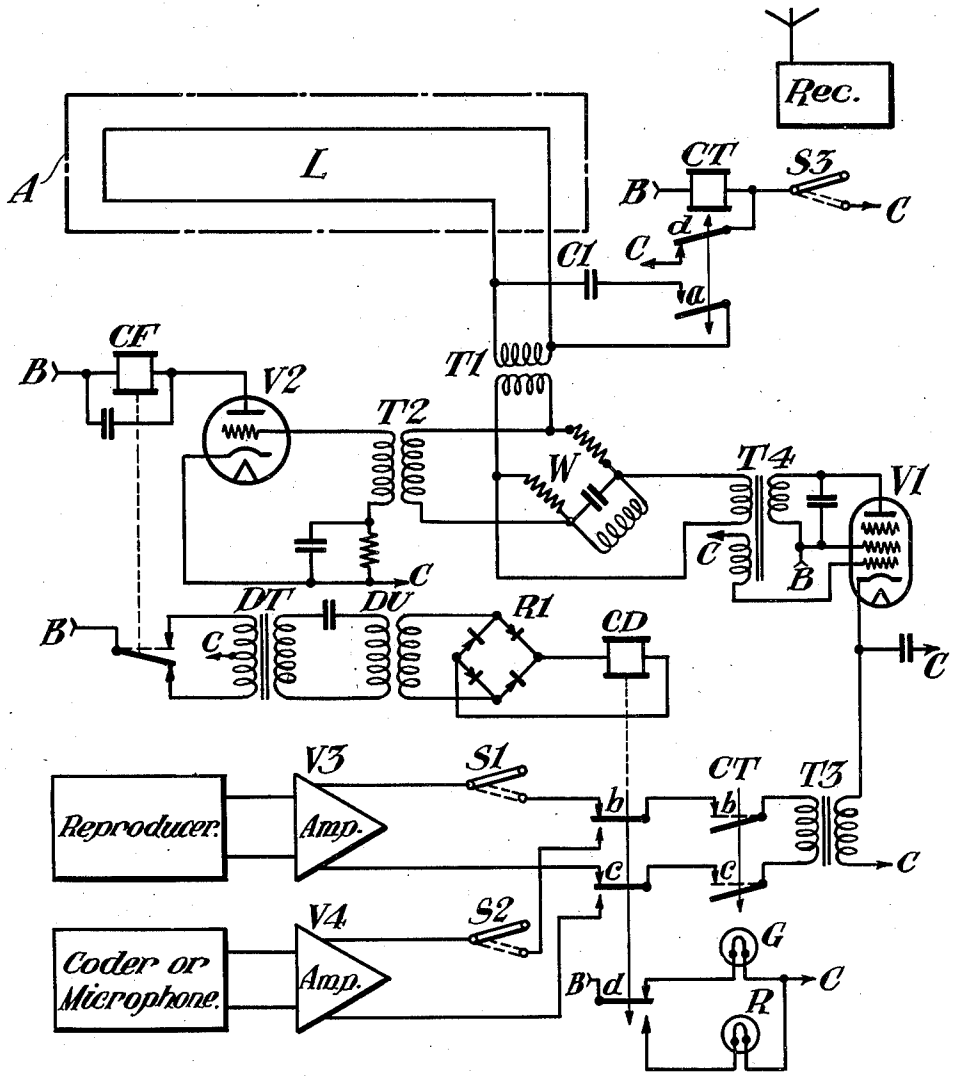
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PROXIMITY COMMUNICATION SYSTEM WITH WHEATSTONE BRIDGE DETECTOR

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PROXIMITY COMMUNICATION SYSTEM WITH WHEATSTONE BRIDGE DETECTOR

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My invention relates to traffic controlling apparatus, and more particularly to improved proximity detecting apparatus of the electronic type for the detection of the presence of a vehicle or airplane on the ground in a protected area, such as an airport zone, which apparatus provides means for communication between the vehicle or airplane and a control tower.

My invention is an improvement upon that disclosed in my prior application for Letters Patent of the United States, Serial No. 625,561, filed October 30, 1945, for Railway traffic controlling apparatus, and comprises a system for enabling the presence of a vehicle or other movable object in a stretch of roadway or in an airport area to be reliably detected without reliance upon physical contact with the earth, which embodies the closed circuit principle of operation and is thus suitable for use in indicating traffic conditions or for controlling traffic in a manner analogous to the control of railway traffic by means of track circuits.

