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(54) **Method for controlling a street lamp or a lamp for interiors to compensate ambient light**

(57) The proposed method is related to the construction and use of a light with multiple light sources and the relative regulation system based on chromatic coordinates acquired and stored in a way to allow a correct regulation and control of the luminosity emitted and measured .The proposed method and the relative device are suitable to use in the management of street lamps in relation to intensity and quality of the light, and in the management of lighting devices for interiors and exteriors and for urban lighting. The application is particularly advantageous to the management of the light level and thus to the involved energy level and could be finalized both for energy saving and for a defined enlightening purpose.

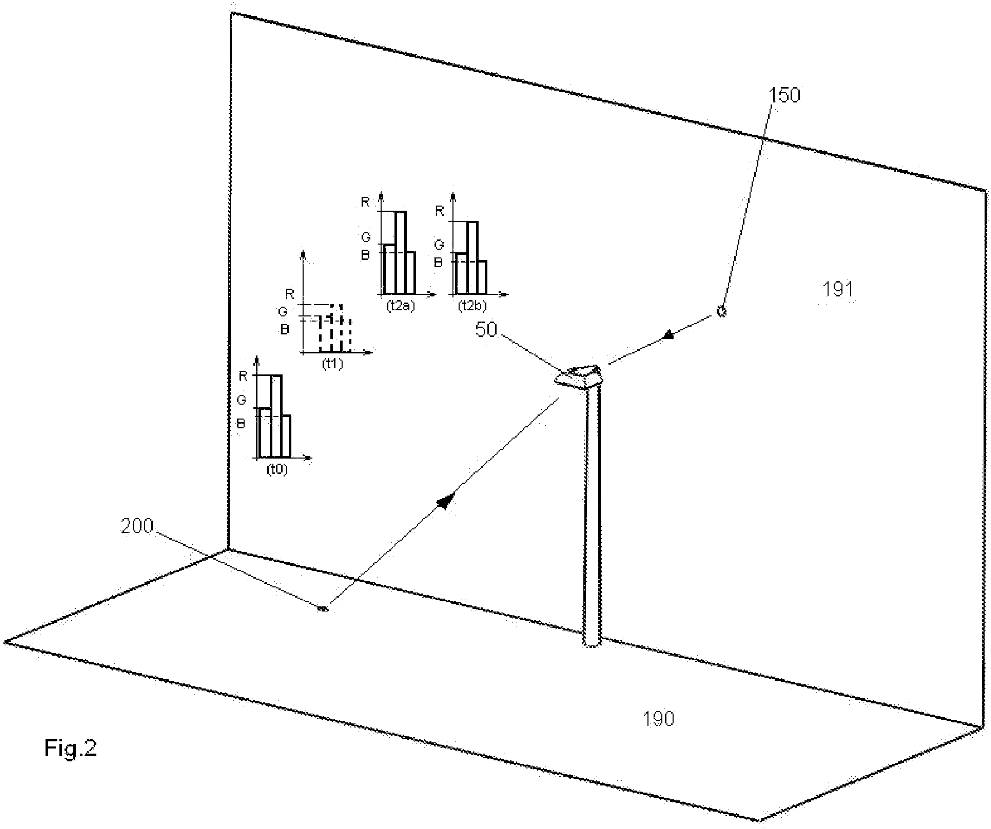

Fig.2

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Description

Prior art

[0001] Lighting systems have evolved in the past years with increasingly efficient solutions, which first involved the simple evolution of the light source from incandescent filament to mercury vapors, and then metal halide lamps.

[0002] These last sources have a high efficiency but show drawbacks in terms of minimum available power, directionality and control. The efficiency of a vapor or metal halide source grows with the power of the source and this led to light assemblies with large dimensions and diffusing systems more and more complex, introducing a limit to the applications of these systems. They are in practice applicable only to large areas and they are not suitable for street lighting or lighting of a city centre, due to loss of efficiency caused by distribution and lighting interference with home buildings.

[0003] Concentrated high efficiency and high power sources make necessary to distribute the light with suitably shaped reflecting surfaces, which require multiple reflection and penalize the efficiency of the lighting body. Moreover said surfaces require the use of transmission angles to the output, such that the protection losses become relevant for modern installations with sparse light posts.

