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[31] 42-79,645

[54] **TRAFFIC SIGNAL CONTROL SYSTEM**
4 Claims, 2 Drawing Figs.

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[51] Int. Cl. G08g 1/097
[50] Field of Search 340/46, 41, 37

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ABSTRACT: A system is provided for controlling the operation of traffic control systems at an intersection in the event of certain malfunctions in signal operation. A normally operative traffic signal controller is continuously monitored and in the event of malfunction, a malfunction signal is produced which causes deactivation of the normally operative signal controller and causes a normally inoperative controller to assume operation of the signals for a predetermined period of time, after which the normally operative controller is reactivated. However, if the malfunction signal recurs within the first operation cycle after reactivation of the normally operative controller, then it is again deactivated and the reactivating means is disabled.

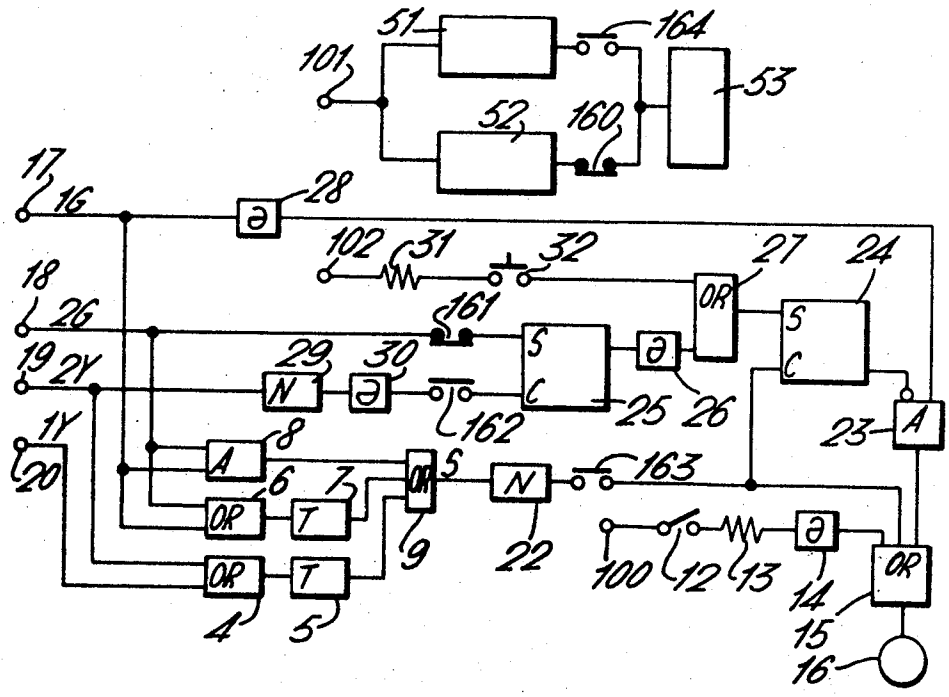


Fig. 1.

