

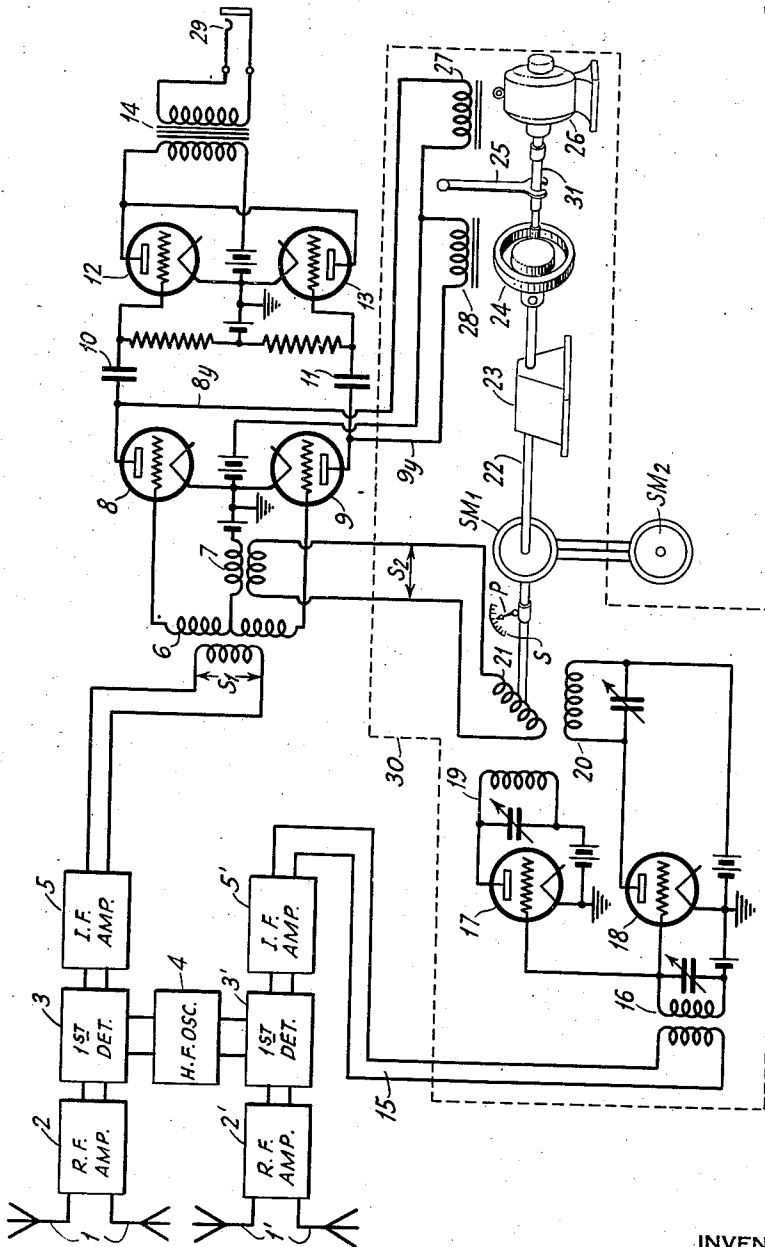
April 20, 1937.

M. G. CROSBY

2,077,401

DIRECTIVE CONTROL SYSTEM

Filed April 30, 1936



INVENTOR
MURRAY G. CROSBY
BY *H.S. Hoover*
ATTORNEY

UNITED STATES PATENT OFFICE

2,077,401

DIRECTIVE CONTROL SYSTEM

Murray G. Crosby, Riverhead, N. Y., assignor to
Radio Corporation of America, a corporation of
Delaware

Application April 30, 1936, Serial No. 77,138

6 Claims. (Cl. 172—282)

This invention relates to directive control systems and more particularly to a radio receiving system which is provided with a plurality of antennae on which energy from a radio beacon may be simultaneously received.

This application is a continuation in part of my co-pending application, Serial Number 727,931, which was filed on May 28, 1934, patented June 2, 1936, No. 2,042,831.

It is an object of my invention to provide means for diversity reception of signals on an array of antenna systems.

It is another object of my invention to so combine the energies of radio signals when received upon different antennae that the output of a receiving system may be utilized in various ways.

