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(54) Control apparatus for electric installations, in particular for domestic electric installations

(57) A control apparatus for electric installations comprises at least a control device (10) and at least a piloting device (30) for a load associated to the control device (10); the device further comprises supply means (21, 21', 21'') interconnected at least to the control device (10) and designed to supply the latter with a light energy coming from a room.

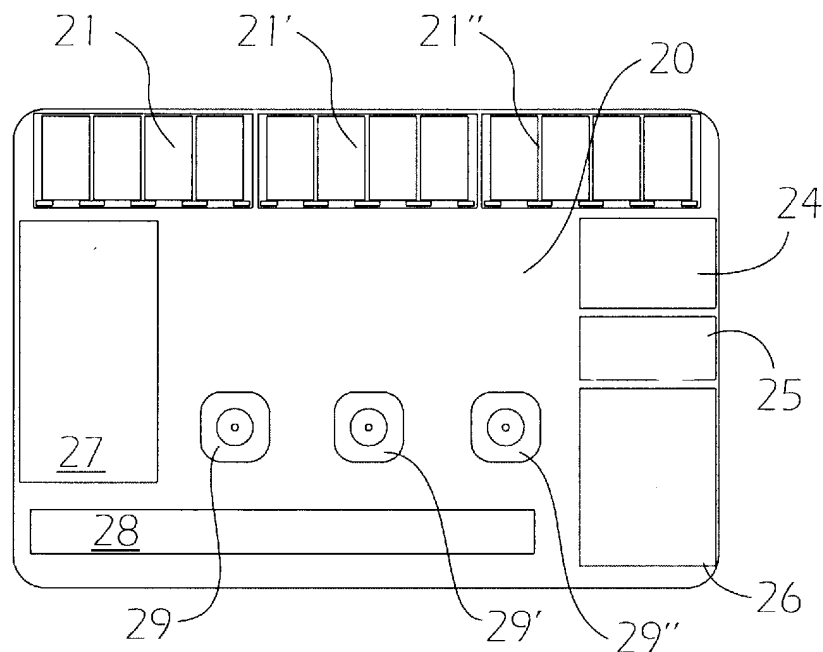


FIG. 4

Description

[0001] Wireless devices can be unidirectional or bidirectional, depending on the kind of communication they can support.

[0002] Unidirectional wireless devices can either transmit or receive, whereas bidirectional devices can perform both transmission and reception.

[0003] The advantage of bidirectionality in relation to the system according to the invention consists in checking that the radio signal transmitted by the control device has been successful, i.e. it has been received by the piloting device and it has been correctly performed.

[0004] In order to work and transmit, receive or process controls, wireless devices need a given amount of energy.

[0005] Most of known wireless control devices are supplied by batteries that have to be replaced at given intervals, thus increasing maintenance costs.

[0006] There are other self-supplied devices that use the activation force and the movement of the control lever for obtaining the required energy. In this case, the conversion systems used, generally electromagnetic induction or piezoelectric systems, are disadvantageous because of their bulky size, because they need a relatively high mechanical activation force and they provide too short an energy pulse to support a bi-directional data communication, thus not permitting to check whether the electric load piloting operation has been performed correctly.

[0007] An aim of the present invention is to eliminate the aforesaid problems related to known devices.

[0008] The main feature of the control device of the system according to the invention consists in that it takes the energy required for its operation from photovoltaic cells, which convert into electricity the light from the room where they are installed.

[0009] Since the light intensity of a room is highly variable - so that there can even be none at night or in shut rooms without windows - the electric energy derived therefrom is also highly variable. Moreover, the amount of light detected by the device, which depends on the exposed surface and on the light intensity of the room, together with the low performance of photovoltaic cells, results in an insufficient condition for the direct use of electric current produced by photovoltaic cells during active periods.

[0010] However, the normal use of the control device is characterized by an extremely high ratio of rest times to operating times. This means that, if designed and built correctly, the average energy used by the device is lower than the average energy supplied by photovoltaic cells.

[0011] In order to store surplus energy during rest periods and then use it during the short active periods for supplying the various circuits required for operation, a storage element is absolutely necessary.

[0012] To this purpose electrolytic capacitors, electro-

chemical capacitors (or any other type of capacitors) or batteries can be used. Anyway, storage elements should have a very low local action current, so as to keep previously stored energy as unchanged as possible for the whole duration of darkness or periods of low lighting in the room.

[0013] In the light of the above description and in order to enable the continuity of the service performed by the control device, even under disadvantageous lighting conditions, it is further necessary to minimize energy used during active periods.

[0014] This results in that electronic circuits designed for radio transmission and reception, including antennas, should have a high electric performance and in that the coding and modulation algorithms used are designed so as to enable to send the control as rapidly as possible, in accordance with admissible bandwidth and with control decoding capacity of the load piloting device.