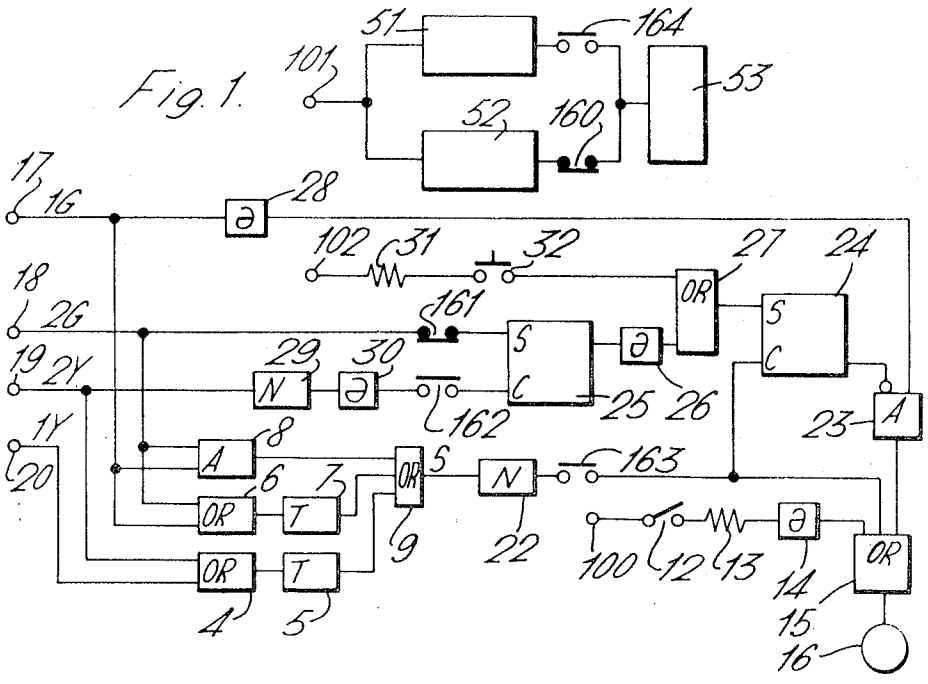
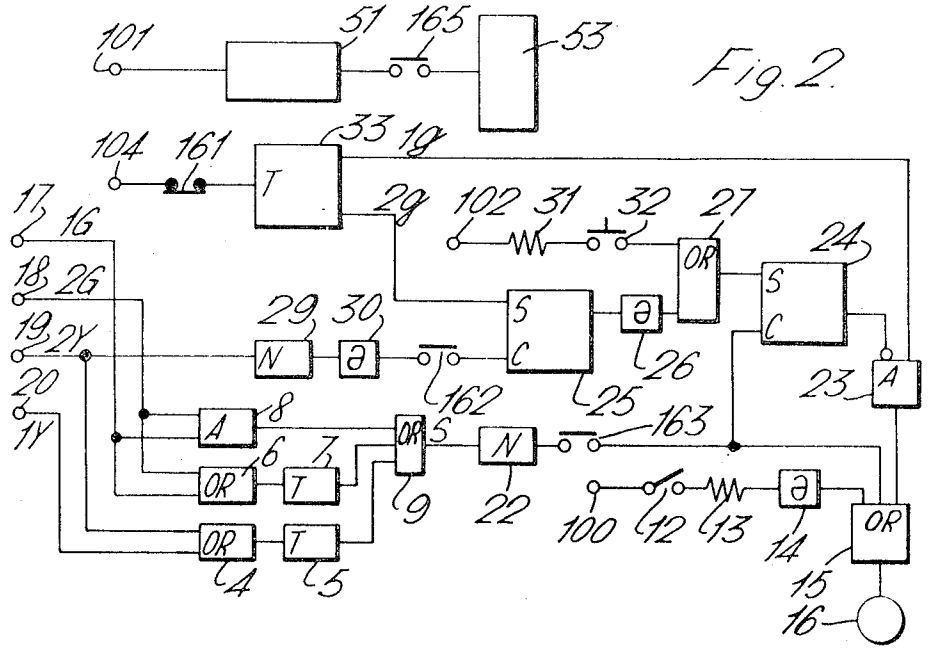


Fig. 2.



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TRAFFIC SIGNAL CONTROL SYSTEM

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a traffic signal control system wherein when predetermined abnormal illuminating conditions of the traffic signals occur, the signals are controlled in such a manner as to enable as prompt restoration of their normal illuminating condition as possible.

In traffic signals abnormal illuminating conditions sometimes occur, such as simultaneous illumination of the green signals facing two or more intersecting streets, or prolonged illumination of the green or yellow signals. Such abnormal conditions may well result in traffic confusion or accidents at the street intersection or irritate waiting drivers and pedestrians.

When such abnormal illumination of the traffic signals takes place, it has hitherto been customary to turn off all the signals at the street intersection. Generally, such an abnormal condition that has occurred at a local controller is detected at a central station, and engineers are dispatched to the local controller for repair work. Therefore, the signal lamps are kept turned off for a considerably long time, that is, from the time the disorder occurred to the time it is remedied, causing serious confusion to traffic around the street intersection. Moreover, it is very inconvenient to have to dispatch engineers to the local controller whenever an abnormal illuminating condition occurs.