[0004] The so optimized sources are suitable for operation at fixed point in terms both thermal and of current/tension excitation. The variations which are artificially imposed, made necessary by the norms, lead to deviation of behaviour that allow poor control and affect the quality of the emission and life of the source.

[0005] Sources have been studied with high efficiency but low specific power and high directionality such as LED sources and more recently the quartz metallic micro sources. Their application allowed to distribute punctually and with defined direction the sources obtaining a gain in efficiency and an improved quality of the light. A LED road lamp is described for example in EP 2 101 106.

[0006] Said sources together with directionality have a sharp controllability which is a consequence of the physical principles underlying the emission of electrons and their conversion by means of the converting means (phosphor, etc.) involved. Intensity and fast response in status change allow to manage dimming by high frequency on-off techniques allowing a regulation from 0% to 100% of the emission but maintaining quality of the same.

[0007] These sources are based on new and fast developing technologies, allowing to pass in two years from products with specific luminosity of 80-90 lumen per watt to commercially available products of 130 lumen per watt and products under laboratory testing of 190 lumen per watt.

[0008] The accurate disposition of the leds is the first cause of saving, which is not dependent on the source, that was possible after the market introduction of these new sources. It has been addressed the need to orient light rays in a more efficient way in order to fully exploit the increasing efficiency of the sources and to optimize the overall cost of the lighting body (see KR 20010069867 and CA2411219).

[0009] The introduction of these light sources has been so fast that it was not possible to provide adequate infrastructures and the culture of use and, despite the high performances, the issue of control has been overlooked.

Summary of the invention

[0010] In this context, the disclosed method and the relative system have the advantage of optimizing the energy saving, maintaining the light intensity adapted to the purpose, as it is often required by norms.

[0011] According to the invention, the light emission of a lighting body comprising at least two light sources is controlled by means of measuring and storing a set of chromatic emissions, also named chromatic coordinates, made in at least one reference point. According to different embodiments of the invention, said reference point may belong or may not belong to the area which is lightened by the lighting body.

[0012] A first aspect of the invention consists in a method for controlling the light emission of a lighting body having at least two light sources that can be controlled in intensity, said method comprising the steps of:

- defining at least one reference point in a zone lightened by said lighting body,
- making a measure of the intensity of each component of a set of chromatic emissions in said reference point, said measure being carried out with a natural or artificial reference light and in a defined first time instant (t0),
- computing the difference of intensity between said chromatic emissions and computing the measured absolute intensity, obtaining a set of parameters,
- storing said parameters in a suitable memory location of said lighting body,
- comparing said parameters with a measure of the chromatic emissions made in a generic second time instant different from said first instant,
- regulating the intensity of the light sources of said lighting body in a way to bring the intensity of the chromatic emissions to the values measured in said first time instant or to a predetermined value.

[0013] A second aspect of the invention consists in a method for controlling the light emission of a lighting body having at least two light sources that can be controlled in intensity, said method comprising the steps of:

- defining at least a reference point in a zone which is not lightened by said lighting body;
- making a measure of the intensity of each component of a set of chromatic emissions in said reference point, said measure being carried out with a natural or artificial reference light and in a defined first time instant,
- computing the difference of intensity between said chromatic emissions and computing the measured absolute intensity, obtaining a set of parameters,
- storing said parameters in a suitable memory location of said lighting body,
- storing in said lighting body the intensity that must be given to the source as a function of said differences,
- interpolating the intensity to be given to the light sources in a generic second time instant as a function of said differences between said parameters.

[0014] It is an object of the invention also a lighting apparatus suitable to operate according to the above described method. Preferably said apparatus comprises at least: a control system adapted to control the light intensity of said at least two sources continuously and independently; at least one microcontroller that manages said control system; at least one sensor adapted to measure the intensity of a set of chromatic emissions in at least one location, for example inside or outside the lightened area; at least a data memory.

[0015] The above mentioned set of chromatic coordinates is for example represented by the triad of emissions red, green and blue (RGB) at reference frequencies.

[0016] Preferably the invention applies to LED equipments. Hence, the above said light sources are preferably LED diodes. A preferred application is the street lighting or public lighting, but the invention is also applicable to interior lighting.

[0017] Further aspects of the invention are described in the dependent claims.

