



## Description

**[0001]** The present invention has for its object a piloting device for the current supply of light emitting diodes (LEDs) as the basic components of solid-state lamps replacing equivalent incandescent lamps.

**[0002]** The purpose of the present invention is to realize a system of containment within a safe limit of the current of the LEDs for reliable operation in time thereof in the presence of high overvoltages and with the lowest possible production costs compared with those known at the state of the art and available in trade.

**[0003]** In the more general form, all present control systems call for the use of a 4-diode rectifier stage known as "Graetz' bridge" for the purpose of obtaining pulsing one-way current starting from the alternating supply voltage present on the lines dedicated to that use.

**[0004]** Another characterization of the systems presently in use is the presence of a suppressor stage of the transitory overvoltage phenomena and in some devices even circuitries for automatic regulation of the piloting current to the LEDs based on semiconductor electronic devices in order to extend their operating life in the presence of moderate supply voltage changes.

**[0005]** The main purpose of the present invention is to make available better functional performance towards resistance to failure for high-intensity electrical overvoltages both towards present solid state lamp models and towards the incandescent ones allowing their use in operational situations where the protection installed in the systems is inadequate or absent or where electrical system handling errors have caused anomalous voltage levels higher than the nominal ones required for operation of the lamps.

**[0006]** Other advantages of the present invention are fitting into extremely miniaturized lamps thanks to reduced number of components, limited cost and no need of complex instrumentation or procedures for functional inspection at the end manufacturing.

**[0007]** These purposes and advantages are all achieved by the present invention as characterized by the claims below.

**[0008]** Other characteristics and advantages of the present invention are clarified by the detailed description given below of preferred if not exclusive embodiments of the present invention all based on the same principle and illustrated by way of nonlimiting example in the annexed figures in which:

FIG 1 shows the circuit diagram for piloting of one or more LEDs with resistance to permanent overvoltages,

FIG 2 shows the circuit diagram of FIG 1 modified for resistance to both permanent and transitory overvoltages,

FIG 3 shows the circuit diagram of FIG 2 modified to introduce the functionalities of current pi-

loting regulation based on alternating supply voltage changes whether permanent or transitory,

FIG 4 shows the circuit diagram for complete elimination of the diodes necessary in the supply line alternating voltage rectifier stage with electrical characteristics with overvoltages equivalent to those of FIG 1,

FIG 5 shows the circuit diagram of FIG 4 modified for resistance to either permanent or transitory overvoltages,

FIG 6 shows the circuit diagram of FIG 5 modified to allow use of an unequal number of LEDs in both nonparallel series,

FIG 7 shows a simple basic version suited only to direct voltage functionality and permanent overvoltages only for definite work polarity,

FIG 8 shows a simple basic version suited to the functionalities for direct and alternating supply voltages in individual half-wave and only for permanent overvoltages,

FIG 9 shows a modified version compared with that of FIG 8 for behavior improvement with permanent overvoltages,

FIG 10 shows a reduced version of that illustrated in FIG 5 modified to function with alternating voltages in individual half-wave, and

FIG 11 shows a version equivalent of that of FIG 3 modified to avoid the use of a double half-wave rectifier with four diodes as for the versions of FIGS 4 and 5.

**[0009]** With reference to the above-mentioned FIGS, 9, 20, 34, 40, 48, 56, 59, 63, 67, 13, 88 indicate the connections of the control circuit to the alternating voltage supply line typically with a lamp base (Edison) or bayonet connection. The remaining circuit components are housed inside the lamp body (of which the connection represents a terminal part) generally but not exclusively through the help of a printed circuit shaped and formed so as to fit into the internal cavity of the connection and/or of an extension component integral therewith.

**[0010]** With reference to the above-mentioned FIGS, 7, 8, 18, 19, 32, 33, 36, 37, 38, 39, 44, 45, 46, 47, 52, 53, 54, 58, 62, 66, 71, 72, 84, 85, 86, 87 indicate the LEDs connected to the control circuit and generally housed so that the primary lens installed therein directs the light flow emitted toward the outside in the useful direction or, if provided, better operation of secondary optical devices that can be plugged into or are integral with the connection and/or one of its extension components for completion of the remaining end of the lamp body.