The principal object of my invention is the provision in a proximity detecting system of this character of facilities for communication by voice or code with a vehicle or airplane approaching or occupying the protected area or for the control of indication means on the vehicle or airplane from a central office or control tower.

A particular object of the present invention is the provision of means for enabling the detecting system to transmit information to the pilot of an airplane approaching an airfield whereby the particular zone within which he is to land may be identified and its condition of occupancy indicated.

A further object of my invention is to enable a vehicle or airplane on the ground which has entered the protected area to be communicated with for identifying its location in the event of poor visibility or to enable its further movement to be directed from the control tower.

A feature of my invention is that the communication means referred to functions in such a manner that the operation of the detecting relay which results when an airplane or vehicle enters an unoccupied protected area is indicated on the airplane or vehicle.

A further feature of my invention is that the communication facilities are so arranged as to not impair the sensitivity of the proximity detecting system.

I shall describe one form of apparatus embodying my invention and shall then point out the novel features thereof in claims.

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In the accompanying drawing, the reference character L designates a conductor comprising a loop of insulated wire adjacent to and surrounding the major portion of a protected area or space A, so disposed that when supplied with alternating current it creates a magnetic field which is subject to a detachable variation in the presence of a vehicle or of an airplane on the ground within the perimeter of the space A as indicated by the broken line. The loop L is connected through a suitable transformer T1 to a Wheatstone bridge W, the input terminals of which are supplied with alternating current of a fixed frequency such, for example, as 50 kilocycles per second, by an electronic oscillator comprising a transformer T4 and an electron tube V1 energized over connections to the positive or supply terminal B and the negative or ground terminal C of a suitable local source of current. The output terminals of the bridge are connected through a transformer T2 to the input circuit of a detector tube V2 which tube is energized over connections to terminals B and C of the local source, and has a sensitive relay CF included in its plate circuit. Relay CF is in this manner maintained energized as long as the bridge is unbalanced.

To obtain a balance, the bridge arms are so proportioned that when the loop L is energized but unoccupied, its impedance is matched by a balancing impedance so as to reduce the potential across the output terminals of the bridge substantially to zero, tube V2 being so biased that this reduces the current through relay CR correspondingly so that relay CF releases.

Since this balanced condition corresponds to the safety condition of the system, means are provided for making the indication of the balanced condition of the bridge dependent upon a distinctive mode of energization of relay CF in order to conform with the closed circuit principle of operation which is a necessary requisite for traffic control systems. This is accomplished by the provision of a code transmitter relay CT, of the pendulum type or the like, which is energized from terminals B and C of the local source and opens its contacts periodically for brief periods at a fixed low rate. Contact *a* of relay CT, when closed, connects a condenser C1 across the loop terminals, condenser C1 preferably being of such a value as to tune the loop to parallel resonance and thereby unbalance the bridge, the balanced condition by which relay CF is released being attainable only during the intervals when contact *a* or relay CT is open.

It follows that when the loop L is energized and

unoccupied, relay CF is operated periodically at a rate determined by relay CT, but when the loop L is occupied, a balance is unattainable and relay CF is steadily energized, provided the system is in working order, while in the event of a fault or loss of energy, relay CF remains steadily released.

To detect this distinctive mode of operation of relay CF, decoding apparatus of a conventional type is provided. This comprises a decoding transformer DT having a primary winding supplied with impulses of alternately opposite polarity in response to the periodic operation of relay CF, and a secondary winding which supplies alternating current through a decoding unit DU resonant at the code frequency to a rectifier R1 to effect the steady energization of a slow release detector relay CD, controlling suitable indication or traffic controlling means illustrated typically by the lamps G and R.

This decoding apparatus is generally similar to that disclosed in Letters Patent of the United States No. 1,773,472, issued August 19, 1930, to Paul N. Bossart, for Railway traffic controlling apparatus, and a detailed description thereof is deemed unnecessary.

It will be readily apparent that relay CD is normally held energized provided the system is in working order and the loop L is unoccupied, that relay CD releases when an airplane or ground vehicle enters the protected area A so as to unbalance the bridge, and is reenergized when the area is vacated, and further, that relay CD releases in the event of loss of energy or the occurrence of a fault in the detecting system.

In accordance with my invention, the detecting system is arranged to provide additional facilities which will now be described.

