

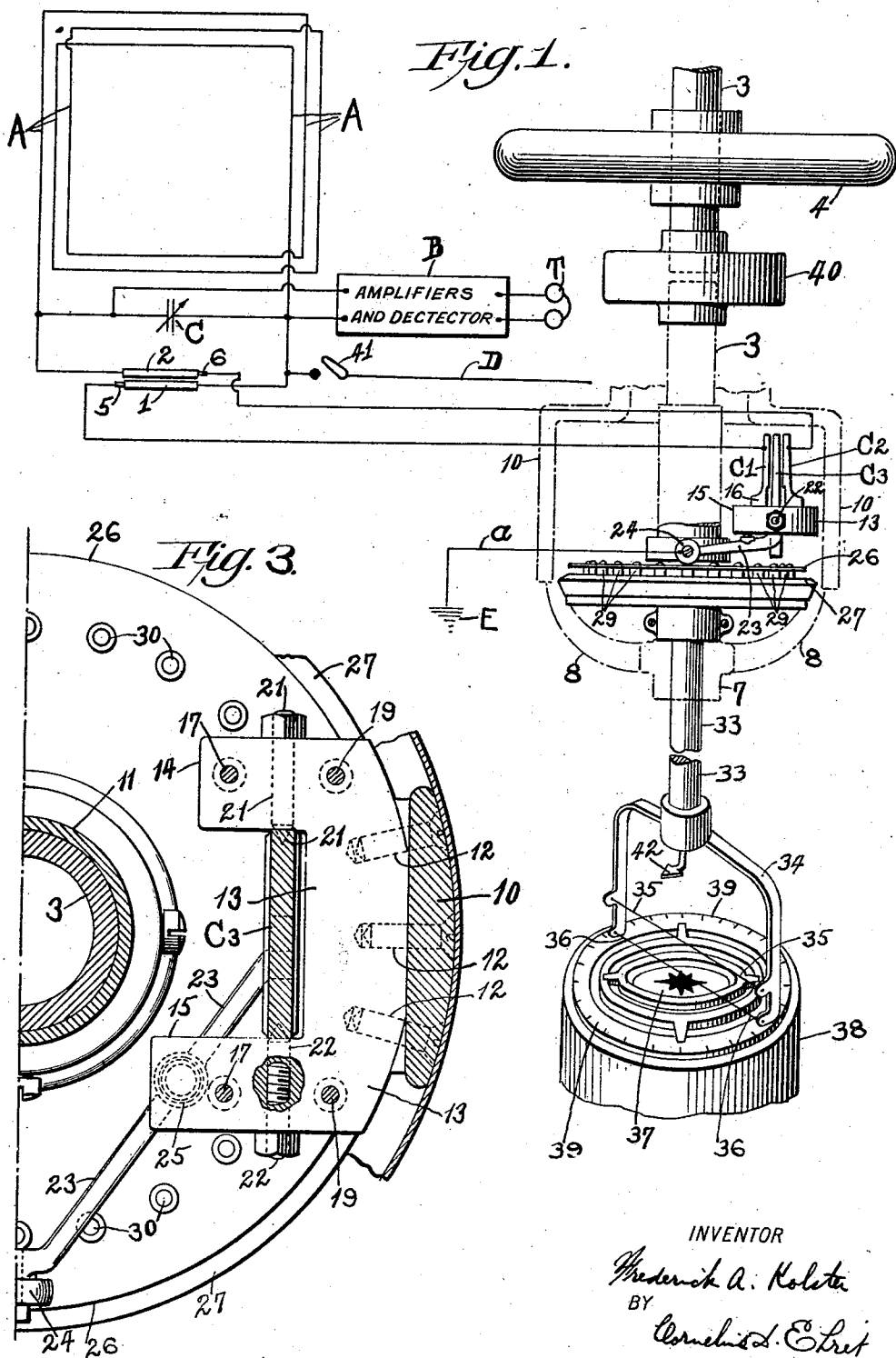
June 2, 1931.

