June 7, 1966 J. P. LIMON 3,254,871

TIME DELAY SYSTEM

Filed Oct. 31, 1963 2 Sheets-Sheet 1

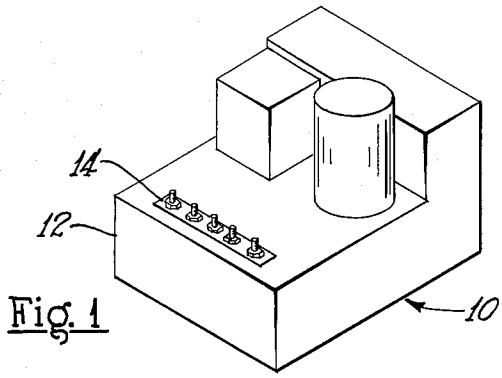


Fig. 1

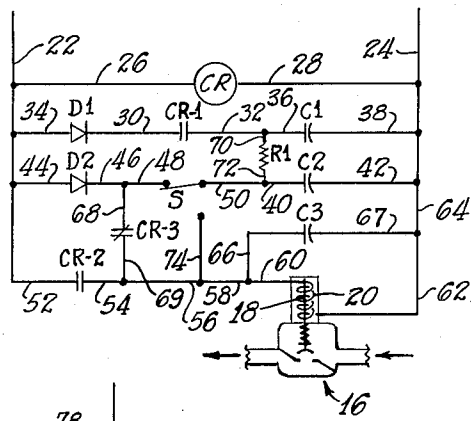


Fig. 2

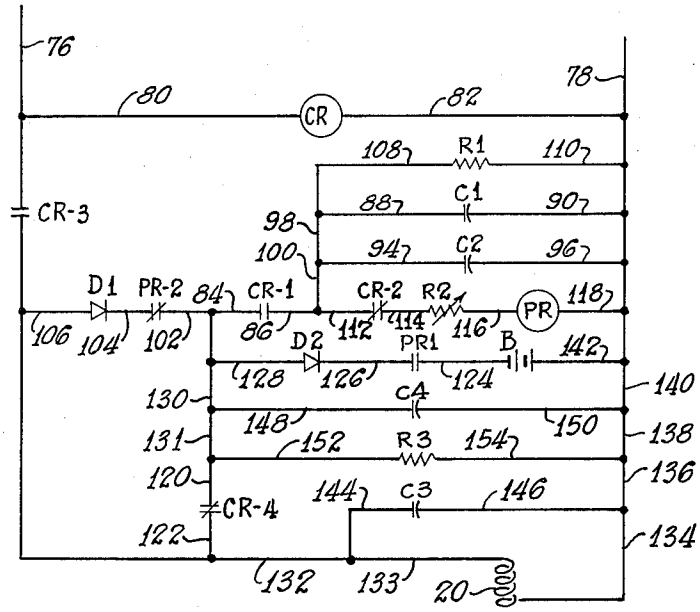


Fig. 3

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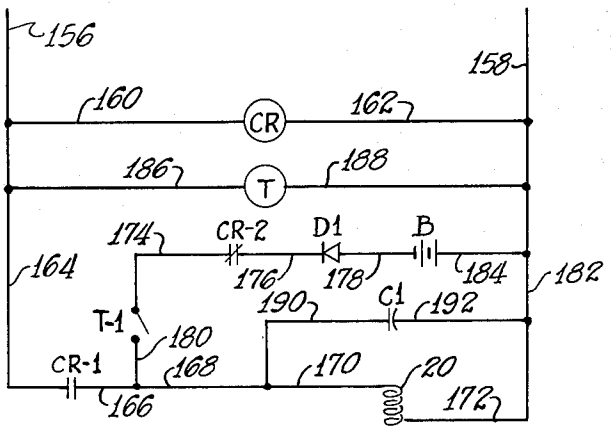


