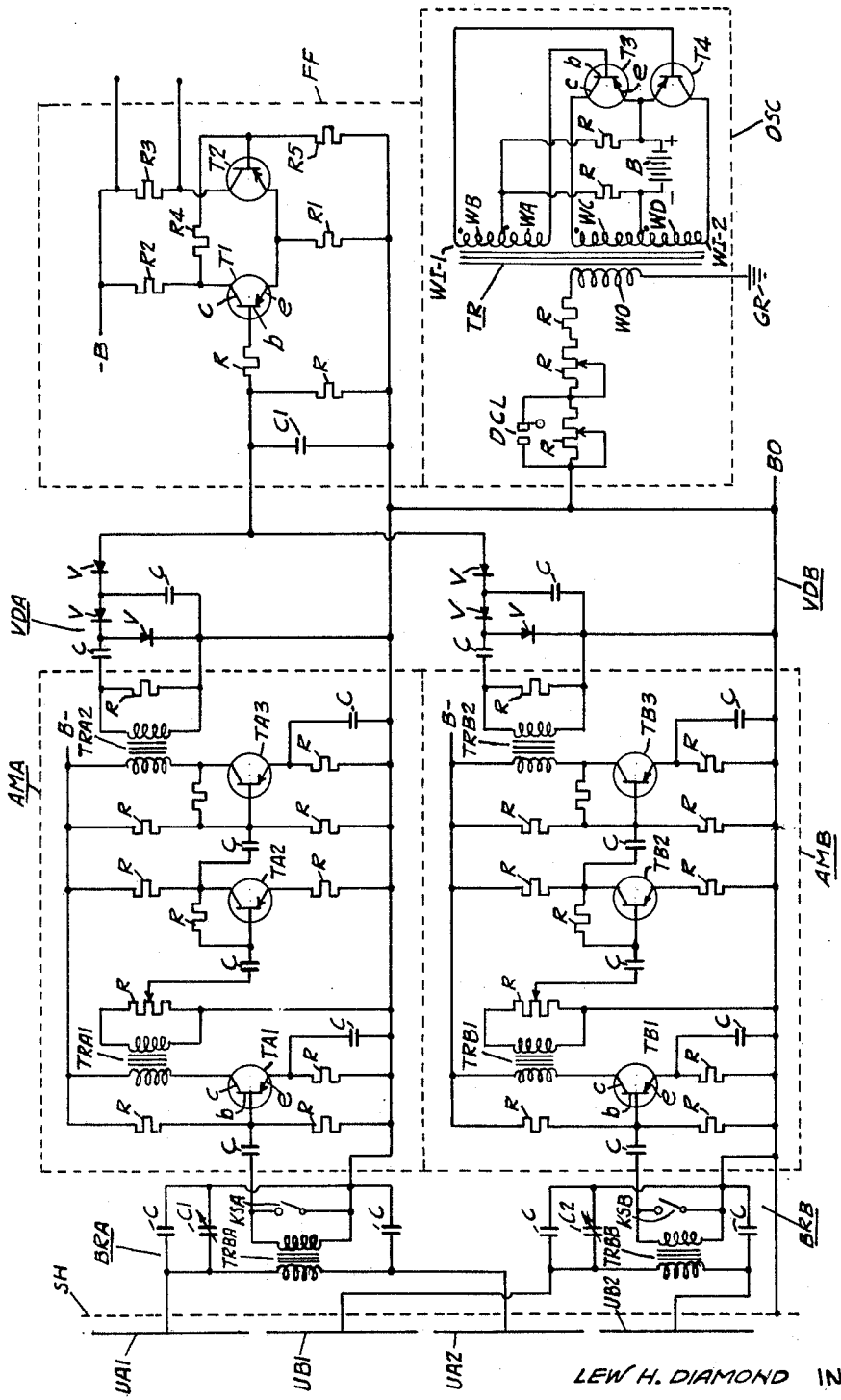
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PROXIMITY DETECTOR CIRCUITRY FOR ELEVATOR CLOSURES

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PROXIMITY DETECTOR CIRCUITRY FOR ELEVATOR CLOSURES

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This invention relates to electric control circuitry and especially to safety controls for doors of elevators.

