(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 718 784 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.10.2020 Bulletin 2020/41

(51) Int Cl.:
B44C 5/04 *(2006.01)*

(21) Application number: **19219450.4**

(22) Date of filing: **23.12.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **22.03.2019 IT 201900004217**

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(54) **FINISH PANEL**

(57) The invention relates to a finish panel which comprises a front surface and a rear surface, wherein:
- the front surface is smooth and, in use, is exposed to the sight of a user;
- the rear surface, in use, is hidden from the sight of a user;
- the panel thickness varies between a maximum and a minimum value in order to reproduce a predefined graphic solution, wherein the areas of the panel with minimum thickness correspond to the lighter areas of the graphic solution and the areas of the panel with maximum thickness correspond to darker areas of the graphic solution; and
- the thickness is between 0.05 mm and 10 mm.

According to the invention, the areas of the panel with minimum thickness have a transparency of less than 40%.

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Description

[0001] The present invention relates to a finish panel for furnishing items.

[0002] Here and below, the expression "furnishing item" means any item or device which, during its correct use, remains at least partially visible to a user who is in the same space in which the furnishing item itself is located. Therefore, such expression also includes items or devices which are not properly pieces of furniture but which, in the space considered, have been provided for a specific function, even very different, e.g. a structural function. By way of example, the space in which the furnishing items considered herein can be placed, can be a closed space such as the passenger compartment of a vehicle, the rooms of a house or the spaces of a building used for administrative, commercial or industrial purposes; or it can be an open space, such as a garden, an urban space, and so on. The furnishing items considered herein comprise a finish panel in polymeric material which extends over at least a part of their surface visible during use. Some of these furnishing items can therefore be, purely by way of example, a dashboard of a vehicle, an internal or external covering of a vehicle or of a building, a door, a piece of furniture or an architectural element inside or outside a building, a furnishing accessory, and so on.

[0003] Polymeric materials (commonly called plastic materials or even plastics) have various advantageous features which have made them very successful in many sectors. From the industrial point of view, the main advantage of polymeric materials lies in the fact that they can be processed with specific technologies which allow the production of a very large number of pieces at low costs. Moreover, polymeric materials are generally durable, resistant and lightweight.

[0004] Among the disadvantages of the use of polymeric materials, there is the fact that they are traditionally associated with medium-low quality products. In the past, fine finishes were made exclusively of materials such as wood, hide, leather, ceramic, glass, metals and the like.

[0005] The processing technologies and the formulations themselves of the polymeric materials are constantly evolving with the aim, among others, of giving the polymeric products high and very high quality finishes. In some cases, the polymeric materials are formulated and processed in order to simulate other materials of greater value. This therefore allows in some cases to replace valuable materials when their use is disadvantageous in terms of processability, supply, cost, safety and so on. Often the common user does not even notice the replacement, simply perceiving the high quality of the product.

[0006] Furthermore, an aesthetic taste inspired by high-tech solutions, which has given impetus to the development of further technical and aesthetic solutions, has recently developed. Such solutions allow to give polymeric materials also very high quality finishes, but without necessarily simulating a different material.

[0007] In the context of these recent developments, the possibility of obtaining a finish panel of high-quality polymeric material that can take two different visual configurations is perceived as desirable. Particularly, it would be desirable that a finish panel in polymeric material could switch, at will, from a first configuration, intuitively called "switched-off configuration", to a second configuration, called by contrast "switched-on configuration". More specifically, it would be desirable that the same finish panel which in some conditions has an even, solid and compact appearance, could assume, in other conditions, a different aspect in which an image, an inscription, a logo or a graphic solution is highlighted.

[0008] A similar solution can be obtained by means of known technologies for producing the displays commonly used in portable consumer electronic devices such as smartphones, tablets and the like. Such displays can for example be made using LCD (*Liquid Crystal Display*), OLED (*Organic Light Emitting Diode*) technologies or the like. Such a finish panel could be shaped quite freely and would have the possibility to switch at will from a switched-off configuration to a switched-on configuration. More specifically, in the switched-off configuration such a finish panel could have an even, solid and compact appearance, while in the switched-on configuration it could show images, inscriptions, logos or variable graphic solutions, even in motion, such as the reproduction of a photograph or a video. However, this solution implies an excessive degree of complication and production cost for the purposes of the finish panel of the invention. CA 2 809 943 describes a lighting apparatus suitable for showing graphics when illuminated by a light source.

