United States Patent [19]

Aizenberg et al.

[11] **3,902,056**

[45] **Aug. 26, 1975**

[54] INTERIOR LIGHTING FIXTURE

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[21] Appl. No.: **470,288**

[52] **U.S. Cl.** ..... **240/1 LP;** 240/10 C; 240/41.1; 350/264

[51] **Int. Cl.** **F21**

[58] **Field of Search** ..... 240/1 LP, 1 EL, 10 C, 41.1, 240/1 R; 350/96 R, 258, 264

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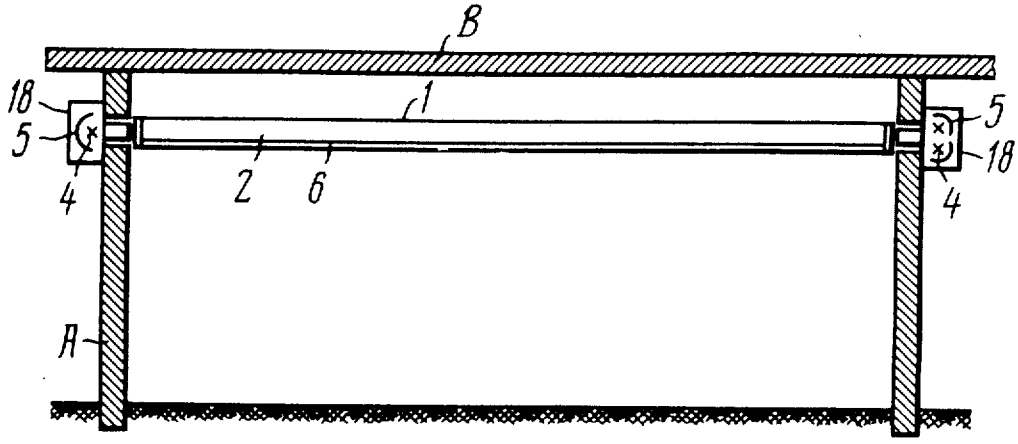
Primary Examiner—Richard L. Moses

Attorney, Agent, or Firm—Waters, Schwartz & Nissen

[57] **ABSTRACT**

An interior lighting fixture comprising a light guide whose casing is covered on the surface at least partly with a layer which reflects the luminous radiation emitted by a light source and is made of an elastic light-transmitting film; said casing is provided with devices for imparting the desired shape to the light guide installed in the building.