F. A. KOLSTER

1,807,919

RADIO COMPASS

Original Filed June 6, 1925 2 Sheets-Sheet 1



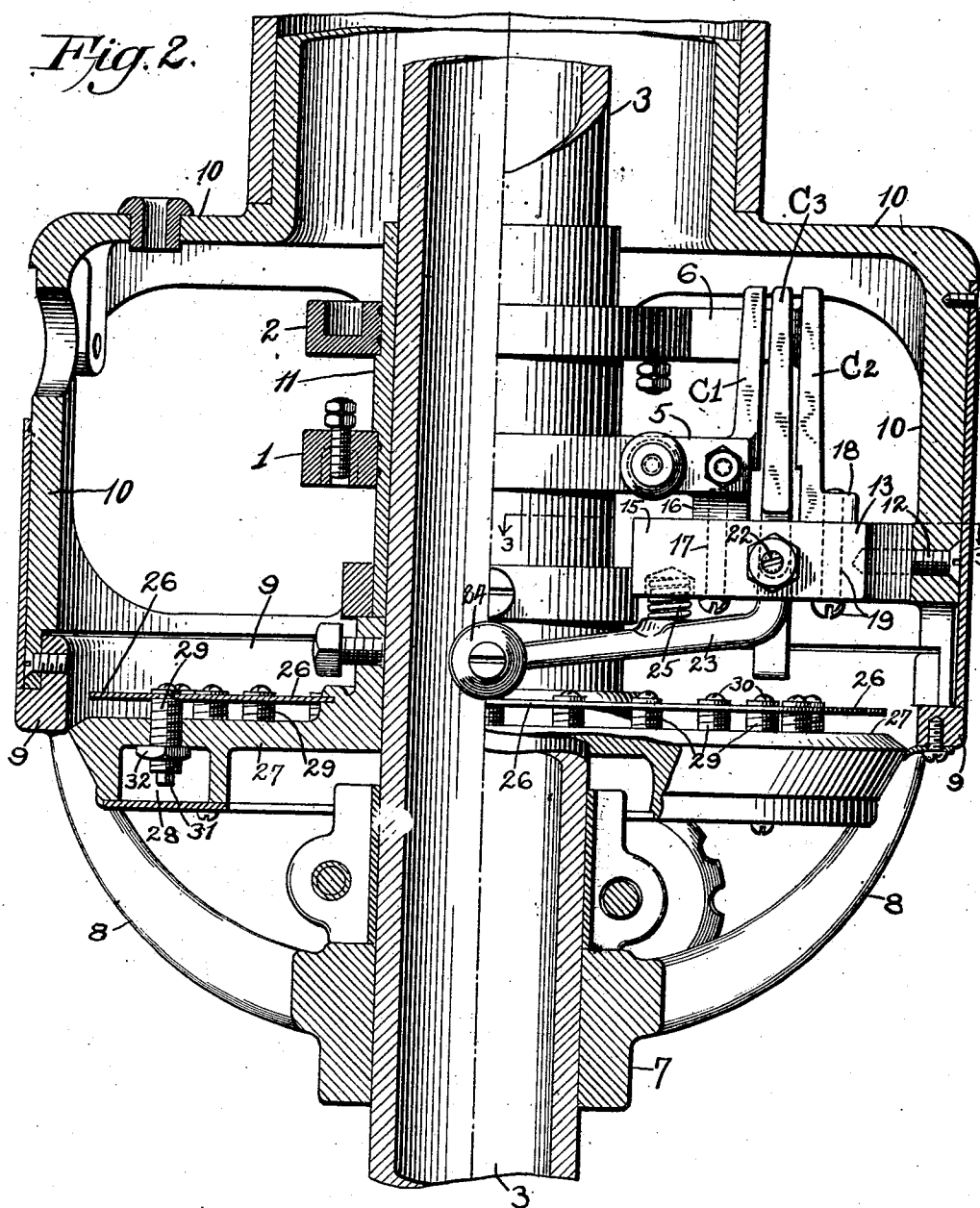
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RADIO COMPASS

Application filed June 6, 1925, Serial No. 35,295. Renewed October 14, 1929.