[0009] Therefore, the object of the present invention is to overcome the drawbacks underlined before with respect to the prior art.

[0010] Particularly, a task of the present invention is to make available a low-cost finish panel which in a switched-off condition has an even, solid and compact appearance, and which, in a switched-on condition, can show a static or predefined image, inscription, logo or graphic solution.

[0011] Such object and such tasks are achieved by means of a finish panel of polymeric material according to claim 1.

[0012] In the context of the present discussion, some terminological conventions have been adopted in order to make reading easier and smoother. Such terminological conventions are clarified below.

[0013] First of all, the invention relates to a finish panel which, during its correct use, is intended to be visible to an observer. In the following therefore "front" refers to a position which, in the correct use of the panel, is relatively close to the observer. Likewise, "rear" refers to a position which, in the correct use of the panel, is relatively far from the observer. Moreover, there are some conventions and definitions which are widely used in the field of optics and lighting. These conventions and definitions are briefly reproduced below for the reader's convenience.

[0014] The way a person sees bodies around him/her depends on the interaction between light and matter. In particular, this study takes into account the optical properties of moulded plastic objects.

[0015] Whenever light passes through a separation surface between different materials (e.g. air-plastic or glass-air), a certain amount of light is reflected, a part is subject to surface scattering and another part is transmitted. Inside the material, the portion of transmitted light may in turn be progressively reduced due to the absorption and volume scattering phenomena. In absorption, a photon is absorbed and then re-emitted in a non-radiative way, typically as heat. In atomic and molecular scattering, however, the photon is absorbed and then immediately re-emitted but with a variation in its propagation direction. Scattering can also occur due to structures of much larger dimensions than those of atoms or molecules. In volume scattering, this can occur due to the presence of particles of a foreign material dispersed in the main medium; in surface scattering, light deviation can be due to the microscopic morphology of the surface, as in the case of roughness and processing grooves, but also to the presence, for example, of small prisms, small lenses, bosses, or other alterations appropriately obtained on the surface of the medium.

[0016] Reflectance, absorption and scattering are properties of each material and depend on the wavelength of light across the respective spectrum. These properties can therefore be used to influence the colour of the light that interacts with the body.

[0017] In the case of pure absorption, the amount of light that passes through the material, I, given the initial flow I_0, can be described by the following equation (Beer-Lambert law):

$$I = I_0 \exp(-\varepsilon_{abs} c_{abs} t) = I_0 \exp(-\alpha t) \quad \text{Eq. (1)}$$

[0018] Beer-Lambert law states that the absorbance of a body depends on the length of the path of light in the medium, t, on the concentration of the molecules or atoms responsible for absorption, C_{abs}, and on the molar extinction coefficient of the same elements, ε_{abs}. It is the molar extinction coefficient that depends on the wavelength of light and this phenomenon is responsible for the colouring of bodies in the vast majority of cases. The product $\varepsilon_{abs} C$ is the absorption coefficient α.

[0019] In case of pure volume scattering it is possible to describe the reduction of the luminous flux with the following equation:

$$I = I_0 \exp(-\varepsilon_{sc} c_{sc} t) = I_0 \exp(-\sigma t) \quad \text{Eq. (2)}$$

where ε_{sc} *is* the molar scattering coefficient, c_{sc} is the concentration of scattering elements and σ is known as scattering coefficient. The two equations can be combined in the following expression, which takes into account both absorption and scattering:

$$I = I_0 e^{-(\alpha+\sigma)t} = I_0 e^{-kt} \quad \text{Eq. (3)}$$

where k is called the extinction coefficient, or opacity. The transmittance T is defined as $I/I_0 = \exp(-kt)$ and represents the relative light quantity that passes through the material. T depends on the wavelength and this is the reason why the expression "transmittance spectrum" is used.

[0020] Total transparency, i.e. across the whole spectrum, can be quantified by the tristimulus luminance variable Y and can be calculated with the usual integration techniques applied to the product of the spectral density of incident radiation, S, times the aforementioned transmittance spectrum of the material, T, times the sensitivity curve of the human eye, y:

$$Y = k \int_{\lambda}^{Vis} T(\lambda) S(\lambda) y(\lambda) d\lambda$$

$$k = 100 \Big/ \int_{\lambda}^{Vis} S(\lambda) y(\lambda) d\lambda$$

[0021] Using the above laws, it is possible to control the quantity and quality of the transmitted light by varying the thickness, the chemical composition of the medium, the concentration of dyes or dispersed particles that may be present and finally the surface texture of any body that allows the passage of light, and namely of moulded plastic bodies. The variation in thickness means a distribution of variable thickness, in the form of a difference in height or in any case of a non-flat surface or flat surface with non-coplanar segments. The surface with variable thickness can be either the one facing the observer or the one facing the opposite side, or both, but the case in which the surface with variable thickness is the one on the opposite side of the observer is of particular interest for this invention.