[0015] An example of use of the control system according to the patent in a domestic electric lighting installation will now be described with reference to Figure 1 of the accompanying drawings. Figure 1 shows a central room 40, or corridor, which can be entered through the front door 45. Said central room gives access to the side rooms 41, 42, 43 and 44 through the corresponding doors 45', 45'', 45''' and 45''''. The example also shows a window 46 letting light into the room, which window - as shall be mentioned below - is not strictly necessary for ensuring the supply of the control devices of said room 102, 103, 105, 107 and 109, since the required light energy can also be only artificial light generated by lighting devices 46', 46'' and 46'''.

[0016] The various control devices are arranged near the doors, on both sides of the walls, so that both the lighting devices of the room one is getting out of and those of the room one is getting into can be controlled. Each device is therefore equipped with various buttons, each controlling its own lighting device to which it has been associated.

[0017] Sometimes, a room can have two or more areas requiring separate lighting. It is the case of room 41, in which two lighting apparatus 14A and 14B have been placed; the device 104 will therefore be provided with: a button for controlling the apparatus 14A, a second button for apparatus 14B and a third button for controlling the apparatus of room 40. Still referring to Figure 1, the device 103, placed on the other side of the wall, can either have the same combination of buttons as described for device 104 or only two buttons, one for controlling the lighting apparatus of room 40 and one for controlling only the apparatus 14B of room 41.

[0018] As far as control devices are concerned, an example of embodiment, which should not be regarded as limiting in its shape and in the number of controls thereto associated, will now be described with reference to the accompanying drawings, in which:

Figure 2 is an outside view of the device

Figure 3 is an assembly drawing of the device

Figure 4 is a diagram showing the inner arrangement of the various components of the device

Figure 5 is a functional block diagram of the device.

[0019] As far as load piloting devices are concerned, an example of embodiment, which should not be regarded as limiting in its shape and in the type of piloting performed, will now be described with reference to the accompanying drawings, in which:

Figures 6, 8 and 10 show three possible outer shapes of the device

Figures 7, 9 and 11 show the related applications

Figure 12 is an example of diagram showing the inner arrangement of the various components of the device

Figure 13 is a functional block diagram of the device. With reference to Figures 2, 3, 4 and 5, the control device appears as a group of standard buttons. In this specific case, the device is provided with three buttons with related control levers 12, 12' and 12'', each of which can control a separate electric load, for instance three light connections placed in the same room or in adjacent rooms, though the piloting device thereto associated (number 30 in Figures 7, 9 and 11.

[0020] The device is preferably made of plastic. The levers or control elements are surrounded by the front plate 11 having semitransparent and translucent optical features, such that it has its own color and can be partially got through by room light. The material the front plate 11 is made of should also be as transparent as possible to radio waves.

[0021] In short, in order to achieve the technical aims of the present invention, at least the control device 10 is made at least partially of a material which can be got through at least partially by a light coming from said room, and at the same time at least the control device (and preferably the load piloting device 30, too) are at least partially made of a material at least partially transparent to radio waves.

[0022] The front plate 11 is the exposed portion of the housing, which is closed on the back with a smooth plate 13, so as to be easily applied to a wall or a piece of furniture with biadhesive tape or any other simple fastening system. This feature is particularly advantageous since it allows to greatly simplify cabling and implementation of lighting installations, and to dramatically reduce execution times.

[0023] The thickness of the device can be very small, since inner components are very thin.

[0024] Figure 4 shows a possible arrangement of the component groups of the device, divided into areas.

[0025] In the following descriptions reference is made to Figures 3, 4 or 5, depending on whether the descrip-

tion deals with the arrangement of the components or with their function.

[0026] All the electronic and electromechanical components are mounted and welded onto a printed circuit 20. Said printed circuit will be placed behind the front plate 11 and the control levers 12, 12' or 12'' and fastened onto the base 13 constituting the back side for fastening the device onto a wall.

[0027] By pressing one of the control levers 12, 12' or 12'' shown in Figure 2, the corresponding electromechanical contact 29, 29' or 29'' is actuated, thus transmitting the radio control signal.

[0028] The electromechanical contacts 29, 29' and 29'' (which are suitably connected at least to the printed circuit 20, as can be seen also in the accompanying figures) can be carried out in several ways: a first example consists in using preloaded spring plates which under pressure put into contact two conductive tracks of the printed circuit. Another possibility consists in using magnetic contacts (or reed-type contacts) which close due to the approach during active periods of a small magnet mounted below the contact levers 12, 12' and 12'', and which are integral with said levers.

[0029] When said contacts close, the active period of the device starts, i.e. the period in which the control signal is processed and transmitted, followed by a period in which the confirmation response from the load piloting device 30 is expected, as explained later in further detail.

[0030] The upper portion of the printed circuit houses the photovoltaic modules 21, 21' and 21''. In this specific case, these modules comprise a thin film laid onto a ceramic substrate, though any type of photovoltaic cells suiting the object size can be used. Also the selected position should be no limitation at all; the important thing is that said cells have the largest exposed surface as possible, so as to convert and supply a sufficient amount of energy also in unfavorable light conditions.