13 Claims, 18 Drawing Figures



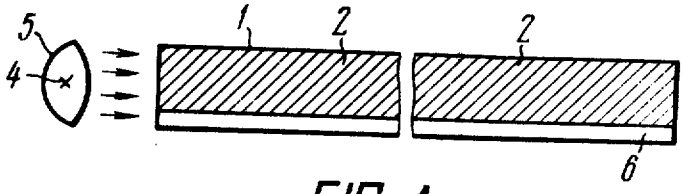


FIG. 1

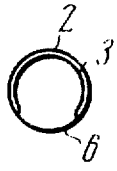


FIG. 2

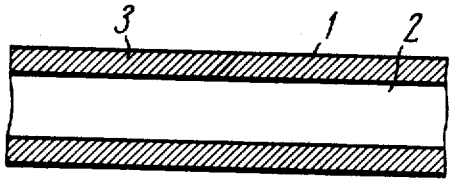


FIG. 3

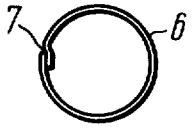


FIG. 4

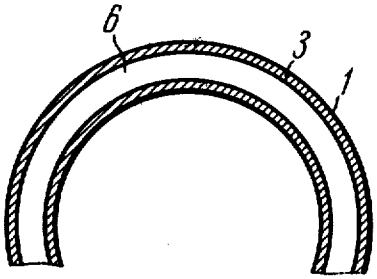


FIG. 5

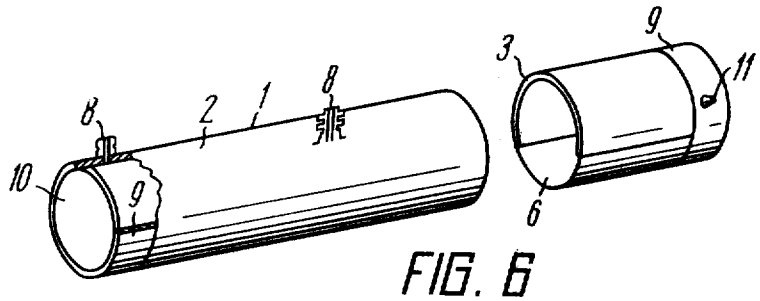


FIG. 6

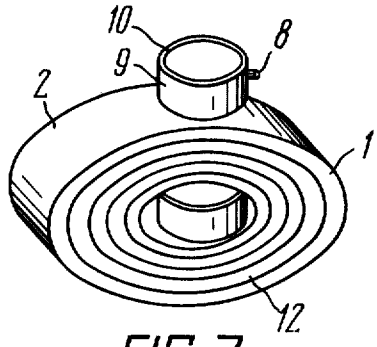


FIG. 7

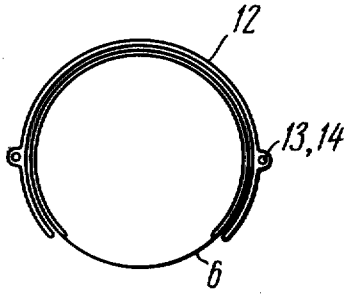


FIG. 8

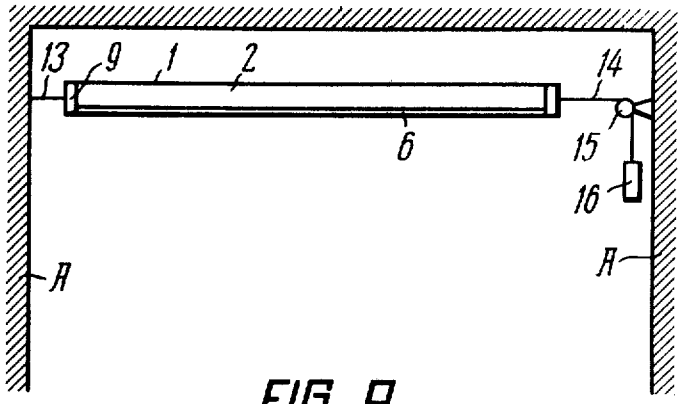


FIG. 9

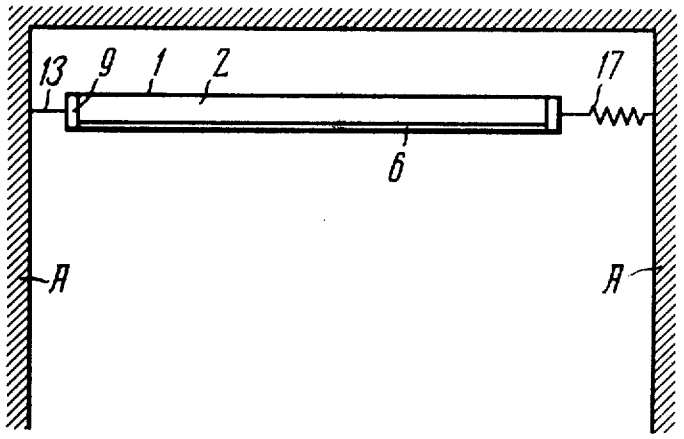


FIG. 10

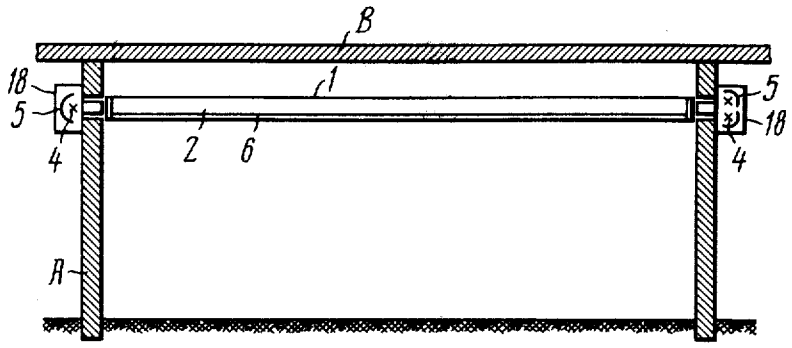


FIG. 11

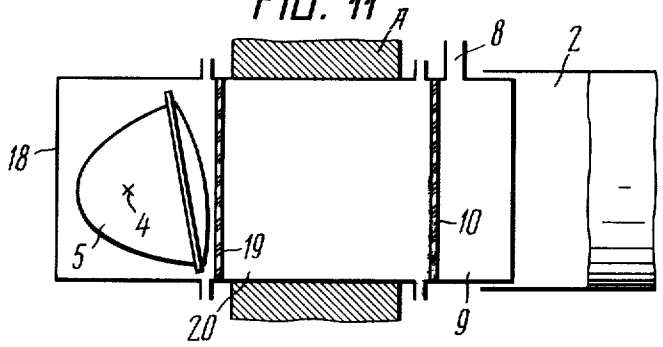


FIG. 12

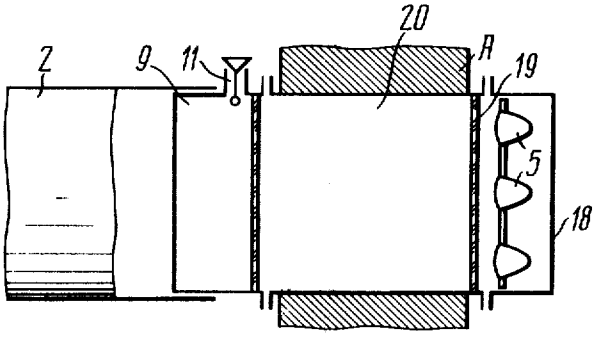


FIG. 13

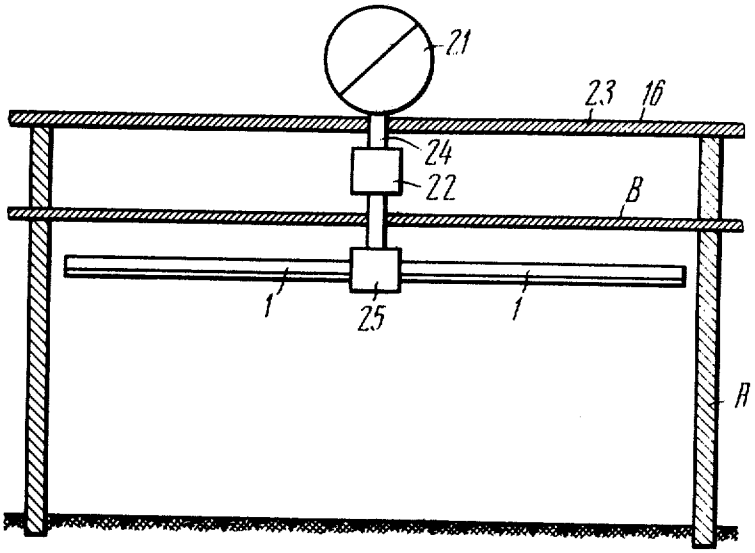


FIG. 14

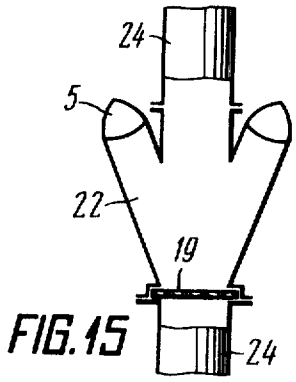


FIG. 15

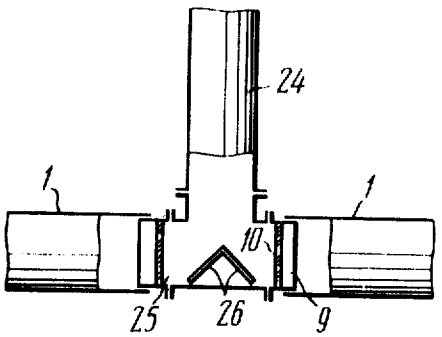


FIG. 17

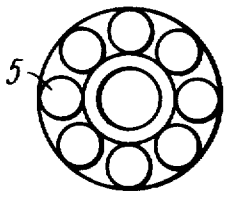


FIG. 16

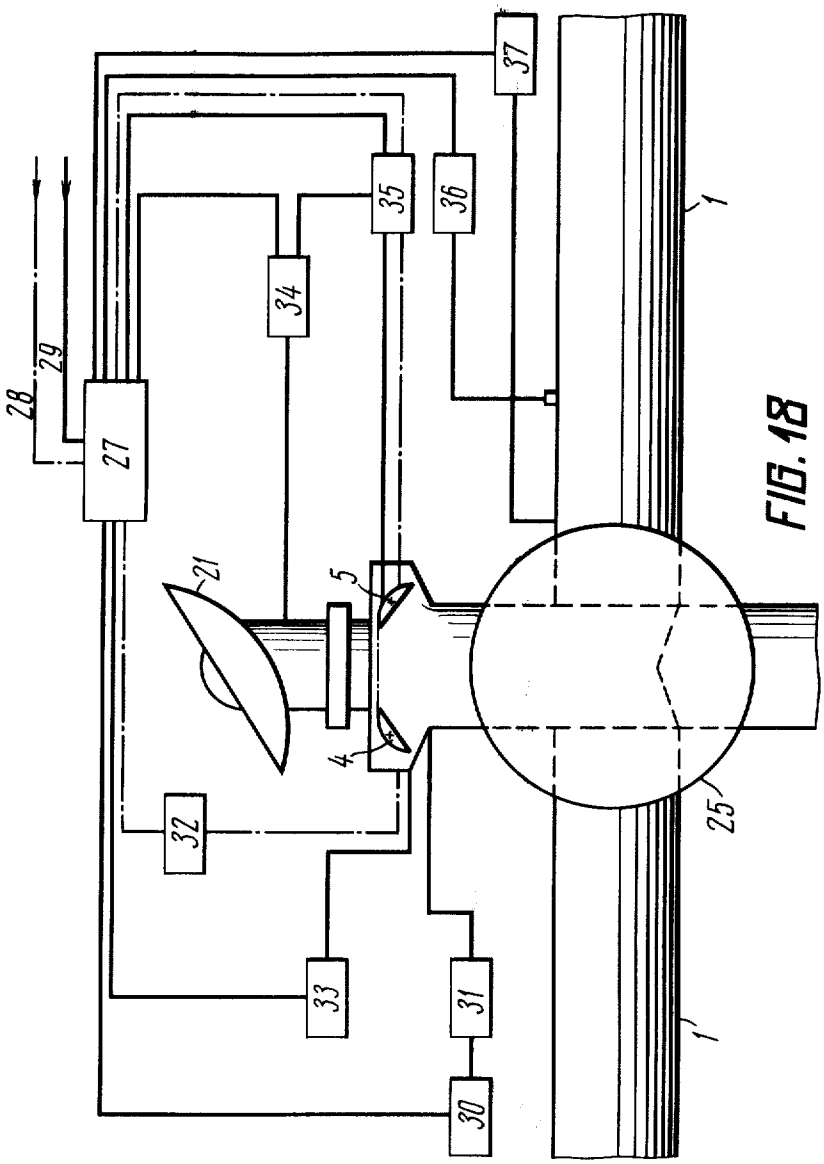


FIG. 18

INTERIOR LIGHTING FIXTURE

The present invention relates to the field of illumination engineering and more specifically, to interior lighting fixtures.

The interior lighting fixture according to the invention can be used, for example, in the workshops of chemical, textile, machine-building and other industries, in industrial and other buildings not provided with natural daylight illumination.

Another possible field of application of the interior lighting fixture according to the invention is its employment in public and administrative buildings for general and architectural lighting.

Besides, the lighting fixture according to the invention can also be used for local lighting of workplaces where a high luminous intensity is required.

