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Lourigan

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[54] **TIME DELAYED SOLENOID VALVE**

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[73] Assignee: **Webster Electric Company, Inc.,** Racine, Wis.

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[52] **U.S. Cl.** ..... **317/141 S;** 251/129; 307/252 R; 317/148.5 B

[51] **Int. Cl.**[2] **H01H 47/18**

[58] **Field of Search** ..... 317/141 S, 142 R, 148.5 B, 317/DIG. 7, 154; 323/22 SC; 251/129, 54; 431/29, DIG. 45, 52, 53; 307/293, 252 N, 252 W, 252 R

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Attorney, Agent, or Firm—Mason, Kolehmainen, Rathburn & Wyss

[57] **ABSTRACT**

A time delayed solenoid valve includes a control circuit coupled between a source of AC power and a solenoid coil, the energization of which coil controls the opening and closing of the valve to supply fuel oil or the like at appropriate times. The control circuit has a half wave rectifier coupled to the source of AC power through a thermostat or the like in order to supply half wave rectified power to a time delay circuit and a normally nonconductive silicon control rectifier coupled between the half wave rectifier and the solenoid coil. After a specified time delay following the closing of the thermostat, the time delay circuit, which is regulated so as not to be significantly affected by changes in the AC power, renders the silicon controlled rectifier conductive so that a half wave rectified energizing current is supplied to the solenoid coil. The silicon controlled rectifier is maintained conductive by means of a latching circuit including the solenoid coil. In the preferred embodiment, the solenoid coil and the control circuit are disposed in a single housing with the valve portion of the solenoid valve attached thereto.