In elevator installations in which the elevator cars are operated without attendants, it is common practice to provide safety control mechanisms to protect passengers from injury by closing doors. Among these mechanisms are arrangements, termed proximity detectors, in which antennas are provided along the leading edge of the elevator car door to detect the presence of a person within a certain range of the antennas. As usually employed, the proximity type safety mechanism responds to a change in the capacity of an antenna to ground caused by the proximity to the antenna of a person in the elevator doorway. It is arranged to interrupt or prevent the door closing operation of the elevator car so long as an object is in the doorway such that it would interfere with the door's movement.

The patent to Bruns et al., No. 2,601,250, granted June 24, 1952, and the patent to Galanty, No. 2,720,284, granted October 11, 1955, are directed to such proximity detector arrangements.

It is desirable to minimize the physical size, the power consumption and the maintenance requirements of such proximity detector arrangements.

It is, therefore, an object of the invention to provide safety mechanism for elevator doors, which mechanism is of minimal size and is reliable and economical in operation.

In carrying out the invention according to one arrangement thereof, four vertically disposed antennas are arranged in pairs and are positioned one above the other along the leading edge of the car door. The antennas of each pair are arranged to form two of the arms of a capacity bridge circuit by being connected directly to opposite ends of the diagonal of the bridge. Each antenna is connected to a different bridge circuit from the one in which is connected the next adjacent antenna. A grounded oscillator applies a periodic voltage to the capacity bridge circuits so that each antenna has a predetermined capacitive coupling to ground. A variable capacitor in one arm of each bridge may be adjusted to provide substantially zero voltage across the bridge diagonal when no object, such as a person, is proximate to the antennas connected in that bridge. When such an object comes into the field of influence of one or more antennas, there is sufficient change in the capacitive coupling to ground of such one antenna with respect to that of the other of its bridge to provide a signal voltage across the diagonal of the bridge. This signal voltage is amplified and is transmitted to the input of a utilization circuit which may take the form of a mono-stable multivibrator. The output of the multivibrator may be used to control the door movements.

In the arrangement of this preferred embodiment transistors are used to minimize the physical size of the mechanism and to provide extremely reliable and economical operation.

Features and advantages of the invention will be seen from the above, from the following description of the operation of the preferred embodiment when considered in conjunction with the drawing and from the appended claims.

In the drawing, the figure is a simplified schematic wiring diagram, illustrating the circuits of the safety control for elevator doors in accordance with the invention.

In the drawing, condensers are generally designated C, resistors R, rectifiers V, iron core transformers TR and three element transistors T, suffix letters and/or numerals being added thereto to differentiate similar circuit elements from each other.

In the embodiment illustrated, two pairs of antennas UA1, UA2 and UB1, UB2 are arranged in two capacity bridge circuits, generally designated BRA and BRB, respectively. Antennas UA1, UA2 are arranged in two oppositely disposed arms of capacity bridge BRA, and are connected directly to opposite ends of the bridge diagonal which includes the primary winding of transformer TRBA. Antennas UB1, UB2 are similarly connected in bridge BRB, the primary winding of transformer TRBB being connected in their bridge diagonal. Variable condensers C1, C2 are provided for balancing the bridges under static conditions, and manual switches KSA, KSB are provided to short-circuit the secondary windings of the transformer (TRBA, TRBB) of one bridge when the other bridge is being balanced. A periodic voltage source, the broken line outline of which is designated OSC is connected from supply line BO to ground GR, and applies a periodic voltage at a given frequency across both bridges.

The secondary winding of transformer TRBA of bridge BRA is connected to the input wires of a three-stage amplifier, the broken line outline of which is designated AMA, and the secondary winding of transformer TRBB of bridge BRB is similarly connected to the input terminals of a companion amplifier, the broken outline of which is designated AMB. The outputs of amplifiers AMA and AMB are connected through voltage doubler circuits VDA, VDB, respectively (which convert amplified periodic signals to unidirectional signals), to a common junction point at the input to a signal utilization circuit, the broken line outline of which is generally designated FF.

