Aug. 29, 1939. C. W. HICKS 2,171,432

RADIO APPARATUS

Filed July 12, 1935 3 Sheets-Sheet 1

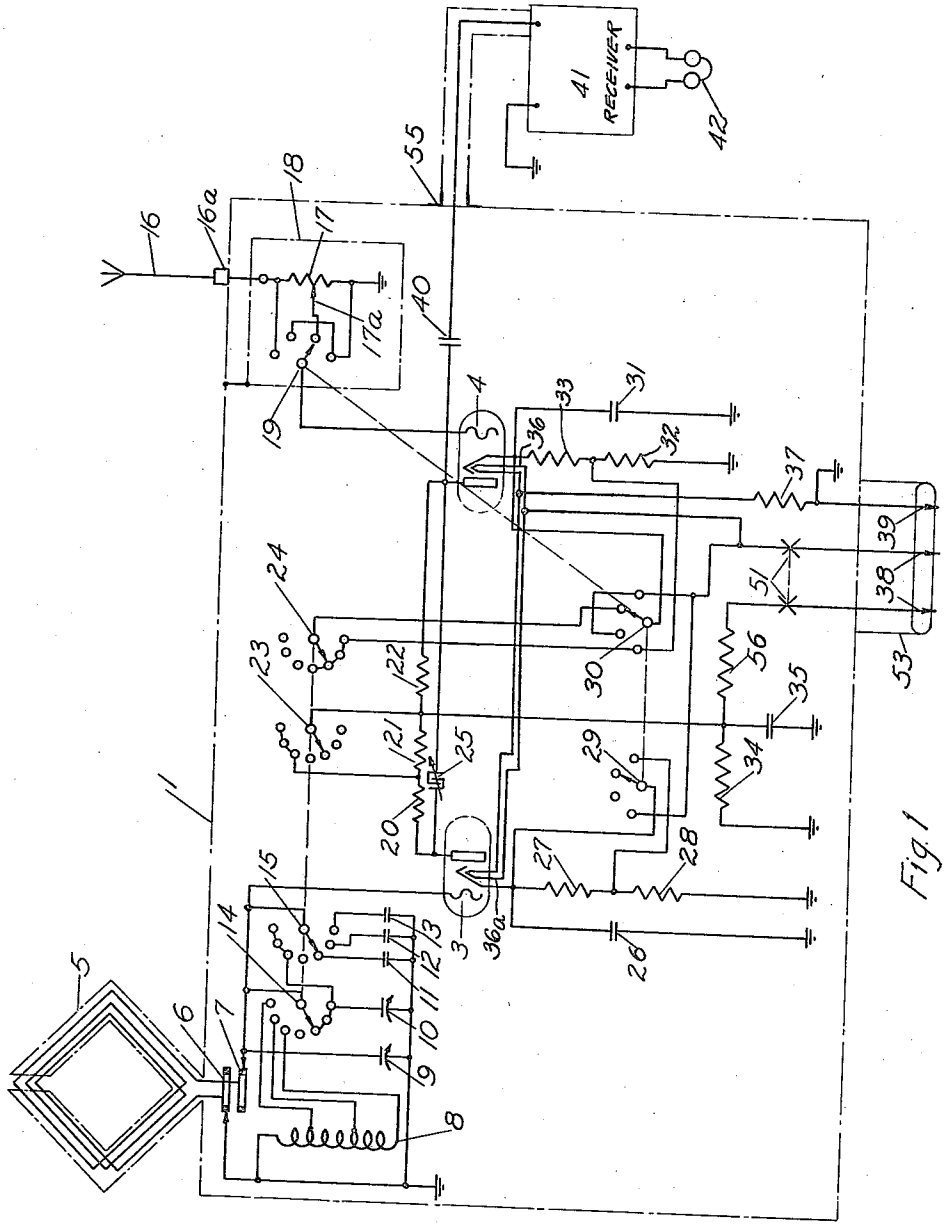


Fig 1

INVENTOR.

