Oct. 7, 1969 A. W. WETMORE 3,471,689

LOGIC CIRCUITRY FOR RAILROAD CROSSING SYSTEMS

Filed Oct. 23, 1967 5 Sheets-Sheet 1

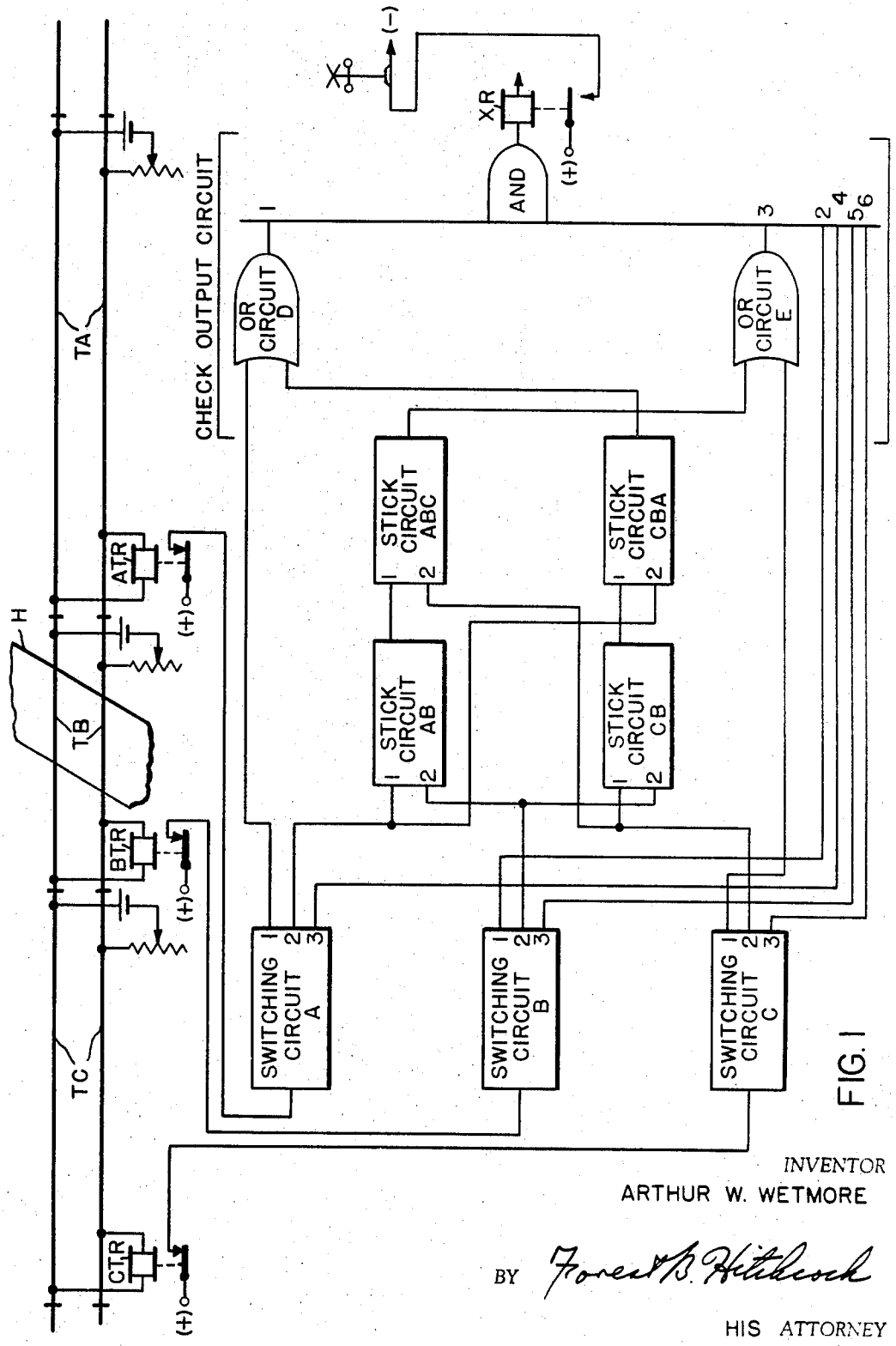


FIG. 1

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LOGIC CIRCUITRY FOR RAILROAD CROSSING SYSTEMS

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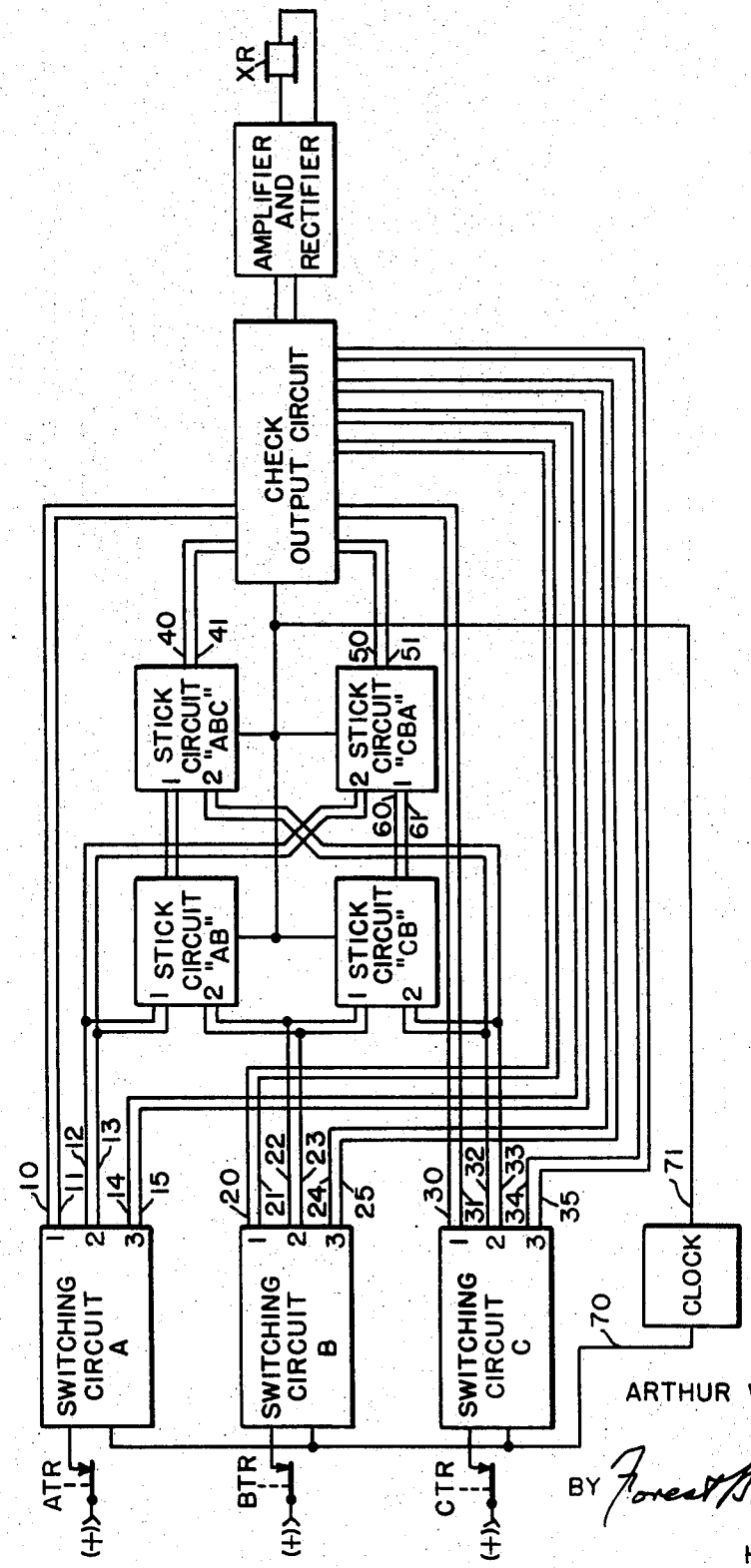


