

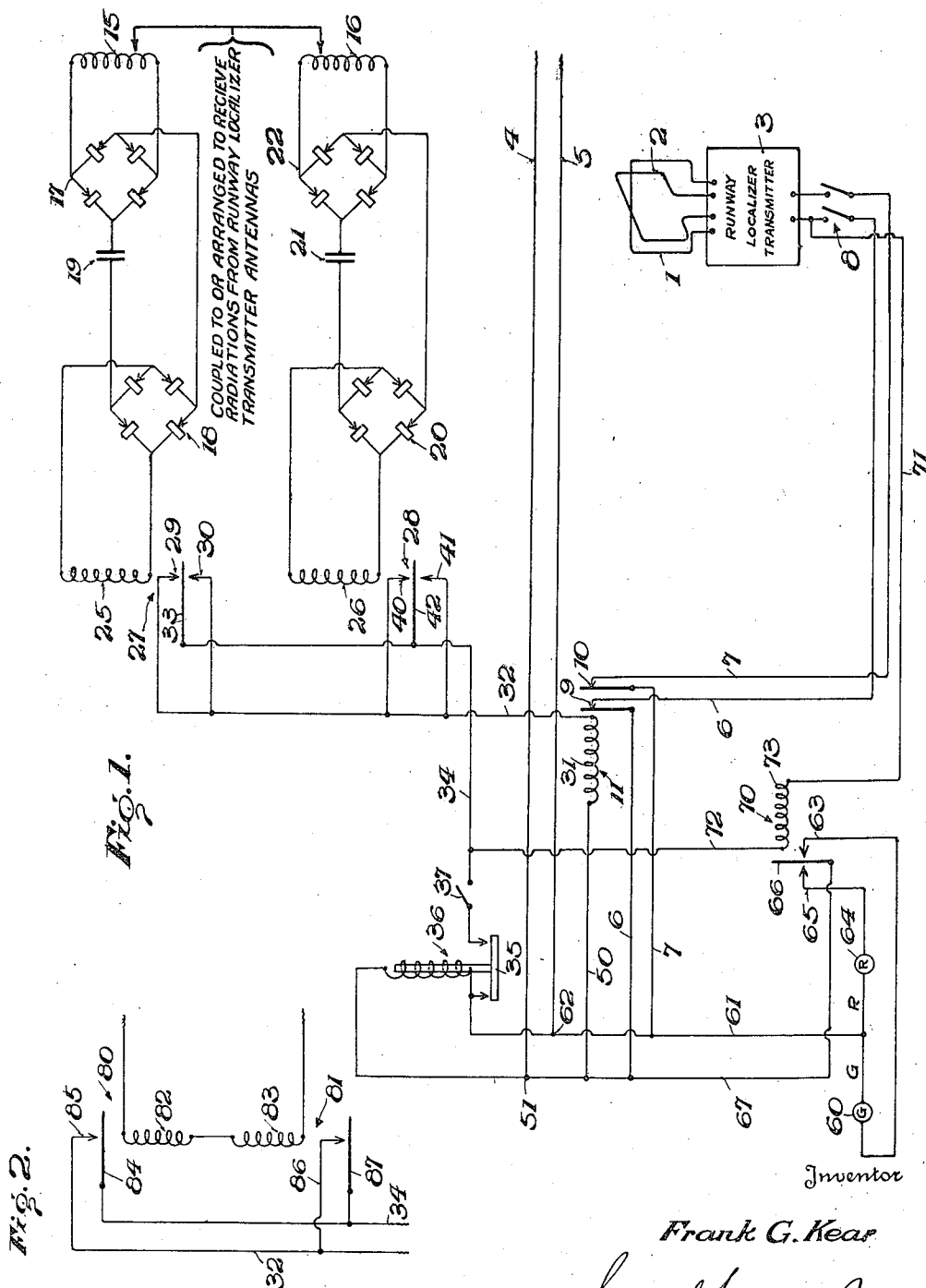
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CONTROL SYSTEM FOR RADIO BEACON

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## CONTROL SYSTEM FOR RADIO BEACONS

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This invention relates generally to the control of radio beacons of the type employing a plurality of intersecting characteristically modulated radiated fields, the area of intersection of which defines a zone in which the modulations impressed on the radiated carrier are of equal amplitude. This equi-signal zone, which may be identified by observing the respective amplitudes of the characteristic modulations over the area covered by the radiated fields, is directional in character and, being generally elongated and relatively narrow, may be employed as a directional guide or beacon for guiding mobile stations toward or away from the transmitting station. Continuous characteristic modulations may be impressed on the two carriers in the manner and for the result first disclosed by T. E. Brockstedt in Patent No. 1,865,826, which type of characteristic signal is preferable if a visual indication in the mobile station is desired.

