Nov. 24, 1970 A. C. PFISTER ET AL 3,543,090

OVERLOAD PROTECTION CIRCUIT

Filed Dec. 13, 1968

Fig. 1

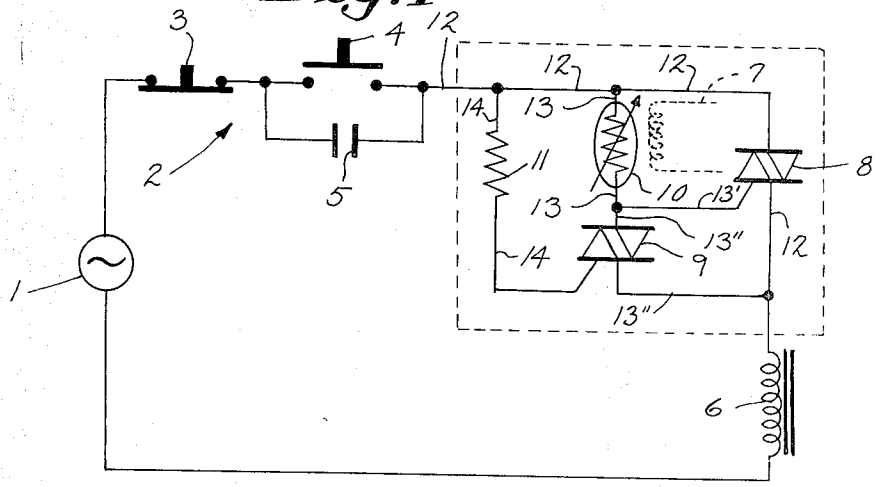
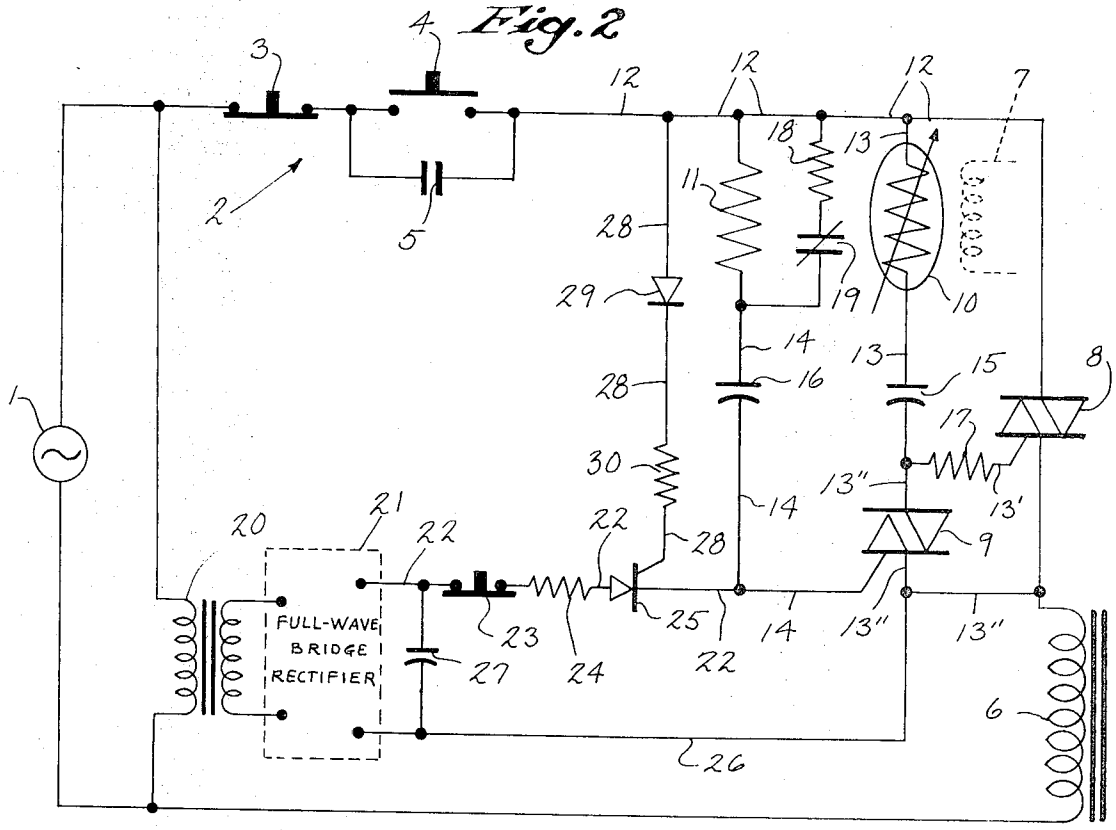



