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RADIO DIRECTION-FINDER

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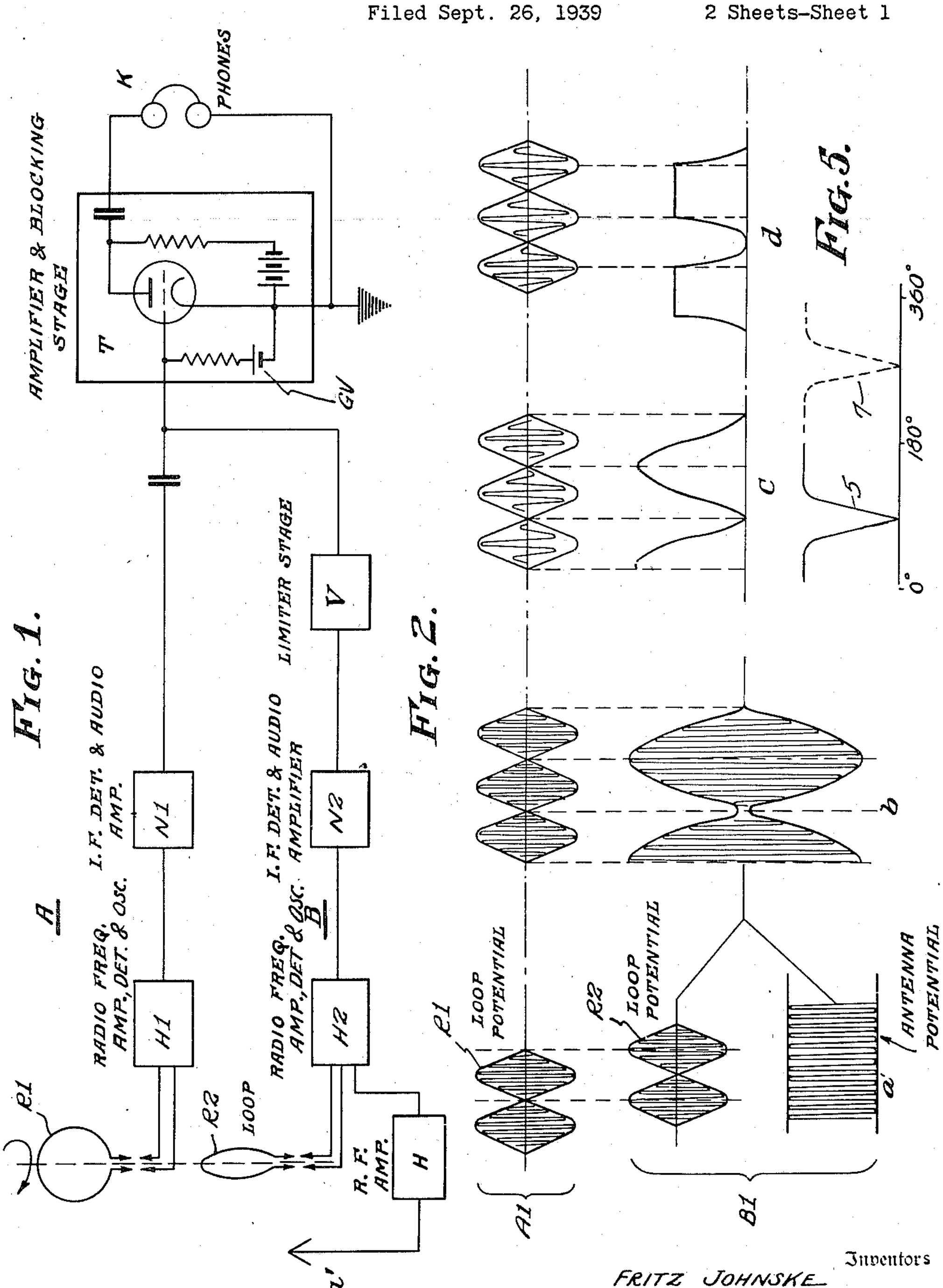

