

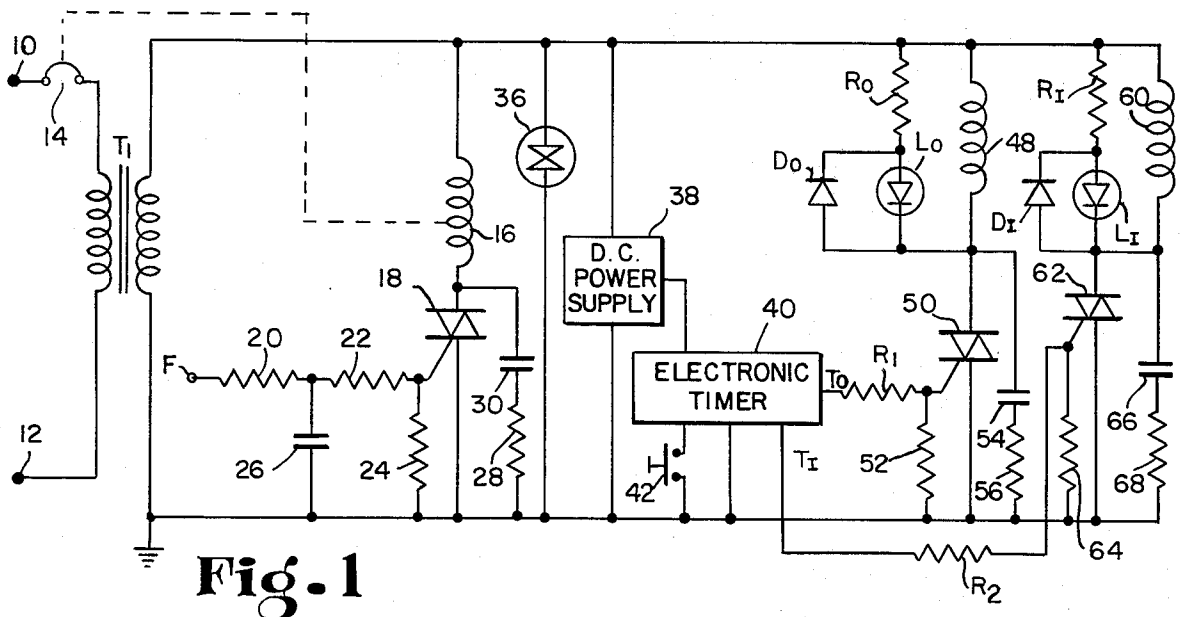


Fig. 1

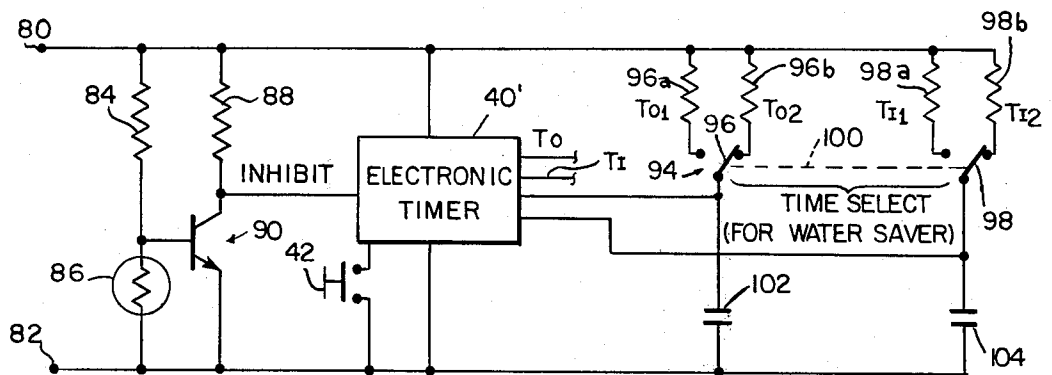


Fig. 1a

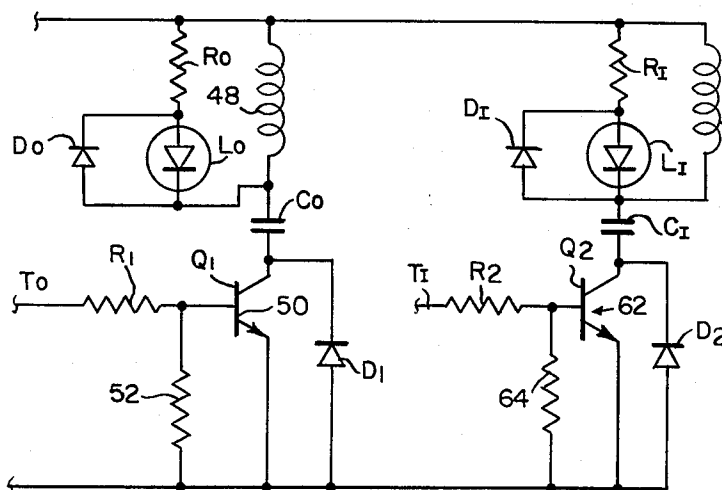


Fig. 1b

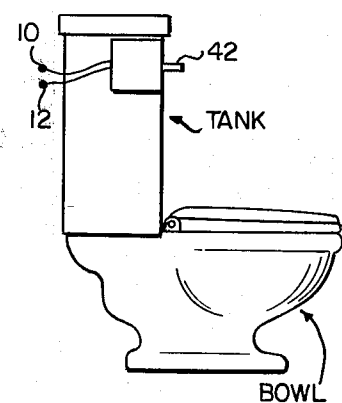


Fig. 1c

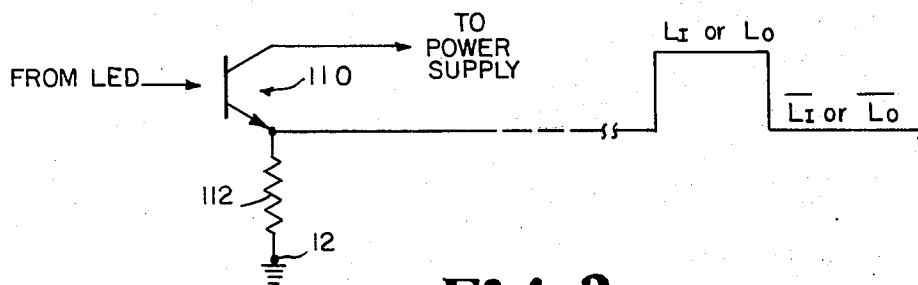


Fig. 2

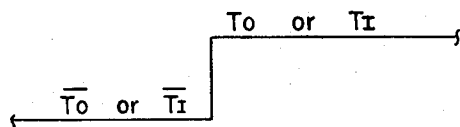


Fig. 3

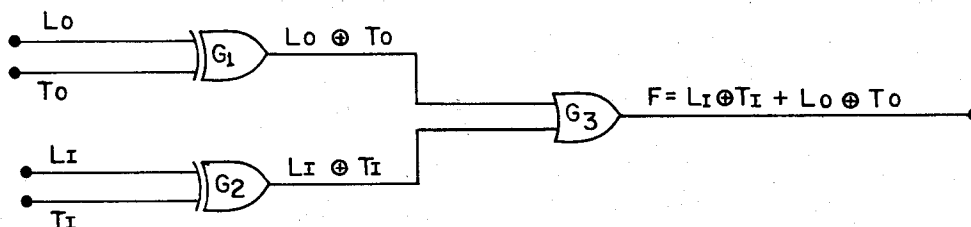


Fig. 4

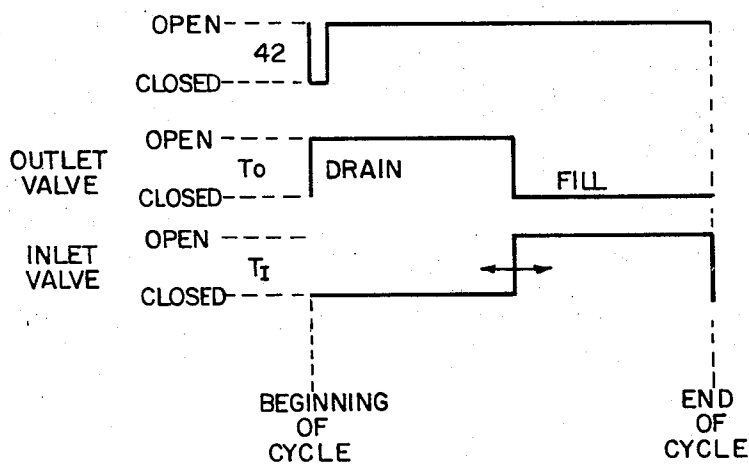


Fig. 5

ELECTRONIC WATER CLOSET CONTROLLER

The present invention relates to water closets or flush toilets and more particularly to the provision of an electronically controlled water closet comprising a bowl, a flush tank, and electrically operated valves or solenoid valves for draining the flush tank to initiate the flushing cycle and for admitting water to refill the flush tank.

Many prior patents have disclosed electrically and electronically controlled water closets and urinals. Among those are U.S. Pat. Nos. 1,985,314 issued Dec. 25, 1934 in Cl. 4-101; 2,858,546 issued Nov. 4, 1958 in Cl. 4-68; 3,121,880 issued Feb. 25, 1964 in Cl. 4-249; 3,334,359 issued Aug. 8, 1967 in Cl. 4-67; and 3,713,177 issued Jan. 30, 1973 in Cl. 4-95. These patent references show electrically and electronically controlled water closets and urinals having some features similar to the features of my present invention. In addition, I am familiar with U.S. patent references 2,552,625; 2,603,794; 2,612,901; 2,635,691; 2,707,482; 2,908,017; 3,024,469; 3,034,151; 3,066,314; 3,115,643; 3,314,081; 3,329,974; 3,339,212; 3,593,346; and 3,751,736 showing electrically or electronically controlled or operated water closets or urinals and features thereof.