FIG. 2

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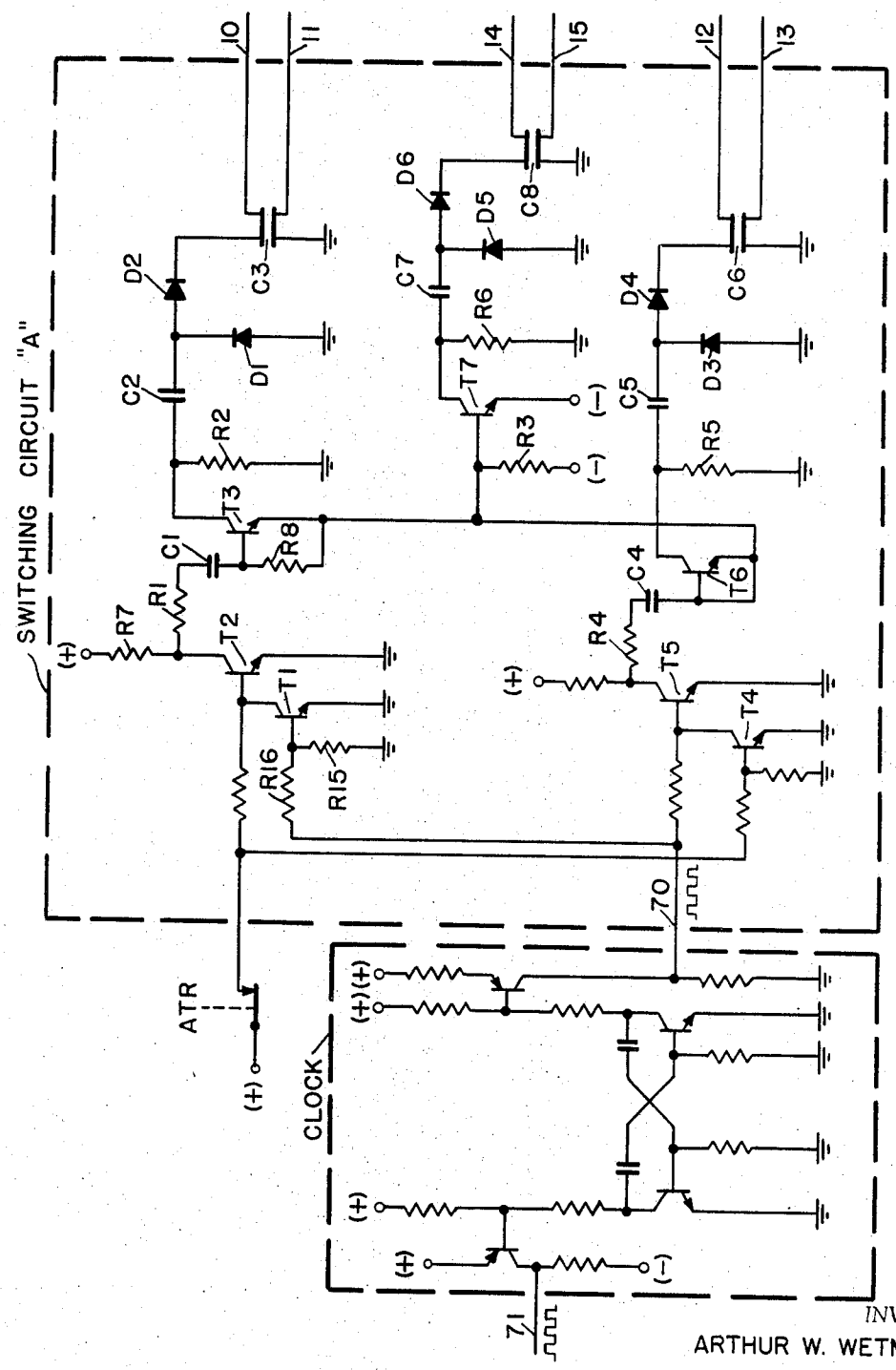


