

[54] RELAY WITH TIME DELAY COIL

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[51] Int. Cl. **H01h 47/18**

[58] Field of Search **335/59, 67, 202;**
317/141 S

[56] **References Cited****UNITED STATES PATENTS**

3,501,723	3/1970	Marien.....	335/202
3,558,996	1/1971	Mitchell et al.	317/141 S
3,562,595	2/1971	Swanson et al.	317/141 S
3,641,397	2/1972	Elliot et al.	317/141 S
3,683,301	8/1972	Boley et al.	335/59
3,688,130	8/1972	Granieri.....	317/141 S

OTHER PUBLICATIONS

"The Class 8501 Type GT Solid State Timer", Timing Relays, Square D Company, Bull. SM321 FAK, 1/64, p. 6.

Primary Examiner—James D. Trammell

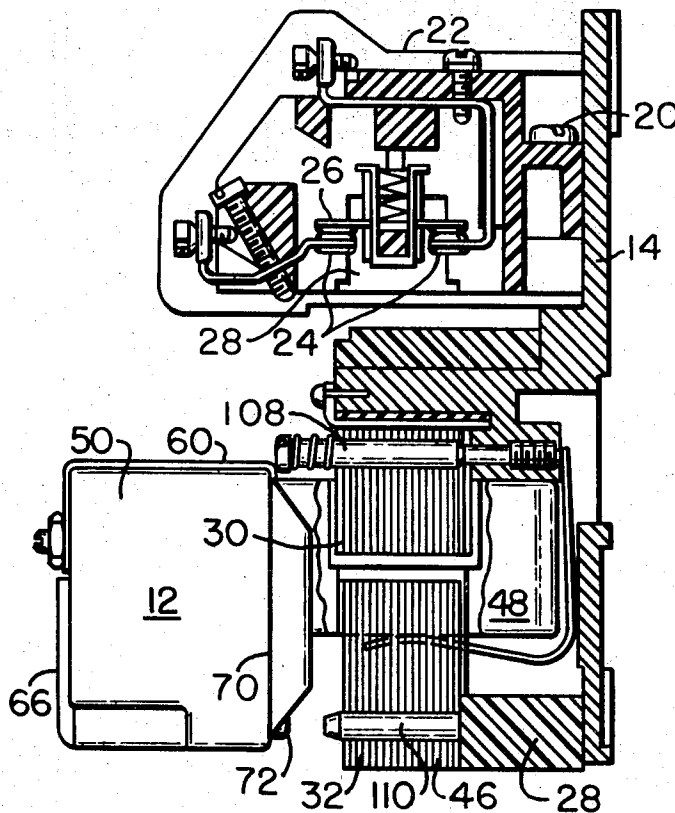
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[57]

ABSTRACT

An electromagnetically operated A.C. relay which is actuated an adjustable timed interval after the relay is energized. The relay incorporates the timing accuracy provided by a solid state timing circuit and the power switching advantages provided by mechanically operated switching contacts. The relay includes a unitary coil and timing unit which may be substituted for a coil in an instantaneous operated relay to convert the instantaneous operated relay to a relay which is actuated a predetermined time interval after the relay is energized.

