# United States Patent [19]

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[11] **3,796,884**

[45] **Mar. 12, 1974**


## [54] THERMOGRAPHIC PLATE


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[22] Filed: **Oct. 18, 1971**

[21] Appl. No.: **190,384**

[30] **Foreign Application Priority Data**

Oct. 20, 1970 France ..... 70.37758

[52] **U.S. Cl.** ..... **250/316,** 250/474, 350/160 LC

[51] **Int. Cl.** ..... **B41n 5/00**

[58] **Field of Search** ..... 250/65 T; 350/160 LC



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*Attorney, Agent, or Firm*—Spencer & Kaye; Harvey Kaye; Jay M. Finkelstein



[57] **ABSTRACT**

A process for manufacturing a thermographic plate is disclosed, wherein a sensitive layer comprised of liquid crystals, is associated to a heat guiding layer made of latex and producing a screen effect perpendicularly to said sensitive layer. The thermographic plate is used for diagnosis of several cutaneous and subcutaneous affections. The invention relates also to the thermographic plate itself as well as to thermographic recording device comprising said thermographic plate and a fixture connecting at an adjustable distance said plate with a photographic camera.


**22 Claims, 10 Drawing Figures**

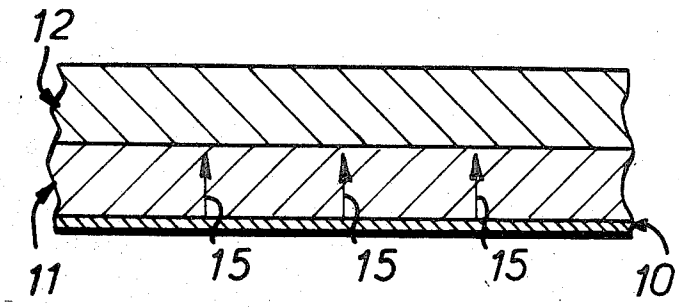


FIG. 1

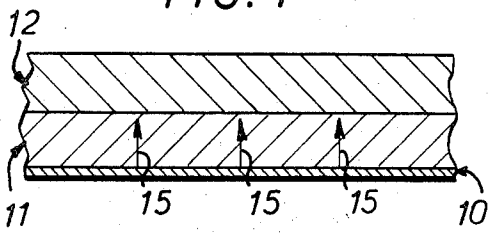



FIG. 2

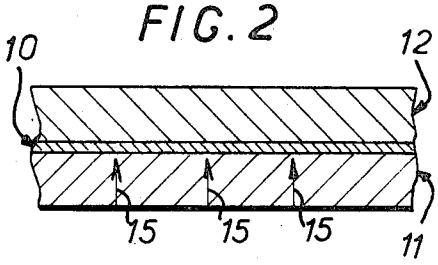



FIG. 4

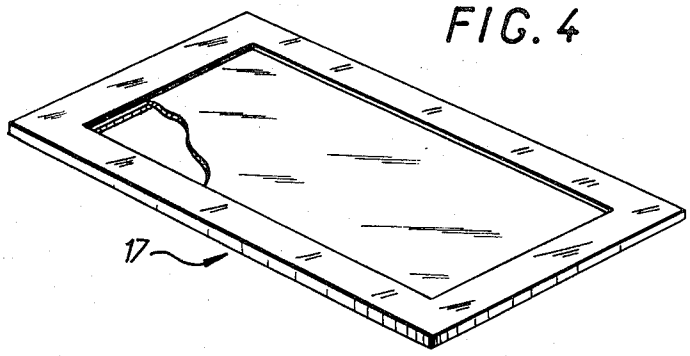



FIG. 3

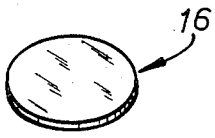
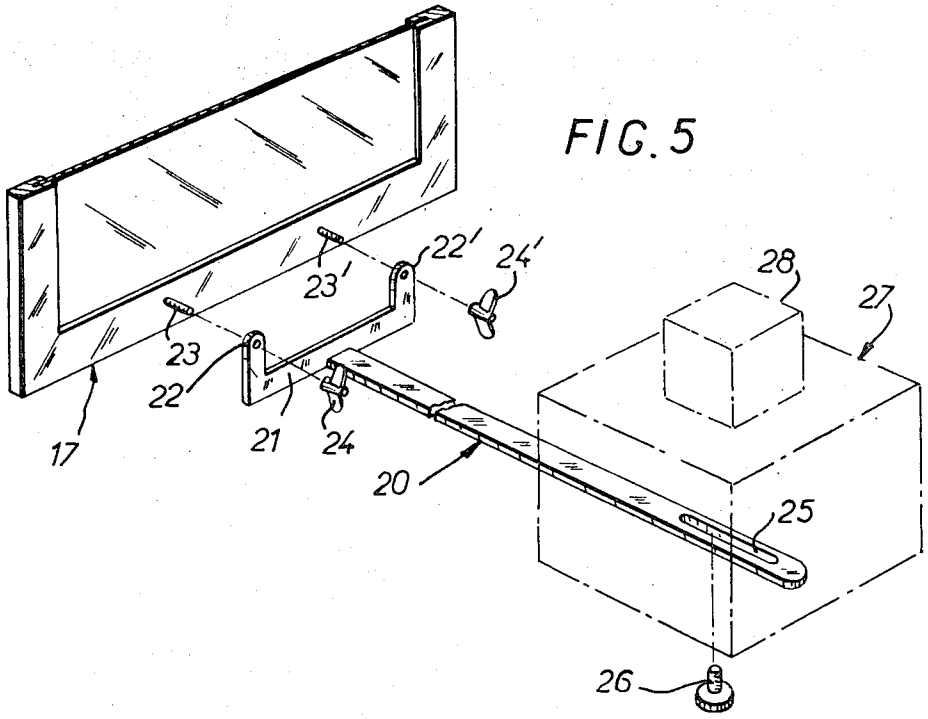