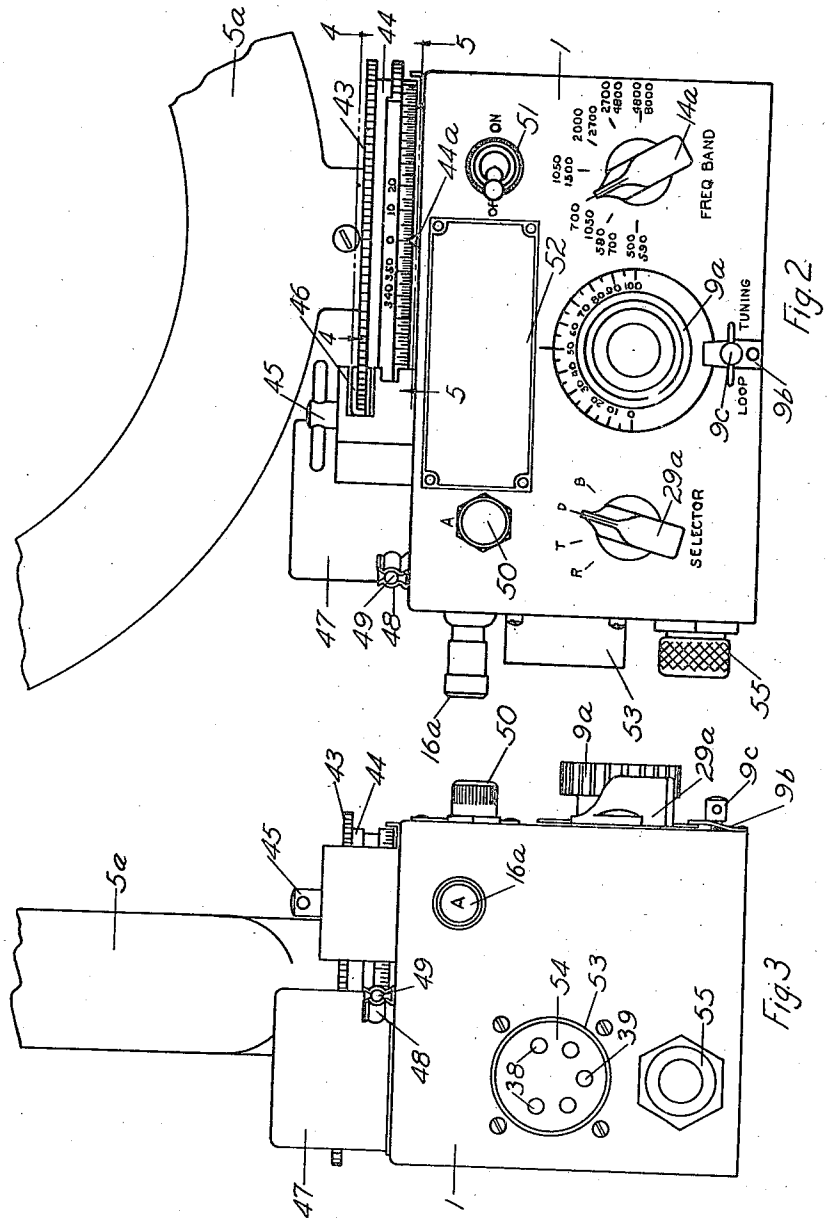
BY Charles W. Hicks

Ben J. Chappell ATTORNEYS.

Aug. 29, 1939. C. W. HICKS 2,171,432

RADIO APPARATUS

Filed July 12, 1935 3 Sheets-Sheet 2



INVENTOR.
Charles W. Hicks
BY
Benj. Thorn
ATTORNEYS.