My invention relates to directional radio apparatus or radio compasses utilizable on shipboard, aircraft, or at shore stations, for determining with accuracy or nicety the direction or bearing of a radio beacon or other distant radio transmitter.

In accordance with my invention, there are provided means for automatically maintaining a predetermined relation between components of an electrical system, such as a directional radio system, and more particularly for maintaining, notwithstanding disturbing influences, symmetry or predetermined degrees of symmetry between a closed circuit and a path, such, for example, as a closed circuit of a directional radio system with respect to an earth connection or equivalent path thereof.

Further in accordance with my invention, a closed circuit of a radio directional system, and including a rotatable coil or other means having a directional characteristic, is automatically maintained symmetrical with respect to an open antenna path of earth connection, by variation of electrical means by a member, such as a cam, having a form representative of the compensations or corrections required for effecting the aforesaid symmetry or predetermined degree of symmetry.

My invention resides in a system, apparatus and features of construction and arrangement hereinafter described and claimed.

For an illustration of one of the various forms my invention may take, reference is to be had to the accompanying drawings, in which:

Fig. 1 is in part electrically diagrammatic and in part an elevational view of apparatus in accordance with my invention.

Fig. 2 is a vertical sectional view of the automatic correction structure.

Fig. 3 is a horizontal sectional view, partly in plan, taken on the line 3—3 of Fig. 2.

Referring to Fig. 1, A is a rotatable inductance or coil absorbing electro-radiant energy directly from the natural media and having a non-uniform directional characteristic, as well understood in this art. The coil A is included in a closed circuit with the

condenser C variable for tuning the closed circuit to the radiant energy received from a distant radio beacon or other transmitter. The coil A and the slip rings 1 and 2, constituting terminals of the closed circuit, are carried upon and rotatable with the vertical shaft 3 rotatable by the operator by means of the hand wheel 4.

In shunt to the condenser C is the usual radio receiving apparatus, such as amplifiers and detector, indicated at B, and comprising, for example, one or more stages of radio frequency thermionic amplifiers, followed by a detector tube followed in turn by one or more stages of audio frequency amplifying tubes, in the anode circuit of the last of which is connected the telephone or other signal-translating instrument T.

Bearing upon the slip rings 1 and 2 are the brushes 5 and 6, respectively, electrically connected with the stationary condenser armatures C1 and C2, between which is disposed the movable condenser armature or plate C3, whereby there are in effect two condensers in series with each other and in shunt to the condenser C or connected across the terminals of the coil A. The condenser armature C3 is connected to earth, ship's hull or counter-capacity E, this connection α forming in effect an open path with respect to which the symmetry of the closed circuit AC is determinable by the complementarily variable condensers C1 and C2, movement of the common armature or plate C3 causing decrease in the capacity of one of these condensers and increase in capacity of the other, without material effect upon the tuning of the closed circuit AC. In apparatus of the character described, it is found, particularly on shipboard, that surrounding conducting masses, such as masts, smoke stacks, etc., exert such influence that, for a predetermined or fixed position of the condenser armature C3, corresponding, for example, with symmetry of the closed circuit with respect to the earth connection, the symmetry of the closed circuit with respect to the earth path is disturbed or altered for different positions to which the coil A is rotated about its vertical axis.