The known interior lighting systems are based on the use of separate fixtures for natural and artificial lighting. The natural lighting is ensured through various light apertures which are the structural elements of buildings, such as windows, skylights, etc. Artificial lighting is ensured by a multitude of various lighting fixtures comprising many luminaires with various lamps. The luminaires used in the industrial and public buildings can be installed remotely from one another, in concentrated groups or rows, or in other geometrical layouts.

Known in the art are luminous ceilings and strips consisting of a multitude of lamps installed above light-diffusing surfaces or screening grilles.

Also known in the art is an interior lighting installation comprising devices for admission of natural radiation, a solar energy concentrator and a light redistributor (U.S. Pat. No. 3,511,559). However, such installations fail to ensure uniform general lighting of buildings and are incapable of providing adequate lighting conditions in absence of natural radiation.

Also known are individual lighting fixtures (Authro's Certificate No. 181,023, USSR) with rigid channels of louver-type light guides, a part of their surface in length being covered with a reflecting layer while the light entering the end of the light guide is emitted from it along its generatrix.

The disadvantages of all the known fixtures for lighting industrial and public buildings become particularly pronounced under the conditions of ever-growing illumination standards and can be summarized as follows: a large number of luminaires (tens and hundreds of thousand units) of a comparatively low power (up to 1.5 – 2.0 kW) used in the lighting installations; extremely long electrical circuits of the lighting installations involving inevitable losses of electrical energy in these circuits; a large amount of labour required in manufacturing the lighting fixtures