10 Claims, 5 Drawing Figures



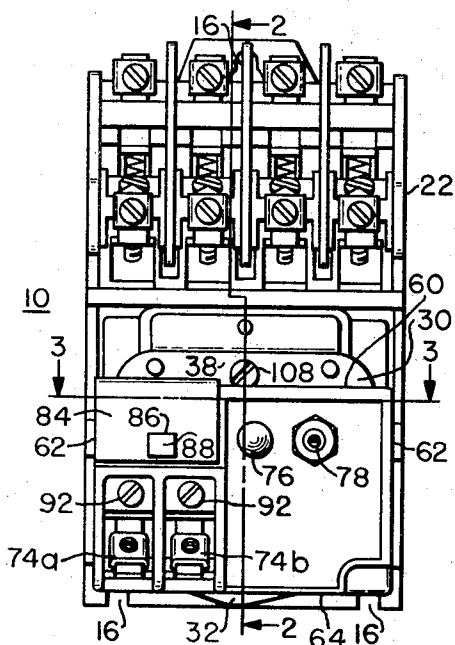


FIG. 1

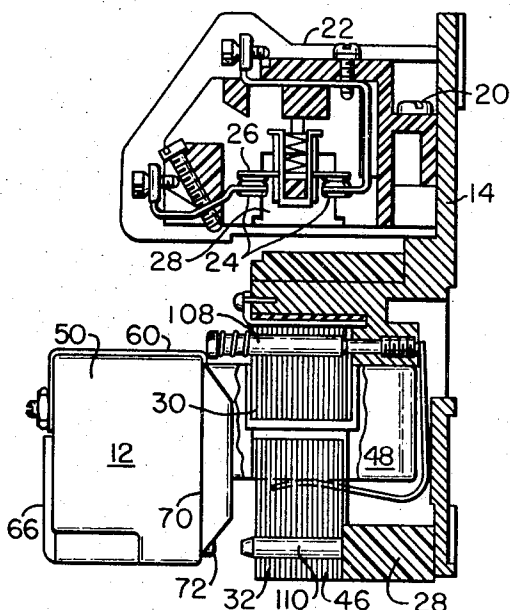


FIG. 2

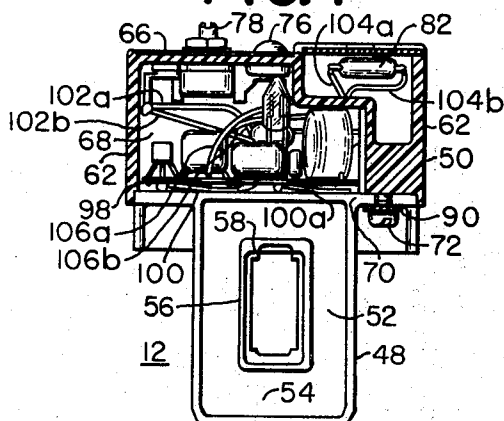


FIG. 3

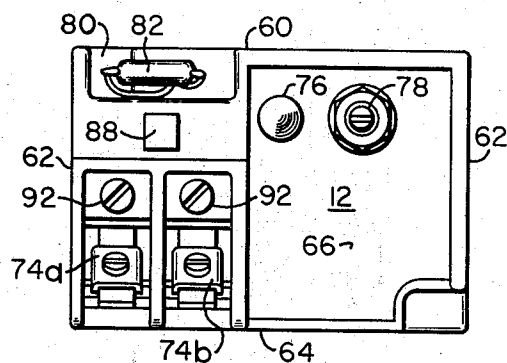


FIG. 4

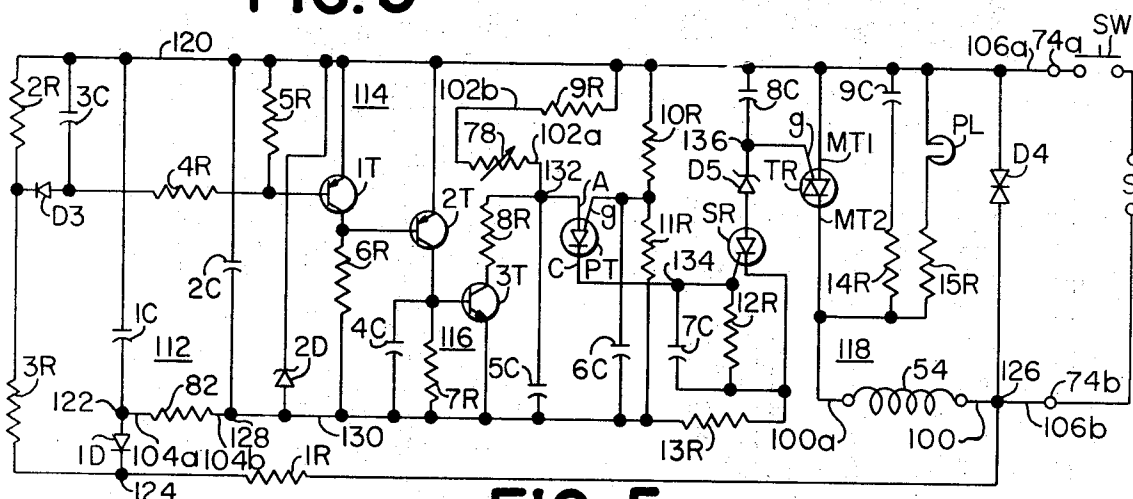


FIG. 5

RELAY WITH TIME DELAY COIL

This invention relates to electromagnetically operated switching devices and is more particularly concerned with a device having an alternating current magnet which is energized a predetermined time interval after power is applied to a control circuit of the device.

Timing devices are frequently used in industrial equipment to control an operating interval of a machine function or a process step as well as provide an output signal if an anticipated event fails to occur within a prescribed time interval. One form of a timing device frequently used in industrial installations is known as a pneumatic timer, an example of which is illustrated in U.S. Pat. No. 2,929,898, which was granted to Carl A. Schaefer on Mar. 22, 1960. While timers as shown in the Schaefer patent have been used with success in industry, their accuracy generally is limited when timing prolonged time intervals and their function may be impaired by dusty or highly corrosive environments. Another form of timing unit, which has been more recently introduced, is a device known as a solid state timer which uses solid state circuitry to measure a time interval and solid state components, such as silicon controlled rectifiers, to control the opening or closing of an output circuit. While solid state timing devices may be constructed to accurately time prolonged timing periods and to be unaffected by substantially all environments, their use is restricted in that they are usually expensive and limited because of the heat sinks which are required to dissipate the heat generated in the solid state components by currents in the output circuit. Another form of a timing device is disclosed in U.S. Pat. No. 3,683,301 which was granted to the inventors Robert D. Boley, Charles F. Meyer, Rudolf H. Kiessling and Kenneth L. Paape on Aug. 2, 1972. While the timing device as shown in the