FIG. 3

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LOGIC CIRCUITRY FOR RAILROAD CROSSING SYSTEMS

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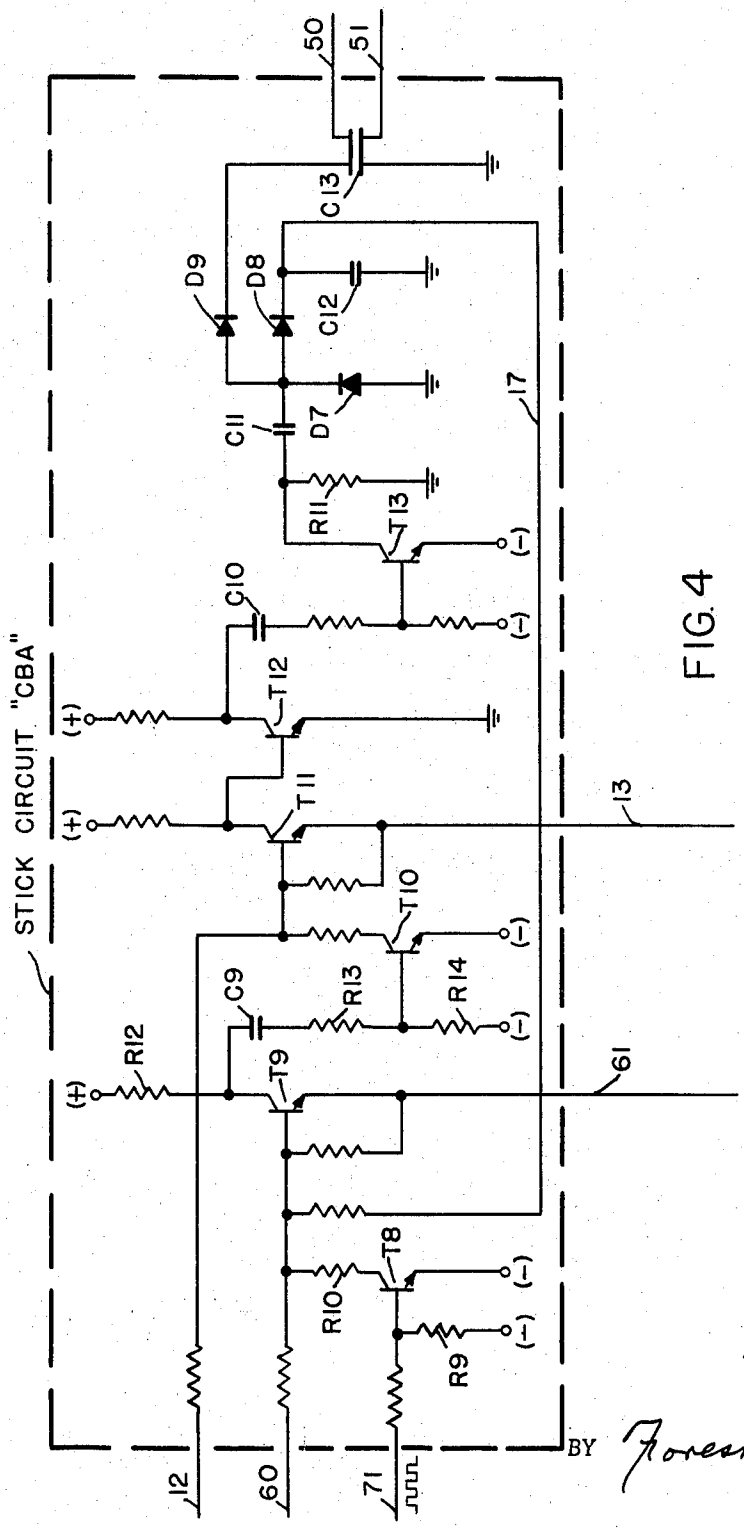


FIG. 4

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LOGIC CIRCUITRY FOR RAILROAD CROSSING SYSTEMS

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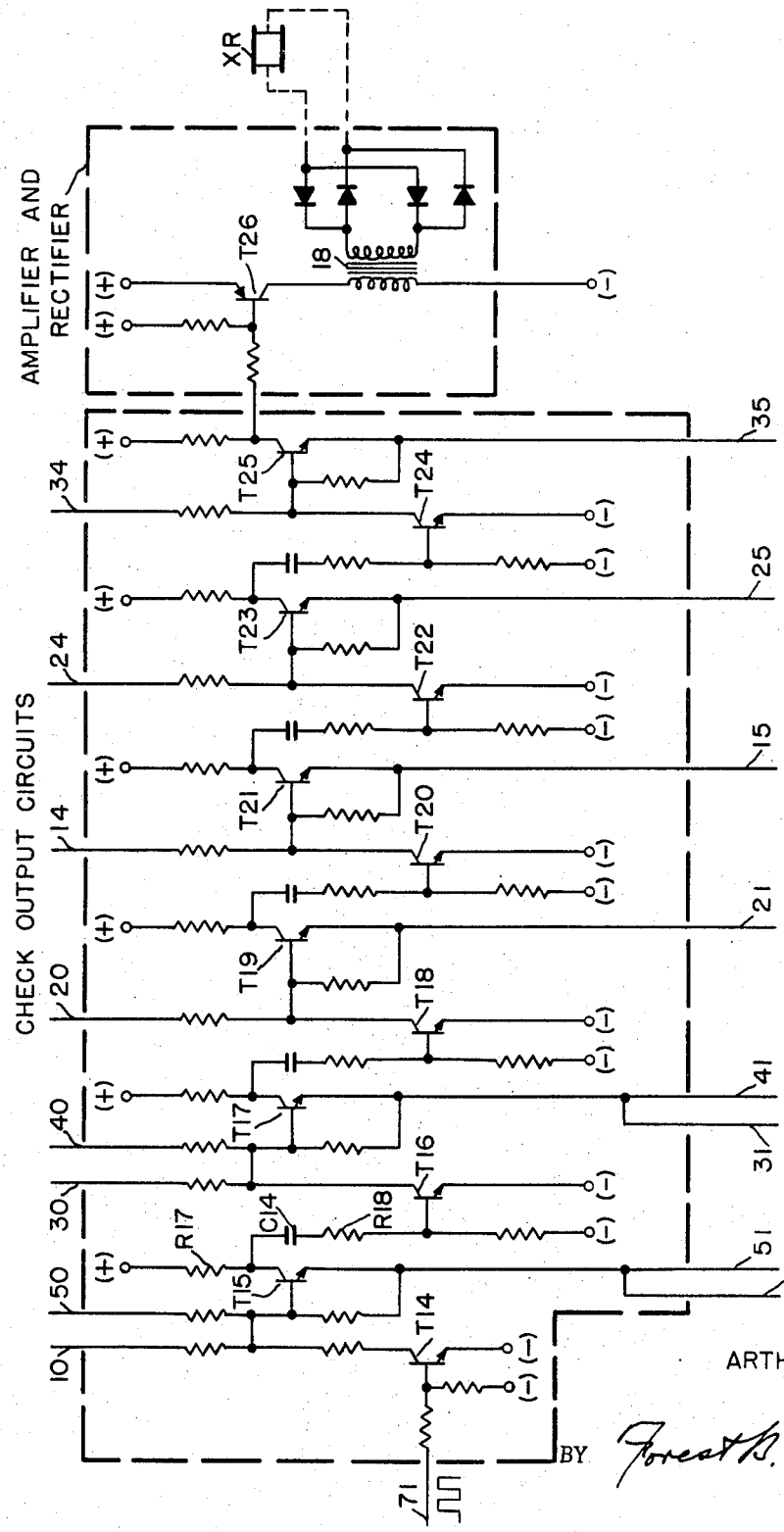