Accordingly, it is one object of the invention to provide a traffic signal control system which minimizes the duration of abnormal illuminating condition of the signals that has occurred at a street intersection. In accordance with the invention, normally a traffic actuated controller controls the signals at a street intersection. When an abnormal illumination has occurred to the signal lamps, the operation of the traffic actuated controller is temporarily stopped, and after a predetermined period of time the operation of the controller is automatically resumed. To this end, the system of the invention is provided with means operable in response to the occurrence of a predetermined abnormal illuminating condition of the signal lamps to temporarily render the traffic actuated signal controller inoperative, and means operable a predetermined period of time after the controller was rendered inoperative to render the controller operative again.

There are cases in which an abnormal illuminating condition of the signal lamps has been caused by such a simple disorder as naturally disappears without any repair work done and in a relatively short period of time. If the disorder has disappeared while the operation of the signal controller is stopped, the operation of the controller, when resumed after a predetermined period of time, may continue. However, if the disorder recurs or a new disorder occurs during the first signal cycle after the operation of the signal controller has been resumed, the resumed operation of the controller is again stopped. In this case, if the operation of the signal controller that has been stopped for the second time were resumed again, the operation of the controller would be repeatedly stopped and resumed, causing a prolonged confusion to traffic.

Accordingly, it is another object of the invention to provide such a traffic signal control system as aforesaid wherein if during the first signal cycle after the operation of the signal controller has been resumed for the first time, the abnormal illuminating condition of the signals recurs, the operation of the signal controller is again stopped and will not be resumed again.

As previously mentioned, when an abnormal illuminating condition of the signals is detected, the operation of the traffic actuated signal controller is stopped until it is resumed after a predetermined period of time. If there is no signal indication being displayed to traffic while the controller is kept inoperative, the traffic around the intersection would be seriously disturbed or confused.

Accordingly, it is still another object of the invention to provide such a traffic signal control system as aforesaid, wherein the signal lamps are illuminated on a fixed cycle from the time the traffic actuated controller has been rendered inoperative upon detection of a predetermined abnormal illuminating condition of the signal lamps to the time it is rendered operative again. The illumination of the signals "on a fixed cycle" means that each signal is illuminated for a predetermined fixed period of time regardless of actual traffic conditions on the streets. To this end, the system of the invention is further provided with a fixed cycle signal controller, means operable in response to the occurrence of an abnormal illuminating condition of the signals to actuate the fixed cycle signal controller in place of the traffic actuated signal controller, and means for causing the traffic actuated signal controller to resume its operation after one cycle of operation of the fixed cycle signal controller. In this case, when the traffic actuated signal controller resumes its operation, it is required that the first signal in the signal cycle be indicated at first. Otherwise confusion would be caused to signal indication during the transient period of time from the fixed cycle control to the traffic actuated control.

As previously mentioned, when the operation of the traffic actuated controller is stopped for a second time, the inoperative condition of the controller will continue, that is the operation of the controller will no longer be resumed unless a central control station dispatches engineers to the local controller for repair of the disorder that has caused the abnormal illumination of the signals. When the repair works have been finished, the normal traffic signal control must be manually resumed by the engineers.

Accordingly, it is a further object of the invention to provide such a traffic signal control system as aforesaid, wherein after the operation of the traffic actuated controller has been stopped for a second time, it can be resumed only manually. To this end, the system of the invention is additionally provided with means including a manually operable switch for rendering inoperative the means for preventing the traffic actuated signal controller from resuming its operation. When the disorder has been removed, the switch is manually actuated on by the engineer to render the traffic actuated signal controller operative again in place of the fixed cycle signal controller.

The invention will be better understood from the following detailed description of some preferred embodiments thereof with reference to the accompanying drawings, wherein like reference numerals denote corresponding elements, and wherein:

FIG. 1 is a block diagram of one embodiment of the invention; and

FIG. 2 is a block diagram of another embodiment of the invention.

The illustrated embodiments are designed for two-phase control. That is, one signal cycle consists of a major street green signal, a major street yellow signal, a minor street green signal and a minor street yellow signal. It is obvious that the major street green and yellow signals coincide with the minor street red signal, and that the minor street green and yellow signals coincide with the major street red signal.