5 Claims, 6 Drawing Figures

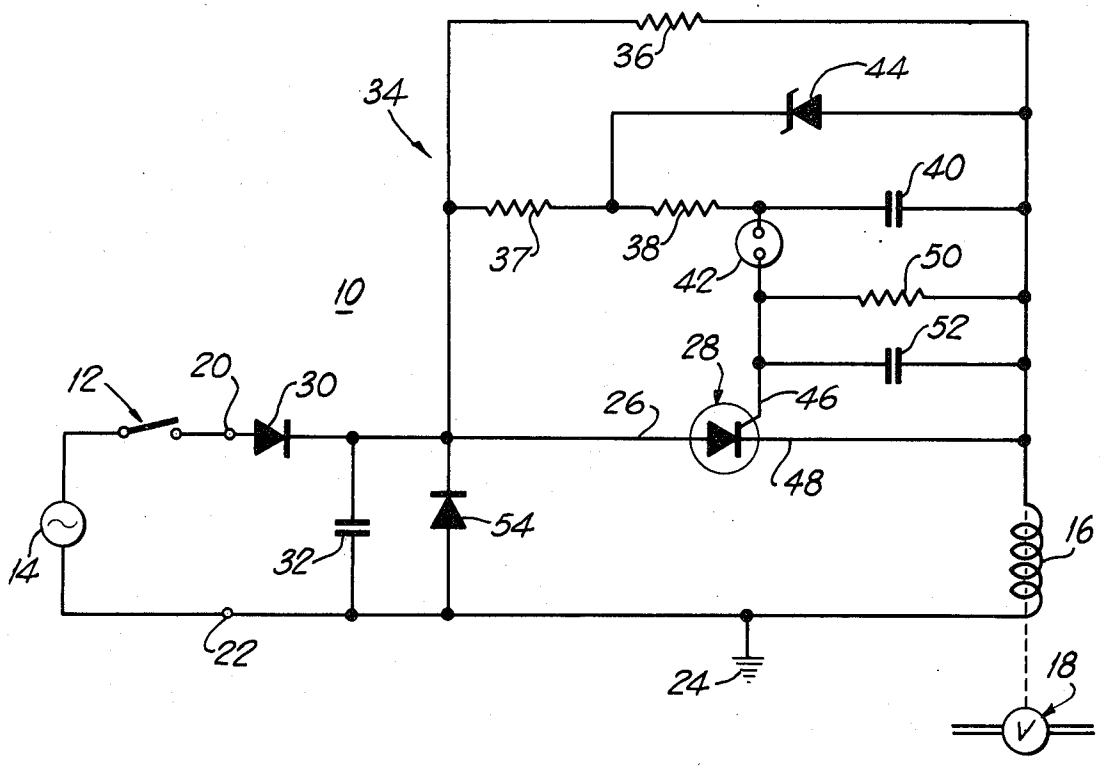


Fig. 1

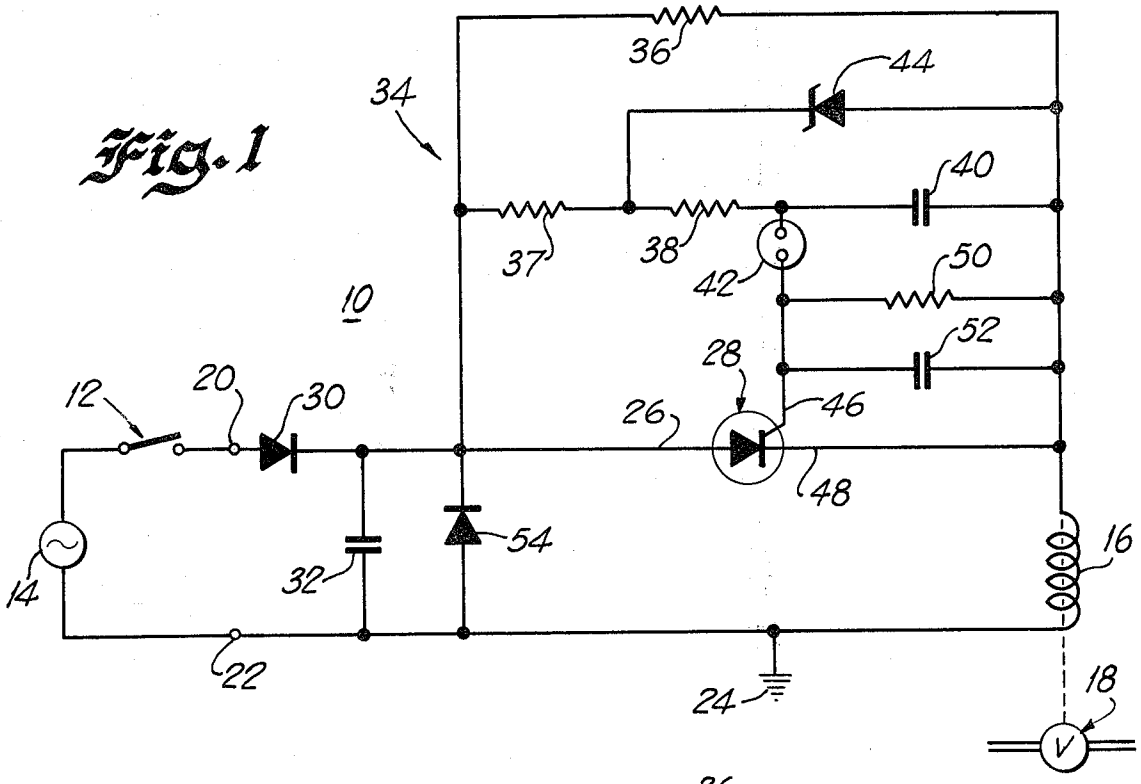

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Fig. 2

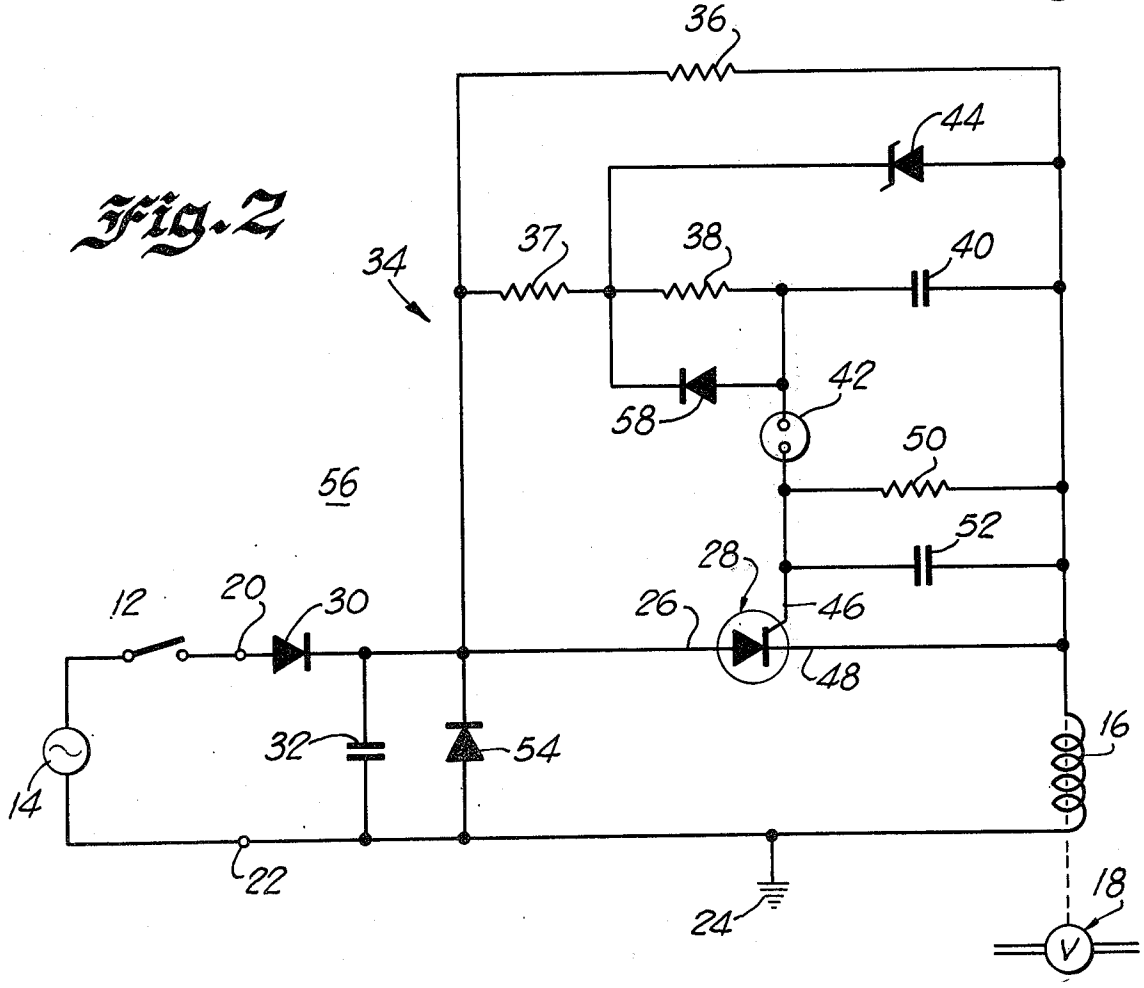

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Fig. 3

