

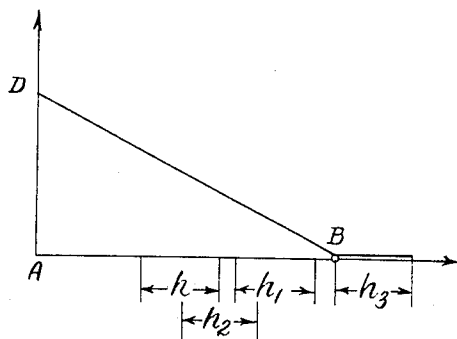
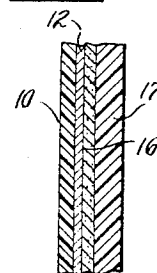
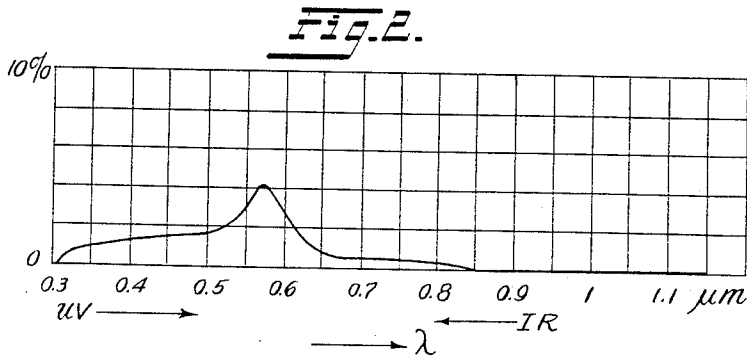
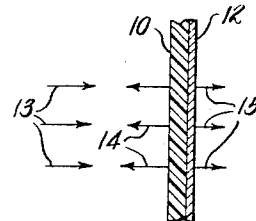
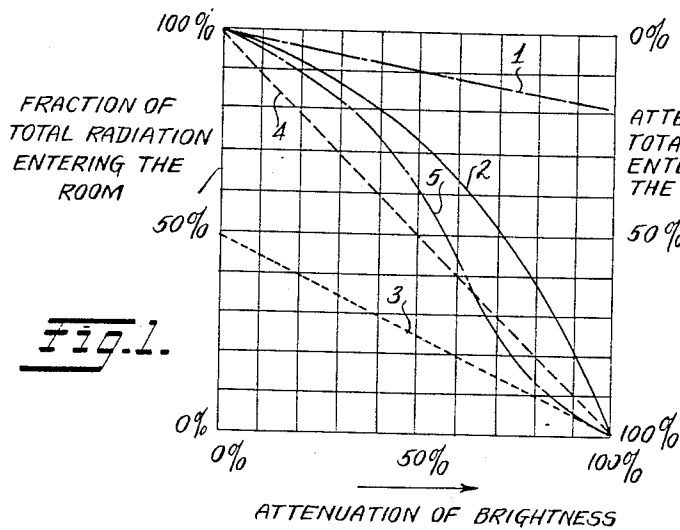
Feb. 22, 1966

H. LUEDER
METHOD AND APPARATUS FOR CONTROLLING
RADIATION THROUGH A WINDOW

3,236,290

Filed Feb. 12, 1963

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

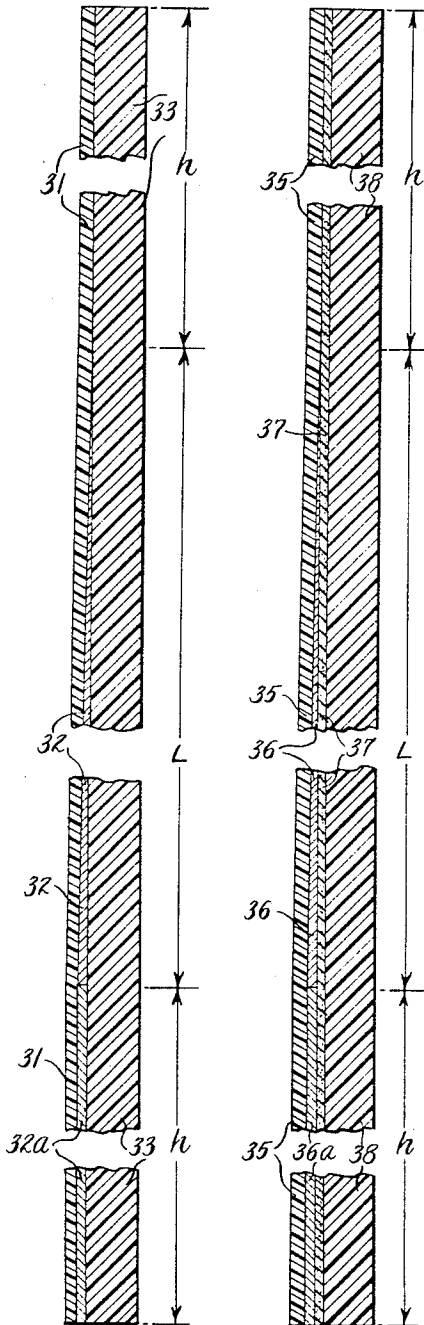


Fig. 7.