When determining the bearing of a radio beacon or distant radio transmitter, the operator, by the hand wheel 4, rotates the coil A through the medium of the shaft 3 to a position of critical response, such, for example, as minimum response in the telephone T, when the plane of the coil A is normal to the direction of propagation of energy from the distant beacon or transmitter. The position to which the coil is so rotated may not be true bearing position, for that some slight signal may still be heard in the telephone T. The condenser armature C3 is moved backwardly and forwardly while the coil A is also moved backwardly and forwardly within a narrow arc until absolute silence in the telephone T is obtained, this position of the coil corresponding with that position of the condenser armature C3 for which the closed circuit AC is strictly symmetrical with respect to the earth connection or open antenna path *a*, and for this position of the coil A its plane is normal to the bearing (disregarding wave front distortion) of the distant beacon or transmitter. In other words, it is desirable for sharp bearing determination to have the closed circuit AC strictly symmetrical with respect to the earth connection *a*, for all positions of the coil A throughout the circumference of its movement. But the influence of conducting masses, as aforesaid, is such that for different direction-determining positions of the coil A the closed circuit will not be symmetrical with respect to the earth connection unless the position of the condenser armature C3 be varied to effect symmetry for each position of the coil A.

The aforesaid movement or adjustment of the condenser armature C3 to effect symmetry of the closed circuit with respect to the earth connection for all positions of the coil A is automatically effected by the structure of the character hereinafter described.

The shaft 3 has a bearing in the fixed member 7 having the upwardly extending arms 8 terminating in the ring member 9, upon which is carried the housing member 10. Carried by the shaft 3 within the housing 10 is the sleeve 11 of insulating material, upon which are secured the aforesaid slip rings 1 and 2. Disposed within the housing 10 and secured thereto by screws 12 is the bracket 13 of insulating material having the arms 14 and 15. The condenser armature C1 has the lug or boss 16 secured by screws 17 to the arms 14 and 15 of the bracket member 13. Similarly, the condenser armature C2 has the lug or boss structure 18 secured by screws 19 to the bracket member 13. Secured to the armature member C1 by bolt 20 is the brush 5, electrically connecting with the armature C1 and bearing upon the slip ring 1. Similarly, there

is secured upon and electrically connected to the armature C2 the brush 6 bearing upon the slip ring 2. Extending through the arms 14 and 15 of the bracket 13 are the pivot screws 21 and 22, upon which is pivoted the movable armature member C3, to which is secured the arm 23 for rocking it upon its pivotal axis and thereby moving it with respect to the stationary condenser armatures C1 and C2, which may carry upon their inner faces adjacent the armature C3 mica or equivalent dielectric material. Upon the outer end of the arm 23 is pivoted the cam follower or roller 24 pressed downwardly, by spring 25, confined between the bracket 13 and the arm 23, into engagement with the cam member 26, which may be rigid and cut or engraved to proper cam face form, or which, as indicated, and preferably, is a deformable sheet or plate of metal supported upon the disk 27. Disposed in a circumferential series in the channel 28 are the cam-deforming and adjusting screws 29, each threaded through the rigid disk 27 and having an upper end portion of reduced diameter extending freely through an aperture in the cam plate 26 and terminating in a head 30, between which and the screw 29 the cam plate 26 is confined, though the screw 29 may rotate with respect to the plate 26 and therefore raise or lower it locally. Each adjusting screw 29 may be provided with a squared end 31 to receive a socket wrench or key for adjusting the screw 29, which may then be locked in adjusted or desired position by the lock nut 32.

Cam structure of the character described, comprising a sheet deformable in directions substantially parallel with the axis of the shaft, is disclosed and claimed in Brower application Serial No. 34,006, filed June 1, 1925.

The roller or cam follower 24 engages the cam plate 26 outside of the annular series of screws 29.

Inasmuch as the cam 26 is fixed to the shaft 3 and rotates therewith, the plate 26 is deformed or waved locally by the adjusting screws 29 to cause the plate C3 to take such positions with respect to the armatures C1 and C2 for all successive positions of the coil A that the closed circuit AC remains or is maintained symmetrical with respect to the earth connection *a*.