[0022] The light can be produced by an illuminator placed behind the moulded plastic material plate. The distribution of this light can be even, or uneven, and can be characterized by a colour, or be white.

[0023] Under these conditions, the thicker areas of the plate will appear darker than the thin ones, because a greater thickness *t* will correspond to them, and therefore a greater extinction (or opacity), according to equation (3), regardless of this being due to colouring or volume scattering. The thickness modulation therefore translates into a modulation of light intensity that reaches the observer, and the illumination map can be designed so as to offer the observer's eye a graphic or a drawing.

[0024] If the opacity of the plate is properly calibrated, then the embedded image will appear to the observer only when the rear illuminator is activated, while it will be invisible in other conditions. For example, the plate may appear completely black, or of a well-defined and opaque colour. For this reason, it is particularly useful that the surface with variable thickness is the one located on the opposite side of the observer.

[0025] As regards the scope of this application, the differences in height of the surface with variable thickness can vary between 0.05 and 10 mm. Some materials suitable for making the panel are the polymers usually used in the optical field, such as for example polycarbonate, polymethyl methacrylate, copolymers of cyclic olefins, and the like. The absorption coefficient and the scattering coefficient can be chosen in such a way as to achieve a transparency between a minimum close to 0% and a maximum close to 100%, obtaining the maximum possible excursion in the brightness scale perceived by the observer. The maximum effectiveness of the proposed invention requires a low transparency value, less than 40%, in order to make the image invisible in the absence of backlighting.

[0026] A method suitable for experimentally measuring the transparency of an object is described below, for example in order to verify whether a panel falls within the scope of the present invention. The method involves setting up an emitter and a light sensor in series. The emitter must be able to emit a collimated and concentrated light beam on the sensor. In turn, the sensor must be suitable for providing an indication of the intensity of the incident light. By turning on the emitter in the presence of air only between it and the sensor, the light beam will reach the sensitive area of the sensor substantially in its entirety, generating a signal that will be considered 100% of transparency. On the other hand, 0% transparency occurs when the sensor does not receive any fraction of the light beam. By interposing a body between the emitter and the sensor, the signal returned by the latter and scaled with respect to the 100% defined above provides the percentage of transparency considered here.

[0027] Surface scattering can be introduced to further modify the appearance of the device. If the surface facing the observer is perfectly shiny, there will be a strong reflectivity, with the additional effect of further masking the underlying design. However, this surface can also be rough or in any case capable of scattering, if it is considered more useful or necessary to offer the user this type of finish. In this case, the absorption and volume scattering must be dosed so as to ensure the non-visibility of the design. All the phenomena described above can be suitably used in order to obtain a desired aesthetic effect for an observer looking at a backlit, side-lit or front-lit plastic body.

[0028] The combination of thickness and concentration of the dyes and the characteristics of volume and/or surface scattering will determine a sharp transmittance variation, which will be recognized by the observer as a variation in brightness, and therefore as a design or graphic.

[0029] A particular application of these phenomena is the production of a suitably loaded and coloured panel, so that it will appear even and opaque in the absence of backlighting, while, in the presence of backlighting, the graphics obtained by means of the phenomena described above will be revealed in transparency.

[0030] The invention relates to a finish panel which comprises a front surface and a rear surface, wherein:

- the front surface is smooth and, in use, is exposed to the sight of a user;
- the rear surface, in use, is hidden from the sight of a user;
- the panel thickness varies between a maximum and a minimum value in order to reproduce a predefined graphic solution, wherein the areas of the panel with minimum thickness correspond to the lighter areas of the graphic solution and the areas of the panel with maximum thickness correspond to darker areas of the graphic solution; and
- the thickness is between 0.05 mm and 10 mm.

[0031] According to the invention, the areas of the panel with minimum thickness have a transparency of less than 40%.

[0032] Preferably, according to the invention, the areas of the panel with minimum thickness have a transparency of less than 35%.