**[0011]** With reference to FIG 1, reference number 6 indicates a PTC type thermistor for limiting the piloting current of LEDs 7 and 8 (of the same or different color and/or white light), 1 indicates a full-wave rectifier stage consisting of the diodes 2, 3, 4, 5 which allow the func-

tionality with alternating or direct supply voltage with either applied polarity.

**[0012]** The output of this rectifier stage is connected directly to one or more LEDs in series or parallel (in FIG 1, 7 and 8 show a circuit diagram calling for the use of two LEDs in series by way of example of one of the possible embodiments) while the input is connected to lamp connection 9 through the interposition in series of the PTC type thermistor indicated by reference number 6.

**[0013]** The device of FIG 1 allows containment of the piloting current of the LEDs at a safety level for LEDs 7 and 8, adopting a PTC thermistor device 6 whose transmissible maximum current characteristics (at thermal equilibrium, Trip Current) are lower than or equal to those tolerable for long term reliable operation of the components 7 and 8.

**[0014]** For purposes of protection with overvoltages and therefore with overcurrents on the pilot circuit and with the LEDs connected thereto, the device of FIG 1 is effective only for permanent overvoltages or those characterized by slow changes in time while it is not suitable for resisting overvoltages of a transitory nature or in any case characterized by fast changes in time.

**[0015]** This functional characteristic is due to the heating time of the PTC thermistor 6 in the presence of an overvoltage and hence an overcurrent traversing it to which it responds by opposing rise of the current beyond the trip current thereof while increasing internal resistance.

**[0016]** It is clear that the current increase due to fast changes in the overvoltages as compared with the thermal inertia typical of the PTC thermistor 6 is not limited, resulting in an overcurrent on the supplied electronic devices often inadmissible for those more sensitive ones among which are the LEDs 7 and 8.

**[0017]** To avoid this shortcoming, the electrical circuit of the device shown in FIG 2, compared with the circuit of FIG 1, calls for two added circuit components, one zener diode 16 or other device (TVS) fit to suppress voltage overvoltages, and an uncoupling resistor 17.

**[0018]** Introduction of these two additional components allows containing the momentary overcurrent due to the thermal inertia of the PTC thermistor 15 by diverting it so that it does not traverse the LEDs 18 and 19 and allowing obtaining functional immunity of the piloting device even in the presence of high transitory overvoltage phenomena.

**[0019]** The zener diode or TVS component 16 will be sized so as to withstand the transitory and static powers resulting from the specifications of the PTC thermistor component 15 selected for use under the nominal and anomalous operating conditions expected.

**[0020]** The device of FIG 3 introduces another functional improvement in comparison with FIG 2 by replacing the uncoupling resistor 17 with a constant current electronic regulator stage 28 for the supply current of the LEDs 32 and 33.

**[0021]** This improvement consist of perfect uncou-

pling of the current running through the zener or TVS diode 27 and that of the LEDs 32 and 33 in case of operation in the presence of anomalous overvoltages whether transitory or permanent so that it is possible to use the LEDs 32, 33 at the highest current limit provided by their manufacturer for reliable long-term operation.

**[0022]** Further improvement can be obtained in operation for nominal voltages called for by being able to raise the figure of the zener diode or TVS 27 to the security level for the electronic stage 28 so as to obtain an ample working zone with high compensation of the light flux emitted by the LEDs 32 and 33 as the supply voltage changes.

**[0023]** The steady current regulating electronic stage 28 is made up by way of example of an integrated circuit regulator of the National Semiconductor LM317 type or with equivalent functionality 29, a stabilization condenser 30 and a resistor (shunt) 31 defining the level of steady current delivered.

**[0024]** The circuit of FIG 4 is a version corresponding to that of FIG 1 as concerns the behavior under overvoltages, in which the PCT thermistor is maintained but on the contrary for reasons of an economical nature the rectifier stage is absent by virtue of the parallel connection of LEDs with opposite polarity (antiparallel) and allows, in the presence of an alternating light flux emission for each half-wave of the supply voltage in the LEDs used, greater long term reliability thereof because of the reduced effectiveness level of the current circulating in them.

**[0025]** It is specified that one or more LEDs in series or parallel for each polarity group are possible. FIG 4 shows a circuit diagram calling, with 36 and 38, for the use of two LEDs in series for one polarity group and, with 31 and 39, another two LEDs in series for the opposite polarity group by way of example of one of the possible embodiments.

**[0026]** The circuit of FIG 5 is a version corresponding to that of FIG 2 as concerns behavior under overvoltages in which for economical reasons the rectifier stage is absent by virtue of the connection of LEDs in parallel with opposite polarity (antiparallel) and allows in the presence of an alternating light flux emission for each half-wave of the supply voltage in the LEDs used a greater long term reliability thereof because of the reduced effectiveness level of the current circulating therein.

**[0027]** It is specified that one o more LEDs in series or parallel for each polarity group are possible. FIG 5 shows a circuit diagram calling with 44 and 46 for the use of two LEDs in series for one polarity group and with 45 and 47 another two LEDs in series for the opposite polarity group by way of example of one of the possible embodiments.

**[0028]** It is underscored that, differently from the component 16 of the circuit of FIG 2, the corresponding component 42 of the circuit of FIG 5 is the 2-way TVS type or realized by means of two zener diodes connected in

series but with opposite polarity.

**[0029]** The circuit of FIG 6 offers the functionalities of the circuit of FIG 5 in case the number of LEDs to be used is unequal. In the circuit of FIG 6 the component 55 (zener diode with equal value or near the direct conduction voltage of the LEDs 52, 54, 53) replaces the corresponding LED 47 of FIG 5 for electrical balancing of the system. In like manner the same solution is applicable to the variant of FIG 4 for replacement of the LED 39.

**[0030]** The diagram of FIG 7 shows maximum circuit simplification of the variants of the present invention illustrated in FIGS 1, 2, 3, 4, 5, 6 and described above for the application ambits where it is sufficient to offer only direct supply voltage functionalities and protection from overvoltages having slow change in time with polarity coinciding with that of the supply voltage.

**[0031]** The diagram shown in FIG 8 allows offering additional functionalities compared with those of FIG 7 in relation to protection against direct supply polarity reversal and the possibility of use with alternating supply voltage with light flux emitted for a single half-wave in addition to protection of the overvoltages with slow change in time of both polarities.

**[0032]** For the circuit components the corresponding descriptions given above apply with the exception of the rectifier stage made up of a single diode 61 in series with the LED 62 or series or parallel group of LEDs.

**[0033]** The diagram shown in FIG 9 is an alternative circuit to that of FIG 8 in which the position of the rectifier diode 68 instead of being in series with the LED 66 (or series or parallel group of LEDs) is placed in parallel with opposite polarity (antiparallel) to allow better protection from reversal of polarity of the voltages applied both for supply and for overvoltage phenomena with slow change in time.

**[0034]** The diagram shown in FIG 10 adds to the functional characteristics of that of FIG 9 protection from overvoltages with fast change in time similarly to those of FIG 2 compared with FIG 1 or that of FIG 5 compared with FIG 4. It is noted that, for intrinsic operation for a single half-wave of the alternating supply voltage, the component 69 is the one-way zener or TVS diode type.

**[0035]** The diagram of FIG 11 allows modifying the circuit of FIG 5 to obtain additional functionalities analogous to the additional functionalities that the circuit of FIG 3 presents compared with the circuit of FIG 2.

**[0036]** In this variant of the present invention the uncoupling resistor 43 of FIG 5 was replaced with a constant current electronic regulating stage 76 for the supply current of LEDs 84, 86, 85, 87.

**[0037]** This stage allows achieving the advantages described above for FIG 3.

**[0038]** The constant current electronic regulating stage 76 is made up by way of example of two integrated circuit regulators of the National Semiconductor LM317 type or with equivalent functionalities 78 and 81, a stabilization capacitor 80 and two resistors 79 and 82 (shunt) that define the level of constant current deliv-

ered.

**[0039]** For the remaining circuit components the corresponding descriptions given above apply.

**[0040]** Containment of costs together with high performance resistance to the overvoltages offered gives a clear advantage of the present invention in its variants compared with the state of the art in many application fields.

**[0041]** Indeed, the cost of manufacturing and of the components used and the technical characteristics of electrical robustness achieved are decisive for the purposes of replacement of equivalent incandescent filament lamps, especially those designed for operation in SELV or equivalent systems; with PTC thermistors and TVS diodes currently available in trade, 500V for permanent overvoltages and 1500V for transitory overvoltages are reached and exceeded.

**[0042]** It is specified that in case of use of series or parallel combinations of LEDs in the possible variant embodiments of the present invention as described above, balancing of the electrical characteristics will be held in due account where necessary according to what is known to those skilled in the art in the sector and known with regard to the current state of the art, for example use of additional uncoupling resistors 17, 43, 51, 70.

**[0043]** In addition, to increase the level of electrical insulation of the PTC thermistor used 6, 15, 26, 35, 41, 49, 57, 60, 64, 68, 74 with regard to other components or the metallic mass of the lamp connection, embodiment devices will be used among which incorporation in plastic sheaths, insertion in anchoring cavities or holes on a possible printed circuit of the entire body of the component and/or other methods known in the present state of the art.

**[0044]** Sizing of the PTC thermistors will be done so that the trip current figure will be lower than the current withstandable in the long term by the LEDs used in the versions in which zener or TVS diodes are not called for and of appropriate figure to also obtain minimization of the variation of the current absorbed with the variation of the supply voltage in a preferred range.

**[0045]** In the remaining cases, sizing of the PTC thermistors will be done in such a manner that the trip current figure does not cause exceeding of the maximum power that can be dissipated by the zener or TVS diodes and at the same time is appropriate for the functionalities of the LEDs used.

**[0046]** It will also be possible to use two or more PTC thermistors in parallel with different trip currents instead of only one to obtain a more limited change in the absorbed current or light flux emitted - in the cases in which an electronic regulator is not provided - with variation in the supply voltage.

**[0047]** It is underscored that in the present invention and its circuit variants described, numerous changes of a practical application nature of the construction details can be made without thereby abandoning the protection

of the following claims. For example, instead of the four diodes of the double half-wave rectifier, one or more integrated devices can be used, the position of the zener or TVS diode or diodes can be at the input instead of the output of the rectifier stage or omitted if incorporated therein in place of two of the four diodes that realize it, and the location of the PTC thermistors can be on their output instead of the input to the rectifier circuits, even though not preferably, without going beyond the scope of the inventive idea claimed below.

## Claims

1. Light emitting diode piloting device **characterized in that** it comprises two LEDs (7,8), a PTC thermistor (6) for limiting current absorbed from the supply line with respect to high permanent overvoltages through the input terminals (9), one whole-wave rectifier stage (1) made up of four diodes (2,3,4,5) connected in such a manner as to deliver a one-way current to the two LEDs (7,8) and receive the supply voltage through the PTC thermistor (6) from the input terminals (9) for increasing the resistance of the LEDs to electrical stresses.
2. Light emitting diode piloting device **characterized in that** it comprises two LEDs (18,19), one PTC thermistor (15) for limiting current absorbed from the supply line in the presence of high permanent and transitory overvoltages through the input terminals (20), one whole-wave rectifier stage (10) made up of four diodes (11,12,13,14) connected in such a manner as to deliver a one-way current to a zener diode or TVS unidirectional device (16), a resistor (17) for uncoupling therefrom, to the two LEDs (18,19), and to receive the supply voltage through the PTC thermistor (15) from the input terminals (20) for increasing the resistance of the LEDs to electrical stresses.
3. Light emitting diode piloting device **characterized in that** it comprises two LEDs (32,33), one PTC thermistor (26) for limiting current absorbed from the supply line in the presence of high permanent and transitory overvoltages through the input terminals (34), one whole-wave rectifier stage (21) made up of four diodes (22,23,24,25) receiving the supply voltage through the PTC thermistor (26) from the input terminals (34) connected so as to deliver a one-way current to a one-way containment or escape path zener or TVS diode (27) for the residual overcurrents upon the action of the PTC thermistor (26) associated with the external overvoltages and the two LEDs (32,33) through interposition of a current stabilizing electronic stage (28).
4. Light emitting diode piloting device as claimed in
- claim 3 **characterized in that** said current stabilizing electronic stage (28) is made up of an LM317 National Semiconductor or other integrated circuit regulator with equivalent functionality (29) equipped with an uncoupling capacitor (30) and completed by a resistor with the function of delivered current sensor (31) for the purpose of presenting greater resistance to electrical stresses and ensuring considerable stability of the light flux emitted or functionality in time.
5. Light emitting diode piloting device **characterized in that** it comprises a first group of LEDs (36,38) connected in series and a second group of LEDs (37,39) connected in series, which are connected together in parallel with opposite polarity, said two groups being connected to the supply line through a PTC thermistor (35) connected in series for the purpose of ensuring functioning with alternating supply voltage without using a dedicated-diode rectifier, the PTC thermistor (35) limiting the current absorbed from the supply line in the presence of high permanent overvoltages through the input terminals (40).
6. Light emitting diode piloting device **characterized in that** it comprises a first group of LEDs (44,46) connected in series and a second group of LEDs (45,47) connected in series, which are connected together in parallel with opposite polarity, for the purpose of ensuring functioning with alternating supply voltage without using a dedicated-diode rectifier, a PTC thermistor (41) for limitation of the current absorbed from the supply line in the presence of high permanent and transitory overvoltages through the input terminals (48), two zener diodes connected in series with discordant polarity or TVS bidirectional device (42), a resistor (43) for uncoupling from the latter for increasing the resistance of the LEDs to electrical stresses.
7. Device as claimed in claim 6 **characterized in that** in one of the two groups of LEDs a zener diode is present with breakdown voltage equal to that of direct conduction of a LED for electrical balancing of the circuitry in case of operation with a different number of LEDs in the two groups.
8. Light emitting diode piloting device **characterized in that** it comprises one LED (58), one PTC thermistor (57) connected in series for limiting current absorbed from the supply line in the presence of high permanent overvoltages through the input terminals (59), with direct supply voltage having possible slow change in time, for increasing the resistance of the LED to electrical stresses.
9. Light emitting diode piloting device **characterized**

**in that** it comprises one LED (62), one PTC thermistor (60) for limiting current absorbed from the supply line in the presence of high permanent overvoltages having possible slow change in time through the input terminals (63), a rectifier diode (61) in series for the purposes of single half-wave rectifier stage functionality for increasing the resistance of the LED to electrical stresses.

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10. Light emitting diode piloting device **characterized in that** it comprises one LED (66), one PTC thermistor (64) for limiting current absorbed from the supply line in the presence of high permanent overvoltages through the input terminals (67), one rectifier diode (65) placed in parallel with the LED (66) with function of single half-wave rectifier stage, for increasing the resistance of the LED to electrical stresses. 10
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11. Light emitting diode piloting device **characterized in that** it comprises two LEDs (71,72), one PTC thermistor (68) for limiting current absorbed from the supply line even in the presence of high permanent or transitory overvoltages through the input terminals (73), one one-way zener diode or TVS unidirectional device (69) having the function of single half-wave rectifier, a resistor (70) for uncoupling from the latter, for increasing the resistance of the LEDs to electrical stresses. 20
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12. Light emitting diode piloting device **characterized in that** it comprises a first group of LEDs (84,86) connected in series and a second group of LEDs (85,87) connected in series, which are connected together in parallel with opposite polarity, for the purpose of ensuring functioning with alternating supply voltage without using a dedicated-diode rectifier, a PTC thermistor (74) for limitation of the current absorbed from the supply line in the presence of high permanent or transitory overvoltages through the input terminals (88), two zener diodes connected in series with discordant polarity or TVS bidirectional device (75), and a electronic current stabilizer stage (76) operating for both the polarities or half-waves of the supply voltage. 35
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- 45
13. Light emitting diode piloting device as claimed in claim 12 **characterized in that** said electronic current stabilizer stage (76) is made up of two LM317 National Semiconductor integrated circuit regulators or others with equivalent functionality (78,81) equipped with an uncoupling capacitor (80) and completed by two resistors (79,82) with function of delivered current sensors for the purpose of presenting greater resistance to the electrical stresses and ensuring considerable stability of the light flux emitted and functionality in time in comparison with present solid state and incandescent lamps. 50
- 55

14. Device as claimed in one of the above claims in which the physical containers of the PTC thermistors are insulated in increased manner towards adjacent electrical members or components by means of added plastic sheaths and/or incorporation in resins.

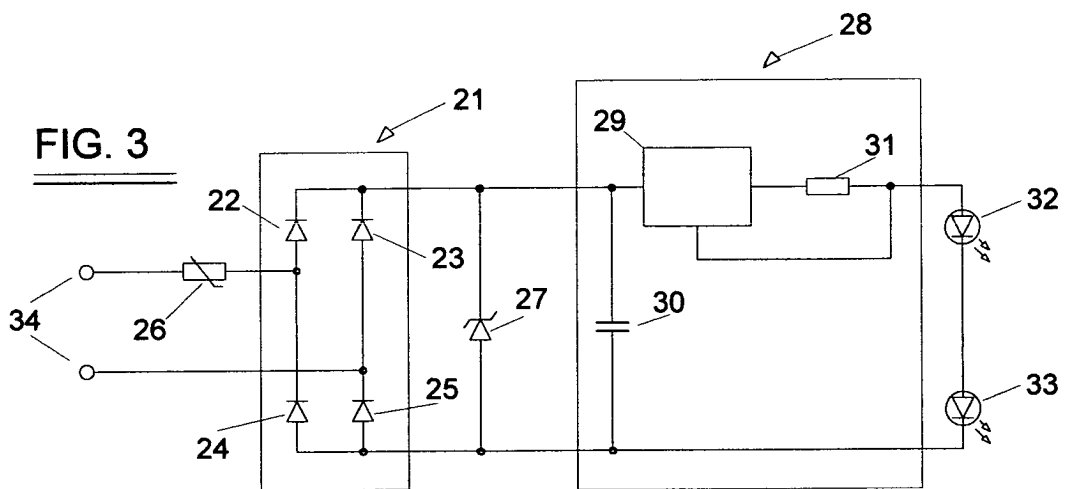
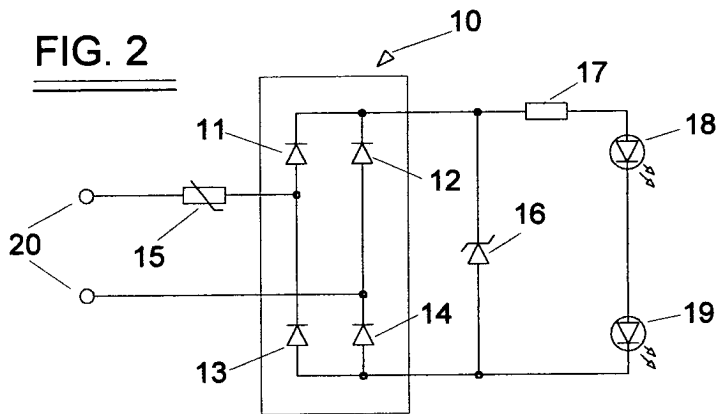
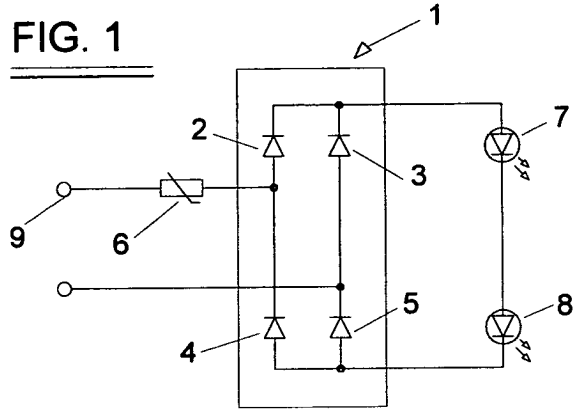


FIG. 4

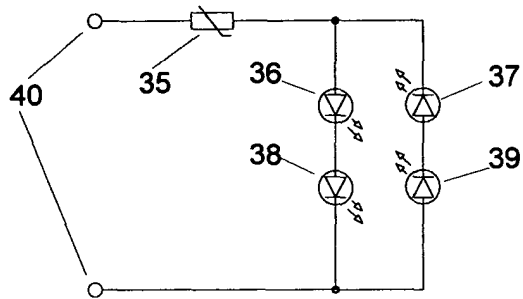


FIG. 5

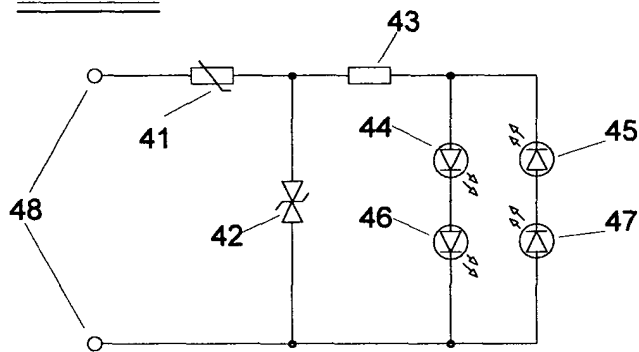


FIG. 6

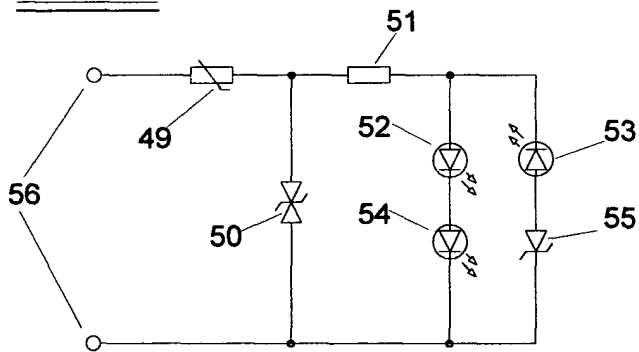


FIG. 7

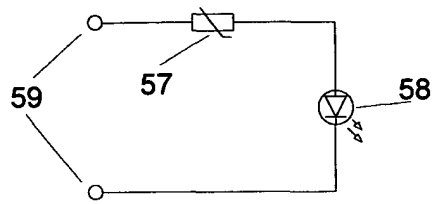


FIG. 8

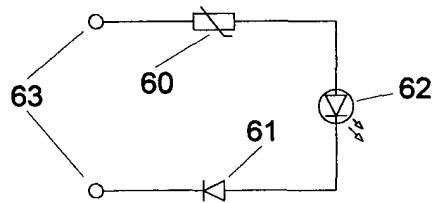


FIG. 9

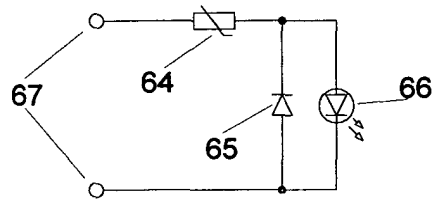


FIG. 10

