, in the system assumed as having six transmitting stations, six slots, each slot occupying a different one-sixth of a circle and each slot being at a different radial distance from the center of the disk, as shown in Fig. 4.

Behind the disk at each receiver is arranged a chart or template on which is marked out the names of the six transmitting stations in the system, these names being printed along arcuate lines and being underneath one another. This arrangement will be described hereinafter in greater detail.

The received signals corresponding to signals obtained from a photoelectric cell at a transmitter, or derived from the distributor at X, as the case may be, are employed to energize a suitable illuminating lamp, for example, a neon discharge tube, which is arranged to illuminate the chart and which is preferably concealed by the disk. For example, a convenient arrangement is to provide a neon tube with a plate-like cathode of approximately the same area as the chart and to make the chart of translucent material, the said chart being arranged immediately behind the disk and between the disk and the neon tube and a lens being provided through which the disk with the chart and lamp behind may be viewed.

Each receiving station also incorporates means for separating the synchronizing signals from the picture signals by reason of the difference in amplitude level. For example, the radio receiver at each receiving station may incorporate what is in effect two receiving circuits connected in parallel, one receiving the synchronizing signals and the picture signals and amplifying them to supply the amplified energy to the synchronous motor and the other also receiving both signals but containing in the circuit of one of the valves a neon lamp or like device which is arranged to "break down" to become conductive only when the signals exceed a predetermined amplitude so that in the circuit following that in which this neon tube is incorporated, only the large amplitude picture signals will occur. These large amplitude picture signals are supplied to the neon tube associated with the chart.

It will be seen therefore that at each receiver, when signals from a particular beacon are being received, for example, when the frame aerial of the receiving station is pointed towards a particular beacon, the picture signals therefrom will illuminate the neon lamp only at those periods of time when the disk at the receiver is exposing on the receiver chart the name of the beacon station being received so that the operator is shown the actual name of the station he is receiving on the chart.

The synchronous motors are run at such speed that, although each name is in fact only shown for one-sixth of a revolution, in the particular example described, the periods during which the name is shown and illuminated are so close together in point of time that the name appears continuously to the eye. For example, the disks might be run at a speed of 20 revolutions per second and synchronized at any suitable frequency, for example 300 cycles per second and it will be apparent that the frequency spectrum occupied by such a system will be very narrow.

A suitable preferred receiving station for cooperation with a transmitting portion as illustrated is illustrated in Figures 3, 4 and 5 of the companying drawings. In Figure 3 SM is a synchronous motor driving a disk RD which is shown in face view in Figure 4, said disk having six

slots SA, SB, SC, SD, SE, and SF arranged as shown in the said Figure 4. Immediately behind the disk, which is viewed in the direction of the arrow in Figure 3, is a transparent template T which is shown in face view in Figure 5. This template is marked out, as indicated, with the names of the various stations, these names being abbreviated A to F respectively. The names are so positioned that as the disk RD rotates the slot SA moves once per revolution over the marking for station A, the slot SB moves over the marking for station B, and so on. Behind the template T is a neon lamp N or other suitable electric discharge lamp which is energized by the output from a radio receiver DF receiving input signals from a directional aerial or aerial system DFA. The synchronizing windings of the motor SM are energized by the output from a second radio receiver R receiving input signals from a substantially omni-directional aerial or aerial system OA.

When a particular name is exposed, that name will appear to the eye and, assuming the disk to run at a sufficiently high speed, that name will appear to the eye, by reason of persistence of vision, continuously.

The operation of the whole system illustrated is therefore as follows: Each transmitting station sends out an impulse lasting $\frac{1}{60}$th of a second every $\frac{1}{10}$th of a second so that during $\frac{1}{10}$th second six impulses are sent out by the complete system in the order A B C D E F, i. e., one impulse from each station in turn. At the receiver the omni-directional aerial picks up all the signals from the system and applies them, after amplification at R, to the motor SM which is designed to run at 600 revolutions per minute when controlled by a synchronizing frequency of 60 cycles per second. The aerial DFA is tuned to the same wave length as the aerial OA, i. e., the common wave length of all the transmitters, so that, if the frame aerial be so adjusted as to receive all the transmitted signals the lamp N will light up for every signal and all the names on the template will be illuminated. When, however, the frame aerial DFA is swung at right angles to the direction of any particular transmitter, say the transmitter C, no signals will be received from that transmitter and the lamp N will not light at the moments when the name C is exposed by the disk RD. Hence the name C will not appear and this fact indicates that the station C is in a direction at right angles to the direction in which the aerial DFA is pointing.

In an alternative form of receiving station as shown in Fig. 6, the outputs from the directional and omni-directional aerial receiving systems are fed to a common amplifier at which the said signals are combined in opposite phase. The neon lamp is energized from the common amplifier and the arrangement is such that when signals are received both directionally and omni-directionally the neon lamp does not light so that when zero signal strength is obtained directionally from any particular station, i. e., when the frame aerial is at right angles to the direction of that station, the omni-directional and directional signals from that station will not balance out in the common amplifier, as they will as regards all other stations, and in consequence the neon lamp will be lit as a result of the omni-directional reception of signals from the station in question, at the moments when the name of that station is exposed by the slotted disk, so that the name of the said station will be illuminated.