Boley et al patent incorporated the advantages of both pneumatic and solid state timing devices, it included a complicated latch mechanism and was capable of switching only a limited number of power circuits. The timing device as will be hereinafter described incorporates the advantages of both pneumatic and solid state timing devices in that it will provide accurately timed periods and is capable of switching the same number of circuits and has the same voltage clearances as required by industry standards as a relay, the parts of which form the basic structure of the device.

It is an object of the present invention to provide a replacement coil assembly in an alternating current type relay which will cause the relay to actuate its switching contacts an adjustable timed interval after the coil assembly is energized.

Another object is to provide a coil assembly in an electromagnetically operated device which will cause the device to operate its switching contacts a predetermined time interval after the coil assembly is energized.

An additional object is to provide a replacement coil assembly for a coil of an A.C. relay so the relay will operate with a timed delay after the coil assembly is energized with the assembly including a coil winding and a circuit having solid state components which will delay the energization of the coil for an adjustable timed interval after an alternating current is supplied to a pair of input terminals of the assembly.

Further objects and features of the invention will be readily apparent to those skilled in the art from the following specification and from the appended drawings illustrating certain preferred embodiments in which:

FIG. 1 is a front view in elevation of an electromagnetic switch including a coil assembly according to the present invention;

FIG. 2 is a cross-sectional view taken along line 2—2 in FIG. 1;

FIG. 3 is a cross-sectional view of the coil assembly in FIG. 1;

FIG. 4 is a front view of the coil assembly in FIG. 1 with a cover for an external resistor removed; and

FIG. 5 is a schematic diagram of a circuit controlling the energization of a coil winding according to the present invention.