It will be apparent, from a consideration of the method of establishing the beacon that the maintenance of a pre-determined directional characteristic thereof is dependent upon the maintenance of a pre-determined relationship between the two overlapping radiated fields. If both of the radiated fields change their positions in space, it will be apparent that the spatial position of the equi-signal zone will be changed. Further, if one of the radiated fields changes its position in space with respect to the other radiated field, the equi-signal zone will become either wider or narrower, depending upon the direction of the shift of the varying field. In either case the position of the real equi-signal zone will be changed and, if the equi-signal zone had been previously aligned with a particular airport runway, will be moved from such alignment, thereby providing an incorrect path for the runway involved.

It has been found that the spatial and directional characteristics of the radiation from a given antenna are dependent upon and a function of the current flowing in the antenna. Accordingly, the spatial and directional characteristics of the equi-signal zone defined by the overlapping radiations from a plurality of antennas will be varied by increase or decrease in the current in any one of the antennas. This effect is employed by the present invention as a means for monitoring and controlling the operation of a radio beacon transmitting means.

While the invention is intended to provide control means for directional radio beacons generally, it is of particular use and adaptability when

such a beacon forms part of a radio landing system. It has heretofore been proposed and is known to employ a radio beacon of the type described as a guide for landing aircraft. In such a use of the beacon, the transmitter therefor is arranged on or adjacent to, either above or below, the surface of the ground, and is so placed with reference to a runway of the airport that the directional equi-signal zone defined by the overlapping radiations therefrom is aligned with the runway. The pilot of an aircraft which is to be landed on the airport may, by proper interpretation of the instrument indications of the radiated fields of the beacon, guide the aircraft along or in line with the runway. Such a landing system preferably employs other co-operating means for bringing the craft to earth, such as the curved landing beam and the marker beacons, and such landing beams or marker beacons may be controlled within the broad scope of the invention.

It will be apparent that the runway beacon, providing as it does the sole directional guide for a landing aircraft in conditions of low or no visibility, must provide a correct path which is aligned with the proper runway in order to be of material assistance to a pilot attempting to land on an airport. It will be apparent that if the directional characteristic of the beacon is such that it will cause the aircraft to fly over or land along any other than a pre-determined path, the danger to persons carried by the landing aircraft may be very great.

It is, accordingly, an object of the present invention to provide means for controlling the operation of the runway localizing beacon of a radio landing system in such a manner that if the directional characteristics of the beacon vary from pre-determined settings, the transmitting means establishing the beacon will be de-energized. In a landing system provided with means according to the present invention, the runway localizing beacon will, whenever operating, conform to pre-determined directional and spatial characteristics and, if these are departed from, the beacon will be de-energized in order to prevent the establishment of an incorrect path in space.

In the absence of some means according to the present invention, the operator of the transmitting station will not be appraised of the fact that the directional beacon has shifted and is so disposed as to cause a landing aircraft to fly over an incorrect course or to land along a path which may not be cleared of obstructions. It is therefore of primary importance that a proper landing sys-

tem provide means for indicating to the operator of the transmitting station of the system the fact that the directional beacon is operating in a proper and pre-determined manner and is therefore in such a position as to provide a proper path for a landing aircraft. Inasmuch as the operator of the ground station is constantly informed, by means according to the present invention, of the proper operation or de-energization of the runway localizer beacon, he may transmit such information to the pilot of a landing aircraft in order that the pilot may be fully apprised of the condition of operation of the landing system.

It is therefore an object of the invention to provide means at the transmitting station, or at any remote control station, for indicating by aural or visual means, the condition of energization or de-energization of the transmitting means. In view of the fact that a transmitting station provided with the present invention will operate only when the beacon established thereby adheres to pre-determined spatial and directional characteristics, it will be seen that an indication at the ground station or in the aircraft that the transmitting means is operating will insure to the operator or observer that it is operating in a proper, predetermined manner.

Other objects and features of novelty of the invention will be made apparent by the following description and the appended drawing, it being expressly understood however that such description and drawing are merely illustrative of the invention, for the limits of which reference must be had to the appended claims.