Fig. 4

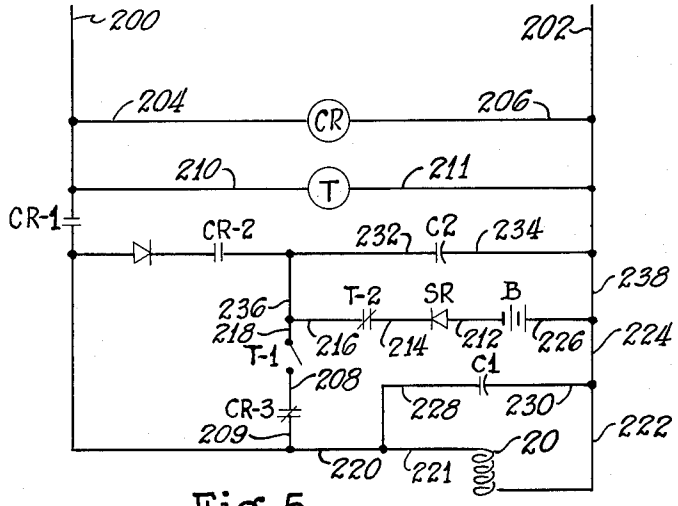


Fig. 5

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TIME DELAY SYSTEM

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This invention relates to time delay means to delay inactivation of a load because of a temporary power interruption or fluctuation in current and more specifically to a time delay unit for delaying the closing of a coil-operated gas supply valve when a temporary interruption or fluctuation of current occurs.

Industrial furnaces employing many gas-fired burners have gas supply valves which are designed to cut off gas flow to the burners if an electrical power failure occurs. There are several reasons for shutting down the burners in case of a power failure. For one thing, most industrial furnaces are equipped with complex safety devices which are inoperative in case of a power failure so that continued firing of the furnaces would be without the benefit of such safety devices. The combustion air for the burners also may be supplied by a blower and this air source will fail if the power does, thereby allowing fuel gas to be supplied directly into the furnace without air, if not shut off. Conveyors carrying products to be heat-treated through the furnace also are usually electrically driven and, if the conveyor stops, pieces or products carried thereby may be overheated and ruined if the burners are not shut down.

The principal difficulty with the operation of these coil-operated gas supply valves is that they will also close in the case of a brief, temporary power failure or even a current fluctuation. Such an interruption or change in current would not, of course, be enough to require shutting down of the furnace but, nevertheless, this occurs when the valve closes. Once the gas supply is cut off, each of the furnace burners must be relighted and it is not infrequent that an industrial furnace will employ twenty or thirty burners or more. In such an instance, the time required for relighting is often substantial. Further, brief power interruptions or fluctuations will occur in some areas rather frequently so that a considerable amount of time may be expended in restarting a furnace after a shut-down. In addition, many industrial furnaces now employ heat-treating atmospheres of combustible gases for various heat-treating processes such as carburizing, by way of example. Although these gases are combustible, they are contained within the furnace chambers without air and under a slight pressure to prevent air from entering. Consequently, the only place where combustion of these gases can occur is where they escape through the openings in the furnace and combine with atmospheric air. The only time such gaseous combustible atmospheres are dangerous is if they are held at a temperature below approximately 1400° F. since, if they are below such a temperature, they will not burn even if combined with air. Consequently, an explosive mixture can form with this mixture subsequently exploding if brought into contact with an ignition point or if once again heated to a temperature above approximately 1400° F. As a result, if the furnace burners are shut off due to a power failure and cannot be quickly relighted, it is necessary to purge the entire furnace chamber of the atmosphere gases to prevent the possibility of an explosion if the temperature should drop below the ignition temperature of approximately 1400° F. and is subsequently heated again to a higher temperature. Hence, even for a very brief power failure up to a few seconds in duration ordinarily the burners must all be relighted by hand and if not relighted soon enough, any atmospheric gas in the furnace must be purged. Such periods of time may be lengthy and result in substantial production loss during the period.

The present invention relates to a time delay unit which can be electrically connected with a gas supply valve to prevent closing of this valve in the event of a current fluctuation or interruption which may even be up to several seconds in duration. When the new unit is incorporated with the valve, the valve will remain open for a predetermined period after a current failure and, if the current is restored within the predetermined period of time up to approximately seven seconds, for example, the gas valve will remain open continuously.