An electromagnetic switch or relay 10, as shown in the drawings, is identical with an electromagnetic relay as disclosed in U.S. Pat. No. 3,501,723, which was granted to Kenneth J. Marien on Mar. 17, 1970 and assigned to the assignee of the present invention, with the exception that the coil for the electromagnet in the relay shown in the Marien patent is replaced by a coil assembly 12 in the relay 10. As the constructional details of the relay 10 are fully disclosed in the Marien patent, only a brief description necessary to understand the present invention will be set forth herein, it being understood that the invention disclosed herein may be used with electromagnetic devices other than shown in the Marien patent.

The relay 10 includes a base 14 which is formed as a unitary part of die cast metal material and has openings 16 which receive screws for mounting the relay 10 on a panel. Positioned at a top portion of the base 14 by suitable screws 20 is an insulating support 22 carrying a row of spaced pairs of stationary contacts, each designated by a numeral 24. The respective pairs of stationary contacts 24 are located to be bridged by individual movable contacts 26 which are resiliently supported by springs and movable contact retainers on a movable contact carrier 28. The structure of the support 22, the stationary contacts 24, the movable contacts 26, the carrier 28, are more fully disclosed and described in U.S. Pat. No. 3,501,717, which was granted to the inventors Allin W. Schubring and Kenneth L. Paape on Mar. 17, 1970 and assigned to the assignee of the present invention.

An electromagnet assembly, which when energized causes the movable contact carrier 28 to move upwardly on the base 14, includes a stationary magnet 30, a movable magnet part or armature 32, and the coil assembly 12. The magnet 30 includes a stack of E-shaped magnet iron parts which are laminated upon each other and tightly held assembled between a pair of magnetic E-shaped side plates by rivets. The magnet 30 has a pair of spaced arms extending downwardly from opposite ends of a body portion 38 with a central leg extending from the body portion so that the spaced arms are spaced on opposite sides of the central leg. The spaced arms have flat downwardly facing pole faces at their free ends.

The armature 32 is formed of a stack of T-shaped laminated magnet iron parts which are tightly held assembled by rivets. The armature 32 has a central leg and flat upwardly facing pole faces on the opposite ends of a body portion 46.

The coil assembly 12 includes a molded shell 48 and a molded housing 50. The shell 48 has a cavity 52 extending from an open top end. A coil winding 54 surrounds a projection 56 that extends upwardly in the cavity 52 from the bottom side of the shell 48. The projection 56 has a rectangular opening 58 which receives the central leg of the magnet 30 while the spaced arms of the magnet 30 extend along the opposite sides of the shell 48 so that portions of the coil winding 54 are located between the central leg on the magnet 30 and the spaced arms. The cavity 52 is filled with a suitable epoxy type encapsulating material after the coil 54 is positioned in the cavity 52.