Referring to the drawing, in which similar reference numerals refer to like parts,

Fig. 1 is a circuit diagram disclosing the present invention, and

Fig. 2 is a circuit diagram disclosing a modified form of certain elements of the system illustrated in Fig. 1.

The present invention provides means for controlling the operation of a radio beacon, of the type known as the equi-signal beacon, in such a manner that if the beacon established departs from pre-determined spatial and directional characteristics the transmitters establishing the beacon will be de-energized and this condition of de-energization will be made known to the operator of the ground station by aural or visual signals.

The equi-signal beacon which is controlled by the present invention, is defined by the intersecting or overlapping area of the directional radiations from two antenna systems 1, 2, which may be loop antennas or any other directional type. Each of these antennas is supplied, by a transmitter 3, with characteristically modulated carrier. As stated hereinbefore the characteristic modulations are continuous signals of different audio frequencies.

The transmitter 3 is supplied with electrical energy from main power supply lines 4, 5 through leads 6, 7, in which is inserted the manually operable switch 8, whereby the transmitter may be disconnected from the source of power as desired. The leads 6, 7 also include, respectively the contacts 9, 10 of a relay 11, each of which comprises a fixed contact member and a movable contact member. Both of the movable contact members are controlled by the relay in such a manner that during the normal condition of de-energization of the relay the switches 9, 10 will remain closed. As will be described more fully hereinafter the

relay 11 will be de-energized during proper operation of the transmitter in a predetermined manner, but will be energized to open the switches 9, 10 and disconnect the transmitter 3 from the source of power when the directional characteristics of the beacon established by antennas 1, 2 vary from pre-determined characteristics.

Means provided by the present invention for controlling the operation of the relay 11 and thereby controlling the connection of the transmitter 3 to the source of power. Such means comprise the coils 15, 16 which respectively receive the radiations from the transmitting antennas 1, 2. The coils 15, 16 are preferably arranged locally with respect to the transmitting antennas 1, 2 and are preferably inductively coupled thereto.

If desired, metallic plates may be substituted for the coils 15, 16 and may be capacitatively coupled to the transmitting antennas, or antennas arranged locally with respect to the transmitting antennas may be employed in place of the coils 15, 16, all without departing from the scope of the invention.

The coil or antenna 15 may be arranged to receive principally the radiations from transmitting antenna 1 and is therefore preferably arranged substantially in the direction of maximum radiation from that antenna and in the direction of minimum radiation from antenna 2. Conversely, coil or antenna 16 may be arranged substantially in the direction of maximum radiation from antenna 2 and in the direction of minimum radiation from antenna 1.

Regardless of the spacing or coupling between coils 15, 16 and antennas 1, 2, the currents induced in coils 15, 16 will be respectively proportional to the currents flowing in antennas 1, 2. As stated hereinbefore, the spatial and directional characteristics of the radiations from antennas 1, 2 are functions of the current flowing in antennas 1, 2 and of the amplitude of the carrier radiated by those antennas. The strength of the currents induced in coils 15, 16 will therefore lie between certain pre-determined limits so long as the currents in antennas 1, 2 lie within pre-determined limits and therefore so long as the radiations from antennas 1, 2 adhere to pre-determined spatial and directional characteristics.

The received current in the coil 15, which is arranged to receive principally the radiations from antenna 1 consists of the radiated carrier together with the characteristic modulation impressed thereon. The current in coil 16, which is so arranged to have induced therein principally the radiations from antenna 2, consists principally of the radiated carrier and the characteristic modulation radiated by antenna 2.

The current flowing in coil 15 due to the current flowing in antenna 1 is rectified by means of a rectifier, the oxide rectifier 17 being preferably employed. The output of the rectifier 17 consists of a direct current component and an audio frequency current component, the latter being due to the modulation of the carrier in the source 1, and this current is delivered to a second rectifier 18, a condenser 19 being inserted in the circuit leading to rectifier 17 in order to remove the direct current component of the output of rectifier 17. The audio frequency delivered to rectifier 18 is rectified thereby and the output of rectifier 18 is therefore a direct current which is proportional in strength to the amplitude of the current flowing in transmitting antenna 1 and

the strength of which will therefore lie between pre-determined limits so long as the pre-determined directional characteristics of the radiations from antenna 1 are adhered to.