[0033] Preferably, according to the invention, the areas of the panel with minimum thickness have a transparency of less than 30%.

[0034] Preferably, according to the invention, the areas of the panel with minimum thickness have a transparency of less than 25%.

[0035] Preferably, according to the invention, the areas of the panel with minimum thickness have a transparency of less than 20%.

[0036] Preferably, according to the invention, the areas of the panel with maximum thickness have a transparency close to 0%.

[0037] As the skilled person can well understand, since the front surface is smooth and the thickness of the panel is variable, the rear surface is characterized by level variations.

[0038] According to the different possible embodiments of the invention, the panel can be flat, it can have a simple curvature or a more complex shape, such as for example a double curvature.

[0039] Preferably, the finish panel is made from a transparent, semitransparent or opalescent material. Preferably, the finish panel is made from a polymeric material or from glass.

[0040] Preferably, the finish panel is coupled to a rear shell, suitable for alternatively assuming two different configurations. In a first configuration (called switched-off) the rear shell is suitable for preventing any backlighting of the panel, that is, it is suitable for shielding the light radiation that could reach the rear surface of the panel.

[0041] In a second configuration (called switched-on) the rear shell is instead suitable for providing a backlighting of the panel, that is, it is suitable for producing or conveying a light radiation so that it reaches the rear surface of the panel. Preferably, the light radiation of the backlighting obtained through the rear shell is distributed in a substantially even way over the entire extension of the graphic solution of the panel.

[0042] The transparency values indicated above are sufficiently low because in the switched-off configuration, i.e. in the absence of a backlighting, the panel appears even, solid and compact, and gives the impression of having a massive structure.

[0043] The light coming from the environment in which the observer is immersed can in fact pass through the panel to a minimum, especially in areas with minimum thickness. In turn, the smallest part of light that passes through the panel can only be partially reflected by the rear shell. The amount of light that was reflected is therefore so small that it cannot reasonably pass through the panel again, due to its low transparency.

[0044] In this way, in the switched-off configuration, the panel appears as if it does not include any graphic solution.

[0045] At the same time, however, the transparency levels of the panel are such that, in the switched-on configuration, i.e. in the presence of an adequate backlighting, the light radiation that reaches the rear surface of the panel passes through the latter with variable intensity. More specifically, the maximum transparency areas appear as the lightest areas of the graphic solution, while the minimum transparency areas (which can also be completely opaque) appear as the darkest areas of the graphic solution. Preferably, the assembly consisting of the panel and the relative rear shell are integrated into a furnishing item, so that, in the correct use, the front surface of the panel is exposed to the view of an observer. Preferably, if the rear shell requires electrical power to be able to switch from the switched-off configuration to the switched-on configuration, the shell power line is integrated into the furnishing item and appears hidden while in use. Depending on the specific graphic solution, the thickness of the panel in the different areas can vary with a substantial continuity between the minimum thickness and the maximum thickness. In this way, the panel can reproduce a graphic solution that requires an almost continuous variation in brightness between the different areas. The graphic solution of the panel can thus reproduce, for example, a black and white photograph.

[0046] In other cases, on the other hand, the thickness of the panel in the various areas can assume a finite number of values between the minimum thickness and the maximum thickness. In this way, the panel can reproduce a graphic solution that requires sharp variations in brightness between the different areas. The graphic solution of the panel can thus reproduce, for example, a logo or an inscription.

[0047] In accordance with the invention, the transparency values of the panel can be predefined during project development thanks to the variation of some parameters which are described below.

[0048] As an example, some materials suitable for the production of the panel are: polycarbonate (PC), polymethylmethacrylate (PMMA), cyclic olefins copolymers (COC), polyurethane (PU), polystyrene (PS), polypropylene (PP), a mixture of polycarbonate and acrylonitrile butadiene styrene (PC-ABS). Some of these materials are widely appreciated for their high transparency. Other materials, on the other hand, usually have a semitransparent or opalescent appearance.

[0049] For the purposes of the present invention, however, the transparency of the panel must be limited in a controlled way, and this can be achieved by acting on some parameters. The parameters on which it is preferable to act are the thickness of the panel and the addition of an opacifying filler dispersed in the mass of the base material. Another way to limit transparency could be the addition of a surface opacifying layer, such as the deposition of a coloured layer (like

in sunglasses lenses) or a semi-reflective layer (like in mirror sun lenses).

