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[54] BODY DETECTING INDUSTRIAL SAFETY SYSTEM

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[52] **U.S. Cl.**.....**317/33 R**, 317/33 SC, 317/148.5 B, 317/135 R, 317/135 A, 317/DIG. 2, 307/202, 307/252 B

[51] **Int. Cl.**.....**H02h 7/00**

[58] **Field of Search**.....317/33 R, 33 SC, 317/148.5 R, 148.5 B, DIG. 2, 135 R, 135 A; 307/202, 252 B; 328/80

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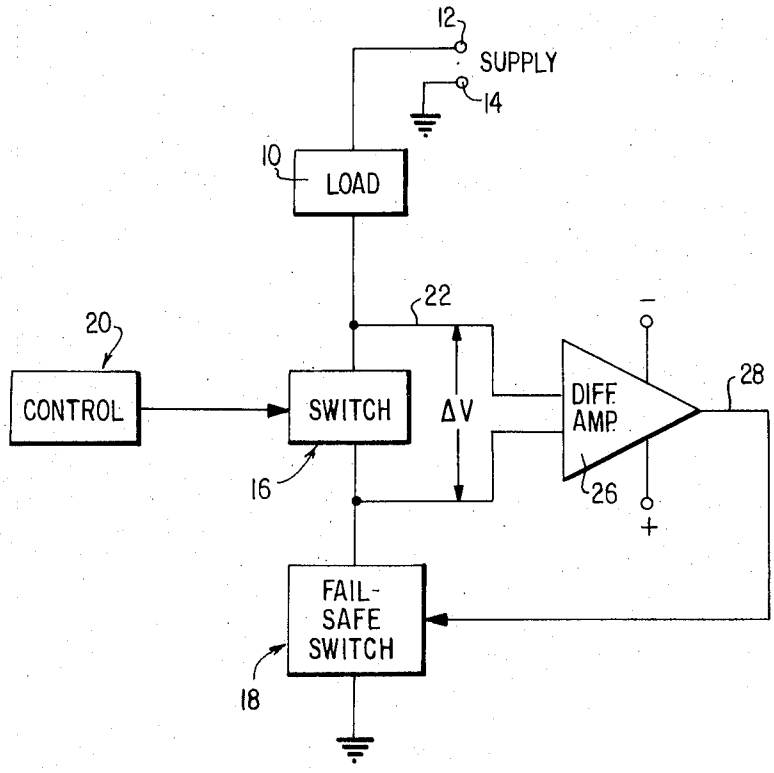
Primary Examiner—L. T. Hix

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[57] **ABSTRACT**

An industrial safety system includes an improved fail-safe system in which a TRIAC switch is connected in series with a relay switch and with a load circuit to complete the circuit from a source through the load. A gating circuit for the TRIAC normally provides a closed switch effect so that a normal voltage drop appears across the TRIAC. An amplifier detects this voltage drop and keeps the relay closed but when the voltage drop disappears indicating a short fault in the TRIAC, the relay opens. If an open fault occurs in the TRIAC, the load circuit is not completed. The gating circuit for the TRIAC is one in which the presence of a human body, or a part of the human body, at or near to an industrial machine such as a press causes the TRIAC to be non-conductive and the load circuit is the power control for the machine. The gating circuit is driven by an oscillator and features a pair of parallel LC tuned circuits one of which has a fixed frequency response and the other of which includes an antenna as the capacitive element so as to have a variable frequency response dependent upon the prohibited presence of the human body. The frequency response of the fixed circuit is lower than that of the variable circuit when the latter is unaffected by a human body and both are resonant at frequencies lower than the oscillator frequency. The TRIAC is gated open when the outputs of the two circuits decrease to a predetermined threshold.