The current induced in coil 16 by the current flowing in transmitting antenna 2 is rectified and filtered, in the same manner as described above, by means of rectifiers 20 and 22 and condenser 21. The output of the second rectifier 20 will therefore be a direct current which will be proportional in value to the amplitude of the current flowing in transmitting antenna 2 and the value of which will lie between pre-determined limits so long as the pre-determined directional characteristics of the radiation from antenna 2 are maintained.

The output terminals of rectifiers 18 and 20 are respectively connected to coils 25, 26 which, respectively, form parts of relays denoted generally at 27, 28. The relay 27 includes the two fixed spaced contacts 29, 30 which are both connected to one terminal of the solenoid winding 31 of relay 11 by lead 32 and the movable contact 33 which is connected to main power supply line 5 through lead 34 and the armature 35 of time delay relay 36. The relay 28, which is controlled by coil 26, includes the fixed, spaced contact members 40, 41, which are connected by lead 32 to the one terminal of winding 31 of relay 11, the other terminal of which is connected by lead 50 to main power supply line 4 at point 51. Between the fixed contacts 40, 41 and movable into engagement with either is arranged the movable contact member 42 which is connected by lead 34 and armature 35 of time delay relay 36 to main power supply line 5.

The movable contact members 33, 42 are normally maintained out of engagement with fixed contacts 30, 41, respectively, by action of the current in coils 25, 26 respectively. Means such as springs, are provided however, for moving the movable contacts into engagement with fixed contacts 30, 41 when the currents in either of coils 30, 41 decreases below a pre-determined value.

The movable contact members 33, 42 are maintained out of engagement with the fixed contact members 29, 40, respectively, by some means, such as springs, but are adapted to be moved into engagement with such fixed contact members by the action of the current in the coils 25, 26 when such current increases above pre-determined limits, which will be sufficient to overcome the force of the springs or other means tending to hold the fixed and movable contact members apart.

It will be apparent from the above description that movement of either of the movable contact members 33 or 42 of the relays 25, 26 respectively, into engagement with any one of the fixed contact members 29, 30, 40, 41 will cause winding 31 of relay 11 to be connected across the main power supply lines 4, 5 through lead 50, winding 31, lead 32, either of contacts 29, 30, 40 or 41, either of movable contacts 33, or 42, lead 34 and armature 35 of time delay relay 36, thereby energizing the relay 11 and opening the switches 9, 10 to disconnect the transmitter 3 from the source of power.

The winding of the time-delay relay 36 is connected directly across the main power supply lines 4, 5 and such relay is accordingly supplied with electric energy as soon as the power supply lines are connected to a source of electric energy. It will be apparent that the transmitter 3 will be

connected to the source of power immediately upon energization of the power supply lines 4, 5. On the contrary, the monitor system is not rendered operative until the time-delay relay closes, which will occur after a pre-determined interval following the connection of the main power supply lines to a source of electric energy. A switch 37 is provided in lead 34 which may be opened to disconnect the monitor system from other parts of the system.

Means are provided by the invention for indicating to the operator of the transmitting station, or at any remote control point, the condition of energization or de-energization of the transmitter 3. Such means comprise the signal 60 which may be of any aural or visual type, but which is preferably a green signal light, which is adapted to be energized when the transmitter 3 is energized and supplying energy to antennas 1, 2. One terminal of the signal 60 is connected by lead 61 to main power supply line 5 at point 62, while the second terminal of the signal is connected to a fixed contact member 63. A second signal 64 is provided which may also be of any desired aural or visual type, but which is preferably a red visual signal which is operated by operation of the monitor system to provide an indication that the transmitter 3 is deenergized or that the monitor system has not yet begun to function. One terminal of the signal 64 is connected to main power supply line 5 at terminal 62 through lead 61, while the other terminal of the signal is connected to a fixed contact member 65 which is disposed adjacent to but spaced from the fixed contact 63. Disposed between and movable into engagement with either of the fixed contacts 63, 65 is a movable contact member 66 which is connected to main power supply line 4 at terminal 51 through lead 67. It will be apparent that if movable contact member 66 is moved into engagement with fixed contact 63 a circuit will be established from main power supply line 4 through lead 67, movable contact 66, fixed contact 63, green signal 60 and lead 61 to main power supply line 5, thereby energizing green signal 60 to indicate that the transmitter 3 is operating in a proper and pre-determined manner. If the movable contact 66 is moved into engagement with fixed contact member 65, a circuit will be established from main power supply line 4 through lead 67, movable contact 66, fixed contact 65, red signal 64 and lead 61 to main power supply line 5, thereby energizing the red signal 64 to thereby indicate that the transmitter 3 is de-energized.