In FIG. 1, a potential of, say, +12 volts is applied to a terminal **100**, to which is connected a switch **12** through a resistor **13**. When the whole system is to be operated, the switch **12** is closed, whereupon a differentiator **14** produces an output pulse to be applied through an OR element **15** to a relay **16** to energize the same. The relay **16** has two normally closed contacts **160** and **161** and three normally open contacts **162**, **163** and **164**. Upon energization of the relay **16**, the contact **164** is closed, so that a traffic actuated signal controller **51** produces a series of signals which illuminate a group of signal lamps **53** in a predetermined order and in accordance with the traffic condition on the streets. When the major street green lamp is illuminated, an electrical signal 1G appears at a terminal **17**; when the minor street green signal is illuminated, an electrical signal 2G appears at a terminal **18**; when the minor

street yellow signal is illuminated, an electrical signal 2Y appears at a terminal 19; and when the major street yellow signal lamp is illuminated, an electrical signal 1Y appears on a terminal 20.

As examples of predetermined abnormal illuminating conditions of the signal lamps there may be given simultaneous illumination of the major and the minor street green signal lamps and prolonged illumination of the major or minor street green or yellow signal lamps over a predetermined maximum period of time of duration of the green or yellow signal indication.

The signals 1G and 2G are applied to an AND element 8, the output from which is applied as one input to the OR element 9. The signals 1G and 2G are also applied through an OR element 6 to a timer 7 which provides a delay time equal to the predetermined maximum period of time for green signal indication. Upon lapse of the delay time, the timer 7 produces an output to be applied as another input to the OR element 9. The signals 1Y and 2Y are applied through an OR element 4 to a timer 5 which provides a delay time equal to the maximum period of time of duration of yellow signal indication. Upon lapse of the delay time, the timer 5 produces an output to be applied as a third input to the OR element 9. With the circuit arrangement, it will be easily seen that when one of the predetermined abnormal illuminating conditions of the signals has occurred, the OR element 9 produces an output malfunction signal S to be applied to a NOT element 22. The OR element 15 is connected via the normally open relay contact 163 to the output of the NOT element 22. Therefore, if there is no signal S when the switch 12 has been closed, the OR element 15 receives an input, so that the relay 16 that has been energized upon closing of the switch 12 is kept energized by the output from the OR element 15.

In the following description, when an element in the circuit produces an output, the condition will sometimes be referred to as a signal "1" having been produced by the circuit element or the signal from the element becoming "1"; and when an element produces no output, the condition will sometimes be referred to as a signal "0" having been produced or the signal from the element becoming "0."

The OR element 15 receives as a third input the output from an INHIBIT element 23. The element 23 receives as the inhibit input the reset output from a flip-flop 24, to which the output from the NOT element 22 is applied as a reset input.

Under the normal illuminating condition of the traffic signals, the electrical signal S is "0," so that the output signal from the NOT element 22 is "1." This signal "1" resets the flip-flop 24, which produces an output signal "1" to be applied as an inhibit input to the INHIBIT element 23. As a result, the output from the element 23 is "0," so that the relay 16 is not affected by the element 23.

When one of the predetermined abnormal illumination conditions of the signal lamps has occurred, the signal S becomes "1," so that the output from the NOT element 22 becomes "0," thereby deenergizing the relay 16. As a result, the contacts 160 and 161 are closed and the contacts 162, 163 and 164, opened.

Upon opening of the contact 164, the traffic actuated signal controller 51 is rendered inoperative, and instead a substitute fixed cycle signal controller 52 is started to control the illumination of the signal lamps on a fixed cycle. If the arrangement were such that the instant an abnormal illuminating condition of the signal lamps took place, the controller 52 was started to control the signals on a fixed cycle, the signal indication would be so suddenly changed that there would be a tendency to traffic confusion resulting in accidents. Therefore, to avoid this, the signals to the major and minor streets are both rendered red or yellow at the same time, or all the signal lamps at the intersection are turned off, for a predetermined period of time before the fixed cycle control is started.