Inventors
FRITZ JOHNSKE
JOHANNES REBMANN

By

Attorney

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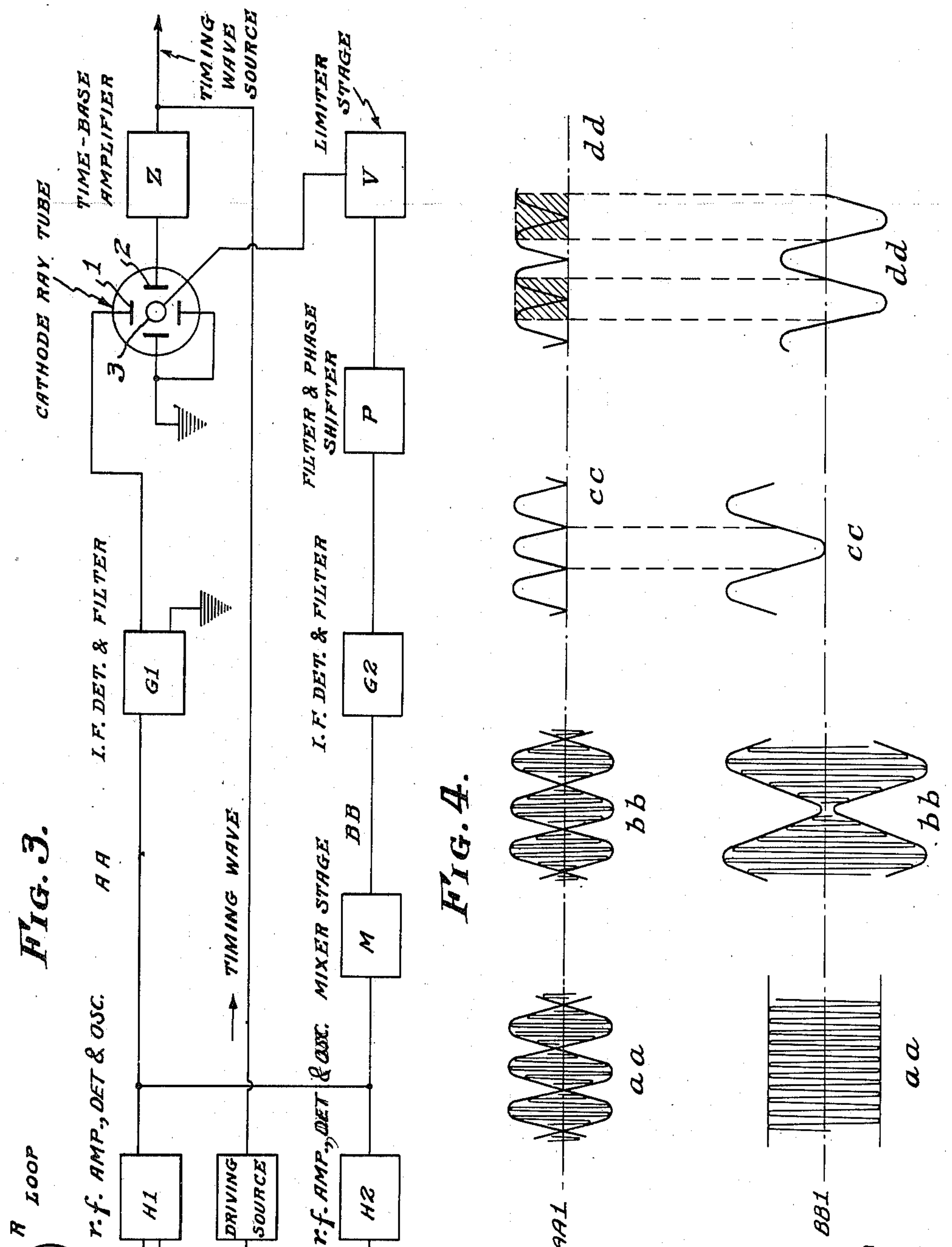

Inventors
FRITZ JOHNSKE
JOHANNES REBMANN
By
Attorney

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RADIO DIRECTION FINDER

Fritz Johnske and Johannes Rebmann, Berlin, Germany, assignors to Telefunken Gesellschaft für Drahtlose Telegraphie m. b. H., Berlin, Germany, a corporation of Germany

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4 Claims. (Cl. 250—11)

The present invention is concerned with radio direction-finders which use a figure 8 directional pattern and which, therefore, allow minimum signal strength direction-finding in such a way that of two minimum or zero values located during a full rotation of the direction-finding means the one of correct sense is ascertainable by special ways and means. The method here disclosed is useful both in connection with auditory as well as visual-reading direction-finder apparatus.