The housing 50 includes a top wall 60, side walls 62, a bottom wall 64 and a front wall 66 which define a cavity 68 having an open rear side which is closed by a front end wall 70 on the shell 48, when the shell 48 and housing 50 are secured together by a pair of screws 72 located at diagonally opposite corners of the wall 70. Positioned on the front wall 66, so as to be externally accessible, are a pair of terminals 74a and 74b, a lens 76 and an adjustment knob of a potentiometer resistor 78. Extending in the top wall 60 and the front wall 66 is an alcove 80. A resistor 82 is positioned in the alcove 80 and a metal cover 84 is positioned to cover the alcove 80. The cover 84 is secured on the housing 50 by an opening 86 in the cover 84 which receives a boss 88 on the front wall 66 and an apertured ear 90 which receives one of the screws 72. The terminals 74a and 74b are positioned on the front wall 66 by screws 92 which extend through suitably located openings in the front wall and are threaded into portions of the terminals 74a and 74b respectively that are located in the cavity 68. Positioned within the cavity 68 by resilient pads is a thick-film substrate board 98, preferably formed of alumina which provides a mounting for the circuit and components shown in FIG. 5, with the exception of the resistor 82 and potentiometer resistor 78. The active components, i.e., transistors, triacs and capacitors, are mounted on the front side of the substrate 98 and the resistors and conductive circuitry are printed on the rear side of the substrate 98 by thick film technology in a manner well known to those skilled in the art. The winding of the coil 54 is connected to the circuit on the rear side of the substrate 98 by a pair of leads 100 and 100a. The potentiometer 78, the resistor 82 and the portions of the terminals 74a and 74b are connected to the circuit on the front side of the substrate 98 by pairs of leads 102a-b, 104a-b and 106a-b, respectively. The coil assembly 12, the magnet 30, and the armature 32 are assembled in the switch 10 in a manner described in the Marien patent. During assembly of the electromagnet, the magnet 30 is positioned so its central leg is received in the opening 58 from the top side of the coil assembly 12 and the armature 32 is positioned so its central leg extends in the opening 58 from the bottom side of the coil assembly 12 while the electromagnet assembly is detached from the base 14. The electromagnet assembly is then positioned on the base 14 to have a mounting screw 108 extending through a bore in the body portion 38 aligned with the threaded opening in the base 14 and a bore in the body portion 46 aligned to receive a pin 110 that extends from the movable contact carrier 28. The electromagnet assembly is maintained in its position by tightening the screw 108. The removal of the electromagnet assembly is accomplished by merely loosening the screw

108 and lifting the electromagnet assembly from its position on the base 14.

The timing circuit shown in FIG. 5 includes components which provide a power supply circuit 112, a reset circuit 114, a timing circuit 116 and an output circuit 118. The power supply circuit 112 includes a capacitor 1C, a capacitor 2C, a resistor 1R, a rectifying diode 1D, a Zener diode 2D and the resistor 82 which is mounted in the alcove 80. The capacitor 1C acts as a filter capacitor and is connected between a lead 120 and a junction 122. The lead 120 is connected through the lead 106a to the terminal 74a. The terminal 74a is connected through a switch SW to a first side of an alternating current source S. The diode 1D is connected between the junction 122 and a junction 124. The junction 124 is connected through the resistor 1R to a junction 126. The junction 126 is connected through the lead 106b and terminal 74b to a second side of the alternating current source S. The capacitor 2C is connected between the lead 120 and a junction 128. The resistor 82 is connected between the junctions 122 and 128. The Zener diode 2D is connected between the lead 120 and a lead 130 which is connected to the junction 128. The diode 1D acts as a half wave rectifier and is connected so the lead 120 is positive in polarity relative to the lead 130 and the junction 124. The Zener diode 2D is connected to regulate the voltage between the leads 120 and 130. The capacitors 1C and 2C respectively act as filter and noise suppressing capacitors. The resistor 1R limits the charging current of capacitor 1C and the resistor 82 acts as a dropping resistor.

The reset circuit includes transistors 1T, 2T and 3T, capacitors 3C and 4C, resistors 2R-8R and a diode 3D. The transistors 1T and 2T have their emitters connected to the lead 120 and their collectors connected through resistors 6R and 7R respectively to the lead 130. The transistor 3T has its emitter connected to the lead 130 and its collector connected through the resistor 8R to a junction 132. The resistors 2R and 3R are connected between the lead 120 and the junction 124 to act as voltage divider resistors. The base of the transistor 1T is connected through the resistor 4R and the diode 3D to a junction between the resistors 2R and 3R and the capacitor 3C is connected between the lead 120 and a junction between the diode 3D and the resistor 4R. The diode 3D acts as a half wave rectifier in the charging circuit for the capacitor 3C. The resistor 5R is connected between the base of transistor 1T and the lead 120 to act as a bias resistor. The capacitor 4C is connected between the base of the transistor 3T and the lead 130 as a noise suppressor. The bases of transistors 3T and 2T are connected to the collectors of the transistors 2T and 1T respectively.