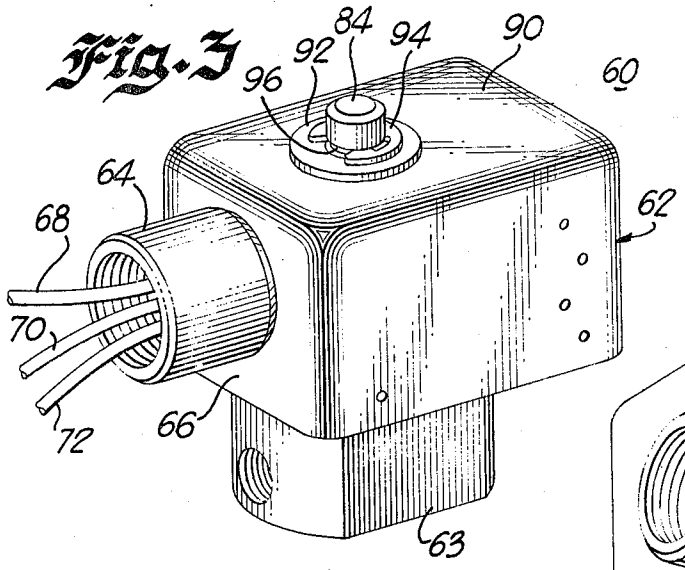


Fig. 6

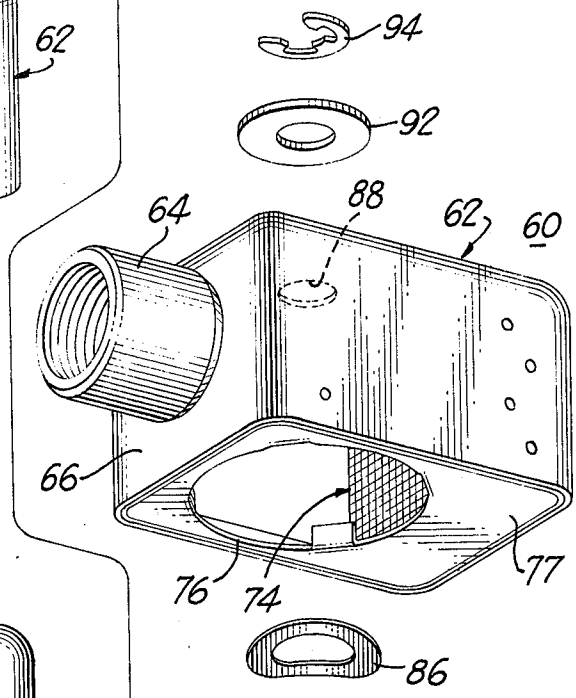
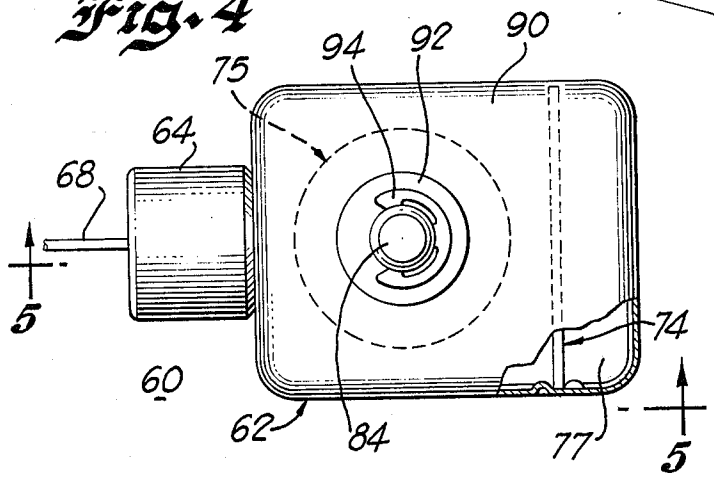


Fig. 4



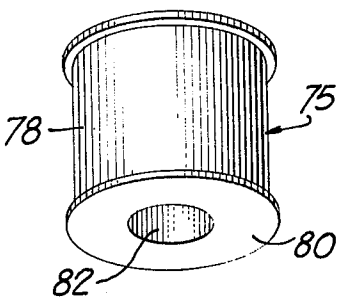
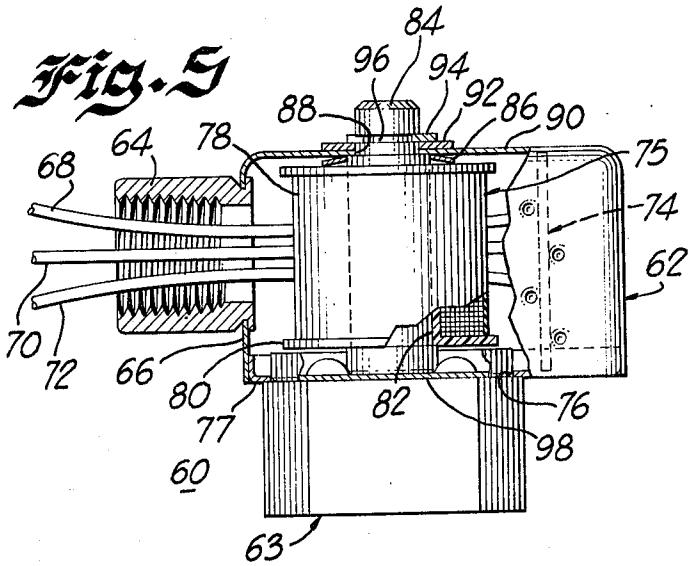
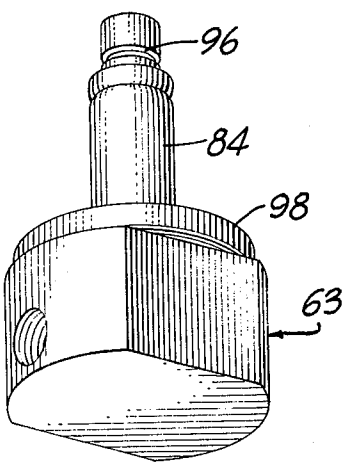


Fig. 5





TIME DELAYED SOLENOID VALVE

This invention relates to a solenoid valve, and, more particularly, to a new and improved time delayed solenoid valve that can be contained within a single housing or package.