FIG. 5

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United States Patent Office 3,471,689
Patented Oct. 7, 1969

3,471,689

LOGIC CIRCUITRY FOR RAILROAD CROSSING SYSTEMS

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Filed Oct. 23, 1967, Ser. No. 677,139
Int. Cl. B61l 1/02, 1/12
U.S. Cl. 246—125 13 Claims

ABSTRACT OF THE DISCLOSURE

Logic circuitry utilizing transistorized switching circuits arranged to provide a check on their own proper operation. Each switching circuit monitors a single track section and provides three electrical outputs indicating respectively, train absence, train presence, and the proper functioning of the device itself. These outputs are fed into other transistorized circuit elements consisting of stick circuits, "AND" circuits and "OR" circuits logically arranged so as to activate a motorist warning system when a train is approaching a crossing from either direction, when a train is traversing the crossing, or when a circuit failure occurs and to deactivate the warning system as soon as a train has cleared the crossing.

BACKGROUND OF THE INVENTION

Field of use

This invention relates to highway crossing systems for railroads, and more particularly relates to solid state logic circuitry for use in such systems with the organization arranged to check the operability of the system.

Description of the prior art

The purpose of the logic circuitry found in a typical railroad crossing protection system is to automatically cause the warning system for motorists to be activated during the time when a train is approaching a crossing from either direction, to remain activated while the train is traversing the crossing and to be deactivated as soon as possible thereafter, even though the train may still be influencing the circuitry as it is leaving the crossing area. A further requirement imposed upon railroad crossing protection system circuitry is that it be fail-safe. In other words, if a malfunction occurs, it should result in the activation of the motorist warning system. At present these logic functions are accomplished largely through the use of relays. Although the relays employed for this purpose are highly reliable, it is nonetheless desirable to replace them, If possible, with solid state devices. Since solid state devices do not have moving parts, increased reliability is attainable through their use. Furthermore, by the use of solid state devices the cost of installing, maintaining and operating the logic circuitry for crossing protection systems may be lowered.

One reason why transistors have not been used heretofore in the logic circuitry of crossing protection systems is the difficulty of achieving fail-safe operation with their use. In present day crossing protection systems train presence in a track section in approach of a crossing is detected and used to initiate an electrical signal which, in turn, energizes a directional stick relay. This electrical signal is easily obtained by passing current through the back contact of a track relay. This is considered to be safe because the materials and design used in such track relays make it extremely improbable that the back contact will fuse and provide a false electrical signal. Those versed in the art will realize that if such a malfunction does take place when a train passes in a given direction, a second train subsequently approaching the crossing in

the opposite direction will not be protected. Thus, great care must be taken to insure that a stick circuit, once established, will be deenergized after a train has passed. A transistor can be used to supply an electrical signal analogous to that obtained from the back contact of the track relay. But the degree of certainty that a transistor will cease to provide such a signal command is not sufficient for use in railroad work. As is well known, a sufficiently high spurious voltage can cause a transistor to fuse, thereby rendering it incapable of being turned off. This invention overcomes this problem through the use of novel circuit arrangements which cause the warning system to be activated in the event of a circuit failure, including the type mentioned.

It is accordingly an object of this invention to provide logic circuitry for railroad crossing protection systems which takes advantage of the characteristics of transistors.

It is a further object of this invention to provide transistorized logic circuitry for railroad crossing protection systems which will be fail-safe in operation.

SUMMARY OF INVENTION

The invention contemplates the use of switching means to monitor the occupancy conditions of track sections on and about a crossing. Each switching means provides an indication of train absence, of train presence and of its own proper functioning. Check output means, responsive to the switching means are provided to activate the motorist warning system when a train is present in a track section in approach of or on the crossing or when any switching means is not operating properly. Stick circuit means, also responsive to the switching means, are provided to deactivate the motorist warning system while a train which has traversed the crossing continues to travel in a monitored track section.

BRIEF DESCRIPTION OF THE DRAWINGS

A fuller understanding of the present invention will be had by reference to the following description taken in connection with the accompanying drawings briefly described as follows:

FIG. 1 is a schematic drawing of a portion of the invention showing the logic functions performed by the invention.

FIG. 2 is a general wiring diagram of the invention.

FIG. 3 is a schematic drawing typical of the switching circuits shown in FIGS. 1 and 2.

FIG. 4 is a schematic drawing typical of the stick circuits shown in FIGS. 1 and 2.

FIG. 5 is a schematic diagram of the check output circuits shown in FIGS. 1 and 2.

Throughout the drawings conventional symbols have been used for brevity. For example, a center tapped D.C. supply is employed in the invention and the symbol (+) is used to indicate its positive terminal; the symbol (−) is used to indicate its negative terminal; and the symbol normally employed to designate ground is used to indicate the center or common terminal of the supply.

A general understanding of the overall operation of the invention and of the logic functions it performs will be obtained from a study of FIG. 1. A detailed explanation of the invention will be given in connection with the other figures. At the top of FIG. 1 there is shown a stretch of railway track intersected by a highway H. This stretch of track is divided into three sections, two approach sections TA and TC separated by an intermediate section TB. Each section comprises a track circuit and the associated relays, normally energized, are designated ATR, BTR and CTR. Connected to the front contact of each track relay there is shown a separate switching circuit means designated A, B or C, each having three outputs. Output 1 of each switching circuit is connected to the

check output circuits shown in the figure. For example, output 1 of circuit A and output 1 of circuit C are connected to the OR circuits D and E respectively. Output 1 of switching circuit B is connected directly as an input to the AND circuit. The output of the AND circuit is connected to the winding of relay XR, shown as being normally energized. The back contact of relay XR is connected to a motorist warning system. The stick circuits shown have inputs designated 1 and 2. Stick circuits AB and CB receive their inputs, as shown, from certain ones of the outputs marked 2 of the various switching circuits. Stick circuits ABC and CBA receive their inputs from outputs 2 of switching circuits C and A respectively, and from the stick circuits AB and CB. The output of stick circuits ABC and CBA are connected to the check output circuit at OR circuits E and D respectively. Output 3 of each switching circuit forms a direct input to the AND circuit.

