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DIODE SWITCHING MEANS

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FIG. 1

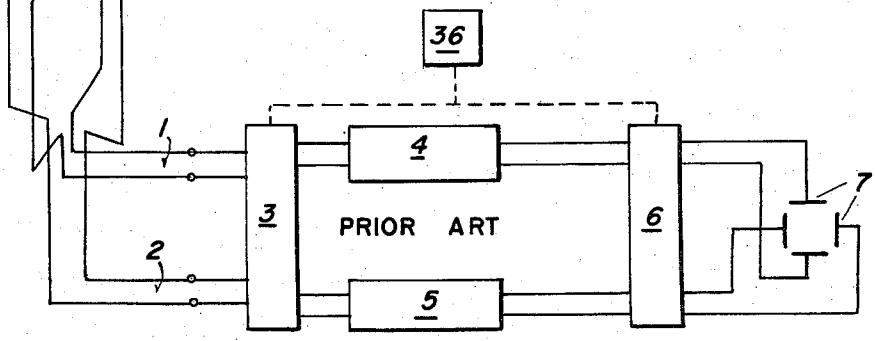

FIG. 2

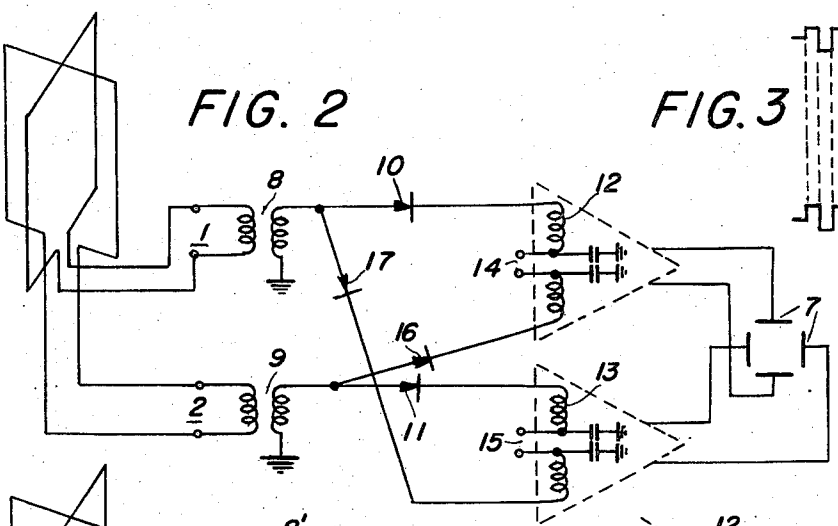

FIG. 3

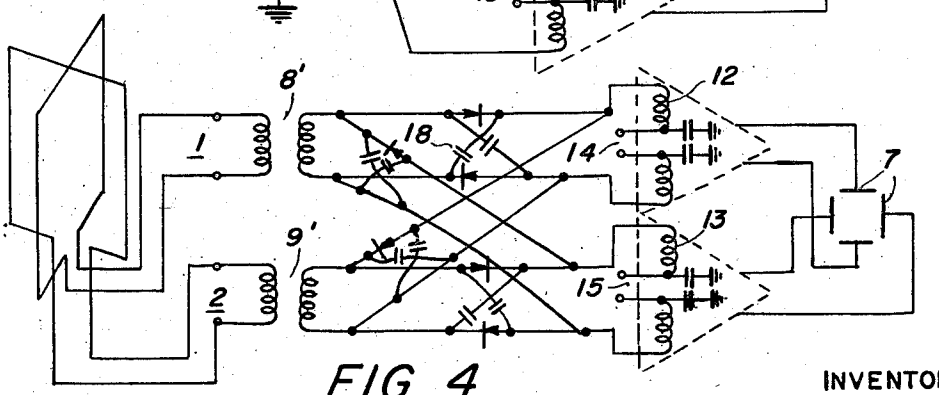

FIG. 4

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DIODE SWITCHING MEANS

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The present invention relates to a radio direction finding receiver or, more specifically, to a switching means in such receiver.

In the known receivers or apparatus of this type, dual antenna systems supply voltages corresponding to two directional signals crossing each other in space at an angle of 90°. These two voltages are separately amplified in the receivers, the inputs to the separate amplifiers are periodically interchanged by means of switching devices, and the thus amplified voltages are fed to comparison indicators, such as cathode ray or Braun tubes, to give directional indications, for example, on the screens of these tubes. Such tubes have two deflection systems displaced at an angle of 90° with respect to one another and are respectively energized by the two mentioned amplified voltages. As a result of these amplified voltages energizing the deflection systems of the cathode ray tube, two luminous ellipses appear on its screen, the axes of said ellipses being displaced with respect to each other. The bisector of the angle formed by the major axes of these two ellipses indicates the bearing direction to be ascertained.

