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(54) **Apparatus for controlled supply of lighting systems**

(57) An apparatus for controlled supply of lighting systems powered by an alternating voltage ($V_{AC}$) source, with interposition of protection means and supplying a plurality of electric loads ($L_1$, $L_2$, ..., $L_j$, ..., $L_n$), includes a device for converting the alternating voltage ($V_{AC}$) into a direct voltage ($V_{DC}$), made available at the outlet terminals.

A plurality of modulating units ($U_1$, $U_2$, ..., $U_j$, ..., U,) are connected respectively to the plurality of electric loads ($L_1$, $L_2$, ..., $L_j$, ..., $L_n$) and supplied by the direct voltage ($V_{DC}$).

Each unit ($U_j$) includes at least one solid state electronic switch ($E_1$, $E_2$, ..., $E_j$, $E_J^A$, $E_J^B$, $E_J^C$, $E_J^D$), which is enabled/disabled to allow circulation of an electrical current ($I_j$) through the corresponding load ($L_j$).

A central unit is provided for enabling/disabling the solid state electronic switches ($E_1$, $E_2$, ..., $E_j$, $E_J^A$, $E_J^B$, $E_J^C$, $E_J^D$, ...,$E_n$) by respective control signals ($S_1$, $S_2$, ..., $S_j$, $S_J^A$, $S_J^B$, $S_J^C$, $S_J^D$, ..., $S_n$), according to a prefixed modulation technique.

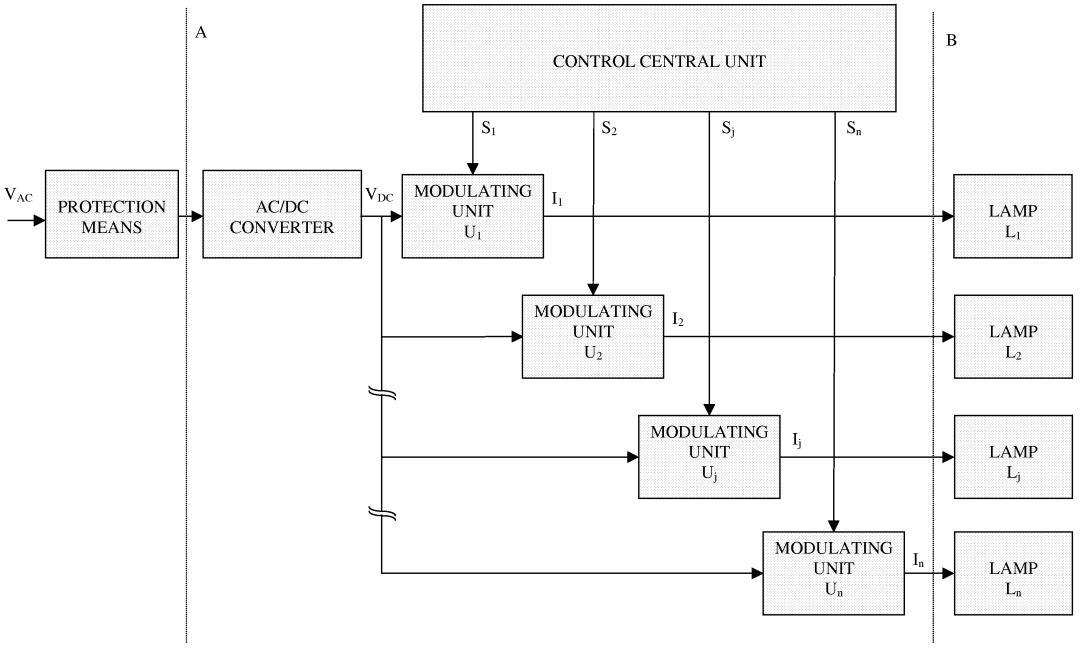


FIG 1

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## Description

**[0001]** The present invention relates to apparatuses for controlled supply of lighting systems, in particular including gas discharge lamps, according to prefixed energy saving programs.

**[0002]** In case of big working environments (warehouses and big open areas) and every time a specific high power is necessary to light big surfaces, concentrating the lighting power on few limited spots, the above mentioned type of lighting is the most efficient and widespread type of light source characterized by limited operation costs, simple operation principle, high lighting degree and possibility of long periods of continuous lighting.

**[0003]** On the other hand, the gas discharge lamp light sources have drawbacks, such as very a bad chromatic performance, a considerable energy consumption and, consequently, a high degree of light pollution of the environment.