The data for determining the deformation of the cam plate 26 are obtained in any suitable way. For example, a radio transmitter is disposed upon a small boat which travels completely around the vessel upon which the radio compass is installed and within sight thereof. Sightings are taken upon the small vessel at suitable intervals throughout the complete circumference of its travel, and for each bearing taken by sight a radio compass bearing is taken, and for each radio compass bearing there is determined the position

of the armature C3 necessary for effecting balance or symmetry of the closed circuit with respect to the earth connection. From these various settings of the armature C3 for the various positions of the coil A it is readily determinable to what extent and in what direction each of the screws 25 shall be adjusted suitably to deform the cam plate 26 to cause the condenser armature C3 to maintain symmetry for all positions of the coil A.

Upon an extension shaft 33, secured to the shaft 3, is disposed a bracket 34 carrying the sighting wires 35 and 36, disposed one vertically above the other and co-acting with the direction scale 37, which may be the card of a magnetic compass or which may be the card of a dumb compass, or the card of the repeater of a gyroscopic compass.

When the critical bearing position of the coil A is obtained, as hereinbefore described, the bearing may be read off upon the scale or card 37 by sighting down thereon with the eye placed vertically above the wires 35 and 36.

Upon the support or binnacle 38 may be disposed the fixed correction scale 39 having thereon markings which indicate the correction to be applied to the bearing read upon the scale or card 37 to correct or compensate for wave front distortion of the energy transmitted from the distant beacon or transmitter and caused by the mass of the ship or other masses adjacent the compass station when on shore, as described in my application Serial No. 425,834, filed November 22, 1920.

However, the scale 39 may be omitted, and automatic compensation for wave front distortion may be obtained by the compensator indicated at 40 and comprising means, such, for example, as described in application Serial No. 531,079, filed January 23, 1922, for causing the lower portion of the shaft 3 to take correcting or compensating positions with respect to the upper portion of the shaft 3.

It will be understood, however, that the compensating structure 40 may be disposed below the structure for complementarily varying the condensers C1 and C2 for maintaining symmetry, in which case the shaft 33 will be divided into two parts, the lower pointer-carrying portion of which will be shifted with respect to the upper portion to compensate or correct for wave front distortion.

When the compensator 40 is above the symmetry-maintaining structure, the cam 26 of the latter is shifted in position with respect to the shaft 3 in accordance with corrections for wave front distortion, and for each corresponding true bearing position of the pointer structure 35, 36, the symmetry-maintaining structure maintains balance or symmetry of the closed circuit with respect to

the earth connection for all positions of the coil A.

If the sense of direction of a radio beacon or distant transmitter is desired in addition to its bearing, it is only necessary, after the bearing has been obtained, to close the switch 41, normally held in open position, thereby connecting the auxiliary antenna or absorption structure D to the closed circuit, upsetting or changing its symmetry with respect to the earth connection E, and thereby affording means, as described in my prior application Serial No. 9,936, filed February 18, 1925, for determining sense of direction, which may be indicated by the pointer 42 carried by the shaft 33.

While I have more particularly referred to variable capacity for affecting the symmetry of the closed circuit with respect to the open path or earth connection, and more specifically for maintaining symmetry, it will be understood that impedance variation broadly, including variation of inductance or of inductive reactance, may similarly be used.

What I claim is:

1. The combination with an electric circuit including a movable element, of variable electrical means for determining the degree of symmetry of said circuit with respect to a point therein, and means movable in response to change of position of said movable element to vary said electrical means.

2. Radio apparatus comprising a closed circuit including a movable coil effecting interchange of high frequency energy between itself and a natural medium, a path, variable electrical means for determining the degree of symmetry of said closed circuit with respect to said path, a bearing scale, a pointer co-operating therewith, means for compensating for wave front distortion, and means varying said electrical means in response to changes of position of said coil.

3. Radio apparatus comprising a closed circuit including a movable coil absorbing radiant energy directly from a natural medium, a path, variable electrical means for determining the degree of symmetry of said closed circuit with respect to said path, and means comprising mechanism movable by said movable coil to vary said electrical means to maintain symmetry between said closed circuit and said path for different positions of said coil.