I refer to the above-identified patent references as being the prior art known to me. I believe that my present invention constitutes a significant improvement over the prior art for several reasons. First of all, my system very efficiently makes use of modern electronic devices in a manner not suggested by the prior art. For instance, my preferred system includes a fail-safe arrangement comprising light emitting diodes, a photo-transistor, and a logic circuit for processing the outputs of the timer and the photo-transistor to make the determination as to whether or not the system is working properly. If the system is not working properly, the logic circuit will provide an output which will be effective to operate a switch or switch means including a circuit breaker to keep the valves closed.

The system of my invention has two independent water saving features, i.e., the timer switch for changing the flushing times and the opening of the inlet valve simultaneously with the outlet valve closing. Different types of timer means may be used in my system. For example, if it is desired to open the inlet and outlet valves simultaneously, then two timers may be used, both being triggered simultaneously. If it is desired to open the inlet valve simultaneously with the closing of the outlet valve, two timers may be used, the outlet valve timer triggering the inlet valve timer. Three timers may be used to provide an adjustable time delay prior to the inlet valve opening, the outlet valve timer and a delay timer being triggered simultaneously with the inlet valve timer being triggered at the conclusion of the time delay timer.

I provide Triacs for controlling the opening and closing of each solenoid valve and provide timer means with outputs for controlling the Triacs. The timer means is preferably selectively variable so that the amount of water used in the flushing cycle can be selectively determined. The light emitting diodes are connected in series with the Triacs so that each light emitting diode is emitting light when its associated Triac is rendered conductive. The photo-transistor is optically coupled to the light emitting diodes to provide an electrical output when one of the Triacs is conducting. An-

other Triac, hereinafter referred to as the third switch means, is provided with its gate control electrode connected to the output of the logic circuit. When a failure mode exists, as determined by the logic circuit, the third switch means is rendered conductive to energize a circuit breaker to disable the solenoid valves.

While I have illustrated Triacs and presently prefer such devices, it will be appreciated that I may use a variety of switching means or solid state switching means such as transistors, silicon controlled rectifiers, and the like.

My preferred system also includes a level sensing arrangement which is effective to inhibit the timer means so that the flushing cycle cannot be initiated when the water level in the bowl exceeds a predetermined maximum level.

It is an object of my present invention, therefore, to provide an electronically controlled water closet including a bowl, a flush tank, a first solenoid valve for draining the flush tank, a second solenoid valve for admitting water to refill the flush tank, first switch means for controlling the opening and closing of the first valve, second switch means for controlling the opening and closing of the second valve, timer means for sequencing the operation of the first and second switch means, and manual switch means for starting the timer means to initiate the flushing cycle. The timer means provides outputs to open the first valve to initiate the flushing cycle, then to close the first valve after a first predetermined time period, then to open the second valve, and then to close the second valve after a second predetermined time period to stop the flushing cycle.

