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(54) Title: ILLUMINATION SYSTEM

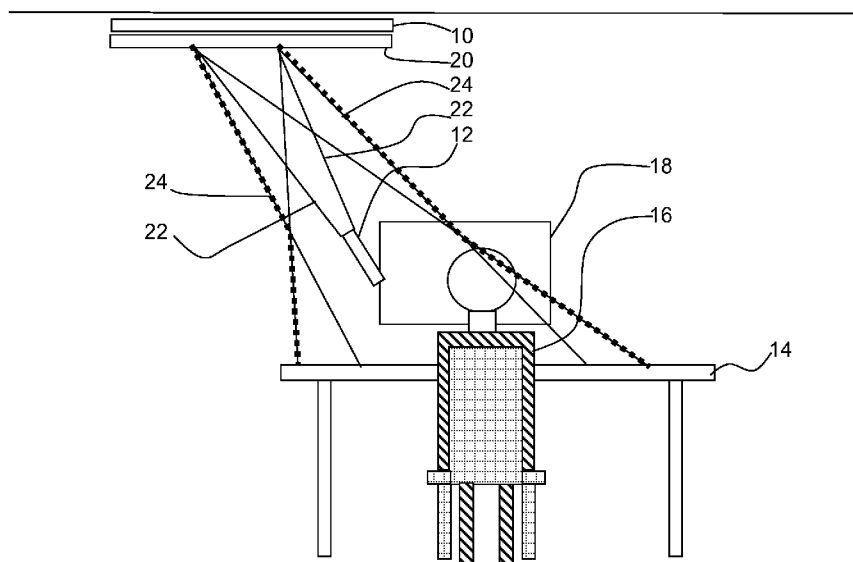


FIG. 1

[Continued on nextpage]

Illumination system

FIELD OF THE INVENTION

This invention relates to illumination systems, for example for illuminating indoor office or home areas.

5 BACKGROUND OF THE INVENTION

There are many different types of illumination systems. There include floor standing, table standing, wall mounted and ceiling mounted lighting fixtures, with diffuse or focussed light.

Diffuse fixtures can make use of diffusers and white reflective surfaces, which reflect light in a wide range of directions. Diffusers and white reflectors are not expensive. The surfaces can be relatively large, and have a much lower brightness than the light source (e.g. a bulb or an LED) itself. A larger area light source is less distracting to a user. Lighting in a uniform way over a large area nevertheless requires a certain distance from the light source, and a certain size of the lighting fixture.

To focus light into a certain direction, lighting systems can make use of lenses and mirrors. From a cost and volume point of view, the size of these parts needs to be limited. This results in high brightness of spot lights when directly looked at. As result of the limited size, spotlights also cause cast shadows.

Lighting fixtures can light a target directly, or indirectly via diffuse reflecting walls or ceilings for example. In the latter case, the user can be prevented from looking directly into a high brightness fixture or light source. However, the possibilities to focus the light on a smaller area are limited.

Lighting systems based on light guides with a diffuse out-coupling of light are also known.

There are various problems with the different known systems.

In many cases, a horizontal surface such as a desk has to be illuminated. To spread the light, and to avoid that lighting fixtures are in the way, a remote position is preferred. Often, the most attractive solution is a ceiling mounted fixture. Ceiling mounting has a large impact on the infrastructure: the electrical supply has to be integrated into the

ceiling, and often also the lighting fixtures are integrated to give an acceptable appearance. Because the infrastructure is modified, the type of light fixture and location are fixed, and cannot be changed easily.

In many cases, a focussed beam is required for illumination of a specific area.

5 In general, a system using lenses and/or mirror reflectors is then used. These lenses and reflectors have a limited size. As a result, when looking directly into the spot light, a small area with an extremely high brightness will be visible. This is not pleasant for the user. The small area of the lens or reflector will result in shadows being cast, which is not preferred in many situations

10 There is therefore a need for a system which can address these problems.

SUMMARY OF THE INVENTION

According to the invention, there is provided a lighting system, comprising a reflector assembly for reflecting light with a reflection direction substantially equal and
15 opposite to the direction of incidence, wherein the reflector assembly is adapted for mounting in the vicinity of an area to be illuminated and for receiving lighting from a light source in the area to be illuminated.