Fig. 8.

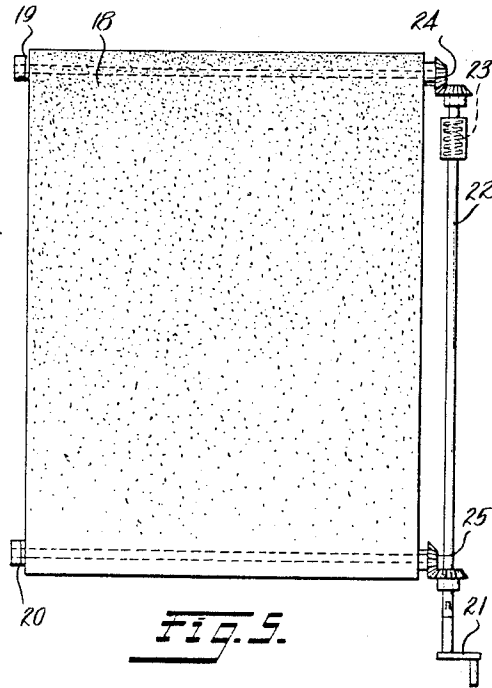


Fig. 9.

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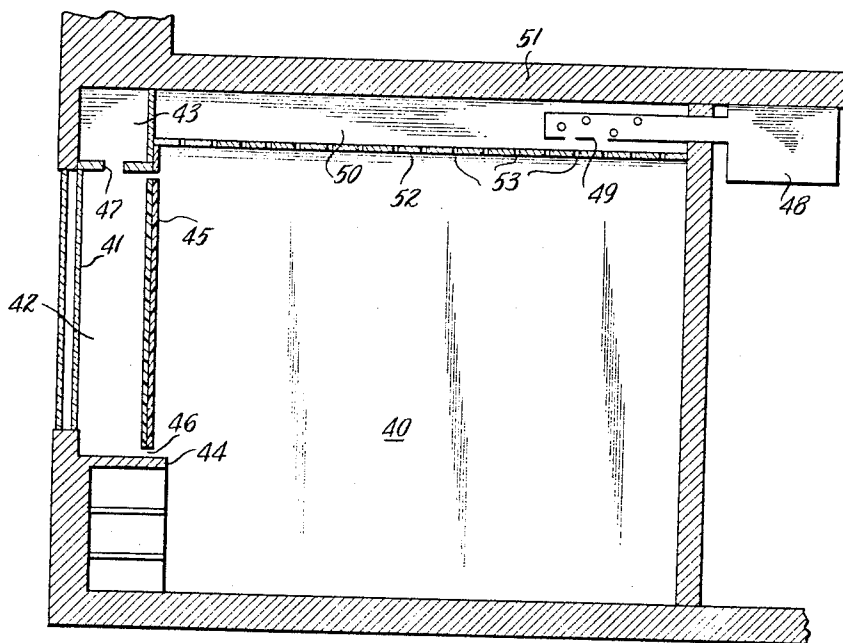


Fig. 9.

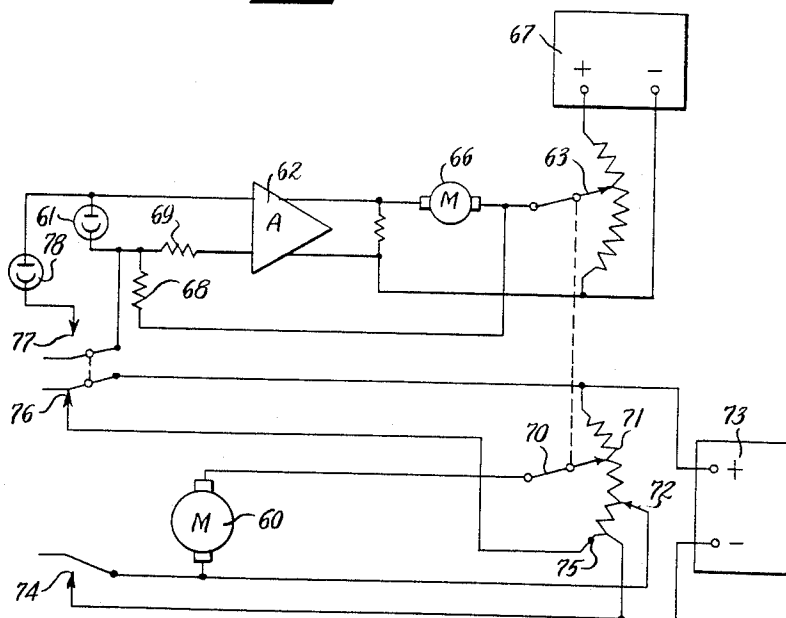


Fig. 10.

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3,236,290

METHOD AND APPARATUS FOR CONTROLLING RADIATION THROUGH A WINDOW

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Filed Feb. 12, 1963, Ser. No. 257,972

6 Claims. (Cl. 160—241)

The present invention relates to a method and apparatus for controlling the radiation energy entering and/or leaving a room having a window and a shade covering substantially the whole window and being capable of selectively attenuating light entering the room and controlling the brightness in the room from about 0 to 100%. This application is a continuation-in-part of my copending application Serial No. 851,697, filed November 9, 1959, now abandoned.

