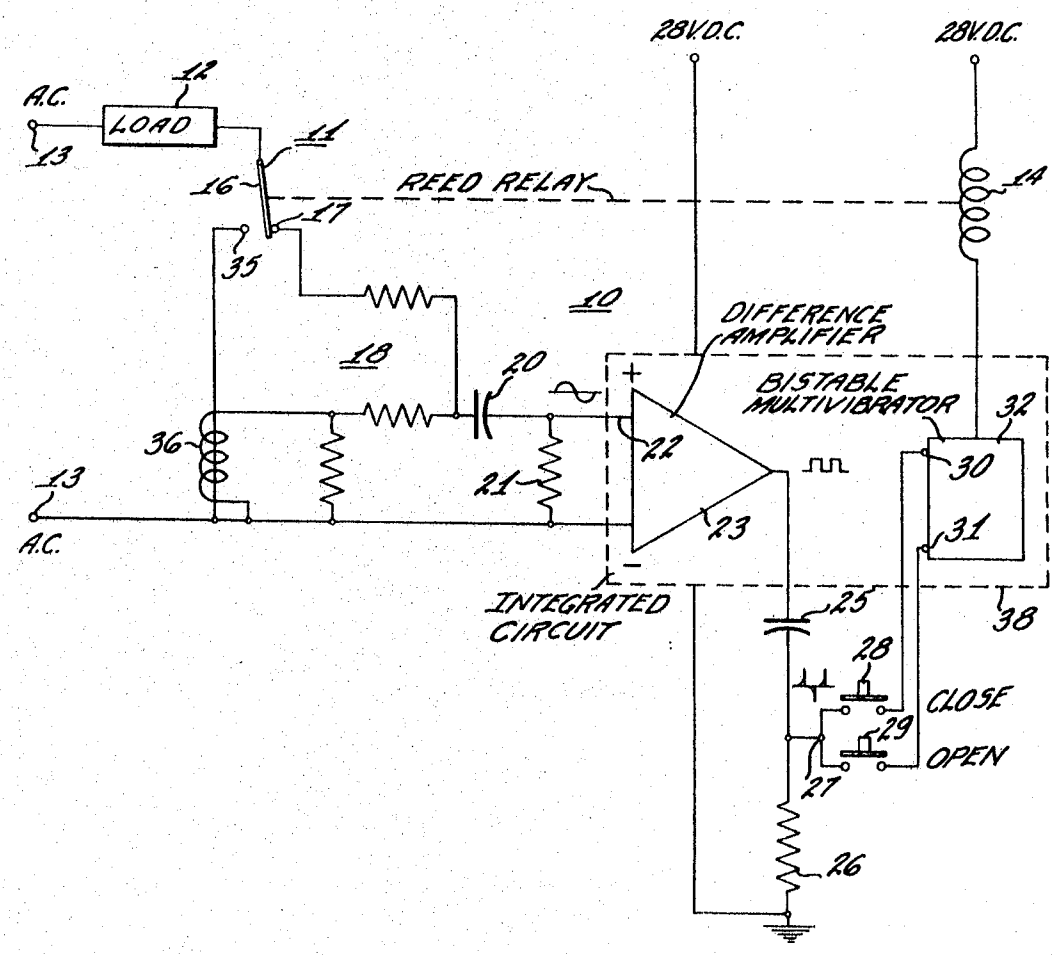
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SYNCHRONOUS SWITCH CIRCUIT FOR REED RELAYS

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SYNCHRONOUS SWITCH CIRCUIT FOR REED RELAYS

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ABSTRACT OF THE DISCLOSURE

A zero cross-over switching circuit comprises a sensing means to simulate the load current waveform, a difference amplifier responsive to the sensing means to produce a square-wave output, a differentiator connected to the output of the difference amplifier to produce sharp spikes at the load current zero cross-over points, and a multivibrator and relay responsive to the spikes to switch the load current on and off.

This invention relates generally to control circuits for switches. More specifically, this invention relates to an electronic circuit for controlling the operation of a relay so that the relay operates near the zero voltage and current points of an alternating current wave.

For many years there have been available on the market small reed relays, used as dry circuit switches. These relays are very small and hermetically sealed so that they are relatively insensitive to environmental changes. The major limitation on the use of this type of a relay has been its relatively low current interrupting capability. As an example, a relay may be rated as a three amp AC interrupting switch, but it may be capable of carrying as high as 7 or 7½ amperes steady-state current. It is only when the circuit is opened or closed that the relay is a problem because arcing at that time pits the contacts and may at times weld the contacts together. If it were not for this problem, the relays could be rated for much higher currents.

Applicant's invention controls the relay in such a manner that it only closes the circuit at or near the zero point in an alternating voltage wave and only interrupts the circuit at or near the zero point in an alternating current wave. Therefore, when the relay is actuated, it is interrupting a very small amount of current which it can easily handle. Hence, this same relay can be rated much higher than its previous interrupting capacity because the conducting material of the relay is capable of handling three or four times as much current on a continuous basis as compared to an interrupting basis. Therefore, the limiting factor of a relay having this kind of a control circuit associated therewith is the upper limit of its conducting capability rather than its interrupting capability.