As switching means to interchange the amplifier inputs, mechanical switches have been heretofore employed. Such mechanical switches have proven objectional, primarily because the unavoidable transients produced during the switching cause disturbances in the cathode ray tube traces.

Furthermore, it has been known to use electron tubes in radio direction finding apparatus of the type described to periodically interchange the two amplifiers. However, such tubes are not practical for this purpose for the following reasons:

The electron tubes have high interelectrode capacities causing considerable limitation of the useful frequency band of the receiver. This is due to the fact that the switching capacity of the electron tube, when cut off, is parallel to the simultaneously non-blocked tube elements. Only crystal diodes have a practically negligible low switching capacity. Such crystal diodes have not heretofore been used in radio direction finding apparatus. Electron tubes can only be used in connection with a receiver input of high resistance due to the tube noise. If crystal diodes are employed, a receiver input of low resistance can be used without difficulties, because the noise of these crystal diodes is practically negligible. Furthermore, when electron tubes are applied, the antenna voltages have to be pre-amplified to be distinguishable above the electron tube noises to obtain a sufficient sensitivity in the direction finding apparatus. Generally, electron tubes have non-linear characteristics and in case of simultaneous reception of two transmitters cross-modulation may occur, because the mixing takes place on the non-linear portion of the tube characteristic. Crystal diodes also generally do not have a linear characteristic. However, their characteristic is more linear, because a pre-amplification of the signal voltages is not necessary and

therefore the range of the characteristic used is small. Consequently, there is no risk for cross-modulation, if crystal diodes are used as switching means to periodically interchange the amplifiers.

It is, therefore, an object of this invention to provide in a radio direction finding apparatus of the type described an amplifier interchanging switching means which does not have the disadvantages mentioned above.

It is a further object of the invention to provide as such interchanging switching means, a set of crystal diodes in the circuit of the radio direction finding apparatus, said diodes being coupled to the two antenna systems and being adapted to periodically interchange the two directional signal voltages fed to the respective deflection systems of the cathode ray tube.

It is another and important object of the present invention to provide such crystal diodes at the amplifier input side of each of the coils which couple the antennas to the amplifiers and furnish one of the directional signal voltage components, said crystal diodes connecting said coils alternately to the input side of the first amplifier and to the input side of the second amplifier.

It is a still further object of the invention to provide a source for supplying a switching or control voltage to the new switching means, said voltage source being adapted and arranged in the radio direction finding apparatus in such a manner that the crystal diodes mentioned in the foregoing are periodically and alternately rendered conductive and nonconductive, whereby currents induced in the coupling coils are fed in accordance with the cycle of this switching or control voltage alternately to the input coil of the first and to the input coil of the second amplifier.

It is another object of this invention to make the amplifier input coils open at their centers and to connect the centers to ground via condensers so far as high frequency is concerned, whereby said source of square-wave control or switching voltage may be applied to the open ends of said amplifier input coils.

As diodes of the interchanging switching means, there should preferably be used low-resistance crystal diodes which are constructed substantially free of noise and have a very low capacity. Today, such diodes are made of germanium crystals. Thus, the new switching means can be manufactured on a practical basis.

These and other important objects and advantageous features of this invention will be apparent from the following detailed description and drawing, appended thereto, wherein merely for the purposes of disclosure non-limitative embodiments of the invention are set forth.

To give a better understanding of the background of the present invention, a diagram of a prior-art two-way radio direction finder apparatus with periodical interchange of the two amplifiers is shown in Fig. 1 of the drawing. Circuits of two embodiments of the invention are respectively illustrated in Figs. 2 and 4 of the drawing. Fig. 3 of the drawing shows the curve of the square-wave voltage controlling the diodes.

In the prior-art two-way direction finder apparatus according to the diagram of Fig. 1, terminals 1 and 2 are to be connected to two directional antennas disposed perpendicularly with respect to one another. In place of these antennas, a transformer can be connected to the terminals 1 and 2, in case more than two directional antennas are employed, said transformer being adapted to separate the directional voltages into Cartesian coordinates. These two voltages are fed to the interchanging switching means 3 from which two outputs lead to the amplifiers 4 and 5. The output voltages of the two amplifiers are fed to another interchanging switching means 6 which is operated synchronously with the first inter-

changing switching means 3 by an operator 36. A cathode ray or Braun tube is employed as the indicating means. Of this tube, only the deflection systems or plates 7 are indicated in Fig. 1. These plates 7, which are displaced 90° with respect to one another, are electrically connected to the second interchanging switching means 6.