4. Radio apparatus comprising a closed circuit including a movable coil absorbing radiant energy directly from a natural medium, a path, variable electrical means for determining the degree of symmetry of said closed circuit with respect to said path, and means for maintaining symmetry of said closed circuit with respect to said path comprising a member having a surface representative of dissymmetry of said closed cir-

cuit with respect to said path for different positions of said coil, and a member controlled by said surface for varying said electrical means to maintain symmetry of said closed circuit with respect to said path for different positions of said coil.

5 5. Radio apparatus comprising a closed circuit including a movable coil absorbing radiant energy directly from a natural medium, a path, variable electrical means for determining the degree of symmetry of said closed circuit with respect to said path, and means for maintaining symmetry of said closed circuit with respect to said path comprising a member movable with said coil and having a surface representative of dissymmetry of said closed circuit with respect to said path for different positions of said coil, and a member controlled by said surface for varying said electrical means to maintain symmetry of said closed circuit with respect to said path for different positions of said coil.

20 6. Radio apparatus comprising a closed circuit including a movable coil absorbing radiant energy directly from a natural medium, a path, electrical means having a movable member for determining the degree of symmetry of said closed circuit with respect to said path, a cam movable by said coil having a surface representative of degrees of symmetry of said closed circuit with respect to said path, and a co-acting cam follower for actuating said movable member of said electrical means.

35 7. Radio apparatus comprising a closed circuit including a movable coil absorbing radiant energy directly from a natural medium, a path, complementarily variable impedances determining the degree of symmetry of said closed circuit with respect to said path, and means movable in response to change of position of said movable element to vary said impedances.

40 8. Radio apparatus comprising a closed circuit including a movable coil absorbing radiant energy directly from a natural medium, a path, complementarily variable capacities determining the degree of symmetry of said closed circuit with respect to said path, and means movable in response to change of position of said movable coil to vary said capacities to maintain symmetry of said closed circuit with respect to said path for different positions of said coil.

55 9. Radio apparatus comprising a closed circuit including a movable coil absorbing radiant energy directly from a natural medium, a path, complementarily variable capacities determining the degree of symmetry of said closed circuit with respect to said path, said capacities comprising fixed and movable armatures one of which is common to said capacities, a cam representative of degrees of dissymmetry of said closed circuit

with respect to said path for different positions of said coil, and a cam follower actuating said movable armature.

70 10. Radio apparatus comprising a closed circuit including a rotatable coil absorbing radiant energy directly from a natural medium, a rotatable shaft carrying said coil, a bearing scale, a pointer co-acting therewith and with said shaft, a path, complementarily variable capacities determining the degree of symmetry of said closed circuit with respect to said path, a housing enclosing said capacities, a cam on said shaft within said housing having a surface representative of dissymmetry of said closed circuit with respect to said path for different positions of said coil, and a co-acting cam follower effecting complementary variation of said capacities.

80 11. Radio apparatus comprising a closed circuit including a rotatable coil absorbing radiant energy directly from a natural medium, a shaft rotatable with said coil, a path, complementarily variable capacities for determining the degree of symmetry of said closed circuit with respect to said path, said capacities comprising a pivoted armature, stationary armatures disposed on opposite sides of said pivoted armature, a cam rotatable with said shaft and having a surface representative of degrees of dissymmetry of said closed circuit with respect to said path, and a cam follower for moving said pivoted armature.

100 12. In a radio compass, a rotatably mounted coil arranged to act as an absorbing device for receiving electromagnetic radiations, said coil being arranged near objects having material disturbing effect upon the electrical symmetry of the coil, and means operated in response to the rotation of the coil for electrically compensating the coil for this disturbing effect.