The oscillator tube V1 as shown has the secondary winding of a transformer T3 included in its cathode circuit which serves, when voice or code frequency current is supplied to the primary of transformer T3, to periodically vary the potential supplied by transformer T4 to the circuit by which tube V1 is maintained in oscillation and so serves to modulate the high frequency current supplied to the loop at the voice or code frequency rate. Each airplane is provided with a radio receiving set as indicated by the legend "Rec." on the drawing, which can be tuned to receive signals of the carrier frequency supplied to the loop and is capable of detecting the modulation thereof by transformer T3.

If the loop is unoccupied, relay CD is held energized as already explained, and by closing a switch S1, the operator is enabled to connect a suitable reproducer through an amplifier V3 to transformer T3, over the front contacts *b* and *c* of relays CD and CT, to communicate with the plane by the transmission of voice or code frequency currents generated by the reproducer.

It will be noted that the current is modulated only during the periods when the front contacts of relay CT are closed, at which time the bridge is unbalanced. At this time loop L is tuned to parallel resonance by condenser C1, which greatly increases the loop current and thereby increases the radiation and the range of the loop as a radio transmitter so as to enable the modulation to be detected at a greater distance.

It is contemplated that the reproducer will be arranged for control by a phonograph record, magnetic tape, or the like, to communicate by words. For example, it may be arranged to repeatedly transmit the number or other identification of the air strip upon which the plane is to land. It will be readily apparent that such identification will also indicate to the pilot that the particular air strip is unoccupied.

It will be understood that the modulation of the current supplied to the loop produces side band frequencies which are the sum and difference of the carrier and modulation frequencies, having the effect of a change of frequency which might prevent the bridge from being balanced. For that reason the modulation circuit is opened at contacts *b* and *c* of relay CT each time contact *a* of that relay opens to place the bridge in condition to be balanced. It follows that the accurate balancing of the bridge is not interfered with and the difficulty of balancing the bridge when supplied with currents of varying frequency is thereby avoided.

When a plane lands within the area A, relay CD releases to indicate the occupancy of the area A to the tower operator, and due to the fact that the reproducer is disconnected by the opening of the front contacts of relay CD, its release is also indicated to the pilot of the plane. If switch S2 is closed, the closing of the back contacts of relay CD connects a coder or microphone through a suitable amplifier to transformer T3 so that the current supplied to the loop may be modulated for communication with an airplane or vehicle on the ground within the area A. As long as relay CT is in operation, this communication circuit is intermittently available, but the rate of operation of relay CT is generally of the order of three cycles per second or less and preferably slow enough to permit a distinctive signal of the Morse code type to be transmitted during each period when relay CT is released, for identifying the area A or for directing the movements of an airplane or vehicle therein. By closing a switch S3 the operator may hold relay CT energized and thereby render the circuit available for communication for an extended period, enabling a microphone to be used for directing traffic within the area A. It will be understood that each vehicle which is to enter the area may be provided with a receiver such as the one indicated on the drawing by the legend "Rec.," responsive to the signals from the coder or microphone.

It will also be understood that since the operation of relay CD is in accordance with the closed circuit principle, its contacts may be employed in safety circuits for interlocking purposes or for the control of wayside signals for the control of traffic entering or approaching the area A in the same manner as track relays are employed for the control of railway traffic.

Although I have herein shown and described only one form of apparatus embodying my invention, it will be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. A system for indicating the presence of a movable object in a protected area comprising, a conductor arranged to form a loop surrounding the major portion of said area, means for energizing said conductor by alternating carrier current to create a magnetic field in said area, comprising a source of said current and a bridge having four arms formed by four impedance elements connected in the form of a square with two input terminals at diagonally opposite corners and two output terminals at the other two corners, said

bridge having its input terminals connected to the source of said current and having said loop included in one of its arms, the other arms of said bridge comprising fixed impedances of such value that the bridge is balanced to current of the carrier frequency when said area is unoccupied and is effectively unbalanced when a movable object such as a vehicle or airplane enters said area, a sensitive relay, means responsive to the voltage at the output terminals of said bridge for causing said relay to assume its energized position when the bridge is effectively unbalanced and to assume its released position when the bridge is balanced, a mobile receiver, means for modulating the carrier current supplied from said source to transmit communication signals to said receiver when outside of said area, unbalancing means operating periodically between two positions, means controlled by said unbalancing means in one position for effectively unbalancing the bridge by tuning the loop. substantially to parallel resonance to increase the current transmitted to said receiver and to energize said sensitive relay due to the resulting unbalance, means for interrupting the modulation of said current when said unbalancing means assumes its other position to enable the bridge to be balanced to effect the release of said relay in the event the area is unoccupied, a detector relay, means for causing said detector relay to assume its energized position only in response to the periodic operation of said sensitive relay, and means governed by said detector relay for controlling the character of said modulation whereby signals of one character or another are transmitted to said receiver depending upon whether said detector relay is energized or released.