[0018] An advantage of the present invention is the possibility to use led of the same type, differencing lighting behavior of the lamp in various zones thus having a product which is a standard product but able to provide optimal efficiency also near internal walls of a shed or the facade of a palace.

[0019] A further advantage of the present invention is to allow non-lightened zones such as for example a private home window under a street lamp or a green area during night time.

[0020] A further advantage of the proposed invention is to allow to pass to full power upon receipt of an alarm signal issued from an exterior agent or optically produced in the field of the luminosity sensor, restoring or increasing the local luminosity level e.g. in case of an accident in the lightened zone.

[0021] The invention provides a system for acquisition and regulation of a light source, for example a headlight or a street lamp, based on chromatic coordinates which are acquired and stored, in a way to allow a correct regulation and control of the measured and radiated light. The proposed method and the relative equipment are particularly adapted to use in management of street lamps, relative to intensity and quality of the light, as well as management of lighting devices for interiors and exteriors and for urban architectural lighting. The application is particularly advantageous in the management of the level of luminosity and energy required and may be addressed to energy saving as well as to the aim of achieving a given lighting.

Description of a preferred embodiment

[0022] The proposed method is implemented by the physical system represented in Fig. 2. A light device 50 lightens a lightened zone 190 and does not lighten a zone 191. A set of chromatic coordinates is measured in at least one point 200 in said zone 190, for example the values of the triad of radiations red, green and blue, at given reference frequencies. Said measure is performed at a time t0 and the so measured set of chromatic coordinates is stored in a suitable memory location of the device 50. The coordinates measured at said instant t0 are depicted in the graph (t0) of Fig. 2.

[0023] Said triad of radiation red, green and blue (RGB) is part of the light ray sent in the radiation which is schematized by the arrow line of Fig. 2 to at least one sensor in the light device adapted to receive and decompose the light, so to allow to measure the components of the triad.

[0024] As time passes, the lighting conditions and then the emitted radiation change, as is depicted for example in graph (t1) of Fig. 2, registered by the sensor at time t1 always in the reference light conditions. The light device thanks to its own means which are described in the following regulates the level of its emission in order to restore completely the sum of the intensities taken at time t1 and bring them back to the same values of time t0 or to a predetermined value which is set in the lighting device. Said value can be set depending on time or depending on an external input such as a control center, a user remote control or automatic control system.

[0025] Said lighting device acts in a first case in autonomous way trying to lower the difference between the value $(R+G+B)_{t0}$ and the value $(R+G+B)_{t1}$ by increase of the intensity of its emission. Said increase of intensity, as said before, may be limited to a stored value $(R+G+B)_{max}$ due to an external agent, see as example the condition depicted at time t2a were the graph (t2a) represents the situation produced by this control algorithm intervened at time t1.

[0026] Said lighting device acts in a second case in autonomous way to lower the differences between the n-th components intensity ratio $(R/G, B/G)_{t0}$ and the value $(R/G, B/G)_{t1}$ increasing the intensity of its own light emission. This increment of light emission could be, as mentioned above, cut at a stored level $(R+G+B)_{max}$ depending on an external agent choice, see as example the condition at time t2b where the graph (t2b) represents the situation produced by this algorithm at time t1.

[0027] In other words said lighting device in general is able to act autonomously to regulate the intensity of light radiation according to an algorithm which is predetermined but modifiable during time so to allow a lighting level in control points adapted to the purpose defined by the external agent, setting the algorithm and defining limits.

[0028] If it is chosen to use more than a point, the lighting device can operate by summing the homologous members of the radiation received by sensor (or sensors) from different points, or exploiting a plurality of intensity control channels and acting on channels that power light sources specifically directed to said point in order to obtain application of said algorithms each for a different zone of the lightened area (190).

[0029] What has been described apply also independently or together to the radiation received by said sensors from any non-lightened area 191 created by an object or by a free surface. In this specific case there is no possibility for the sensor to check its direct action and the lighting device according to the selected algorithm has a series of internally stored intensities corresponding to the values of differences between the reference and the measured that the lighting device execute in a continuous way.

[0030] Said lighting device is also equipped with a time signal internally generated by an RTC (real clock timer) or universal timer or generated by an external time signal received preferably, but without loss of generality, via radio. Said time signal may be processed by the lighting device to obtain the maximum power output by an internal memory device linked to the internally generated time scale.