The prior art describes auditory direction-finders in which a unidirectional cardioid directional diagram is obtained by adding currents from a non-directional antenna to the currents from a loop circuit to obtain a cardioid directive characteristic. However, inasmuch as the cardioid minimum does not afford as sharp bearing as the figure 8 pattern, it has become customary first to ascertain the minimum signal strength by the figure 8 diagram and to then obtain, by additional operating steps and means, a cardioid pattern by the aid of which sense-finding is feasible. These additional steps involve an undesirable loss of time, not to mention the fact that errors in sense-finding with catastrophic consequences are not entirely impossible; in fact, have happened several times in practice.

The auditory sense-finding methods are applicable to the visual direction-finder. By pressing, for instance, upon a sense-finding button, the minimum signal point in the pattern is shifted to the left or to the right hand side according to whether the minimum is in the right sense or in the wrong sense. Although being basically less complicated, the loss of time in such system is more serious than in the case of auditory reception for the reason that the reduction of the time required for taking bearings is claimed to be a chief advantage in visual readings of the direction-finder.

The present invention has for one of its objects the provision of means for ascertaining automatically unidirectional or unambiguous bearings without sacrificing the advantage of obtaining sharp bearing data by using figure 8 direction-finding patterns. The invention and the method disclosed therein is predicated upon the fact in an auxiliary channel of the direction-finder a cardioid-shaped voltage wave is produced and the latter is utilized for the purpose of deriving control potentials. These controlling potentials are used to suppress the minimum corresponding to the incorrect bearing and to make evident the correct bearing of a figure 8 direction-finder.

The phase position of the cardioid-shaped potential wave in relation to that of the figure 8 potential wave is so chosen that the minimum of the cardioid (or else its maximum) coincides with a minimum of the figure 8 pattern, preferably with the one giving the proper sense. The means which are required to secure such phase relations are known from the art of auditory direction-finding. They are based upon the use of rotatable crossed loops, one of these looks serving for the figure 8 direction-finding; the second loop, being displaced an angle of 90 degrees and in combination with an auxiliary antenna, serving to produce the cardioid. For rotating visual direction-finders the means adapted to obtain the proper phase position of the auxiliary potential fall inside the spirit and scope of the present invention.

In the accompanying drawings, Fig. 1 is a schematic circuit diagram of one embodiment of the invention; Fig. 2 is a graphic illustration of the several operating characteristics; Fig. 3 is a schematic circuit diagram of a modification of the invention; and Figs. 4 and 5 are graphic illustrations of the operating characteristics of the modification. Similar reference numerals will be used to indicate similar elements in the several figures.

Referring to Fig. 1, a conventional direction-finding receiver A comprising a directional antenna or loop R1, a radio frequency amplifier, detector and oscillator H1 and an intermediate frequency amplifier, detector and audio amplifier N1 are connected as shown. The audio frequency amplifier is followed further by an amplifier and blocking stage T which is subject also to the action of the output stage of an auxiliary receiver channel B. The auxiliary channel is supplied with R.-F. input potential from a non-directional antenna a', preferably by way of a radio frequency amplifier, detector and oscillator H2 and the directional antenna R2, which is positioned at right angles to R1. The nondirectional antenna and the loop are arranged so that their R.-F. potentials add during one half-rotation of the loop R2 and subtract during the other half-rotation. Hence, the potential diagram in polar coordinates exhibits the classical cardioid form of the envelope, or else, in rectangular coordinates a curve shape of the kind as schematically illustrated in Fig. 2 by graph *b*. In Fig. 2 are separately represented the potential of the loop R1, the potential of the loop R2, and the potential of the auxiliary antenna *a'*. The potential curves A1 show schematically the voltage wave in the R.-F. portion of the normal receiver A with consecutive bearing maxima and minima, such as corresponds to the figure 8 diagram in polar coordinates. The auxiliary channel of the receiver includes a radio frequency amplifier, detector and oscillator H2, I.-F. detector, and A.-F. amplifier N2, the output potential of which is illustrated by curve B1—C of Fig. 2. The graph B1—C shows a sinusoidal curve in which the lowest dip reaches the zero line if the maximum R.-F. potential of the directional antenna or loop R2 is equal to the non-directional input potential. This shape of the potential wave corresponds to the cardioid in polar coordinates. Above it, the curve A1 shows the shape of the potential in the A.-F. portion of the direction-finding receiver A.