The timing circuit includes a programmable unijunction transistor PT, resistors 9R-11R, capacitors 5C-6C, and the potentiometer resistor 78. The programmable transistor PT has an anode A connected to the junction 132, a gate g connected to a junction between the resistors 10R and 11R, which are connected between the leads 120 and 130, and a cathode C connected to a junction 134. The capacitor 6C is connected between the gate g and the lead 130. The capacitor 5C is connected between the junction 132 and the lead 130 and the potentiometer resistor 78 and the resistor 9R are connected in series between the junction 132 and the lead 120. The resistors 10R and 11R act as voltage dividers and determine the intrinsic stand-off

ratio of the transistor PT. The capacitor 6C acts as a noise suppressor and the resistor 9R and the potentiometer 78 control the rate at which the timing capacitor 5C is charged with the resistor 9R limiting the maximum rate at which the capacitor 5C charges.

The output circuit 118 includes a triac TR, a silicon controlled rectifier SR, a pilot light PL, a voltage suppressing diode D4, a Zener diode D5, capacitors 7C-9C and resistors 12R-15R which are connected to control the energization of the coil winding 54.

The term "triac" is an acronym that has been coined to identify the triode (three-electrode) A.C. semiconductor switch which is triggered into conduction by a gate signal in a manner similar to the action of an SCR. The triac, generically called a bidirectional triode thyristor, first developed by General Electric (U.S. Pat. No. 3,275,909, and others applied for) differs from the SCR in that it can conduct in both directions of current flow in response to a positive or negative gate signal.

The diode D4 is connected across the source S and acts as a transient voltage clipper. The triac TR has a main terminal MT1 connected to the lead 120 and a main terminal MT2 connected through the coil winding 54 to the junction 126. The gate g of the triac TR is connected to a junction 136. The capacitor 8C is connected between the junction 136 and the lead 120 to suppress noise signals at the gate g of the triac TR. The Zener diode D5 has a cathode connected to the junction 136 and an anode connected to the anode of the controlled rectifier SR. The controlled rectifier SR has a cathode connected through the resistor 13R to the lead 130 and a gate connected to the junction 134. The capacitor 7C and the resistor 12R are connected between the gate and the cathode of the rectifier SR and act as noise suppressors and gate resistors respectively for the rectifier SR. The pilot light PL is preferably of the neon type and is connected in series with the resistor 15R. The series connected pilot light PL and the resistor 15R are connected in parallel with the triac TR and in parallel with the series connected capacitor 9C and the resistor 14R which are also connected in parallel with the triac TR for noise suppression.

All of the capacitors 1C-9C are discharged and all of the solid state components are nonconducting when the switch SW is open and the circuit is reset. The switch SW, when closed, connects the circuit including the lead 120 to the source S. The switch SW, when initially closed, causes the capacitor 1C to be charged through the diode 1D and the Zener diode D2, together with the capacitor 2C, causes the lead 120 to be approximately 20 volts positive in polarity relative to the lead 130. The transistor 1T conducts when the switch SW is closed and causes the transistors 2T and 3T to be nonconducting. The nonconducting transistor 3T permits the capacitor 5C to be charged at a rate determined by the impedance of the resistor 9R and the potentiometer 78. The voltage divider provided by the resistors 10R and 11R determines the intrinsic standoff ratio of the programmable unijunction transistor PT. After a predetermined time interval, when the charge on the capacitor 5C reaches the value dictated by the intrinsic stand-off ratio of the transistor PT, the transistor PT switches to its conductive state and supplies a sharp voltage pulse through its anode to cathode to the gate and cathode of the rectifier SR. The rectifier SR is switched to its conductive state by the voltage pulse and remains conducting as it is connected across the

direct current source between the leads 120 and 130.