[0031] The number and type of photovoltaic cells to be used, connected in series one to the other, should be calculated so that the open-circuit voltage supplied by the series in minimum lighting conditions has the same value as or slightly above the voltage of the storage means 24, which store electric energy transformed by photovoltaic cells and give it back in suitable conditions.

[0032] Advantageously, the storage means can comprise at least a battery 24 (which can advantageously be rechargeable) or at least a capacitor.

[0033] Thus, the corresponding lighting degree will represent the useful threshold of minimum light intensity for energy storage.

[0034] It should be considered that, in order to ensure a continuous energy supply, photovoltaic cells should be calculated depending on the average energy expected to be consumed by the control device, which depends on the frequency with which activations are deemed to be performed. Concerning this, the more the

control levers in the device, the more likely the number of activations will be high.

[0035] The calculation of the surface covered by the photovoltaic cells should be made redundantly, also taking into account their conversion efficiency and the fact that the front plate (element 11 in Figure 2) is got through only partially by light. The redundancy condition, however, can be easily achieved since the exposed surface of the front plate has a large extension.

[0036] Photovoltaic cells made with technologies characterized by a high conversion efficiency should preferably be used.

[0037] As was said previously, the electric energy coming from the photovoltaic cells should be stored by a suitable element; in the example this element is a ultrathin battery 24 using a solid electrolyte lithium technology.

[0038] It should be pointed out that the supply means 21, 21' and 21" generate an open-circuit voltage that is at least the same as a corresponding voltage of the storing means 24: if the latter comprise a battery, said voltage will be at least the same as, or slightly higher than, battery voltage, whereas if the latter comprise a capacitor, the higher the voltage supplied by the supply means the more efficient the charge storage on the capacitor.

[0039] If the electronic circuits 25, 26, 27 and 28 are properly designed, so as to ensure an energy reserve ensuring a continuous operation of the device also for long periods of darkness, the use of a battery with a capacity of fractions of mAh can be sufficient.

[0040] Preferably, said capacity should not be too high since, by increasing its value, beyond increasing battery volume, charge time and self-discharge current increase almost proportionally, thus not improving in any way the operation of the device.

[0041] As far as battery size is concerned, it can be kept into account that room brightness, consisting in most cases mainly of sunrays, can come from the same artificial light controlled by the device.

[0042] In most unfavorable exposition cases, e.g. when the device is installed in a room without windows and almost always shut, artificial light can even be regarded as main energy source.

[0043] The nominal voltage of the battery, and as a consequence the number of photovoltaic cells to be provided for, is chosen depending on the operating voltage of the electronic circuit connected to said battery and on the requirements of the technology used in said battery.

[0044] The supply management circuit 25 has the task to manage battery charge, preventing that during dark periods it can partially discharge on photovoltaic cells.

[0045] Another task of said circuit is to switch on and/or off (or in other words, connect and/or disconnect the supply) the downstream electronic circuits 26 and 27, which are in their turn interconnected at least to the electromechanical contacts 29, 29', 29" during rest periods, so as to minimize used current when no activity is re-

quested, i.e. for most of the time.

[0046] From a structural point of view, it can thus be seen that the main components of the printed circuit 20 are the following: a given number of electromechanical contacts 29, 29', 29" causing a transmission of a radio control signal; a primary processing and coding/decoding circuit 26 interconnected to the electromechanical contacts 29, 29', 29" and designed to process a radio signal to be sent to the load piloting device 30; a primary transceiver circuit 27 interconnected to the electromechanical contacts 29, 29', 29" and/or to the primary processing and coding/decoding circuit 26 (and preferably connected to an antenna 28). Anyway, the primary transceiver circuit 27 can be simply replaced by a transmission circuit (or by a reception circuit), should the device be simplified for cost reduction.

[0047] When a button 12, 12' or 12" (Figure 2) is pressed, the supply management circuit 25 supplies the processing circuit 26 and the radio signal transceiver circuit 27. Supply will go on until the primary processing and coding/decoding circuit 26 communicates to the supply management circuit 25 it has completed both the step of control transmission and the step of confirmation reception.

[0048] The circuits 26 and 27 are thus supplied only for the time strictly required to complete control functions.

[0049] The primary processing and coding/decoding circuit 26 can have different tasks depending on the control modes to be implemented on the piloted load, for instance on the lighting apparatus. Some of these modes could be:

- pulse control (pushbutton)
- bistable control (on/off switch)
- light variator (dimmer)
- etc.

[0050] Anyway, said circuit 26, preferably comprising a microprocessor and various additional components, should construe the control given by the user and translate it into a code, which the load piloting device 30 should be able to decode. The generated code should possibly contain a univocal address, associated to each control element of the device 12, 12' and 12" (Figure 2), comprising a given number of bits identifying unambiguously the device that has transmitted the radio signal and the actuated control element.