**[0004]** At present, the above drawbacks have been avoided by an apparatus, disclosed by the Applicant in the Patent number IT 1.321.138, for reducing energy dissipated by the power supply busbars of lighting systems.

**[0005]** This technical solution includes a multi-tap voltage autotransformer, functionally interposed between the group of lamps and the line for supply thereof, and an electronic control system, aimed at piloting the autotransformer, allowing a fairly good control of the value of the power applied to the lamps terminals.

**[0006]** The control system is programmed to supply different power levels, in relation to the time and the day of the year, so as to optimize the quantity of light emitted by the lamps, avoiding wastes; it can be remote controlled by means of e.g. GSM modem.

**[0007]** The main object of the present invention is to propose an apparatus for controlled supply of lighting systems, including in particular gas discharge lamps, which allows to prepare an efficient program of energy rationalization in any load condition, assuring the minimum standards required by the specific environment and reducing the light pollution.

**[0008]** Another object of the present invention is to propose an apparatus, which is able to change in a continuous way the supply tension applied to the terminals of the lamps in the lighting systems.

**[0009]** A further object of the present invention is to propose an apparatus, whose weight and dimensions are reduced, and which allows also to perform a remote-diagnosis the operation state of each single lamp, allowing in this way rapid localization of a faulty lamp and its substitution.

**[0010]** The above mentioned objects are obtained by proposing an apparatus, which is reliable in any operation conditions, whose concept is simple and costs contained with respect to the purposes to be achieved.

**[0011]** The above mentioned objects are obtained in accordance with the contents of the claims.

**[0012]** The characteristic features of the invention are pointed out in the following description of some preferred but not exclusive embodiments, with reference to the enclosed figures, in which:

- Figure 1 is a functional block diagram of the apparatus proposed by the invention, which is defined between an inlet section A and an outlet section B;
- Figures 2 and 3 show as many schematic and exemplifying electrical circuit diagrams of a generic block shown in Figure 1.

**[0013]** Regards the enclosed Figures, in particular Figure 1, the proposed apparatus is defined between inlet section A and outlet section B, in the regions of which it is connected respectively to an alternating voltage $V_{AC}$ source, after the interposition of protection means of known type, and to a plurality of electrical loads $L_1$, $L_2$, ..., $L_j$, ..., $L_n$ representing a lighting system, for example including gas discharge lamps.

**[0014]** The apparatus includes substantially: a device situated functionally at the relative inlet section A, aimed at the conversion of the alternating voltage $V_{AC}$, for example a three phase voltage, and supplied by the public supply net in low voltage (rms line voltage value equal to 380 Volt), into a continuous voltage $V_{DC}$ of a given value, made available at its outlet terminals; a plurality of modulating units $U_1$, $U_2$, ..., $U_j$, ..., $U_n$, connected respectively to a plurality of lamps $L_1$, $L_2$, ..., $L_j$, ..., $L_n$ and supplied with the continuous voltage $V_{DC}$, with each unit $U_j$ including one or more solid state electronic switches $E_1$, $E_2$, ..., $E_j$, $E_J^A$, $E_J^B$, $E_J^C$, $E_J^D$, ...,$E_n$, which can be enabled or disabled to allow circulation of a relative electrical current $I_j$ through the corresponding lamp $L_j$; a central unit aimed at enabling/disabling the solid state electronic switches $E_1$, $E_2$, ..., $E_j$, $E_J^A$, $E_J^B$, $E_J^C$, $E_J^D$, ..., $E_n$, by means of respective control signals $S_1$, $S_2$, ..., $S_j$, $S_J^A$, $S_J^B$, $S_J^C$, $S_J^D$, ...,$S_n$, according to a prefixed modulation technique of known type, for example the modulation based on the pulse duration (PWM) or the modulation based on the pulse frequency.

**[0015]** Figure 2 shows schematically and by way of an example a known circuit configuration of a generic modulating unit $U_j$, suitably connected to a relative lamp $L_j$, according to a bridge configuration, in case the modulation technique based on the pulse duration (PWM) has been used.

**[0016]** The voltage $V_{DC}$ rectified by the converter device supplies the bridge, and the current $I_j$ applied to the lamp $L_j$ can assume a substantially sinusoidal shape with a variable amplitude enabling and disabling, for a prefixed time within each basic cycle time unit, the pair of switches $E_J^A$, $E_J^B$, so as to obtain a positive current half-wave, and the pair of switches $E_J^C$, $E_J^D$, to obtain the negative one,.

**[0017]** The above Figure does not show, for sake of simplicity, the relative low-pass filter, aimed at attenuating the harmonics of the current $I_j$ having higher frequen-

cy.