It is difficult to maintain comfortable conditions inside rooms having windows, particularly rooms with large window areas as used in modern buildings, because of the solar and diffuse sky radiation entering the room through the window during daylight or because of the rather high energy discharge from the room to the cold window surface during the night or in cold weather. In air conditioned rooms it is nearly impossible to even out, by means of conventional air-conditioning equipment, the differences in radiation temperature caused by the sun's rays in various parts of the room, or to compensate quickly enough for the heat gains caused by sudden changes in sky radiation.

Conventional window shades fitted inside the window have the disadvantage of absorbing a considerable portion of the solar and sky radiation of wavelengths shorter than 2.3μ and of giving this energy up in the form of heat to the air adjacent the shade and as heat radiation from the shade. Shades act as radiation transformers, absorbing a part of the energy from the infra-red and visible spectral range with wavelengths up to 2.3μ which falls upon them and changing it into heat which is then given up to the room by convection or in the form of long-wave infra-red radiation. Conventional sun blinds, although they screen off a good deal of visible light, consequently do little to prevent heat gains due to solar and sky radiation.

A shade showing ideal qualities should be able to alter the brightness in the room continuously and to effect an attenuation of the entering total radiation increasing proportional to the decreasing brightness in the room.

To overcome the disadvantages described above, U.S. Patent 2,774,421 (K. S. Lion) proposes a shade comprising a sheet-like material which is highly reflective to the invisible infra-red radiation but at the same time substantially transparent to the visible part of the spectrum. The disclosed material is not clear like glass but causes diffusion of the transmitted light; such behavior makes the suggested shade unsuitable for most windows. Such material absorbs energy from a broad range of radiation.

For the above reasons buildings are often provided with shades outside of the windows, in which case the heating thereof does not influence the conditions inside the rooms. Such shade devices are exposed to the weather and must be equipped with complicated mechanical devices for controlling the attenuation of the brightness inside the room.

It is also known in the art to provide a window with a lamellated shade having reflecting segments and being cooled by an air stream along the shade and the window surface. But such a lamellated shade has the disadvantage of disturbing the view through the window and does not control the entering radiation over all area elements in equal degree.

Another known proposal is to provide the window with a glass pane carrying a metal layer thin enough to pass a sufficient part of visible radiation, but reflecting back a considerable part of other components of the total radiation.

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For such a glass screen a compromise must be made, choosing the thickness of the metallic layer to provide sufficient light transmittance on gloomy days and a high enough reflecting effect for sunny days. A shade of this type absorbs a remarkable amount of the sunlight by the translucent layer, resulting in a temperature of up to 15°C . higher than the room atmosphere. Hence the absorbed radiation energy is again emitted as heat radiation to the furniture and persons in the room and to the air and adds an additional load to the air conditioning equipment. The reason for such disadvantage is the fact that thin translucent metal layers having a light transmittance of about 25 to 50% are unable to reflect more than 10 to 25% of the radiation, but show an absorption of 25 to 50% of the energy.

In contrary the method and apparatus according to the present invention makes it possible, on gloomy days, to admit light nearly without attenuation but on sunny days to reflect the sun radiation nearly lossless and with absorption so small that the desired brightness and minimum energy flow into the room is maintained.

It is an object of the present invention to provide a method of controlling the total radiation entering a room at the same time in its visible and its invisible components, the room having at least one window covered substantially over its whole area with a light-transmitting shade capable of brightness attenuation from 0 to 100%.

Another object is to provide a shade having controllable reflective characteristics for all components of the total radiation entering the room.

Another object is to provide a shade capable of attenuating the total radiation entering a room from about 1% to a brightness attenuation of 100%.

Another object is to provide a shade of the character set forth wherein upon increasing brightness attenuation the attenuation of total radiation energy entering the room is greater than the attenuation of the visible components of the radiation energy.

It is a further object of the present invention to provide a shade through which an outdoor object is visible from inside the room with a brightness, being controllable in a manner to make substantially constant the mean value of the apparent brightness of said object.

Another object of the present invention is to control the energy flowing from a room to a window through a partly transparent shade which is capable of absorbing the heat radiation from the room and emitting the said heat outwardly through the said window, having an emission ability adjustable to the amount of room heat losses desired.

In the present invention that part of the incident radiation which would cause undesirable heat gains in the room is reflected to the outside of a thin metal layer of negligible absorptive capacity which is applied to a carrier foil itself pervious to incident and room radiation, fitted inside the window.