Zero current interrupting devices have been used in the past, but were very complex and expensive. Hence, it was impractical to use such a zero current interrupting device in combination with small relays. This invention overcomes the above problem by providing a simple triggering circuit that can be used to close and open at or near the zero point of the AC voltage wave, respectively.

Therefore, it is the object of this invention to provide a new and improved control circuit for small relays.

Another object of this invention is to provide a simple, inexpensive and reliable control circuit for initiating the operation of the relay to interrupt the current only at or near current zero.

Another object of this invention is to provide a simple, inexpensive and reliable control circuit for initiating the operation of the relay to close the load circuit only at or near voltage zero.

Referring more particularly to the drawing by characters of reference, the control circuit **10** of this invention is illustrated in connection with the reed type relay **11** positioned to connect a load **12** directly across an AC source **13**. The relay control circuit is supplied by a 28 volt DC source and has a coil **14** that is inductively related to the relay **11** for closing the relay which is normally biased toward an open position. The values assigned to the various elements of the control circuit are for illustration purposes only and are not intended to be limiting in any way.

With the movable contact **16** of the relay **11** in engagement with terminal **17**, the AC line voltage is presented to an appropriate resistor string **18** shown as the 500K, 3K, 6.8 ohm resistor string. The value of the resistances is such that only a negligible current flows through the load and hence this can be considered as a functionally open circuit. This string of resistors **18** acts as an attenuator and provides an alternating low voltage sginal in phase with the line voltage. This signal is fed to control circuit **10** and is ultimately used to close the relay when the line voltage curve is passing through zero. The value of the voltage signal is predetermined by the size of the resistors in the string and in the illustrated case is a 2 volt peak-to-peak signal. The signal is phase shifted by the capacitor **20** and the 30K resistor **21** and is presented to the input **22** of a conventional high gain difference amplifier **23** that is supplied by an appropriate DC source illustrated as a 28 volt source. The signal to amplifier **23** is amplified sufficiently to drive the output of the amplifier from 28 volts to zero volts rapidly thus producing a square-wave output which has a zero crossing phase lead of about 2 degrees.

The output of the difference amplifier **23** is connected to capacitor **25** and resistor **26**. Here the square-wave output of the amplifier **23** is differentiated by the capacitor and the resistor-circuit combination to give an output signal having a wave form at the junction **27** that has positive and negative spikes. This signal is then presented through the close button **28** and open button **29** to the input terminals **30, 31** respectively of the bistable multivibrator **32**. Difference amplifier **23** and bistable multivibrator **32** are known types of apparatus and are described in detail in a text entitled "Pulse and Digital Circuits" by Millman and Taub published by McGraw-Hill.

When the close button **28** is depressed, the output of the capacitor-resistor junction **27** is connected to the input **30**. The multivibrator **32** is designed so that it will receive only positive voltage pulses through this input **30**. Hence, the next positive-going spike in the signal wave flips the multivibrator **32** to a conductive state. The output of the multivibrator is connected to a reed relay coil **14** which is energized when the vibrator is conducting. This causes the red relay to close and the movable contact **16** of the relay moves from terminal **17** to terminal **35**, thus placing the load **12** directly across the AC line **13**. Hence, the circuit is closed.

The multivibrator **32** will remain in a conductive stage until a negative-going spike is presented to terminal **31**. This is accomplished by depressing the open button **29** which connects the output from the differentiating resistor-capacitor junction **27** to the input **31** of the bistable multivibrator. The multivibrator **32** is designed so that this input terminal **31** accepts only the negative voltage pulses. Hence, the next negative pulse received at the input terminal **31** will drive the multivibrator **32** to its nonconducting state whether or not the close switch **28** is released. This cuts off the current to coil **14**, which in turn releases the movable contact **16** of the relay **11**

so that it assumes its initial position in contact with terminal **17**.

When the relay is energized, the movable contact element **16** of the relay is in contact with terminal **35** and the load is directly across the AC source. A device such as current transformer **36** monitors the load current and produces a signal that is proportional to, and in phase with, the load current and presents it to the control circuit **10**. This signal is acted on by the control circuit including the difference amplifier **23** and the resistor-capacitor combinations **20**, **21** and **25**, **26** in substantially the same manner as described above in connection with the signal produced through the resistor string **18**. This results in the production of phase-locked spikes at the junction **27** of capacitor **25** and resistor **26**. Hence, when the open button **29** is depressed, the next negative-going spike in the wave from junction **27** is presented to input terminal **31** and flips the multivibrator **32** to its nonconducting stage, thus deenergizing relay coil **14** which causes the movable contact **16** to return to its normal position engaging terminal **17**.