Another object is to provide such a system including third switch means for disabling the first and second switch means and their respective first and second valves when a failure mode exists, and logic circuit means for establishing a circuit condition effective to operate said third switch means when a failure mode exists, the logic circuit means being operatively connected to the third switch means.

Another object is to provide such a system including first and second light emitting means connected respectively to the first and second valves or to the first and second switch means to emit light when their respective valves are open or their respective switch means are conducting. Then, light responsive means is optically coupled to the emitting means to establish a circuit condition indicating that one of the valves is open or that one of the switch means is conducting. The said logic circuit means is connected to and responsive to the outputs of the said timer means and the said light responsive means to operate the third switch means when a failure mode exists.

Other objects and features of my present invention will become apparent as this description progresses.

To the accomplishment of the above and related objects, this invention may be embodied in the forms illustrated in the accompanying drawings, attention being called to the fact, however, that the drawings are illustrative only, and that change may be made in the specific constructions illustrated and described, so long as the scope of the appended claims is not violated.

In the drawings:

FIG. 1 is a schematic view of the controller of my present invention;

FIG. 1a is a schematic view of a preferred modification of a portion of the system shown in FIG. 1;

FIG. 1b is a schematic view of a preferred modification of a portion of the system shown in FIG. 1 using transistors instead of Triacs;

FIG. 1c is an elevational view showing a water closet with a flush tank and bowl and with my controller mounted thereon;

FIG. 2 is a brief schematic view showing the output of the photo-transistor used with the light emitting diodes;

FIG. 3 is a diagram showing the output of the timer means;

FIG. 4 is the logic circuit used in my fail-safe system; and

FIG. 5 is a chart showing the time sequencing of the flush cycle.

FIG. 1 shows the electronic control circuit for the water closet with the terminals 10, 12 being connected to the conventional 60 Hz power lines. I show a conventional circuit breaker 14 with its coil 16 connected to the secondary of isolation transformer T₁. The coil 16 is in series with a Triac 18. The gate circuit of the Triac 18 includes resistors 20, 22, 24 and a capacitor 26 as illustrated. The Triac 18 will be rendered conductive by a signal F applied to its gate control terminal when a failure mode exists as will be discussed hereinafter. Of course, when the Triac 18 is rendered conductive, the coil 16 is energized to trip the circuit breaker 14 which will remove current from solenoid valves as will be discussed hereinafter. In parallel with the Triac 18 is a series circuit including a resistor 28 and a capacitor 30 for purposes of decreasing the noise susceptibility of the Triac. A thyrector 36 is used as a transient voltage suppression device to protect Triac 18 and Triacs 50, 62 which will be discussed in detail hereinafter.

A direct current power supply 38 is connected to the terminals 10, 12 to provide the necessary voltage and current for operation of an electronic timer 40 and to control the aforesaid Triacs 50, 62. The power supply 38 may be one of any number of conventional direct current power supplies. A pushbutton momentary switch 42 starts the electronic timer 40 which provides two outputs, one labeled as T₀ and the other labeled as T₁. The output T₀ is fed to the gate of the Triac 50 while the output T₁ is fed to the gate of the Triac 62. The timer 40 is constructed such that a momentary pulse by the switch 42 will start the cycle.

The Triac 50 controls current flow through the coil of solenoid valve 48. A resistor 52 is connected between the gate control circuit of the Triac 50 and the terminal 12 which is ground. The resistor 56 and capacitor 54 decrease the noise susceptibility and enhance turn-off of the Triac 50.

The Triac 62 controls current flow through the coil 60 of a solenoid valve. A resistor 64 connects the gate control circuit of the Triac 62 to ground and a resistor 68 and capacitor 66 are provided to decrease the noise susceptibility and enhance turn-off of the Triac 62.