7 Claims, 4 Drawing Figures



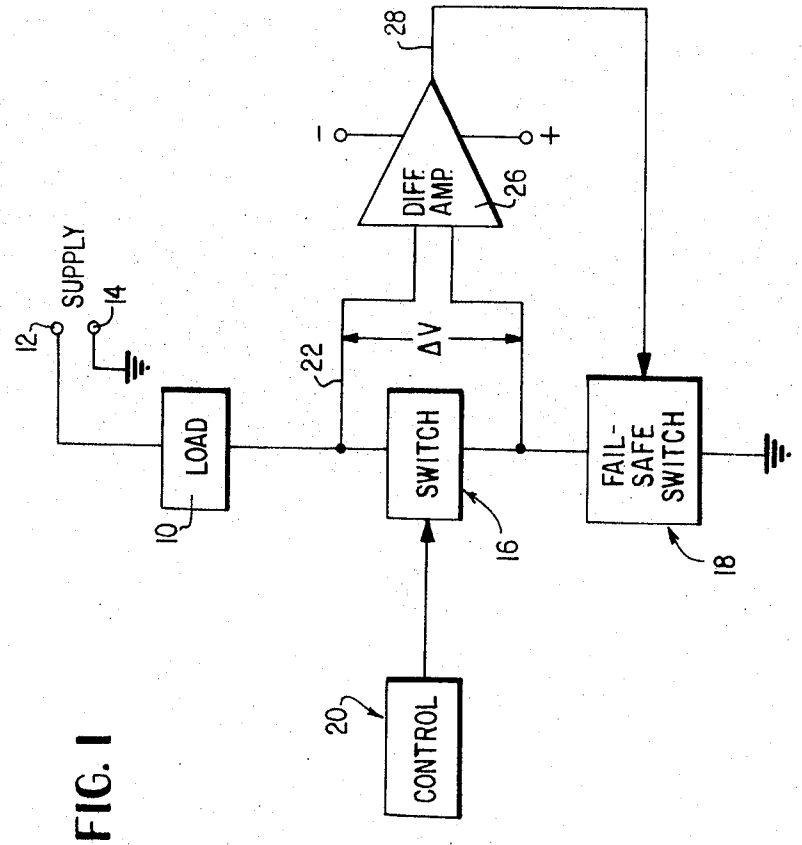

28
DIFF. AMP.
26
-
+
SUPPLY
14
12
22
ΔV
LOAD
10
SWITCH
16
FAIL-SAFE SWITCH
18
CONTROL
20

FIG. 1

