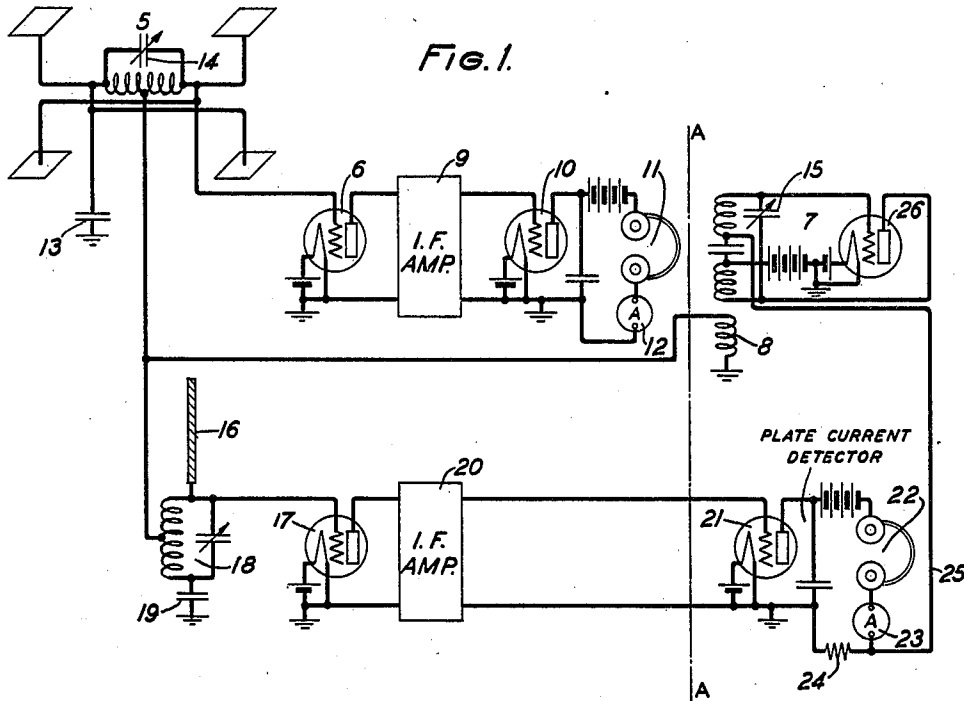


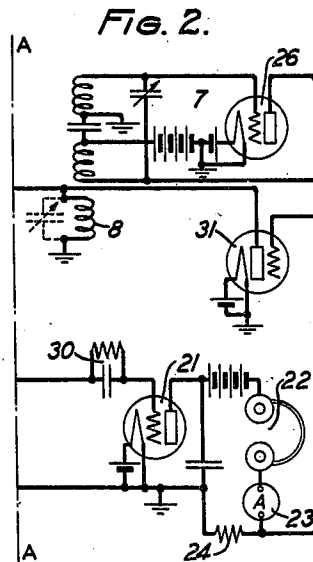
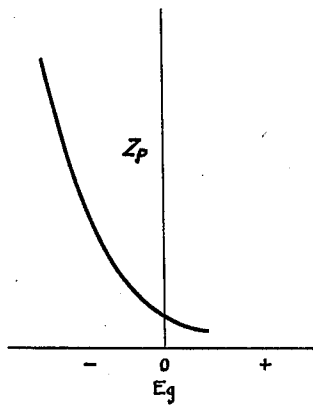
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E. BRUCE ET AL  
RADIO DIRECTION FINDER  
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**Fig. 3.**



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## UNITED STATES PATENT OFFICE

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## RADIO DIRECTION FINDER

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This invention relates to radio receiving systems and particularly to radio direction finders.

pedance in shunt to the oscillator pick-up coil, as best suits the particular condition for which the system is designed.

5 An object of the invention is to reduce the deleterious effects of fading on the operation of radio direction finders.

When a system of this type is operated by adjusting the two receivers to receive the same radio waves, the gain control of the non-directive receiver will respond to variations in the strength of the received wave and maintain the output of the directive receiver substantially constant independent of such variations. Therefore, the output of the directive receiver will depend only on the adjustment of the antenna and will be substantially independent of any fading effects.

10 A very marked disturbance encountered in the reception of radio waves is fading, that is, variations in the strength of the received signals. This type of disturbance is particularly severe when short waves are being received. One method widely used for overcoming the effects of fading is to employ an automatic gain regulator or control.