Several metals, for example, gold, platinum, nickel and copper, have a very high reflecting power for rays within the red and infra-red wavelengths, which power diminishes at the shorter wavelengths. When using a layer of such metals on screens for the windows of a room, that portion of the visible light which is required for adequately lighting may be allowed to enter the room through the screens. If the metal is applied to a flexible base of a screen, for example, by vacuum deposition, in such a way that the thickness and consequently the reflecting power of the metal layer change over at least a portion of the screen, the light intensity in the room can be adjusted as desired by providing a screen which is longer than the height or the width of the window, and a roll on top of the window and a roll at the bottom of

the window, or a roll at each side of the window, and unrolling a portion of the screen from one of the rolls and winding a corresponding portion on to the other of the rolls so that the portion of the screen having the desired light reflecting power is adjacent to the window. Movement of the screen so as to place before the window a length of the screen or shade material which has the desired light transmittance may be effected automatically so that the light intensity in the room has, for example, a constant value in spite of fluctuations of the intensity of the incident light.

A window shade according to the invention may comprise an oblong flexible carrier base on which a reflecting metallic layer is carried, the carrier base serving also to protect the metallic layer and being made of a synthetic material which is pervious to rays of a wavelength between 0.4μ and 35μ , and the thickness of the metallic layer increasing in the longitudinal direction of the shade. The flexible shade is longer than the height or the width of the window and extends between two rolls placed either horizontally at the top and bottom or vertically at the sides of the window, that length of the shade which exceeds the height or the width of the window being rolled on said rolls. By winding shade material on one roll and unwinding it from the other roll, a portion of the shade in which the metallic layer has the desired thickness and light transmittance can be placed in front of the window without impairing the clarity or uniformity of the view.

The metallic layer of material may be, for example, gold or copper, which, if the layer is sufficiently thin, transmits a portion of the visible light rays but almost completely reflects the long-wave infra-red heat radiation.

The invention makes it possible to air condition various rooms, whose windows are in different positions with respect to the points of the compass, by means of a single uniformly operated air-conditioning apparatus.

By placing the window shades composed of a radiation-pervious material and a metallic layer inside the room, the shades can be made quite thin, so that radiation absorption by the protective carrier base can be reduced to a minimum. The shade may be so constructed that the protective carrier base, which does not absorb the radiation entering through the window, is also sufficiently transparent to rays within the spectral region of heat radiation of 300°K . This is the case if a thin film of polyethylene or a polyester such as polyethylene terephthalate is used.

The air between the shade and the window glass will be heated, because the glass will absorb part of the radiation energy which, owing to the reflection from the window shade, passes through it twice. It is, therefore, of advantage to place the metallic layer so spaced from the window that there is a layer of air between the metallic layer and the window which cannot mix with the air in the room. To prevent the air between the window and the shade escaping, the lateral marginal portions of the shade are preferably guided in slots on either side of the window for substantially sealing the space between the window and the shade from the room.

A further object of the invention is an indoor installation on an outside window of a room adapted to carry out the control method claimed herein, comprising a shade in the form of a flexible sheet covering at least the greatest part of the window area and consisting of several transparent layers, the sheet having a length being a multiple of the window dimensions and having on at least a part of the whole length a metal layer having both a thickness and a reflection ability for visible and infrared radiations of nearly zero at one end of the sheet and increasing uniformly to a value at the other end sufficient to let pass only few percent of the impinging radiation, rolls placed at opposite sides of said window being provided to wind the said sheet and to stretch the part of the sheet covering the window area. There is also preferably

provided a mechanism for driving the two rolls to transport a desired part of the sheet in even stretched condition to a position to cover the window area.

A further object of the present invention is to provide a sheet composed of several glass-like limpid plastic foils having mirror-like smooth parallel surfaces, the thickness of the said metal layer increasing continuously from one to the other end of the sheet and having the quality of not deflecting passing light rays. The said partly transparent metal layer may consist of a metal selected of the group of metals having a high electrical conductivity and a quality similar to gold in that a layer of 0.075 micron lets pass up to 4% of visible radiation but reflects the infrared radiation of the sun and shows reflectivity for heat radiation at 300°Kelvin nearly as high as a thick opaque layer of the same metal. The end of the sheet carrying the thickest metal layer may be connected to a further sheet having the dimensions of the window area and carrying a layer of a metal selected of the group of metals having an electrical conductivity as high as aluminum, said metal layer being opaque and having a thickness sufficient to nearly completely reflect impinging radiation. The said metal layer may be covered by a protective glass-clear limpid layer having a mirror-like smooth surface and a thickness of some microns of a material selected of the group of materials having the quality of letting pass not only the ultrared sunlight passing the window, but also the heat radiation at 300°Kelvin like the materials polyethylene and polyethylene-terephthalate. The sheet may be composed of several glass-like limpid plastic foils having mirror-like smooth surfaces, the uppermost foil adjacent the window having a thickness of some microns of a material selected of the above-mentioned group of materials, carrying a metal layer on its backside surface and being affixed by a glass-clear transparent adhesive to a second plastic foil being thicker, more rigid and more resistant than the first mentioned foil.