FIG. 5



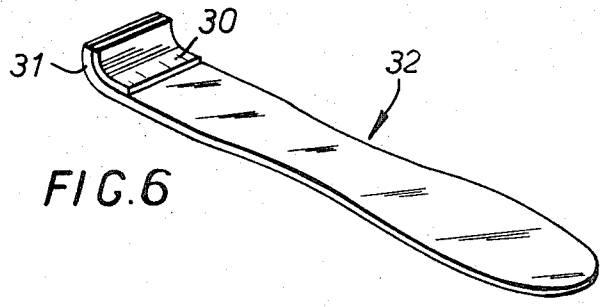



FIG.6

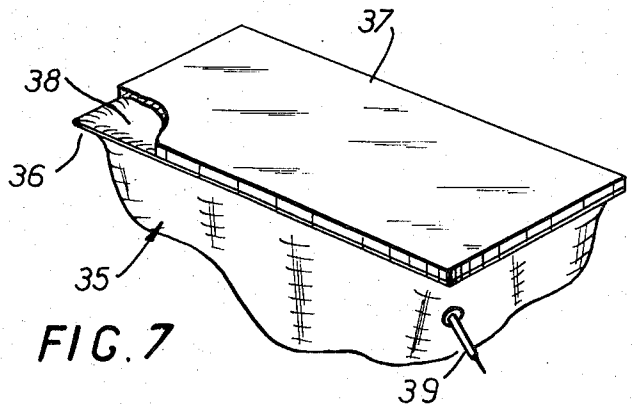



FIG.7

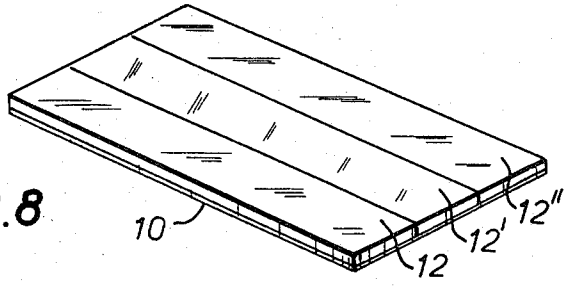



FIG.8

FIG. 9A

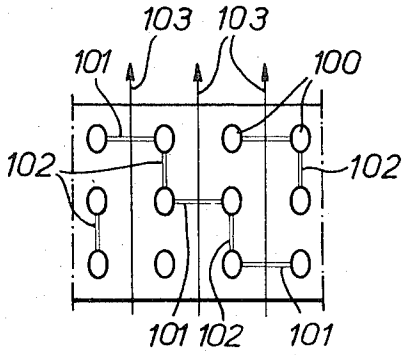
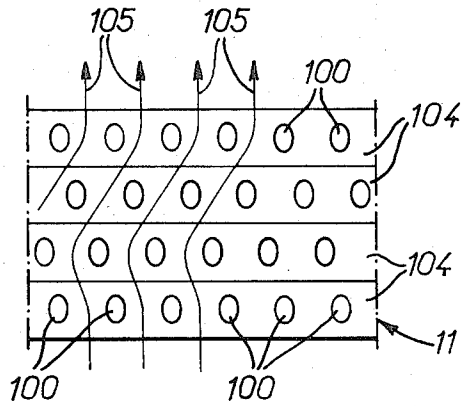

103
103
101
100
102
102
101
102
101

FIG. 9B


105
105
100
104
104
11
100
100

# THERMOGRAPHIC PLATE

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to thermographic surveys and more particularly application of thermography to the diagnosis of several cutaneous or subcutaneous affections such as malignant tumours or stoppage of some blood-vessels.

2. State of the Art

As it is well known, these affections cause local thermal anomalies, for instance in the order of 0.5°C, positive in the case of malignant tumours and negative in the case of stopped up blood-vessels.

A classic method of diagnosis of these affections consists of measuring the cutaneous or subcutaneous temperatures of the interested areas.

Such a measure may be effected in an exact and direct manner by means of the conventional thermometry, for instance with the aid of thermometres, thermocouples or thermistors.

However, it is difficult under these conditions to plot in a sufficiently detailed way the general thermographic map of a certain area.

It is now known to effect directly such a thermographic map by means of infrared cameras. However, these apparatus are extremely expensive, the thermographic maps they allow to obtain are not sufficiently sharp to be satisfactory and the time required for their establishment is relatively long.

## SUMMARY OF THE INVENTION

The main object of the present invention is that of removing the above mentioned drawbacks in a general way.

More particularly, the present invention relates to a thermographic plate of any size suitable for the test to be effected, allowing to obtain any desired thermographic survey in an economic and about immediate way.

The present invention is based on the existence of the so-called liquid crystals. Briefly speaking, liquid crystals are particles with a molecular orientation variable according to temperature. The light is being polarized at any reflection on these liquid crystals and then they show to the observer a dichroism which is characteristic of their temperature.