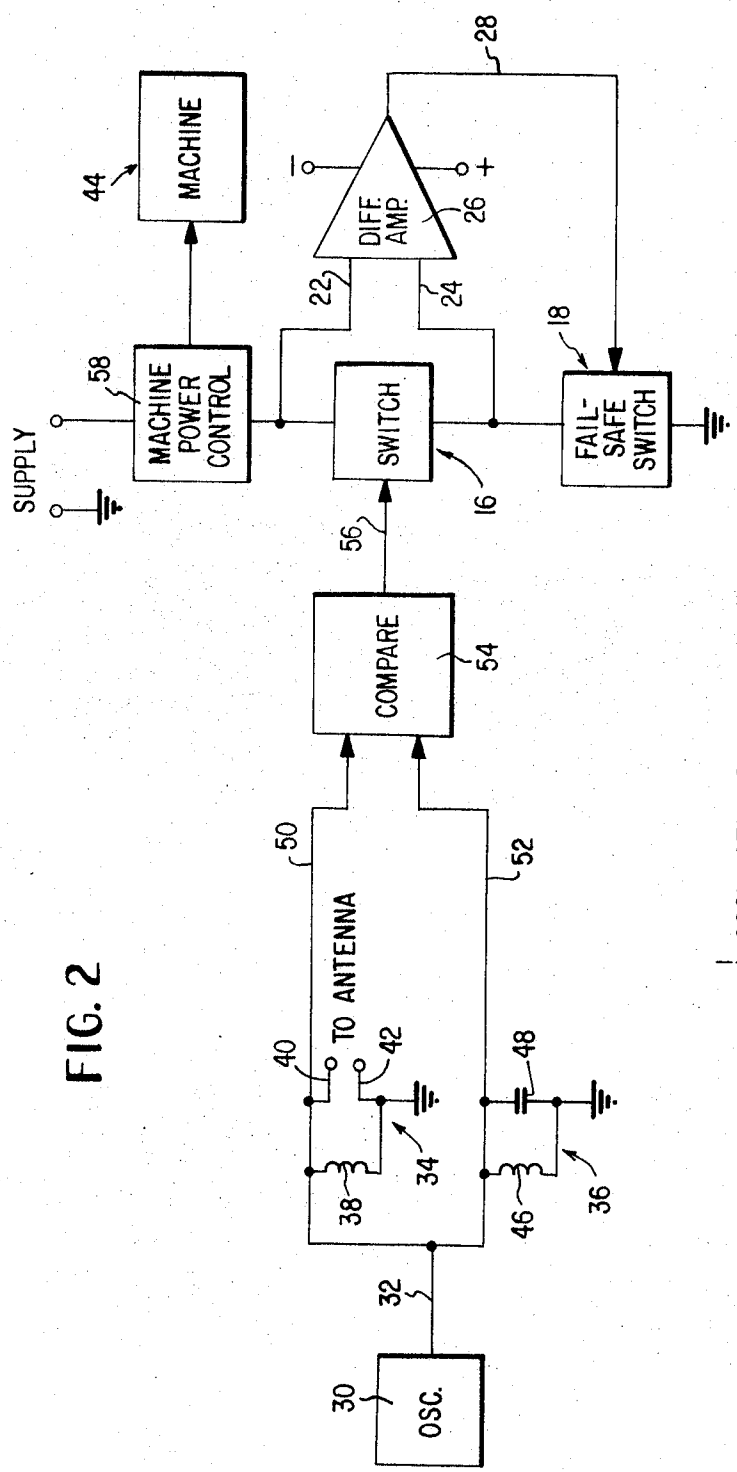

28
MACHINE
44
DIFF AMP
26
22
24
18
58
MACHINE POWER CONTROL
SUPPLY
SWITCH
16
FAIL-SAFE SWITCH
56
COMPARE
54
50
52
TO ANTENNA
40
42
48
34
38
46
36
32
30
OSC.