[0051] Each load piloting device 30 will have the task to acquire and store such identifier through a suitable self-learning process, so as to identify the device and the associated control element. Concerning this, said load piloting device 30 should preferably be designed to acquire and store a number of identifiers corresponding to maximum number of control points which might be desired to be associated to each light connection. After decoding the received signals, the load piloting device 30 should only actuate those controls which come from

the device control elements and are associated to it and recorded.

[0052] The selected coding mode and issue times for the code constituting the modulating wave of the transmission carrier, should be compatible with the occupation of band on which the signal is transmitted.

[0053] As a general rule, in order to minimize the amount of energy used for transmission, the duration of the code to be transmitted should preferably be reduced as much as possible.

[0054] Any type of modulation can be chosen for transmitting the signal. However, it should be kept into account that to each type of modulation corresponds a different spectrum of emission of radio frequency (amplitude, frequency, phase etc.), with subsequent modes of occupation of the selected band.

[0055] Still in order to minimize the amount of energy used during transmission, the transmitter circuit should preferably be designed envisaging the use of active elements (bipolar transistors or field-effect transistors) keeping a high amplification also under conditions of low operating current, and having a cutoff frequency dramatically higher than the one to be used.

[0056] It is further necessary to use a particular care when designing the antenna 28, since the power actually sent out by the circuit depends on it. The higher the performance of the antenna the smaller the energy to be used during transmission in order to obtain the same intensity of electromagnetic field.

[0057] The power sent out by the control device should ensure a good quality of reception by the load piloting device 30 at the maximum distance provided for. In most cases, inside buildings a maximum limit of 30 m should be enough.

[0058] With reference to Figures 6, 7, 8, 9, 10, 11, 12 and 13, the load piloting device 30 can have several outer shapes depending on the type of load (or in other words, depending on the electric users, such as for instance the lamps 46, 46', 46" of Figure 1) to be piloted. Figures 7, 9 and 11 refer to lighting apparatus, a ceiling lamp (Fig. 7), a floor lamp (Fig. 9) and a wall lamp (Fig. 11) respectively.

[0059] In all cases the electronic and electromechanical components of the inner circuits are mounted and welded onto a printed circuit 31. Said printed circuit will have a suitable shape so as to be arranged inside corresponding housings.

[0060] The device can be equipped with an input terminal board 32 for the connection to the electric supply network 34, and with an output terminal board 33 to which the load to be piloted 35 will be connected (for sake of simplicity, said terminal boards can be replaced by simple electric cables).

[0061] Similarly to what has been described with reference to the control device 10, from a structural point of view the main components of the load piloting device 30 can be: a secondary radio transceiver circuit 37 (which as before can be replaced by a simple reception

circuit or by a simple transmission circuit); a secondary processing and coding/decoding circuit 38 interconnected to the secondary radio transceiver circuit 37; a power load piloting circuit 39 interconnected at least to the secondary processing and coding/decoding circuit 38 and to be actuated on a load 35.

[0062] The secondary radio transceiver circuit 37, the secondary processing and coding/decoding circuit 38 and the power load piloting circuit 39 take their supply from the electric network 34 by means of a supply circuit 36 obtaining from it the various voltages required for the operation of said electronic circuits.

[0063] Considering that said circuits will be designed so as to require very little energy, the supply circuit 36 can be relatively small.

[0064] Differently from control devices, which are actuated by the user with the modes described above, the load piloting devices 30 are always active and under watch, so as to receive the radio signal, if present, coming from one of the control devices.

[0065] Each piloting device 30 should save the identifiers corresponding to the control devices associated to it, so that only said devices can communicate with it; all signals coming from other control devices will be ignored.

[0066] In order to save said identifiers, a suitable self-learning process should be used, enabling to acquire during installation the univocal code generated by each control device to be recorded.

[0067] The ways in which said process is activated can be manifold and are not described in further detail in the present patent. Only the following possibilities are mentioned by way of non-limiting examples:

activation through pushbutton on piloting device
activation at first supply of piloting device
activation through suitable remote control using radio waves, infrared rays or ultrasounds.

[0068] During normal operation, the load piloting device 30, after having decoded and identified one of the controls addressed to it, should implement it through the power piloting device 39. Said circuit can comprise an electromechanical relay or a solid-state relay based on triac or other semiconductor component, and should be designed so as to tolerate with a given redundancy the current and voltage of the electric load to be piloted.

[0069] Once load piloting is performed, the piloting device 30 should send a confirmation signal to the control device that had generated the request.

[0070] Thus the control device 10 can check the success of the operation and otherwise it can start an automatic process of control repetition with an algorithm attempting to overcome possible difficulties that might have caused the failure of said operation.

[0071] The invention has interesting advantages.

[0072] First of all, it should be noted that the peculiar architecture of control and piloting devices enables a

highly reliable operation and at the same time an extremely simple structure, with favorable consequences in terms of operating costs and installation flexibility.