Fig. 2





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United States Patent Office 3,543,090 Patented Nov. 24, 1970



3,543,090

# OVERLOAD PROTECTION CIRCUIT

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Filed Dec. 13, 1968, Ser. No. 783,616
Int. Cl. H02h 5/04
U.S. Cl. 317—13 6 Claims

## ABSTRACT OF THE DISCLOSURE

An overload protection circuit in series with a control relay coil includes two triacs in shunt relationship and two resistances, one of which is a thermistor with a positive temperature coefficient. The thermistor is in the actuating circuit of the first triac and the operating circuit of the second, and the second resistance is in the actuating circuit of the second triac. The resistances and triacs are selected so that at normal temperatures the actuating current for the first triac is proportionately greater, and, therefore, during any half cycle the first triac is triggered first, shorting out the second triac and allowing normal coil operation. The value of the PTC resistance rises in response to heat indicating an overload condition, however, and the relative values change so that the second triac triggers first, which shorts out the first triac and puts the now relatively high value PTC resistance in series with the coil, reducing the voltage across the coil and causing it to drop out. A preferred embodiment includes a storage capacitor to insure full cycle triggering of the second triac, a holding resistance which is connected across the second resistance upon dropout to insure maintenance of the desired value ratio between the two resistances, and a latching circuit which insures continuous triggering of the second triac to prevent reactivation of the coil until the latching circuit is broken in a reset action.

## BACKGROUND OF THE INVENTION

This invention relates to an overload protection circuit, and particularly to a temperature-responsive circuit particularly adapted to act on the operating coil of an electromagnetic switch or control relay. While a wide variety of devices and circuits have been designed and used in the past to accomplish this general purpose, they have usually been subject to one or more serious deficiencies.

One particular problem often encountered with prior arrangements is a failure to have clearly defined "on" or "off" points, and this can result in undesirable chatter in marginal overload situations. Attempts have been made in the past to use temperature-responsive resistors in overload circuits or devices and, while these are highly desirable because of their simplicity and reliability, chattering is an especially serious problem when such resistors are used because it is difficult to provide for a distinct enough change in resistance at the desired dropout temperature.

In addition to the chattering problem, prior overload arrangements have often suffered from a general lack of speed or reliability, or have been unduly expensive, complicated, or bulky.

## SUMMARY OF THE INVENTION

This invention provides an overload protection circuit utilizing a temperature-responsive resistance and two triacs, or equivalent gating elements of the type requiring an actuating signal, which are connected in shunt relationship. One gate element is arranged to trigger before the other under normal conditions and provides a normal operating circuit for a coil. Heat resulting from an overload condition affects the temperature-responsive resistance and causes a change in relative values, however, which ultimately causes the other gate element to trigger first. This shunts the first gate and also puts a relatively high resistance in series with the coil causing it to drop out almost instantly.



It is the general object of this invention to provide an overload protection circuit of the above-mentioned type which is highly effective and reliable and readily adapted to use in various environments, but which is still relatively simple and inexpensive, requires a minimum number of elements, and occupies a minimum amount of space.

It is another object of the invention to show a particularly preferred circuit including efficient and reliable holding and/or latching means to insure against undesired reactivation of the controlled load.

Still other objects and advantages will be apparent to those skilled in the art from the description to follow.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic electrical circuit diagram illustrating a preferred embodiment of the basic circuit of the invention, and

FIG. 2 is a schematic electrical circuit diagram illustrating a particularly preferred circuit incorporating holding and latching means and other additions.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, the basic circuit shown therein includes certain conventional and well-known elements, including an A-C supply **1** and a start-stop station designated generally by the reference numeral **2** and including a normally closed stop button **3**, a normally open start button **4**, and a set of normally open auxiliary contacts **5** connected across the start button **4**. The controlled load element of the circuit is a coil **6** which, as will be readily appreciated by those skilled in the art, might be the operating coil of an electromagnetic switch or relay or form a part of any of several other types of devices. Those skilled in the art will also recognize that the coil **6** will be adapted by suitable means (not shown) to close the auxiliary contacts **5** when it picks up so that the basic operating circuit will remain closed after depression and release of the start button **4**. The known elements further include a heater coil **7**, shown in broken lines, which is connected in series with a motor or other device (not shown) to be protected and which will, in usual fashion, signal an overload condition in the protected device by means of an increase in temperature.