[0031] A functional description of the light device which implements the described method as represented in Fig. 1 is now given.

[0032] The lighting body has a structure (51) able to host and support the internal components, composed of metal, plastic and any material adapted to the main purpose and able to dissipate by convection or conduction the heat produced by the components.

[0033] Said lighting body holds a plurality (at least two) of light sources 100 which are independently controlled by a control system 120 through connecting branches 110 obtained in the structure or discretely made as wires according to per se known technique. The arrangement of the leds in three-dimensional inclination in the space is advantageous for the purpose of uniformity and efficiency of the emitted light radiation, and is per se known art, in fact the product available on the market are uniforming their disposition.

[0034] Said system for powering and regulating the sources 120 is controlled by on board micro controller of the light device that executes the algorithms and the strategies described in the method, and operates the accessory functions of measure and active check of consumption, control of the system by means of check of temperature and magnetic fields induced by operation.

[0035] A micro controller 130 receives the data of the chromatic set from at least one sensor 140 which may receive them (210) from different locations, indicated for example with numerals 200 and 150, or from a single location. The microcontroller computes the signal from said chromatic sensors 140 and save them in a stable and safe position such as eeprom 160 or more eeproms in a suitable format to be used by the algorithms as chromatic coordinates. Those memory locations or eeprom stores also the data necessary for autonomous operation of the lighting body such as the tables of correspondence between the measured intensity and the light radiation to emit, ratio between the intensities of the set and power output, the maximum limit of light radiation to emit as a function of the time scale.

[0036] The micro controller may generate autonomously a time scale but it is preferred to use a dedicated and more precise RTC system (170) which feeds the clock to the micro controller.

[0037] According to another of the preferred aspects of the invention, the sunlight is measured at regular intervals, e.g. at 15'-45' intervals, obtaining a curve of sunlight intensity; the maximum of said curve is identified with a parabola or other interpolation; said maximum is given the meaning of midday and, as a consequence, the midnight is also indentified. This process is carried out for every day of the year, with a possibility of self-adaptation of the lighting body to the actual sunlight conditions, and with a considerable energy saving compared to a conventional lighting system that is activated at predetermined times.

[0038] Modifications to data, function parameters are made for example by means of a communication device 180 integrated in the microcontroller or external as in the figure.

Claims

1. Method for controlling the light emission of a lighting body (50) having at least two light sources that can be controlled in intensity, said method comprising the steps of:

    a) defining at least one reference point (200) in a zone (190) which is lightened by said lighting body,
    b) making a measure of the intensity of each component of a set of chromatic emissions in said reference point, said measure being carried

out with a natural or artificial reference light and in a defined first time instant (t0),
c) computing the difference of intensity between said chromatic emissions and computing the measured absolute intensity, obtaining a set of parameters,
d) storing said parameters in a suitable memory location of said lighting body,
e) comparing said parameters with a measure of the chromatic emissions made in a generic second time instant (t1) different from said first instant,
f) regulating the intensity of the light sources of said lighting body in a way to bring the intensity of the chromatic emissions to the values measured in said first time instant or to a predetermined value.

2. Method according to claim 1 **characterized in that** the step of regulating the intensity of the light sources is effected using the mutual ratios between the differences of intensities of the chromatic emissions of said set of emissions.

3. Method for controlling the light emission of a lighting body (50) having at least two light sources that can be controlled in intensity, said method comprising the steps of:

a) defining at least a reference point (200) in a zone (191) which is not lightened by said lighting body,
b) making a measure of the intensity of each component of a set of chromatic emissions in said reference point, said measure being carried out with a natural or artificial reference light and in a defined first time instant (t0),
c) computing the difference of intensity between said chromatic emissions and computing the measured absolute intensity, obtaining a set of parameters,
d) storing said parameters in a suitable memory location of the lamp,
e) storing in said lighting body the intensity that must be given to the source depending on said differences,
f) interpolating the intensity to be given to the light sources in a generic second time instant (t1) as a function of said differences between said parameters.

4. A method according to claim 3 **characterized in that** said step of regulating the intensity of the light sources is made using the mutual ratios between the differences.

5. A method according to claim 1 or 2 comprising the further steps of measuring the intensity table as a function of time and regulating the intensity as a function of time instant derived upon interpolation of said table.

