Oct. 23, 1945. A. HAGUE 2,387,258

THERMAL APPLICATOR

Filed May 16, 1941

FIG. 1

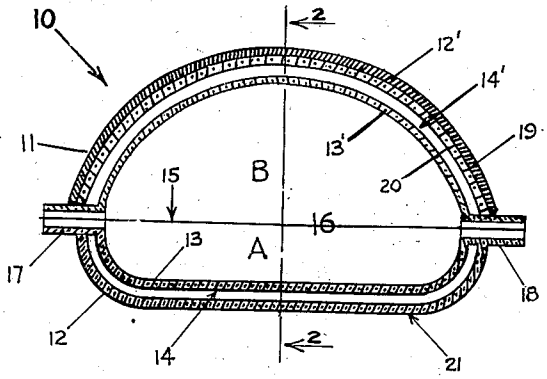


FIG. 2

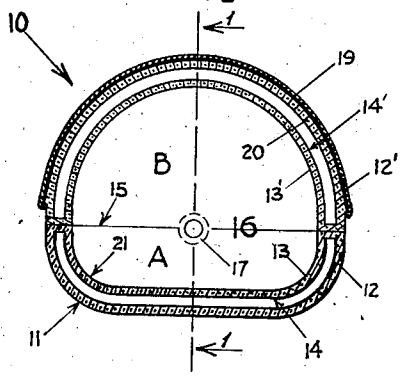


FIG. 3

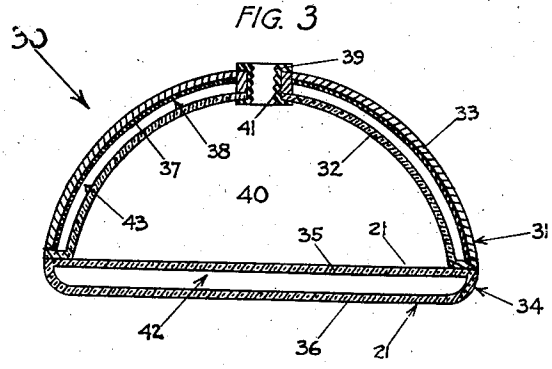
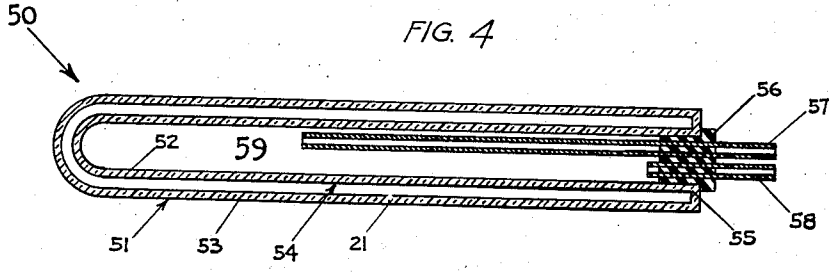


FIG. 4



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2,387,258

THERMAL APPLICATOR

Alfred Hague, Ossining, N. Y.

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5 Claims. (Cl. 128—403)

This invention relates to thermal applicators used for heating or cooling purposes, and has for its object the provision of an improved thermal applicator and method of transmitting the thermal energy for application. More particularly, my invention relates to thermal applications wherein the thermal energy is transmitted by radiation.

Illustratively, in the hot water and ice bags heretofore utilized for the application of thermal energy, the source of thermal energy, viz. the hot water or ice, must be all too frequently replenished, due, to a considerable extent, to the energy lost to the surrounding atmosphere by conduction through the material of which the bag is made. In an endeavor to reduce this necessity for frequent replenishment, particularly in the case of hot water, there is a tendency to supply the hot water at a temperature considerably higher than that required, with the danger of burning the patient unless the hot water bottle is wrapped in a towel or other insulator until it cools sufficiently to be used directly, which common practice in turn involves unnecessary waste of the heat energy. Even where normally poor conductors of heat, e. g. rubber, are used in the fabrication of these appliances, the transmission by and loss of heat as a result of conduction is none the less very substantial.