A further and more specific object is to provide a system wherein the phase relation of currents derived from a diversity antenna system are maintained at a constant value so that currents derived from the antennae may be combined as though the phase of each antenna remained constant.

In the invention herein described means are provided for combining the R. F. or I. F. energies in a diversity system so that the system, instead of having a directivity equivalent to that of a single antenna, has a directivity equivalent to a combination of all of the antennae. The phases of the energies from each antenna are automatically controlled so that the phase of combination is always proper. Hence, a super-directive system is obtained.

A further advantage of the system herein described is that it may be utilized to effect a directive system which automatically changes its directivity in accordance with the changes in the bearing of the signal. Thus, as the signal comes in from different directions the antenna system automatically "follows" it. Such a system would be valuable where atmospheric conditions change the apparent direction of the source of signal and where communication is with mobile conveyances wherein the direction of the signal source is actually changing.

Other objects, features and advantages of my present invention will become self evident as the more detailed description thereof proceeds.

In the accompanying drawing I have shown as the sole figure thereof a circuit diagram of a diversity receiving system wherein a phase shifting device is embodied.

In the figure the two heterodyne receivers 2, 3 and 5 and 2', 3' and 5' are fed by diversity antennae 1 and 1'. The high frequency oscil-

lator 4 furnishes beating energy for both receivers so that the intermediate frequency of both receivers will be the same. The output of one I. F. amplifier is fed directly to anti-phasal transformer 6 of differential detectors 8 and 9. The output of the other I. F. amplifier is fed to co-phasal transformer 7 of the differential detectors via the automatic phase shifting unit in the dotted line enclosure 30. The energy from I. F. amplifier 5' is fed via line 15 to transformer 16. Transformer 16 feeds coupling tubes 17 and 18 having tuned circuits 19 and 20 in their plate circuits. The tunings of 19 and 20 are adjusted so that their voltages, induced in coupling coil 21, are 90 degrees out of phase, thus effecting a phase shifter.

Coil 21, which feeds transformer 7, is mounted on shaft 22 in bearing 23. On the other end of shaft 22 is a friction drive wheel 24 circularly slotted so that flexible drive shaft 31, driven by motor 26, rotates wheel 24 in a forward direction when drive shaft 31 engages one side of the slot, and in a reverse direction on the other side of the slot. (For a more complete description of this type of drive see D. R. Goddard application Serial Number 11,915, filed March 20, 1935.)

Rectified I. F. energy from detectors 8 and 9 operates solenoids 27 and 28 to move armature 25. Arm 25 is pivoted at one end and is provided with a forked bearing at the other end for engagement with the shaft 31 so as to reversibly operate a clutch mechanism associated therewith. An unbalance of currents in solenoids 27 and 28 causes armature 25 to shift shaft 31 to the forward or reverse engagement with wheel 24.

Rectified audio frequency energy is obtained from detectors 8 and 9 via blocking condensers 10 and 11 to coupling or amplifier tubes 12 and 13. The combined A. F. output is obtained from jack 29 and transformer 14.

The automatic phase control obtains its controlling energy from the differential detectors such as 8 and 9 of the figure. These differential detectors are fed co-phasally by one of the signal or signal intermediate frequencies and anti-phasally by the other. As long as the two signals are 90 degrees out of phase the plate currents of the detectors 8 and 9 are balanced and no differential voltage is passed on to operate the controlling circuits. As soon as the relative phase of the two signals deviates from 90 degrees, the detector plate currents are unbalanced and a differential voltage operates the controlling circuits to correct the phase relation to 90 degrees.

The system illustrated may be used for direction finding by, for example, associating with shaft 22 a pointer P movable angularly with shaft 22, and a relatively stationary scale S. The antennae I and I' for this purpose should be spaced or be two directional arrays of antennae. With such an arrangement, the pointer P would indicate on the scale the phase relation between the waves picked up upon I with respect to I'. By having previously calibrated the scale when in harbor, say, on known directions of several known transmitting stations, then, when at sea, deviation from the calibration would give deviation from the course.

If desired, by means of the Selsyn motors SM1, whose armature coincides with shaft 22, and SM2 operating steering mechanism, guidance or steering of a ship may be made automatic.