A solenoid valve is utilized in oil burner systems to supply fuel oil to the burner at the appropriate times. In most oil burner systems, the introduction of the fuel oil to the burner and thereby the ignition of the burner is delayed a short period of time, such as three to seven seconds, after closing of a thermostat or the like. The short time delay allows the draft fan to establish a stable air pattern at a high enough velocity to establish good fuel mixing when the burner is actually ignited.

Various time delay devices have been used to delay ignition of the oil burner. At one time, a resistance wire was wound about bimetallic blades on which were mounted switch contacts. After a short time, the heat generated from the resistance wire would cause the blades to move together closing the switch contacts. In addition, the same type of switches were mounted in a glass enclosure similar to a vacuum tube.

Thereafter, vacuum tube rectifiers having an indirectly heated cathode were utilized for establishing the delayed operation of the solenoid valve. The delay time was determined by the time required for heating the cathode in the tube. Subsequently, a thermistor was mounted in series with the solenoid coil and the delay time was determined by the resistance change of the thermistor as it was self-heated by the current being supplied to the coil.

Unfortunately, these various arrangements were all dependent on some type of thermal mechanism and had very little or no compensation for thermal changes, especially as the ambient temperatures decreased. When such devices were installed in an unheated area where the ambient temperature might be as low as 40° F, the delay time established by these devices tended to increase and many times increased to such an extend that the delay time was longer than the safety lock out time required by the burner system. In these instances, such thermal devices became completely unusable.

In order to overcome the inherent difficulties in these temperature sensitive devices, one type of solid state control circuit was developed and made commercial. This type of control circuit was packaged in a separate housing from the solenoid coil itself and connected to the solenoid coil by appropriate conductors or leads. In this type of control circuit line potential is coupled to a normally nonconductive silicon controlled rectifier (SCR) through a thermostat or switch and a full wave rectifier. When the SCR is placed in a conductive state due to the supplying of its gate electrode with a positive potential, the SCR supplies an operating potential through a choke to a solenoid coil located in a separate package or housing. In order to delay the rendering of the SCR conductive for a short period of time after the closure of the switch, the positive potential supplied to the gate electrode is delayed by a delaying circuit including a neon light and an integrating capacitor. Once rendered conductive, the SCR is maintained conductive by discharging the choke into the gate electrode of the SCR so as to maintain a positive potential on the gate electrode.

Unfortunately, since such a device requires the utilization of a full wave rectifier and a choke, the resulting high operating temperatures of the solenoid coil and the control circuit causes excessive temperatures so that the delay circuit and the solenoid coil cannot be placed in a single package. Moreover, this type of device tended to have radically different delay times if the line voltage varied.

Accordingly, objects of the present invention are to provide a new and improved solenoid valve for utilization with an oil burner system; to provide a time delay solenoid valve that can be placed in a single package or housing; to provide a new and improved time delay circuit for a solenoid valve for an oil burner system; to provide a new and improved time delay circuit for an oil burner valve such that the valve can be operated on half wave rectified current; and to provide a new and improved time delay circuit for a solenoid coil that is not appreciably affected by line voltage discrepancies.

In accordance with these and many other objects, an embodiment of the present invention comprises a time delay control circuit for a solenoid valve used with an oil burner system. The control circuit operates on normal line voltage and includes a half wave rectifier that supplies a regulated time delay circuit with a DC potential. After a predetermined time delay, the time delay circuit renders a silicon controlled rectifier conductive so that the rectified current is also supplied through the silicon controlled rectifier to a solenoid coil resulting in the opening of the solenoid valve. The silicon controlled rectifier is maintained conductive by means of a latching circuit including the coil and a rectifier. In the preferred embodiment, the control circuit is mounted within the same housing or package in which the coil of the solenoid valve is located.