A shield SH is provided for the antennas and is connected by way of supply line BO to a voltage source (not shown).

For simplification, and because it forms no part of this invention, the exact mounting arrangement of the circuit components has not been illustrated. However, it is to be understood that antenna pair UA1, UA2 and UB1, UB2 along with their capacity bridge circuits, BRA, BRB, associated amplifiers AMA, AMB and voltage doublers VDA, VDB preferably are all mounted on the leading edge of the car door upon which shield SH is also mounted, while power source OSC and signal utilization circuit FF may be mounted on top of the car. It is also to be understood that the antennas are mounted in spaced vertical alignment with the antennas of one pair alternating with the antennas of the other pair.

Periodic voltage source OSC includes transformer TR, having an output winding WO and two input windings WI–1, WI–2, a direct low voltage source B (shown as a battery), and transistors T3, T4 of the Texas Instrument 2N457 type. The transistors each have collector *c*, base *b* and emitter *e* electrodes, their emitter *e* electrodes being connected together and to the positive terminal (+) of voltage source B. The collector electrodes of transistors T3, T4 are connected directly to the opposite ends of transformer winding WI–2, while their base electrodes are connected to the opposite ends of transformer winding WI–1. A mid tap on transformer winding WI–1 divides the winding into two base windings WA and WB and is resistively connected to both terminals (+, —) of voltage source B. A mid tap on transformer winding WI–2 divides the winding into the collector windings WC, WD and is connected to the negative terminal (—) of voltage source B. One side of transformer output winding

WO is connected to ground GR while its other side is resistively connected to supply line BO. DCL designates a mechanical switch actuated by movement of the car door and is shown for the closed position of the door.

Since the amplifiers AMA and AMB and voltage doubler circuits VDA and VDB for both bridges BRA, BRB are identical, only the circuitry for the amplifier AMA and voltage doubler VDA associated with bridge BRA will be described. Amplifier AMA is composed of three semi-conductor transistors TA1, TA2 and TA3 of the General Electric 2N265 type, each having emitter *e*, collector *c* and base *b* electrodes. The base *b* and collector *c* electrodes of each transistor are biased negatively with respect to their respective emitter *e* electrodes from a voltage source (not shown) over supply lines B— and BO for Class A operation of the amplifiers. The secondary winding of transformer TRBA is connected on one side through a condenser C to the base electrode *b* of transistor TA1 and on its other side to supply line BO to apply a periodic signal to be amplified to the base-emitter input circuit of transistor TA1. The collector electrode *c* of transistor TA1 is transformer coupled by means of transformer TRA1 to the base-emitter input circuit of transistor TA2, while the collector electrode *c* of transistor TA2 is condenser coupled to the base-emitter input circuit of transistor TA3, thereby providing three stages of amplification of the applied signal. The collector electrode *c* of transistor TA3 is in turn coupled by transformer TRA2 to voltage doubler circuit VDA which may be of any standard design for converting the amplified periodic signal to one of unidirectional character.

Signal utilization circuit FF comprises a mono-stable multivibrator circuit in which two transistors T1, T2 of the General Electric 2N525 type are provided. A source (not shown) supplies direct voltage over supply lines —B and BO to the circuits of transistors T1, T2. Each transistor has emitter *e*, collector *c* and base *b* electrodes, the emitter electrodes being connected together and through a common resistor R1 to supply line BO. The outputs of voltage doublers VDA and BDB are connected in common across the base-emitter input circuit of transistor T1; condenser C1 being provided to filter out noise signals picked up by the wires connecting the voltage doublers on the car door to transistor T1 which may be located on top of the car. The collector electrodes of transistors T1 and T2 are connected through resistors R2, R3, respectively, to supply line —B. The collector electrode of transistor T1 is connected through resistor R4 to the base electrode of transistor T2 which is in turn connected through resistor R5 to line BO.