Aug. 29, 1939. C. W. HICKS 2,171,432

RADIO APPARATUS

Filed July 12, 1935 3 Sheets-Sheet 3

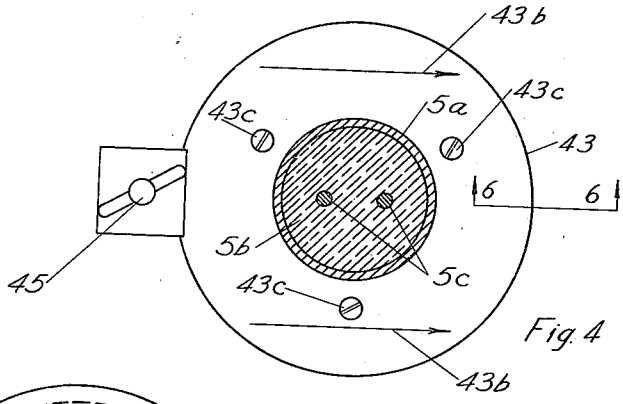


Fig. 4

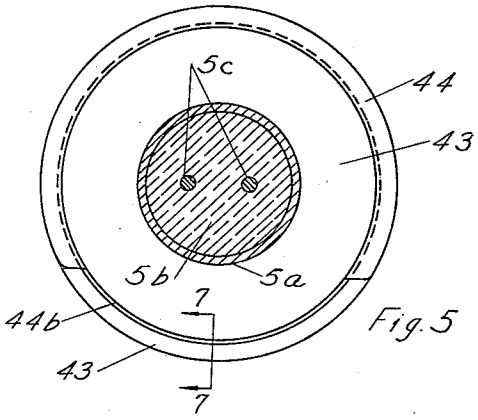


Fig. 5

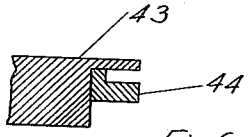


Fig 6

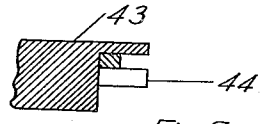


Fig. 7

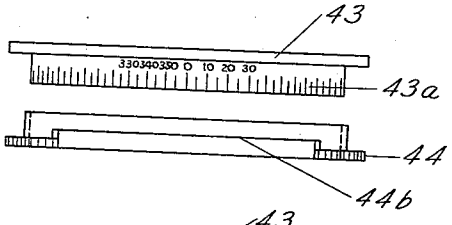


Fig. 8

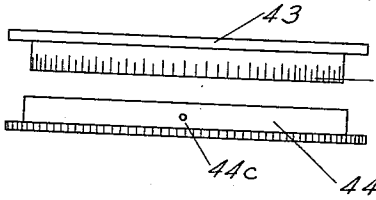


Fig. 9

INVENTOR.

BY Charles W. Hicks

Ben J. Gherardi ATTORNEYS.

Patented Aug. 29, 1939 2,171,432

UNITED STATES PATENT OFFICE

2,171,432

RADIO APPARATUS

Charles William Hicks, Hyattsville, Md., assignor, by mesne assignments, to Bendix Radio Corporation, New York, N. Y., a corporation of Delaware

Application July 12, 1935, Serial No. 31,084

8 Claims. (Cl. 250—11)

This invention relates to radio apparatus generally. More particularly, this invention relates to radio receiving apparatus adapted for obtaining bearings, determining direction, courses, positions, and the like with respect to one or more transmitting stations.

An object of this invention is to provide a circuit arrangement for controlling the reception of a conventional radio receiver and for permitting uni-directional, bilateral directional, and for omni-directional reception over said radio receiver.

Another object of this invention is to provide an attachment for a conventional radio receiver whereby the directional receiving characteristics of said radio receiver may be changed at will.

Still another object of this invention is to provide a signal receiving device, having an input circuit adapted to be energized from a signal transmitter, with means for accurately balancing the maximum intensity of signal energy impressed upon said signal receiving device from a directional antenna and from a substantially non-directional antenna.

A further object of this invention is to provide an arrangement, adapted for use as a directional receiver, which may be readily employed with a directional antenna of small signal pick-up characteristics and a non-directional antenna of substantially greater pick-up characteristics.

Another object of this invention is to provide a circuit for coupling a pair of antennas to the input of a receiving set and for controlling the intensities of the signal energies used from each antenna without altering the characteristics of either of said antennas.

Another object of this invention is to provide a signal mixing circuit arrangement adapted to equalize the useful intensities of signal energies derived from a non-directional antenna and a directional antenna without altering the characteristics of either antenna.

Another object of this invention is to provide an amplifying-coupling arrangement employing thermionic tubes for connecting a directional and a substantially non-directional antenna arrangement to the input of a radio receiver for controlling the intensities of the signal energies impressed upon the input of said receiver without altering or affecting the characteristics of said antenna arrangement.

Other and further objects of this invention will be apparent to those skilled in the art to which it relates, from the following specification and the claims.

In accordance with this invention I provide a circuit arrangement which employs plural tubes, each having an input circuit, one of which is connected to a directional antenna and the other of which is connected to a substantially non-directional antenna. I also provide means to the input or output circuits of the tubes for controlling the amplifying characteristics thereof and for blocking either one of these tubes at will so that signal energy from either the directional antenna or non-directional antenna or from both antennas may be impressed through said tubes upon an amplifying and/or detecting circuit of a radio receiver.