The capacitor 1C, the diode 1D and the Zener diode 2D rectify and filter the alternating current output of the source S when the switch SW is closed and cause a direct current potential of approximately 20 vdc to be present between the leads 120 and 130. Thus when the rectifier SR conducts, a direct current will flow from the lead 120 through the terminal MT1 to the gate g of the triac TR through a circuit that includes the Zener diode D5, the anode to cathode of the rectifier SR, the resistor 13R, the lead 130, the resistor 82, the diode 1D, the junction 124 and the resistor 1R during the half cycle when the terminal 74a is positive in polarity relative to the terminal 74b. During the half cycle when the source S causes the alternating potential at the terminal 74a to be negative relative to the terminal 74b, the charge on the capacitor 1C causes the direct current to continue to flow through the terminal MT1 and the gate g of the triac TR. The direct current flow through the terminal MT1 and the gate g of the triac TR switches the triac TR to a conductive state and causes alternating current to flow from the source S through the closed switch SW, the conducting triac TR and the coil winding 54. The alternating current flow through the coil winding 54, as caused by the conducting triac TR, causes the electromagnet assembly of the relay 10 to be energized and the movable contact carrier to move upwardly and actuate the switching contacts of the relay 10. Thus the relay 10 is actuated a predetermined time interval after the switch SW is closed.

The pilot light PL is positioned on the front side of the substrate 98 so as to be visible through the lens 76 and is connected across the source S in a circuit that is parallel to the triac TR. Thus during the timing interval after the switch SW is closed and prior to the switching of the triac TR to a conductive state, the pilot light will be illuminated by current flowing from the source S through the resistor 15R and the coil winding 54. The current flowing through the coil winding 54 during periods when the pilot light PL is illuminated is insufficient to cause the electromagnet assembly of the relay to be energized to the degree necessary to cause the armature 32 to move into engagement with the magnet 30. Thus during the timing period the relay 10 will be de-energized and the pilot light will be illuminated and be visible through the lens 76 to indicate the presence of the timing period and that the timing circuit is energized. At the end of the timing period, the triac TR conducts and provides a low impedance path in parallel with the pilot light PL and the resistor 15R which causes the pilot light PL to be de-energized and not be visible through the lens 76 to signal the end of the timing period.

The reset circuit 114 causes the capacitor 5C to be rapidly discharged when the switch SW is opened either during the timing period or after the timing period has ended and the relay 10 is energized. The opening of the switch SW interrupts the circuit between the source S and the lead 120 and the junction 126 thereby causes the coil winding 54 to be de-energized and the armature 32 and the movable contact carrier 26 to move to their de-energized positions. The opening of the switch SW also interrupts the charging circuit for the capacitor 3C and removes the emitter to base bias of the transistor 1T so the capacitor 3C rapidly discharges and the transistor 1T switches to its non-

conductive state. The charging circuit for the capacitor 3C, that is connected between the lead 120 and the junction 124, includes the diode D3 and the resistor 3R. The bias circuit for the emitter to base circuit of the transistor 1T includes the voltage divider resistors 2R and 3R which causes a current flow in the base circuit of the transistor 1T that includes the resistor 4R, the diode D3 and the resistor 3R. The removal of the potential on the lead 120, when the switch SW is opened, causes the capacitor 3C to rapidly discharge through the emitter to base of the transistor 1T and through the resistor 5R.