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawings in which:

FIG. 1 is a schematic diagram of one embodiment of a time delay control circuit for a solenoid actuated valve for an oil burner or the like;

FIG. 2 is another embodiment of the time delay control circuit of FIG. 1;

FIG. 3 is a perspective view of a solenoid valve package made in accordance with the present invention;

FIG. 4 is a top view partially cut away of the solenoid valve package of FIG. 3;

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 4; and

FIG. 6 is an exploded view of the solenoid valve package of FIG. 3.

Referring now more specifically to FIG. 1 of the drawings, there is illustrated a control circuit for a solenoid valve, which control circuit is indicated generally as **10** and which embodies the present invention. Upon closing of a switch **12**, either manually or automatically by means of a thermostat or the like, a source of AC potential **14** is coupled to the control circuit **10**. Under normal circumstances, the source **14** is a power distribution line or the like having a line voltage of **60** cycles, single phase, **120** volts. After a predetermined period of time, the control circuit **10** supplies an energizing current to a solenoid coil **16** resulting in the opening of a valve **18** so that fuel oil or the like is allowed to pass through the valve **18** to a burner system (not shown). The period of time after the closure of the switch **12** before the coil **16** is energized allows a draft fan in the burner system to establish appropriate air patterns in

the burner for good fuel mixing of the fuel oil before the burner is actually ignited due to the supplying of oil through the open valve **18**.

More specifically, with the closing of the switch **12**, AC input power or line potential from the power source **14** is supplied to a pair of input terminals **20** and **22** of the control circuit **10**, the input terminal **22** being coupled directly to a ground terminal **24**. The line potential received at the input terminal **20** is coupled to an anode electrode **26** of a normally nonconductive silicon controlled rectifier **28** through a diode **30**. The diode **30** acts as a half wave rectifier so that the line potential is converted into a DC potential and is supplied to the anode electrode **26** of the silicon controlled rectifier **28**. Coupled between the anode electrode **26** and the input terminal **22** is a capacitor **32** which filters the rectified potential being supplied by the diode **30** and assists in filtering out any line transients that might adversely affect the operation of the control circuit **10**.

The rectified potential supplied by the diode **30** is also coupled to a timing or delay circuit **34** including resistors **36, 37** and **38**, an integrating capacitor **40**, a neon light **42**, and a Zener diode **44**. When the rectified potential is supplied to the timing circuit **34** and in particular to the capacitor **40** through the resistors **37** and **38**, the capacitor **40** begins to charge. Once the capacitor **40** charges to a potential beyond the breakdown potential of the neon light **42**, the neon light **42** fires allowing a positive potential to be supplied to a gate electrode **46** of the silicon controlled rectifier **28**. Upon application of the positive potential to the gate electrode **46**, the silicon controlled rectifier **38** is actuated or becomes conductive and remains conductive as long as the anode electrode **26** receives a relatively positive potential with respect to the potential at a cathode electrode **48** of the silicon controlled rectifier **28**. The capacitor **32** ensures that the anode electrode **26** is receiving a relatively positive potential when the positive potential is supplied to the gate electrode **46** through the neon light **42**.

Since the stability of the silicon controlled rectifier **28** increases in proportion with decreasing gate resistance, a resistor **50** is coupled between the gate electrode **46** and the cathode electrode **48** and is selected to provide a minimum amount of gate resistance commensurate with the timing circuit **34**. In addition, a capacitor **52** is also coupled in parallel with the resistor **50** between the gate electrode **46** and the cathode electrode **48** to assist the capacitor **32** in preventing undesired actuation of the silicon controlled rectifier **28** due to line transients or other voltage changes.

Upon rendering of the silicon controlled rectifier **28** conductive, the half wave rectified current from the diode **30** is allowed to pass through the conductive path between the anode electrode **26** and the cathode electrode **48** of the silicon controlled rectifier **28** so that a DC half wave rectified energizing current is supplied to the solenoid coil **16**. With the coil **16** energized, the valve **18** opens and fuel oil or the like can be supplied to the burner system. Accordingly, the control circuit **10** only allows fuel oil to be supplied through the valve **18** after a short time delay has occurred subsequent to the closing of the switch **12**.