When power is applied to the circuits, battery B in the circuits of periodic source OSC biases the base electrode of transistors T3, T4 negatively with respect to their respective emitter electrodes. Due to a lack of symmetry in the circuit components, this applied bias initiates conduction through the emitter-collector circuit of one of these transistors, say, for example, transistor T3. Current thus flows through collector winding WC in the emitter-collector circuit of transistor T3, inducing a voltage across winding WI–1 of transformer TR. The polarities of the windings of transformer TR are arranged so that the induced voltage appearing across base winding WA is of a polarity such as to increase the negative bias of the base *b* electrode of transistor T3 with respect to its emitter *e* electrode, thereby increasing the conduction of that transistor. At the same time, base winding WB biases the base electrode of transistor T4 sufficiently positive with respect to its emitter electrode to maintain transistor T4 in non-conducting condition.

As the collector current flowing in transistor T3 increases, its induced base-emitter circuit voltage correspondingly increases, thereby increasing the negative bias applied to transistor T3. This regenerative action causes a continuous rise of collector current through collector winding WC of transformer winding WI–2 and a corresponding increase in core flux until transformer TR becomes magnetically saturated. At saturation there is no further increase in flux density so that the induced base-emitter circuit voltages fall to zero, causing a corresponding decrease in collector current of transistor T3 and of the core flux in transformer TR. The decreasing core flux induces a reverse voltage in winding WI–1, so that base circuit winding WA rapidly biases transistor T3 to non-conducting condition. Transistor T4, which was maintained in non-conducting condition by the previously induced base to emitter positive bias due to base winding WB, is now biased by means of its base winding WB sufficiently negative with respect to its emitter electrode to start conducting through its emitter-collector circuit, extending through collector winding WD. The action previously described for transistor T3 is repeated for transistor T4. The resultant induced output voltage appearing across transformer output winding WO is a square wave which is applied across bridges BRA and BRB. For the circuit parameters used in one tested embodiment in which the specified transistors were provided, 11 volts direct voltage, supplied by battery B, was converted to 230 volts square wave at 1 kilocycle at the output of transformer winding WO, which periodic voltage was found to be satisfactory.

Opening movement of the car doors at a floor landing actuates mechanical switch DCL to its closed position, short-circuiting a portion of the resistance in the output of source OSC to render the antennas effective for detecting persons in the elevator entranceway.

The antennas form capacitance couplings to ground in the bridge circuits. Thus ground GR and line BO form two junctions of the arms of each bridge and source OSC applies periodic voltage between these points of the bridges. Shield SH isolates the antennas from adjacent ground potentials.

Assume that the bridges are balanced by means of adjustable condensers C1, C2 and that manual switches KSA, KSB are open so that with no one sufficiently near the antennas there is no appreciable voltage signal across the diagonals of the bridges. Under these circumstances there is no periodic signal applied to base-emitter input circuits of amplifiers AMA and AMB. Consequently, the amplifier transistors are in a steady state conducting condition of Class A operation and do not apply a signal to the base-emitter input circuit of transistor T1 of signal utilization circuit FF. Under such conditions, the base electrode of transistor T2 is biased from supply line —B sufficiently negative with respect to its emitter electrode to conduct current through its collector-emitter circuit, extending through common emitter resistor R1 and collector resistor R3. The voltage drop appearing across common emitter resistor R1, due to such collector current flow, biases the emitter electrode of transistor T1 sufficiently negative with respect to its base electrode to maintain the transistor in non-conducting condition.

When an object, such as a person's body, comes into proximity to the door edge, it affects the antennas differently. Due to the object's irregularity, it increases the antenna to ground capacitance, thus decreasing the antenna to ground impedance, of the antenna nearest the person more than that of the others. As a result, an imbalance of one or both bridges occurs, causing a signal voltage to appear across the primary winding of the transformer (TRBA or TRBB) in the diagonal of the bridge. This signal induces a periodic voltage in the secondary winding of the transformer, for example transformer TRBA, which is applied to the base-emitter circuit of transistor TA1. It amplifies the periodic signal in its emitter-collector circuit from which it is then applied through transformer TRA1 to the base-emitter circuit of transistor TA2. The periodic signal is amplified by TA2 before being applied to the base-emitter circuit of transistor TA3 for further amplification before being applied

through transformer TRA2 to voltage doubler circuit VDA. The periodic signal is converted by voltage doubler VDA to one of unidirectional character the negative polarity of which is applied to the base-emitter circuit of transistor T1 of the flip-flop multivibrator circuit FF.