[0073] Moreover, it should be pointed out that radio communications between the two main devices constituting the device according to the present invention can be "bi-directional", so as to further increase reliability.

[0074] More to the point, it should be pointed out that thanks to the photovoltaic cells, the control device does not practically require maintenance and/or used battery replacement.

[0075] Note also that all electronic components used in the present invention can be quite small, and namely quite thin.

[0076] From a structural point of view, it should also be noted that the base of the control device can have an outer smooth configuration and can thus be installed on the walls of a room with extremely simple and cheap fastening systems.

[0077] On the whole, it should therefore be noted that this device is particularly suitable for use in lighting installations inside buildings.

Claims

1. Control apparatus for electric installations, in particular for domestic electric installations, comprising:

- at least a control device (10); and
- at least a piloting device (30) for a load associated to said control device (10);

characterized in that it further comprises supply means (21, 21', 21'') interconnected at least to said control device (10) and designed to supply the latter with a light energy that is present in a room.

2. Apparatus according to claim 1, **characterized in that** said supply means (21, 21', 21'') comprise at least a photovoltaic cell.

3. Apparatus according to claims 1 or 2, **characterized in that** at least the control device (10) is made at least partially of a material designed to be got through at least partially by a light coming from said room.

4. Apparatus according to any of the preceding claims, **characterized in that** at least the control device (10) and preferably also the piloting device (30) are at least partially made of a material at least partially transparent to radio waves.

5. Apparatus according to any of the preceding claims, **characterized in that** the control device (10) comprises:

- a front plate (11) made at least partially of a material designed to be got through at least partially by a light and preferably at least partially transparent to radio waves;
- a circuit, preferably a printed circuit (20), arranged behind the front plate (11); and
- a base (13) onto which said printed circuit (20) is fastened, which base (13) can be fastened onto a wall of a room.

6. Apparatus according to claim 5, **characterized in that** said printed circuit (20) comprises:

- a given number of electromechanical contacts (29, 29', 29'') for causing a transmission of a radio control signal;
- a primary processing and coding/decoding circuit (26) interconnected to said electromechanical contacts (29, 29', 29'') and designed to process a radio signal to be sent to the load piloting device (30);
- a primary transceiver circuit (27) interconnected to the electromechanical contacts (29, 29', 29'') and/or to said primary processing and coding/decoding circuit (26) and preferably connected to an antenna (28).

7. Apparatus according to claim 6, **characterized in that** the circuit (20) further comprises storage means (24), the circuit (20) still more preferably further comprising a supply management circuit (25) designed to manage a charge and/or a discharge of said storage means (24) and/or on/off switching conditions of said processing circuit (26) and of said primary transceiver circuit (27).

8. Apparatus according to claim 7, **characterized in that** the supply means (21, 21', 21'') are designed to generate an open-circuit electric voltage corresponding to a voltage of the storage means (24).

9. Apparatus according to claims 7 or 8, **characterized in that** said storage means (24) comprise at least a battery, preferably a rechargeable battery and still more preferably with a capacity of fractions of mAh.

10. Apparatus according to claims 7 or 8 or 9, **characterized in that** said storage means (24) comprise at least a capacitor.

11. Apparatus according to any of the preceding claims, **characterized in that** the load piloting device (30) comprise:

- a secondary radio transceiver circuit (37);
- a secondary processing and coding/decoding circuit (38) interconnected to said secondary

- radio transceiver circuit (37); and
- a power load piloting circuit (39) interconnected at least to said secondary processing and coding/decoding circuit (38) and to be actuated on a load.

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12. Apparatus according to claim 11, **characterized in that** the load piloting device (30) further comprises a supply circuit (36) for the connection to a supply network and interconnected to said secondary radio transceiver circuit (37) and/or to said processing and coding/decoding circuit (38) and/or to said power load piloting device (39).

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13. Apparatus according to claims 11 or 12, **characterized in that** the load piloting device (30) further comprises an input terminal board (32) for the connection to an electric supply network, and an output terminal board (33) for the connection to a load to be piloted (35).