This time delay is determined by the timing circuit **34**, and, in particular, the amount of time to charge the capacitor **40** to a value in excess of the breakdown voltage of the neon light **42**. By appropriately adjusting the RC value of the timing circuit **34** and particularly the value of the resistors **36, 37** and **38** and the capacitor **40** and by selecting the appropriate neon light **42**, the time delay produced by the timing circuit **34** can readily be selected. However, this time delay would change significantly with changes in the line potential received from the power source **14** if it were not for the Zener diode **44** that is coupled across or in parallel with the series circuit of the resistor **38** and the capacitor **40**. With the Zener diode **44** so connected, the Zener diode **44** regulates the potential supplied to the capacitor **40** through the resistor **38** and enables the timing circuit **34** to provide a time delay that does not change significantly with changes in the potential received from the power source **14**.

Once the silicon controlled rectifier **28** is rendered conductive, the capacitor **40** tends to discharge through the neon light **42** and the gate electrode **46** until the neon light **42** can no longer be maintained ignited. Then the capacitor **40** continues to slowly discharge through the resistors **37** and **38** because the RC time constant provided by the timing circuit **34** is relatively high.

As long as the silicon controlled rectifier **28** remains conductive, energizing potential is supplied to the coil **16** and the valve **18** remains open. In order to maintain the silicon controlled rectifier **28** conductive during the entire time period in which the switch **12** is closed, the anode electrode **26** must be supplied with a relatively positive potential as compared to the potential at the cathode electrode **48**. Seemingly, the capacitor **32** would ensure that such a positive potential is continuously being supplied to the anode electrode **26**. However, the value of the capacitor **32** cannot be made sufficiently large to maintain such a positive potential at the anode electrode **26** because the capacitor **32** must be small enough to filter the output of the diode **30**.

Accordingly, a diode **54** is coupled between the coil **16** and the anode electrode **26**. The latching circuit including the inductance of the coil **16** and the diode **54** provides for the latching of the silicon controlled rectifier **28** in its conductive state until the switch **12** is opened. Once the switch **12** is opened, the silicon controlled rectifier **28** returns to its nonconductive state and the valve **18** closes.

Advantageously, additional valves like the valve **18** can be controlled by the control circuit **10**. This is accomplished by coupling additional coils between the cathode electrode **48** of the silicon controlled rectifier **28** and the ground terminal **24**.

Referring now to FIG. **2**, an alternate embodiment of the control circuit **10**, control circuit **56**, is disclosed. The control circuit **56** operates in essentially the same manner as the control circuit **10** shown in FIG. **1** and the components in the control circuit **56** have been designated by the same reference numerals by which corresponding components in the control circuit **10** have been designated. The only additional component is the diode **58** coupled in parallel with the resistor **38**.

As heretofore indicated, after the neon light **42** fires and a positive potential is supplied to the gate electrode **46**, the capacitor **40** first discharges through the neon light **42** and the gate electrode **46** and then through the resistors **37** and **38**. However, in some circumstances the rate of discharge of the capacitor **40** is too slow if the control circuit **10** is utilized during a time when the switch **12** is being opened and closed at a fairly rapid

rate. In the event that the capacitor **40** does not completely discharge between such closures of the switch **12**, the time delay provided by the time delay circuit **34** is of a shorter duration then desired and the silicon controlled rectifier **28** is rendered conductive too quickly. Accordingly, by coupling the diode **58** in parallel with the resistor **38**, the effective RC time constant for the discharge of the capacitor **40** is lowered and the capacitor **40** is allowed to discharge at a greater rate. In this manner, the capacitor **40** should be fully discharged before the switch **12** is again closed and the timing circuit **34** provides the appropriate time delay for the control circuit **56** even during repeated rapid opening and closing of the switch **12**.