and considerable expenditures of materials and associated equipment; high operating expenses caused by the necessity for periodical replacement of lamps and cleaning of luminaires; great captial investments for the construction of lighting installations; a ssharp difference in the conditions of natural and artificial lighting.

All the above-listed disadvantages are considerably aggravated in industrial buildings with a high dust content in the air, and in presence of chemically active or explosive vapours and gases.

The known lighting fixtures based on louver-type luminaires — light guides — could not overcome the above disadvantages since they could utilize only short

small-diameter channels by reason of a practical impossibility of making, transporting, installing and operating rigid large-size ducts made of such traditional materials as lime silicate glass, extruded plastics or metal-glass and metal-plastic compositions. Besides, the application of the mirror reflecting layer on the inner surface of long pipes is also highly complicated from the technological point of view. Hence, individual lighting fixtures based on louver-type light guides were not put in common practice.

Thus, the contemporary world standards achieved in interior illumination of industrial and public buildings cannot introduce qualitative changes into the lighting systems employed at present because all the advances in this field in many recent years have been achieved basically on merely quantitative lines, i.e., increasing the number and power of the lamps and luminaires and employing the light sources with a high luminous efficiency.

An object of the present invention resides in eliminating the aforesaid disadvantages of the existing interior lighting fixtures by providing radically new lighting fixtures.