It is, therefore, a principal object to provide a time delay unit for delaying the inactivation of an electrical load because of a temporary interruption or fluctuation in current.

Another object of the invention is to provide a time delay unit for use with a gas supply valve to prevent closing of the valve during current fluctuations or temporary power failures.

Other objects and advantages of the invention will be apparent from the following detailed description of a preferred embodiment thereof, reference being made to the accompanying drawing, in which:

FIG. 1 is a view in perspective of a time delay unit according to the invention ready to be electrically connected to a coil-operated, gas supply valve or other load;

FIGURE 2 is a diagrammatic view of a time delay circuit embodying the invention and incorporated in the unit of FIG. 1, in combination with a gas supply valve for controlling the flow of fuel gas to a plurality of burners;

FIG. 3 is a diagrammatic view of a modified time delay circuit according to the invention;

FIG. 4 is a diagrammatic view of another slightly modified circuit according to the invention; and

FIG. 5 is another diagrammatic view of still another slightly modified time delay circuit according to the invention.

Referring to the drawings, and more particularly to FIG. 1, a time delay unit embodying the invention is indicated at **10** and includes a suitable casing **12** carrying electrical components connected into the furnace control system and a gas supply valve by terminals indicated at **14**. The unit **10** is compact and lightweight and can be added to almost any existing furnace control system and coil-operated gas supply valve.

Referring more particularly to FIG. 2, a coil-operated gas supply valve is indicated at **16** and includes a spring-loaded valve stem **18** extending upwardly through an electro-magnetic coil **20** when the valve is open. When the coil **20** is energized, it holds the valve stem **18** in the open position, thus permitting flow of gas through the valve **16**. When the coil is de-energized, the spring-loaded stem **18** immediately drops to close the valve **16**. If any power failure occurs or, in some valves, even if there is a current fluctuation, the spring-loaded valve stem **18** will immediately move downwardly to the closed position when the coil **20** is temporarily de-energized. Even if the power is restored quickly, the valve will remain closed until the valve is manually opened by an operator. At this time, all of the burners must be individually re-lighted and a large number of burners are often incorporated in a single industrial furnace. Further, all of the individual, manually-operated valves for the burners must be closed before the gas supply valve **16** is again opened, after which the individual valves are opened one at a time as the burners are lighted.

Referring to the details of the circuit of FIG. 2, with lead lines **22** and **24** connected to a suitable source of current, usually 110 volts A.C., a control relay CR connected across the lead lines **22** and **24** by lines **26** and

28, will be actuated. This will close normally-open contacts CR–1, close normally-open contacts CR–2, and open normally-closed contacts CR–3. The closing of contacts CR–1 connects lines 30 and 32 to complete a circuit across the lead lines 22 and 24 along with additional lines 34, 36, and 38. This causes a capacitor C1 to charge with the aid of a diode D1 in series therewith which provides half-wave rectification for the A.C. current. At the same time, a second capacitor C2 between lines 40 and 42 is charged through additional lines 44, 46, 48 and 50 through a second diode D2. A switch S connects the lines 48 and 50 for A.C. operation and will be discussed more fully subsequently. With the contacts CR–2 closed, the coil 20 is connected across the lead lines 22 and 24 by lines 52, 54, 56, 58, 60, 62, and 64 and is held in as long as there is power to the lines and the contacts CR–2 are closed.