2. A system for indicating the presence of a movable object in a protected area comprising, a conductor arranged to form a loop surrounding the major portion of said area, means for energizing said conductor by alternating carrier current to create a magnetic field in said area, comprising a source of said current and a bridge having four arms formed by four impedance elements connected in the form of a square with two input terminals at diagonally opposite corners and two output terminals at the other two corners, said bridge having the source of said current connected to its input terminals and having said loop included in one of its arms, the other arms of said bridge comprising fixed impedances of such value that the bridge is substantially balanced to current of the carrier frequency when the area is unoccupied and become effectively unbalanced when a movable object such as a vehicle or airplane enters said area, a sensitive relay, means controlled from the output terminals of said bridge for causing said relay to assume its energized position when the bridge is effectively unbalanced and to assume its released position when the bridge is balanced, means for periodically unbalancing the bridge to cause the relay to periodically assume its energized position when the area is unoccupied, a detector relay, means for selectively energizing said detector relay in response to the periodic operation of said sensitive relay, a mobile receiver responsive to said carrier current, and means controlled by said detector relay for modulating the carrier current supplied to said loop to transmit communication signals to said mobile receiver for indicating the condition of occupancy of said area.

3. A system for indicating the presence of a movable object in a protected area comprising, a

conductor arranged to form a loop surrounding the major portion of said area, means for energizing said conductor by alternating carrier current to create a magnetic field in said area, comprising a source of said current and a bridge having four arms formed by four impedance elements connected in the form of a square with two input terminals at diagonally opposite corners and two output terminals at the other two corners, said bridge having the source of said current connected to its input terminals and having said loop included in one of its arms, the other arms of said bridge comprising fixed impedances of such value that the bridge is substantially balanced to current of the carrier frequency when the area is unoccupied and becomes effectively unbalanced when a movable object such as a vehicle or airplane enters said area, a sensitive relay, means controlled from the output terminals of said bridge for causing said relay to assume its energized position when the bridge is effectively unbalanced and to assume its released position when the bridge is balanced, unbalancing means, a condenser, means controlled by said unbalancing means for periodically connecting said condenser across the terminals of said loop whereby the current is increased due to resonance at the carrier frequency and said sensitive relay is energized due to the resulting unbalance, a detector relay, means for selectively energizing said detector relay in response to the periodic operation of said sensitive relay, a mobile receiver responsive to said carrier current, and means controlled by said detector relay when energized for distinctively modulating the carrier current when said current is increased by said unbalancing means, to effect the transmission of signals from said loop to said mobile receiver for indicating whether said detector relay is energized or released.

4. A system for indicating the presence of a movable object in a protected area of the type described in claim 2, in which the mobile receiver is mounted on a vehicle or airplane adapted to traverse the protected area and in which the modulation of the carrier current supplied to the loop when the detector relay is energized constitutes signals repeated periodically by which the unoccupied condition of said area is indicated to the operator of said vehicle or airplane and the modulation of the carrier current supplied to the loop when the detector relay is released constitutes signals of a different character for directing the movement of said vehicle or airplane within said area.

5. A system for indicating the presence of a movable object in a protected area of the type described in claim 2, in which the mobile receiver is on an airplane approaching said area and the protected area is one of a plurality of similarly equipped areas in different landing strips in an airport, and in which the modulation of the carrier current supplied to each loop when the corresponding area is unoccupied constitutes a distinctive signal repeated periodically, said signal identifying to the pilot of said approaching airplane the particular strip upon which he is to land his airplane and also indicating the unoccupied condition of the selected landing strip.

6. A system for indicating the presence of a movable object in a protected area of the type described in claim 2, in which the protected area is in a landing strip in an airport and the mobile receiver is mounted on a vehicle or airplane adapted to traverse said area, and in which the modu-

lation of the carrier current supplied to the loop when such area is occupied constitutes signals for directing the movement of said vehicle or airplane.

GEORGE W. BAUGHMAN.

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