It will be seen from the above description that my invention has utility, for example, in the automatic steering of a boat or airplane. In this case the antennae I and I' may be spaced on a line at right angles to the direction of travel. The Selsyn motors SM1 and SM2 may be coupled to the rudder. The coil 21 may be mounted on the shaft 22 so that when the vessel is head-on to the radio beacon the phase difference between the voltages in the lines S1 and S2 will be 90 degrees and the detector currents will then be balanced. Under this condition the clutch arm 25 is disengaged and the shaft 22 will remain stationary.

Assuming now that the vessel becomes misdirected, one antenna will receive the incoming energy slightly before the other antenna so that a phase difference will be introduced between the voltages of the lines S1 and S2. This phase difference will unbalance the detector currents so that the clutch 25 will be impelled either by the magnet 27 or the magnet 28 to engage the disc 24 with the end of the shaft 31. Rotation will then be imparted to the shaft 22 in a suitable direction to adjust the rudder by means of the Selsyn motors SM1 and SM2. This operation will restore the vessel to its direction head-on with respect to the radio beacon. As soon as this steering operation has been completed the clutch arm 25 will again be disengaged by the balancing of the detector currents.

In place of the Selsyn motor arrangement for coupling shaft 22 to the rudder, this shaft may, if desired, be directly geared to the rudder control mechanism.

Another advantage to be derived from my invention may be seen if the shaft 22 is caused to control any suitable indicating device such as the arrangement of scale S and pointer P for direction finding purposes. This arrangement does not require the manual adjustment of a loop antenna which has heretofore been used. On the other hand, the direction finder is seen to be a direct reading instrument showing left and right digressions of the vessel from its course.

Other arrangements and embodiments of my invention will readily occur to those skilled in the art. It is, therefore, to be understood that the scope of the invention is limited only by the claims themselves.

I claim:

1. In a directive control system, a radio receiver having two aerials spaced apart, means in said receiver for combining the energies collected by said aerials, means operable in dependence

upon the phase relationship between the energies collected by said aerials for introducing phase compensation into the energy combining means, and steering apparatus operable under control of the phase compensating means.

2. A radio receiving and directive control system for use on board mobile craft, said system having two aerials spaced apart and symmetrically mounted on opposite sides of said craft so that when the craft follows a course directly toward or away from a source of signals the energy of said signals as collected by said aerials will be in phase agreement, means for monitoring the phase relation between the signals collected by said aerials and steering means operable under control of the monitoring means to maintain said craft on said course.

3. In a navigating system, the method of steering a vessel along a course which is defined by the direction of propagation of radiant energy signals which comprises the steps of collecting the energy at separated points on an axis transverse to the longitudinal axis of the vessel, differentially detecting and combining the energy of said signals, applying phase correction to said signals, and causing the vessel to be steered under control of the phase-correcting action.

4. In a navigating system of the type wherein the steering apparatus of a vessel is controlled by existing differences of phase between two alternating voltages, the method of linking together a phase correcting operation and a steering operation which comprises differentially detecting and combining the energy of said alternating voltages, producing a one-way response when the first of said voltages has a phase lead over the second, producing a one way response opposed to the response first mentioned, when the first of said voltages has a lag behind the second, and causing said response to be effective to compensate for the phase difference between the voltages and simultaneously to cause a readjustment of the steering apparatus in a direction suitable for maintaining said vessel on a course such as is defined by the direction of propagation of radiant energy signals producing said voltages.

5. In a system for steering a craft along a predetermined course, the method which comprises propagating radiant energy signals from a point in the general direction of travel in which the craft is to be steered, collecting the energy at separate points aboard the craft, spaced on a line at right angles to said direction of travel, differentially detecting and combining the energies of said signals, deriving currents which vary in accordance with phase differences between the energies of said signals as collected at said separate points, and steering the craft in accordance with the derived currents.

6. Apparatus for steering a craft along a predetermined course defined by radiant energy signals propagated from a point in the general direction of travel in which the craft is to be steered, comprising a pair of energy collectors mounted on board said craft and spaced on a line at right angles to said direction of travel, means for differentially detecting and combining the energies of said signals as collected by said pair of collectors, means for differentiating between the respective phases of said energies, and steering apparatus responsive to the action of the phase differentiating means.

MURRAY G. CROSBY.