If a power failure or a significant power fluctuation should now occur, the current through the coil 20 will immediately drop and, at the same time, a capacitor C3 across the coil by means of lines 66 and 67 will immediately discharge to initially hold in the coil 20. At the same time, the relay CR is de-energized to open its contacts CR–1 and CR–2, thereby separating the capacitor C1 and the coil 20 from the power source; the contacts CR–3 between lines 68 and 69 are also closed to connect lines 48 and 56. This enables the capacitor C2 to quickly discharge across the coil 20 thereby continuing to hold it closed. Also, the capacitor C1 can now discharge through a resistance R1 between lines 70 and 72 which connect the lines 36 and 50. Because the capacitor C1 discharges through the resistance R1, it discharges more slowly and prolongs the length of time in which the coil 20 remains energized due to the discharging of the three capacitors C3, C2, and then C1. By appropriately selecting the values of the capacitor C1 and the resistance R1, the time in which the coil 20 remains energized after a power failure can be selected, a period of time from three to seven seconds usually being desired. If the power should be restored during this period, the relay CR will again be energized to close its contacts CR–2 and thereby hold in the coil through power from the lines 22 and 24. Again, the contacts CR–3 will be opened and contacts CR–1 closed to enable the capacitors C1 and C2 to charge again.

On some gas supply valves, D.C. rather than A.C. coils are employed. D.C. coils generally require less voltage than A.C. ones, but either type of coil can be energized through the time delay circuit of FIG. 2 for short periods of time without harm. In the case a D.C. coil is employed with a D.C. power source connected across the lines 22 and 24, the switch S is moved into contact with a line 74. In practice, a jumper wire can be used in place of the switch S for economical purposes since the use of a D.C. power source and coil are infrequent. In any event, with the lines 50 and 74 connected, the capacitors C2 and C1 will always be connected across the coil 20 regardless of the control relay CR which is not needed with a D.C. power source to separate the capacitor C1 from the power source during discharging. Also in this instance, the capacitor C3 and C2 will discharge substantially together since the capacitor C2 is always conected directly across the coil 20. The capacitor C1, however, will again discharge more slowly since it is still connected in series with the resistance R1.

FIGS. 3–5 show three modifications of the circuit of FIG. 2 with the coil of the coil-operated gas valve being energized or held in upon a power failure or fluctuation by a direct current power source in the form of a battery, rather than capacitors, with the connection of the battery and the coil controlled by separate means. In particular, the battery is advantageous because it provides more reliable operation than capacitors. Nickel-cadmium cells can be used for this purpose, being changed or re-charged every year to assure reliable operation.

Referring more particularly to FIG. 3, the coil 20 is connected to a power source through lead lines 76 and 78. A control relay CR also is connected to the source of power through lines 80 and 82 and is energized with the coil 20. The control relay CR then closes its normally-open contacts CR–1 to connect lines 84 and 86. This connects capacitors C1 and C2 across the lead lines 76 and 78 through connecting lines 88 and 90 and 94 and 96, respectively, and also by lines 98 and 100, the lines 84 and 86, and lines 102, 104, and 106. The capacitors C1 and C2 thereby are charged when the supply valve is normally open with a bleeder resistance R1 being in parallel with the capacitor C1 and C2 by means of lines 108 and 110 connecting the lead line 78 and the line 98. The resistance R1 tends to bleed off any excess charge on the capacitors C1 and C2 to prevent overcharging.

When the relay CR is energized, it also opens its normally-closed contacts CR–2 connecting lines 112 and 114 to prevent operation of a high-impedance plate relay PR connecting lines 116 and 118. A variable resistance R2 is located between the lines 114 and 116 in series with the plate relay PR to control its operation by controlling the discharge of the capacitors C1 and C2 when the power source fails and the contacts CR–2 close.

The energization of the control relay also closes its contacts CR–3 to connect the coil 20 with the power source. The contacts CR–3 open upon a power failure to separate the time delay circuitry from the power source, during operation of the time delay system.

Finally, the control relay CR opens its contacts CR–4 when energized to disconnect the battery B from the coil during normal operation. Upon a power failure, the contacts CR–4 again close to connect lines 120 and 122 and complete a circuit from the battery to the coil through lines 124, 126, 128, 130, 131, the lines 120 and 122, and lines 132, 133, 134, 136, 138, 140, and 142. During a power failure then, the coil 20 will remain energized by the battery B, providing that normally-open contacts PR–1 between the lines 124 and 126 are closed. These contacts are controlled by the relay PR which, in turn, is controlled by the capacitors C1 and C2 and the variable resistance R2. Thus, the battery B supplies the power to keep the coil 20 closed during a power failure while the relay PR and its contacts PR–1 control the time of energization of the coil 20. The relay PR also has normally-closed contacts PR–2 to separate this relay from the power source when energized by the capacitor.