These liquid crystals are presently known under two different types of preparation, namely in a free chloroformic solution or encapsulated into gelatine.

The liquid crystals in free chloroformic solution show as main inconvenience that of having an extremely short life when exposed to free air; in the range of 5–10 minutes they are oxidized and are no more able to show any dichroism.

However, one sought to apply these liquid crystals in a free chloroformic solution, to carry out thermographic surveys. To this end it was disclosed to paint the areas to be surveyed with these liquid crystals, after degreasing and black painting such areas.

In addition to the fact that this painting process is not at all practical and the observation of the appearing dichroism must be hasty because of the transient character of such dichroism, these process has two more inconveniences. First, it leads to a continuous consumption of liquid crystals which are relatively expensive,



and secondly the obtained images or surveys are relatively fuzzy and the cause of this may be ascribed to a heat diffusion both laterally and transversely in the layer of liquid crystals.

Now, only a transversal heat diffusion in this layer may lead to sharp images or surveys. It is possible to use in thermography the gelatine encapsulated liquid crystals, which are mostly suspended in latex; encapsulation of liquid crystals avoids that they oxidize in free air.

It was therefore possible to propose preparation of thermographic plates comprising a flexible support layer and a layer of liquid crystals associated to a latex layer. However, experience shows that images or surveys obtained by such thermographic plates have the same evanescence inconveniences of those obtained by painting liquid crystal in chloroformic solution.

The main object of the present invention is therefore to obtain sharp thermographic images or surveys. The present invention is based on the discovery that latex, applied under particular conditions, may allow obtainment of a screen effect capable of being used to prevent the lateral heat diffusion, which is, as above mentioned, the main ground of the inopportune fuzziness of the thermographic images obtained with the hitherto known thermographic plates.

Actually, reticulation which some latexes undergo under heat, leads to such an effect of screen perpendicularly to the latex support layer.