The novel features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, and additional objects and advantages thereof will best be understood from the following description of embodiments thereof when read in connection with the accompanying drawings, in which:

FIG. 1 is a diagram showing the percentage of total radiation energy entering the room at the left-hand ordinate and the attenuation of that radiation energy at the right-hand ordinate, plotted against the attenuation of the brightness in the room at the abscissa axis;

FIG. 2 is a diagram of the transmittance T of thin gold layers of 0.075μ thickness plotted against the wavelength of radiation;

FIGS. 3 and 4 are diagrammatic cross-sectional views of two modifications of material for a flexible window shade according to the invention;

FIG. 5 is a front view of a window shade according to the invention;

FIG. 6 is a diagram showing the radiation transmittance D of the shade material plotted against the length of the whole shade;

FIGS. 7 and 8 are diagrammatic cross-sectional views of two modifications of the different portions of a flexible shade according to the invention;

FIG. 9 is a diagrammatic cross-sectional view of room showing the arrangement of the window and the shade according to the invention; and

FIG. 10 is a circuit of an electronic driving equipment for shade according to FIG. 5.

FIG. 1 of the drawings shows at the right ordinate the attenuation of the total radiation entering and the attenuation of the brightness in the room at the abscissa. In this diagram the ideal behavior of a shade is shown by the straight line numbered 4, in which the desired shade causes an attenuation of the total radiation from 0 to

100% proportional to the brightness attenuation increasing from 0 to 100%.

The plotted characteristics of shades known in the art are substantially displaced from line 4 and show an attenuation characteristic like line 1 in FIG. 1 because at complete brightness attenuation of 100% (darkness in the room) only about 20% of the radiation energy passing the window is reflected back to the window, corresponding to an energy attenuation of only 20%. The other 80% of the entering radiation energy being transformed into heat by the shade. The invisible part of the energy (about 50%) is completely transformed to heat. Also, a part of the visible light entering the window is not reflected back but is also changed to heat, thus causing further heating of the shade.

The method of the present invention provides for controlling the brightness inside the room by controlling the visible components of the radiation entering the room and for controlling the invisible components. Referring to the diagram of FIG. 1 the present method aims at approaching the characteristic of straight line 4 as closely as possible. The effective characteristic of a shade arranged according to the invention and described in detail later is shown by the lines 2 and 5, respectively.

Previously known shade materials and arrangements have a control characteristic like line 1 which shows a large energy flow into the room even at a brightness attenuation of 100%, an effect caused principally by the invisible components of the radiation being absorbed in the shade and transformed into heat.

It is obvious to provide a window with glass panes that are not fully transparent for screening out the invisible radiation components and to use a conventional shade at this window. But such an arrangement has disadvantages compared to a control means with the characteristic of line 4; the glass panes cause an undesirable attenuation of visible light and must be arranged outwards of the window to prevent room heating by absorption of that radiation which does enter. Furthermore, it is often desirable to let the total radiation into the room, for example, during the early morning, if the room temperature is too low or in cold weather.

It can be seen from the above explanations that hitherto the problem of controlling the brightness inside a room was not recognized in its different aspects. Hence, it is novel to provide a solution according to the present invention characterized by the steps:

Controlling together and with the same indoor means the visible as well as the invisible components of the entering radiation.

Attenuating the entering radiation corresponding to a characteristic approaching line 4 in FIG. 1.

The shade according to the present invention is a flexible sheet covering substantially the whole area of the window. The sheet consists of several transparent layers as shown in FIG. 3 and 4 and its length is a multiple of the window dimensions and carries at least on a part of the whole length a metal layer having a thickness and a reflection ability for visible and infra-red radiations such that the reflectivity of the shade may be substantially zero at the one end of the sheet and increase uniformly to a value at the other end sufficient to let pass only few percent of the impinging radiation.

The distance to be passed by the radiation in the partly transparent metal layer can be changed by moving the sheet along the window area. The preferred metals for the thin layer being metals having a high electrical conductivity like aluminum, gold and silver. Such metals used in a thin layer having a reflection behavior which permits the preparation of a shade with a control characteristic like the line 2 in the diagram of FIG. 1, showing with increasing attenuation of the brightness an attenuation of the total radiation substantially steeper than the attenuation of the visible light passing the shade. The visible components have an amount of about

50% of the total radiation energy and the line 3 in the diagram of FIG. 1 shows this portion plotted against the brightness attenuation. It is to be noted that the actual shade characteristic line 2 is steeper than the line 3 at all its points.

Thin layers of some metals, with high electric conductivity, per example gold, are more reflective to the infra-red components than to the visible components of the impinging radiation. The diagram of FIG. 2 shows the transmittance T of a gold layer having a thickness of 0.075 micron plotted against the wavelength of impinging radiation up to 4% of the visible components pass such a layer but the infra-red components beyond a wavelength of 0.085 μ and the heat radiation corresponding a temperature of 300° Kelvin being reflected nearly as completely as by a thick nontransparent layer of the same material. Transparent gold layers used on a shade according to the present invention permit a control characteristic like line 5 in FIG. 1 being lower than the line 4 and approaching a parallel relation to the line 3 at higher brightness attenuations and crossing the line 4 approaching closer the line 2 with decreasing brightness attenuation.