Having thus described our invention and the operation thereof, what we claim is:

1. A wireless direction finding system comprising a receiver having a directional aerial, a plurality of transmitting stations located in different directions with respect to the location of said receiver, means common to said transmitting stations for causing each in succession to transmit signals for predetermined cyclic periods, synchronizing means at the receiver actuated in dependence upon the rate of change of the signal transmission from one transmitting station to another for enabling said receiver to respond differentially to said signals according to the source thereof, and means connected with said receiver for indicating the response thereof to signals from the particular transmitting station toward which the aerial is directionally oriented.

2. A system as recited in claim 1 in which each of said transmitting stations includes a source of carrier waves, and means for controlling the transmission of the same comprising a synchronously driven disc at each transmitting station, each of said discs being slotted, a source of light on one side of each disc, a photo-electric cell on the other side of each disc, said cell being connected to said source of carrier energy, each slotted disk having a slot which is parallel to the edge of the disk and embraces an arc substantially equal to 360° divided by the number of transmitting stations in the system, the relative rotary positions of the various slotted disks being such that when one has just finished passing light to its associated photoelectric cell, the one at the next station to transmit commences to pass light to its cell, no two disks passing light at the same time.

3. In a signal receiving system for receiving and identifying signal impulses of like period sent out in a cyclic manner from a plurality of transmitting stations, a receiving station comprising a synchronous motor running synchronously at a speed determined by the frequency of transmission of signals from the various transmitting stations, a slotted shutter driven by said motor, a chart marked out with the names or other indications of the various transmitting stations in the system, said shutter being associated with said chart in such manner as to expose the various names thereon in turn and at times when the correspondingly named stations are transmitting their signals, a directional aerial system of adjustable directivity responsive to the signals from said transmitting stations and means actuated in dependence upon the relative intensity at which signals from the various transmitting stations are picked up, for indicating upon the chart that transmitting station to which said receiving directional aerial system is adjusted.

4. Apparatus as claimed in claim 3 and in which the indicating means associated with the chart include a neon lamp.

5. In a wireless direction finding system, a plurality of geographically separated transmitting stations each adapted to transmit impulses, means coordinating the operation of said transmitting stations whereby said impulses are transmitted from one station at a time and from each station in cyclic order, means at each transmitting station for sending out periodically a synchronizing impulse, a receiving station having an omni-directional aerial and a directional aerial of adjustable directivity, synchronizing means operative in accordance with the reception of

said synchronizing impulses as received upon said omni-directional aerial for controlling the operation of apparatus at said receiving station, and indicating means operative under control of signals received upon said directional aerial and in accordance with the synchronization of apparatus at said receiving station with the impulses sent out by said transmitting stations for identifying the particular transmitting station, the signals from which are received on said directional aerial with maximum amplitude.

6. Apparatus as claimed in claim 3 including an omnidirectional aerial in which said omnidirectional aerial and said directional aerial of adjustable directivity are connected with a combining circuit for combining energy derived from said aerials in phase opposition, and means for energizing the indicating means associated with the chart with resultant combined signals.

7. A system as recited in claim 1 in which each of said transmitting stations comprises a synchronous motor, a rotatable disc having a slot therein driven by said motor, a source of light and a photo-electric cell adjacent the path of rotation of said slot in said disc, and a circuit connecting said cell to said transmitting station whereby said slotted disc controls the output from said photo-electric cell, and said cell in turn controls the output from said transmitter station.

8. In a signal transmitting and receiving system a plurality of geographically separated transmitting stations, means for emitting cyclic impulses of wave energy successively and at a predetermined repetition rate from each of said transmitting stations, said means comprising a synchronous motor at each station having a speed control device responsive to the frequency of transmission of said impulses, a receiving station having a rotatable directional antenna, synchronizing means at the receiver actuated in dependence upon the rate of change of the signal transmission from one transmitting station to another, and means for identifying signals received in varying intensity from the different transmitting stations as said antenna is rotated.

9. A receiving system comprising a directional aerial, a receiver including radio frequency amplifying and demodulating means, a neon lamp coupled with the output of said receiver, a rotatable disc mounted adjacent said neon lamp, said disc having a plurality of radially displaced arcuate slots therein, and means including a chart located between said disc and said neon lamp for indicating which one of the arcuate slots is in front of said neon lamp at the moment when it is lighted.

10. In a wireless direction finding system, a plurality of geographically separated signal transmitting stations, each adapted to transmit a succession of signals like those from the other stations, means including a control station for alloting to each transmitting station in succession a predetermined transmitting period, thereby to control the transmission of said signals from one station at a time and in cyclic order, a receiving station located within the range of reception of signals from at least one of said transmitters, said receiving station comprising a directional aerial of the radiogoniometer type, a non-directional aerial, and indicator control apparatus operative in dependence upon synchronizing impulses received on said non-directional aerial, indicator means at said receiving station operable by said control apparatus for differentiating between the signals received from any of the several transmitting stations, and a luminous device in said indicator means responsive to variations in the orientation of said directional aerial for identifying the signals received from a given transmitting station.

11. A system in accordance with claim 10, in which the indicator means at the receiving station comprises apparatus operative in synchronism with the frequency of allotment of signal transmitting periods to each of the several transmitting stations.

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