However, and this is also an important discovery on which the present invention is based, even if cold applied a layer of latex or of usual latex paint, may lead to a screen effect similar to that of the heat reticulable latexes, provided that in this case such a layer consists of very thin overlapped discrete little layers.

Thus the present invention first relates to a process of manufacturing a thermographic plate, characterized by the fact that to a sensitive layer comprised of liquid crystals, a heat guiding layer is associated, showing a screen effect perpendicularly to said sensitive layer, either if said heat guiding layer is formed by depositing only one layer of a heat reticulable latex, or if it is formed by sequential deposits of a plurality of little discrete layers of latex paint each having a thickness lower than 50 microns.

The present invention also relates to a thermographic plate so obtained, having a support layer, a heat guiding layer and a sensitive layer.

The heat guiding layer advantageously forms a sort of oriented screen for the heat to be transmitted to the sensitive layer, opposing the lateral diffusion of said heat which is affecting the sharpness of the obtained images, as already mentioned.

According to a preferred embodiment, this heat guiding layer is arranged between the support and the sensitive layer, or on the side of the support layer opposite the sensitive layer.

According to several variants, the heat guiding layer itself forms the support layer and/or the liquid crystals of the sensitive layer are directly dispersed in the heat guiding layer, which in this case is itself the sensitive layer.

In any case a thermographic plate according to the present invention may have very variable sizes, going from those of a simple tablet allowing a point observation of a doubtful area up to those e.g., of a large sized

sheet of paper capable of being applied as a whole to a relatively extended doubtful area.

In the latter case, the thermographic plate according to the present invention is preferably supported by a flexible or rigid frame or fixed at its periphery to a transparent plate defining together with the thermographic plate an inflatable sealed space.

The present invention further relates to a thermographic recording assembly comprising said thermographic plate, an arm fixed preferably in a removable way to the plate or the plate supporting frame, said arm being provided with means allowing to fasten at an adjustable distance a photographic camera.

It is to be understood that said assembly may also comprise said photographic camera, preferably provided with a flash lamp, allowing to take photographs of the thermographic surveys obtained by means of the associated plate.

In any case, these surveys are almost immediate, as soon as the plate according to the present invention is applied on the area to be observed, and such a plate may be indefinitly reused.

The thermographic surveys obtained by the present invention are therefore particularly economical.

## BRIEF DESCRIPTION OF THE DRAWINGS

The features and the advantages of the present invention will become apparent from the following detailed description of the preferred embodiments, given by way of example only, with reference to the accompanying diagrammatic drawings, in which:

FIG. **1** is a partially sectioned view on a very enlarged scale of a thermographic plate according to the present invention;

FIG. **2** is a view similar to FIG. **1** and relating to a variant;

FIG. **3** is a perspective view of a possible embodiment of a thermographic plate according to the present invention;

FIG. **4** is a perspective view, with a portion taken away, of another possible embodiment of the plate;

FIG. **5** is an exploded perspective view of a recording assembly associated with such a plate;

FIG. **6** and **7** are perspective views showing other embodiments of the present invention;

FIG. **8** is a perspective view showing the application of the present invention for carrying out a thermographic plate comprising several juxtaposed sensitive layers;

FIGS. **9A** and **9B** are diagrammatic sections showing a possible interpretation of the function of the heat guiding layer, characterizing a thermographic plate according to the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to the embodiment shown in FIG. **1**, a thermographic plate according to the present invention comprises the sequence of a support layer **10**, a heat guiding layer **11** and a sensitive layer **12**.

Thus, according to this embodiment the heat guiding layer is arranged between the upport layer **10** and the sensitive layer **12**.

As a variant in FIG. **2** the heat guiding layer **11** and the sensitive layer **12** are arranged at the opposite sides of the support layer **10**.

The support layer **10** is preferably formed by a thin not coloured sheet of a product marketed under the trade mark "MYLAR." As it is known, this is a film of the ethylene glycol terephtalate. Its thickness is preferably under 0.1 mm and is for instance in the order of that of a sheet of paper, that is in the range of four hundredths to six hundredths of a millimetre.