6. A method according to claims 3 and 4 comprising the further steps of measuring the intensity table as a function of time and regulating the intensity as a function of time instant derived upon interpolation of said table.

7. Lighting apparatus comprising at least two light sources (100) that can be controlled in intensity, and **characterized in that** it is suitable to operate with a method according to any of claims 1 to 6.

8. Apparatus according to claim 7, comprising at least: a control system (120) adapted to control the light intensity of said at least two sources (100) continuously and independently; at least one microcontroller (130); at least one sensor (140) adapted to measure the intensity of a set of chromatic emissions in at least one location (150, 200); at least a data memory (160).

9. Apparatus according to claim 8, further comprising a clock generator (170) defining the time scale of said microcontroller (130).

10. Apparatus according to claim 8 or 9, said light sources being LED diodes.

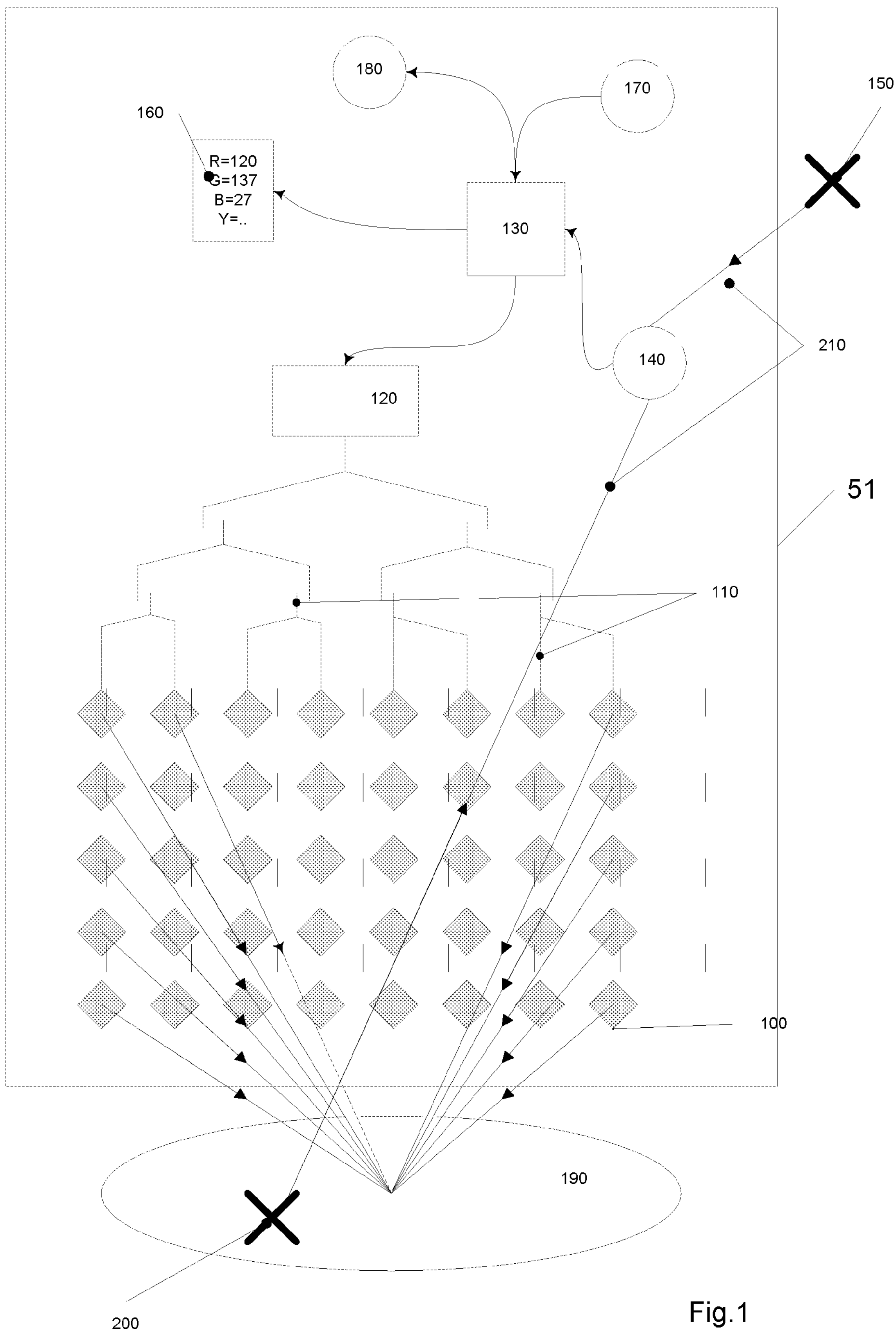
180
170
160
R=120
G=137
B=27
Y=..
130
150
140
210
120
51
110
100
190
200