**[0018]** Therefore, the just described solution allows to apply to each generic lamp $L_j$, for example a sinusoidal current $I_j$ having variable amplitude and frequency, in a continuous way within a wide value interval.

**[0019]** Moreover, the possibility of managing in an independent way each lamp $L_j$ and of the functional provision in the circuit, of devices for measuring the electrical quantities, such as digital analyzers (likewise not shown for sake of simplicity), allows the maximum efficiency and the possibility of diagnosing a premature malfunction.

**[0020]** Actually, lamps of the same type have different electrical characteristics due to their different age and fatigue degree and this can be detected by the analysis of the wave shape of the current $I_j$ circulating therein, in relation to the application of a prefixed wave shape of the voltage $V_j$ to the relevant terminals.

**[0021]** Thus, the analysis (for example performed automatically by a software) of the electrical characteristics of each lamp supplies indications concerning its operation state and the type of voltage wave shape, which is preferable to apply in order to optimize its operation.

**[0022]** The analogous considerations are valid also for the circuit configuration shown in Figure 3, related still to a generic lamp $L_j$.

**[0023]** In this case, the activation and deactivation of the switch $E_j$ for prefixed time intervals within a period of basic cycle allows, as it is known, to change the medium value of the voltage $V_j$ applied to the lamp $L_j$.

**[0024]** Also in this case, a not shown filter attenuates all the harmonic elements of the current $I_j$ circulating through the lamp $L_j$.

**[0025]** The above considerations make appear the big potentiality and advantageous technical functional characteristics, which make the proposed apparatus very interesting from its functional, economic and ecological point of view.

**[0026]** The present invention eliminates the bulky parts and mechanical parts subjected to wear and tear, such as the autotransformer and the contactors.

**[0027]** Actually, the apparatus includes only solid state elements, and consequently it is much more compact, reliable and obviously cheaper.

**[0028]** Each lamp $L_j$ belonging to the lighting system can be supplied in an independent way, applying the wave shapes of voltage $V_j$, aimed at optimizing its light efficiency.

**[0029]** Then, the measuring electronic instruments, integrated with the apparatus, are able to detect the lamp electrical characteristics, which allows to use the lamps in optimal way, allowing also to define their possible malfunction or breaking (remote-diagnosis).

**[0030]** Moreover, the above technical solution allows a continuous variation of the amplitude and the frequency (as well as of the wave shape more generally) of the voltage applied to the terminals of each generic lamp $L_j$.

**[0031]** Therefore, it is obvious that the present apparatus makes it possible to activate a program of energy rationalization, which in itself brings to not only economic but also ecological implications.

**[0032]** Actually, it is possible to reduce in a considerable way the energy absorbed by the lamps and the light pollution, prepare an efficient program of energy saving in any load condition, and to assure the minimum lighting standards required by the specific environment, giving the best ratio: energy save - light flow emitted.

## Claims

1. Apparatus for controlled supply of lighting systems, with said apparatus powered by a source of alternating voltage ($V_{AC}$), with interposition of protection means and supplying a plurality of electric loads ($L_1$, $L_2$, ..., $L_j$, ..., $L_n$), which define said lighting systems, **characterized in that** it includes:

   a device, functionally situated at the inlet section (A) of said apparatus for converting said alternating voltage ($V_{AC}$) into a continuous direct voltage ($V_{DC}$), made available at its outlet terminals;

   a plurality of modulating units ($U_1$, $U_2$, ..., $U_j$, ..., $U_n$), connected respectively to said plurality of electric loads ($L_1$, $L_2$, ..., $L_j$, ..., $L_n$) and supplied by said direct voltage ($V_{DC}$), with each unit ($U_j$) including also at least one solid state electronic switch ($E_1$, $E_2$, ..., $E_j$, $E_J^A$, $E_J^B$, $E_J^C$, $E_J^D$), which is enabled/disabled to allow circulation of a electrical current ($I_j$) through the corresponding load ($L_j$);

   a central unit for enabling/disabling said solid state electronic switches ($E_1$, $E_2$, ..., $E_j$, $E_J^A$, $E_J^B$, $E_J^C$, $E_J^D$, ...,$E_n$), by respective control signals ($S_1$, $S_2$, ..., $S_j$, $S_J^A$, $S_J^B$, $S_J^C$, $S_J^D$, ..., $S_n$), according to a prefixed modulation technique.