FIG. 2

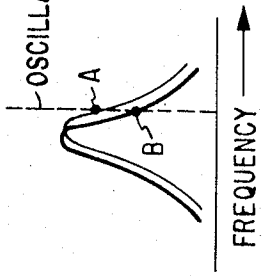

OSCILLATOR FREQUENCY
A
B
FREQUENCY

FIG. 2A

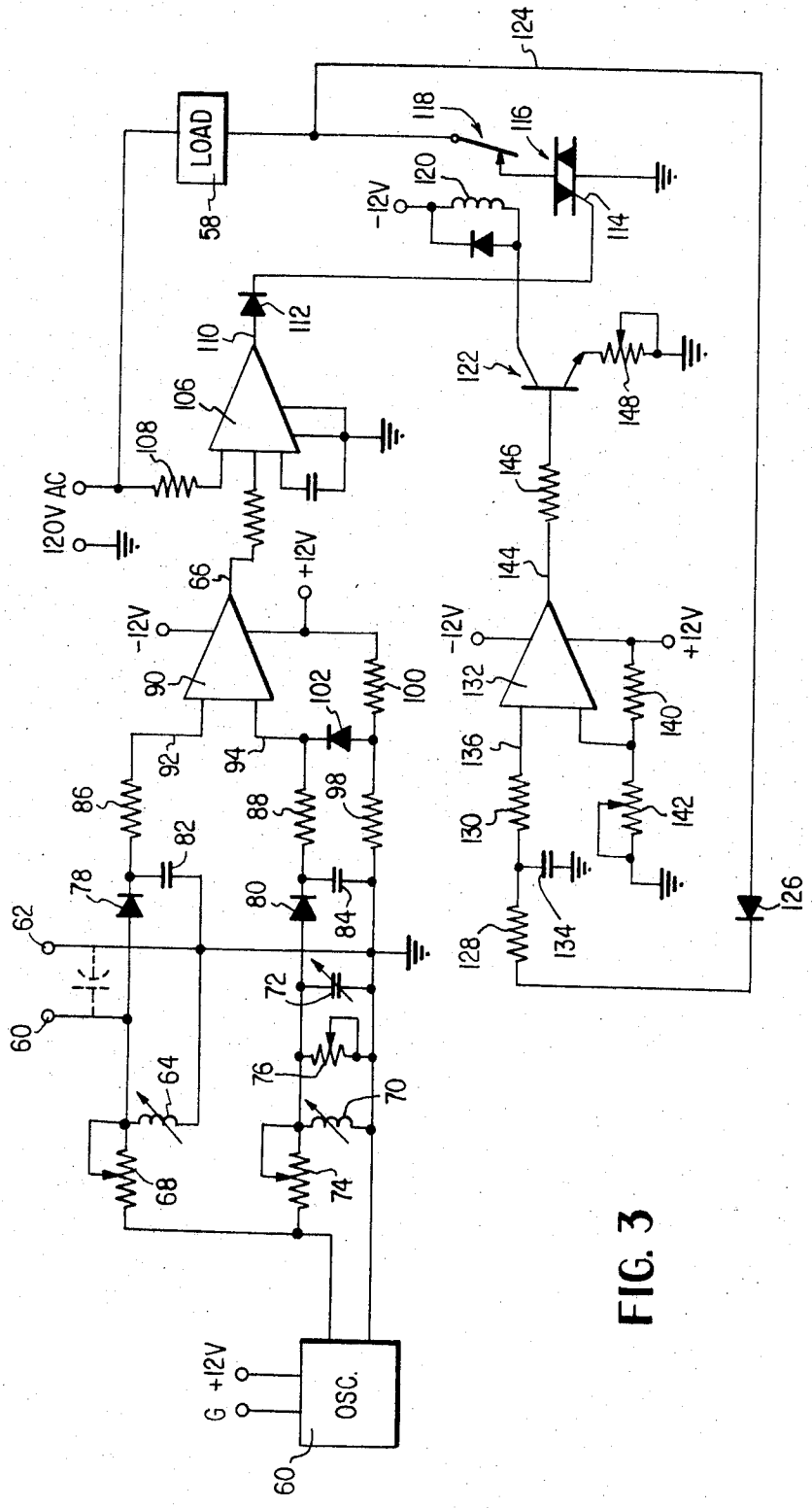

LOAD
58
124
118
116
120
-12V
114
112
110
106
108
122
148
120V AC
146
144
+12V
-12V
66
90
102
100
132
140
92
94
136
86
88
98
130
142
82
78
80
84
62
126
128
134
72
60
64
76
70
68
74
G +12V
OSC.
60

FIG. 3

BODY DETECTING INDUSTRIAL SAFETY SYSTEM

BACKGROUND OF THE INVENTION

It is well known of course that many industrial machines are extremely hazardous and dangerous to operate, a punch press being an example of such a machine. In addition to simple inattention during which time an operator may place his hand, for example within the danger zone area of the machine while it is operating, it is also common that operators tempt to "beat" the machine when it is in an automatic or semi-automatic mode, as for example by attempting to displace scrap material or the like without shutting down the operation of the machine.