In parallel with the coil 48 is a light emitting diode L₀ and in parallel with the coil 60 is another light emitting diode L₁. Resistors R₀ and R₁ limit the current through L₀ and L₁ respectively while diodes D₀ and D₁ limit the reverse voltage across L₀ and L₁ respectively. The functions of these light emitting diodes will be discussed hereinafter in conjunction with the failure protection part of the present invention. The light emitting diodes L₀ and L₁ are, of course, in series with the Triacs 50, 62, respectively.

The coil 48 is in the solenoid valve which controls the flow out of the tank. The coil 60 is in the solenoid valve which controls the flow into the tank. For simplifying this discussion, the reference numerals 48, 60 shall refer respectively to solenoid valves.

Once the timer 40 is energized by momentarily closing the push button switch 42, the first output T₀ operates the Triac 50 to open the valve 48 so that water may flow from the tank for flushing purposes.

After a predetermined amount of time, sufficient for the tank to drain and to complete a flush, the timer 40 output T₀ goes to a level that renders Triac 50 nonconductive and, simultaneously, or substantially simultaneously, the timer output T₁ is set to such a level as to render the Triac 62 conductive. When the Triac 62 is rendered conductive, the inlet valve 60 is opened for a predetermined amount of time sufficient to allow the flush tank to refill with water. At the same time, the valve 60 is used to perform the same function that it performs in conventional mechanical or hydraulic water closet systems, i.e., to add water through the overflow pipe. This helps refill a trap that will prevent sewer gas from escaping from the sewage system into the house and completes refilling of the bowl. The two outputs from the solid state electronic timer 40 (T₀ and T₁) may preferably be independently adjustable. At the conclusion of the refill cycle, the timer 40 output T₁ goes to such a voltage level that the Triac 62 is rendered nonconductive. This closes the inlet valve 60 and completes the flush cycle for the water closet. The timing cycle may be adjustable, if necessary, to compensate for the different water pressures, flush tank sizes and bowl sizes that may be encountered.

While I have shown alternating current operated valves 48, 60, it will be appreciated that I may use direct current operated solenoid valves. Circuitry may also be added to sense line power outages and automatically to switch over to emergency power sources. The emergency source may be either alternating current or direct current.

Turning next to FIG. 1a, before discussing the self-checking features of my present invention, it will be seen that I have shown a portion of the system of FIG. 1 modified to include a water level sensor arrangement and a time selector or water saver arrangement. I show terminals 80, 82 which may be connected to the power supply 38 and an electronic timer 40' which may preferably be selectively adjustable for providing different flushing time cycles. Across the terminals 80, 82 is a series circuit or voltage divider circuit consisting of a resistor 84 and a level sensor 86. A resistor 88 and transistor 90 are connected across the terminals 80, 82 with the base electrode of the transistor connected to the junction between the resistor 84 and the level sensor 86.

Switch means are indicated generally by the reference numeral 94 including switches 96, 98 which are mechanically connected together by a linkage indicated at 100. The switch 96 is for selecting a timer output T₀ and more particularly a resistor 96a or 96b for T₀₁ or T₀₂, respectively. Similarly, the switch 98 selects a resistor 98a or 98b for timer outputs T₁₁ or T₁₂. Both the switches 94, 98 are connected to the timer 40' and, respectively, to ground by capacitors 102, 104.

The water saving feature is provided because less flushing water is needed for urination than for defecation. I accommodate this by controlling the output of

the timer 40'. This feature may be especially desirable in arid regions and also for households that are water-bill conscious.

The level sensing feature is provided as a precaution against flooding. In the event of bowl stoppage, a device for preventing flushing is desirable. A water level sensor 86 is incorporated into the control system. The level sensor 86 may take the form of a temperature sensor such as a thermistor or an electrical conductivity sensor. The sensor 86 is mounted in the bowl corresponding to the desired maximum water level. The sensor 86 is then electrically connected to the timer 40' in such a manner as to render the push button switch 42 ineffective in initiating a flush cycle if the water in the bowl exceeds a predetermined level.

In the illustrative embodiment of FIG. 1a, the level sensor 86 is a negative temperature coefficient thermistor. The resistance of the sensor 86 forms a voltage divider with the resistor 84. When the sensor 86 is not immersed in water, the voltage at the base of the transistor 90 is such that the transistor is in the nonconducting state. The INHIBIT voltage is thus high and the timer may be triggered. When the sensor is immersed in water, the sensor will become lower in temperature and its electrical resistance will increase. The voltage at the base of the transistor 90 then can increase due to the divider action to the extent that the transistor conducts and places the INHIBIT input near the reference. When this occurs, the timer 40' will be disabled, i.e., cannot be started by pushing the push button switch 42.