This applied unidirectional signal is of greater magnitude than the bias that is applied to the base-emitter circuit of transistor T1 by the negative voltage drop normally appearing across common resistor R1 when transistor T2 is conducting. It biases the base electrode of transistor T1 sufficiently negative with respect to its emitter electrode to cause conduction through the collector-emitter circuit extending through collector resistor R2 and common resistor R1. This conduction acts to increase the voltage at the junction of resistors R2–R4 and acts to decrease the negative bias applied (from supply line —B through resistors R2, R4) to the base-emitter circuit of transistor T2. This action is regenerative and is sufficient to drive transistor T2 quickly to its non-conducting condition, while transistor T1 is driven to saturation. In this manner, the output voltage drop formerly appearing across collector resistor R3 in the circuit of transistor T2 is reduced substantially to zero.

When the person moves out of the field of the antennas, the bridge returns to its balanced condition, removing the biasing signal voltage from the base-emitter circuit of transistor T1 thereby causing it to return to its non-conducting condition. Transistor T2 again conducts and is driven to saturation to provide again an output voltage drop across its collector resistor R3. The absence or presence of this output voltage drop across resistor R3 of flip-flop circuit FF is available for use as an indication that an object is in the closing path of the door and it may be utilized to control door movement. If desired it may be used directly to control a relay by substituting the coil of the relay for the resistor itself.

During the door closing operation mechanical switch DCL is actuated by door movement to its open position as the car door (not shown) approaches its fully closed position. This increases the resistance in series with the output of source OSC to desensitize the antennas and prevent unwanted reversal of the doors as they approach the door jamb, or, as in center opening installations, the doors approach each other.

Although the invention has been described as being incorporated in the above described arrangement it should be apparent that it can be used with a greater or lesser number of bridge circuits and antennas. Also, more than one pair of antennas may be provided for each bridge circuit and amplifiers having more or less gain may be used as desired.

As changes can be made in the above described construction and many apparently different embodiments of this invention can be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown on the accompanying drawing be interpreted as illustrative only and not in a limiting sense.

What is claimed is:

1. In a proximity detector circuit, in combination, two capacitive type bridge circuits, each one of which has a pair of antennas electrically connected directly to opposite ends of the diagonal of the bridge to form two of its oppositely disposed arms; a source of periodic voltage connected across each of said bridges; means for balancing each bridge under static conditions; amplifying means individual to each of said bridges, said amplifying means including three semi-conductor elements, each one of which has base, emitter and collector electrodes, said elements being series coupled to provide three stages of amplification, the first said element of said series having its collector electrode transformer coupled to the base-emitter circuit of the second element of said series, said second element having its collector electrode condenser coupled to the base-emitter circuit of the third element of said series; means biasing the base electrodes of said elements negative with respect to their respective emitter electrodes; transformer coupling means individual to each of said bridge circuits coupling the diagonal of its bridge to the base-emitter circuit of the corresponding said first elements, whereby under conditions where its corresponding bridge is unbalanced a periodic signal is produced and applied to such first element base-emitter circuit for amplification; and signal utilization means electrically coupled to the collector electrodes of both the last ones of said series coupled elements for controlled operation in response to said amplified signals.

2. In a proximity detector circuit, in combination, two capacitive bridge circuits, each of which has a pair of antennas electrically connected directly to opposite ends of the diagonal of the bridge to form two of its oppositely disposed arms; a source of periodic voltage connected across each of said bridges; means for balancing each bridge under static conditions; amplifying means individual to each of said bridges and having a plurality of three terminal semi-conductor elements series coupled electrically to provide a plurality of stages of amplification, each of said semi-conductor elements having base, emitter and collector electrodes; means biasing the base electrodes of said elements negative with respect to their respective emitter electrodes for Class A operation; electric coupling means individual to each of said bridge circuits and, under conditions where its corresponding bridge is unbalanced, applying a periodic signal to the base-emitter circuit of the first of said series coupled elements associated with such corresponding bridge circuit for amplification of said periodic signal; two voltage doublers, one for each of said bridges, for converting the periodic output signal of the corresponding amplifying means to a unidirectional signal; and signal utilization means electrically coupled to the output of both said voltage doublers, said signal utilization means being operatively responsive to said unidirectional signals.