Before discussing the overall operation of the crossing system, the mode of operation of the individual circuit components shown in FIG. 1 will be explained. The switching circuits A, B and C are identical in structure and operation. When an input is supplied from its associated relay, each switching circuit will provide its output 1 while not providing its output 2. When the input is removed, output 1 will cease and output 2 will appear. Output 3 is always given unless a malfunction develops in the switching circuit. Thus, output 1 may be thought of as a train absence indication; output 2 may be thought of as a train presence indication, and output 3 may be thought of as a check upon the switching circuit.

The stick circuits AB, CB, ABC and CBA are likewise identical with one another in structure and operation. If inputs 1 and 2 are simultaneously applied to a given stick circuit, it will be energized and will provide an output. Once energized, the output of a stick circuit will continue as long as input 2 is maintained. Any time input 2 is removed, the stick circuit will be deenergized.

The circuit components collectively designated "Check Output Circuits" have been illustrated with conventional logic symbols. When one or both inputs are supplied to an OR circuit, it will provide an output; when and only when all inputs are simultaneously supplied to the AND circuit, it will provide an output.

When no train is present, all track relays are energized and all switching circuits are supplied with an input. Switching circuits A and C each provide output 1 to their respective OR circuit which, in turn, supplies the AND circuit with inputs 1 and 3. Switching circuit B provides AND circuit input 2. Output 3 of the respective switching circuits form AND circuit inputs 4, 5 and 6. All inputs being present, the AND circuit provides an output which maintains relay XR energized and the crossing signal is not activated. No stick circuit is energized at this time.

When a train, travelling from east to west enters track section TA, relay ATR will release. With its input thus removed, switching circuit A will provide output 2 and output 1 will cease. Input 1 is supplied to stick circuit AB and input 2 is supplied to stick circuit CBA. Input 1 of the AND circuit is removed. This causes its output to cease, dropping relay XR and activating the warning system.

When the train enters track section TB, relay BTR will release, removing the input to switching circuit B. Output 1 of switching circuit B will cease and output 2 will commence. The condition of switching circuit A will remain unchanged, at least momentarily, because the train, even if short, will straddle track sections TA and TB. Therefore, stick circuit AB is supplied with inputs 1 and 2 simultaneously and it provides input 1 to stick circuit ABC. Input 2 is supplied to stick circuit CB. The motorist warning system remains activated because AND circuit input 2 is not available as long as the train occupies track section TB.

When the train enters track section TC, output 2 of switching circuit C will begin and output 1 will cease.

During the time when the train occupies track sections TB and TC simultaneously, stick circuit AB remains energized since its input 2 is maintained. Stick circuit ABC is therefore energized because inputs 1 and 2 are supplied to it simultaneously. Stick circuit CB likewise is energized at this time. Stick circuit CBA may be energized if all three track sections are being occupied, but it will be deenergized as soon as the rear of the train clears track section TA, removing its input 2.

As mentioned above, while the train occupies track section TB, the warning system will remain activated because input 2 will not be supplied to the AND circuit. When the rear of the train clears track section TB, switching circuit B provides output 1 and output 2 ceases. Sticq circuits AB and CB are deenergized since no input 2 is supplied to either of those circuits. Stick circuit ABC is maintained energized as long as the train occupies track section TC. At this point therefore, the situation is as follows: switching circuit A supplies output 1 which passes through OR circuit D to input 1 of the AND circuit; switching circuit B supplies its output 1 to input 2 of the AND circuit; and stick circuit ABC supplies an input through OR circuit E to input 3 of the AND circuit. Assuming that the switching circuits have continued to operate properly, AND circuit inputs 4, 5 and 6 are maintained. Consequently, the warning system is deactivated. It can be noted in passing that if a following train were to enter track section TA at this time, the warning system would be activated. Switching circuit A would not, in that case, supply its output 1 to the AND circuit.

After the rear of the train clears track section TC, switching circuit C will no longer provide an output 2 and output 1 will be restored. Stick circuit ABC is therefore deenergized. The various circuits are thus returned to their original condition of holding the warning system deactivated. For trains travelling from west to east, a cycle of operation similar to that described above takes place.

Referring now to FIG. 2, there is shown a general organization and wiring diagram of the logic circuitry of the crossing system. It is generally similar to FIG. 1. In addition to the circuit components shown in FIG. 1, however, there is shown a clock, an amplifier and a rectifier. Also, the switching circuits and stick circuits are shown as providing for various outputs on conductor pairs. As mentioned earlier, the switching circuits are identical with one another in structure and operation, as are the stick circuits. For brevity therefore, only switching circuit A and stick circuit CBA are shown in detail in FIGS. 3 and 4 respectively. The check output circuits are shown in detail in FIG. 5, together with the amplifier and rectifier. The clock is shown in detail in FIG. 3. The same designations used for the conductors shown in FIG. 2 are used in the remaining figures. For example, conductors 10 and 11 in FIG. 2 are the conductors bearing the same designations in FIGS. 3 and 5. Conductors 12 and 13 in FIG. 2 are the conductors bearing the same designations in FIGS. 3 and 4. Conductors 14 and 15 in FIG. 2 are the conductors bearing the same designations in FIGS. 3 and 5. Conductors 60 and 61 in FIG. 2 are the conductors bearing the same designations in FIG. 4. Conductors 50 and 51 in FIG. 2 are the conductors bearing the same designations in FIGS. 4 and 5.

FIG. 3 shows, in detail, switching circuit A and the clock circuit. The clock may be any circuit capable of producing a square wave of suitable frequency and having two separate outputs, one referenced to common, the other to negative. A simple multivibrator is shown by way of example only. Its mode of operation is familiar to those versed in the art.