The mode of operation may be deduced from the schematic illustration of Fig. 2. One minimum of the normal direction-finder channel coincides with the minimum of the auxiliary channel, and the next minimum coincides with the maximum of the auxiliary channel. A limiter stage V is included in the auxiliary channel and is designed to limit the D.-C. output potential which, for a range of rotation of 180 degrees, furnishes a practically constant D.-C. voltage, and, for the 180-degree range next following, a voltage which rapidly drops towards zero, the shape thereof coinciding, as represented, with the voltage wave shape of the main receiver channel (Fig. 2, A1—*d* and B1—*d*). This output potential is so proportioned that the maxima thereof will be just able to offset the blocking negative grid biasing potential *Gv* of the blocking stage T and to raise the amplifier tube T to a convenient working point. As a result, an A.-F. voltage will be applied to the headset K only during those half rotations of the direction-finder frame R1 which contain the minimum of proper sense. In the other half-rotation, stage T is blocked so that the minimum of incorrect sense will not be indicated at all.

In addition to the above-exemplified embodiment of the invention, a great many modifications of the basic principle of the invention are conceivable, without departing from the spirit and scope of the invention. For instance, the derived control potential, (Fig. 2, B1—*d*) may be of any other nature, though in selecting the same this basic point must be kept in mind; namely, all risks of a faulty indication should be absolutely precluded. Moreover, means may be provided so that, under limiting circumstances or in case of failure of the automatic means, no minimum at all should be indicated. What is essential in the invention is that control potentials are derived from the cardioid-shaped pattern which are designed to cause extinction of the minimum of incorrect sense. It will be expedient to provide a joint volume control for both the main and the auxiliary channels, the value of the blocking potential *Gv* in the blocking stage T being, if desired, included in this combined volume control in order to make conditions so that the blocking, independent of the gain in the two channels, will always cover roughly a 180-degree loop motion. It may, moreover, be found suitable to make the D.-C. part of the curve B1—*c* of Fig. 2 greater than indicated, this being accomplishable by increasing the auxiliary antenna response in the side channel B. The "blocking" of the direction-finder channel proper may also be effected by an arrangement which will furnish a constant A.-F. potential to the headset whenever the minimum of incorrect sense appears, while in the presence of the minimum of the correct sense, by the control potential coming from B, this constant A.-F. potential is suppressed so that the direction-finding channel will be cleared for an undisturbed transmission of the direction-finding signal. Where direction-finding equipment comprising goniometers is concerned, it is feasible either to use a twin-type search coil or else two goniometers may be coupled together, one thereof being used for taking bearings with a figure 8 diagram and the other one for obtaining cardioids of proper phase according to the invention.

The invention is useful also in connection with rotating visual reading direction-finders. In connection with these, the advantage is obtained that it may be carried into practice with less elaborate means than is required for the above-described aural species because no distinct directional aerial is required for producing the auxiliary potential. In fact, the directional antenna which is used for taking bearings with the figure 8 diagram may be employed also for the production of the cardioid potential. This potential does not present the proper phase relation to the figure 8 diagram, that is to say, the minimum (or the maximum) of these cardioids does not coincide with a minimum of the figure 8 diagram, but rather with the maximum thereof. However, since the voltage wave is cardioid in shape in polar coordinates, there actually results a D.-C. with a superposed sinusoidal A.-C. (Fig. 4, BB1—*cc*). This A.-C. component can be filtered out and its phase altered by 90 degrees, thus resulting in an A.-C. whose negative voltage peaks will coincide with one of the minima of the figure 8 diagram, more precisely with the one giving the wrong sense. From the shape of the potential, the control potential for the blocking stage may be derived in the sense of what has been described in the preceding part of the specification.

In the case of visual indicating direction-finders of the oscillographic type, according to another object of the invention, the control potentials are brought to act upon the cathode ray, rather than upon the direction-finding receiver. Where cathode ray tubes are used for oscillographic indication, the cathode ray, in the presence of the minimum of wrong sense, may be blanked by potentials derived from the directional antenna. Referring to Fig. 3 in which the normal direction-finder receiving channel AA includes a directional antenna or loop R, a radio frequency amplifier, detector and oscillator H1, I.-F. and detector stage including filters G1. The voltage curves corresponding thereto are schematically shown in Fig. 4, AA1—*aa* through *cc*. The output potential of the detector stage acts directly upon one of the deflection systems 1 of the cathode ray tube. The other deflecting system 2 has impressed upon it a scanning potential from the time base amplifier Z, which is a function of the prevailing angular position of the rotary directional system. In other words, a visual direction-finding method has been chosen in which the bearing appears in the form of a curve with a minimum dip over a linear scale as in Fig. 5, for instance.