The elements of the overload protection circuit proper are shown enclosed in a broken line box in FIG. 1, and include a first triac **8**, a second triac **9**, a first, variable resistance **10**, and a second, constant resistance **11**. The triacs **8**, **9** are known types of solid state devices which are essentially bidirectional A-C switches which require an actuating or gating signal to become conductive or operative so that they can be said to be gating devices. The constant resistance **11** is of any suitable type. The variable resistance **10** is a temperature-responsive resistance, or thermistor, of any suitable known type and, in the embodiment shown, has a positive temperature coefficient of resistance so that its resistance value increases as ambient temperature increases. The heater coil **7** is wound around the thermistor **10** or otherwise suitably placed in a heat transfer relationship with it. The absolute value of the resistances **10**, **11** will depend on general circuit requirements, but the relative resistance values of the thermistor **10** and resistance **11** should be such as to provide the desired ratios discussed below.

The protection circuit consists essentially of three branches. A main branch designated by the numeral **12** leads through the first triac **8** and also constitutes a portion of a normal operating circuit for the coil **6**. A first control branch **13** leads from the branch **12** through the thermistor **10** and is then divided to form a first subbranch **13'** which leads to the gate terminal or actuating signal connection of the first triac **8** and a second subbranch **13''** which leads through the second triac **9** back to the main branch **12**. Thus, the second triac **9** is connected in shunt relationship with the first triac **8**, and the thermistor **10** is in the actuating circuit of the triac **8** and is also in the operating circuit of the triac **9**. A second control branch **14** leads from the main branch **12** through the resistor **11** to the actuating signal connection of the triac **9**, thus putting the resistor **11** in the actuating circuit of the triac **9**.

In the embodiment shown, the triacs **8** and **9** are substantially identical and require actuating signals of substantially equal magnitude, and the cold resistance value of the thermistor **10** is significantly less than that of the resistor **11** while the hot value of the thermistor **10** is significantly higher than that of the resistor **11**. It will be obvious, however, that different types of triacs might be used with appropriate adjustments in the values of the thermistor **10** and resistor **11**. Since under normal conditions in the preferred embodiment the value of the thermistor **10** is lower than that of the resistance **11**, the current value in the actuating circuit of the triac **8** will be greater at any point in time than that in the actuating circuit of the triac **9**. This means that an actuating signal of the required magnitude will be received first by the triac **8** and it will become conductive and provide an operating circuit for the coil **6**, the triac **9** then being effectively shunted out of the circuit. This will continue to occur for each half cycle of operation, so long as the resistance value of the thermistor **10** is less than that of the resistor **11**.

In the event of an overload, however, the heater coil **7** will cause the temperature of the thermistor **10** to be raised, which will result in an increase in its resistance value. When the resistance value of the thermistor **10** becomes higher than that of the resistance **11**, the actuating current available to the triac **9** will be greater at any time point than that of the triac **8**, and as a result the triac **9** will receive an actuating signal of the required magnitude first and will become conductive. As soon as this occurs, the triac **8** is shunted and the now high value resistance of the hot thermistor **10** is placed in series with the coil **6**. The voltage drop across the thermistor **10** will result in a lowering of the voltage drop across the coil **6**, which will in turn cause the coil **6** to drop out thus opening line contacts or otherwise cutting off the supply of current to the motor or other device being protected in the usual fashion. The precise operating characteristics of the circuit will depend on several factors including, for example, the response curve of the thermistor **10**, the characteristics of the coil **7**, the physical relationship of the elements, etc. These considerations are known and understood by those skilled in the art, and such persons will readily be able to select and arrange components for particular requirements.