The main object of the invention is to provide an interior lighting fixture with a minimum number of radiation sources of a maximum possible power whose luminous flux is distributed as required throughout the building with the aid of long lighting fixtures characterized by a sufficiently uniform brightness of permissible intensity. This lighting fixture is called upon to provide uniform interior illumination at any time of day, to reduce sharply the length of electric supply circuits, to bring to a minimum the influence of the atmosphere in the building on the operational characteristics of new lighting fixtures, to ensure their absolute explosion-and-fire safety and to provide a possibility of varying the illumination intensity and the spectral composition of the radiation within any limits without changing the structural parameters of the lighting fixture.

This object is accomplished by providing an interior lighting fixture comprising a light guide installed in a building, at least a part of the surface of the casing of said light guide being covered with a layer which reflects the luminous radiation introduced into said light guide from a light source with the aid of reflectors wherein the light guide casing is made, according to the invention, from elastic light-transmitting polymer film and is provided with devices for imparting the desired shape to the light guide installed in a building.

It is practicable that the elastic light-transmitting film should be a vacuum-tight polyethyleneterephthalate or triacetate film.

The light guides can be made of a toroidal shape.

It is practicable that the desired shape should be imparted to the light guide by means of air delivered under an overpressure into the inlet valves installed on the light guide casing.

The desired shape can be imparted to the light guide installed in a building by means of at least two rigid shaping elements in the form of rings located at least on the ends of the light guide.

Said rings can be provided with inlet valves for the supply of air into the light guide at a pressure exceeding atmospheric.

Besides, it is practicable that at least one rigid shaping element of the light guide should have an outlet

valve through which the air heated by the radiation source would escape into the illuminated building.

It is possible to fasten the ends of at least two cable on said rings, securing the end of one of the cables to one ring located at one end of the light guide and passing the other end of the same cable provided with a weight over a sheave mounted on a supporting surface, e.g. on a building wall, and to fasten one end of the second cable to the second ring located at the other end of the light guide, securing the other end of said second cable to the opposite wall of the building.

Besides, it is practicable that the light guide should be located in the illuminated building in such a manner as to install both its ends in close proximity to the opposite walls of the building and that it should be provided with at least one optical reflector for the admission of light radiation, said device being located at the end of the light guide outside the building.

It is good practice to locate the light guide in the illuminated building so as to install both its ends in closed proximity to the ceiling and floor of the building and to provide it with at least one optical reflector for the admission of light radiation, locating this device at the end of the light guide outside the building.

It is good practice that the light guide should be in optical communication with at least one concentrator of solar energy located outside the illuminated building and directing natural radiation into the same light guide channel which conducts the radiation of artificial light sources.

The employment of the lighting system according to the invention with powerful light sources with light guides made of elastic light-transmitting film redistributing the luminous flux of the radiation sources in illuminated buildings and with devices for imparting the preset shape to the light guides installed in a building yields the following advantages:

- it reduces radically (10 to 100 times) the number of light sources and luminaires in industrial and public buildings;
- it reduces many times the length of electric supply circuits in the lighting installations;
- it curtails radically the expenditures of materials and labour for the manufacture of luminaires, start-control devices and electrical fittings;
- it ensures the possibility of transmitting simultaneously or alternately the natural sun radiation and the radiation of artificial light sources through the same light guides with the use of a photoelectric illumination control system and using the same light guides to ensure various luminous intensities and different spectral compositions of radiation in one and the same building;
- it improves the reliability of the lighting system by enabling reservation of light sources;
- it improves the appearance of the lighting installation since failure of a lamp in a group source makes practically no changes in the lighting installation;
- it reduces the heat transfer from the lighting installation into the illuminated building either completely (when the group source of light is located outside the building, above the ceiling or behind the wall) or several times (when the lighting installation is installed in the building but in a ventilated chamber);
- it cuts down sharply the expenses for mounting and operation of the lighting installation.

Now the invention will be described in detail by way of example with reference to the accompanying drawings, in which:

FIG. 1 is an elementary diagram of the light guide;

FIG. 2 shows a cross section of the light guide;

FIG. 3 is a view of the light guide casing when developed onto a planar surface according to the invention;

FIG. 4 shows the design of the light guide channel according to the invention;

FIG. 5 shows a curvilinear light guide of a toroidal shape, according to the invention;

FIG. 6 shows the light guide with a casing of elastic light-transmitting polymer film according to the invention;

FIG. 7 shows the light guide made of a film and coiled for transportation, according to the invention;

FIG. 8 shows the design of the shaping elements according to the invention;

FIG. 9 shows a device with a weight for imparting the preset shape to the light guide installed in a building;

FIG. 10 same, with a spring-type take-up unit;

FIG. 11 shows the interior lighting system employing a light guide with the optical devices for the admission of luminous flux installed outside the building;

FIGS. 12 and 13 illustrate the devices for admitting luminous radiation into the light guide and their connection with the light guide channels;

FIG. 14 shows the interior lighting system employing light guides optically connected with a solar energy concentrator and with devices for the admission of radiation of artificial light sources according to the invention;

FIG. 15 shows the joint between the channel conducting natural radiation and the chamber accommodating the devices for admitting radiation of artificial sources;

FIG. 16 same, top view;

FIG. 17 shows the light radiation redistributor;

FIG. 18 is an elementary diagram of the interior lighting fixture.