A secondary receiver channel BB is provided for indicating the sense automatically. The non-directional antenna *aa* acts upon the radio frequency amplifier, detector and oscillator H2. In the mixer stage M, its output potential is superposed with an R.-F. potential derived from the directional channel AA to obtain the cardioid voltage curve which, plotted linearly, corresponds to the curve BB1—*bb*, Fig. 4. After detection and filtering in the stage G2, the voltage wave BB1—*cc* is obtained. By comparison with graph AA1—*cc* (above BB1—*cc*) showing the rectified shape of the potential, it will become evident that zones of equal potential in the cardioid diagrams are coordinated to directional minima of the figure 8 pattern. According to the invention, therefore, the alternating voltage component of the voltage wave as shown in BB1—*cc* is filtered out and is turned an angle of 90 degrees by the interposition of a filter and phase shifter P. An alternating potential BB1—*dd* is obtained, the positive peaks of which coincide with minimum points of the directional channel, preferably the minimum of proper sense. As a result, in the limiter stage V, the control potentials proper are derived. These potentials are applied to the control or modulation electrode 3 of the cathode ray tube so that the cathode ray pencil is brightened up only while the minimum of proper sense operates, while being otherwise extinguished. Of the complete directional curve shown in Fig. 5, only the solid portion 5 representing the minimum of proper sense appears and the broken line portion 7 representing an incorrect minimum is blanked out as described.

The present invention is useful in connection with all types of rotating visual direction-finders, while it is capable of such modifications and additions as have above been outlined in connection with auditory direction-finders, such as coupled volume control between the main and the auxiliary channel. When using I.-F. amplifiers in both channels, a common local oscillator may be employed.

We claim as our invention:

1. A direction finder including a main radio receiving channel including means for obtaining currents corresponding to a figure 8 directive response pattern and means for indicating the minima thereof, an auxiliary radio receiving channel including means for obtaining a substantially unidirective response pattern, means for deriving from said auxiliary channel controlling currents having an amplitude substantially equal to and limited to the maximum amplitude of the currents corresponding to said figure 8 pattern and having a minimum substantially equal in phase and magnitude to the currents corresponding to one of said minima, means for applying said controlling currents to said indicating means so that one of said minima is suppressed, and in which said means for deriving controlling currents from said auxiliary channel includes a current limiter so adjusted that the controlling currents are substantially constant over approximately 180° of the response pattern of said auxiliary channel.

2. A direction finder including a main radio receiving channel including means for obtaining currents corresponding to a figure 8 directive response pattern and means for indicating the minima thereof, an auxiliary radio receiving channel including means for obtaining a substantially unidirective response pattern, means for deriving from said auxiliary channel controlling currents having an amplitude substantially equal to and limited to the maximum amplitude of the currents corresponding to said figure 8 pattern and having a minimum substantially equal in phase and magnitude to the currents corresponding to one of said minima, means for applying said controlling currents to said indicating means so that one of said minima is suppressed, and in which the indicating means includes a thermionic tube, means for biasing said tube to cut-off and means for applying said controlling current to render said tube responsive.

3. A direction finder including a main radio receiving channel including means for obtaining currents corresponding to a figure 8 directive response pattern and means for indicating the minima thereof, an auxiliary radio receiving channel including means for obtaining a substantially unidirective response pattern, means for deriving from said auxiliary channel controlling currents having an amplitude substantially equal to and limited to the maximum amplitude of the currents corresponding to said figure 8 pattern and having a minimum substantially equal in phase and magnitude to the currents corresponding to one of said minima, means for applying said controlling currents to said indicating means so that one of said minima is suppressed, and in which said indicating means is a cathode ray tube and in which said controlling currents are applied to said tube to extinguish said cathode ray to prevent the indication of an incorrect bearing.

4. A direction-finder including a main radio receiving channel including means for obtaining a figure 8 directive response pattern, a cathode ray tube including ray controlling electrodes for indicating the minima thereof, means for rotating said response pattern, means for moving said ray in synchronism with said rotating means, an auxiliary radio receiving channel including a phase shifter and means for deriving therefrom a controlling current, and means for applying said controlling current to one of said ray controlling electrodes to prevent the ray from responding to one of said minima and to make the ray responsive to the other minima to indicate correctly the wave front of received waves.

FRITZ JOHNSKE.
JOHANNES REBMANN.