The thermistor **10** has two major functions. First, it varies the relative magnitude of the gate currents for the two triacs **8, 9**. Second, when the triac **9** is triggered the thermistor **10** acts as a high resistance in series with the coil **6** and effectively causes the coil **6** to drop out. It is not a high absolute resistance value of the thermistor **10** that is critical, however, except insofar as the value must be high enough to cause the coil **6** to drop out, but rather that relative resistance values of the two resistance elements, comprising the thermistor **10** and the resistor **11**. Accordingly, it would obviously be possible to replace the thermistor **10** with a constant resistance and to replace the resistor **11** with a temperature-responsive resistance having a negative temperature coefficient. In this case, assuming identical triacs, the value of the NTC resistance would initially or in a cold state be selected to be higher than that of the constant resistance, but would become lower in the event of an overload, and the heater coil **7** would of course be in a heat transfer relationship with the NTC resistance. Similarly, the absolute resistance values necessary will depend on the actuating requirements of the triacs or other gate devices used and if one triac requires an actuating signal of much greater magnitude than the other the absolute resistance values might even be reversed. The essential feature is that the relative resistance values and actuating requirements be such that actuating current to the first triac **8** is proportionately higher at normal temperatures and actuating current to the triac **9** is proportionately higher at elevated overload temperature.



The arrangement shown minimizes the possibility of chatter in marginal situations. That is, the triac **8** remains effective and allows normal relay operation until the time that the resistance value of the thermistor **10** has reached a predetermined required value, whereupon the thermistor **10** is shunted or switched instantly into a series relationship with the coil **6** causing substantially instantaneous dropout.

The circuit shown in FIG. 2 operates in essentially the same fashion as the circuit of FIG. 1 (and like reference numerals have been used for the same elements) but incorporates certain additions to provide a particularly preferred embodiment. By way of general additions for circuit design purposes, a capacitor **15** is placed in the control branch **13** to provide additional current limiting reactance. This allows the hot resistance value of the thermistor **10** to be lower and helps in eliminating possible relay hum. Also, a resistance **17** of suitable value is placed in the sub-branch **13'** to reduce the gate sensitivity of the triac **8** and insure when the triac **9** is turned on that most of the current in the branch **13** will be shunted through it. Other elements may be desirable for particular applications or in view of the characteristics of particular components that are available.

A storage capacitor **16** is inserted in the circuit branch **14** to be in the actuating circuit for the triac **9**, and serves two important functions. First, it compensates for lack of triggering symmetry in the triacs **8** and **9**, such asymmetry being quite likely with commercially available triacs. That is, during normal operation, the triac **8** will be triggered first for both the positive and negative half-cycles. Upon an overload, however, the triac **9** will be triggered first during either a positive or a negative half-cycle. If the two triacs **8** and **9** were symmetrical, or in other words if their triggering characteristics were identical in both directions, the triac **9** would again be triggered first on the succeeding half-cycle. It is entirely possible with commercial triacs, however, that the triggering characteristics of one or both will be asymmetrical, and this could result in the triac **9** being triggered first during one half-cycle and the triac **8** being triggered first during the succeeding half-cycle, which would have the net effect of feeding half wave rectified current to the controlled element which could cause severe chattering or other serious problems.

The storage capacitor **16** avoids the problems which might result from asymmetry. During the first half-cycle that triac **8** is off, the capacitor **16** charges to nearly line voltage. During the next half-cycle it discharges, and the discharge current is sufficient to insure first triggering of the triac **9**. The capacitor **16** also functions to provide *dv/dt* protection for the triac **8**. That is, when the coil **6** drops out, line voltage is suddenly impressed across the triac **8**—which might cause it to turn on—and the capacitor **16** acts as a shunt for this surge. The capacitor **16** must be large enough, however, to present a low enough

reactance in series with the resistance **11** to allow the triac **9** to be triggered first.

In addition, the circuit of FIG. 2 includes a constant resistance **18** and a set of normally closed auxiliary contacts **19** connected in series and across the resistance **11**. The contacts **19** are arranged to be acted on in any suitable known fashion so that they will be open when the coil **6** is actuated and will close when it drops out, and this means that the resistance **18** will be connected in parallel with the resistance **11** upon dropout. This effectively lowers the value of the resistance **11** and acts to hold the protection circuit open against accidental or intentional reactivation in the event of a continuing overload. That is, because the value of the resistance **11** is made lower by connecting the resistor **18** across it, the value of the resistance **10** must also become proportionately lower to allow reactivation, which means that the thermistor **10** will have to cool substantially before reactivation is possible.