The interior lighting fixture (FIGS. 1, 2) comprises a light guide 1 with a casing 2 whose surface is covered, at least partly, throughout its length with a layer 3 reflecting the light radiation introduced from a light source 4 with the aid of optical reflectors 5.

The light guide 1 may have any shape and its casing 2 is made of elastic light-transmitting film, e.g. vacuum-tight polyethyleneterephthalate film.

Besides, the elastic light-transmitting film can be made of vacuum-tight triacetate film.

The case 2 of the light guide 1 is covered with a layer 3 reflecting luminous radiation either for transmission of luminous radiation from one end of the light guide 1 to the other, or partly along the cross-section throughout its length so that part of the surface of the casing 2 having no layer 3 serves as a light-transmitting optical slot 6. The reflecting layer 3 will be most efficient if it is made of a mirror coating which can be applied to the casing 2 either by aluminizing in a vacuum or by applying multiple-layer interference coatings.

The casing 2 of the light guide 1 can be made of a film strip (FIG. 3). The strip is made as a single piece of a light-diffusing or transparent film whose edges are covered with a light-reflecting layer 3, the optical slot 6 being located in the centre along the strip axis. The casing 2 of the light guide can also be made of a heat-sealed or glued strip consisting of ribbons of light-

transmitting film covered with a light-reflecting layer 3.

Shown in FIG. 4 is a heat-sealed or glued channel of the light-guide 1 with a vacuum-tight seam 7. The vacuum-tight seam 7 can be produced by ultrasonic welding. It is also possible to manufacture the casing 2 of the light guide 1 by the seamless extrusion method.

The light guide 1 can have a rectilinear shape with smooth curves for bypassing such obstacles as trusses, girders and other structural elements, ventilating and other sanitary pipes. The light guide 1 in the lighting fixtures of public buildings may be of a curvilinear shape, e.g. toroidal.

The light guides have different cross sections, including circular and elliptical. The optical slot 6 (FIGS. 1–5) extends the whole length of the light guide 1. It is possible to make the light guides 1 with an intermittent optical slot 6 when the strip of the light-transmitting film has alternating portions covered with, and free of, the light reflecting layer.

The optimum parameters of the light guides 1 with regard to the characteristics of the layer 3 lie within the following limits: the relation of the length of the light guide 1 to its diameter ranges from 30 to 50, the angular size of the optical slot being from 90 to 60°.

Air supplied under an overpressure through the inlet valves 8 located on the casing 2 of the light guide 1 (FIG. 6) can be used as a device for imparting the desired shape to the light guide 1 installed in a building. The device for imparting the desired shape to the light guide 1 installed in a building can also be constituted by rigid shaping elements 9 in the form of rings arranged along the length of the light guide 1. The rings can be provided with inlet valves 8 for feeding air into the light guide at a pressure exceeding atmospheric. Besides the rings 9 are provided with light-transmitting end elements 10 for sealing the inside space of the light guide. The light-transmitting elements 10 are made of lime silicate glass, heat-resistant plastic, e.g. polycarbonate, or heat-resistant polymer film.

One of the rigid shaping elements 9 of the light guide can be provided with an outlet valve 11 which lets the air heated by the light sources into the illuminated building.

For transportation and storage, the light guides of a considerable length (25–100 m) can be wound in coils, for example as shown in FIG. 7.

For imparting the desired shape to the light guide in a building, the rigid shaping elements in the form of rings 9 (FIG. 6) or ribs 12 (FIG. 8) are connected to cables 13 and 14 (FIG. 9) one of which 14 is passed over a sheave 15 secured to a supporting surface, for example the wall A of the building with a weight 16 fastened to the end of said cable 14.

With the same purpose in view it is possible to use light guides 1 (FIG. 10) with the shaping elements 9 located at their ends and provided with spring-type take-up units 7.

The light guide 1 can be located in the interior lighting fixture is such a manner that both its ends are in close proximity to the opposite walls of the building (FIG. 11) and have at least one optical reflector 5 for admitting the luminous radiation from the light source 4, said device being housed in a chamber 18 at the end of the light guide 1 outside the building. The light guide 1 proper is mounted at the required height under the ceiling inside the building.