The contact members 63, 65 and 66 form a part of a relay denoted generally at 70. This relay is so constructed and adjusted that the movable contact member 66 thereof is normally in engagement with the fixed contact 65, thereby establishing a circuit through the red signal 60.

Means are provided by the invention for controlling the movement of the movable contact member 66 so that the same will move in a manner to provide an indication of the condition of operation of the transmitter 3. Such means comprises the winding or solenoid 73 which forms part of the relay 70 and which controls the movement of the movable contact member 66. One terminal of the solenoid 73 is connected to main power supply line 4 through lead 71, switch 8, lead 6, switch 9 and lead 6, while the other terminal of the winding is connected to main power supply line 5 through lead 72 and armature 35 of time-delay relay 36. The relay 70 is so con-

structured and adjusted that when the solenoid 73 is energized, the movable contact member 66 will be moved into engagement with the fixed contact 63, thereby completing the circuit through the green signal 60 and energizing the same to indicate that the transmitter 3 is operating properly and that the monitor system is functioning. The circuit through solenoid 73 will be completed after operation of the time-delay relay 36 and after connection of the transmitter 3 to the source of power, and such circuit will be maintained closed so long as the switch 8 and the relay contacts 9 and 10 are closed. When, however, for any cause, the switch 8 is manually opened, or the relay contacts 9, 10 are automatically opened by operation of either of relays 27, 28, the circuit through winding 73 will be broken and the relay 70 will be deenergized to thereby cause the movable contact member 66 to engage fixed contact 65 and thereby energize the red signal 64.

In the operation of the monitoring and signaling system described, the main power supply lines 4, 5 may be connected to a source of power by means of a linestarter switch. The relay contacts 9, 10 are normally closed and if the manual switch 8 is closed current will be supplied to transmitter 3. The transmitter supplies to each of the antennas 1, 2 characteristically modulated current at radio frequency, and the antennas each radiate the modulated carrier, the directional radiation fields of the two antennas being such as to overlap in space to provide an equi-signal zone which may be aligned as desired. The coils 15, 16, being locally arranged with respect to the antennas 1, 2, will each respectively have induced therein currents corresponding to the radiations from one of the transmitting antennas. Current thereby induced in each of the coils is rectified and filtered to provide two direct currents, one in each of the coils or solenoids 25, 26 which operate the relays 27, 28.

The directional characteristics and the spatial positions of the fields radiated by antennas 1, 2, and consequently the position and directional characteristics of the equi-signal zone, are functions of the current flowing in antennas 1, 2. The currents flowing in coils 25, 26 are proportional to the currents induced in coils 15, 16 and are also proportional to the currents flowing in antennas 1, 2 respectively. Accordingly, so long as the pre-determined directional characteristics and spatial disposition of the fields radiated by antennas 1, 2 are maintained, the currents flowing in windings 25, 26 will remain within pre-determined limits.

The relays 27, 28 are so adjusted and arranged that so long as the currents in coils 25, 26 remain within the pre-determined limits which define the proper operation of the transmitting system, the movable contact members 33, 42 will remain out of engagement with the fixed contact members 29, 30, 40, 41. When, however, the current in either coil decreases below a pre-determined value, denoting that the current in the corresponding one of the transmitting antennas has decreased and that the radiation therefrom has varied outside of pre-determined limits, the movable contact member of the affected relay will be moved by some means such as a spring, into engagement with the corresponding fixed contact member of the relay. If the current in either of coils 25, 26 increases above pre-determined limits, the movable contact member of the affected relay will be moved by the affected sole-

noid into engagement with the corresponding fixed contact member of the relay.

Regardless of whether the movable contact member is operated by increase or decrease of current in coil 25 or 26, any movement of either movable contact member into engagement with either of its associated fixed contact members will cause a circuit to be completed through winding 31 of relay 11, thereby energizing such relay and opening the relay contacts 9, 10 to disconnect the transmitter 3 from the source of power.