I have shown the antenna coupling circuit, including the novel tube circuits as a separate unit attachable to any conventional radio signal receiver; however, it is apparent that this coupling circuit may be incorporated into the receiver and employed as the first stage radio frequency amplifier or detector of said receiver. It is, of course, also obvious that the tubes used need have no amplifying characteristics but may act merely as coupling devices. In practice, it is generally desirable to reduce the intensity of the signal component impressed upon the tube from the non-directional antenna and increase the intensity of the signal component impressed upon the tube from the directional antenna in order to balance the maximum signal intensities derived from both antennas. For this purpose one tube, that is the tube connected to the directional antenna, is controlled by proper bias potentials to act as a relatively efficient amplifier, while the other tube is adjusted to act more or less as an inefficient amplifier or coupling unit. The signal intensities derived from the directional and non-directional antennas are thus conveniently equalized.

The signal components obtained from the directional and non-directional antennas are impressed upon a common circuit in the output circuits of the tubes and the resultant is a substantially uni-directional signal characteristic.

It is, of course, possible to amplify the outputs of the two tubes separately before impressing the signal components therefrom on a common circuit.

The operation of this invention will be more clearly understood from the following detailed description and the drawings in which, briefly, Fig. 1 illustrates a schematic diagram of connections of an embodiment of this invention; Figs. 2 and 3 illustrate the manual controls and cabinet for housing the apparatus connected in

accordance with the diagram of Fig. 1; Fig. 4 is a sectional view along the line 4—4 of Fig. 2; Fig. 5 is a sectional view along line 5—5 of Fig. 2; Fig. 6 is a sectional view along the line 6—6 of Fig. 4; Fig. 7 is a sectional view along the line 7—7 of Fig. 5 and Figs. 8 and 9 are exploded views of the scale and mask. Referring to Fig. 1 in detail, reference numeral 1 designates a metal cabinet or shield for housing the vacuum tubes 3 and 4, each employing a cathode, grid or control electrode and an anode. Heater filaments 36 and 36a are used to heat the cathodes of tubes 3 and 4. The grid electrode of tube 3 is connected to the connector or slip ring 7 of the loop antenna 5 through a suitable brush or similar contact. This loop is partially enclosed in a tubular screen or shield of metallic material for electrostatically shielding the conductors thereof. One end of the loop is connected to the slip rings 6 and the other end is connected to the slip ring 7. The rings 6 are connected to one end of the inductance 8 and to the condensers 9, 10, 11, 12 and 13. These rings 6 are also grounded to the frame, chassis or cabinet. The condenser 9 is permanently connected across the loop 5, as shown, however, multiple contact switches 14 and 15 are employed to control the connections between the inductance 8, and the condensers 10, 11, 12 and 13 and the loop, whereby a plurality of circuit combinations may be obtained between the loop, the inductance and the condensers for extending the tuning range thereof.

Taps of the inductance 8 are connected to different contact points of the switch 14 for the purpose of enabling the operator to use all or only certain parts of this inductance at one time. A plurality of adjacent contacts of the switch 14 are connected together into a unit and this unit is connected to the variable condenser 10. Likewise a series of the contacts of the switch 15 are connected together, as shown, and this unit is connected to a similar unit of switch 14 which is connected to the condenser 10. Three contacts of switch 15 are connected to the condensers 11, 12 and 13, respectively; these latter contacts correspond, in position to the contacts of switch 14, which are connected to the condenser 10 and the contacts of switch 15 that are connected to the condenser 10 correspond to the contacts of switch 14 that are connected to sections of the inductance 8. The switches 14 and 15 are mounted in tandem to be controlled by a single shaft, knob, handle pulley, gear or similar device, either manually or by some remote control mechanism.

Switches 23 and 24 are also mounted in tandem or in any other desirable manner to be controlled simultaneously as a unit for the purpose more fully described in the following paragraphs.

The antenna 16 is connected to the resistance 17, which is enclosed in the metal shield 18 together with the switch 19. The switch 19 is provided with a plurality of contacts, two of which are connected to the grounded end of resistance 17, one to the antenna end of the resistance 17 and one to a variable contact on said resistance. The contact arm of the switch 19 is connected to the grid electrode of the tube 4.