With the circuit as described above, the relay **11** can close only when the AC supply voltage wave passes through zero and can open only when the load current wave passes through zero. This protects the relay **11** so that there is no excessive current or voltage between the contacts when it is opening or closing and prevents pitting and excessive arcing which would burn or cause unnecessary wear on the contacts. Such a relay can be significantly uprated and still be more reliable and have a longer life. For example, a reed relay rated at 3 amp capacity was recently tested with this circuit and performed over 10 million operations at 140 volts 7.14 amperes without a failure.

The use of a difference amplifier **23** with a high common mode rejection ratio makes it possible to use an economical, unfiltered 28 volt DC power supply. In addition, the components of this circuit enclosed in box **38** are especially adapted to be used as an integrated circuit. Hence, most of this control circuit **10** can be formed into an integrated circuit and placed in the same enclosure as the relay. This, of course, results in a total package which is only slightly larger than the reed relay per se and allows the packaging of the relay and substantially the entire circuit within an appropriate hermetically sealed container. The resulting relay-control package is relatively insensitive to temperature, pressure, atmosphere and other environmental factors, such as corrosive and explosive atmospheres, thus providing a much more reliable relay.

Although but one embodiment of this invention has been illustrated and described, it will be apparent to those skilled in the art that various modifications and changes can be made therein without departing from the spirit of the invention or the scope of the appended claims.

The embodiments of the invention in which an exclusive property or prvilege is claimed are defined as follows:

1. A combination switch and control circuit therefor comprising:

a load connected across an AC power source,

impedance means,

a switch connected between said load and said source, said switch having a first position connecting said load directly to said source and a second position connecting said load to said source through said impedance means,

means inductively coupled to detect load current and for providing an alternating voltage signal in phase with said AC source current when said switch is in said position,

means including said impedance means for providing an alternating voltage signal that is an analog of the voltage of said AC source when said switch is in said second position,

a control circuit for receiving either of said signals and producing an output that has a predetermined time relation to the signal received,

the output of said control circuit being connected to a device for moving said switch between said first and second positions.

2. The combination of claim **1** in which the output of the control circuit precedes the zero crossing point in the AC source current wave by substantially the amount of time required to move said switch from one of said positions to the other of said positions.

3. In combination:

an AC source,

a load for energization from said AC source,

resistance means,

a switch having one position for connecting said load directly across said AC source so that said load is energized,

said switch having another position for connecting said load across said AC source in series with said resistance means so that said load is substantially deenergized,

first means inductively coupled to detect load current and for generating an AC low voltage signal in phase with the load current when said switch is in its one position,

second means including said resistance means for generating an AC low voltage signal in phase with the AC source voltage when said switch is in its other position,

phase shifting means for receiving said low voltage signals from said first and second means and for shifting the phase thereof,

a difference amplifier for receiving the phase shifted signal from said phase shifting means and for producing a square-wave output signal,

differentiating means for receiving said square-wave output signal from said difference amplifier and for producing output signal having positive and negative spikes,

a bistable multivibrator for receiving said output signal from said differentiating means and for effecting activation of said switch, and

switching means for selectively presenting either positive or negative spikes of the output signal of said differentiating means to said multivibrator to effect actuation of said switch to its one position or to its other position.

4. A control for operating a relay comprising:

an AC source of power,

a load,

a relay normally biased to a first position to substantially deenergize said load and having a second position wherein said load is energized from said source,

resistance means connected across said AC source in series with said relay and said load when said relay is in said first position, said resistance means presenting a predetermined voltage signal to a control circuit,

said signal being in phase with the AC source voltage,

inductive means coupled to detect load current and to present a predetermined voltage signal to said control circuit when said relay is in said second position and said relay is connected directly in series with said load and said AC source,

a DC source of power for said control circuit,

said control circuit comprising a first resistance-capacitor circuit arranged to phase shift said signals,

the output of said first resistance-capacitor circuit being connected to a high gain difference amplifier to transform said signal to a square-wave, the output of said difference amplifier being connected to a second resistance-capacitor circuit which differentiates said square-wave into a wave having positive and negative-going spikes,

a bistable multivibrator having first and second input terminals, said first terminal being conditioned to accept only positive current pulses and said second terminal being conditioned to accept only negative current pulses,

means for selectively connecting the output of said second resistance-capacitor circuit to said first terminal of said bistable multivibrator to place it in a conducting mode,

means for selectively connecting the output of said second resistance-capacitor circuit to said second terminal of said multivibrator to place it in a nonconducting mode,

a coil controlling said relay and being connected to the output of said multivibrator,

whereby upon connecting said first terminal to the output of said second resistance-capacitor circuit said multivibrator is forced to its conducting mode and said coil is energized and moves said relay to its second position and upon connecting said second

terminal to the output of said second resistance-capacitor circuit said multivibrator is forced to its nonconducting state whereby it cuts off the current to said coil and causes said relay to return to its first position.

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U.S. Cl. X.R.

307—232; 317—11; 328—109

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,457,432 July 22, 1969

Roger A. Korn

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 70, after "said" insert -- first --.

Signed and sealed this 21st day of April 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents