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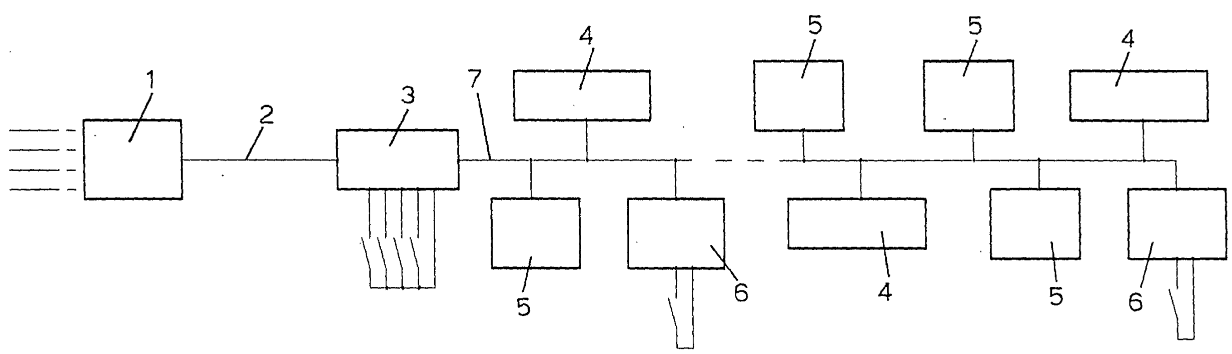
(54) **Integrated system for the diagnosis and controlling of fluorescent lamps**

(57) An integrated system for the diagnosis and handling of fluorescent lamps (4, 5), comprising a series of lighting devices (4) which share the same physical communication element or bus (7) with emergency lighting devices (5) and are driven by a single control and/or supervision board (3), in order to facilitate the installation and maintenance operations of the system; the system can also handle different configurations, indifferently with or without simple lighting lamps, such as a group of single lamps, totally autonomous, suitable for forming a plant in compliance with safety regulations, the same group of lamps which can be activated by a centralized remote control system, that allows and facilitates various maintenance operations, and/or the same group of lamps, connected to a central board which handles light and test running and maintenance data.

Fig.1



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Description

[0001] The present invention relates to an integrated system for the diagnosis and handling of fluorescent lamps.

[0002] Central boards are currently known for the handling of a series of lighting lamps according to a standard communication protocol ("DALI" protocol), which allows the local and/or centralized diagnosis of lamps, and there are still specific central boards for the supervision and diagnosis of emergency lighting lamps.

[0003] The designing of the new system, according to the present invention, derives from the intention of providing an innovative mixed emergency lighting system, with illuminating appliances (ballasts), which share the same communication bus with the emergency devices and are subject to the same central control board, also for the purpose of facilitating installation and maintenance operations.

[0004] In view of the above demands, an objective of the present invention is therefore to provide an integrated system for the diagnosis and handling of fluorescent lamps, which allows a single product to be used, suitable for effecting a local and/or centralized diagnosis of lighting lamps and emergency lamps.

[0005] Another objective of the present invention is to provide an integrated system for the diagnosis and handling of fluorescent lamps which facilitates the installation and maintenance operations of the lighting and/or emergency plants.

[0006] A further objective of the invention is to indicate an integrated system for the diagnosis and handling of fluorescent lamps, which is particularly reliable and is easy and economical to produce, without the use of complex or costly technologies, and which allows a precise, rapid and economical installation of lighting and/or emergency plants.

[0007] These and other objectives are achieved by an integrated system for the diagnosis and handling of fluorescent lamps, according to claim 1, to which reference should be made for the sake of brevity; other specific characteristics are indicated in the subsequent claims.

[0008] The mixed emergency lighting system, according to the present invention, advantageously uses lighting appliances (ballasts) which share the same communication bus with the emergency devices and are subject to the same central control body, with the additional purpose of facilitating installation and maintenance operations.

[0009] With only a few and extremely versatile products to be purchased, it is possible to satisfy numerous requirements with the flexibility, moreover, of also being able to change the type of plant at a later date, without modifying or substituting the appliances already purchased.

[0010] For this reason, the lamps used in the system provide an intelligent handling of their functioning, both in an autonomous and centralized manner.

[0011] Finally, the devices forming the system are both electrically and mechanically easy to install and set up, thanks to self-programming functions, contained in the central board, simplified for the installer and oriented towards the type, and above all use, of plant which is created (such as scholastic, hospital, office, projection room installations, etc.).

[0012] The versatility and convenience for installation and maintenance operators allow local or centralized diagnoses to be effected, differentiating the autonomies in complete freedom, even if the plant has already been installed.

[0013] As this is a system which incorporates lighting, not only is the installation facilitated but the also handling of the light for the final user is further facilitated.

[0014] In practice, various configurations can be used in the system, all indifferently with or without simple lighting lamps (with the DALI communication protocol), i.e.:

- a group of totally autonomous single lamps which already form a mini-plant in compliance with safety regulations, also without centralization;
- the same group of lamps, with a centralized remote control system which allows and facilitates various maintenance operations, or
- the same groups of lamps with a central board which handles and centralizes all the light and test running and maintenance data.

[0015] Further objectives and advantages of the present invention will appear evident from the following description and enclosed drawings, provided for purely illustrative and non-limiting purposes, in which:

- figure 1 shows a block scheme of the integrated system for the diagnosis and handling of fluorescent lamps, produced according to the present invention;
- figure 2 shows a preliminary block scheme of the control and supervision central board of the lighting and emergency lamps used in the integrated system for the diagnosis and handling of fluorescent lamps, according to the present invention;
- figure 3 shows a preliminary block scheme of the piloting circuit of each lamp installed in the integrated system for the diagnosis and handling of fluorescent lamps, according to the present invention;
- figures 4-11 represent electronic circuits and equivalent circuits, suitable for forming the high frequency piloting block as per figure 3 of each lamp installed in the integrated system for the diagnosis and handling of fluorescent lamps, according to the present invention;
- figure 12 is an overall and complete circuital scheme of the high frequency piloting circuit for fluorescent lamps as per figures 4-11;
- figures 13-17 refer to circuital functioning modes of the control and supervision board of the lighting and

emergency lamps as per figure 2, according to the invention.

[0016] With particular reference to figures 1-3 mentioned above, 1 indicates a communication interface towards which a series of inlet commands are directed, connected, by means of a serial line 2, to a diagnosis and supervision board 3 which is, in turn, connected, by means of a serial connection, to a first series of lighting lamps, indicated with 4, to a second series of emergency lamps 5 and to one or more intelligent pushbuttons 6.

[0017] The board 3 allows the whole lighting and emergency plant to be handled and, in particular, set up, without the necessity of using a Personal Computer, but only using a keyboard and display, assembled on the board 3.

[0018] The board 3 also provides an intuitive and descriptive user interface, which remains enclosed with the plant also after its installation; a more sophisticated instrument than the board 3 is not necessary for the full configuration of the plant.

[0019] The integrated system, according to the invention, thus provides for the handling of a mixed lighting and emergency plant, wherein each device 4, 5, 6 can be remote controlled by the same board 3.

[0020] In this way, the board 3 englobes the functions of two boards: one for controlling the lighting lamps and one for controlling the emergency lamps.

[0021] Furthermore, each lighting lamp 4 or emergency lamp 5 is created as an autonomous device, with automatisms which allow it to periodically effect automatic tests and provide visual information of their results.

[0022] The same appliance, without any modification, can also be incorporated into a centralized plant, wherein the central unit takes over its control, substituting its automatisms (test temporizations) with those of the unit; analogously, if the lamp is abandoned by the central unit (due to the removal of the central unit itself, or in any case as a result of a prolonged interruption of the communication) and it consequently no longer receives remote-controlled orders, it will continue its own activity autonomously, without any problems or reductions in its functionality and therefore effecting the periodical tests for which it has been set up.

[0023] With such a versatile device, it is possible to satisfy a wide range of demands with the guarantee that, in the case of communication malfunctioning, each appliance maintains its autonomous functionality (including the performing of the tests).

[0024] The lamps 4, 5 effect their own operations in a totally autonomous manner, and the central unit 3 sends its own orders by writing the data directly in the memory of the lamps themselves: in this way, the lamp 4, 5 does not have to waste time in decoding the orders, or verifying its own state prior to the orders themselves (in order to effect them or not), but must simply continuously realign its functioning with the state imposed by the data contained in its memory.

[0025] In particular, there is a special register, called "Action Register", containing 8 bits which determine the future functioning of the device: by modifying one of these bits, the lamp immediately triggers the realignment operations of its own functioning without any sign as to by who or when said bit was modified; during normal functioning, these bits are modified by the lamps itself, for example upon reaching a certain meter count.

[0026] The demands of the communication protocol are thus significantly reduced and all the operations to be effected by remote-control in the simple autonomous functions of the lamp 4, 5 are unified: it does not act differently if a meter count expires or if it receives a remote-control command, but simply effects the cyclic operations relating to the current state of the memory.

[0027] The control and supervision board 3 can also communicate with the lamps 4, 5 in an emergency, by feeding the serial bus 7 for the communication, thanks to its own accumulators; by driving the bus 7 only during the brief period of the communication, a considerable energy saving is obtained which maximizes its autonomy.

[0028] When there is a lack of power supply only to a part of the plant, including the control board 3, or also to the whole plant, the control is maintained of the part of the lighting plant still possibly being fed and all the emergency part and orders can also be given, whereas normally, in a conventional DALI communication protocol plant, the batterization of the communication bus feeder 7 is not envisaged.

[0029] The control board 3 can also handle lighting and emergency plants with a rescue group; in this case, when there is central power supply, each lamp 4, 5 is handled with simple lighting, whereas, when there is no central power supply to the rescue group, the control board 3 detects this and brings all the lamps 4, 5 to the respective emergency light (pre-set by the installer), and they are maintained in this state until the expiry of the respective autonomies. The lamps 4, 5 regulated for maximum autonomy remain switched on until the charge of the rescue group becomes exhausted.

[0030] The whole plant is therefore fed until the charge of the rescue group has been exhausted so that the lamps 4, 5 can in any case be manually controlled by switching them on and off or modifying their light.

[0031] In particular, figure 2 shows a block scheme of the hardware present in the diagnosis and supervision board 3, which comprises an AC/DC 8 switching feeder, a feeder 9, a battery 10, a battery-charger 11, a booster 12, a microprocessor 13, suitable for exchanging data and commands with the user inlet/outlet interface 14, with a count meter or timer 15 and with a serial line 16, of the RS485 type, which forms the connection to the communication bus 17 of the various control and supervision boards 3, or to the serial line 2 connecting with the communication interface 1.

[0032] Finally, a receiver/transmitter interface 18 of the control board 3 is connected to the communication bus 7 of the lamps 4, 5.

[0033] More specifically, the control and supervision board 3 is illustrated in the equivalent electronic circuits according to figures 13-17.

[0034] With particular reference to these figures, it can be noted that the control board 3, suitable for running a lighting plant with a standard DALI communication protocol also in the absence of central power supply, as it is autonomously fed by a series of rechargeable accumulators 10, consists of a central power supply AL step, the battery-charger 11, the series of rechargeable accumulators 10, the DC/DC booster 12, a control organ CC, which comprises the microprocessor 13 and which handles the functioning of the whole equipment, and a transmitter/receiver step 18 for communication with the serial bus 7 of the plant of lamps 4, 5.

[0035] By using the circuital configuration according to the invention, it is possible to control a lighting plant having a standard communication protocol, of the DALI type, also in the absence of the central power supply, and, by carefully running the feeding of the bus 7, also in the energy saving mode, with a consequent increase in the autonomy provided by the battery accumulators 10.

[0036] In traditional lighting plants, with a DALI communication protocol, the possibility of communicating is guaranteed by a single unit, destined for feeding the two-wired bus 7 with a well-defined current limitation; whoever wishes to communicate with the bus 7 must "introduce" a low impedance so as to lower the voltage present on the bus 7.

[0037] By short-circuiting the bus 7, the transmission of a logic zero is obtained; the information is therefore transmitted with a serial sequence of short-circuits and releases of the communication line.

[0038] The problem of communication arises when the feeder is switched off, for example during a blackout, as no lighting device connected to its bus can communicate any longer, because it has lost the support for its own transmissions.

[0039] This problem obviously only concerns appliances having a secondary energy source and which for some reason are still fed during the switching off of the feeder of the bus line 7.

[0040] In this respect, figures 14 and 15 enclosed respectively illustrate the energy circulation and control logic of the control board 3.

[0041] During functioning with the electric power supply, the AL feeder supplies energy to the control organ CC, the battery-charger 11 and transmission/reception block 18; the transmission/reception block 18 is constantly tuned in to the plant bus 7, and the control logic or organ CC, comprising the microprocessor 13, activates its supervision.

[0042] The battery-charger block 11 regulates the necessary current for recharging the battery accumulators 10, under the control/command of the control organ CC, until a full charge is reached; from this moment, the battery-charger 11 supplies the battery accumulators 10 with the charge maintenance current.

[0043] During the presence of the central power supply, the DC/DC booster 12 is switched off, as the feeding AL already supplies a sufficient voltage to the transmission/reception block 18, which polarizes the plant bus 7 (figure 16).

[0044] In the absence of the central power supply, on the contrary, the internal feeding is taken from the battery 10 and a precise sensor positioned in the feeder AL communicates to the control organ CC in real time, the presence or absence of the external supply (figure 15).

[0045] When the latter descends below the minimum level allowed for guaranteeing the functioning of the system, the control organ CC turns on the booster 12 exploiting the energy of the battery 10 and continues the handling of the plant bus 7, by controlling the transmission/reception block 18, as in the presence of the central power supply (figure 17).

[0046] This functioning proceeds until the external supply has returned or total discharge of the battery 10, at which point a protection system against over-discharging interrupts the current supply from the battery 10 and switches off the system.

[0047] In this phase, the use of available energy can be adopted as desired: on the one hand, the bus 7 can be kept continuously active for the whole time allowed by the capacity of the battery accumulators 10 or, a more intelligent solution, the communication can be activated only for the sending of messages to the plant on the part of the control body 3, so as to exploit to the utmost the charge stored in the accumulators, as it is used only and when strictly necessary.

[0048] Figure 3 shows a block scheme of the hardware of each lamp 4, 5, which comprises a transformer 20 of the central power voltage, a battery-charger 21, a battery 22, an oscillator 23, a central power sensor 24, a battery sensor 25, a feeder 26, a control microprocessor 27, a sensor of the fluorescent tube 31 of each lamp 4, 5 and a series of communication interfaces 29, 30 with the user and with the connection bus 7 of the lamps 4, 5.

[0049] The oscillator 23 allows the tube 31 to be turned on at various light levels (and, consequently, supply absorption), in relation to the frequency and duty-cycle of a digital PWM signal.

[0050] The circuit which generates this signal contains the various combinations necessary for obtaining the desired light power in relation to the voltage supplied by the feeding 33 (which can be the battery 22 or other means).

[0051] Figures 4-12 illustrate in more detail the high frequency electronic piloting circuit of the fluorescent tube 31 of each lamp 4, 5.

[0052] The circuit comprises the two-coil voltage raiser transformer 32, a power switch Q1 and the relative pilot circuit DR, a series condenser C1, which supplies the electric current to the tube 31, a preheating condenser C2, which supplies the preheating current to a cathode of the tube 31, the tube current sensor 28, and a control element CL, comprising the microprocessor 27, which controls the commutation of the power switch device Q1 in relation to the current indicated on the tube 31 by the sensor 28; the whole equipment is fed by the DC feeder 33 (figure 4).

[0053] When using the circuital configuration according to the invention, a precise control is obtained of the quantity of energy transferred to the fluorescent tube 31 on the part of the controller CL, with the possibility of directly modifying this quantity of energy during the functioning and obtaining various outgoing luminosities, or maintaining the luminosity constant regardless of the power voltage of the circuit; furthermore, a considerable improvement is obtained in the operating conditions of the fluorescent tube 31, in particular upon lighting up, with a consequent increase in the life expectancy of the tube itself.

[0054] The functioning of the piloting circuit described above is substantially as follows.

[0055] Let us initially (with the circuit switched off) consider the mesh comprising the secondary circuit of the transformer 32, the condenser C1, the tube 31 and the current sensor 28 which does not influence the functioning, as the conductance of the inactivated tube 31 is negligible with respect to the respective conductances of the other elements of the mesh itself and the energy supplied by the transformer 32 is limited.

[0056] As a result of this, we can consider as equivalent circuit, in this initial phase, that shown in figure 5, which indicates the primary circuit T1p of the transformer 32 and the impedance RC, more or less resistive, of the cathode of the tube 31.

[0057] During this initial phase, the circuit must activate the preheating of the cathodes RC without lighting up the tube 31, which occurs after exceeding a certain voltage between its cathodes.

[0058] To comply with the preheating, the circuit is piloted by the controller CL, by means of a periodical rectangular signal, with the following procedure:

- at the initial moment, the switch Q1 is open, there is therefore no current to the primary circuit T1p and the preheating condenser C2 is charged due to the mesh comprising, in addition to the condenser itself C2, the feeder 33, the primary circuit T1p and the cathode RC;
- as a result of the piloting circuit DR, the controller CL causes the closing of the switch Q1 (figure 6) and the energy stored in the preheating condenser C2 is discharged onto the cathode RC, heating it by joule effect; at the same moment the current flows from the feeder 33 through the primary circuit T1p and the switch Q1;
- the primary circuit current in this phase has the effect of energetically charging the magnetic nucleus of the transformer 32;
- the closing phase of the switch Q1 lasts for a period of time defined as $T_{ON(1)}$;
- at the end of the period $T_{ON(1)}$ the controller CL causes the opening of the switch Q1 and most of the energy stored in the magnetic nucleus by the primary circuit T1p is discharged onto the preheating condenser C2 and onto the cathode impedance RC: this current has the effect of recharging the preheating condenser C2 and contributing to the heating, by joule effect, of the cathode RC (figure 7);
- the opening phase of the switch Q1 lasts for a period of time defined as $T_{OFF(1)}$;
- at the end of the period $T_{OFF(1)}$ the controller CL restarts from the $T_{ON(1)}$ phase and continues, alternating the two states in order to adequately preheat the cathode RC;
- in this initial phase, the transformer 32 is already transferring voltage to its own secondary circuit, but it does not reach sufficient level for causing the lighting of the tube 31 for the following reasons:

  during the $T_{ON(1)}$ period, the voltage on the secondary circuit is equal to the voltage on the primary circuit T1p multiplied by the coil ratio, and this coil ratio is dimensioned so as not to reach, under any feeding condition of the feeder 33, the lighting voltage of the tube 31;
  furthermore, during the $T_{OFF(1)}$ period, the primary overvoltage due to the sudden interruption of the primary current is reproduced (again multiplied by the coil ratio) at the secondary circuit itself and, due to the very short duration of the $T_{ON(1)}$ period, the magnetic nucleus of the transformer 32 has not been able to store much energy; this small amount of energy is not sufficient for supplying, in this subsequent phase, an overvoltage which is sufficient for the lighting up, due to the charge, represented by the preheating circuit (C2 + RC) which dampens its reaction;

- in both cases, during this first phase, the secondary circuit of the transformer 32 has a voltage which is too low at the cathodes of the tube 31, which it cannot therefore light up.

[0059] The general effect is to send current to the cathode RC both during the $T_{ON(1)}$ period and also during the $T_{OFF(1)}$ period without causing a premature lighting of the fluorescent tube 31, and thus keeping the mesh comprising the tube 31 itself, negligible, as considered above.

[0060] Finally, it should be pointed out that the maintaining of a low secondary voltage is also helped by the parasite capacity effect and dispersed inductance of the secondary circuit of the transformer 32.

[0061] In order to explain the lighting up and maintained lighting, we will consider the current sensor block

28 as negligible.

[0062] The preheating phase lasts for a reasonably sufficient time for preheating the cathode RC, considering as optimum preheating, a value which reaches the cathode RC resistance, approximately quadruple with respect to the value measured before heating.

[0063] At the end of this phase, the controller CL modifies the frequency and duty-cycle of the periodical rectangular signal which commands the driver DR, in order to provoke the lighting of the tube 31.

[0064] It should be pointed out that the preheating of the cathode, considerably decreases the voltage necessary for lighting the tube 31.

[0065] The T_{ON} and T_{OFF} times are lengthened and, in this phase, we will call them $T_{ON(2)}$ and $T_{OFF(2)}$.

[0066] As $T_{ON(2)}$ is much greater than $T_{ON(1)}$, we can say that the quantity of energy which is stored in the magnetic nucleus of the transformer 32 is much higher than the first phase (preheating).

[0067] With particular reference to figure 8, we can initially consider the presence of the preheating circuit (C2+RC) along as charge: the overvoltage which is generated on the primary circuit during $T_{OFF(2)}$, due to the greater quantity of energy available in the nucleus, becomes sufficient (multiplied at the secondary circuit by the coil ratio) for overcoming the lighting threshold of the tube 31.

[0068] The lighting of the tube 31 consists in a substantial lowering of its impedance series, which makes the mesh to which the tube 31 itself belongs, no longer negligible; this mesh has not been considered so far due to the negligible current it received, but with the lowering of the impedance of the tube 31 this current becomes significant for the analysis of the circuit.

[0069] Once lit, the tube 31 maintains lighting even if the voltage at its cathodes drops below its nominal lighting voltage; we can therefore assert that, also during $T_{ON(2)}$, the current can circulate through the tube 31; it should be remembered that in the preheating phase, the voltage during $T_{ON(1)}$ was not sufficient for lighting it, but now the tube 31 has already been lit thanks to the overvoltage of $T_{OFF(2)}$.

[0070] In this phase, there is a transfer of energy to the tube 31 on the part of the secondary circuit T1s of the transformer 32 both during $T_{ON(2)}$ and during $T_{OFF(2)}$, with limitation of the current supplied by the condenser series C1, whereas the preheating function of the cathode RC continues, to a lesser extent than before, due to both the lower commutation frequency and also to the new charge (the mesh comprising the tube 31), which dampens the overvoltage characteristic of the initial $T_{OFF(2)}$ phase.

[0071] During the $T_{ON(2)}$ period, the primary current, which relates to the primary circuit T1p, is functionally composed of two parts: one part is destined for the magnetization of the nucleus of the transformer 32, whereas the other part is brought back to the secondary circuit with the classical transfer procedure of transformers.

[0072] The storage current has an increasing linear trend during the whole of $T_{ON(2)}$, whereas the component transferred to the secondary circuit has an exponentially decreasing trend according to the time constant between the condenser series C1 and the lit tube 31; this constant is dimensionally several times the duration of $T_{ON(2)}$ (figure 9).

[0073] During $T_{OFF(2)}$ the energy stored in the previous $T_{ON(2)}$ is responsible for a primary and a secondary overvoltage, which generate two currents: the primary current flows in the preheating circuit completely recharging C2 up to the feeding voltage of the feeder 33, whereas the secondary current flows through C1 (tending to recharge it) and the tube 31.

[0074] The succession of the two phases described in this paragraph must obviously be maintained for the whole time in which the tube 31 is to be kept alight. This functioning, according to which the current flows through the tube 31 in both directions, avoids the problem of the shifting of the light towards a cathode, a problem often observed in the functioning of circuits which pilot the fluorescent tube 31 with a current always flowing in the same direction.

[0075] As already mentioned, this circuit preheats a single cathode, the cathode RC.

[0076] In order to maximize the life of the fluorescent tube 31, in a classical piloting circuit, it is advisable to effect the preheating of the cathodes.

[0077] In this circuit, however, it is also possible to obtain a considerable increase in the life of the fluorescent tube 31, with respect to igniters with cold cathodes, with the preheating of a single cathode RC.

[0078] This is possible as the lighting up can only take place during $T_{OFF(2)}$, during which period the emission of the electrons responsible for the ionization of the gas contained in the tube 31 takes place from the preheated cathode and not the other.

[0079] The tube current sensor 28 consists of two diodes, D1 and D2, a current reading resistance R_{SHUNT} having a negligible value with respect to the equivalent impedance of the lit tube 31, a resistance R1 and a measuring condenser/filter C3 (figure 10).

[0080] The current sensor 28 is structured for only "reading" the current flowing in the tube during T_{ON}; it reproduces on the condenser C3 a voltage proportional to the average value of the current which flowed during T_{ON} relating to the whole period.

[0081] The current flows through D2 and R_{SHUNT} and the voltage deriving therefrom is filtered by the low pass block R1-C3, to be stored in the form of an average value on the condenser C3 itself.

[0082] During T_{OFF}, the current flows through the diode D1 and contributes with a null value to the average value measured.

[0083] The average current of T_{ON} is proportional according to the coil ratio to the current supplied by the feeder 33 and consequently, if the duration of T_{ON} and the value indicated at the primary circuit of the inductance of the transformer 32 are known, and by measuring the feeding voltage of the feeder 33, it is possible to calculate with very good approximation the current supplied by the feeder responsible for the energy stored in the magnetic nucleus during T_{ON}.

[0084] As the measurement is effected directly on R_{SHUNT}, it is not even influenced by the variability of the threshold of the diode D2.

[0085] Furthermore, during T_{OFF}, the presence of the diode D1 guarantees a reduced power dissipation.

[0086] The circuit driver for the switch Q1 consists of a condenser series C4, a resistance series R2, a protection diode D3 and a switching off resistance R3 (figure 11).

[0087] In this configuration, a MOSFET transistor was considered as Q1 in order to maintain a high performance; analogously, it is possible to use a BJT transistor, but in this case it is necessary to amplify in the current, the command signal sent by the controller CL, to be able to guarantee adequate currents on the collector of the transistor.

[0088] By using, therefore, a device controlled in voltage, it is possible to set the driver only in relation to the response times required by the circuit, freeing it of the necessity of having to handle high currents in its interior and of having to consider the accumulation of minority carriers inside the bipolar transistors (which cause delays in the switch-off).

[0089] The function of this block is to transmit switch-on and switch-off commands to the switch Q1; in particular, the condenser series C4 prevents a continuous high level coming from the controller CL from keeping the transistor running for excessive times which could cause its destruction.

[0090] The time constant between the condenser C4 and the sum of R2 and R3 is, in fact, in any case lower than the time sufficient for the transistor to become damaged.

[0091] During T_{ON}, the resistances R2, R3 and the condenser C4 take to the MOSFET gate Q1 the necessary part of voltage for effecting its activation, whereas the resistance R3 has the function of discharging the MOSFET gate Q1 if the command coming from the controller CL remains fixed at a high level.

[0092] During T_{OFF}, the diode D3 protects the transistor gate from inverse voltage, coming from the shunt C4 and is also responsible for the rapid discharging of the voltage memorized on the condenser series C4 within the time T_{OFF}, (figure 12 shows a complete piloting circuit scheme). The control logic CL must itself control the switch Q1 and its function is to regulate the power requested at the outlet of the fluorescent tube, regardless of the feeding voltage of the feeder 33 available, and variation in the characteristics of the tube 31 as a result of its aging or temperature variation.

[0093] This potentiality can be exploited in order to keep the luminosity at the outlet constant, or to effect controlled variations in the luminosity over a certain period of time.

[0094] The control logic CL does in fact contain an algorithm which processes the information available; this information is:

- the measurement of the average current of the tube 31 circulating during the T_{ON} measured with a digital analogical converter from the condenser C3 of the current sensor 28;
- the feeding voltage of the feeder 33, measured in real time with a second digital analogical converter;
- the duration of the previous T_{ON} given by the controller CL,
- the inductance value (brought back to the primary circuit) of the transformer 32, known by the project and characterized within the algorithm with an adequate parameter.

[0095] The algorithm gives, as a result, the length of the subsequent T_{ON} and T_{OFF}, which characterize the rectangular command sent to the pilot circuit DR, and from there to the switch Q1.

[0096] The handling of the light in real time allows the trend of the light emitted in relation to the time to be established, to help, for example, the pupil of the human eye to adapt itself to the change in luminosity.

[0097] In an application on emergency lighting equipment, for example, a circuit with this potentiality can immediately provide a luminosity comparable with that of the lighting prior to a black-out, gradually decreasing it as the eye becomes accustomed to the less intense luminosity (also maximizing the autonomy of the accumulators).

[0098] A further advantageous characteristic of the system is due to the fact that it has a functioning of the Rest-Mode type, i.e. that it automatically adjusts itself to the implementation of the emergency which has just been fed.

[0099] This automatic lighting up does not take place during maintenance: with the circuit without feeding, in fact, when the operator has to substitute the battery, when connecting the new battery, the device is not automatically lit up, preventing dangerous currents or voltages from circulating in areas accessible to the maintenance operator.

[0100] Furthermore, the system effects the tube 31 test of each lamp 4, 5 during its lighting from the central power supply and provides an immediate error signaling upon breakage of the tube 31, also in a normal electric power supply lighting.

[0101] As already described above, moreover, the microprocessor 27 of each lamp 4, 5 enters materially and closely the functioning of the various sections and is not limited to controlling their functioning, so that the lighting lamp and emergency lamp entirely depend on it.

[0102] The microprocessor 27 is therefore an integral part of the feedback rings of the various regulators and, in particular, with respect to the functions of the batterychargers 21 and oscillator 23, said functioning can be attributed to various complex algorithms which provide, in relation to the sensors available, double frequency/duty-cycle information which is sent to the final transistors.

[0103] Finally, each lamp 4, 5 has a fixed identification number; if this number is even, the appliance (when it is not remote-controlled by the control board 3) establishes its own count meters for effecting the periodical tests at the moment established by the user (by means of a synchronization procedure), whereas if it is an odd number, it establishes them for effecting the tests with a week's delay.

[0104] This avoids discharging the whole plant for an autonomy test in complete automatism, instead of having to physically dissect the plant to synchronize the two parts separately.

[0105] The arrangement can also be inverted by means of a remote-control element (control board 3 or remote-control); this remote-controlled set up is not definitive, as each lamp 4, 5, in the absence of further orders, returns, after a certain period of time, to the original set up, as regulations prohibit having a plant totally synchronized on the same time schedules.

[0106] In the case of a prolonged black-out, each appliance which has reached the minimum battery (completely flat) maintains its own count meters active for a further 24 hours, so as not to lose the synchronization with the other appliances of the plant.

[0107] In the case of extraordinary maintenance, it is also possible to inhibit the lamps 4, 5 which must be switched off, and in this case, the whole residual charge of the accumulators is destined to be temporized in order to prolong its functioning until the gradual but inevitable definitive discharge of the battery.

[0108] Each device is set up to zero (synchronize) its own count meters in relation to a certain absence and return sequence of the power supply. It is therefore possible to establish when the following automatic tests should be effected by manually applying with the energy switch, a definite switch-on and switch-off sequence: the system guides the operator for effecting this sequence (whose temporization is fundamental) by the precise flashing of its own LED signaling diode.

[0109] In this case, the operator can effect the synchronization of the whole plant without the necessity of adopting a remote-control device or any other remote-controlled unit.

[0110] As already mentioned, the system can also guarantee autonomy with greater light in the first minutes of an emergency, which is much higher than the minimum required by law, subsequently terminating the autonomy until the exhaustion of the charge of the accumulators and supplying the minimum luminosity guaranteed.

[0111] It is evident, in fact, that the first minutes of the lack of voltage supply are the most important for evacuating the rooms, and this system provides a greater illumination in this first and delicate phase, without obviously reducing the total autonomy required; for all the rest if the time, the lighting is in any case greater than the minimum luminosity requested by law.

[0112] Finally, it is possible to envisage a series of pre-established programmings which conveniently allow all the autonomy and test parameters of the whole emergency/lighting plant to be set in a single operation, in relation to specific regulation requirements or plant rules.

[0113] It is possible, for example, to set pre-established programmings for hospitals (the law requires autonomies of at least two hours after 12 hours of recharging), cinemas and projection rooms (daily functioning tests and obviously outside the projection times, are required), offices, schools, etc.

[0114] In this way, obvious advantages are provided for the installer for activating a whole series of compulsory operations by law which should be effected manually, at times lamp by lamp, and in any case with a loss of time and the risk of human errors; programmings are also ensured for low-risk plants, where a careful programming is in any case requested.

[0115] The system uses the same electric communication bus described in the standard DALI specifications; the communication protocol used is therefore put in communication with proprietary frames which should in no case be confused with the official DALI frames.

[0116] In order to describe the functionality which leads to this, it is necessary to start with a description of the DALI frame: this consists of 17 bits (commands) or 9 bits (responses), transmitted with a Manchester coding, i.e. each bit consists of two inverted half-bits, which acquire the meaning together (two half-bits 01 mean a 1 logic, two half-bits 10 mean a 0 logic); this datum frame is followed by two stop bits which do not have inversion between the first and second half-bit, and are at a high logic level (basically they are four half-bits at 1).

[0117] In all the DALI frames consist of from 19 to 11 bits, codified as described and each frame which does not have a datum bit with the Manchester inversion or does not have the two stop bits fixed at 1, is discarded.

[0118] The communication protocol frames used in the system according to the invention have two stop bits fixed at zero (four half-bits at 0): this coding can in no way cause confusion between these frames or parts thereof and correct DALI frames.

[0119] The frames of the system according to the invention which are longer than the DALI frames, have (for the DALI receivers) Manchester inverted stop bits, whereas the frames which are shorter than the DALI frames have (for the DALI receivers) at least one Manchester non-inverted datum bit; in both cases, the DALI receivers reject the frames of the present invention.

[0120] In the case of very long frames of the invention, after discarding the first part of the frame, a receiver can start receiving the final part of the same transmission as a second transmission, but for the same reasons described above, this will also be discarded.

[0121] For analogous reasons, no receiver of a protocol according to the invention could confuse a DALI frame with a frame of the invention, or vice versa. The communication protocol used is thus inserted on the electric/DALI logic protocol so as not to damage it, or be damaged by it and, furthermore, with the efficacy of the intelligent dispute of the bus described below.

[0122] As all the lamps 4, 5 share the same communication bus, if various entities wish to transmit at the same time, there must be an evaluation mechanism of the bus dispute. In the first instance, it would be sufficient for each lamp 4, 5 to verify the state of the free bus 7 immediately before occupying it: this works, but there are still cases, in which, whereas a lamp has already verified the freedom of the bus but has not yet actually occupied it (due to the effective time necessary for carrying out the occupation logic operations or to electronic delays caused by the transistors), a second lamp effects its verification and finds the bus still free and consequently also starts the response operations.

[0123] A situation of this kind leads to a definite communication failure as, even if the timings are more or less superimposed, there will be conflict at the moment in which the two entities transmit a different bit from each other and, in the best of cases, the response will be discarded (and therefore lost).

[0124] The system according to the invention, on the other hand, also effects a verification of the state of the bus 7 during the response, before the transmission of each half-bit, with particular attention to those at 1 (which correspond to the free state of the bus).

[0125] If, during one of these tests, an opposite state to that set by the transmitter is found on the bus, the presence of a second transmitting lamp will be evident: in this case, the transmission of its frame is immediately interrupted so as to allow the other lamp to correctly complete its transmission.

[0126] In this way, the system allows a more efficient dispute of the communication bus 7, thus reducing cases of discarded responses due to conflicts between various transmitting lamps, as the first lamp which realizes that it is under dispute will withdraw without "fouling" the datum transmitted by the other lamp.

[0127] On the basis of the efficacy of the intelligent dispute of the communication bus 7, the lamps installed only obey certain commands if their own response has been accepted.

[0128] It is obvious that a lamp cannot know if its response has effectively been received, but this is based on whether it succeeds in completing it without conflicts or disputes of the communication bus 7.

[0129] This method forms an extra safety means for effecting certain commands which relate to delicate parts of the functioning of a lamp, or in which it is important for only one entity to be active.

[0130] When, for example, two lamps must be distinguished which, unfortunately, have the same destination, it is possible to ensure that only one is active to allow it to be changed; after the operations, the one which did not have a response maintains its previous destination, whereas the one which received a response has a new destination, and both can be identified.

[0131] The characteristics of the integrated system for the diagnosis and handling of fluorescent lamps, object of the present invention, appear evident from the above description, as also its advantages.

[0132] Finally, numerous other variants can obviously be applied to the diagnosis and handling system in question, all included in the novelty principles inherent in the inventive idea. It is also evident that in the practical embodiment of the invention, the materials, forms and dimensions of the details illustrated can vary according to the demands and can be substituted with other technically equivalent alternatives.

Claims

1. An integrated system for the diagnosis and handling of fluorescent lamps (4, 5), comprising a first series of lighting devices (4) and a second series of emergency lighting devices (5), **characterized in that** said lighting devices (4) and said emergency lighting devices (5) are connected to a single physical communication element (7) and are driven by a single control and/or supervision board (3), in order to facilitate the installation and maintenance operations and also handle different configurations comprising autonomous lighting lamps, lamps which can be activated by centralized commands and/or lamps connected to at least one central board for the diagnosis and handling of lights and functioning tests.

2. The integrated diagnosis and handling system according to claim 1, **characterized in that** said control and/or supervision board (3) is connected, by means of a serial line (2), to a communication interface (1), towards which a series of inlet commands are directed.

3. The integrated diagnosis and handling system according to claim 1, **characterized in that** said control and/or supervision board (3) comprises at least one feeder (8, 9), at least one battery for recharge accumulators (10), connected to a battery-charger (11), at least a booster (12), and at least one microprocessor (13), suitable for exchanging data and commands with the user inlet/outlet interface (14), with a count meter (15) and with a serial line (16), which forms the connection to the communication bus (17) of the various boards (3) present in the system, said control and/or supervision board (3) being suitable for controlling a lighting plant having a

standard communication protocol, of the DALI type, also in the absence of central power supply, as said battery-charger (11) regulates the current necessary for the recharging of the accumulators of said battery (10), on the basis of commands of said microprocessor (13), until a full charge is reached, and also supplies said battery accumulators (10) with a maintenance current of the charge.

4. The integrated diagnosis and handling system according to claim 1, **characterized in that** each lighting (4) and/or emergency (5) device comprises at least one power voltage transformer (20), at least one battery-charger (21), at least one accumulator battery (22), at least one oscillator (23), a series of central power sensors (24, 25, 28), of the battery (22) and fluorescent tube (31) of each lamp (4, 5), at least one feeder (26), a control microprocessor (27) and a series of communication interfaces (29, 30) with the user and with said physical element or communication bus (7) of the lamps (4, 5).

5. The integrated diagnosis and handling system according to claim 4, **characterized in that** said oscillator (23) allows the tube (31) to be switched on at different luminosity levels, in relation to the parameters of a digital PWM signal generated by a circuit containing the various combinations necessary for obtaining a desired luminosity power in relation to the connected feeding voltage.

6. The integrated diagnosis and handling system according to claim 5, **characterized in that** said circuit comprises said two-coil voltage raiser transformer (32), a power switch (Q1) and a relative pilot circuit (DR), at least a first condenser element (C1), which supplies the electric current to the tube (31) of the lamp (4, 5), at least a second preheating condenser element (C2), which supplies a preheating current to said tube (31), said sensor (28) of the tube (31) current, and said control microprocessor (27), which controls the commutation of said power switch (Q1) for the switching on and/or off, by means of a periodical and variable frequency and duty-cycle signal, in relation to the current detected on the tube (31) by said sensor (28), so that the current flows through the tube (31) in both directions, regardless of the feeding voltage available and variation in the characteristics of the tube (31) as a result of aging or temperature variations.

7. The integrated diagnosis and handling system according to claim 6, **characterized in that** said circuit allows to control at once the trend of the light emitted in relation to the time established, to help, for example, the pupil of the human eye to adapt itself to the change in luminosity.

8. The integrated diagnosis and handling system according to claim 4, **characterized in that** said system effects functional tests, automated or remote-controlled by remote-control devices, in pre-established periods of time, of the fluorescent tubes (31) of each lamp (4, 5) connected to the system, said tests being carried out during lighting from the central power supply or being preprogrammed, by means of a suitable programming, for various uses in schools, cinemas, projection rooms, offices, hospitals, etc.

9. The integrated diagnosis and handling system according to claim 1, **characterized in that** it uses a communication protocol suitable for being inserted on the electric/DALI logic protocol of lighting appliances, said system also being suitable for effecting a control of the state of said physical communication element or bus (7) when both transmitting and receiving, so as to allow all the lamps (4, 5) connected to said bus (7) to correctly complete their own frame transmissions, with the use of a variable localization direction.

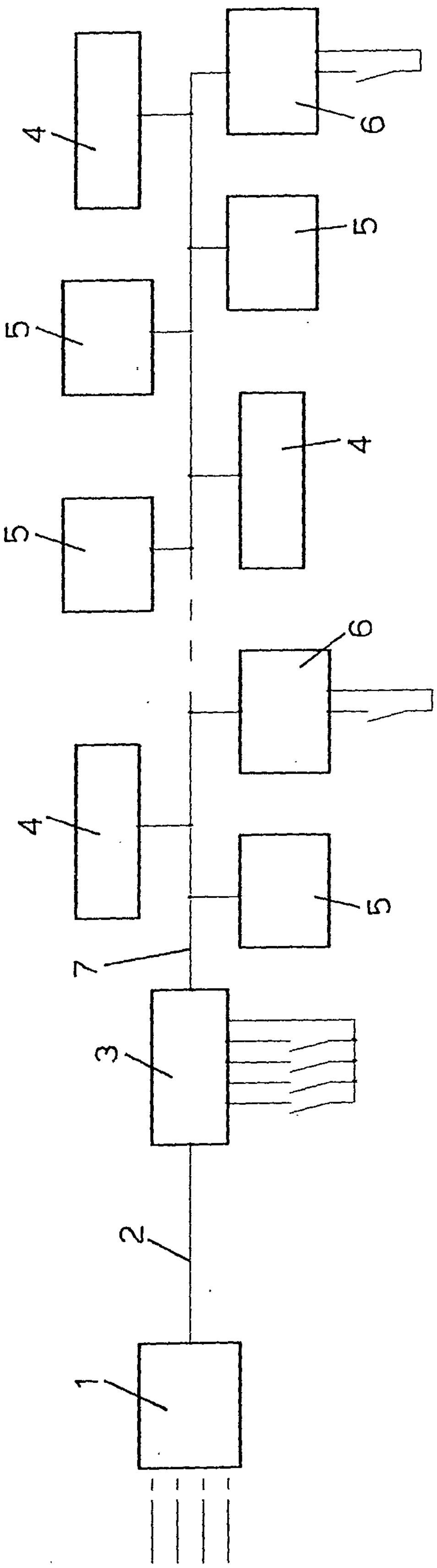
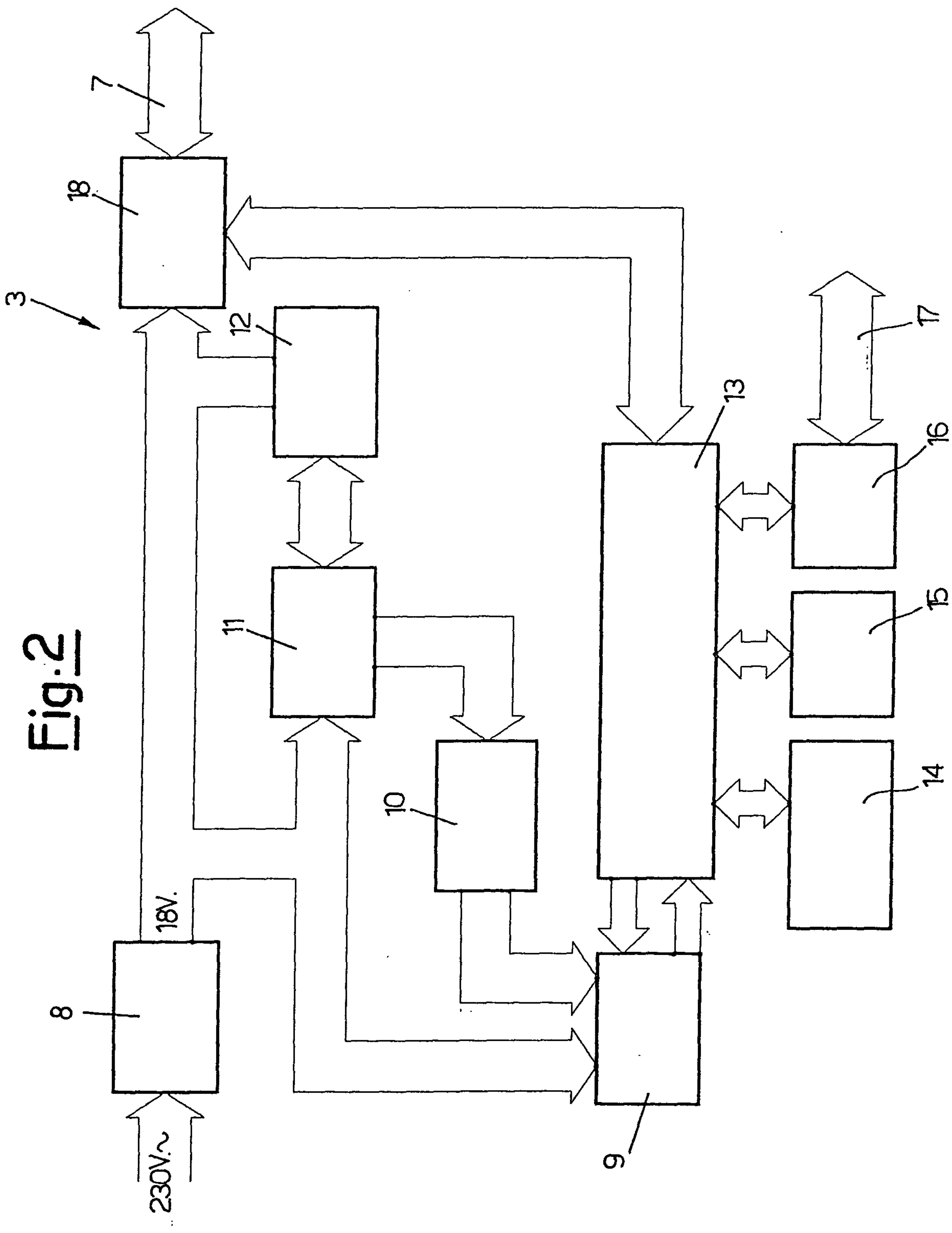


Fig.1

Fig.2



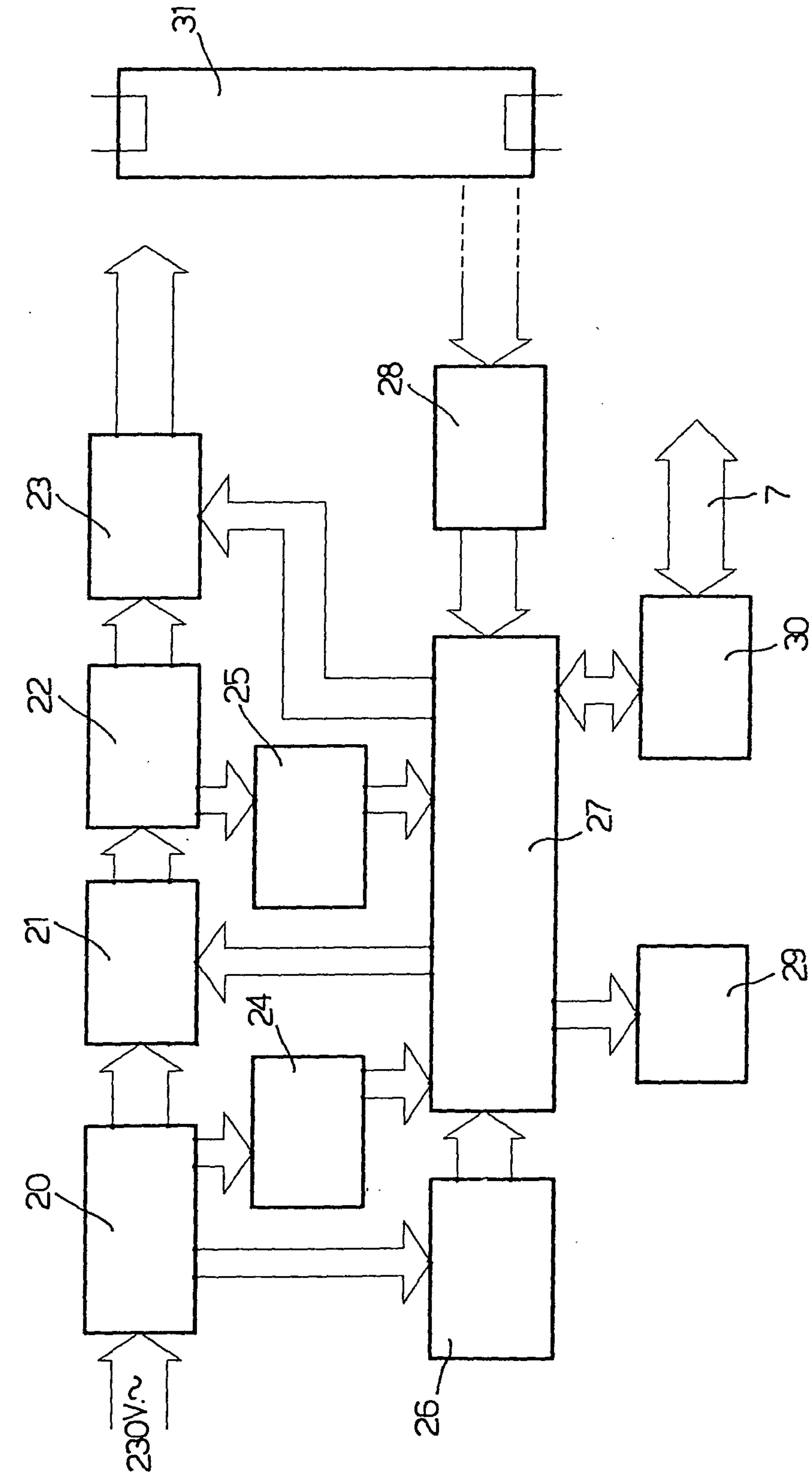


Fig.3

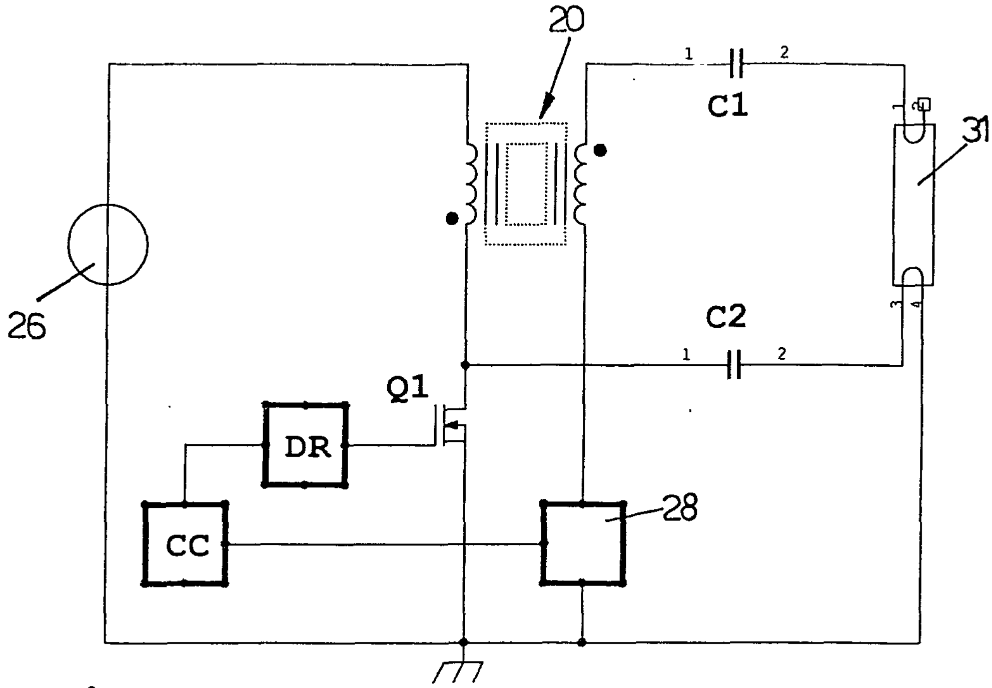


Fig.4

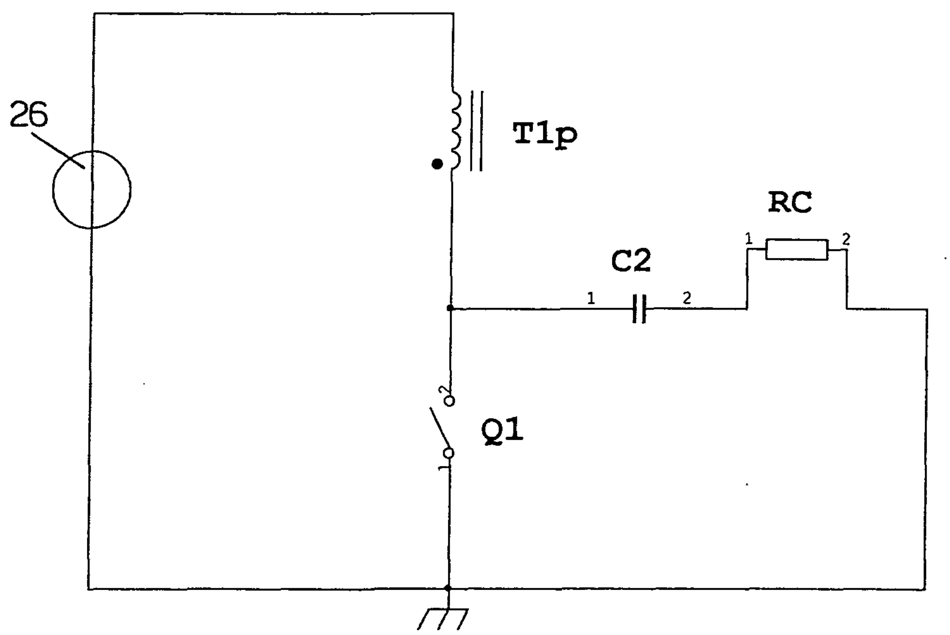


Fig.5

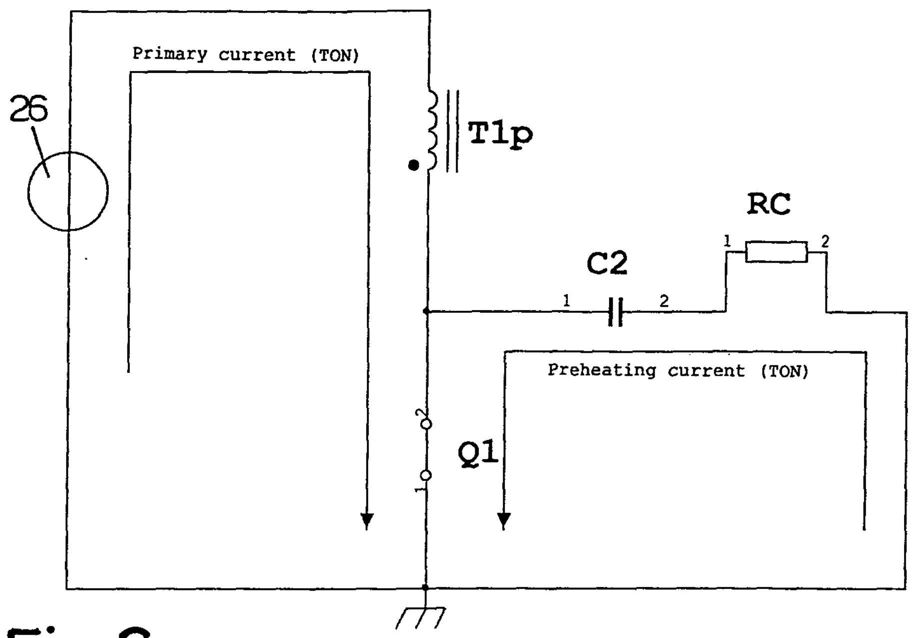

26
Primary current (TON)
T1p
RC
C2
1
2
1
2
Preheating current (TON)
Q1
2
1

Fig.6

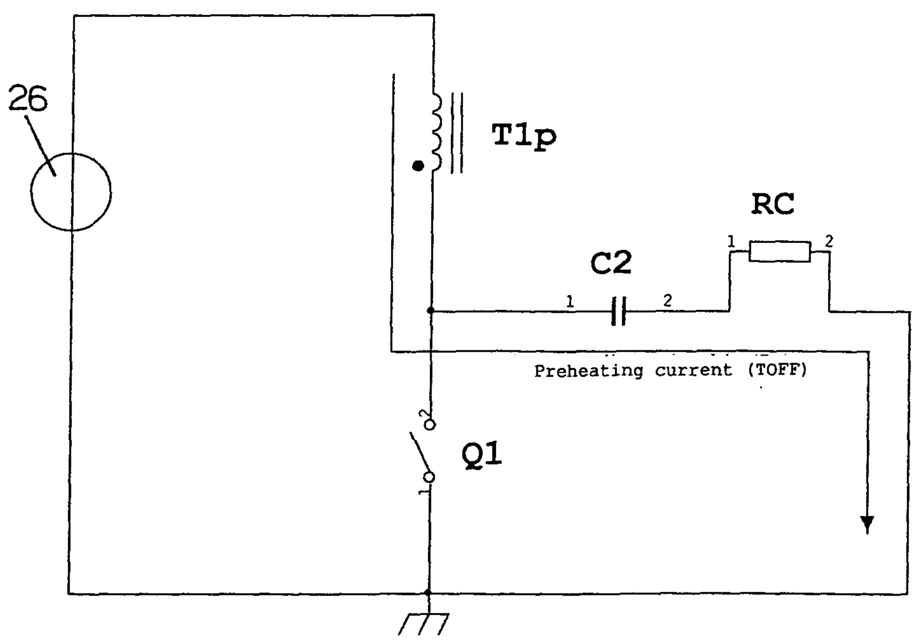

26
T1p
RC
C2
1
2
1
2
Preheating current (TOFF)
Q1
2
1

Fig.7

Fig.8

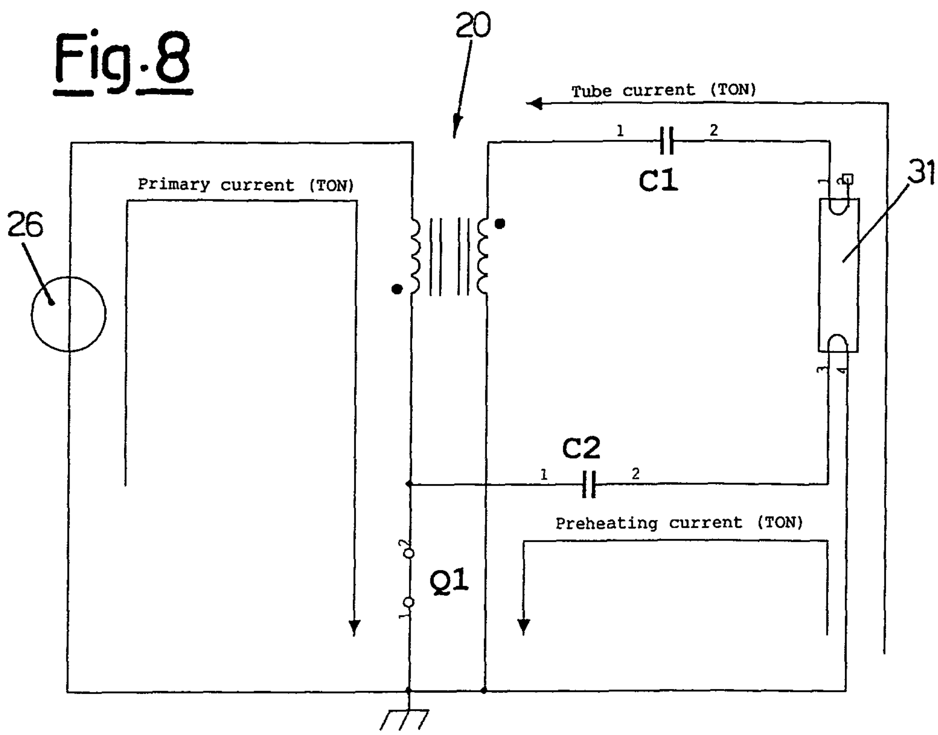

20
Tube current (TON)
1
2
C1
31
Primary current (TON)
26
1
2
3
4
C2
1
2
Preheating current (TON)
Q1
1
2

Fig.9

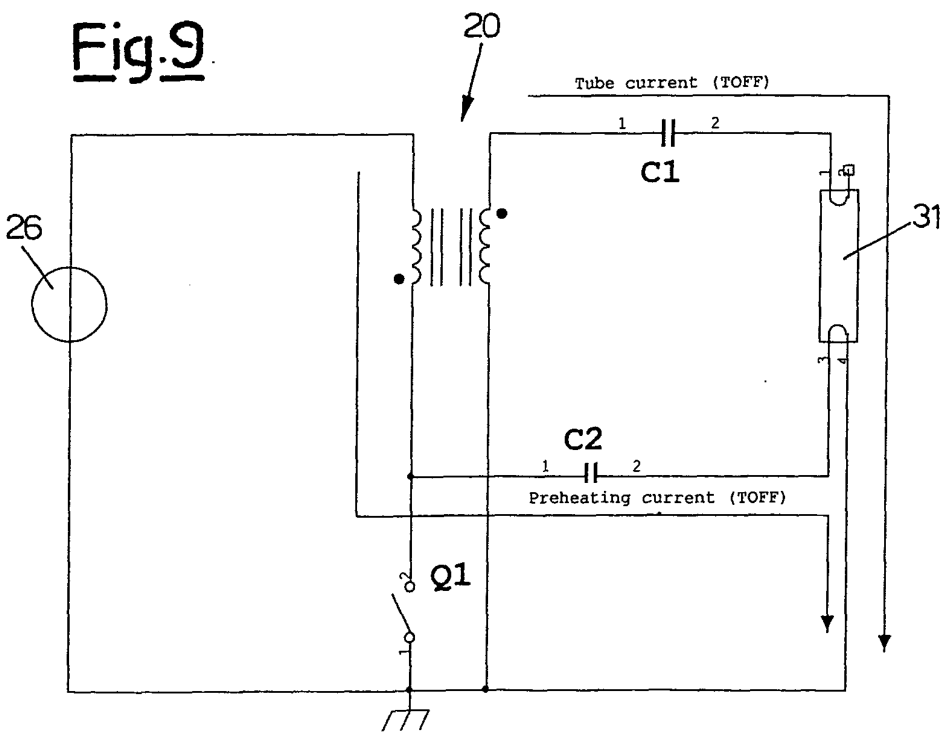

20
Tube current (TOFF)
1
2
C1
31
26
1
2
3
4
C2
1
2
Preheating current (TOFF)
Q1
1
2

Fig.10

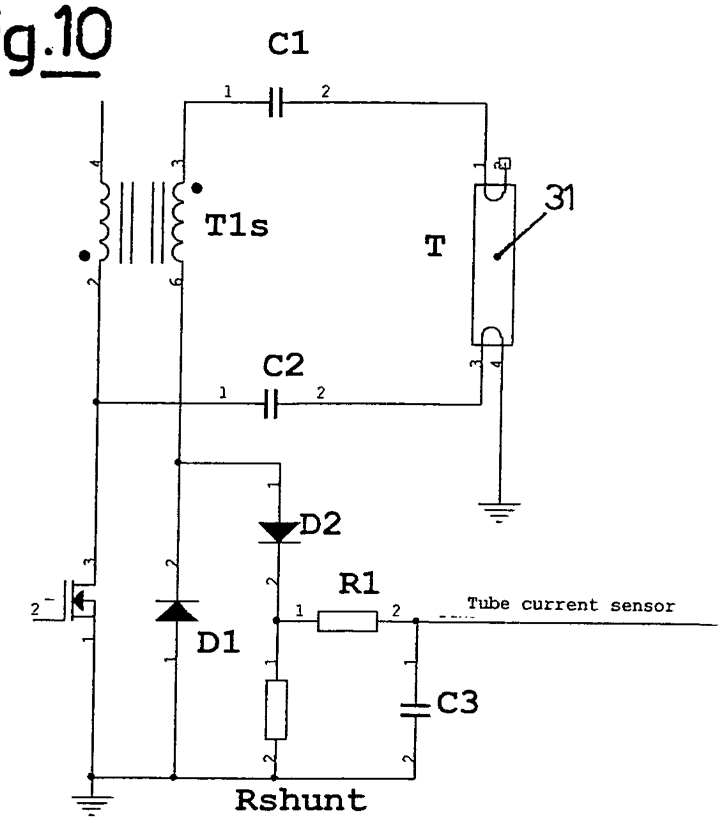

C1
1
2
4
3
T1s
2
6
31
T
1
3
4
C2
1
2
D2
R1
1
2
Tube current sensor
D1
C3
Rshunt

Fig.11

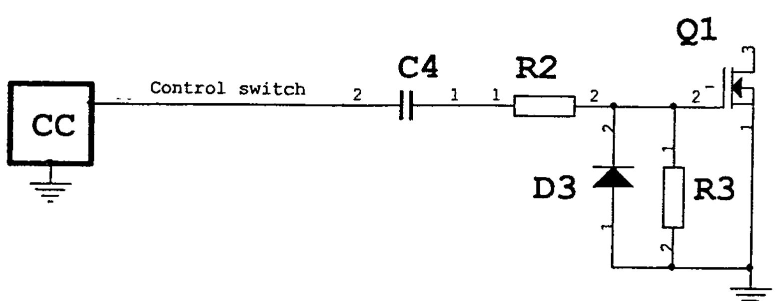

Q1
CC
Control switch
C4
R2
2
1
1
2
2
D3
R3

Fig.12

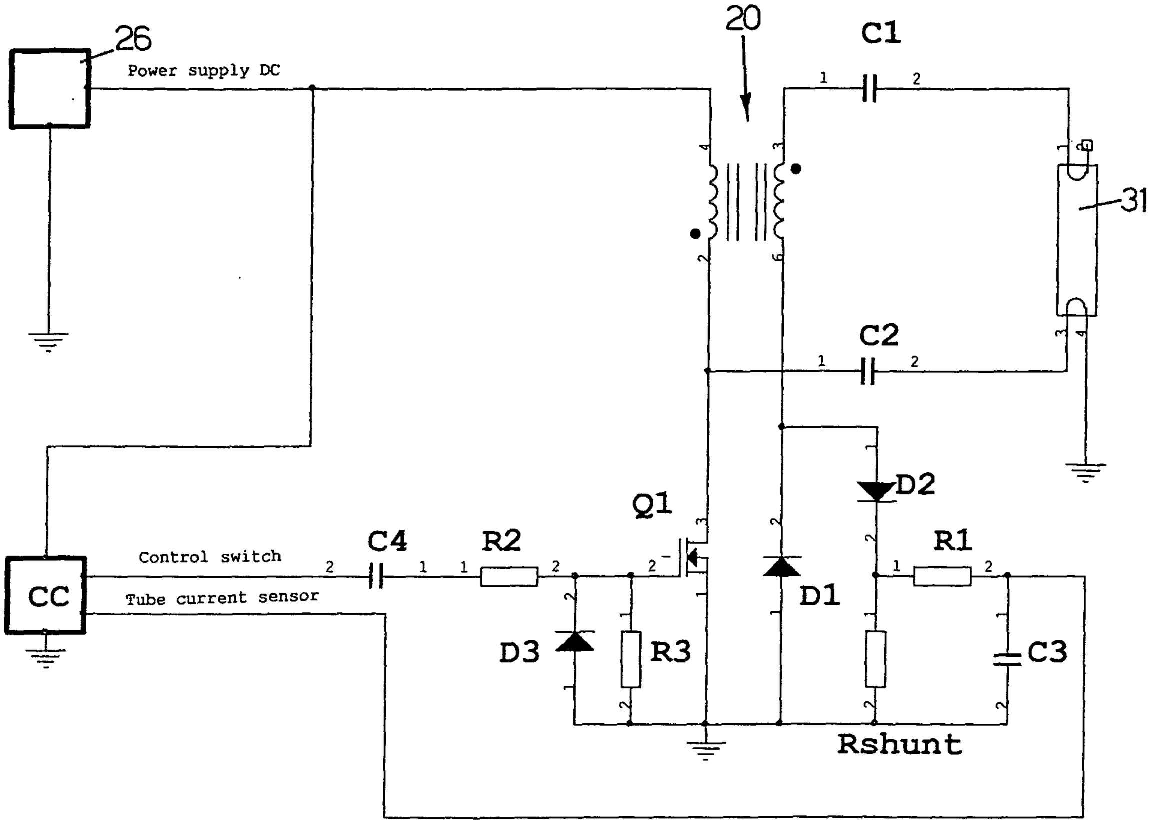

26
Power supply DC
20
C1
1
2
31
C2
1
2
D2
Q1
C4
R2
R1
Control switch
CC
Tube current sensor
D1
D3
R3
C3
Rshunt

Fig.13

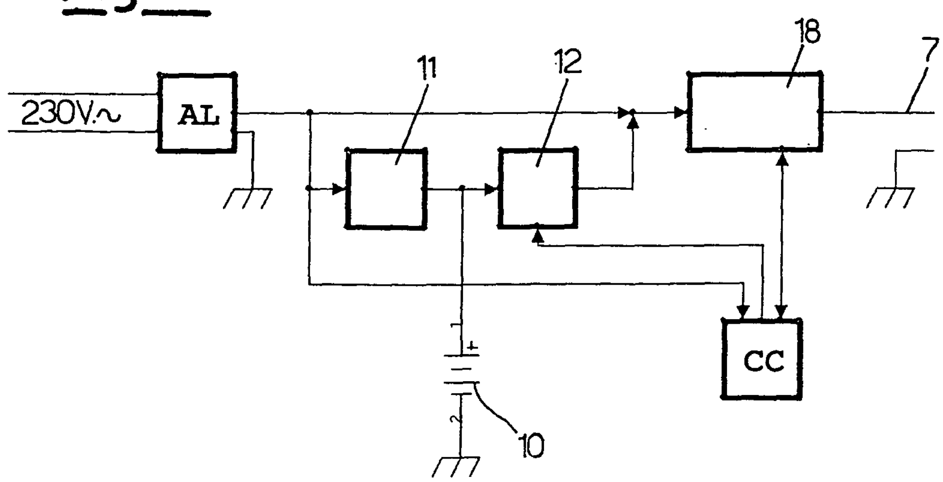
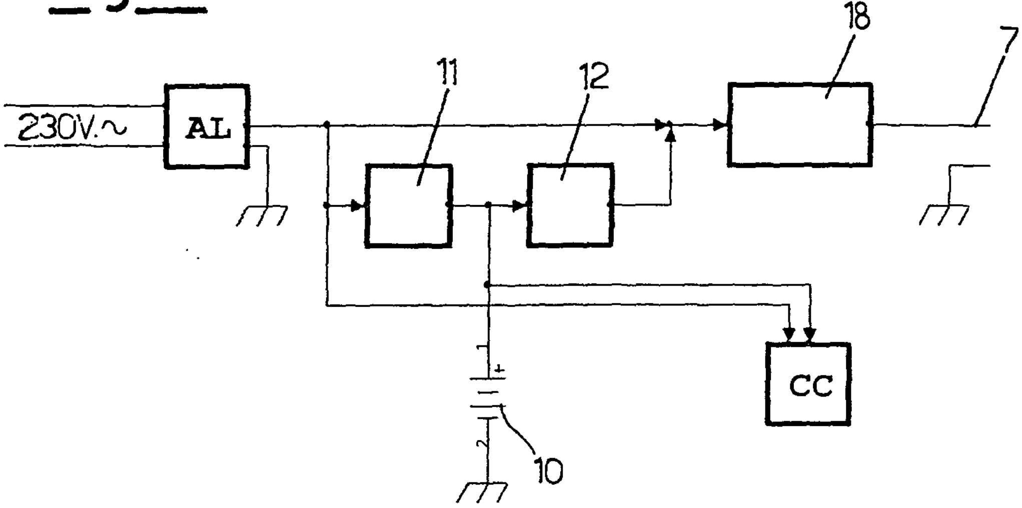
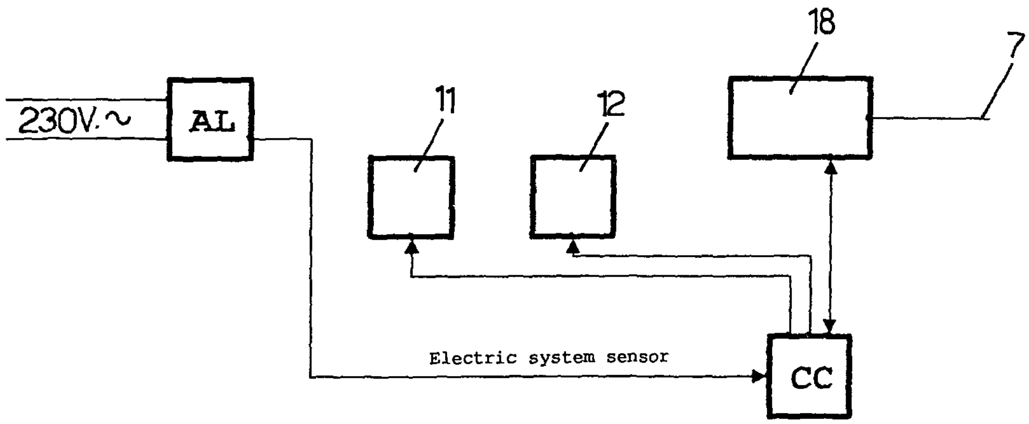

230V~
AL
11
12
18
7
CC
10

Fig.14



18
7
11
12
230V.~
AL
CC
10

Fig.15



18
7
11
12
230V.~
AL
Electric system sensor
CC

Fig.16

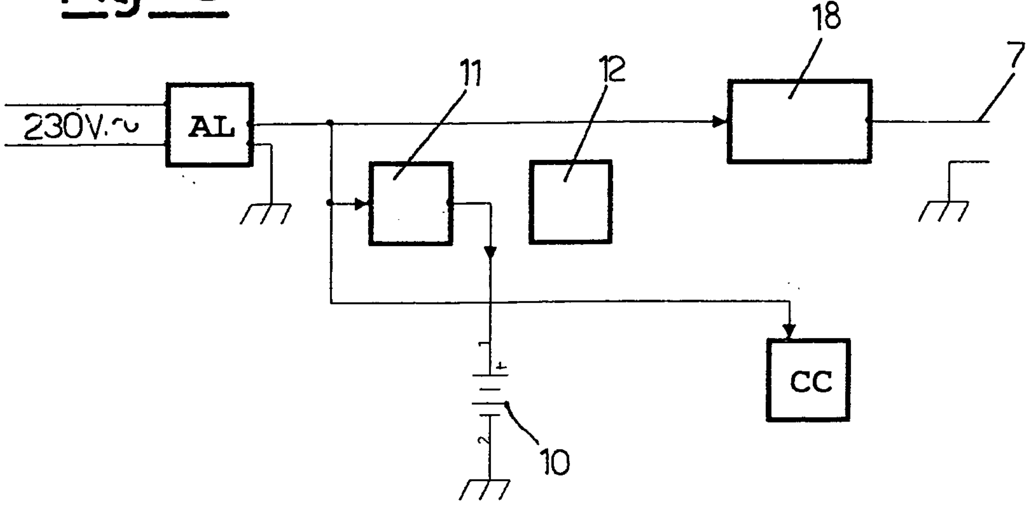


Fig.17