The switching circuit is supplied with two inputs, one from the front contact of track relay ATR and one from the clock. There are three output conductor pairs designated 10 and 11, 14 and 15, and 12 and 13. As shown, the base of transistor T1 is connected to common through resistor R15 and to the clock pulse source

through resistor R16. Its emitter is connected to common also, while its collector is connected to the base lead of transistor T2. The emitter of transistor T2 is connected to common and its collector is connected through resistor R7 to positive. The collector of transistor T2 is coupled through resistor R1 and capacitor C1 to the base lead of transistor T3. The collector of transistor T3 is connected to a D.C. restoring circuit comprised of resistor R2, condensers C2 and C3 and diodes D1 and D2. The output of this branch of the circuit appears across conductors 10 and 11. The other branch of the circuit which provides an output across conductors 12 and 13 is comprised of similarly arranged circuit elements. As shown in FIG. 3, the base lead of transistor T7 is connected to the emitters of transistors T3 and T6. Its emitter is connected to negative while its collector is connected to a D.C. restoring circuit comprised of resistor R6, capacitors C7 and C8 and diodes D5 and D6. An output appears across conductors 14 and 15.

The square wave signal impressed upon conductor 70 by the clock is applied to the bases of transistors T1 and T5. This signal varies between common and positive and the bias conditions are such that it will have the effect of turning transistor T1 on and off at the clock frequency. With track relay ATR energized, a positive D.C. signal is applied through its front contact to the base of transistor T2, biasing that transistor on. However, with transistor T1 switching on and off, this D.C. signal will be chopped. The result of this chopping action is that transistor T2 will likewise be switching on and off at the clock frequency. When transistor T2 is off, condenser C1 will charge by way of a path from positive through resistors R7 and R1, and through the base emitter junctions of transistors T3 and T7 to negative. The initial effect of this forward biasing current is to turn transistors T3 and T7 on. When transistor T2 subsequently turns on, the voltage at the junction between resistors R7 and R1 will decrease below that of the charged capacitor C1. At this time the capacitor will discharge and current will flow in the opposite direction from negative through resistor R3, resistor R8, capacitor C1, resistor R1, transistor T2 to common. The effect of this is to bias transistors T3 and T7 off. It can thus be seen that transistors T3 and T7 will be switching on and off at the clock frequency. It should be noted that if transistor T2 should fail by opening from collector to emitter, capacitor C1 would, in effect, be continuously connected across the positive and negative sides of the power supply. A current would then flow through the base emitter junctions of transistors T3 and T7 only long enough to bring capacitor C1 to a full charge. Thus, transistors T3 and T7 could not be switching. Furthermore, if condenser C1 shorted, the bases of transistors T3 and T7 would receive a signal directly from the collector of transistor T2 through resistor R1. This would cause the voltage applied to the bases of transistors T3 and T7 to swing between positive and common. Since the emitters of these transistors are connected to the negative supply they would not be switching, but would remain steadily on. Again the switching action is lost.

When transistor T3 is on, capacitor C2 will charge from common through diode D1, transistor T3, resistor R3 and transistor T7 to negative. When transistor T3 is off, capacitor C2 will discharge through diode D2, capacitor C3 and resistor R2. Capacitor C3 is a four terminal capacitor. The terminals on each side are located at either end of the capacitor plates. Thus, as capacitor C2 discharges, the upper plate and conductor 10 will be driven positive while the lower plate and conductor 11 will be maintained at common. At the same time capacitor C3 will receive a charge. During the times when capacitor C2 is charging, capacitor C3 will discharge across any load placed between conductors 10 and 11. The result is that conductor 10 will be continuously maintained positive while conductor 11 will be maintained at common.

As explained above, with a D.C. input through the front contact of relay ATR, an output will appear across conductors 10 and 11. At this time transistor T4 will be driven to saturation by the positive D.C. input, thus biasing transistor T5 off. When relay ATR releases, transistor T4 will be off. The clock pulse on conductor 70 will therefore be applied to the base of transistor T5 causing it ot switch on and off. Transistors T6 and T7 will switch on and off also, causing outputs to appear across conductors 14 and 15 and 12 and 13. At this time however, no output will appear across conductors 10 and 11 because there will be no positive input to the base of transistor T2 to turn it on. Although transistor T1 will be switching, the potential of its collector will never rise above common.

In summary, it can be seen that with a D.C. input from the front contact of relay ATR, a D.C. output will appear across conductor pairs 10 and 11 and 14 and 15 while no output will appear across conductor pair 12 and 13. When the D.C. input is removed, no output will appear across conductor pair 10 and 11 while a D.C. output will appear across conductor pairs 14 and 15 and 12 and 13.

The clock signal goes through one more stage in reaching transistor T3 than it does in reaching transistor T6. As can be readily seen, the signal applied to the base of transistor T6 is out of phase with the clock, while the signal applied to the base of transistor T3 is in phase with the clock. If a failure should occur, such that both T3 and T6 should be driven simultaneously, the sum of their respective driving signals would be applied to the base of transistor T7. Under those circumstances T7 could not switch and its output appearing across conductor pair 14 and 15 would cease. Of course, if neither transistor T3, nor transistor T6, is being driven, T7 could not switch and again, the output across conductor pair 14 and 15 would cease. The reader's attention is directed to the fact that conductors 14 and 15 feed directly into the AND portion of the check output circuit, as shown in FIGS. 1 and 5. This serves as a check upon the switching circuit. If the output across conductors 14 and 15 should cease at any time, the output from the check output circuits would cease, causing the crossing relay XR to release and activating the motorist warning signal. The switching circuit could also fail in such a manner that an intended output would not appear across conductor pairs 10 and 11 or 12 and 13. But such a failure is on the side of safety as will be more fully appreciated hereinafter.

FIG. 4 shows in detail the circuitry of stick circuit CBA. Conductor 71 is connected to the clock. The square wave impressed upon this conductor by the clock swings between positive and negative. The base of transistor T8 is connected to conductor 71 and to negative through resistor R9. Its emitter is connected to negative while its collector is connected through resistor R10 to the base of transistor T9. The base of transistor T9 is also connected to conductor 60. The emitter of transistor T9 is connected to conductor 61 while its collector is connected to positive through resistor R12. The base of transistor T10 is coupled through capacitor C9 to the collector of transistor T9. Its emitter is connected to negative while its collector is connected to the base of transistor T11. Also connected to the base of transistor T11 is conductor 12. The emitter of transistor T11 is connected to conductor 13 while its collector is connected to positive through a resistor. The base of transistor T12 is connected to the collector of transistor T11. Its emitter is connected to common while its collector is connected to positive through a resistor. The base of transistor T13 is capacitively coupled to the collector of transistor T12. Its emitter is connected to negative while its collector is connected to a D.C. restoring circuit comprised of capacitors C11, C12 and C13, resistor R11, and diodes D7, D8 and D9.