15 However, when such regulators are employed with direction finders which depend for their operation on the orientation of a directive antenna until a minimum or maximum response is obtained from the receiver, the gain control responds to variations in the signal strength which are produced by adjustments of the antenna in the same way as it responds to variations produced by fading. The result is that the gain control will operate to mar the effects of an adjustment of the antenna and make observations of signal minima and maxima difficult if not impossible.

20 In accordance with a specific preferred embodiment of this invention there is employed with a radio direction finder of the conventional type, a non-directive receiver having an automatic gain control which is also used to control the gain of the receiver of the direction finder proper. To simplify the adjustment and operation of this gain control system, both receivers are operated on the double detection principle and one heterodyning oscillator is used to supply the beating wave to the two receivers. By using such an arrangement the amplitude of the common heterodyne wave can be caused to vary in an inverse manner to the field strength of the received waves and thereby offset the effects of fading in the direction finding receiver. This control of the oscillator output may be accomplished, for example, by controlling the grid bias or by using a control amplifier to provide a variable im-

55 The invention can be more readily understood by reference to the following detailed description in connection with the drawing in which:

Fig. 1 shows diagrammatically one embodiment of the invention in which the gain is controlled by means of a variable grid bias;

Fig. 2 shows diagrammatically a second embodiment of the invention in which a control tube is used; and

Fig. 3 shows graphically the grid voltage-plate current characteristic of the control tube of the modification of Fig. 2.

Referring to the circuit of Fig. 1, there is shown a directional antenna system 5 arranged so that it may be oriented to give a characteristic effect in the receiver associated therewith to indicate the direction of the station from which the waves received are being transmitted. The antenna system comprising a double balanced arrangement in which currents caused by horizontal fields are balanced out making the antenna system effective for accurately indicating the direction of short waves. The output of the antenna system is connected to the grid circuit of a vacuum tube 6 which is operated as a high frequency detector. Heterodyning waves from a heating oscillator 7 are also supplied to the grid circuit of the tube 6 through the coupling coil 8. The output of the high frequency detector tube 6 is filtered and amplified in the intermediate frequency amplifier 9 and supplied to a low frequency detector 10 where the signal waves are de-

tected. A telephone receiver 11 and a milliammeter 12 are connected in the plate circuit of the detector tube 10 to permit observation of the detected signals.

5 Condenser 13 is provided for preventing unbalance of the capacities connected to the antenna system with respect to ground.

As so far described the system is a conventional type radio direction finding system. In operation, the condenser 14 of the antenna system and the condenser 15 of the beating oscillator are adjusted so that the circuit is tuned to receive the wave, the direction of which it is desired to determine. After tuning the circuit in this manner the antenna system 5 is oriented until the amplitude of the signal received is a minimum as indicated by either or both the telephone receivers 11 and the milliammeter 12. The direction from which the wave is being received is indicated by the position of the antenna system 5 at which such an indication is obtained.

In using systems of this type, particularly when operating on short waves, fading may affect the accuracy of the measurements. For example, if the signal fades during the measurement a false minimum signal value may be observed due to the fading rather than due to the proper adjustment of the antenna system. The main object of this invention is to overcome such difficulties and facilitate the adjustment of the antenna system 5 independent of any fading.

For this purpose there is provided a vertical antenna 16 the reception characteristic of which is practically non-directional. This antenna is connected to the grid circuit of a vacuum tube 17 through a tuned circuit 18. The pick-up coil 8 of the beating oscillator 7 is connected in series with the tuned circuit 18 in the grid circuit of the tube 17. Condenser 19 is provided for neutralizing the ground capacities of the antenna system in a similar manner to the condenser 13 in the directional antenna system 5. Tube 17 operates as a high frequency detector in a similar manner to tube 6, the waves received in the antenna 16 being modulated by the waves from the oscillator 7 to produce waves in an intermediate frequency range which are selected and amplified by the intermediate amplifier 20. The output of this amplifier is connected to the grid circuit of a low frequency detector tube 21.

The low frequency detector tube 21 is operated as a plate current detector so that signal current in the plate circuit is directly proportional to the amplitude of the received wave.