Referring now to FIGS. **3–6**, therein is disclosed a time delayed solenoid valve package **60** which utilizes either the control circuit **10** shown in FIG. **1** or the control circuit **56** shown in FIG. **2**. The package **60** includes a hollow, generally rectangular shaped housing **62** and a valve **63** (schematically shown in FIGS. **1** and **2** and designated as **18**). The housing **62** has a conduit **64** inserted through one of its side walls **66**, through which conduit **64** extends leads or conductors **68, 70** and **72** into the housing **62**. Two of the leads **68** and **70** are coupled to the input terminals **20** and **22**, respectively, of the control circuit **10** or **56** so as to provide AC line potential to the control circuit **10** or **56**. The third lead **72** is coupled to the cathode electrode **48** so that if additional solenoid valves are to be controlled by the control circuit **10** or **56**, they merely have to be coupled to the lead **72**. In the event no additional valves like the valve **63** are to be controlled by the control circuit **10** or **56**, the lead **72** is not used.

Within the housing **62** is mounted a printed circuit board **74** on which the components of the control circuit **10** or **56** are mounted. A solenoid coil **75**, which is schematically shown in FIGS. **1** and **2** and referred to as **16**, is also located within the housing **62** and is coupled by appropriate leads to the cathode electrode **48** and the ground terminal **24** of the control circuit **10** or **56** located on the printed circuit board **74**. The coil **75** is inserted into the housing **62** through a generally circular opening **76** in the bottom wall **77** of the housing **62**. The coil **74** consists of a plurality of turns of wire **78** on a generally cylindrical base **80** having a bore **82** extending through the center thereof. When the coil **75** is positioned within the housing **62**, a stem portion **84** of the fuel valve **63** is inserted through the bore **82**, a washer **86**, a hole **88** in the top wall **90** of the housing **62**, and a washer **92**. The stem portion **84** is locked in position by a C-ring **94** that fits into a groove **96** in the upper end of the stem portion **84**. By so locking the stem portion **84**, a cap **98** on the valve **63** maintains the coil **75** properly positioned within the housing **62** and encloses the hole **76**.

When the coil **75** is energized by the control circuit **10** or **56** after a desired time delay, the valve **63** is opened so that fuel oil or the like is allowed to flow through the opened valve **63**. Advantageously, by utilizing the control circuit **10** or **56** on the printed circuit board **74** enables the placing of both the circuit board **74** and the solenoid coil **75** in a single package **60** having the small housing **62**. One factor in enabling the mounting of the coil **75** in the housing **62** along with the control circuit **10** or **56** is that the control circuit **10** or **56** utilizes half wave rectified current for energizing the coil **75**. If AC current is used in such a valve assembly, the temperature rise is quite significant and the circuit board **74** cannot be placed in the same package or housing as the coil **75**. In addition, by utilizing the control circuit **10** or **56** on the printed circuit board **74**, larger components used in previously designed control circuits are eliminated so that the printed circuit board **74** can be easily mounted within the housing **62**.

While the present invention has been described in connection with the details of a single illustrative embodiment thereof, it should be understood that these details are not intended to be limitative of the invention except insofar as set forth in the accompanying claims.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. A time delayed control circuit adapted to be coupled to a source of AC power to energize a solenoid coil, said control circuit comprising:

a half wave rectifier means coupled to said source of AC power;

a controlled conduction means coupled to said half wave rectifier means and said solenoid coil;

a timing circuit coupled to said half wave rectifier means and said controlled conduction means, said timing circuit rendering said controlled conduction means operable to supply said solenoid coil with power from said half wave rectifier means after a predetermined time subsequent to the supplying of said half wave rectifier means with power from said source of AC power; and

a latching circuit means including said solenoid coil and a rectifier means coupled to said controlled conduction means to maintain said controlled conduction means operable during the time in which said half wave rectifier means in receiving power from said source of AC power and in which said controlled conduction means is not maintained operable by said half wave rectifier means.

2. The time delay circuit as set forth in claim **1** wherein said timing circuit includes a regulator means to maintain said predetermined time constant notwithstanding changes in the power received from said source of AC power.

3. The time delay circuit as set forth in claim **1** wherein said controlled conduction means is a silicon controlled rectifier having a pair of output electrodes and a control electrode, said half wave rectifier means being coupled to one of said output electrodes, said timing circuit being coupled to said control electrode, and said solenoid coil being coupled to said other output electrode.

4. The time delayed control circuit as set forth in claim **1** including mounting means on which is mounted said control circuit, and a housing in which is disposed said mounting means adjacent said solenoid coil.

5. The time delayed control circuit as set forth in claim **4** wherein said housing has a single compartment in which said mounting means and said solenoid coil are disposed.

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