As a result, many attempts have been made to provide fool proof industrial safety devices for such machines and they may be divided broadly into two categories, one in which switch mechanisms are required to be actuated by the operator at such a position as positively assures its presence remote from the danger area of the machine and, two systems which detect the presence of the human body or a portion of the human body which is at hand at or near a danger zone area. Obviously, the former type is not entirely satisfactory because a third party may operate the controls while the operator has his hand or a portion of his body in the danger area. Perhaps more importantly, however, such devices can be defeated easily by the operator himself (i.e. by tying down the controls) and this remains one of the most serious hazards. Insofar as the second category of systems is concerned, those which rely upon photoelectric cells or the like are propense to deterioration in performance due to the presence of dust, dirt and the like which over a protracted period of time may decrease the sensitivity of the system such as to render it substantially useless. Radiant energy systems, likewise, are extremely vulnerable to interference due to spurious effects which may emanate from adjacent machinery or from the machinery itself and when designed so as to minimize this outside source of interference, either becomes so complex as to be prohibitive in cost or of insufficient sensitivity to achieve the desired results.

BRIEF SUMMARY OF THE INVENTION

Accordingly, it is of primary concern in connection with this invention to provide an improved form of industrial safety system which is essentially immune from outside interference and does not suffer from the defect of deterioration and sensitivity over periods of protracted and prolonged use and which, in addition, features a fail-safe system which automatically renders the associated machine inoperative if the main switching component of the system develops a short fault.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is a diagrammatic view illustrating certain principles according to the present invention;

FIG. 2 is a diagram illustrating additional features of the present invention;

FIG. 2A is a graph illustrating the relationships between oscillator frequency and the frequency responses of the tuned circuits according to the present invention; and

FIG. 3 is a circuit diagram of a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

With reference to FIG. 1, there is shown therein a somewhat diagrammatic and simplified system according to the present invention and which will illustrate certain novel fail-safe features according to the present disclosure. As shown, a load which, for the purpose of FIG. 1, could be any type of load which is desired to be controlled and which is to be cut off positively in the event in a failure in the main switch of a control circuit, is indicated by the reference character **10** and will be seen to be connected to one terminal **12** of a source or supply of operating potential, the other terminal **14** of which is illustrated as being connected to ground. Connected in series with each and with the load **10** to complete the circuit through the load across the supply terminals **12, 14** are the first and second switch means indicated generally by the reference characters **16** and **18.** The switch means **16** is the main switch of the control system and is operated between open and closed conditions through the intermediary of a control system indicated generally by the reference character **20.** The switch means **18** is the fail-safe switch and normally is in closed condition. A prerequisite for the switch means **16** is that when it is in closed condition and is operating normally, a voltage drop appears across this switch means as indicated by the symbol V indicated as appearing between the conductors **22** and **24** of FIG. **1.** This voltage drop is connected to a difference amplifier **26** which produces an output at its conductor **28** so long as a threshold value of this voltage drop appears and the output of the amplifier **26** is connected to the fail-safe switch means **18** normally to maintain it in closed condition when the threshold of the voltage drop is exceeded but which, upon failure of the input to the amplifier **26** to be equal to or greater than the threshold, to allow the switch means to assume an open condition.

Thus, if the switch means **15** is, for example , a TRIAC switch whose gate electrode is controlled by the circuitry **20,** the predictable voltage drop thereacross when the TRIAC is operating normally may be utilized as the input to the differential amplifier **26** so as to maintain the fail-safe switch **18** in closed condition. In the event that the switch means **16** develops a short fault, the voltage drop thereacross will disappear or will at least decrease before the aforementioned threshold so that the output of the amplifier **26** at the conductor **28** is such as establishes the switch means **18** in open condition thus automatically terminating the circuit from the supply through the load **10** even though the switch means **16** is now permanently in closed condition and is no longer controllable by the gating circuit **20.** On the other hand, if the switch means **16** develops an open fault, the supply circuit through the load **10** of course will be cut off automatically and the response or non response to the gating circuit **20** is immaterial.