When the linestarter switch is closed to connect the main power supply lines to a source of power, the transmitter 3 will be immediately energized and, due to the fact that the movable contact 66 of the signal control relay 70 is normally in engagement with fixed contact 65, a circuit will be established through the red signal 64, thereby energizing this signal and indicating to the operator that the monitor system is not yet in operation. It will be seen that the circuit through winding 73 of relay 70 is open at this time due to the fact that the time-delay relay 36 has not yet closed.

The winding of the time-delay relay 36 is connected directly across the main power supply lines and, accordingly, after a pre-determined interval following the connection of the main power supply lines to a source of power, the time-delay relay will close, thereby completing the circuit through winding 73 of signal control relay 70 and also connecting the movable contacts 33 and 42 of relays 27, 28 to main power supply line 5. The monitoring system is now in condition to function and upon energization of the relay 70 by operation of the time-delay relay 36, the movable contact member 66 of signal control relay 70 is moved into engagement with contact 63, thereby de-energizing the red signal 60 and energizing the green signal 64 to indicate to the operator that the transmitter is energized and that the monitoring system is operating to properly control the operation of the transmitter.

So long as the transmitter 3 is operating properly and so long as the radiated fields maintain pre-determined spatial dispositions and directional characteristics the operation will be uninterrupted and the green signal 60 will remain energized. If the relay 11 is operated or if the manual switch 8 is opened, the transmitter 3 will be de-energized and the circuit through winding 73 of relay 70 will be broken, thereby causing the circuit through the green signal 60 to be broken and the red signal to be energized, indicating to the operator that the transmitter is de-energized. This information may be transmitted to an incoming aircraft by radiophone in order to provide the pilot thereof with proper information to enable him to land.

It will be seen that if the modulation is removed from the carrier in either of antennas 1, 2 the corresponding relay 27 or 28 of Fig. 1 or 80 or 81 of Fig. 2 will be operated thereby de-energizing the transmitter. This effect will be due to the presence of the condensers 19, 21 in the output circuits of the rectifiers 17 and 22, respectively, which eliminate the direct current output of the rectifiers 17, 22 due to the unmodulated carrier.

In Fig. 2 of the drawing there is disclosed a modified arrangement of certain features of the invention. In this modification there is disclosed a different form of relay means, which modified form may be employed in place of either of the relays 27, 28 of Fig. 1. In Fig. 2 there are dis-

closed the relays 80, 81, the coils 82, 83 of which are connected to the output terminals of a rectifier which corresponds in function to the rectifier 18 of Fig. 1. The winding 82 is adapted to control the movable contact member 84 which is normally held out of engagement with a fixed contact 85 by the action of current in coil 82, but which is adapted to be moved into engagement with the fixed contact member by some means, such as a spring, upon decrease of the current in coil 82 below a pre-determined limit. The second coil 83 of the relay 80 controls the operation of a second movable contact member 87 which is normally held out of engagement with fixed contact member 86 by some means, such as a spring, and which is adapted to be moved into engagement with the fixed contact member by increase of the current in coil 83 above a pre-determined limit.

While I have illustrated and described certain embodiments of my invention, it will be apparent to those skilled in the art that numerous variations, embodiments and improvements may be made therein without departing in any way from the scope of the invention, for the limits of which reference must be had to the appended claims.

I claim:

1. A control means for a radio transmitting system which comprises transmitting means adapted to establish a plurality of radiated fields, a source of power and means operable to connect said transmitting means to a source of power, said control means comprising a plurality of energy collecting means each of which is disposed within one of said fields, means for pro-

ducing from each received radiation a current which is proportional in strength at all times to the strength of the radiation producing it, and separate means each continuously controlled by one of said produced currents and operable thereby to maintain the connection between the transmitting means and the source of power and operable in response to increase or decrease of the controlling produced current from predetermined upper and lower limits to cause the operation of said connecting means to disconnect the transmitting means from the source of power.

2. A radio system comprising transmitting means adapted to establish a plurality of radiated fields, a source of power, means operable to connect said transmitting means to said source of power, a plurality of energy receiving means each of which is positioned in one of said radiated fields and adapted to receive the radiations establishing such field, means for producing from each received radiation a direct current which is proportional in strength at all times to the strength of the radiated field from which it is produced, and separate control means each continuously controlled by one of said produced direct currents and operable thereby to maintain the connection between the transmitting means and the source of power and operable in response to any increase or decrease of the controlling current from predetermined upper and lower limits to cause the operation of said connecting means to disconnect the transmitting means from the source of power.

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