The plate electrodes of the tubes 3 and 4 are connected together by a series of resistance units 20, 21 and 22. A condenser 25 is also connected between these plate electrodes. Multiple contact switch 23 is connected across the resistor 21 in such a manner that this switch short circuits this resitor in three positions of the contact arm thereof. The switch 23 is arranged to be rotated in step with the switches 14, 15 and 24 and these switches are all illustrated with their contacts in proper relation with respect to the contact arms thereof. Thus rotation of the common shaft of these switches establishes the proper circuit connections in these switches simultaneously. The switch 24 is employed to close the circuit between two contacts of the switch 30 to enable this switch to short circuit the cathode resistor 33 when the switch 29, which is mounted in tandem with the switches 19 and 30, is in the position designated D.

The switch 30 is connected to the cathode of the tube 4 to control the biasing potential of the grid electrode of this tube with respect to the cathode. Two of the contacts of this switch are connected to the negative terminal of the plate power supply leads 38. The terminal R of switch 29 and the tube heater filaments 36 and 36a are also connected to this negative power supply terminal as shown in Fig. 1 of the drawings. As described above two contacts of switch 30 are connected to the switch 24, one to the contact arm and one to a series of electrically connected contacts of this switch 24. Thus when the contacting arms of these switches are in positions shown in the drawings, they co-operate to short circuit the resistor 33.

Another resistor 32 is connected in series with the resistor 33 and this series is shunted by a fixed by-pass condenser 31. A similar series of reistors 27 and 28, shunted by a condenser 26 is connected to the cathode of tube 3. The contact arm of switch 29 and the end contact B are connected to the resistor 27 in such a way that this resistor is short-circuited when the switch arm of this switch is in contact with the terminal B.

Resistor 56 is connected in series with the positive power supply lead 38 to the resistances 21 and 22 connected between the plates of the tube. Another resistance 34 and fixed condenser 35 are connected to the resistances 21, 23 and 56 to form a shunt circuit between these resistances and the ground, which may be the metal cabinet, chassis and the like. Resistor 37 is connected in parallel with the filaments 36 and 36a and in series with the heating current power supply terminal 39; this resistor is also connected to the chassis as shown.

The output or plate circuits of the tubes 3 and 4 are coupled to the input circuit of the signal receiving apparatus 41 by the condenser 40 and the leads connected thereto, all of which are enclosed in suitable metal shields. The condenser 40 may be connected to the antenna binding post, connected to a radio frequency simplifier, of a conventional radio receiving set or it may be connected to the input circuit of the detector tube of a signal receiver. Where desired, the tube 3 or 4 may be operated as a detector and the output thereof fed into an audio frequency amplifier through the condenser 40. In either case the telephone receivers 42 or similar translating or indicating devices are connected to be energized in accordance with signal energy.

The apparatus schematically illustrated in Fig. 1 is assembled into the cabinet, preferably of metallic material, such as, copper or aluminum, shown in front vertical elevation in Fig. 2. The loop antenna container 5a is mounted on the top of the cabinet and is rotatable with respect to the cabinet. Any convenient form of mounting for the loop housing 5a, so that it may be rotated with reference to the cabinet may be

employed, however, the mounting most readily adopted is a simple friction fit of the bottom tubular end of the loop housing into a hollow bearing formed in the top of the cabinet. The circular scale-carrying member 43 is attached to the loop housing 5a and is rotatable with the loop. This circular member 43 may be employed to rotate the loop when such rotation is accomplished manually, and may be employed in conjunction with a suitable screw operated clamp 46, which is adjusted by the thumb screw 45, to lock the loop in place and prevent its rotation. This clamp 46 is particularly useful when it is desired to shift the scale mask 44 to a certain position for the purpose of covering a certain part of the scale.

An index or pointer 44a is attached to the cabinet 1 adjacent to the scale of the member 43. A hollow dome 47, also of metal, is removably held over a hole in the top of the cabinet to cover the top of the tubes to permit easy access thereto. Suitable spring and pin members 48 and 49 are attached to the cabinet and the dome 47, respectively, and co-operate together to hold the dome in place.

A control 50 is attached to the front of the cabinet and is connected to the contact arm 17a of the resistance 17 for the purpose of controlling the intensity or amplitude of the signal obtained from the antenna 16 when the switch 19 is in the position illustrated in Fig. 1, that is, the position corresponding to the position D of switch 29, which is connected in tandem with switch 19 and is operable by the knob 29a. A switch 51 preferably of the toggle type, is mounted on the front of the cabinet and is connected into the leads 38 as shown in Fig. 1. A plate 52 having inscribed thereon brief instructions for operation of the unit, is attached to the front of the cabinet.