The system of the invention is for lighting areas using a light source located in the area to be illuminated, which can be a spot light, via a retro-reflective surface. The light
20 source will be in the area to be illuminated, in the sense that the reflected light will return to the light source. However, it may be at the edge of the main area of interest, such as a desk, so that any shadows which are cast by the light source are not visible in the central part of the main area of interest.

The retro-reflective surface, when illuminated by the spotlight, can be
25 regarded as a thin extended light source which radiates directional light. The light will be focussed back to the light source and its direct surroundings. The area of illumination will depend on the optical properties of the reflector assembly. The original light source beam divergence will affect the area on the retro-reflector that is used to light the area to be illuminated.

30 The invention can be used to provide additional flexibility to lighting systems, and to enable indirect lighting (avoiding visible light sources with high brightness, and to reduce cast shadows), but still with the option to focus light on a certain area. This flexibility can be obtained by suitable selection of the light source, by its positioning and the properties

of the light output beam. Thus, the reflector assembly can be fixed and yet provide flexibility in the lighting to be obtained.

The reflector assembly can comprise an array of corner retro-reflectors. With such corner retro-reflector foils, the light can be focussed on a relatively small area around the spotlight (of the order of magnitude 0.02 times the distance between the area and the retro-reflector). By using less perfect retro-reflectors, or by adding a soft diffusing layer in front of the retro-reflector, the dimensions of the illuminated area around the spotlight can be increased.

Additionally, the illuminated area can be out of focus, by providing a different distance between the reflector assembly and the light source than between the reflector assembly and the area to be illuminated.

This invention enables an area to be illuminated by an extended light emitting surface which emits directional light. This light emitting area on the retro-reflector can be chosen by aiming and focussing/defocusing the light source. No electrical infrastructure is needed at the location of the light emitting surface (e.g. the ceiling of the room).

If a diffuser is used, it can introduce a diffusion limited such that the angle of reflection is within 30 or more preferably 20 degrees of the direction opposite to the direction of incidence, i.e. the retro-reflection is made imperfect. A diffuser is not perfect and some light will escape at undesired angles. Thus, the diffuser function can be considered satisfactory if at least 50 % of the light through the diffuser is within the desired angular range.

This means that the spread of the reflected light away from the original light source is limited, so that as much light as possible reaches the intended area of illumination, such as a desk. The diffusing properties of the diffuser or less perfect retro-reflector will determine the area that can be illuminated using a given light source. The optimal angle of diffusion will mainly depend on the dimensions of the area that has to be illuminated, and the distance between the reflector assembly and this area. For example, with an illuminated circular area with diameter 70 cm, and a distance to the retro-reflector of 200 cm, the desired angle will be around 10 degrees (i.e. 20 degrees total spread of light, 10 degrees each side of the perfect reflection direction).

The invention also provides a lighting installation comprising a reflector assembly of the invention, and a light source mounted in an area to be illuminated, and directed to the reflector assembly. The reflector assembly is then mounted on a ceiling or

wall in the vicinity of the area to be illuminated, and the light source output is directed to the reflector assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

5 Examples of the invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 shows a first example of lighting installation of the invention; and

Figure 2 shows a second example of lighting installation of the invention.

10 DETAILED DESCRIPTION OF THE EMBODIMENTS

The invention provides a lighting system in which a retro-reflector is mounted, for example to the ceiling or wall of a room, for illumination by a light source mounted in an area to be illuminated. It can be mounted on a partition or a suspended structure.

15 When placing a desk in this room, this desk can be equipped with the light source such as a spotlight aimed at the reflector on the ceiling or wall. The retro-reflector will direct the light back to the desk, lighting its surface. In this way, the light emitting area on the ceiling can be freely adapted to the location of the desk.

20 Figure 1 shows a first example of lighting installation of the invention. The installation comprises a lighting system in the form of a reflector assembly 10 and a light source for illuminating the reflector assembly.

25 The reflector assembly comprises a retro-reflector 10, which is a reflector for reflecting light back along its original angle of incidence. An area of the reflector 10 is illuminated by a light source 12, which in this example is a spotlight mounted on a desk 14 in the area to be illuminated. The user 16 is shown seated at the desk 14 in front of a monitor 18.