The timer 40' may be presently commercially available timer designated by the Signetics Corp. as the "5-5-5" device which is packaged in the DIP (dual-inline package). The timer 40' may consist of two level comparators, a flip-flop, an output driver, and a transistor in parallel with the timing capacitor. The timing components, i.e., the timing capacitor 102, 104 and the timing resistors 96a, 96b, 98a, 98b may be external to the 5-5-5 package. That particular timer is triggered by a negative going signal. In the application described, two timing outputs are shown, i.e., T_0 and T_I , and thus two of the 5-5-5 timers may be used in series. That is, the negative going output of T_0 may be used to trigger the second timer whose output is labeled as T_I . Each output would have its own individual timing capacitor and timing resistors as illustrated. The timer may also have the INHIBIT input as illustrated. When this input is at or near the reference, the timer 40' cannot be triggered.

The particular commercial timer discussed above operates as follows. Upon receiving a negative going signal less than the reference voltage of the first comparator, the flip-flop is triggered thereby rendering nonconductive the transistor shunting the time capacitor. The timing capacitor is thus allowed to charge until it reaches the threshold level of the second comparator. At this time the flip-flop is once again triggered to render the transistor shunting the timing capacitor conductive. The timing capacitor is thus discharged and the timing cycle is complete.

Another commercial variation of this timer 40' is also available. It is presently designated the XR-2240. In this version the external timing resistor and capacitor are connected such that they determine the time base period of an oscillator. The pulses from the oscillator are counted by a chain of flip-flops. When a predetermined count is reached, the timer produces an appro-

priate output level for external control circuitry and also resets itself. The user may program this version either by selecting the external timing components to control the oscillator frequency or by selecting the appropriate flip-flop outputs or a combination of both.

Turning now to the discussion of the failure prevention part of my system, it will be appreciated that the light emitting diodes L_0 and L_I are energized when their respective valves 48, 60 are energized. A system failure of the type involving flooding and continuous draining is detected and circumvented by the following method: The system utilizes feedback in the form of illumination from the load and logically compares this information with information from the electronic timer 40, 40'. If, when compared, the information satisfies the logical requirements that are preprogrammed, then the system operates normally. If not, then a failure mode exists and power is removed from the system by energizing the Triac 18 which conducts current through the coil 16 of the circuit breaker 14. The comparison of information is made by the decoding circuit of FIG. 4. This circuit consists of two Exclusive OR gates G_1 , G_2 feeding the Inclusive OR gate G_3 . The output of G_3 (or output F) is then routed to the Triac 18 or, more specifically, to the gate control circuit of the Triac 18 if a failure mode exists.

The decoding circuit of FIG. 4 logically answers the question as to whether or not either Triac 50, 62 is conducting when it is supposed to be or not conducting when it is not supposed to be. For example, if a Triac 50, 62 is supposed to be conducting, then the means of illumination associated therewith (light emitting diodes L_0 , L_I) will be energized and the appropriate timing signal from the timer 40 will exist at a particular level. If a Triac 50, 62 is not supposed to be conducting, then the means of illumination will not be energized and the appropriate timing signal will exist at the other level. If the illumination exists while the incorrect timing signal is present, then the Triac 50, 62 associated with the signal is shorted. If the illumination does not exist while the correct timing signal is present to render the Triac 50, 62 conductive, then the Triac is behaving as an open circuit.