The shade according to the present invention is a flexible sheet carrying a thin metal layer. The sheet has a length being a multiple of one of the window dimensions and a width corresponding to the other window dimensions. The metal layer thickness increases along the sheet uniformly from one to the other end but being constant over the width of the sheet at all its portions. Preferably the increments of change in the metal layer thickness is made small enough so that the difference in light attenuation is not perceptible along a length corresponding to the length of the window. The attenuation and reflection of the entering radiation then has substantially the same value at all area elements of the shade area.

With attenuation and reflection being almost the same over the whole window area, the changes of brightness with this shade are not readily perceptible inside the room. Furthermore, the view from the room through the window is not disturbed and it is possible to move the shade in such a manner that the mean value of the apparent brightness of any outdoor object visible from the room through the window is made constant. Furthermore, the shade can be controlled automatically to provide a constant brightness at work tables inside the room in spite of changes in intensity of the sunlight entering through the window.

During normal summer operation the described shade arrangement is used to control the radiation energy entering the room through the window. The shade according to the invention is also adapted to control the energy flow from the room to the window caused mainly in winter time by heat radiation from a shade to a window. The radiation energy flow from a light source inside the room to the window can be attenuated uniformly from 0 to 100% by the shade and at the same time the energy is reflected back to the room. The infra-red and heat radiation from the room is substantially completely absorbed by the flexible sheet material, carrying a metal layer only on the surface towards the window, and transformed into heat. The emission of the heated sheet to the window by the emitting ability of the metal layer is a function of the layer thickness being alterable between 100 and about 0% by moving the shade. Hence it is possible, for example, to control the temperature in a room being heated by a constant energy or to substantially throttle the heat radiation from the room to the cold window during the evening and at nighttime.

Referring now to FIG. 3, one embodiment of the shade according to the invention comprises a flexible plastic sheet 10 being transparent without substantial absorption of any visible or invisible radiation components entering through the window or being emitted from the room

to the window. For example, a polyethylene or polyester foil having a thickness of few microns is suitable for such a carrier sheet 10. The sheet 10 is covered by a metal layer 12 preferably deposited on the surface of the sheet 10 by the well known method of vapor deposition of metal in a vacuum.

The sheet 10 carrying the metal layer 12 is arranged with its uncovered surface towards the window and the entering radiation 13. It is necessary to protect the thin metal layer 12 against abrasion as shown in FIG. 4 by affixing a transparent flexible foil 17 to the surface of the metal layer 12 by a glass-clear adhesive 16. The foil 17 can be a flexible plastic sheet which is thicker, more rigid and more resistant to wear than the very thin foil. The shade composed of the thin foil 10 carrying the metal layer 12 which is affixed by the adhesive layer 16 to the thick flexible foil 17 is a preferred embodiment of the invention and has proven highly satisfactory in practice.

The radiation 13 impinging on the surface of the foil 10 is passed to the metal layer 12 which reflects a portion 14 and lets pass another portion 15. Hence, the foil 10 is traversed twice by radiation (13 and 14). It is of importance that the foil 10 have a high transparency for all components of the radiation, i.e. only a very small part of the radiation energy may be absorbed. The very high transparency is necessary not only in the range of visible and invisible sun radiation of wavelengths from 0.4 to 3.2 micron, but also in the range of heat radiations corresponding to a temperature of about 300° Kelvin and having a wavelength of 3.5 to at least 35 micron. A foil of polyethylene or polyethylene-terephthalate having thickness of a few microns is suitable for such purpose.

The metal layer 12 should be deposited directly on the surface of the foil 10 without any adhesive because such an adhesive layer would absorb too much of the radiation which would pass twice therethrough. The shade according to the preferred embodiment of FIG. 4 is prepared by depositing the metal layer 12 directly on the foil 10 and then affixing the metal covered foil 10 to the thicker foil 17 using an adhesive 16.

A preferred embodiment of the shade according to the invention is shown in FIG. 5. The flexible sheet 18 is substantially the same width as the window and its length is a multiple of the height of the window. Portions of the length of the sheet 18 are wound on the rolls 19 and 20 arranged above and below the window, respectively, the portion extending between the two rolls 19 and 20 covering substantially the whole window area and being stretched to form a flat screen without any wrinkles or folds. The sheet 18 is composed of two foils as shown in FIG. 4 with the metal layer between them. The thickness of the metal layer is nearly zero at the one end and increases uniformly along the length of the sheet as suggested by the dotting of the sheet 18 in FIG. 5. The one end of the sheet arranged to have maximum transparency, in FIG. 5 the lower end, may be free of any metal layer and the other end is provided with a metal layer thick enough to achieve an attenuation of brightness behind the shade of about 100%.

The transparency D of such a shade is shown in the diagram of FIG. 6 plotted against the whole length extension of the sheet. The transparency D is high at the left side point A and decreases uniformly to a very small value at the point B. The length of the sheet between the points A and B is a multiple of the window's height h . According to the desired degree of attenuation of the shade the corresponding portion of the sheet is wound up from the rolls 19 or 20, so that for instance the portions h , h_1 or h_2 showing in the diagram of FIG. 6 cover the window. It is to be pointed out that the slope of transparency D is preferably made small enough so that in an arrangement of the shade as shown in FIG. 5 the difference between the more attenuating upper portion and the

less attenuating lower portion of the shade is not perceptible.