I have found that this high thermal conductance and its attendant energy waste in the ordinary hot water or ice bag, proceeds to a large extent from the use of material therein, such as rubber and the like, which is relatively highly absorptive of the long wave infra-red radiation principally characterizing these sources of thermal energy. As a consequence of this high absorption of the radiant thermal energy emanating from the source, it is inevitably transmitted by conduction, regardless of the otherwise poor thermal conductivity of the material, and the ultimate effect secured is substantially an absorption, a conduction, and to a reduced extent a re-radiation of the radiant thermal energy with altered wave length by the material forming the exposed surface, with proportionate increase in the amount of heat lost to the convection currents set up in the atmospheric air in contact with said surface. In other words, the principal function which the internal source of radiant thermal energy in these appliances actually serves, is simply to heat up the outer walls of the appliance which are in contact with the outside atmosphere.

In accordance with my invention, the radiant energy from the source within the hot water or ice bag, or other thermal applicator, is transmitted through a material which is substantially transparent to the infra-red radiation principally characterizing the hot water, ice, or other source of thermal energy, the term "thermal" being used herein to embrace also, radiation which would in common parlance be designated as cold waves rather than heat waves.

In the accompanying drawing I have shown certain illustrative embodiments of my invention, and referring to the same:

Fig. 1 is a sectional front elevation of one form of appliance taken along the line 1—1 of the appliance shown in sectional side elevation in Fig. 2.

Fig. 2 is a sectional side elevation taken along the line 2—2 of the appliance shown in sectional front elevation in Fig. 1.

Fig. 3 is a mid-sectional front elevation of a modified form of structure, which would appear the same in mid-sectional side elevation.

Fig. 4 is a mid-sectional elevation of a further modified form.

Referring to the drawing, and in particular to Figs. 1 and 2, reference numeral 10 generally designates a thermal applicator, such as a hot water bottle, which comprises a hollow shell 11 constituted of an outer wall 12 and an inner wall 13 defining a space 14. For convenience in manufacture, the shell may if desired, be made in two major sections A and B, suitably connected together by cementitious material, fusion or the like along the bisecting line 15; the outer wall of the upper section B being designated 12', the inner wall 13', and the space between them 14'. Access to the interior 16 of the shell 11 is afforded by the tubes 17 and 18. A casing 19 of copper, gold, or other suitable metallic or other material, covers the upper part of the shell and is provided internally with a surface 20 which is suitably reflective of the infra-red radiation emanating from the source of thermal energy contained in the interior 16. This casing, and if desired, the coordinate upper section B of the shell also, may be parabolic or of any other suitable form.

With the exception of the casing 19, the shell 11, as shown, is made of a material 21 which is substantially impervious to the fluid or other tangible medium with which it will ultimately be in contact, but which is substantially transparent to the long wave infra-red radiation which principally characterizes the particular source of thermal energy involved.

Where the appliance is used as a hot water bottle, for most practical purposes the tempera-

ture of the water supplied thereto can be considered to range from a maximum of about 212° F. downwardly to 118° F. or somewhat less, which minimum is still sufficiently above the normal body temperature of 98.6° F. to provide sensible heat, i. e. heat which can be perceptibly felt by the human body. At 212° F. the wave length of maximum radiation characterizing the spectral distribution of energy at this temperature, computed for the theoretical black body by means of the well known Wien's displacement law, would be approximately 77,000 Angstrom units and at 118° F. it would be approximately 90,000 Angstrom units. For all practical purposes in the application of my invention, Wien's law can be used as a guide in the selection of the infra-red transmitting characteristics of my materials 21.

For this hot water bottle type of application, fluorite (calcium fluoride) is one material which I have found to be highly effective for transmitting the long wave infra-red radiation principally characterizing the distribution of spectral energy of the hot water at the temperatures ordinarily utilized. This material has a low thermal conductivity and in a thickness of approximately 1 cm. will transmit over 85% of infra-red radiation shorter than 80,000 A. wave length, around 85% of 80,000 A. wave length, and somewhat over 50% of 90,000 A. wave length, which latter transmission can be stepped up still further by suitably reducing the 1 cm. thickness of the material. Unless otherwise noted herein, the various percentages of infra-red transmissibility given, indicate the ratio of the transmitted infra-red to the incident infra-red for a thickness of approximately 1 cm. of the transmitting material.