A diode D1 between the lines 104 and 106 provides half-wave rectified current for the capacitors C1 and C2. A second diode D2 between the lines 126 and 128 prevents the possibility of the back E.M.F. of the coil 20 damaging the battery which would be possible if the E.M.F. was sufficient to cause arcing across the contacts PR–1.

A capacitor C3 is connected across the coil 20 by lines 144 and 146 and serves to hold in the coil 20 after power failure and until the battery B can take over, as well as to help prevent back E.M.F. of the coil from entering the rest of the circuitry. A fourth capacitor C4 is connected across the lines 130 and 140 by lines 148 and 150 to help absorb voltage fluctuations in the line current which otherwise will affect operation of the plate relay PR and thereby vary the time constant. A resistance R3 between lines 152 and 154 acts as a bleeder resistance for the capacitor C4 to bleed off any excess charge on the capacitor C4.

Another slightly modified time delay circuit is shown in FIG. 4, which circuit also employs a battery but uses a pneumatic timer. A control relay CR is connected across lead lines 156 and 158 by lines 160 and 162. When current is applied, the relay CR is energized to close its contacts CR–1 connecting lines 164 and 166 to complete a circuit with the coil 20 through lines 168, 170, and 172. At the same time, contacts CR–2 of the

relay CR are opened to disconnect lines **174** and **176** to maintain a battery B disconnected from the coil **20**. If the current should fail, the contacts CR–**1** will again open to disconnect the battery circuit from the main power circuit while the contacts CR–**2** will close to connect the battery B to the coil **20** through a line **178**, the lines **176** and **174**, a line **180**, the lines **168**, **170**, and **172** and lines **182** and **184**. Current will thus be supplied to the coil **20** to hold it in until the battery circuit is opened which occurs when a pneumatic timer T connected between the lines **156** and **158** by lines **186** and **188** times out and opens its contacts T–**1** between the lines **174** and **180**. The pneumatic timer T closes its contacts T–**1** when energized and maintains them closed until a predetermined period of time after the pneumatic timer is de-energized, this being up to seven seconds, for example. The contacts T–**1** will then open and disconnect the battery from the coil until the timer T is again energized.

A diode D**1** between the lines **176** and **178** protects the battery B from back E.M.F. of the coil **20**. A capacitor C**1** between lines **190** and **192** discharges when the current fails to hold in the coil **20** until the battery B can take over, and it also tends to absorb back E.M.F. from the coil.

The circuit of FIG. 5 is similar to that of FIG. 4, employing a pneumatic timer, but is designed particularly for counterweighted valves or those employing heavier springs to cause fast closing of them. In this instance, the coil **20** is connected across lead lines **200** and **202** and is actuated when current is supplied through these lines. A control relay CR, which is preferably more sensitive than its counter part in FIG. 4, is also connected across the lead lines **200** and **202** by lines **204** and **206**. The control relay CR has two sets of normally-open contacts CR–**1** and CR–**2** which open when the relay is de-energized to separate the coil circuit and the battery from the main power source. The relay CR also has a third set of contacts CR–**3** which connect lines **208** and **209**.

A pneumatic timer T between lines **210** and **211** operates in the same manner as the timer of FIG. 4 except having the additional contacts T–**2** which separate the battery B from the main power source during normal operation of the coil **20** and which instantly close when the timer T is de-energized. When timer contacts T–**1** are closed, along with the second timer contacts T–**2**, a battery circuit can be completed from the battery B through lines **212**, **214**, **216**, and **218**, the lines **208** and **209**, and lines **220**, **221**, **222**, **224**, and **226**.