To minimize heat losses from rooms during winter time and the night hours, the shade is provided at the high attenuating end with an extension of the length h carrying a non-transparent layer of high reflective material, for example, of aluminum. To minimize the heat losses of the room this extension, marked h_3 in the diagram of FIG. 6 of the shade should cover the window because the emission ability of the shade toward the cold window is almost zero. If it is desired to lower the room temperature, the shade may be moved to cover the window with a portion having a higher transparency and emissivity toward the cold window.

The shade according to FIGS. 4, 5 and 6 is also suitable for reflecting back to the room the light radiation from sources inside the room in an amount adjustable between about 100 and 0%.

A composite sheet for the shade, according to the invention, is described below in two tested examples in connection with FIGS. 7 and 8 which were each designed to be arranged at a window having a height h .

The flexible sheets comprise three portions having the length h , L and h . The sheets are shown in FIGS. 7 and 8 in such position that the total radiation entering the room through the window impinges upon the layers 31 and 35, in FIGS. 7 and 8, respectively.

Example I.—The carrier foil 33 of FIG. 7 is a flexible plastic sheet having a thickness of about 100 micron and a width of about 150 cm. The material of the sheet is polyethylene-terephthalate, a glass-clear foil. The uppermost portion of the foil 33, having a length h , is not covered with metal. The next lower portion having a length in the present example of $L=5h$ being covered with a gold layer 32 of uniformly increasing thickness. The thickness of the gold layer 32 at its upper end is as thin as possible and at the high reflecting end thick enough to attenuate the visible sun radiation at least 95%. The lower portion of the foil 33 having a length of h is covered with a layer of aluminum 32a having a thickness sufficient to make it completely opaque. The two layers 32 and 32a are protected against wearing by a layer 31 of SiO_2 deposited thereon as gas tight as possible, preferably by a vaporizing process.

Example II.—The length of the multilayer sheet forming the shade of FIG. 8 is similar to the Example I, also the thickness and arrangement of the gold layer 36 and the aluminum layer 36a. It differs, however, in that the layers 36 and 36a are deposited on the back side of a very thin flexible gas tight foil 35 of polyethylene-terephthalate having a thickness of about 6 microns and being transparent to the invisible components of the sun radiation and for heat radiation corresponding to a temperature of about 300° Kelvin. Both layers are deposited on the foil 35 using a vaporizing process in vacuum. The foil 35 carrying the metal layers 36 and 36a is affixed to a thicker foil 38 being identical to the foil 33 of the sheet described in Example I; also cellophane may be used as a material for the foil 38.

The shade according to the invention is provided with suitable mechanical means to rotate the rolls carrying the sheet. The embodiment of a shade shown in FIG. 5 comprises a shaft 22 being mounted on the wall alongside the window in suitable bearings. The shaft 22 is equipped with a crank handle 21 at its lower end and divided in two portions connected by a torsion spring device 23. At the lower end the shaft 22 is provided with a bevel gear drive 25 for the roll 20. Another bevel gear drive 24 connects the upper end of the shaft 22, above the torsion spring device 23, with the roll 19. The torsion spring device 23 is arranged to effect biasing the upper roll 19 relative to the lower roll 20 in a direction to stretch the part of the sheet 18 extending between the rolls 19 and 20. The biasing force is adjustable in known manner by the torsion spring 23 and is maintained also when the shaft 22 is

turned with the crank handle 21 to expose another part of the sheet 18 to the radiation entering the window. The arrangement of FIG. 5 may be replaced by any other suitable device to wind the sheet 18 on or from the rolls 19 and 20 while holding it under such tension that the part of the sheet 18 covering the window is substantially free of wrinkles or folds.

FIG. 9 shows preferred arrangement of the shade in a room 40 having a window 41 and being air-conditioned. The window 41 is arranged in a recess 42 formed between a duct 43 for outgoing air and a window bench 44. The recess 42 is almost closed against the room 40 by the shade 45 (only indicated by a double layer sheet) but connected to the room 40 by a slit 46 between the lower roll (not shown) of the shade 45 and the bench 44. Hence the recess 42 forms a chimney in which the outgoing air of the room 40 enters through the slit 46 and is drawn out over the opening 47 of the duct 43. The incoming fresh air is supplied by a duct 48 through a distributing tube 49 and the space 50 formed between the ceiling 51 and a false ceiling 52 having air openings 53.

In a room having a west side window equipped with the shade according to the invention arranged in the above mentioned manner, the brightness was attenuated to a value sufficient for the work desks in the room; the room temperature measured during a summer afternoon with clear sky was 23.8° C. when the air-conditioning was operated at a fixed rate. The temperature in the same room after replacing the shade according to the invention by a normal lamellated shade but under identical other conditions was measured as 26.0° C.; to obtain a temperature of 23.8° C. the supplied fresh air must be cooled more causing an additional energy demand of 49%.