A perfect retro-reflector will return all light to its source, so that the light source 12 will be illuminated. A wider area of illumination is desired, for example the desk area. To achieve this, the reflector 10 can have an imperfect reflection function which is sufficient to create the desired spread in the reflected beam.

30 An alternative is to use a separate "soft" diffuser 20, i.e. one which introduces a limited amount of angular spread, for example less than 30 degrees or less than 20 degrees of angular spread about the initial propagation direction. In the example shown, the light makes two passes through the diffuser 20 so a smaller amount of introduced angular spread for each pass through the diffuser is required.

Figure 1 shows the output of the light source 12 as the envelope 22, and shows a desired reflected envelope 24 for illuminating the desk area. If a large area reflector is provided, the user can choose where to direct the light source to achieve the best lighting, for example to avoid undesired shadows, for example when writing. The direction of

illumination of the light source can for example be adapted for left/right handed people.

Figure 2 shows the same system but with a light source 12a which produces an output beam with a higher divergence. This results in a larger area of the reflector acting as the light source. By using a light source 12a with a beam with a higher divergence, the lighting can thus be made more diffuse.

If the user looks from the illuminated area to the ceiling, no bright hotspots will be visible. The desk will be illuminated by an extended area with lower brightness. By using a spotlight with a beam with a higher divergence, the size of the light emitting area on the ceiling can be increased as explained above, while the lighted area on the desk will not increase significantly. In this way, the brightness of the ceiling can even be set to a lower value than the brightness of the illumination at the area of interest, because the light has been focussed towards the area of interest.

Although the light is still focussed on the area of interest, the cast shadow will be limited as result of the large light emitting area on the reflector assembly. In some situations (e.g. on a working bench), diffuse lighting will be needed, while for other situations (e.g. lighting a sculpture), lighting with more cast shadows will be preferred. It is possible to use a spotlight with an adaptable beam divergence, so the cast shadow can be adapted to the situation and/or object to be illuminated.

When looking to the ceiling from a location outside the illuminated desk area, almost no light will be visible. From outside the desk area, it appears that the desk is illuminated from above by an invisible light source. This invisible light source will not cause disturbing reflections on monitors outside the illuminated area.

No integrated electrical infrastructure or fixtures in the ceiling are required. The reflector assembly can simply be surface mounted to the ceiling or wall.

The system can be used to light desks, but also to light other objects or areas.

The light source for providing upward (or lateral) illumination can be integrated into furniture or other existing devices, preferably already provided with electrical power such as a computer monitor. The light source can be a table mounted lamp, a floor standing lamp, a wall mounted spotlight or a light fixture integrated into the floor.

The reflector can comprise an array of corner reflectors. A corner reflector is a set of three mutually perpendicular specular reflective surfaces, placed to form the corner of a cube. There are two basic types of corner reflector. In the more common form, the corner is the truncated corner of a cube of transparent material such as conventional optical glass or plastic. In this structure, the reflection is achieved either by total internal reflection or by silvering of the outer cube surfaces. The second form uses mutually perpendicular flat mirrors bracketing an air space.

A large relatively thin retro-reflector foil can be formed by combining many small corner reflectors, using standard optimal packing of the plane with congruent triangles. With such corner retro-reflector foils, the light will be focussed on a relatively small area around the spotlight (order of magnitude 0.02 time the distance between the area and the retro-reflector). By using less "perfect" retro-reflectors, or by adding the diffusing layer in front of the retro-reflector, the dimensions of the illuminated area around the spotlight can be increased. Intentionally less perfect retro-reflectors can be made by making the specular reflecting surfaces less flat in order to spread the light over a wider range of angles. Additionally, the angles of the mirrors can be made not perfectly perpendicular, which will result in an angular offset of the reflected light. It is also possible to realize diffusing properties which are different for in different directional axes.

The spread of the light can be further increased by putting the illuminated area "out of focus", so at a different distance to the retro-reflector than the spotlight is situated. Thus, even with a corner reflector foil providing a near perfect reflection profile, the area of illumination can be increased by adding a diffuser foil and positioning the light source some distance above the area to be illuminated. For example, the light source can be mounted at the top of a computer monitor. The light source is still within the area to be illuminated, i.e. within the volume bounded by the envelope 24. Thus, the term "area" in this context is not restricted to a planar area, but relates to a general region (i.e. a volume) where illumination is desired. In practice, the light is only visible once it reflects off an illuminated object, which will generally be on a flat surface such as a desk.