The clock signal is continuously applied to conductor **71**. The base of transistor T8 is therefore made to swing between positive and negative. Transistor T8 will therefore be switching on and off at the clock frequency. When stick circuit CB, shown in FIGS. 1 and 2, is energized, conductor **60** is maintained positive while conductor **61** is maintained at common. This would ordinarily turn transistor T9 on. But the switching action of transistor T8 chops the input to the base of transistor T9, causing it to switch at the clock frequency. When transistor T9 is off, capacitor C9 will charge from positive through resistor R12, resistor R13 and transistor T10 to negative. The result of current flowing in the direction will turn transistor T10 on. When transistor T9 is on, capacitor C9 will discharge in the opposite direction through transistor T9 to common and through resistors R14 and R13. At this time transistor T10 will be biased off. Transistor T10 therefore switches at the clock frequency when transistor T9 is supplied with the input across conductor pair **60** and **61**.

As noted in the above discussion of switching circuit A, when an output appears across conductor pair **12** and **13**, conductor **12** will be maintained positive while conductor **13** is connected to common. With such an input present, transistor T11 will be switching at the clock frequency due to the chopping affect of transistor T10. The base of transistor T12 will be made to swing between positive and common and it will likewise switch at the clock frequency. Transistor T13 will also be switching and an output will appear across conductors **50** and **51**. Conductor **50** will be maintained positive while conductor **51** is connected to common. Part of the positive output of the D.C. restoring circuit is fed back to the base of transistor T9 by way of conductor **17**. Therefore, once the circuit has been supplied with simultaneous positive inputs on conductors **12** and **60**, the removal of the positive signal from conductor **60** will have no effect on the output of the circuit. The positive feedback signal on conductor **17**, in effect, replaces the positive input on conductor **60**. If the positive signal on conductor **12** is removed however, transistor T11 will no longer switch. Its emitter is connected to common through conductor **13**, as shown in FIG. 3, and transistor T10 is referenced to negative. Hence, in that case the output across conductor pair **50** and **51** would cease.

In summary, the stick circuit is energized by the simultaneous application of two positive D.C. input signals. Once energized, the output of the stick circuit will continue even though a certain one of the inputs is removed. Should the other input be removed at any time however, the output from the stick circuit will cease.

FIG. 5 shows in detail the arrangement of the check output circuits. Conductor **71** is connected to the clock. The square wave impressed upon this conductor swings between positive and negative. The base of transistor T14 is connected to negative and to conductor **71**. Its emitter is connected to negative while its collector is connected to the base of transistor T15. The emitter of transistor T15 is connected to conductors **51** and **11**. Its base is connected to conductors **10** and **50**. The collector of transistor T15 is connected to positive through resistor R17 and capacitively coupled to the base of transistor T16. The base of transistor T16 is also connected to negative through a resistor. Its emitter is connected to negative while its collector is connected to the base of transistor T17. It can be seen that the same pattern is repeated throughout the remainder of the check output circuits. One difference to be noted however, is that transistors T19, T21, T23 and T25 are each connected to only one conductor pair. For example, transistor T19 is connected to conductor pair **20** and **21**. Transistors T15 and T17 on the other hand are connected to two conductor pairs.

With a continuous input on conductor **71**, transistor T14 will be switching at the clock frequency. If either conductor **10** or conductor **50** is maintained positive while conductors **11** and **51** are maintained at common, transistor T15 will also be switching at the clock frequency. This is so because the switching action of transistor T14 chops the input to the base of transistor T15. When transistor T15 is off, current will flow from positive through resistor R17, capacitor C14, resistor R18 and transistor T16 to negative, thus causing T16 to go on. When T15 is on, capacitor C14 will discharge, reversing the direction of current flow and transistor T16 will go off. Transistor T16 will therefore be switching at the clock frequency. The remainder of the circuit operates in a similar fashion. It can be seen that if all of the odd numbered transistors are supplied with a positive signal on the associated even numbered conductors, each of those transistors will be switching. An output will thus appear on the collector of transistor T25 in the form of the clock signal. It should be noted at this point, that transistor T15 and its associated conductor pairs **10** and **11** and **50** and **51** corresponds to the OR circuit D of FIG. 1. Transistor T17 and its associated conductor pairs corresponds to OR circuit E of FIG. 1. The remainder of the check output circuit corresponds generally to the AND circuit of FIG. 1.

The output from the collector of transistor T25 is amplified by transistor T26. It is then transferred to the isolated secondary of transformer **18**. After rectification in the usual manner, it is used to hold the crossing relay XR energized.

It should be clear from the above description that this invention proivdes for the use of transistorized circuitry in a crossing system in a safe manner. The transistors used throughout the circuitry are relied upon only so long as they are switching. Should one fail, an essential input to the check output circuitry will cease and the motorist warning system will be energized. Failure in other circuit components would produce the same result.

While there has been described what is at present considered to be the preferred embodiment of this invention it will be obvious to those skilled in the art that various changes and modifications may be made therein, without departing from the invention, and it is therefore aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim is:

1. Control apparatus for a railroad crossing protection system having means for detecting train presence in a predetermined section of track and a motorist warning system comprising:

switching means responsive to the detector means for providing a first output only when no train is detected, and a second output as long as the switching means is functioning properly;

check output means responsive to the switching means and adapted to activate the motorist warning system only when said switching means does not provide its first output of when said switching means does not provide its second output.

2. Control apparatus for a railroad crossing protection system having a plurality of track sections, one of which intersects a highway, and having means for detecting the presence of a train in each section and having a motorist warning system comprising:

a plurality of switching means each selectively responsive to the detector means for providing a first output when no train is detected in a particular track section, a second output when a train is detected in that section and a third output as long as the switching means is functioning properly;

check output means responsive to the switching means for activating the warning system whenever any switching means does not provide its first output or whenever any switching means does not provide its third output; and

stick means selectively responsive to more than one switching means for preventing the check output means from activating the motorist warning system when a train has passed through the section intersecting the highway and is detected in another section only.