Other materials which are highly effective, particularly where wave lengths materially longer than 90,000 A. are contemplated, are sylvine, (potassium chloride) and rock salt (sodium chloride). These two materials are almost perfectly transmissible (over 90%) of the infra-red up to a wave length of 140,000 A. (wave length of maximum infra-red radiation at a temperature of —87° F.), above which wave length the transmissibility begins to drop off. The water solubility problem presented by these potassium and sodium chlorides can be overcome by fabricating the body of the transmitting material of sylvine or rock salt, and providing a suitably thin protective coating of the insoluble fluorite or other suitable insoluble infra-red transmitting material, over that area of the sylvine or rock salt which would come in contact with water or other solvent or disintegrating medium.

Where the transmitting structures required are not unduly extensive and may be cut or bored out from suitably large pieces of the natural crystal, or assembled by cementing or fusing together suitably pre-formed small pieces such as panes, tubes, etc., of the same, the mineral forms of fluorite, rock salt or sylvine may if desired, be used directly as the basic material. Otherwise, these compounds, either as the mineral or a manufactured product, may be fused, and then molded, pressed, rolled, blown, or otherwise formed into the desired shapes. The presence of color and low visible-light transmission in these materials, frequently found in the mineral forms, is of no particular moment so long as the infra-red transmitting properties are not seriously impaired thereby. In fact the material can conceivably be perfectly opaque to visible light rays, provided its transmission efficiency for the infra-red radiation involved is suitably high.

The various infra-red transmitting materials used in my invention, if desirable and if amenable to such treatment, may be ground into the form of lenses, to concentrate or otherwise regiment the radiation.

In another form of composition of the infra-red transmitting material 21, suitably small particles, crystalline or otherwise, of fluorite or other infra-red transmitting material, may be incorporated in or deposited upon the surface of a suitable matrix or binder, e. g. cellulose acetate or other suitable cellulosic compounds, suitable synthetic or natural resins, and various other satisfactory plastics. The dispersion of the particles of the infra-red transmitting material within the matrix, may be accomplished by thoroughly dispersing fine particles of the material in a solution of the matrix in a suitable solvent, e. g., cellulose acetate in acetone, and appropriately extruding, molding, rolling or otherwise treating the dispersion, with evaporation of the solvent, to form a suitably impervious pane, tube or other desired form of the finished material. Alternatively, the infra-red transmitting particles, which may if desired be larger than in the dispersion method, may be rolled or pressed into a suitably plastic mass or sheet of the matrix, and the composite material then formed into the desired shape and hardened by drying or other suitable treatment. With the provision of a suitably large quantity of the infra-red transmitting particles and thorough distribution of the same in the matrix, the infra-red transmitting efficiency of such composite material may be made to approximate that of the dispersed material itself. Where it is desired to utilize rock salt, sylvine or the like in this composite material, and the rock salt or sylvine in the resultant composite material is still materially accessible to solvent, the composite material containing the rock salt, etc., may be provided upon its surface with a protective coating film or pane of fluorite or other suitable insoluble material. This may be done by cementing a thin solid pane of pure fluorite, or fluorite in the composite form with matrix, to the surface of the composite rock salt or sylvine material, or by applying a suitably plastic coating of the fluorite in the composite form with matrix to said surface and permitting it to harden thereon. The protective coating of fluorite, or fluorite in matrix, may be applied to a surface of the pure rock salt or sylvine in like manner. These various forms of infra-red transmitting material described herein may of course be utilized in other applications where their spectral transmission or other properties or the method of composing them, may be advantageous.

The hot water bottle, or ice pack or other appliance may be constructed in whole or in part of any of the specific forms of infra-red transmitting material noted, either alone or in various combinations with the other forms of said material.

The spaces 14, 14', defined by the outer walls 12, 12' and the inner walls 13, 13' respectively, of the shell 11 are preferably hermetically sealed and define a rarefied atmosphere, "rarefied" in the sense that the atmosphere may be constituted of air or any other suitable gas which is substantially transparent to the infra-red radiation involved, but which is suitably non-conductive and non-convective of thermal energy

from the inner walls 13, 13' to the outer walls 12, 12', either normally or with suitable evacuation. This atmosphere should preferably be relatively free from any material amount of suspended foreign particles, e. g., dust, vapour, water and the like, which would have a tendency to absorb infra-red radiation in its transit and act as heat conductors through the spaces 14, 14'. If necessary or desired, the atmosphere in either or both of the spaces 14, 14' may be evacuated to such a degree as to leave insufficient residual gas in the space to afford any objectionable degree of heat exchange by conduction or convection between the inner and outer walls through the space. Likewise, the atmosphere in either of the spaces 14, 14' may be evacuated to a greater degree than the other, as for example, to a greater degree in 14 where the section B is to be in close proximity to the body of a patient. This evacuation can be accomplished by perforating the shell and sealing the orifice by fusion or otherwise after the evacuation.