The heat guiding layer is preferably made of a latex. For instance it is a sole layer of a styrene-butadiene copolymer heat reticulable at 150°C and preferably black painted. However, it may also consist of a latex paint available on the market, opaque and naturally black painted, of the kind of those marketed in aerosol form for instance under the trade marks "KRYLON," "NOVEMAIL," "ASTRAL-JET," "CORO-SPRAY" or "RIPO-MAT."

In such case the layer **11** is obtained by sequential deposits of several little discrete layers, for example from four to eight layers of such a paint.

In any case the thickness of the heat guiding layer **11** is varied according to the requirements and it is preferably greater than one-tenth mm and for instance is in the range of two tenth mm.

The sensitive layer **12** comprises liquid crystals encapsulated in gelatine, dispersed in a latex. Its thickness is variable according to the requirements and may reach three tenth to four tenth mm; however a thickness of two tenth mm is generally proper.

In any case, the application of such a sensitive layer may be effected by means of a coating machine or of a glass rod moved in contact with two bands laterally arranged at a distance from one another and forming the cross bars.

As it may be easily understood, if the heat guiding layer **11** has a sufficient strenght, it may act itself as the support layer, and in this case the support layer **10** is no more required. If the sensitive layer **12** has a sufficient latex thickness, it may likewise act itself as heat guiding layer, so that in this latter case the layer **11** is no more required.

In any case the thermographic plate according to the present invention is used applying it against the area to be surveyed with its side being farther from the sensitive layer **12.**

In the embodiment of FIG. **1** this application is done through the free side of the support layer **10,** while in the embodiment of FIG. **2** it is done through the free side of the heat guiding layer **11.**

In any case the heat diffused from the observed area must therefore cross the heat guiding layer **11.** This promotes a transversal diffusion of said heat according to the arrows **15** of FIGS. **1** and **2,** opposing a lateral or longitudinal diffusion of the heat.

One may ascribe the preferential orientation thus applied to the heat diffusion by the layer **11** of the instant invention, to the reticulated macromolecular structure of the latex forming this layer, said reticulated structure leading to a screen effect perpendicularly to the layer **11.**

This screen effect will be better understood making now reference to FIGS. **9A** and **9B**. FIG. **9A** is a sectional view only of the heat guiding layer **11** according to the instant invention, when this layer is formed by a sole layer of heat reticulable latex; in this case such a layer comprises a superposition of squared lattices of molecules **100,** and the heat reticulation leads to the formation of bridges both between molecules **100** of

the same lattice (bridges **101**) and between molecules **100** of two subsequent lattices (bridges **102**). In all these cases said bridges are forming, according to the arrows **103**, free passages between the molecules perpendicularly to the plane of their lattices, oppsing a lateral diffusion of heat in the plane of said lattices.

FIG. **9B** relates to the case in which the layer **11** is formed by a sequence of cold spread little discrete layers **104**. In this case there is neither reticulation between molecules **100** of the lattice of each discrete layer, not between molecules **100** of two subsequent discrete layers. However, experience shows that, provided that each layer **104** is very thin so as to be formed almost by a sole molecular latex layer, from the superposition of these discrete layers results the same screen effect shown by the arrows **105** of FIG. **9B**; it is probable that the superposition of these discrete layers opposes a too remarkable lateral heat diffusion between the little discrete layers as well as at the outer surface of the layer **11** so formed.

A maximum thickness of **50** microns seems to be convenient for each discrete little layer, the term "monomolecular" having to be considered in a very broad sense. Use of aerosol paint allowing application of these discrete layers by spraying, leads in a particularly advantageous way to very reduced thicknesses. However, it is natural that such spraying technique is not all limiting the invention, since any process or application may be convenient provided that it leads to very thin and preferably monomolecular discrete layers.

The sensitive layer **12** of a plate according to the present invention is normally black or violet at a normal temperature chosen as a reference temperature; when the temperature of the sensitive layer **12** exceeds the reference temperature for a fixed amount, this sensitive layer clearly changes to red. This amount or value, defining the sensitivity range of the layer is preferably narrow and for instance is in the order from 1° to 1.5° centrigrade. Practically, the useful range of liquid crystals presently available goes from the so-called red **27** to red **37**. The plates mostly used will be those coated with red **33**.