3. Logic circuitry for a railroad crossing protection system having a plurality of track sections and means for detecting the presence of a train in each section and having a motorist warning system comprising:

a plurality of switching circuit means each selectively responsive to the detector means for providing a first output when no train is detected in a particular section, a second output when a train is detected in that section and a third output when the first or second, but not both outputs are being provided;

check output circuit means responsive to the switching circuit means for activating the warning system whenever any switching circuit means does not provide its first output or whenever any switching circuit means does not provide its third output; and

stick circuit means selectively responsive to more than one switching circuit means for providing an electrical output to the check output means in place of a first output not being provided by the switching circuit means for a track section in which a train, having traversed the crossing, is present.

4. Logic circuitry for a railroad crossing protection system having a warning system for motorists and a stretch of railway track having two approach sections separated by an intermediate section which is intersected by a highway and having means for detecting train presence in any section, comprising:

first, second and third switching circuit means responsive to the train presence detector means and situated so that the first will be responsive to the presence of a train in one approach section, the second to a train in the intermediate section and the third to a train in the other approach section, each of said switching circuit means being adapted to provide a first electrical output when no train is detected in its respective section, a second electrical output when a train is detected therein and a third electrical output whenever the first or second, but not both, outputs are present;

stick circuit means responsive to more than one switching circuit means for providing a first electrical output when a train has traversed the crossing in one direction and is detected in the one approach section and a second electrical output when a train has traversed the crossing in the other direction and is detected in the other approach section; and

check output circuit means responsive to the switching circuit means and the stick circuit means for activating the warning system only when any switching circuit means does not provide its third output or when the second switching circuit means does not provide its first output or when the first switching circuit means does not provide its first output while the stick circuit means is not providing its first output or when the third switching means does not provide its first output while the stick circuit means is not providing its second output.

5. Logic circuitry for a railroad crossing protection system having a motorist warning system and having two approach track sections divided by an intermediate track section, each section being monitored by a train presence detector, comprising:

a first, second and third switching circuit means selectively connected to the train presence detectors so that the first will be responsive to the presence of a train to one approach section, the second to a train in the intermediate section and the third to a train in the other approach section, each of said switching circuit means being adapted to provide a first electrical output when no train is detected in its section, a second electrical output when a train is detected therein and a third electrical output whenever the first or second, but not both, outputs are present;

a first stick circuit means connected to the second outputs of the first and second switching circuit means for providing an electrical output when those switching circuit means simultaneously provide their second outputs and thereafter as long as the second provides its said output;

a second stick circuit means connected to the output of the first stick circuit means and to the second output of the third switching circuit means for providing an electrical output when the first stick circuit and the third switching circuit means simultaneously provide their said outputs and thereafter as long as the third switching circuit means provides its said second output;

a third stick circuit means connected to the second outputs of the second and third switching circuit means for providing an electrical output when those switching circuit means simultaneously provide their second outputs and thereafter as long as the second switching circuit means provides its said second output;

a fourth stick circuit means connected to the output of the third stick circuit means and to the second output of the first switching circuit means for providing an electrical output when the third stick circuit and first switching circuit simultaneously provide their said outputs and thereafter as long as the first switching circuit provides its said second output; and

check output circuit means connected to the first and third output of each switching circuit means and to the outputs of the second and fourth stick circuit means for activating the motorist warning system only when the third output of any switching circuit means is not present or when the first output of the second switching circuit means is not present or when the first output of the first switching circuit means is not present while the fourth stick circuit means output is not present or when the first output of the third switching circuit means is not present while the second stick circuit means output is not present.

6. The invention according to claim 5 wherein each of said switching circuit means comprises an operating energy input terminal, a terminal for connecting said switching circuit means to the train presence detector means, a first switching device connected to both terminals and adapted to provide the first output when operating energy is applied and there is an input on the detector terminal, a second switching device connected to both terminals and adapted to provide the second output when operating energy is applied and there is no input on the detector terminal, a third switching device connected to the first and second switching devices and adapted to provide the third output when either, but not both, of the first and second devices are providing their respective outputs.

7. The invention according to claim 6 wherein said switching devices are solid state devices.

8. The invention according to claim 7 wherein the operating energy input terminal is an A.C. terminal, the detector terminal is a D.C. terminal and wherein said solid state devices are transistor devices.

9. The invention according to claim 5 wherein the switching means comprises an A.C. energy input terminal, a terminal connection to the train presence detector, a first plurality of transistors connected to the A.C. terminal and to the detector terminal and adapted to be switching on and off in response to the A.C. energy only when an electrical input is supplied to the detector terminal, a second plurality of transistors connected to the A.C. terminal and to the detector terminal and adapted to be switching on and off in response to the A.C. energy only when no electrical input is supplied to the detector terminal and a third transistor connected to the first and second pluralities of transistors and adapted to be switch-

ing on and off in response to the A.C. energy only when either but not both of said pluralities is switching on and off, whereby to provide said first, second and third outputs.

10. The invention according to claim **9** wherein each of said plurality of transistors and the third transistor is connected to a D.C. restoring means for providing said first, second and third outputs as D.C. outputs.

11. The invention according to claim **5** wherein each of the stick circuit means comprises

an A.C. input terminal and more than one other input terminal,

a plurality of transistors serially connected so that the base of a succeeding one is coupled to the collector of the prior transistor, the first of which is connected to the A.C. terminal and successive ones of which are selectively connected to said other input terminals, said plurality of transistors being adapted to switch on and off in response to input A.C. energy, whereby to provide said output, only when all said other input terminals are simultaneously supplied with electrical energy and thereafter as long as a predetermined one of said other input terminals is supplied with electrical energy.

12. The apparatus of claim **11** wherein said output is connected to a D.C. restoring means for providing said output as a D.C. output, and wherein said D.C. output is

connected to at least one of said other input terminals for supplying electrical energy to said terminal.

13. The invention according to claim **5** wherein the check output circuit means comprises

an A.C. input terminal and a plurality of other input terminals,

a plurality of transistors interconnected so that the base of a succeeding transistor is coupled to the collector of the prior transistor, the first of which is connected to the A.C. terminal and successive ones of which are selectively connected to at least one of said other input terminals, said plurality of transistors being adapted to switch on and off in response to the A.C. energy, whereby to provide an output for holding the warning system deactivated, only when each transistor which is so connected to at least one of said other terminals is supplied with an electrical input through at least one of said terminals.

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