The decoding circuit of FIG. 4 compares the aforementioned information and decides whether or not a failure exists. The output F of OR gate G_3 can be expressed as:

$$F = L_I \bar{T}_I + \bar{L}_I T_I + L_0 \bar{T}_0 + \bar{L}_0 T_0$$

This equation stands for the following: The circuit breaker will be tripped and power removed if (1) L_I is illuminated and T_I is at a low voltage level or (2) if L_I is not illuminated and T_I is at a high voltage level or (3) L_0 is illuminated and T_0 is at a low voltage level or (4) L_0 is not illuminated and T_0 is at a high voltage level. As shown in FIG. 2, the illumination may be optically coupled to a phototransistor 110 and thus to the appropriate logic gate as shown in FIG. 4. FIGS. 2 and 3 also define the differences between the timing signal levels and illumination signal levels. For example, when L_0 or L_I is illuminated, transistor 110 will conduct and thus the output voltage across resistor 112 will be at a relatively high level. The opposite is true when the devices L_0 and L_I are not illuminated. The voltage level is then denoted by $\bar{L}_I$ or $\bar{L}_0$. In like manner, when it is desired for a Triac to conduct, the timing signal will be a relatively high level, i.e., T_0 or T_I . The opposite level de-

noted as $\overline{T}_O$ or $\overline{T}_I$, will exist when it is desired that a Triac not be conductive.

It is recognized that a time delay may exist between the timing signal changes from the timer 40 and the response to these changes by the means of illumination, i.e., the light emitting diodes. If these delays exist, then errors will propagate through the decoding network and false circuit breaker trips will occur. This condition may be obviated by proper design of the resistor-capacitor network comprising the resistors 20, 22 and 24 and capacitor 26. This network will effectively negate the errors associated with the aforementioned time differences. This is accomplished by delaying the signal F by an amount necessary to compensate for the lag in illumination response.

The illustrative and preferred means for illumination includes the light emitting diodes L_O and L_I together with the phototransistor 110. It will be appreciated that other such photosensitive and light emitting devices may be used within the scope of the present invention.

It will be appreciated that conventional solenoid-operated valves may be used as the valves 48, 60 with springs to hold the valves in their closed position and the electromagnetic force developed by current flow through the coils moving the valves against the urgings of the springs to their open position. Assuming that the valve 48 is the first solenoid valve for draining the flush tank while the valve 60 is the second solenoid valve for admitting water to refill the flush tank, then the Triac 50 constitutes first switch means for controlling the opening and closing of the first valve while the Triac 62 constitutes second switch means for controlling the opening and closing of the second valve. The timer 40, 40' constitutes timing means for sequencing the operation of the said first and second switch means 50, 62 to open the first valve 48 to initiate the flushing cycle, then to close the first valve 48 after a first predetermined time period, then to open the second valve 60, and then to close the second valve 60 after a second predetermined time period to stop the flushing cycle. The switch 42 constitutes manual switch means for starting the timer means to initiate the flushing cycle. The Triac 18 may constitute third switch means for disabling the system when a failure mode exists. The logic circuit shown and discussed in conjunction with FIGS. 2-5 constitutes logic circuit means for establishing when a failure mode exists and operating the said third switch means to effect said disabling function.

FIG. 1b shows an embodiment including transistors Q_1 , Q_2 instead of Triacs. Diodes D_1 and D_2 serve to limit the reverse voltage across transistors Q_1 and Q_2 , respectively, when terminal 12 goes positive with respect to terminal 10. The opposite half of the alternating current wave (terminal 10 positive and terminal 12 negative) is also allowed to energize the valve when either transistor Q_1 or Q_2 , or both, are rendered conductive. When the transistors are nonconductive, then neither valve 48, 60 is energized since the capacitors C_O or C_I , or both, will charge to a direct current voltage through the diodes D_1 , D_2 and therefore prevent the energization of the associated valve.

I claim:

1. An electronically controlled water closet including a bowl, a flush tank, a first solenoid operated valve for draining the flush tank, a second solenoid operated valve for admitting water to refill the flush tank, first electronic switch means for controlling the opening

and closing of said first valve, second electronic switch means for controlling the opening and closing of said second valve, electronic timer means for sequencing the operation of said first and second switch means to open said first valve to initiate the flushing cycle, then to close said first valve after a first predetermined time period, then to open said second valve, and then to close said second valve after a second predetermined time period to stop the flushing cycle, and manually operated momentary switch means for starting said timer means to initiate the flushing cycle.

2. The invention of claim 1 including third switch means for disabling the first and second switch means and their respective first and second valves when a failure mode exists, and logic circuit means for establishing a circuit condition effective to operate said third switch means when a failure mode exists, said logic circuit means being operatively connected to said third switch means.