105 13. In a radio compass, a rotatably mounted coil arranged to act as an absorbing device for receiving electromagnetic radiations, said coil being arranged near metallic objects having material disturbing effect upon the electrical symmetry of the coil, a ground connection leading to the coil so that there are two paths leading from the coil to ground, a variable impedance device in each path, and means responsive to the movement of the coil for oppositely varying the impedance devices, whereby the disturbing effects are compensated.

120 14. In a radio compass, a rotatably mounted coil arranged to act as an absorbing device for receiving electromagnetic radiations, a ground connection leading to the coil so that there are two paths leading from the coil to ground, a variable condenser in each path, and means responsive to the movement of the coil for oppositely varying the condensers.

125 15. In a radio compass, a rotatably mounted coil arranged to act as an absorbing device

for receiving electromagnetic radiations, a ground connection leading to the coil so that there are two paths leading from the coil to ground, a variable impedance device in each path, and means responsive to the movement of the coil for oppositely varying the impedance devices, comprising a cam and a follower, said cam and follower being connected one to the variable impedance devices and the other to the coil.

16. In a radio compass, a rotatably mounted coil arranged to act as an absorbing device for receiving electro-magnetic radiations, a variable condenser in series with the coil for tuning it, a receiving circuit associated with said coil and condenser, a ground connection having a pair of branches, each leading to one of the coil terminals, a variable condenser in each branch, and means responsive to the movement of the coil for oppositely varying the condensers.

17. In a radio compass, a rotatably mounted coil arranged to act as an absorbing device for receiving electromagnetic radiations, a variable condenser in series with the coil for tuning it, a receiving circuit associated with this coil circuit, a ground connection having a pair of branches, each leading to one of the coil terminals, each of said branches having a stationary condenser plate, a movable condenser plate disposed between the two stationary ones and forming the junction point for the two branches to ground, and means responsive to the movement of the coil for moving the movable condenser plate.

18. In a radio compass, a rotatably mounted coil arranged to act as an absorbing device for receiving electromagnetic radiations, a receiving circuit associated with the coil, a variable impedance device arranged to affect the coil and the circuit, and means for varying said impedance device, comprising an adjustable cam connected to the coil, and a cam follower connected to the impedance device.

19. In a radio compass, a rotatably mounted coil arranged to act as an absorbing device for receiving electromagnetic radiations, a receiving circuit associated with the coil, a variable condenser having a stationary and a movable plate, for affecting the coil and the circuit, and means for moving the movable plate, comprising a cam formed of a resilient disc, means for adjusting the disc so that it can be warped at the edges to a desired degree, and a cam follower, said cam and follower being connected, one to the coil and the other to the movable plate.

20. In combination, a movable device the position of which affects its electrical condition, and means for compensating for the variation in the electrical condition, comprising a variable impedance device, a disc cam, means for distorting the disc cam near its edge, and a cam follower, said cam and fol-

lower being connected, one to the movable device and the other to the variable impedance device.

21. In combination, a movable device the position of which affects its electrical condition, and means for compensating for the variation in the electrical condition, comprising a variable condenser having a movable plate, a disc cam, means for distorting the disc cam near its edge, a cam follower, said cam and follower being connected, one to the movable device and the other to the movable plate, whereby said plate is moved in accordance with the movement of said movable device.

22. In a radio compass, a coil forming a loop absorbing device for electromagnetic radiations, a support rotatable about a vertical axis, for said coil, a variable condenser in series with the coil for forming a tuned circuit therewith, a receiving circuit connected to this loop circuit, a pair of oppositely disposed stationary condenser plates, connected respectively to the terminals of the coil, a plate movable between the two stationary plates and connected to ground, a flexible disc concentric with the rotatable support, a plurality of adjusting screws for distorting the disc near its edge, and a cam follower riding on the disc near its edge and connected to the movable plate so as to vary its position as the coil is rotated.

In testimony whereof I have hereunto affixed my signature this 19th day of May, 1925.

FREDERICK A. KOLSTER.