The knob 14a is employed to control the position of the tandem mounted switches 14, 15, 23, and 24.

The knob 14a may be set in any one of seven positions, each of which correspond to one of the contacts of each of the tandem switches that this knob controls. The primary purpose of this control is to select the signal frequencies to which the vacuum tube circuit is to respond and each setting of this knob is accordingly calibrated in accordance with a predetermined frequency band. The position occupied by the pointer of the knob 14a corresponds to the position of the contact arm of switch 14.

The dial 9a is used to control the position of the rotary plates of condensers 9 and 10. A locking clamp 9b is attached to the front of the cabinet and after the dial 9a and condensers are adjusted to the proper setting the thumb screw 9c may be tightened to clamp the dial in place to prevent further rotation thereof until the tension of the clamp is released.

A plug receiving socket 53 is attached to a side of the cabinet 1 for the purpose of facilitating making connections with an external power supply. A panel 54 of insulating material is supported inside of the socket 53 and connections 38 and 39 are supported on this panel. Binding post 16a is provided for connecting the antenna 16 to the unit and the coupling member 55 is employed to couple the unit to a shielded conductor connected to the conventional signal receiver input circuit.

The scale and scale mask carried by the stem of the loop antenna housing are illustrated in detail in Figs. 4, 5, 6, 7, 8 and 9 of the drawings. The dial 43 consists of a circular member fitted around the stem of the loop housing 5a in such a manner that the loop may be turned manually by engaging the periphery of the dial. The loop stem is provided on the inside with a suitable ceramic insulator 5b to space the loop conductors 5c. Arrows 43b are engraved on the top of the dial and point in a direction parallel to the plane of the loop.

Fig. 5 shows a bottom view of the scale dial 43 and mask 44. Mask 44 has a cut-away section 44b which extends over approximately half its circumference and when this cut-away portion is over the front of the dial the scale 43a of the dial may be read from the front. When the zero mark 44c of the mask 44 (Fig. 9) is in line with the index pointer 44a (Fig. 2) the mask covers the front section of the scale. This cut-away section is shown in detail in Figs. 5, 7 and 8. Fig. 6 shows a section through the solid part of the mask ring.

The operation of the circuit arrangement and apparatus of my invention is as follows:

The selector 29a is set on the position R wherein the loop tube 3 is blocked through switch 29 applying proper bias to that tube. Omni-directional signal energy is then transferred from the non-directional antenna to the receiver or amplifier 41 through tube 4, antenna connection 16A, switch 19, condenser 40 and coupling connection 55.

The selector 29a is then set on position T, and while the frequency band selector 14a is on one of the four positions adjusting the loop tuning circuit to one of the signal frequency channels between 500 and 8000 kilocycles, the tuning dial 9a is adjusted to tune in a continuous wave carrier, such as is transmitted by a broadcasting station. In this position, switch 19 is connected to a contact that is grounded and the cathode of tube 4 is connected to the filament 36. This tube 4 is thus blocked and is unaffected by signal energy.

The dial 9a is next adjusted until maximum signal strength is obtained through tube 3, using the loop 5 as the signal pick-up. The loop is moved angularly, to the position of maximum signal intensity and acts in the conventional way as a bilaterally selective pick-up.

The knob 29a is then turned to the position D. The loop is then rotated to determine whether or not signals of high intensity are received at one or two positions thereof. If two such positions are obtained, the loop is set in the position at which the weaker of the two high intensity signals is obtained and the control 50 for manipulating the contact 17a is operated until this weaker of the two high intensity signals either disappears or becomes very weak. The loop is then rotated 180° more or less, to the other of the two high intensity signal positions and the signal receiving unit is operated as a uni-lateral receiver employing the loop and the non-directional antenna in equalized and balanced relation.

If the antenna 16 is not of the correct proportions to enable the proper signal intensity balance to be obtained, as outlined above, condenser 20a connected into the circuit, is varied until the weaker of the two high intensity signals disappears. The signal pattern of the antenna system, including the loop and the antenna 16, is then cardiodal or substantially so.