There are connected in series in the plate circuit of tube 21 a telephone headset 22, a milliammeter 23 and a resistance 24. The telephone receiver 22 and the milliammeter

23 are provided for the purpose of facilitating the tuning of the circuit.

The terminal of resistance 24 remote from the cathode of the tube 21 is connected through a wire 25 and the grid inductance of the oscillator circuit 7 to the grid of the oscillator tube 26. Consequently, since the cathodes of the tubes 21 and 26 are connected together to ground, the potential difference across the resistance 24 produced by the signal current flowing in the plate circuit of the tube 21 will be impressed on the grid of the oscillator tube 26. This potential difference will be effective to control the amplitude of the oscillations generated in the oscillator circuit 7. Since the direction of connection of the resistance 24 in the grid circuit of the tube 26 is such that the grid is maintained at a negative potential with respect to the cathode any increase in the potential drop across resistance 24 will tend to decrease the amplitude of the oscillations generated, and any decrease in the potential drop across the resistance 24 caused by a decrease in the signal strength, for example, will produce a corresponding increase in the amplitude of the oscillations generated in the oscillator circuit 7.

This control action regulates the amplitude of the heterodyning wave supplied to the high frequency oscillator or detector tube 17 and consequently the gain of the auxiliary receiver system comprising the high frequency detector 17, the intermediate frequency amplifier 20 and the low frequency detector 21. The action is therefore to maintain the signal output of the detector 21 substantially constant, independent of variations in the amplitude of the received wave caused by fading and the like. Since the same heterodyning wave is supplied to the detector tube 6, the effect is to also control the gain of the main or directional receiver comprising high frequency detector 6, intermediate amplifier 9 and low frequency detector 10. Therefore, the signal output of the detector 10 will also be maintained constant irrespective of changes in the amplitude of the wave the direction of propagation of which is being determined. The gain control of the main receiver being responsive to the amplitude of the waves in the output of the antenna 16 rather than in the output of the antenna system 5 will be independent of any adjustment of the antenna system 5 and consequently dependent only on variations in field strength of the received waves rather than on the directional characteristic of the antenna system 5.

While the system of Fig. 1 is generally effective and satisfactory it possesses certain inherent limitations in that the frequency of the waves generated by an oscillator are to some extent dependent upon the value of the biasing potential applied to the grid. Con-

sequently, the range through which the gain of the system can be controlled is limited to the range through which the biasing potential of the grid of the oscillator can be varied without varying the frequency of the wave generated. Further, even to maintain the frequency stability of the oscillator constant with a comparatively narrow range of variation in the grid biasing potential, it is necessary to take certain precautions in the circuit designed not otherwise necessary. These difficulties are obviated by use of the modification of the invention shown in Fig. 2.

The circuit of Fig. 2 shows a modification of that portion of the circuit of Fig. 1 to the right of the dash-dot line A, the remainder of the circuit being the same as that of Fig. 1. In this case the detector tube 21 is provided in its grid circuit with a condenser-grid leak circuit 30. The tube 21 therefore operates as a grid current detector, the amplitude of the plate current being inversely proportional to the amplitude of the wave supplied to the grid circuit. The grid of the oscillator tube 26 is maintained at a constant direct current potential with respect to the cathode. To provide for the gain control there is employed a control tube 31 having its plate circuit connected in shunt to the pick-up coil 8. By controlling the plate impedance of the tube 31 it is possible to control the amplitude of the heterodyning waves supplied from the oscillator 7 to the detector tubes 6 and 17.

The grid voltage-plate impedance characteristic of the control tube 31 is shown in Fig. 3. It will be noted that for a considerable range of negative grid voltages the plate impedance of the tube varies directly with the value of the negative grid voltage. When the tube is operated in this range, the amplitude of the heterodyning wave supplied to the detector tubes 7 and 11 will be inversely proportional to the value of the negative potential applied to the grid of tube 31. Thus, if the amplitude of the wave received from the antenna 16 tends to decrease there will be a consequent increase in the plate current of the detector tube 21 and a proportional increase in the voltage drop across resistance 24. Since this voltage drop is impressed on the grid of tube 31 there will be produced an increase in the plate impedance of that tube. The resulting decrease in the shunting effect on the pick-up coil 8 will cause an increase of the amplitude of the heterodyne wave applied to the high frequency detector. The effect is to compensate for the decrease in field strength of the received wave and maintain the signal output constant irrespective of changes therein.