In the first cycle of operation of the fixed cycle signal controller, when the traffic signal to the minor street is turned green, the signal 2G becomes "1." This signal is applied as a set input to a flip-flop 25 through the then closed relay contact 161. The set output from the flip-flop 25 then is applied to a differentiator 26, the output pulse from which is applied as a set input to the flip-flop 24 through an OR element 27, whereupon the set output from the flip-flop 24 being applied as the inhibit input to the INHIBIT element 23 becomes "0." Thus, in the first cycle of the fixed cycle signal control, when the traffic signal being displayed to the minor street becomes green, the inhibit signal to the element 23 becomes "0." Then in the next cycle when the major street signal is turned green, the signal 1G at the terminal 17 becomes "1." This signal is applied to the differentiator 28, the output pulse from which is applied to the INHIBIT element 23. At this time, the inhibit input thereto is "0," so that the element 23 produces an output to energize the relay 16 through the OR element 15, whereupon the relay contacts 160 and 161 are again opened and the relay contacts 162, 163 and 164, again closed.

Upon opening of the relay contact 160 the operation of the fixed cycle signal controller 52 is terminated, and the closing of the contact 164 causes the traffic actuated controller 51 to resume its operation, so that the traffic signals are again controlled in accordance with the actual traffic condition on the streets. The controller 51 is so designed that it is reset during the operation of the fixed cycle signal controller 52, and that when it resumes its operation, the signal cycle begins from the start, say, with a green signal indication to the major street.

Simultaneously with the opening of the relay contact 160, the relay contact 163 is closed. If the cause for the abnormal illuminating condition still continues, the signal S remains "1," so that the output from the NOT element 22 is "0." Therefore, when the output pulse from the INHIBIT element 23 presently disappears, the relay 16 is again deenergized. This causes the fixed cycle signal controller 52 to continue its operation.

The signal 2Y on the terminal 19 is applied to a NOT element 29. When the signal 2Y disappears, the element 29 produces an output to be applied to a differentiator 30. As previously mentioned, the signal 2Y becomes "1" when the minor street signal is yellow, and since the yellow signal indication occurs at the end of one signal cycle, it is when one signal cycle has been completed, that is, the minor street yellow signal has ended, that the differentiator 30 produces an output pulse.

Suppose that when the operation of the traffic actuated controller 52 has been resumed as previously mentioned, an abnormal illuminating condition occurs before the end of the first one signal cycle of the resumed operation of the controller 51. Then the signal S becomes "1" so that the relay 16 is deenergized. This deenergization takes place before the flip-flop 25 is reset by the output pulse from the differentiator 30 caused by the termination of the signal 2Y, so that the flip-flop 25 remains set. Upon deenergization of the relay 16, the traffic actuated signal controller 51 is rendered inoperative and instead the fixed cycle signal controller 52 is again rendered operative, with the signal indication started to operate from the beginning of the signal cycle. Under the fixed cycle signal control, when the signal 2G becomes "1," the flip-flop 25 remains set as yet, so that the output from the differentiator 26 remains "0" and consequently the flip-flop 24 will not be set. Under this condition, even when the signal 1G becomes "1," that is, the second cycle of the fixed cycle control comes, the output signal from the INHIBIT element 23 remains "0" because the reset signal "1" from the flip-flop 24 is applied as the inhibit input to the INHIBIT element 23. Therefore, the relay 16 is not energized again, so that the operation of the fixed cycle controller 52 will continue. In short, if the abnormal illuminating condition of the signal lamps recurs within the first signal cycle of the resumed operation of the traffic actuated signal controller, the cause for the abnormal condition is considered as such that it would probably cause the abnormal condition to be repeated many times thereby causing a serious confusion to traffic. Therefore, a malfunction recurrence indication is produced (flip-flop 25 remains set) render-

ing the fixed cycle signal controller again operative until the cause for the abnormal illuminating condition is eliminated, whereupon the traffic actuated signal controller is rendered operative in place of the fixed cycle signal controller.

For the manual restoration of the operative condition of the traffic actuated signal controller **51**, a manually operable normally open push button switch **32** is connected in series with a resistor **31** between a source terminal **102** and the OR element **27**. When the switch **32** is closed, the OR element **27** produces an output to set the flip-flop **24**, thereby removing the inhibit input to the INHIBIT element **23**. Then, when the signal 1G is next rendered "1," the relay **16** is energized to open the contact **160** and close the contact **164**, so that the operation of the fixed cycle controller **52** is terminated and instead the normal traffic signal control by the controller **51** is resumed. At this time the cause for the abnormal illuminating condition must have been removed, so that the signal S is "0" and consequently the output from the NOT element **22** is "1." Therefore, when the relay **16** is energized by the output from the INHIBIT element **23** to close the contact **163**, the output from the NOT element **22** keeps the relay **16** energized and consequently the traffic actuated signal controller **51** operative on the one hand and resets the flip-flop **24** on the other thereby restoring the original condition of the system.