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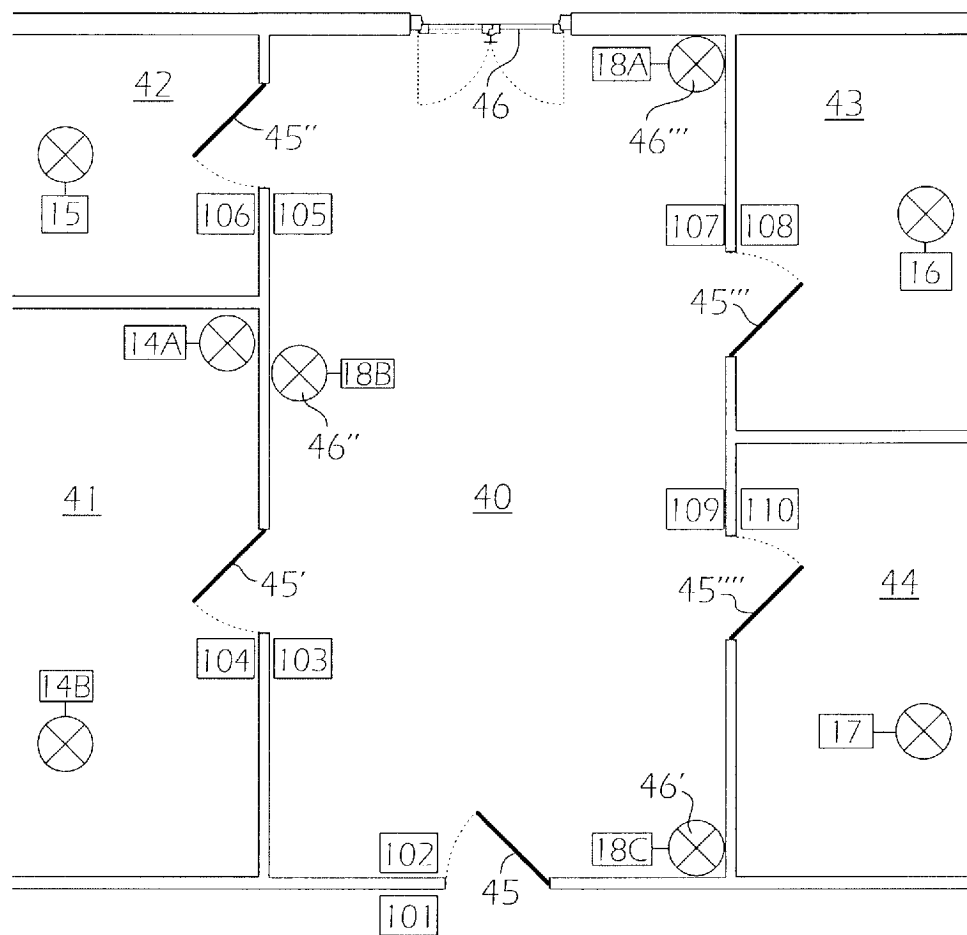