The applicator 10 is designed for continuous or intermittent flow therethrough of the fluid providing the thermal energy. For use with hot water for example, the tube 17 may be connected by means of rubber tubing with a hot water faucet and similar rubber tubing connected with the outlet tube 18 for discharging the fluid, said rubber discharge tube being provided with a suitable pinch cock or like device to restrict the flow sufficiently to keep the interior 16 of the applicator substantially filled, or to periodically cut off the flow. Similarly, one of the tubes 17 or 18 may be plugged, or dispensed with, and continuous or intermittent flow provided through the other tube in the manner of the applicator of Fig. 4. Where continuous or intermittent flow is not desired, either tube 17 or 18 may be plugged with a removable stopper, the applicator filled with the thermal medium through the open tube, and said inlet tube then similarly plugged.

In the operation of the applicator 10, the infra-red rays emitted downwardly from the thermal medium, will pass through the inner wall 13, the rarefied atmosphere in the space 14, and the outer wall 12, and thence, through any intervening atmospheric air, directly to the area of application on a human or other body of matter being treated. This direct transmission is unaccompanied by any material absorption or convection loss in transit. The rays directed upwardly will pass through the inner wall 13', the rarefied atmosphere 14', the outer wall 12', and will then be reflected back into the interior 16 by the reflector surface 20 on the interior of the casing 19, which casing is covered externally with suitable heat insulating material (not shown). This reflection of the rays, permitting their escape into the outside atmosphere only through the bottom of the applicator, is likewise unaccompanied by any material absorption of the infra-red radiant energy and its transmission and loss to the outside atmosphere by conduction and convection. Such channel of conduction to the outside as might be afforded by the inner walls 13 and 13', which are in direct contact with the source of thermal energy, is substantially blocked off by the non-conductive and non-convective rarefied atmosphere in the spaces 14 and 14'. The conduction which takes place through the structures connecting the inner walls 13, 13' with the outer walls 12, 12' is not great, and even this may be substantially reduced by eliminating the partitions between the spaces 14 and 14' in the illustrative two section assembly shown, and restricting the connection between the inner and outer walls solely to the tubes 17 and 18. With further restriction of the inter-connecting structure to a single tube, as in the provision for continuous flow through simply one tube, the escape of thermal energy to the outside by conduction through the connecting structure, is rendered practically negligible.

Where the application of the thermal energy is one involving temperature elevation, utilizing for that purpose a heating fluid such as hot water, oil, steam, or other liquid, vapor or gas, suitable infra-red transmitting material 21 is ordinarily provided by the fluorite in any of the forms noted hereinbefore. The rock salt or sylvine materials may however be used if desired, in the solvent-proof form described if such is called for. Where, on the other hand, the application of the thermal energy involves temperature reduction, utilizing for that purpose a cooling fluid, such as suitably chilled water, brine solution, or the like, the rock salt or sylvine forms of the material 21, solvent-proofed if necessary, are more effective, because of their much higher transmissibility of the wave lengths of infra-red radiation predominating at such low temperatures.

In Fig. 3 I have shown a modified form of applicator 30, comprising an upper shell section 31 having an inner wall 32 and an outer wall 33, and a bottom shell section 34 having an inner wall 35 and an outer wall 36. The walls 32, 35 and 36 are made of the infra-red transmitting material 21 described hereinbefore. The outer wall 33 of the upper section 31 may be constituted of any suitable heat insulating material, and encloses a reflector 37 of copper, gold or other suitable material having an inner polished reflector surface 38 which is suitably reflective of the infra-red radiation involved in the particular application. A neck 39, made of hard rubber or other suitable material, affords access to the interior 40 of the applicator and may be provided with threads 41 to retain a similarly threaded plug (not shown) to close the opening. If continuous flow through the applicator 30 is desired, the neck 39 may be fitted with an apertured plug of the nature shown in Fig. 4, to permit continuous or intermittent flow of fluid medium through the applicator. A space 42 is provided in the section 34 and a space 43 in the section 31 for the rarefied atmosphere described hereinbefore in connection with the applicator 10 of Figs. 1 and 2. Where evacuation of the space 43 is contemplated, this will be facilitated by making the heat insulating wall 33, of material which can be effectively cemented, fused, or otherwise connected with the inner wall 32 to hermetically seal the space 43.