Although it will be apparent that the system according to FIG. **1** is useful as a fail-safe system irrespective of the nature of the load **10,** the system is particularly useful and valuable when the load is the power control for industrial machine and the gating control circuit **20** operates to detect the presence of a human body or a part thereof in a dangerous zone or region of the indus-

trial machine. To illustrate such a system with greater particularity, reference is had now to FIG. 2 wherein the control circuitry 20 of FIG. 1 is illustrated as including an oscillator 30 operating at a fixed frequency and having an output at the conductor 32 which is applied to a pair of parallel tuned circuits indicated generally by the reference characters 34 and 36. Both of these tuned circuits are of the LC resonant type with the inductance 38 of the tuned circuit 34 being connected through leads 40 and 42 to a suitable antenna which forms the capacitive portion of the tuned circuit 34 and which is so constructed and arranged as to exhibit variable capacitance in response to the presence of a human body or part of the human body in a danger zone region of the associated industrial machine 44 which is controlled by the circuit shown.

The other tuned circuit 36 includes an inductance 46 and a capacitance 48. A principle feature of the tuned circuit relationship according to the present invention is that the fixed frequency tuned circuit 36 is tuned to be resonant at a lower frequency than is the circuit 34 when unaffected by the human body. Further, both resonant frequencies of the circuits 34 and 36 are lower than the fixed frequency output of the oscillator 30 so that, as is shown in FIG. 2A, the normal frequency response of the circuit 36 is at the point B in FIG. 2A whereas the normal frequency response of the circuit 34 is at the point A.

As a result, there is a difference in the outputs at the conductors 50 and 52 from these two tuned circuits which is applied to a comparator 54 which has an output at the conductor 56 dependent upon the difference in outputs at the conductors 50 and 52. In the presence of the human body or a portion thereof in the prohibited area of the machine 44, the resonant frequency at the circuit 34 decreases so that, in effect, the points A and B approach each other, thereby decreasing the output level between the conductors 50 and 52. As mentioned before, a preferred form of the switch means 16 is a TRIAC and as the output decreases between the conductors 50 and 52, a threshold will be reached wherein the output at the conductor 56 from the circuit 54 is ineffective to maintain the TRIAC on the circuit through the switch means 16 correspondingly is interrupted.

In the embodiment shown in FIG. 2, the load 10 of FIG. 1 takes the form of the power control system for the machine 44 and is indicated in FIG. 2 by the reference character 58 whereby, when the comparator 54 fails to maintain the switch 16 closed, indicating the presence of the human body or a portion thereof in the prohibited zone of the machine 44, the switch 16 will be opened and the power control system 58 for the machine will be interrupted and the machine correspondingly will cease operation. The operation of the fail-safe circuitry is as described above in conjunction with FIG. 1.

Referring now more particularly to FIG. 3, a preferred and operative embodiment of the present invention as illustrated therein. In FIG. 3, the antenna terminals are indicated by reference characters 60 and 62 and the normal capacitance produced by the antenna in the absence of an interferring human body or portion thereof is indicated in FIG. 3 by dashed lines between the conductors leading to the terminals 60 and 62. The antenna capacitance is connected in circuit with the inductance 64 which, as shown, is variable so as to effect the desired tuning action and this tuned circuit is driven from the oscillator 66 through the variable resistor element 68 which is adjusted to set the level at which the control circuit will respond to the added capacitance effected by the unauthorized or prohibited presence of the human body or portion thereof as previously described. The oscillator 66 also drives the fixed tuned circuit which comprises the variable inductance 70 and variable capacitance 72, both being variable to establish the desired fixed resonant frequency thereof.

The drive from the oscillator 66 to the circuit 70, 72 is through the variable resistor 74 which sets the range from the antenna within which the device will operate. The variable resistor 76 is provided to match the Q of the two tuned circuits.

The outputs from the two tuned circuits are taken through the respective diodes 78 and 80 which pass only the positive pulses from the resonant circuits which are smoothed or filtered by the capacitors 82 and 84 and are applied as dc voltage level signals through the coupling resistors 86 and 88 as inputs to the integrated circuit difference amplifiers 90 at the input conductors 92, 94 thereof. Thus, the slight difference in potentials at the conductors 92 and 94 under normal conditions when the antenna is unaffected by foreign objects, produces a positive output at the conductor 96 from the amplifier 90. The resistor chain 98, 100 forms a voltage divider circuit providing a reference voltage source for amplifier 90 and the diode 102 prevents this voltage divider circuit from loading the output of the diode 80.