Another common type of retro-reflector consists of refracting optical elements with a reflective surface, arranged so that the focal surface of the refractive element coincides with the reflective surface, typically a transparent sphere and a spherical mirror. This same effect can be achieved with a single transparent sphere provided that the refractive index of the material is exactly two times the refractive index of the medium from which the radiation is incident. In that case, the sphere surface behaves as a concave spherical mirror with the

required curvature for retro-reflection. The components making up the reflector, in particular the lens shape, can be designed to give the desired non-perfect reflection characteristics, and thereby achieve the desired diffusion without any additional components.

When a diffuser is used, it can comprise a surface diffuser or a volume
5 diffuser.

A surface diffuser for example comprises a plate or foil made of a transparent material, with a texture or pattern at the surface of one or both sides. By selecting the texture, the diffusing angle can be controlled by refracting the light. It is possible to have different diffusing properties along both axes in the plane of the foil or plate. With this kind of
10 diffuser, it is possible to control the dimension of the lighted area along two axes independently.

A volume diffuser for example comprises a plate or foil made of transparent basic material, containing small particles with a different refractive index to the basic material. The difference in refractive index causes reflection and refraction of the light
15 passing through the foil or plate. Diffusing properties can be controlled by refractive indices, and the size, shape and concentration of the particles.

The reflector assembly can comprise plates or foils that can easily be installed into an existing area, or in the case of a new building they can be formed as an integrated part of the building elements for ceiling or wall construction, replacing the traditional finishing.

20 The reflector surface can be added locally or over a whole ceiling or wall surface, to allow wider illuminated areas, more freedom to choose the direction from which the area is illuminated, and more flexibility in the possible positioning of the light source.

The reflector assembly and the light source can be chosen to give desired illumination effects. For example a small illuminated area may be required to illuminate a
25 specific object, such as a piece of art, whereas a larger area may be desired to illuminate a whole desk. Many adjustments can be made by suitable choice of the light source design (such as the angular spread of the output) and position even for a standard reflector design.

Examples of the parameters that can be controlled are (i) the dimensions of the light source, (ii) the distance between the light source and the illuminated surface; and (iii)
30 the divergence of the light leaving the light source,

As explained above, there may be a shadow of the light source in the area to be illuminated. Choosing a smaller dimension of the light source, a larger distance between the light source and the illuminated surface, and/or a more divergent beam will reduce the visibility of the shadow, if desired.

It is noted that the term "a reflection direction substantially equal and opposite to the direction of incidence" is intended to convey the general return of the light to the light source, but with the intentional diffusion introduced, by the use of a non-perfect retro-reflector and/or the use of a diffuser.

5 Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent
10 claims does not indicate that a combination of these measured cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. A lighting system, comprising a reflector assembly (10, 20) for reflecting light with a reflection direction substantially equal and opposite to the direction of incidence, wherein the reflector assembly (10) is adapted for mounting in the vicinity of an area to be illuminated and for receiving lighting from a light source (12) in the area to be illuminated.

5

2. A system as claimed in claim 1, wherein the reflector assembly (10, 20) comprises an array of corner reflectors.

10

3. A system as claimed in claim 2, wherein the corner reflectors are adapted to diffuse the reflected light in such a way that it is spread within a certain angle with respect to the direction opposite to the direction of incidence.

4. A system as claimed in claim 1, wherein the reflector assembly (10, 20) comprises a diffuser (20).

15

5. A system as claimed in claim 4, wherein the diffuser (20) introduces a diffusion limited such that the angle of reflection for at least 50 % of the reflected light is within 30 degrees of the direction opposite to the direction of incidence.

20

6. A system as claimed in claim 4, wherein the diffuser (20) introduces a diffusion limited such that the angle of reflection for at least 50 % of the reflected light is within 20 degrees of the direction opposite to the direction of incidence.

25

7. A system as claimed in claim 4, wherein the diffuser (20) introduces a diffusion which is different for orthogonal axes in the plane of the diffuser (20).

8. A system as claimed in claim 4, wherein the diffuser (20) comprises a surface diffuser, having one or more surfaces configured to implement diffusion by refraction.