FIG. 1

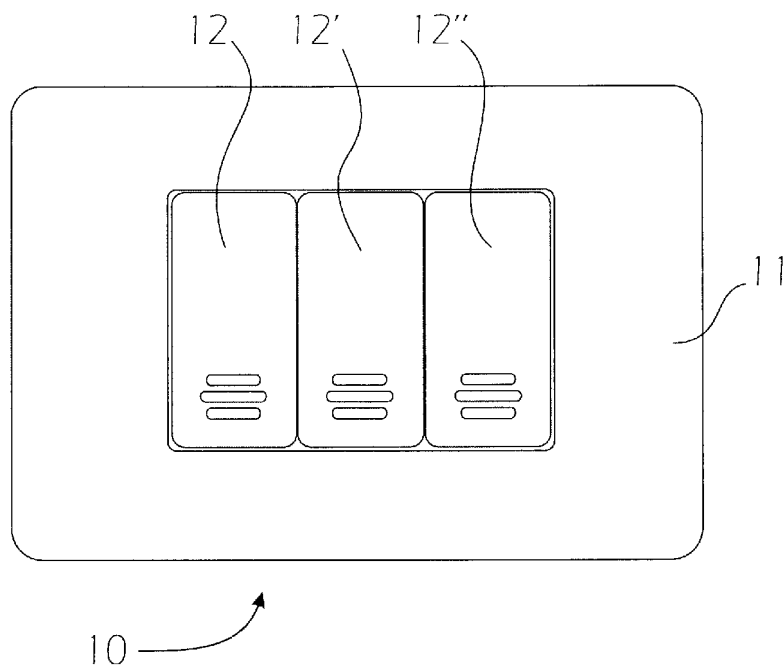


FIG. 2

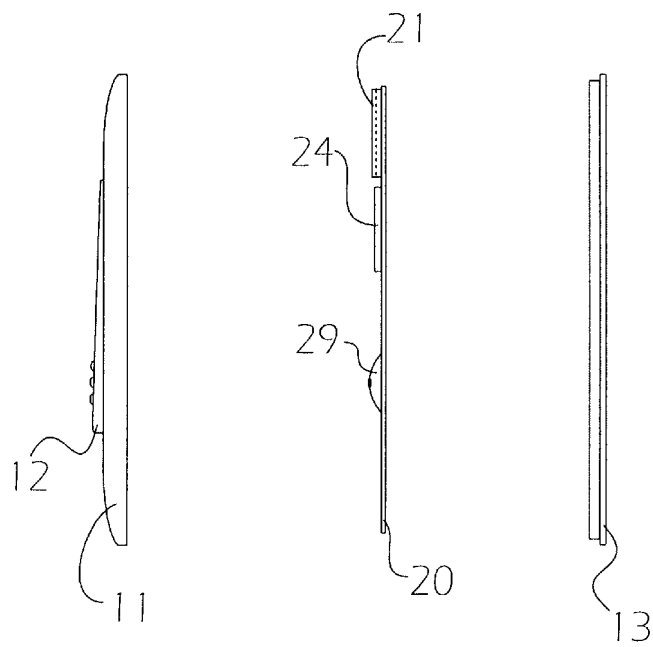


FIG. 3

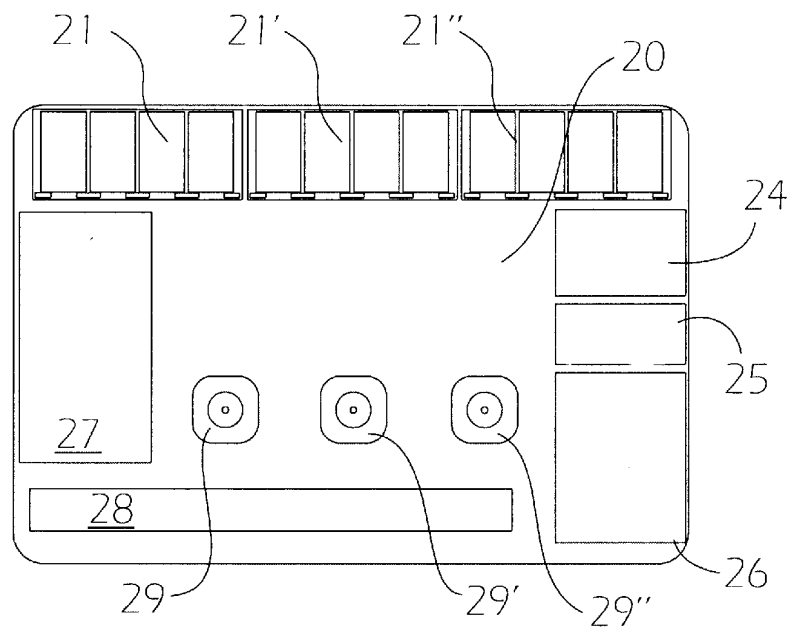


FIG. 4

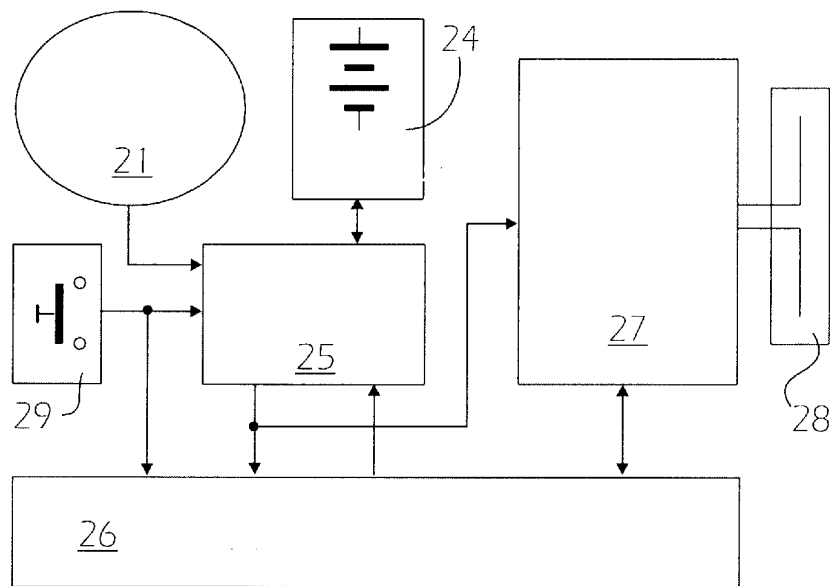


FIG. 5

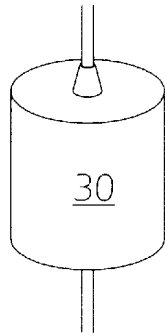


FIG. 6

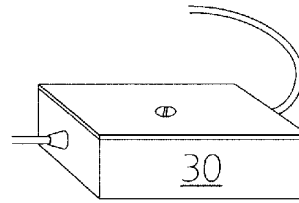


FIG. 8