Fig.1

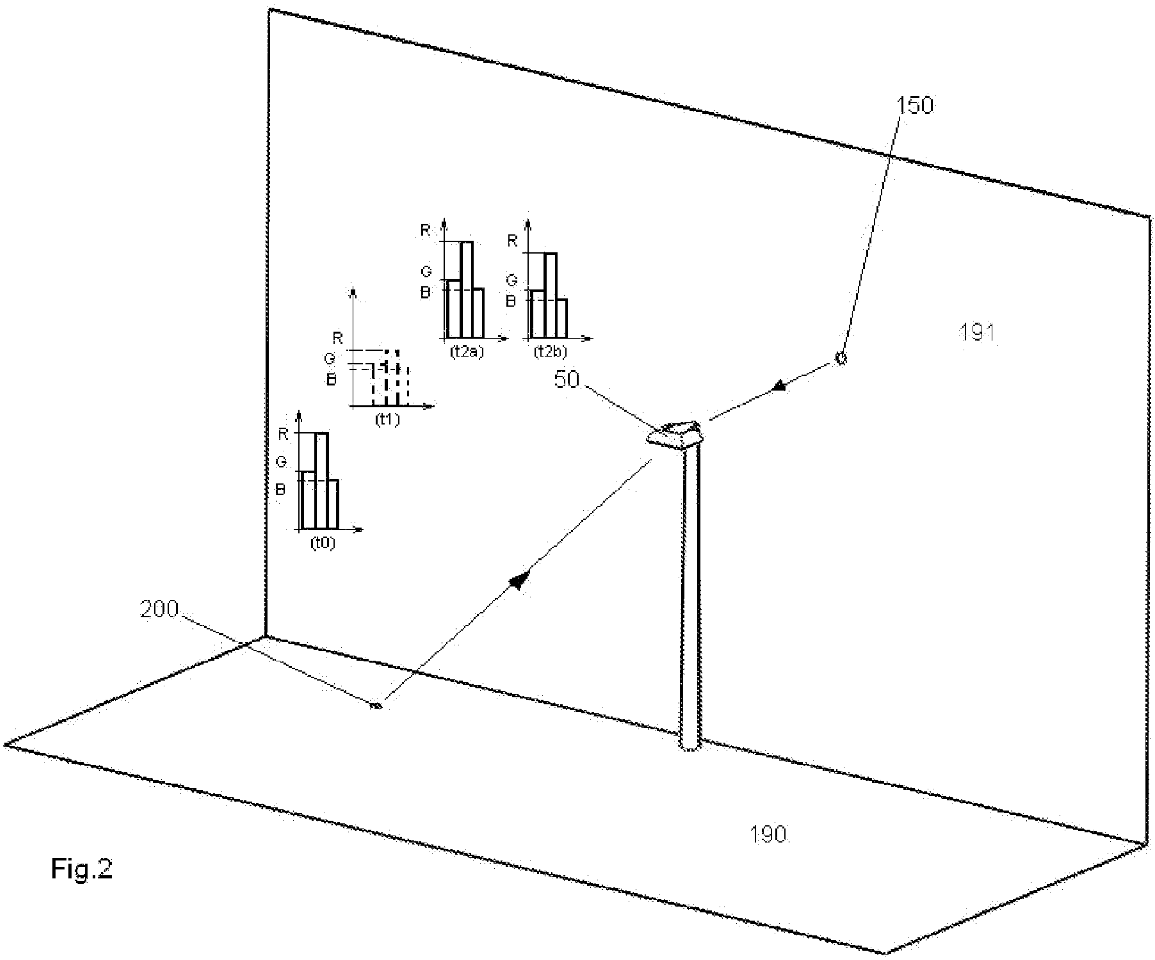

Fig.2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2101106 A **[0005]**
- KR 20010069867 **[0008]**
- CA 2411219 **[0008]**