2. Apparatus, according to claim 1, **characterized in that** said central unit enables/disables said solid state switches ($E_1$, $E_2$, ..., $E_j$, $E_J^A$, $E_J^B$, $E_J^C$, $E_J^D$) by means of respective control signals ($S_1$, $S_2$, ..., $S_j$, $S_J^A$, $S_J^B$, $S_J^C$, $S_J^D$, ..., $S_n$), according to a modulation technique based on the pulse duration (PWM).

3. Apparatus, according to claim 1, **characterized in that** said central unit enables/disables said solid state switches ($E_1$, $E_2$,..., $E_j$, $E_J^A$, $E_J^B$, $E_J^C$, $E_J^D$) by means of respective control signals ($S_1$, $S_2$, ..., $S_j$, $S_J^A$, $S_J^B$, $S_J^C$, $S_J^D$, ..., $S_n$), according to a modulation technique based on the pulse frequency.

4. Apparatus, according to claim 1, **characterized in that** said central unit sends said control signals ($S_1$, $S_2$, ..., $S_j$, $S_J^A$, $S_J^B$, $S_J^C$, $S_J^D$, ..., $S_n$) by wave trains conveyed along the respective power electric lines supplying the loads ($L_1$, $L_2$, ..., $L_j$, ..., $L_n$).

**5.** Apparatus, according to claim 1, **characterized in that** said converter device and the plurality of modulating units ($U_1$, $U_2$, ..., $U_j$, ..., $U_n$) include solid state elements.

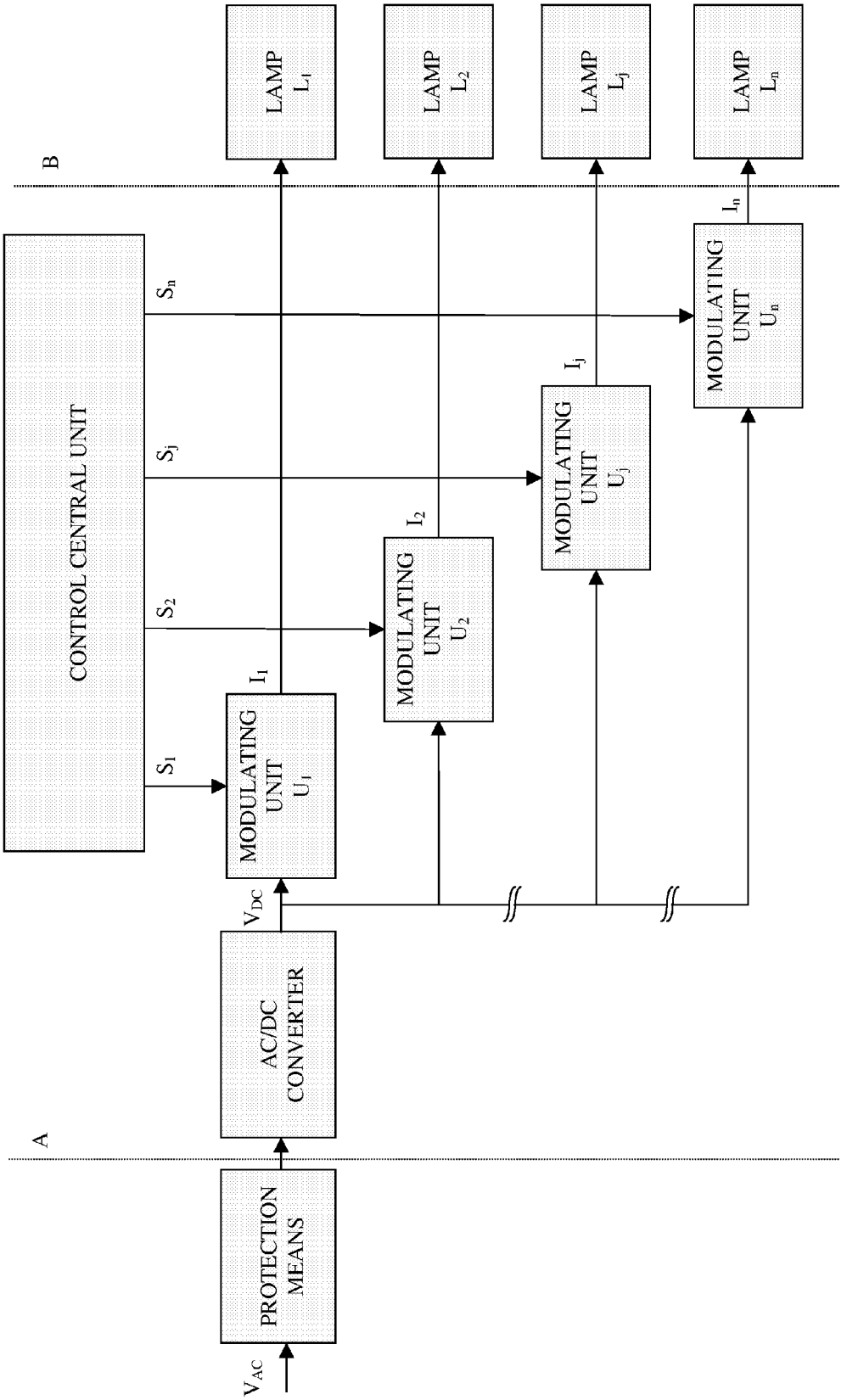
PROTECTION MEANS
AC/DC CONVERTER
CONTROL CENTRAL UNIT
MODULATING UNIT U1
MODULATING UNIT U2
MODULATING UNIT Uj
MODULATING UNIT Un
LAMP L1
LAMP L2
LAMP Lj
LAMP Ln
VAC
VDC
S1
S2
Sj
Sn
I1
I2
Ij
In
A
B