What is claimed is:

1. In combination, an antenna of adjustably directive characteristics, a substantially non-directive antenna, a radio receiver associated with each of said antennæ and both

adapted to receive the same waves, and means responsive to the output of the receiver associated with the non-directive antenna for maintaining the output of the other receiver substantially constant irrespective of variations in the field strength of the received waves.

2. In combination, a substantially non-directive antenna, an antenna of adjustably directive characteristics, a radio receiver associated with each of said antennæ and both adapted to receive the same radio waves, a source of oscillations supplying waves to both of said receivers for combining with the waves impressed thereon by the respective antennæ, and means responsive to the output of the receiver associated with the non-directive antenna for controlling the amplitude of the output of said source to maintain the output of the other receiver substantially independent of variations in the field strength of the received waves.

3. In combination, an antenna of adjustably directive characteristics, a substantially non-directive antenna, a radio receiver associated with each of said antennæ, both of said receivers being adapted to receive the same radio wave, a source of oscillations supplying waves to both of said receivers for combining with the received waves, said source of oscillations including an electric discharge device having an anode, a cathode and a control electrode, means for producing an electromotive force of value proportional to the output of the receiver associated with the non-directive antenna, and means for impressing said electromotive force upon the control electrode of said electric discharge device for controlling the amplitude of the waves supplied to said receivers from said source.

4. In combination, an antenna of adjustably directive characteristics, a substantially non-directive antenna, a radio receiver associated with each of said antennæ, both of said receivers being adapted to receive the same radio wave, an electric discharge device having a cathode, an anode and a control element and arranged to produce electrical oscillations for combining with the waves impressed on said receivers by the respective antennæ, and means responsive to the output of the receiver associated with the non-directive antenna for producing a unidirectional electromotive force of amplitude dependent in value upon the amplitude of the waves received by such non-directive antenna, and means for impressing said unidirectional electromotive force upon the control element of said electric discharge device to control the amplitude of the oscillations supplied to said receivers.

5. In combination, a substantially non-directive antenna, an antenna of adjustably directive characteristics, a radio receiver as-

sociated with each of said antennæ, both of said receivers being adapted to receive the same radio wave, an electric discharge device having an anode, a cathode and a control element and arranged to produce electrical oscillations, means for supplying the oscillations produced by said device to both of said receivers for combining with the waves impressed thereon by the respective antennæ, an electric discharge detector associated with the receiver receiving waves from said non-directive antenna and arranged to operate as a plate current detector, a resistance element in the plate circuit of said electric discharge detector, and connections from said resistance to the grid and cathode of the oscillating electric discharge device for controlling the amplitude of the oscillations generated thereby to maintain the output of said receivers substantially constant independent of variations in amplitudes of the waves received by said non-directive antenna.

6. In combination, an antenna of adjustably directive characteristics, substantially non-directive antenna, a radio receiver associated with each of said antennæ, both of said receivers being adapted to receive the same radio waves, a source of oscillation, an electrical path for supplying waves from said source to both of said receivers for combining with the waves impressed thereon by the respective antennæ, an electrical discharge device having a cathode, an anode and a control element, the cathode and anode being connected in said electrical path to control the impedance thereof, and means for impressing between the control element and

cathode a unidirectional potential proportional to the amplitude of the signal output of the receiver associated with the non-directive antenna.

7. In a radio receiver, a source of waves, a detector for combining the waves being received and waves from said source, an electrical path for supplying waves from said source to said detector, the supply of the received waves to said detector being independent of said electrical path, and means responsive to the amplitude of the output of said detector for controlling the transmission characteristic of said path.

8. In a radio receiver, a source of waves, means for combining the waves being received with the waves from said source, and means responsive to the amplitude of the waves being received for controlling the amplitude of the waves supplied from said source to the combining means without affecting the amplitude of the received waves supplied to the combining means.

9. In a radio receiver, a source of waves, a detector for combining the waves being received with the waves from said source, and means responsive to the amplitude of the output of said detector for controlling the amplitude of waves supplied from said source to said detector without affecting the amplitude of the received waves supplied to the detector.

In witness whereof, we hereunto subscribe our names this tenth day of October, 1930.

EDMOND BRUCE.  
HARALD T. FRIIS.