The unit of my invention may be operated as a bi-lateral direction finder in the following manner: The knob 29a is set on position R and the receiver dial operated to tune the receiver to a

station. Next this knob **29***a* is set on position T and the loop is employed as a pick-up without the antenna **16**. The loop is tuned by means of dial **9***a* and then the switch knob **29***a* is set on position D. The loop is then turned to the position giving the strongest signal and held in this position by turning the thumb screw **45** of the lock clamp which engages a section of the dial **43** and prevents rotation thereof and the loop. The mask **44**, which is carried by the dial **43**, as shown in the detail views Figs. 5, 6 and 7, and the exploded views Figs. 8 and 9, is rotated until the zero index reference **44***c* coincides with the index pointer **44***a*, mounted on the top of the cabinet.

The knob **29***a* is then set on position B, and the unit is operated as a bi-lateral directional receiver. The loop is then unlocked by manipulation of thumb screw **45** and swung to a minimum signal position with an unmasked portion of the dial over the index pointer **44***a*. The setting of the loop for minimum signal will give the bearing of the station, from which signal energy is being received, relative to the head of the ship, carrying the receiving apparatus of my invention. There is another minimum signal position on the opposite side of the dial, however, this portion of the dial is covered by the mask and the taking of bearings on that portion is thus rendered impractical. The mask **44** is made with the zero mark **44***c* and the cut-away section **44***b* arranged in such a way that after adjustment of mask **44** on the D position as described then the unmasked section of the scale **43***a* is in view when the minimum signal is being received from a transmitting station located in the direction of the head or front of the ship.

When it is desired to take very accurate bearings with the apparatus of my invention on an aeroplane, the loop should be adjusted so that a signal dead ahead will have a zero signal at zero on the azimuth dial **43** and a correction curve may be plotted to take care of deviations due to the influence of the plane structure. Should it happen that the unit is not mounted exactly in the proper location and a signal from a station known to be dead ahead gives a bearing that reads some few degrees from zero the dial may be readjusted to read zero by loosening the three screws **43***c* on the top of the dial to read zero by moving the dial, until the reading is on zero while the loop is held in the position of minimum signal reception. The screws should be loosened only a very slight amount and carefully tightened after the dial is readjusted. A total motion of ten degrees in either direction is permitted by the mounting slots in the dial. If the error is more than ten degrees the entire unit must be realigned with the center line of the plane.

In addition to the operation of the unit as a rotating loop direction finder it may be used in a fixed position for homing. For this purpose the procedure is the same as for the operation as a rotating loop except that the loop is locked with the dial at zero over the index pointer and the ship is swung instead of the loop. The direction must be obtained on the D position and then the selector set to B when the pilot merely needs keep the signal at the correct minimum to know that he is headed for the station.

In some cases, particularly at the higher frequencies it will be found that very accurate bearings may be obtained on the D position. In order to obtain the bearing relative to the plane heading when on the D position the mask is adjusted as mentioned above and on the instruction plate and the bearing is read from the azimuth dial over the pointer on the right hand end of the unit. An even more rapid but less accurate method is merely to note the position of the arrows **43***b* engraved on the top of the dial or, more easily still, note that the side of the loop painted in the lighter color always points toward the station when the loop is swung to the maximum signal on the D position.

While the novel direction finder of the invention has been described as employing separate tubes **3** and **4**, it will be readily understood that the necessary tube elements may be enclosed within a single envelope and a single filament or heater element may then be utilized to activate the cathodes of the two tube circuits. Tubes of this character are well known in the art and where space and weight requirements indicate the desirability, such as dual tube can be substituted for the separate tubes **3** and **4** shown in Figure 1.

Other methods of accomplishing the results set forth herein may be devised within the scope and spirit of this invention, and it is, therefore, not desired to limit this invention to the exact details set forth in the foregoing specification except in so far as those details may be defined by the appended claims.

What I claim and desire to secure by Letters Patent is as follows:

1. In radio receiving apparatus the combination of a directional antenna, a substantially non-directional antenna, dual electrical discharge devices, each of which has a source of electrons, a control grid electrode and an anode, connections between one of said control grid electrodes and said directional antenna, connections between said substantially non-directional antenna and the other of said control grid electrodes, indicating apparatus, means for energizing said indicating apparatus, connections between said anodes and said last mentioned means, and means for selectively adjusting the bias potential on said grid electrodes of said electrical discharge devices for rendering said dual electrical discharge devices sensitive to signal energy for receiving signals either uni-laterally or bi-laterally.