A capacitor C**1** is located across the coil **20** by lines **228** and **230** to aid in holding in the coil and in absorbing back E.M.F. However, until the timer contacts can properly close to assure holding in the coil **20** by means of the battery B, a large capacitor C**2** is employed between lines **232** and **234** to complete a circuit for the coil **20** through the line **232**, a line **236**, the lines **218**, **208**, **209**, **220**, **222**, and **224**, a line **238** and the line **234**. The battery B will then continue to energize the coil **20** through its circuit until the contacts T–**1** of the timer open.

Various modifications of the above described embodiments of the invention will be apparent to those skilled in the art, and it is to be understood that such modifications can be made without departing from the scope of the invention, if they are within the spirit and the tenor of the accompanying claims.

What I claim is:

1. In combination with a main power source and a fuel supply valve for supplying fuel to a plurality of burners of an industrial heat-treating furnace, said valve having a valve stem and an electrical coil to pull in said stem when energized and to open said valve when said coil is connected to the main power source, means connecting said coil in circuit to said power source, means for continuing to energize said coil only temporarily during a temporary power failure of said power source comprising a separate, direct current power source in addition to said main power source, circuit means connecting said direct current power source with said coil, a pair of contacts in said circuit means for connecting and disconnecting said direct current power source and said coil, and means to open said contacts while said main power source holds in said coil and to close said contacts upon failure of said main power source to connect said direct current power source and said coil to temporarily energize said coil.

2. For an electrical coil which is energized when connected to a main power source, means for continuing to energize said coil only temporarily during a temporary power failure of said power source comprising a capacitor, circuit means for connecting said capacitor with said coil, a pair of contacts in said circuit means for connecting and disconnecting said capacitor and said coil, and control means opening said pair of contacts when energized and closing said pair of contacts when de-energized.

3. The combination according to claim **2** and a second capacitor, circuit means for connecting said second capacitor with said coil, and a resistance in series with the first capacitor to control the discharge thereof when said contacts are closed.

4. For an electrical coil which is energized when connected to a power source, means for continuing to energize said coil only temporarily during a temporary power failure of the power source comprising a battery, circuit means for connecting said battery with said coil, a pair of contacts in said circuit means for connecting and disconnecting said battery and said coil, and means adapted to be responsive to the failure of the power source to close said contacts temporarily during power failure to connect said battery and said coil to temporarily energize said coil and otherwise to open said contacts to isolate the battery from the coil.

5. The combination according to claim **4** wherein said last-named means is a timer which closes said contacts when de-energized and then opens said contacts a predetermined period of time after de-energization.

6. The combination according to claim **4** wherein said last-named means is a relay which closes the contacts when energized and opens them when de-energized, and a capacitor for energizing said relay when the main power source fails.

7. In combination with a main power source and an electrical coil which is energized when connected to the main power source when operative, means connecting said electrical coil in circuit to said power source, means adapted to continue to energize said coil during a temporary power failure of the main power source comprising a direct current power source, circuit means connecting said direct current power source in parallel with said coil to said main power source, switch means for opening and closing said circuit means for connecting said direct current power source with said coil when closed and for isolating said direct current power source from the coil when open, and means to open said switch means when the main power source is operative and to close said switch means when the main power source is inoperative thereby to connect said direct current power source with said coil to temporarily energize said coil by discharge of direct current from said direct current power source through said coil when said main power source is inoperative.

8. In a combination with a main power source and an electrically-powered device normally operated through the main power source, means for continuing to operate the electrically-powered device during a temporary power failure of the main power source comprising a direct current power source, circuit means for connecting said direct current power source in parallel with said device to said main power source, switch means for opening and closing said circuit means between said direct current power source and said device and adapted to connect said direct current power source with said device when said switch

means is closed and adapted to isolate said direct current power source from the device when said switch means is open, means energized by said main power source during normal operation of the device to open said switch means, and de-energized during power failure of said main power source to close said switch means thereby to connect said direct current power source with the device to temporarily operate the device, and additional switch means connected in series with the device and said main power source, said additional switch means being operated by said energizing means, said additional switch means being closed when said energizing means is energized and opened when said energizing means is de-energized to isolate said device from the main power source when said direct current power source supplies current to said device.

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