A thermographic plate according to the present invention may be used as such, with dimensions in the range e.g., of one centimetre or some centimetres for an almost point-to-point observation of a doubtful area. In FIG. **3** there is shown a tablet **16** useful for such an observation, for instance to show a stopped up blood-vessel, thus for surveying e.g., phlebitis. In such a case the side of application of the tablet will be preferably self-sticking.

However, a thermographic plate according to the present invention may be also supported by a frame **17**, such as that shown in FIG. **4**, particularly when said plate has relatively big dimensions; in FIG. **4** as an example a rectangular plate is shown, having each side from 20 to 30 cm long.

These plates, the outline of which may be practically of any shape, thus even different from the rectangular one, are particularly useful for surveying breast tumours, or with larger sizes for the observation of abdominal organs, or with lower dimensions for examination of vertebrae.

Frame **17** may be semirigid or flexible, for instance made of strong cardboard or light metal, so as to allow an easy bending of the plate born by said frame, thus a better application thereof to the surveyed area.

Frame **17** may also be rigid, made of wood or transparent synthetic material, e.g., opaque resin. Frame **17** may advantageously cooperate, according to the another aspect of the present invention, to carry out a thermographic recording assembly, such as that diagrammatically shown in FIG. **5**. In addition to the frame **17** and the thermographic plate, such an assembly comprises an arm **20** having at one end a forked mount **21** provided with lugs **22, 22'** for engaging threaded pins **23, 23'** fixed to the frame **17** and designed for cooperating with wing nuts **24, 24'**. This arrangement allows rapid and removable fastening of arm **20** to frame **17**.

At its free end arm **20** has a hole **25**. This allows to fasten to the arm **20**, by means of a knurled nut **26** and at an adjustable distance from the plate born by frame **17**, a photographic camera **27** of any suitable type.

This photographic camera **27** preferably comprises a flash lamp **28** oriented according to its optical axis. Thus it is possible to avoid any reflection on the plate supported by the frame **17** and therefore to make very satisfactory photographic reproductions of the dichroism shown by such a plate when it is applied to any doubtful area.

The arm **20** may have any proper length for instance in the range from 30 to 60 centimetres. It is to be understood that said arm **20** may be associated to different thermographic plates made according to the present invention, and the photographic camera **27** associated with this arm may be adjusted in advance to a precise distance corresponding to the lenght of said arm.

According to several embodiments, a thermographic plate according to the present invention may be also associated to any working instrument. Thus, as shown in FIg. **6**, a plate according to the present invention may for instance be born in the curved zone **31** of a retractor **32** made of synthetic transparent material. Such a plate is also particularly useful for instance to survey vascular tracts. In the same way, for endocavitary observations such as those relating to vesica, stomach, rectum, uterus, plates of little sizes must be fixed to little rings mounted on rods forming probes (not shown).

FIg. **7** diagrammatically shows another modified embodiment useful for surveying anfractuous surfaces. According to this variant a plate **35** according to the present invention is fixed at its periphery **36** to a plain transparent plate **37** and together with it forms a sealed volume **38** which may be inflated through a valve **39**. The plate **35**, this term being here to be interpreted in a broad sense going beyond the concept of planar condition generally associated with the term plate, is made of transparent synthetic material. On its inner surface there are liquid crystals applied in suspension in an elastic polymer.

By inflation a certain pressure is established in the volume **38** and this makes the observation of anfractuous surfaces easier, the plate **35** thus being fitted as much as possible to their shape. The dichroism of said plate, is therefore observed through the transparent plate **37**. Of course, to this plate an arm may be fixed, allowing to join a photographic camera as afore mentioned in connection with the embodiments comprising a frame.

According to the variant shown in FIG. **8**, which may be used alone or jointly with any of the preceding em-

bodiments, several sensitive layers, for instance three layers **12, 12', 12''** are juxtaposed as parallel strips on the same support layer **10** with the interposition (preferably but not necessarily) of a common heat guiding layer which cannot be seen on the figure. The width of these bands or layers **12, 12', 12''** is in the range of 0.5 – 1 cm, and these layers comprise liquid crystals having as a normal reference temperature, values different from one another, offset between each other for instance of 1.5° C.

The contemporaneous observation of these layers, e.g., used for a thermal survey of the lower limbs or of the forehead, allows an immediate absolute measurement of the temperature of the surveyed area. In fact, only that layer whose sensitivity range comprises such temperature, changes to red. The number of sensitive bands may be from two to five and even more.