The output of the amplifier 90 at the conductor is applied through the resistor 104 as an input to the amplifier 106. The amplifier 106 is powered from the 120v ac supply through the resistor 108 and the output of the amplifier 106 at the conductor 110 is taken, through the diode 112 as the gating signal input to the gate electrode 114 of a TRIAC device 116. The machine power control load system 58 is also powered from the 120 volt ac supply and is connected in series thereacross through the TRIAC 116 and the relay switch 118. The coil 120 of the relay normally is energized through the transistor switch 122 so that the relay switch 118 is closed to ground as shown to complete the supply circuit through the power control 58, the TRIAC 116 and the relay switch 118.

The conductor 124 is connected to the junction between the load 58 and the TRIAC 116 and is connected, through the diode 126, so as to pass only positive pulses to the voltage divider chain 128, 130 which protect the input to the amplifier 132. These positive pulses are smoothed or filtered by the capacitor 134 so as normally to maintain a dc voltate level input at the conductor 136 to the amplifier 132 due to the normal voltage drop across the TRIAC 116. The other input to the amplifier 132, at the conductor 138 is from the junction between the voltage dividing chain of resistors 140, 142, the latter of which is adjustable so as to adjust the switching point of the amplifier 132. The output of the amplifier 132 at the conductor 144 is applied through a current limiting resistor 146 to the base electrode of the transistor 122 and, in the presence of a voltage level at the input 136 indicative of the predetermined voltage drop across the TRIAC 116, maintains the transistor 122 on. The variable resistor 148 is utilized to adjust the turn on point of the transistor 122.

In the arrangement according to FIG. 3, which is intended for a system as is generally illustrated in FIG. 2, for controlling the operation of a machine such as a punch press or the like, the presence of the human body or a portion thereof within the range of the antenna which is connected to the terminals **60** and **62** will cause sufficient decrease in the output of the amplifier **90** at the conductor **96** as will be insufficient to produce an output from the triggering amplifier **106** as to maintain the TRIAC **116** on. As a result, the circuit through the power control system **58** will be interrupted and the associated machine will be inoperative so that no harm may come to the person affecting the antenna circuitry. If the TRIAC **116** develops a short fault, such that its offset voltage decreases below a predetermined amount, the potential at the conductor **124** will be at or substantially zero and insufficient output will present from the amplifier **132** to maintain the transistor **122** on, thus allowing the relay switch **118** to open and disable the control **58.**

What is claimed is:

1. A control system for use in combination with an electrical load and a source of potential for said load, said control system comprising:

first switch means and second switch means connected in series to each other and to said load for completing the circuit through said load from said supply, said first switch means normally producing a predetermined voltage drop thereacross when closed to complete the circuit through said load;

control means for operating said first switch means between open and closed conditions; and

means responsive to the existence of said predetermined voltage drop across said first switch means for maintaining said second switch means in closed condition:

2. A control system as defined in claim **1** wherein said electrical load is the power control for an industrial machine and said control means is a device for detecting the presence of the human body or a portion thereof in a prohibited region of said machine.

3. A control system as defined in claim **2** wherein said control means includes a capacity tuned circuit for detecting the human body and an oscillator driving such circuit.

4. A control system as defined in claim **3** wherein said control means also includes a second capacitively tuned circuit driven by said oscillator and having a fixed frequency response.

5. In a control system as defined in claim **4** wherein the frequency response of said second tuned circuit is different from the frequency response of the first tuned circuit when the latter is not influenced by the human body, and said control means also includes a comparator having the outputs of said tuned circuits as inputs thereto.

6. In a control system as defined in claim **5** wherein both tuned circuits are initially tuned to the same side of the frequency of said oscillator.

7. In a control system as defined in claim **6** wherein the presence of a human body tends to cause the frequency response of said first tuned circuit to approach that of said second tuned circuit.

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