2. In radio receiving apparatus the combination of a directional antenna, a substantially non-directional antenna, amplifying electrical discharge devices, each of which has a source of electrons, a control grid electrode and an anode, connections between one of said control grid electrodes and said directional antenna, connections between said substantially non-directional antenna and the other of said control grid electrodes, indicating apparatus, means for energizing said indicating apparatus, connections between said anodes and said last mentioned means, and means for selectively controlling the amplifying characteristics of said electrical discharge devices while the cathodes thereof are energized for receiving signals either bi-laterally or substantially uni-laterally by selectively utilizing signal energy from one or both of said antennas.

3. In radio receiving apparatus the combination of a bi-laterally directional antenna, a substantially non-directional antenna, means for tuning said directional antenna, amplifying electrical discharge devices, each of which has a cathode, a grid electrode and an anode, an output circuit connected to the anodes of said discharge devices, an indicating device, means for connecting said indicating device to said output

circuit, means for connecting said directional antenna to one of said grid electrodes, means for connecting said substantially non-directional antenna to the other of said grid electrodes, means for selectively controlling the amplifying characteristics of said electrical discharge devices while the cathodes thereof are energized for controlling the amplitude of the signal energy impressed upon said output circuit from each of said antennas for obtaining either a bi-lateral or a substantially uni-lateral signal response characteristic from said antennas.

4. In a radio receiving apparatus the combination of a bi-laterally directional antenna, a substantially non-directional antenna, amplifying electrical discharge devices, each of which has an input and output circuit, connections between said directional antenna and one of said input circuits, connections between said substantially non-directional antenna and the other of said input circuits, means for selectively controlling the amplifying characteristics of said discharge devices while said input and output circuits thereof are energized for controlling the amplitude of the signal energy impressed from said input circuits upon the corresponding output circuits for obtaining bi-lateral or substantially uni-lateral signal reception.

5. In radio receiving apparatus the combination of a loop antenna, a substantially non-directional antenna, means for tuning said loop antenna, an inductance unit having a plurality of sections, means for connecting different ones of said inductance sections across said loop for varying the frequency range thereof, amplifying electrical discharge devices, each of which has a cathode, a grid electrode and an anode, an output circuit connected to said anodes, means for connecting said loop antenna to one of said grid electrodes, means for connecting said substantially non-directional antenna to the other of said grid electrodes, means for selectively controlling the amplifying characteristics of said electrical discharge devices while the cathodes thereof are energized for controlling the amplitude of the signal energy impressed upon said output circuit from each of said antennas for obtaining either a bi-lateral or a substantially uni-lateral signal response characteristic from said antennas.

6. In radio receiving apparatus the combination of a loop antenna, an inductance unit having a plurality of sections connected to said loop antenna, a plurality of condensers connected to said loop, a pair of switches mounted in tandem and each having a plurality of contacts, connections between a plurality of the contacts of one of said switches and said condensers, a substantially non-directional antenna, a variable impedance device connected to said last mentioned antenna, electron discharge devices each having an anode, a grid electrode and a cathode, means for impressing a biasing potential between each of said grid electrodes and the corresponding cathode, switching means for controlling each of said last means, an output circuit connected to said anodes, an amplifier connected to said output circuit and an indicating device connected to said amplifier.

7. In radio receiving apparatus the combination of a loop antenna, an inductance unit having a plurality of sections, a plurality of condensers, means for connecting different sections of said inductance and different ones of said condensers to said loop antenna for varying and controlling the frequency response thereof, electron discharge device means including a grid, a cathode and an anode, connections between said loop antenna and said grid, an output circuit connected to said anode, an amplifier and an indicator connected to said output circuit, a substantially non-directional antenna, and means for impressing signaling energy upon said output circuit from said substantially non-directional antenna for controlling the directional characteristics of said loop antenna and means for controlling the bias potential of said grid with respect to said cathode to permit either uni-directional or omni-directional reception with said antennas.

8. In radio receiving apparatus the combination of a bi-laterally directional antenna, a substantially non-directional antenna, means for tuning said directional antenna, amplifying electrical discharge devices, each of which has a cathode, grid electrode and anode, an output circuit connected to the anodes of said discharge devices, means for energizing said cathodes, means for connecting said directional antenna to one of said grid electrodes, means for connecting said substantially non-directional antenna to the other of said grid electrodes and means in circuit with said grid electrodes for selectively controlling the amplifying characteristics of said electrical discharge devices for obtaining either a bi-lateral or a unilateral signal response characteristic from said antennas.

CHARLES W. HICKS.