FIG 1

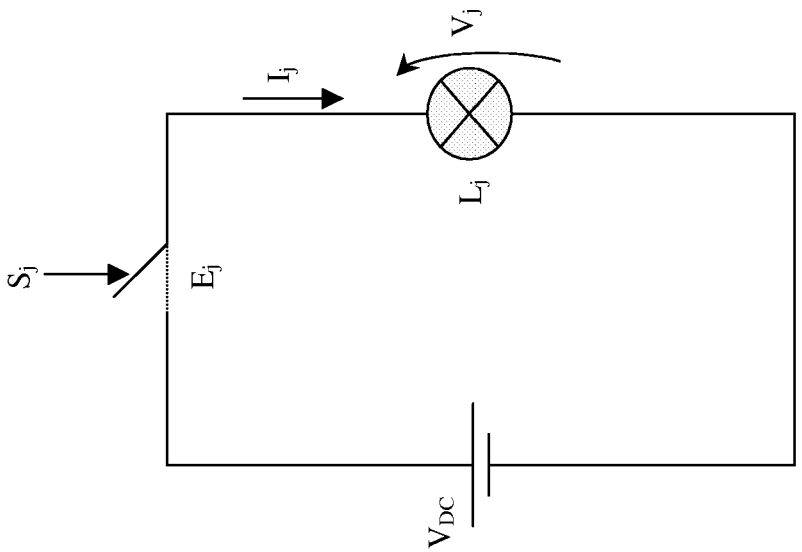


FIG. 3

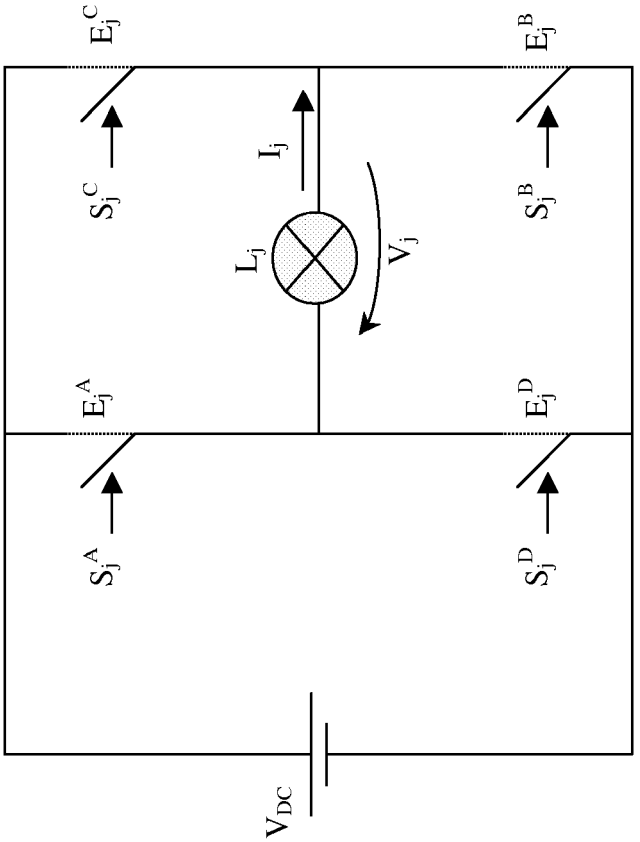


FIG. 2

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- IT 1321138 **[0004]**