The transistor 2T switches to a conductive state when the transistor 1T switches to a non-conductive state and the capacitor 1C is charged. The charge on the capacitor 1C causes base current flow in the transistor 2T through a circuit that includes the lead 120, the emitter to base of the transistor 2T, the resistor 6R, and the resistor 82. The emitter to base current in the transistor 2T causes the capacitor 1C to supply current through the collector of the transistor 2T and through the base and emitter of the transistor 3T which causes the transistor 3T to be conductive and the capacitor 5C to rapidly discharge through the low impedance circuit provided by the conducting transistor 3T and the resistor 8R. Thus the timing capacitor 5C is rapidly discharged immediately after the switch SW is opened. In the embodiment shown, the capacitor 5C has a 47 MFD capacitance and the resistor 8R has a 100 ohm resistance which causes the capacitor to be discharged in approximately 50 milliseconds. The rapid discharge of the capacitor 5C after the switch SW opens prevents a build-up of a charge on the capacitor 5C and false energization of the coil winding 54 when the switch SW is rapidly opened and closed before the end of a timing period and assures that the timing circuit will have a high repeat accuracy when the switch SW is opened and immediately closed after the coil winding has been energized in response to a timed-out timing period. The resistor 82 is provided to limit the gate current in the triac TR to a minimum value which will cause the triac TR to conduct and therefore is mounted externally of the housing 50 so the heat generated in the resistor 82 may be efficiently dissipated by the cover 84.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. In an electromagnetically operated device, the combination comprising: a base, an insulating stationary contact support mounted on the base, a plurality of stationary contacts mounted on the support, a movable contact carrier, movable contacts positioned by the carrier to engage the stationary contacts and provide selected circuit opening and closing functions when the carrier is moved from a first position to a second position, an electromagnet assembly mounted on the base, said electromagnet assembly including a laminated magnet iron stationary magnet positioned on the base, a laminated magnet iron armature connected to the carrier and movable between two positions relative to the stationary magnet part for moving the carrier from the first to the second position and a coil assembly positioned on the stationary magnet part for inducing a

magnet flux in the stationary magnet part and the armature for causing the armature and carrier to move from the first position to the second position a selected time interval after the coil assembly is energized, said coil assembly including a molded shell having a pair of spaced cavities, a projection extending upwardly in a first of said pair of cavities from a bottom wall of the shell, a passage extended through the projection, a coil winding positioned within the first cavity and surrounding the projection, a pair of terminals having wire fastening portions disposed externally of the shell and portions within a second of said pair of cavities, and means including electric circuit having solid state components positioned within the second cavity and connected between the portions of the terminals within the second cavity and the coil winding in the first cavity for delaying the energization of the coil winding for a predetermined timed interval when the electric power is initially applied to the terminals.

2. The combination as recited in claim 1 including a thick-film board and wherein the shell is formed of two parts which are secured together with a first of said two shell parts providing the second cavity and a housing for the thick-film board whereon components of the solid state circuit are carried and a second of the two shell parts providing the first cavity, a housing for the coil winding, and a mounting for the first shell parts.

3. The combination as recited in claim 2 wherein the electric circuit includes a potentiometer having a resistive portion positioned in the second cavity and an adjustment knob extending through a front wall of the first housing part so as to be externally accessible from a front side of the device.

4. The combination as recited in claim 3 wherein the electric circuit includes a light emitting device that is visible through an opening in the front wall during the interval when the electric circuit is delaying the energization of the coil.

5. The combination as recited in claim 3 wherein the first shell part includes an alcove extending in a top wall of the first shell part and the electric circuit includes a resistor which is heated when the pair of terminals are energized and is positioned in the alcove.

6. The combination as recited in claim 5 including a metal cover for the alcove.

7. The combination as recited in claim 1 wherein the electric circuit includes a timing capacitor which is charged at a predetermined rate when electric power is initially applied to the terminals, means responsive to the charge level on the capacitor for causing the coil to be energized when the charge on the capacitor reaches a predetermined level and means for rapidly discharging the capacitor when the electric power to the terminals is interrupted.

8. The combination as recited in claim 2 wherein the second shell part includes an open sided cavity wherein the coil winding is positioned and the cavity is filled with encapsulating material.

9. The combination as recited in claim 1 wherein the plurality of stationary contacts are arranged as a row of spaced pairs of stationary contacts on the support and the movable contacts are arranged as a row of spaced contacts on the carrier to individually bridge one of the pairs of stationary contacts.

10. The combination as recited in claim 1 wherein the stationary contacts and the movable contacts are arranged to selectively provide a normally open and a normally closed contact function.

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