The optical devices for the admission of luminous radiation consisting of reflectors, refractors or combinations thereof are accommodated in the chamber 18 beyond the walls A of the illuminated building (FIG. 11). The chamber 18 may accommodate either a single powerful radiation source (FIG. 11, left) or a group of powerful radiation sources (FIG 11, right). Installation of the radiation sources and optical radiation-admitting devices outside the illuminated building is particularly practicable if the building contains an explosive or fire-hazardous medium.

The interior lighting fixture will include parallel rows of light guides 1 ensuring, say, a uniform distribution of light.

Shown in FIGS. 12 and 13 are the devices for admitting radiation into the light guides with a single light source 4 (FIG. 12) or with several light sources 4 (FIG. 13) located in the chambers 18 outside the buildings. The luminous flux is conducted from the light sources 4 by the reflector 5 into the end of the light guide 1 through a sidelight 19 in the wall A and through a portion 20 of the end light guide extending through the wall A. The ring 9 (FIG. 13) can be provided with an outlet valve 11 for the delivery and distribution in the building of the clean air that has passed through the light guide and has been heated by the radiation sources.

It is possible to use such interior lighting systems wherein the light sources 4 and the optical reflector 5 for admitting radiation are installed above the ceiling B and under the floor of the building with the vertically-positioned light guide 1 and which differ from the above-described systems in that the light sources and the optical devices for admitting radiation into the light guide are located directly in the illuminated building which proves most practicable when the air in said buildings contains no hazardous components.

In both cases the light guides are suspended or stretched in the buildings by means of cables 13 and 14 connected to the shaping elements (FIGS. 9–11).

The interior lighting fixture can comprise a light guide 1 communicating optically with at least one solar energy concentrator 21 (FIG. 14) installed outside the illuminated building and directing artificial radiation into the same the light guide 1 channel which conducts the radiation of artificial light sources.

FIG. 14 shows an interior lighting fixture comprising light guides which receive the luminous flux both from the sun with the aid of the concentrator 21 and from artificial radiation sources installed in the chamber 22 together with the optical devices for admitting radiation. The concentrator 21 is installed outside the illuminated building under the roof 23 whereas the chamber 22 accommodating the artificial radiation sources and the optical devices for admitting said artificial radiation into the light guide is installed above the ceiling B of the building (although it can be installed inside the building too). The concentrator 21 and the chamber 22 with the light sources are in optical communication with each other and with the louver-type light guides 1 by means of channels 24 of the end light guides (FIGS. 14, 15, 16, 17). The luminous flux passing through the channels 24 is directed into the light guides by means of light redistributor 25 (FIGS. 14 and 17) with mirror reflectors 26 or prisms.

To provide for high luminous intensities while illuminating large buildings with light guides, the light

sources and the optical radiation-admitting devices can be spaced at 50–100 m from one another in which case the round cylindrical light guide interconnecting them will be 0.5 – 1.2 m in diameter. To ensure the admission into the light guide channels of the luminous flux of the required intensity and direction, the optical radiation-admitting devices can accommodate a number of powerful (3.5 – 5 kW) gas-discharge lamps with a high luminous efficiency. The required redistribution of their luminous flux is ensured by specially calculated optical elements (reflectors and refractors). Such interior lighting systems are capable of maintaining the necessary temperature and overpressure in the light guide channels. A combination of such systems with the air-conditioning or heating systems makes it possible to use the light guide channels for the delivery and distribution of clean air in the building through the outlet valves **18** (FIG. **13**) in the light guides.

In the arrangement where the light guides are used both for the natural and artificial interior lighting (FIGS. **14–16**) the solar radiation concentrator **21** can be of a parabolic shape with a follow-up system used in solar power engineering, or it can be dome-shaped and camprise prismatic elements.

Shown in FIG. **18** is an elementary diagram of an interior lighting fixture utilizing light guides and representing a combination of possible versions of such a system. Depending on the particular adopted layout it is possible to use either some elements of the elementary lighting system shown in FIG. **18** or a larger or smaller combination thereof. According to the diagram in FIG. **18** electric power is supplied to the manual, automatic or centralized control unit **27** through supply lines **28, 29** and is distributed among several channels. One of these, ensuring the starting and lighting up of the service lighting sources comprises the apparatus for starting and lighting up the light sources and a brightness regulator **31** of the light sources.