9. A system as claimed in claim 4, wherein the diffuser (20) comprises a volume diffuser, having internal refracting regions configured to implement diffusion by refraction.

10. A lighting installation comprising:

- 5 - a reflector assembly (10, 20) as claimed in claim 1; and
- a light source (12) mounted in an area to be illuminated, and directed to the reflector assembly.

11. An installation as claimed in claim 10, wherein the reflector assembly (10, 20)
10 is mounted on a ceiling in the vicinity of the area to be illuminated, and the light source output is directed upwardly to the reflector assembly.

12. An installation as claimed in claim 10, wherein the reflector assembly (10, 20)
is mounted on a wall in the vicinity of the area to be illuminated, and the light source output
15 is directed laterally to the reflector assembly.

13. An installation as claimed in claim 10, wherein the light source (12) comprises a spot light.

20 14. An installation as claimed in claim 10, wherein the direction of the light beam emitted by the light source (12) is adjustable by a user.

15. An installation as claimed in claim 10, wherein the divergence of the light beam emitted by the light source (12) is adjustable by a user.

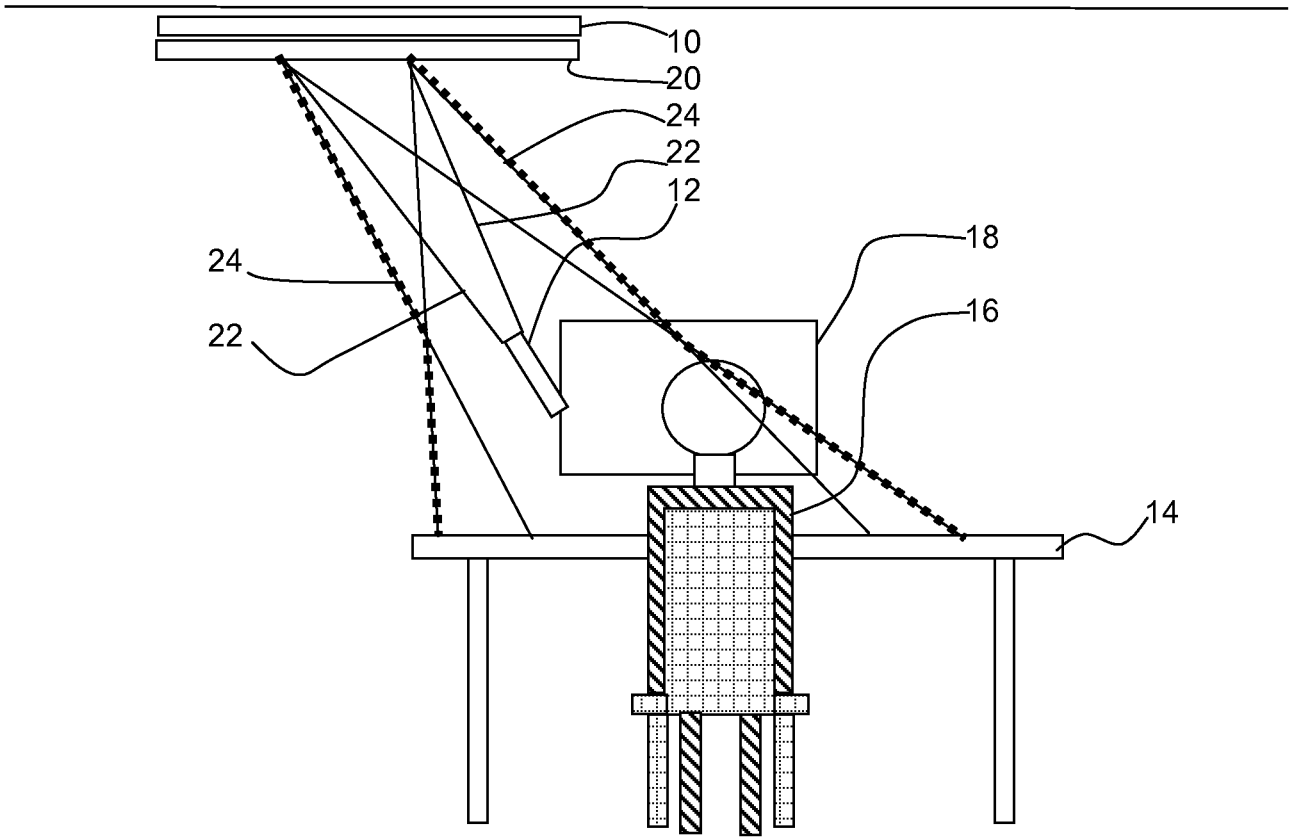


FIG. 1

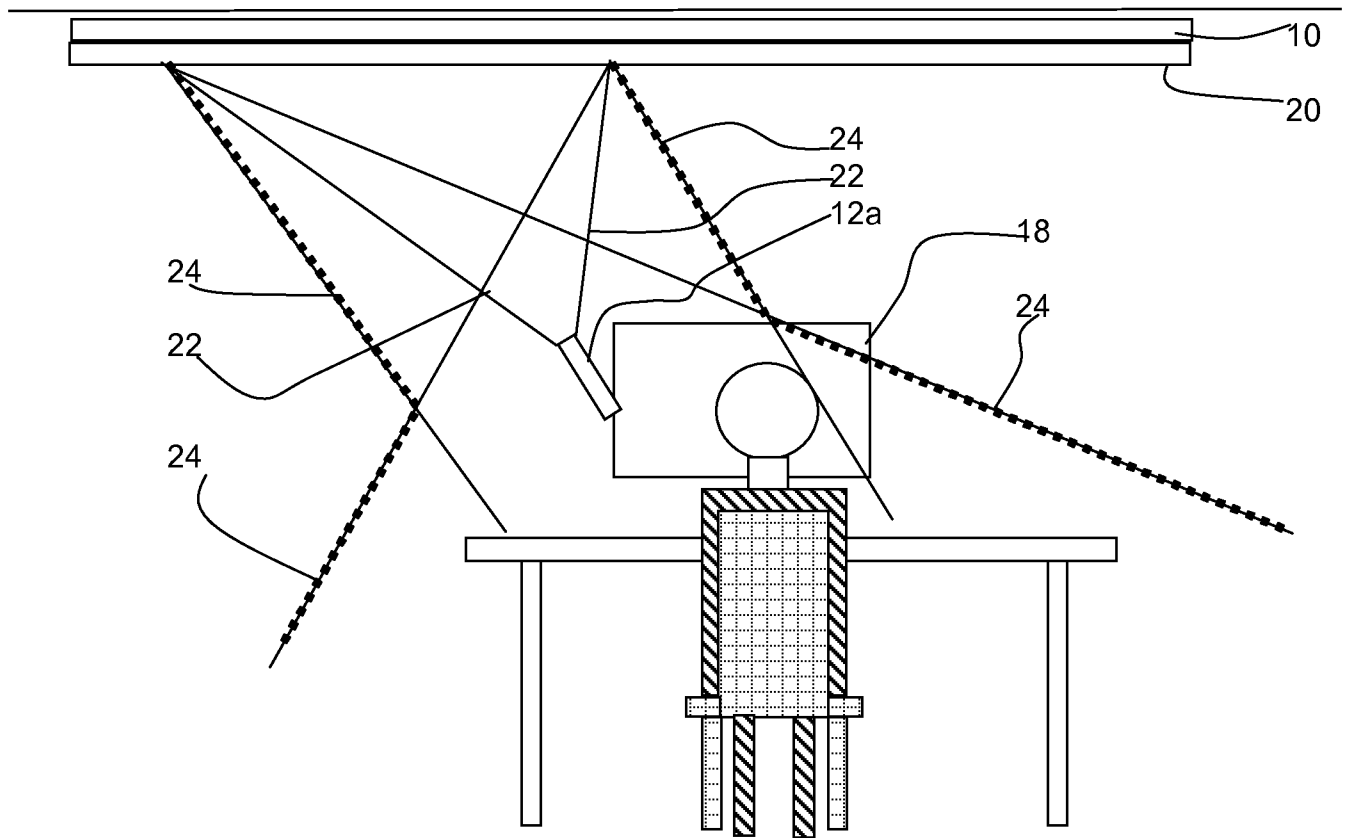


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. F21S8/00 E04B9/00 F21V7/00
ADD. F21W131/402

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F21S E04B F21V F21W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2013/050051

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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