While I have shown the applicator 30 as substantially hemispherical in form, it may be semi-ellipsoidal, parabolic or of any other form desired.

In Fig. 4 I have shown another form of applicator 50 substantially tubular in conformation, though it may be otherwise shaped, which comprises a shell 51 having an inner wall 52 and an outer wall 53 defining a space 54 for the rarefied atmosphere described hereinbefore. The shell 51 is constructed of the infra-red transmitting material 21, and may be provided with a suitable reflector (not shown) around the outside or upon the inner surface, to direct the radiation as desired. The neck 55 of the applicator 50 is fitted with an apertured plug 56, of rubber or other suitable material, provided with an inlet tube 57 and

an outlet tube 58 to permit continuous or intermittent flow of thermal fluid through the interior 59 of the applicator. If continuous or intermittent flow is not desired, an ordinary plug can be substituted for the apertured plug 56.

The applicator 50 may be tubular in form, substantially disc-shaped, parabolically or otherwise curved on its upper surface and flat on the lower, or shaped in any other form dictated by the particular application involved.

Various changes may be made in the illustrative constructions of applicators disclosed without departing from the spirit of my invention. They may, for example, be made either in one piece or as sectional assemblies of greater or fewer sections. Likewise, the reflector surface may be provided on any of the internal wall surfaces of the applicators, including the inner surface of the wall defining the interiors (16, 40, 59). The outer surface of the reflector element may be isolated from the outside atmosphere by an interposed covering of suitable heat insulating material, or said surface may be uninsulated and coated with flat black paint, to absorb heat from the surrounding atmosphere or translate absorbed light into heat, where such expedient will increase the thermal efficiency of the applicator. Where this external absorption is resorted to, the blackened surface should have access to the radiant energy from the outside atmosphere either directly, or relatively directly through suitable infra-red transmitting material, such as 21. An illustration of such access would be presented by blackening the outer surface of the reflector 37 (Fig. 3), and either dispensing with the outer insulating wall 33 or making it of the material 21; similarly, by blackening the outer surface of the reflector casing 19 (Fig. 1) and locating it on either the inner or outer surface of the inner wall 13, instead of externally of the applicator 10 as shown. Conversely, where an ice pack or similar low temperature application is involved, said outer surface of the reflector element, in the various locations noted, may be constituted of highly polished reflective material to repel heat absorption by the reflector, rather than to promote it, with similar provision for its access to the outside atmosphere. For various applications, the double-walled or shell type of construction for the applicator may be dispensed with in whole or in part, and a single wall or transmitting pane used, with elimination of the rarefied intervening space. As illustrations, the lower section A of Fig. 1, or 34 of Fig. 3, may be constituted simply of the single walls 13 and 35, respectively; or wall 53 of Fig. 4 may be dispensed with; or wall 32 of Fig. 3; or both walls 32 and 36 of Fig. 3.

While I have made principal reference in the foregoing to the use of the customary hot water or ice as the source of thermal energy in my applicators, other sources of the same may be readily substituted therefor, in many cases with the attainment of much greater effectiveness than in their usual methods of application. In general, the source of thermal energy may be either physical, chemical, or electrical, and for application of either sensible heat or cold. Suitable liquids include hot or cold water, oil, brine solution, liquid carbon dioxide, etc. Likewise, hot or cold vapours or gases may be used, such as steam, air, or other denser gases. Hot or cold solids may also be used and specifically ice, so called "Dry Ice," solid carbon dioxide, etc. Exothermic chemical reactions may be utilized, for example, hydration of an anhydrous material, and also endothermic reactions where such are suitably applicable. Similarly heat from an electrical resistance element may be used, preferably non-luminous to conserve the energy for heating, e. g. by substituting an iron wire in the rarefied or inert space 59, (Fig. 4).