Of course the present invention is not limited to the described and illustrated embodiments, but comprises also any variant, more particularly as to the nature of the material forming the support layer which could be of the material marketed under the trade name cellophane, of paper or of any of the materials used for manufacturing magnetic tapes.

In any case this support layer will be preferably very thin in order to avoid a lateral heat diffusion, and will be preferably a good heat conductor so as to avoid a too long permanence of the dichronic images obtained. Moreover, it has to be pointed out that the sensitive layer **12** is preferably lacking of any surface protective coating, and more particularly of any brilliant coating. The layer is advantageously opaque, thus avoiding any inopportune reflection during the photographic recording, more particulary when using flash lamp.

I claim:

**1.** A process for manufacturing a thermographic plate comprising: providing a sensitive layer composed of liquid crystals; and disposing in heat conductive association with said sensitive layer means for guiding heat energy incident thereon in a direction perpendicular to said sensitive layer and for opposing diffusion of such heat in directions parallel to said sensitive layer, said means being constituted by a layer of latex.

**2.** A process according to claim **1**, wherein said step of disposing is carried out by depositing only one layer of heat reticulable latex on the sensitive layer, and heating the latex layer sufficiently to give it a reticulated structure.

**3.** A process according to claim **1**, wherein said step of disposing is carried out by sequentially depositing a plurality of discrete layers of latex paint, each having a thickness of less than 50 microns.

**4.** A process according to claim **3** wherein the sequential depositing of the plurality of discrete layers is effected by spraying.

**5.** A thermographic plate comprising, in combination a sensitive layer composed of liquid crystals; means disposed in heat conductive association with said sensitive layer for guiding heat energy incident thereon in a direction perpendicular to said sensitive layer and for opposing the diffusion of such heat in directions parallel to said sensitive layer, said means being constituted by a layer of latex.

**6.** A thermographic plate according to claim **5**, further comprising a flexible support layer and wherein said layer of latex is disposed between said sensitive layer and said flexible support layer.

**7.** A thermographic plate according to claim **6**, wherein said support layer is a sheet of non-colored ethylene glycol terephthalate having a thickness less than 0.1 mm.

**8.** A thermographic plate according to claim **5**, further comprising a flexible support layer and wherein said layer of latex and said sensitive layer are arranged on respectively opposite sides of said flexible support layer.

**9.** A thermographic plate according to claim **5**, wherein said layer of latex forms a support layer.

**10.** A thermographic plate according to claim **5**, wherein the liquid crystals are dispersed in said layer which of latex forms said sensitive layer.

**11.** A thermographic plate according to claim **5**, wherein said layer of latex is a single layer of a heat-reticulated latex.

**12.** A thermographic plate according to claim **5**, wherein said layer of latex is composed of a plurality of discrete layers of black latex paint each having a thickness of less than 50 microns.

**13.** A thermographic plate according to claim **5**, wherein said plate has a self-sticking side.

**14.** A thermographic plate according to claim **5** further comprising a support layer and wherein there is a plurality of sensitive layers which are different from one another and which are associated with said support layer.

**15.** A medical device comprising: a thermographic plate as defined in claim **5** and a support instrument in which said plate is mounted.

**16.** A medical device according to claim **15**, wherein said support instrument is a probe.

**17.** A medical device according to claim **15**, wherein said support instrument is a retractor.

**18.** A medical device according to claim **15**, wherein said support instrument is a transport plate, and said thermographic plate is fixed at its periphery to said transport plate to form therewith an inflatable unit presenting a sealed space between said thermographic plate and said transport plate, and further comprising a valve connected to communicate with said space for enabling said unit to be inflated.

**19.** A medical device according to claim **15**, wherein said support instrument is a peripheral frame.

**20.** A medical device according to claim **15**, wherein the liquid crystals of said sensitive layer are encapsulated.

**21.** A medical device according to claim **15**, wherein said sensitive layer is free of any surface protective coating.

**22.** A medical device according to claim **15**, further comprising a fixed arm on which said support instrument is removably mounted, said arm being provided with means for mounting a photographic camera at adjustable distances from the thermographic plate.

* * * * *