FIG. **2** shows an arrangement that all the signal lamps are temporarily turned off upon occurrence of a predetermined abnormal illuminating condition thereof. In FIG. **2**, there is provided a single-cycle controller or timer **33** instead of a fixed multicycle signal controller such as **52** in FIG. **1**. In FIG. **2** the same reference numerals as in FIG. **1** denote corresponding circuit elements. The timer **33** has its input side connected to a source terminal **104** through the relay contact **161**. Upon passage of a delay time reset in a timer **33**, it produces an output signal **2***g* and then after a predetermined period of time an output signal **1***g*. The signals **1***g* and **2***g* functionally correspond to the signals 1G and 2G of the fixed cycle signal controller in FIG. **1**, respectively.

If, under the condition that the controller **51** is normally operating, an abnormal illuminating condition of the signal lamps has occurred, the signal S becomes "1," as previously mentioned, so that the relay **16** is deenergized. This opens the relay contact **165**, thereby turning off all the signal lamps. At the same time, the relay contact **161** is closed, so that after the delay time the output signal **2***g* from the timer **33** becomes "1" to set the flip-flop **25** and consequently the flip-flop **24**. This renders the inhibit input to the INHIBIT element **23** "0." Presently, the signal **1***g* from the timer **33** becomes "1," so that the inhibit element **23** produces an output to energize the relay **16** through the OR element **15**. This closes the relay contact **165** so that the controller **51** resumes its operation. If during the first signal cycle after the controller resumes its operation, the signal S becomes "1" again, the flip-flop **24** remains reset, thereby keeping the relay **16** deenergized, so that all the signal lamps are kept turned off.

Restoration of the system to the original normal controlling condition is effected by manually closing the switch **32** just in the same manner as in FIG. **1**.

Unless the signal S becomes "1" again, that is, if no abnormal illuminating condition has occurred when the first signal cycle of the resumed operation of the controller **51** has expired, the output from the NOT element **22** keeps the relay **16** energized, so that the operation of the controller **51** will continue.

In the above embodiments the controller **51** is of the traffic actuated type, but any other type of controller may also be employed. The invention may also be applied to multiphase control systems. In this case, signals produced predetermined periods of time after the detection of an abnormal illuminating condition of the signal lamps may be used as the signals 1G and 2G as produced by the fixed cycle controller or as the signals **1***g* and **2***g*; and a signal produced upon completion of one signal cycle may be used as the signal 2Y.

What we claim is:

1. A system for controlling traffic signals at a street intersection, comprising:

a normally operative first signal controller for controlling said signals in accordance with a first cyclical pattern of operation;

a normally inoperative second signal controller for controlling said signals in accordance with a second cyclical pattern of operation for a fixed period of time;

means for continuously monitoring operation of said signals during operation of the first controller to detect predetermined malfunctions of said signals and produce a malfunction signal;

means responsive to said malfunction signal for deactivating the first controller and activating the second controller; and

means coupled with said second controller for reactivating said first controller upon completion of said fixed period of time.

2. The system defined in claim **1** wherein said monitoring means includes means responsive to completion of the first cycle of operation of said signals following reactivation of said first controller for detecting recurrence of said malfunction signal within said first cycle and producing a recurrence indication for disabling said reactivating means.

3. The system defined in claim **2** wherein said monitoring means comprises a plurality of inputs to which individual signal control impulses are provided by said signal controllers, said inputs including go and caution inputs for each of the intersecting streets, the go and caution impulses for one street corresponding to stop impulses for the other street, an AND circuit and a first OR circuit, each having first and second inputs coupled respectively to said go inputs; a second OR circuit having first and second inputs coupled respectively to the caution inputs; first and second timing circuits coupled respectively to the outputs of the first and second OR circuits; and a third OR circuit having inputs coupled respectively to the outputs of said AND circuit and of said first and second timing circuits.

4. The system defined in claim **2** wherein said second signal controller comprises means for deenergizing said signals for a predetermined period of time.