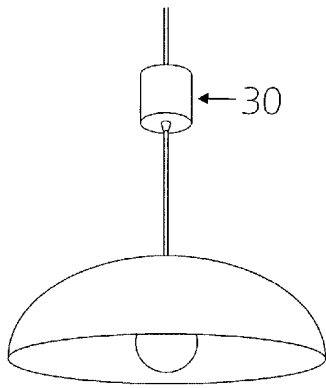


FIG. 7

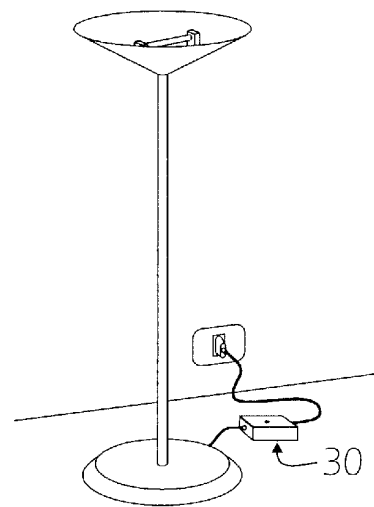


FIG. 9

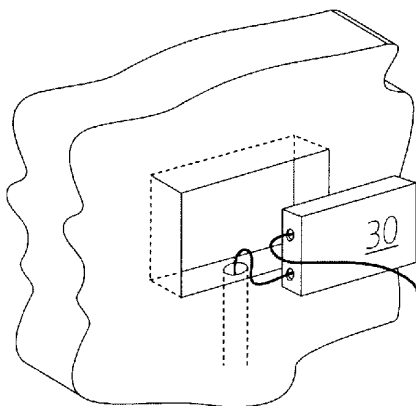


FIG. 10

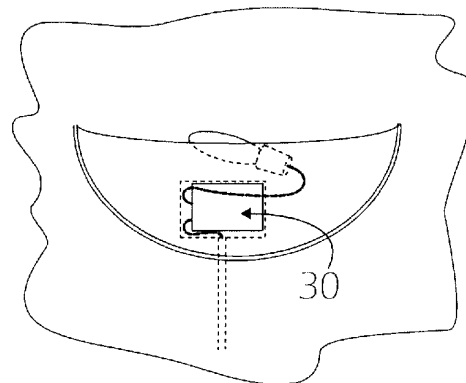


FIG. 11

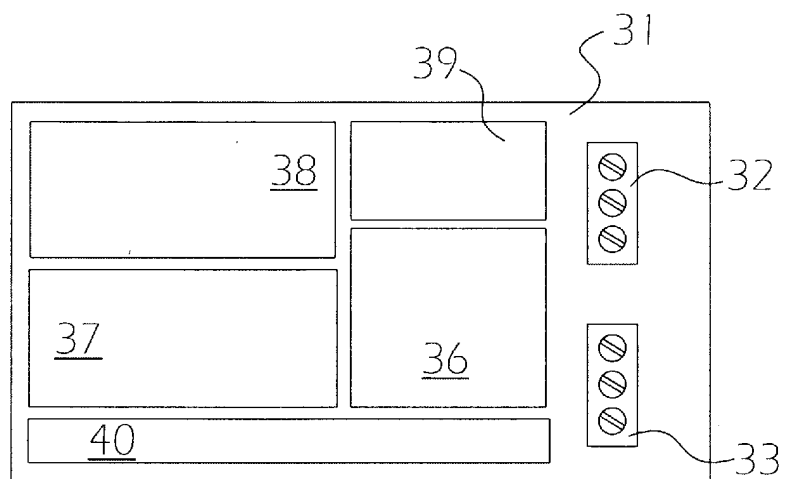


FIG. 12

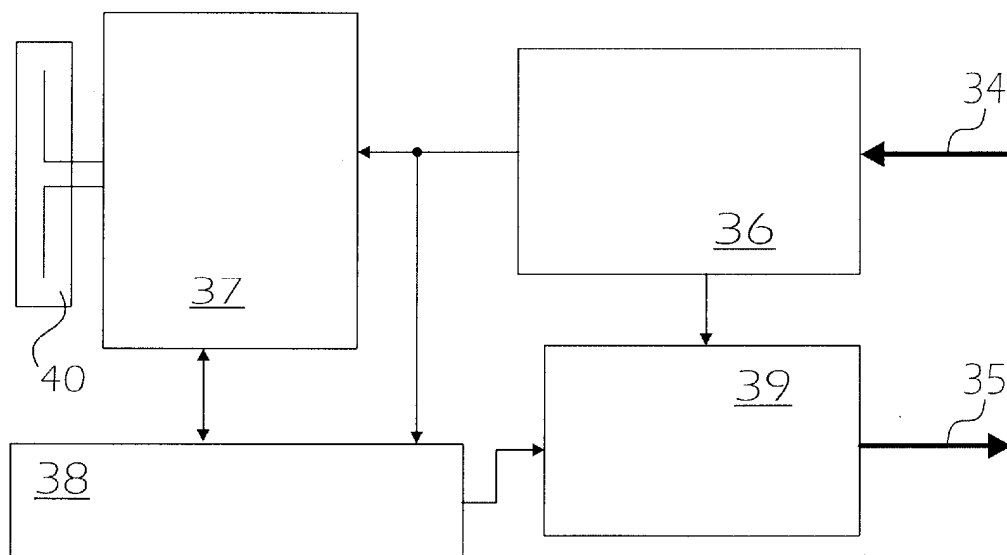


FIG. 13