These applicators and the method of transmission are adapted for a wide variety of uses, where the direct or indirect transmission of thermal energy to the human body or any other body of matter is involved.

For therapeutic uses they find a particularly effective application and may be used either externally of the human body or internally thereof. Their thermal transmission is not greatly diminished at a distance from the body, as is the case for example, with the ordinary hot water bottle which must inconveniently be kept in close proximity or contact therewith; and, moreover, when they are used in close proximity or contact with the body, the attendant discomfort is much less, due to the relatively slight absorption of thermal energy from the inner source by their body-contacting walls. In addition more accurate control of the thermal application is made possible, and by suitable selection of the transmitting material and the thickness of the same, certain wave lengths of infra-red radiation may be partially or substantially obscured from the body, for example cutting off wave lengths longer than approximately 93,000 A. in the heat treatment of the human body, this wave length representing the maximum radiation for the theoretical black body at 98.6° F.

In the case of cooling uses, with liquid carbon dioxide for example, or similar applications of cold to the body, my applicator is equally capable of transmitting the very long wave lengths of infra-red (sylvine transmits approximately 60% of the infra-red of wave length as long as 200,000 A.—maximum radiation at temperature of —200° F.), and the conservation of such radiant energy provided by my applicator against the otherwise enormous conduction and convection loss, without materially interfering with the application, is distinctly advantageous. Moreover, a relatively small amount of the shielded liquid or solid carbon dioxide or similar expensive freezing medium, can radiate over a much larger area of application, with proper direction of the rays as desired, than can be covered by actual physical contact of the medium with the body.

The term "screening" with a medium non-absorptive of the radiant thermal energy or non-conductive of absorbed radiant thermal energy as used in the appended claims, is intended to include either partial or substantial or complete screening, as circumstances may render desirable, of the source of heat energy with a vacuum, reflective material, or the infra-red transparent transmitting material, as well as other suitable media and various combinations of the same, some of which combinations are illustrated in the drawing.

I claim:

1. The method of applying thermal energy which comprises, screening a source of radiant thermal energy from convective or conductive matter externally thereof with a medium which is substantially non-conductive of absorbed radiant thermal energy from said source to said matter, and passing infra-red radiation from said source to the subject of application through a solid material which is substantially transparent to wave lengths of infra-red radiation longer

than approximately 50,000 Angstrom units and shorter than approximately 200,000 Angstrom units.

2. The thermal applicator which comprises, a source of radiant heat energy, means for screening said source from convective atmosphere externally thereof, said means being constituted of a medium which is substantially non-absorptive of the infra-red radiation from said source, and means for transmitting infra-red radiation from said source to a subject of application externally thereof, said means being constituted of material which is substantially transparent to wave lengths of infra-red radiation longer than approximately 50,000 Angstrom units and shorter than approximately 200,000 Angstrom units.

3. A thermal applicator which comprises a double-walled container for material emanating radiant heat energy, the walls of which are provided with a space therebetween and comprise a substance substantially transparent to wave lengths of infra-red radiations longer than approximately 50,000 Angstrom units, the space between the walls being substantially non-absorptive of the infra-red radiations emanating from the material and substantially non-conductive and non-convective of thermal energy from the inner to the outer walls.

4. A thermal applicator which comprises a double-walled container for material emanating radiant heat energy, the walls of which are provided with a space therebetween and comprise a substance substantially transparent to wave lengths of infra-red radiations longer than approximately 50,000 Angstrom units, the space between the walls being substantially non-absorptive of the infra-red radiations emanating from the material and substantially non-conductive and non-convective of thermal energy from the inner to the outer walls, said infra-red radiation transmitting walls being composed of an infra-red radiation transmitting substance selected from the group consisting of fluorite, rock salt and sylvine.

5. A thermal applicator which comprises a double-walled container for material emanating radiant heat energy, the walls of which are provided with a space therebetween and comprise a substance substantially transparent to wave lengths of infra-red radiations longer than approximately 50,000 Angstrom units, the space between the walls being substantially non-absorptive of the infra-red radiations emanating from the material and substantially non-conductive and non-convective of thermal energy from the inner to the outer walls, said infra-red radiation transmitting walls being composed of a matrix having incorporated therein particles of infra-red transmitting material selected from the group consisting of fluorite, rock salt and sylvine.

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