The circuit of FIG. 2 also includes a positive latching circuit designed to insure against anything but intentional reactivation by requiring a reset action. This circuit includes a signal transformer **20** which has its primary connected across the supply **1** and its secondary connected to a full-wave bridge rectifier **21**, which may be of any suitable type well known to those skilled in the art and is shown only schematically. A first or latching line **22** leads from the rectifier **21** through a normally closed reset button **23**, a resistance **24** and a silicon controlled rectifier **25** to the second control branch **14**. The second output line **26** from the rectifier **21** leads directly to the sub-branch **13''**, and a filter capacitor **27** is connected between the lines **22**, **26**. An actuating line **28** leads from the main circuit branch **12** through a diode **29** and a resistance **30** to the gate of the SCR **25**.

In the event of an overload causing the coil **6** to drop out, full line voltage is impressed across the triac **8** and the initial positive half cycle passes through the line **28** and diode **29** to trigger the SCR **25** and cause it to become conductive. This sets up a continuing triggering current for the triac **9** which insures that it will continue to operate and shunt out the triac **8**, thus further insuring that the thermistor **10** will continue to be in series with the coil **6** preventing it from picking up. The coil **6** can only be reactivated by depression of the reset button or switch **23**, which breaks the latching circuit.

Although preferred embodiments of the invention have been shown and described herein, it will be obvious that modifications and alterations might be made without departure from the scope and spirit of the invention. As previously noted, certain elements are not essential to the operation of the invention per se, and other elements might be altered, such as by replacing the resistance **11** with an NTC thermistor and the thermistor **10** with a constant resistance. Similarly, equivalent elements might be substituted for the triacs **8** and **9**. It would be possible, for example, to use triacs with integral triggers (diacs), or it would be possible to substitute entirely different types of gating devices of any type requiring an actuating signal. The invention is not intended to be limited, therefore, by the showing herein.

What is claimed is:

**1.** An overload protection circuit adapted to be connected in series with a relay coil or the like and to operate in response to a heater which senses overload conditions, the circuit comprising: first and second gating devices of the type requiring an actuating signal to be conductive; first and second resistances, at least one of



which has a temperature-responsive resistance value and is adapted to be acted on by the heater; a main branch leading through the first gating device that is adapted to form a part of a normal operating circuit for the coil; a first control branch leading from the main branch through the first resistance and then being divided to form (a) a first sub-branch leading to an actuating signal connection of the first gating device to put the first resistance in an actuating circuit therefor, and (b) a second sub-branch leading through the second gating device and to the main branch to connect the second gating device in shunting relationship with the first gating device and to put the first resistance in an operating circuit for the second gating device and in series with the coil; and a second control branch leading from the main branch through the second resistance to an actuating signal connection of the second gating device to put the second resistance in an actuating circuit therefor, the actuating requirements of the gating devices and the resistance values of the resistances being such that the actuating current to the first gating device is proportionately greater than that to the second gating device at normal operating temperature and is proportionately greater to the second gating device when the heater has acted to raise the temperature of the temperature-responsive resistance.

**2.** A circuit according to claim **1** wherein there is a storage capacitor in the second control branch.

**3.** A circuit according to claim **1** wherein there is a holding resistance connected across the second resistance through auxiliary switch means, which switch means is adapted to be open when the coil is actuated and closed when the coil is not actuated.

**4.** A circuit according to claim **1** wherein there is a latching circuit comprising: D-C supply means; a latching branch leading from the D-C supply means through a reset switch and a silicon controlled rectifier to the actuating signal connection of the second gating device; and an actuating branch leading from the main branch through a diode to the gate of the silicon controlled rectifier.

**5.** A circuit according to claim **2** wherein there is a holding resistance connected across the second resistance through auxiliary switch means, which switch means is adapted to be open when the coil is actuated and closed when the coil is not actuated.

**6.** A circuit according to claim **5** wherein there is a latching circuit comprising: D-C supply means; a latching branch leading from the D-C supply means through a reset switch and a silicon controlled rectifier to the actuating signal connection of the second gating device; and an actuating branch leading from the main branch through a diode to the gate of the silicon controlled rectifier.


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U.S. Cl. X.R.

307—305; 317—16, 33, 41, 148.5