The second channel accommodates the apparatus **32** for controlling the cooling of the light sources whereas the third channel switches on emergency lighting by means of an element **33.** Besides, the control unit **27** adjusts the position of the concentrator **21** by means of a photorelay **34** which actuates the concentrator follow-up system and switches on the light sources **4** by switches **35** as the natural illumination gradually diminishes. In addition, the control unit switches on and controls the pumping of the light guides **1** through compressor plants **36** and the amount of air delivered into the building through regulator **37.**

The interior lighting fixture functions as follows. The light guides suspended or stretched in a building as required and connected with the concentrators **21** and the optical radiation-admitting devices **5** are supplied with air or another gas from compressors or fans through the inlet valves **8** at a pressure exceeding slightly atmospheric (if the required shape of the light guide can be obtained without the higher pressure, the air or gas are not delivered and the inlet devices are not used). In daytime, when the natural lighting ensured by the sun light concentrators **21** is sufficient, as confirmed by the photorelay **34,** the light sources **4** are turned off. In twilight or in cloudy weather the illumination photocontrol system switches on part or all of the light sources by switches **35** so that the light guides **1** conduct both the natural and artificial radiation into the building. In the evening or at night the light guides are used only for artificial illumination.

The air can be pumped into the light guides during operation of the lighting system periodically, when the pressure sensor responds to a pressure drop in the light guide and automatically starts the compressor plant **36.**

In case of employment of powerful groups of light sources the illumination system must be switched on concurrently with the interlocked apparatus **32** for controlling the cooling of the light sources.

The luminous intensity can be adjusted in different versions of the system by means of special automatic or manual brightness regulators **31.** By selecting the spectral composition of the light sources and by ensuring independent control or radiation from each of them, the systems with the light guides **1** are capable of changing the light spectrum inside the buildings within a wide range. The distribution of illumination inside the buildings can be adjusted by appropriate orientation of the optical slot **6** in the light guides **1** or by making the light guides other than rectilinear, also by varying the height of their installation in the building. Should it become necessary to increase considerably the luminous intensity (during reconstructions of lighting systems), all the versions of the lighting systems will allow this object be achieved by replacing only the light sources or only the optical radiation admitting devices **5,** without interfering with the channels of the light guides **1.** If each radiation-admitting device uses several light sources, it is possible to connect a part of the light sources to independent sources of power supply so that one and the same light guide will be able to ensure both the service and emergency lighting. When the lighting systems have radiation-admitting devices with a single light source, and the building is provided with several lines of light guides, some of these light guides supplied from independent electric power sources will also ensure emergency lighting.

We claim:

1. An interior lighting fixture comprising a light guide installed in a building with at least a part of the surface of the light guide casing covered throughout its length with a layer reflecting luminous radiation, said casing being made of an elastic transparent film; a light source with optical means for admitting light into said light guide; and means for imparting a preset shape to the light guide installed in the building.

2. An interior lighting fixture according to claim **1** wherein the elastic light-transmitting film comprises a vacuum-tight polyethyleneterephthalate film.

3. An interior lighting fixture according to claim **1** wherein the elastic light-transmitting film comprises a vacuum-tight triacetate film.

4. An interior lighting fixture according to claim **1** wherein said light guide has a toroidal shape.

5. An interior lighting fixture according to claim **1** wherein said means for imparting the preset shape to said light guide comprises air delivered through the inlet valves installed on the light guide casing said air being delivered at pressure exceeding atmospheric.

6. An interior lighting fixture according to claim **1** wherein said means for imparting the preset shape to the light guide installed in said building comprises at least two rigid shaping elements in the form of rings located at least on the ends of said light guide.

7. An interior lighting fixture according to claim 6 wherein said rings have inlet valves admitting air into the light guide at a pressure exceeding atmospheric.

8. An interior lighting fixture according to claim 6 wherein at least one rigid shaping element is mounted with an outlet valve through which the air heated by the radiation sources is discharged into the illuminated building.

9. An interior lighting fixture according to claim 6 wherein said rings are connected to the ends of at least two cables, one end of one of said cables being fastened to one ring located at one end of the light guide while the other end of the same cable has a weight passed over a sheave fastened to the building wall, the second cable being fastened by one end to the second ring located at the other end of the light guide, the other end of the second cable being fastened to the wall of the building opposite to the first-mentioned wall.

10. An interior lighting fixture according to claim 6 wherein said rings located on the ends of the light guide have spring-type take-up units.

11. An interior lighting fixture according to claim 1 wherein said light guide is mounted in the illuminated building so that both its ends are located in close proximity to the opposite walls of the building and has at least one optical means for admitting luminous radiation, said optical means being located at the end of the light guide outside the building.

12. An interior lighting fixture according to claim 1 wherein said light guide is mounted in the illuminated building so that both its ends are located in close proximity to the ceiling and floor of the building and has at least one optical means for admitting light radiation, said optical means being located at the end of the light guide outside the building.

13. An interior light fixture according to claim 1 wherein said light guide is in optical communication with at least one solar energy concentrator located outside the illuminated building and directing natural radiation into the same channel of the light guide which conducts the radiation of the artificial light sources.

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