In the first embodiment of the invention according to the basic or principle diagram of Fig. 2 of the drawing, the two terminals 1 and 2 are connectable to, for example two antennas crossed with respect to one another at 90°. Two coupling coils 8 and 9, with which these two terminals are associated, are connected to amplifier input coils 12 and 13 via crystal diodes 10 and 17 or 11 and 16, respectively. These amplifier input coils are opened at their centers and connected to ground through condensers for high frequency currents. A control or switching voltage of square-wave shape, such as shown in Fig. 3 of the drawing, is supplied both to terminals 14 and 15 of the amplifier input coils 12 and 13.

In the operation of the apparatus according to the diagram of Fig. 2, the input voltages from the antennas are alternately fed to one or the other of the two amplifiers by means of the new interchanging switching diodes. Under the action of the periodical control or switching voltages fed to the amplifier input coils 12 and 13, only one of the diodes is conductive at a particular instant, while always the other diode is non-conductive. Consequently, the directional voltages supplied from the two antennas are amplified alternately by one or the other of the two amplifiers.

In the circuit diagram of a modified embodiment of this invention, illustrated in Fig. 4, double leads are used to connect the coupling coils 8′ and 9′ to the amplifier input coils 12 and 13, whereby one crystal diode is inserted in each of these double leads. Over the apparatus according to the circuit diagram of Fig. 2, the embodiment of this invention having the diagram according to Fig. 4 has the advantage that the circuit is symmetrical and ungrounded so that the antennas or the coupling transformers are symmetrically loaded. As a result of this, errors are principally avoided which would be caused by a non-directional component of the voltages received from these antennas.

Care should be taken that the capacities in the diodes are absolutely neutralized to prevent cross-talk through the diode capacities. The neutralizing capacities are denoted by 18 in Fig. 4. The same square-wave shaped control or switching voltage (see Fig. 3) as applied in case of the embodiment according to Fig. 2 is fed to the terminals 14 and 15 of the amplifier input coils 12 and 13 in Fig. 4.

Although in accordance with the provisions of the patent statutes this invention is described as embodied in concrete forms and the principle of the invention has been explained together with the best modes in which is now contemplated applying that principle, it will be understood that the elements, combinations and circuits shown and described are merely illustrative and that the invention is not limited thereto, since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of the present invention or from the scope of the annexed claims.

We claim:

1. In a radio direction finding apparatus connectable to an antenna system having a plurality of antennas angularly displaced with respect to one another, separate coupling coils for each of said antennas, said coupling coils having inputs and outputs, each of said coupling coil inputs being connected to one of said antennas, separate amplifiers including one for each of said coupling coils, said amplifiers having inputs and outputs, a comparison indicator means connected to said amplifier outputs, switching circuits between each of said coupling coil outputs and each of said amplifier inputs for selecting paths which determine which coil output connects to which amplifier input, crystal diodes inserted in each of said switching circuits, and a control voltage source connected to said switching circuits and being adapted to periodically and alternately render said crystal diodes in one path conductive and those in another path non-conductive to admit signal voltages from said antennas via said coupling coils and said crystal diodes alternately to one or the other of said amplifiers.

2. In a radio direction finding apparatus according to claim 1, said crystal diodes having a low electrical resistance.

3. In a radio direction finder apparatus according to claim 1, said crystal diodes being made of germanium.

4. In a radio direction finding apparatus according to claim 1, said comparison indicator means being a cathode ray tube having several deflection systems respectively connected to said amplifier outputs.

5. In a radio direction finding apparatus according to claim 1, said comparison indicator means being a cathode ray tube having several sets of deflection plates respectively angularly displaced with respect to one another.

6. In a radio direction finding apparatus according to claim 1, said antenna system comprising two antennas crossed at an angle of 90° with respect to one another, two coupling coils and two amplifiers, separate switching paths connecting said coupling coil outputs to said amplifier inputs, and said comparison indicator means being a cathode ray tube having two sets of deflection plates respectively displaced at an angle of 90° with respect to each other, one of said plate sets being connected to the output of one of said amplifiers, while the other of said plate sets is connected to the output of the other of said amplifiers.

7. In a radio direction finding apparatus according to claim 1, said switching circuits between each of said coupling coil outputs and each of said amplifier inputs double lines, each of said double lines containing one of said crystal diodes.

8. In a radio direction finding apparatus according to claim 1, said control voltage source supplying a square-wave shape voltage to said switching circuits, whereby said control voltage biases said crystal diodes in said paths alternately conductive and non-conductive in accordance with the cycle of said control voltage.

9. In a radio direction finding apparatus according to claim 1, said amplifier inputs having coils opened at their centers and by-passed to ground for high-frequency currents and said voltage source supplying a square-wave shape voltage to said amplifier input coils applied thereto at their open centers to render said crystal diodes conductive and non-conductive in accordance with the cycle of said control voltage.

10. In a radio direction finding apparatus according to claim 1, condensers connected to said circuit means to neutralize the self-capacity of said crystal diodes.

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