3. The invention of claim 1 including circuit means for connecting said first and second valves to a current source, said valves being in parallel, said first and second switch means, respectively, being connected in series with said first and second valves to conduct current through and open said valves when said switch means are rendered conductive, and said switch means being rendered conductive and nonconductive by the outputs of said timer means.

4. The invention of claim 3 including first and second light emitting means connected respectively to said first and second valves to emit light when their respective valves are open, light responsive means optically coupled to said emitting means to establish a circuit condition indicating that one of said valves is open, third switch means for breaking the circuit to said first and second valves, thereby closing said valves, and logic circuit means for operating said third switch means when a failure mode exists, said logic circuit means being connected to and responsive to outputs of said timer means and said light responsive means.

5. The invention of claim 1 including circuit means for connecting said first and second valves to a current source, said first and second switch means, respectively, being connected in series with said first and second valves to conduct current through and open said valves when said switch means are rendered conductive, each said switch means including a semiconductor device having a control gate electrode connected to said timer means.

6. The invention of claim 5 including third switch means for breaking the circuit to said first and second valves, thereby keeping said valves closed, said third switch means including a semiconductor device having a control gate electrode, and logic means for operating said third switch means to keep said valves closed when a failure mode exists, said logic means being connected to the last said control gate electrode.

7. The invention of claim 6 in which said logic means includes first and second light emitting means connected respective to said first and second switch means to emit light when said switch means are conducting, light responsive means optically coupled to said light emitting means to provide a circuit condition corresponding to the conductive condition of said switch means, and a logic circuit operatively connecting the outputs of said timer means and light responsive means to said third switch means.

8. The invention of claim 7 in which each of said first, second and third switch means is a Triac, said current source being an alternating current power source.

9. The invention of claim 7 in which each light emitting means includes a light emitting diode and said light responsive means is a phototransistor.

10. The invention of claim 4 in which each said first and second light emitting means includes a light emitting diode.

11. The invention of claim 1 including level sensor means disposed in said bowl and effective to provide an electrical output inhibiting operation of said timer means when the water level in said bowl reaches a predetermined maximum level.

12. The invention of claim 1 including means for selectively varying said first and second predetermined time periods, thereby varying the amount of water used in the flushing cycle, said varying means being operatively connected to said timer means.

13. An electronically controlled water closet including a bowl, a flush tank, a first solenoid operated valve for draining the flush tank, a second solenoid operated valve for admitting water to refill the flush tank, circuit means for connecting said first and second valves to a current source, said circuit means including first and second switch means, respectively, for operating said first and second valves, each switch means including a semiconductor device having an anode and cathode connected in series with its associated valve and a control gate electrode, and control circuit means for sequencing said first and second switch means, said control circuit means being connected to said gate electrodes, third switch means for breaking the first said circuit means to keep said valves closed when a failure mode exists, and said control circuit means including logic circuit means for establishing a circuit condition effective to operate said third switch means when a failure mode exists to maintain said valves in a closed position.

14. The invention of claim 13 in which said logic cir-

cuit means includes first and second light emitting means connected, respectively, to said first and second switch means to emit light when said switch means are conducting, and light responsive means optically coupled to said light emitting means to provide an electrical output indicating whether said switch means are conducting.

15. The invention of claim 14 in which said control circuit means includes timer means for sequencing said first and second switch means, said timer means having outputs connected to the gate electrodes of said first and second switch means and to said logic circuit means.

16. The invention of claim 13 in which said control circuit means includes timer means for sequencing said first and second switch means, said timer means having outputs connected to the gate electrodes of said first and second switch means and to said logic circuit means.

17. The invention of claim 16 including manually operated switch means for starting said timer means to initiate the flushing cycle.

18. The invention of claim 17 including level sensing means disposed in said bowl and effective to provide an electrical output inhibiting the starting of said timer means when a predetermined water level in said bowl is exceeded.

19. The invention of claim 17 including means for selectively varying said timer means to vary the amount of water used during the flush cycle.

20. The invention of claim 14 in which said light emitting means includes light emitting diodes and said light responsive means includes a phototransistor.

21. The invention of claim 7 in which each of said first and second switch means is a transistor, said current source being an alternating current power source.

22. The invention of claim 7 in which each switch means is a solid state switch means.

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