A shade according to Example I or II permits a continuous control of the brightness in a room, to compensate for fluctuating sun and sky light entering through the window. Hence it is advantageous to provide the shade, for example in an arrangement as shown in FIG. 5, with an automatically controlled drive of the shaft 22. FIG. 10 shows a circuit suitable for controlling the attenuation of the light entering through the window. The shaft 22 is connected to an electric motor 60 of an electronic control device and rotated to adjust the shade so that only enough light enters the room to maintain the desired brightness. With a suitable automatic brightness control the load on the air-conditioning equipment is rather small in summertime because during bright sun shine the shade is adjusted to a portion to let pass only 5 to 10% of visible radiation and reflects 90 to 95% of the total radiation without substantial losses.

The motor 60 shown in FIG. 10 is controlled by a semiconductor photoelectric cell 61 positioned at the work desk or at any other desired location in the room. The voltage supplied by the cell 61 is used to adjust the arm 63 of a potentiometer 64 using a well known self compensating control system comprising an amplifier 62, the motor 66, the voltage source 67 and the feed back path with resistors 68 and 69. The arm 63 is adjusted according to the light intensity impinging upon the cell 61 and mechanically connected with arm 70 of a second potentiometer 71 which is tapped at the adjustable point 72 and being a part of the control circuit for the motor 60. The point 72 is adjusted to a position corresponding to the position of the arms 63 and 70 when the brightness detected by the cell 61 has the desired value. Hence the voltage of the source 73 tapped by the arm 70 corresponds in value and polarity to the deviation of the effective brightness detected by the cell 61 from the desired value of brightness. The motor 60 is driven by this deviation voltage in the one or the other directions causing a movement of the shade to cover the window with a more or less attenuating portion. The effect is that the brightness at the cell 61 is automatically maintained at the desired

value which is adjusted by the position of the tap 72 independently of changes in radiation entering the room through the window.

At the beginning of twilight the motor 60 will have moved the shade to cover the window with the portion without a metal layer. In this position an end contact 74 operated by the end of the sheet is closed so that the voltage at the terminals of motor 60 is zero. A further decrease of the light impinging the cell 61 moves the arms 63 and 70 in clockwise direction to the end position and the arm 70 is connected to the end contact 75 on the potentiometer 71; now the motor 60 is again excited but in a direction to move the shade to progressively re-cover the window with more and more attenuating parts of the sheet and stops only when the non-transparent portion of the sheet covers the window and the end contact 76, operated by the other end of the sheet, is opened. During this movement the end contact 74 is again opened but this has no influence on the motor 60. With opening of the end contact 76 another contact 77 is closed and a circuit through a second photoelectric cell 78 is completed; this second cell 78 is arranged electrically parallel to the cell 61 but positioned between the shade and the window to detect the sunrise the next morning.

The dawn light impinging the cell 78 causes a movement of the arms 63 and 70 in counter-clockwise direction. The arm 70 leaves the contact 75 and approaches the tap 72, the motor 60 is excited in a direction to move the shade back to a position in which the unmetallized portion of the sheet covers the window; thereby the end contact is opened and 76 is closed and the cell 61 again takes over the sole control of the shade position according to the increasing light energy entering through the window in the manner described above.

I claim:

1. The method of controlling the quantity of visible and invisible components of light radiation entering a room through a window, comprising the steps of: reflecting, from adjacent the inside of said window and back outwardly through said window, a predetermined portion of each component of said radiation and permitting the remainder thereof to enter said room; and changing the ratio between reflected and entering portions of both said components in accordance with changes in the total radiation entering said window and at such rate that reflection of both said components simultaneously approach substantially complete reflection.

2. The method of claim 1 wherein the step of increasing the amount of radiation reflected outwardly including the further step of increasing the amount of invisible light reflected more than the increase in the visible light reflected.

3. A window shade comprising: an elongated flexible transparent sheet having a width substantially equal to one dimension of said window and a length at least equal to a multiple of the other window dimension; an infrared reflecting metal layer on said sheet; the thickness of said metal layer varying uniformly along the major portion of the length of said sheet from substantially zero thickness adjacent one end portion thereof to such thickness adjacent the other end portion as to be substantially completely opaque to render the major portion of said shade semi-transparent, the transparency and reflectivity of said shade varying uniformly throughout the major portion of the length thereof; roll means along opposed margins of said window, said sheet extending across said window and having its ends secured respectively to said rolls; means for rotating said rolls to position a desired portion of said sheet across said window; and means holding said sheet taut across said window area.

4. A shade as defined in claim 3 wherein the metal of said layer has high electrical conductivity and of such composition that a layer thereof of about .075 microns

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thickness transmits about 4% of visible light impinging thereon but reflects substantially all solar infra-red radiation and all heat radiation corresponding to a temperature of 300° Kelvin.

5. A shade as defined in claim 3 wherein the endmost portion of said sheet, at the end where said metal layer is thickest, is provided with a substantially uniform layer of metal, the same dimensions as said window; said uniform layer being opaque, of a metal having substantially the same electrical conductivity as aluminum, and substantially completely reflecting said radiation.

6. A shade as defined in claim 3 wherein said metal layer is covered, on its face nearest said window, by a film of transparent material a few microns in thickness and having a mirror-like smooth surface and being transparent to visible and infra-red radiation.

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