3. In a proximity detector circuit, in combination, two capacitive type bridge circuits, each of which has a pair of antennas electrically connected directly to opposite ends of the diagonal of the bridge to form two of its oppositely disposed arms; a source of periodic voltage connected across each of said bridges; means for balancing each bridge under static conditions; amplifying means individual to each of said bridges, said amplifying means including three semi-conductor elements, each one of which has base, emitter and collector electrodes, said elements being series coupled to provide three stages of amplification, the first said element of said series having its collector electrode transformer coupled to the base-emitter circuit of the second element of said series, said second element having its collector electrode condenser coupled to the base-emitter circuit of the third element of said series; means biasing the base electrodes of said elements negative with respect to their respective emitter electrodes; transformer coupling means individual to each of said bridge circuits coupling the diagonal of its bridge to the base-emitter circuit of the corresponding said first semi-conductor elements, whereby under conditions where its corresponding bridge is unbalanced a periodic signal is produced and applied to such first element base-emitter circuit for amplification; and a flip-flop circuit including first and second three element transistors, each having base, emitter and collector electrodes, the emitter electrodes of said first and second transistors being connected directly to each other at a common junction point, the collector electrode of said first transistor being resistively connected to the base electrode of said second transistor, a direct current source having two output terminals, one terminal being connected through a first resistor to the collector electrode of said first transistor and through a second resistor to the collector electrode of said second transistor, the other terminal of said source being resistively connected through a third resistor to

said common emitter junction point and through a fourth resistor to said base electrode of said second transistor so as to bias said base electrode of said second transistor negatively with respect to its emitter electrode; the collector electrodes of the last element of both said amplifying means being electrically coupled to the base-emitter circuit of said first transistor of said flip-flop circuit to apply the amplified output signal of said amplifying means across said first transistor base-emitter circuit, whereby in the absence of such output signal said second flip-flop transistor is biased to conducting condition causing an output potential to appear across said second resistor in its collector circuit and in the presence of such output signal conduction is transferred from said second transistor to said first transistor, reducing said output potential to zero.

4. In a proximity detector circuit, in combination, two capacitive type bridge circuits, each of which has a pair of antennas electrically connected directly to opposite ends of the diagonal of the bridge to form two of its oppositely disposed arms; a source of periodic voltage connected across each of said bridges, said source consisting of an iron core transformer having a secondary winding, one side of which is grounded and the other side of which is resistively connected to said bridge circuits, two primary windings, and two transistors each having base, emitter and collector electrodes, the emitter electrodes being connected directly to each other at a common junction point, a source of relatively low direct voltage connected between said common junction point and a mid tap on the first one of said primary windings, the collector electrodes of said transistors being connected to opposite ends of said first primary winding so as to bias said emitter electrodes positively with respect to their respective collector electrodes, the base electrodes of said transistors being connected directly to opposite ends of said second primary winding, the midpoint of said second input winding being resistively connected to said common junction point and to said mid tap on said first primary winding, the polarities of said first and second windings being such that said transistors conduct alternately through regenerative action, whereby said relatively low direct voltage is converted to a relatively high periodic output voltage applied across said bridges by said secondary winding; means for balancing each bridge under static conditions; amplifying means individual to each of said bridges and having a plurality of three terminal semi-conductor elements series coupled to provide a plurality of stages of amplification, each of said semi-conductor elements having base, emitter and collector electrodes; means biasing the base electrodes of said elements negatively with respect to their respective emitter electrodes for Class A operation of said elements; electric coupling means individual to each of said bridge circuits and, under conditions where its corresponding bridge is unbalanced, applying a periodic signal to the base-emitter circuit of the first one of the said series coupled elements associated with such corresponding bridge circuit for amplification of said signal; two voltage doublers, one for each bridge for converting the output periodic signal of the corresponding amplifying means to one of unidirectional character; and signal utilization means electrically coupled to the output of both said voltage doublers for controlled operation in response to said unidirectional signals.

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