[0050] As mentioned above, for technological and size reasons, the thickness of the panel is limited to 10 mm or less. Therefore, an opacifying filler, i.e. consisting of absorbent and/or scattering particles, is preferably used. Such particles are known in the optics sector.

[0051] Preferably, the particles of the opacifying filler are evenly dispersed in the transparent base material.

[0052] For the purposes of the present invention, in the design of the panel, it is necessary to define the base material to be used in the injection mould. Subsequently, it is necessary to define the maximum and minimum panel thicknesses on the basis of the technological and size limits that derive from the use for which the panel is intended. Subsequently, once the type of filler to be used has been chosen, it is necessary to define the filler concentration necessary to limit the transparency of the areas of minimum thickness of the panel within the desired limits.

[0053] The panel according to the invention is preferably obtained by injection moulding of a polymeric material. The advantages deriving from the use of this process and of this material are widely known and have been briefly described in the introductory part of this discussion.

[0054] A particular advantage relating to the present invention resides in the fact that the variation in panel thickness can be obtained thanks to the precision manufacturing of the mould. This processing can be obtained using different technologies such as: laser processing, plasma processing, numerical control milling by means of mini-milling cutters, electrical discharge machining (EDM), chemical milling or chemical etching. Once the desired mould is obtained, the injection moulding allows the production of a very high number of pieces at a very low cost with a high quality and a minimum error margin.

[0055] Alternatively, the panel according to the invention can also be obtained by other processing technologies, such as for example extrusion, compression moulding, thermoforming and the like.

[0056] As the skilled person can well understand, the effect obtained by the panel of the invention is similar to that obtained with the lithophane technique. Compared to this known technique, however, the present invention includes some important differences. First of all, the polymeric materials used allow the production of the panel by means of the injection moulding technique which allows the rapid production of a very large number of pieces. This potential of injection moulding is particularly important in industrial sectors such as the automotive sector where the same panel must be made available quickly and in a very large number of specimens (in the order of hundreds of thousands). The skilled person can well understand that the lithophane technique, whether it is carried out in a traditional way with ceramic material or by 3D printing with polymeric material, in any case cannot guarantee the times, costs and number of pieces required by the automotive sector at all.

[0057] Furthermore, in the lithophane, in order to make the image clear, the variations in thickness are all reported on the front surface exposed to view, while the rear surface which is affected by the light radiation is smooth. This certainly determines, although imprecisely, the visibility of the graphic solution, even in the switched-off configuration.

[0058] As the skilled person can easily understand, the invention allows to overcome the drawbacks highlighted above with reference to the prior art. Particularly, the present invention makes available a low-cost finish panel which in a switched-off condition has an even, solid and compact appearance, and which, in a switched-on condition, can show a static and predefined graphic solution.

[0059] It is clear that the specific features are described in relation to various embodiments of the invention with exemplifying and non-limiting intent. Obviously, a person skilled in the art may make further modifications and variations to this invention, in order to meet contingent and specific requirements. For example, the technical features described in connection with an embodiment of the invention may be extrapolated from it and applied to other embodiments of the invention. Furthermore, such modifications and variations are included within the scope of protection of the invention, as defined by the following claims.

Claims

1. Finish panel, comprising a front surface and a rear surface, wherein:

- the front surface is smooth and, in use, is exposed to the sight of a user;
- the rear surface, in use, is hidden from the sight of a user;
- the panel thickness varies between a maximum and a minimum value in order to reproduce a predefined graphic solution, wherein the areas of the panel with minimum thickness correspond to the lighter areas of the graphic solution and the areas of the panel with maximum thickness correspond to darker areas of the graphic solution; and
- the thickness is between 0.05 mm and 10 mm;

characterized in that the areas of the panel with minimum thickness have a transparency of less than 40%.

2. Panel according to claim 1, wherein the areas of the panel with minimum thickness have a transparency of less than 30%.

3. Panel according to claim 1, wherein the areas of the panel with minimum thickness have a transparency of less than 20%.

4. Panel according to one or more of the preceding claims, wherein the panel is made of polymeric material.

5. Panel according to claim 4, wherein the polymeric material is selected from the group including: polycarbonate (PC), polymethylmethacrylate (PMMA), cyclic olefins copolymers (COC), polyurethane (PU), polystyrene (PS), polypropylene (PP), a mixture of polycarbonate and acrylonitrile butadiene styrene (PC-ABS).

6. Panel according to claim 4 or 5, wherein the panel is obtained by injection moulding.

7. Panel according to one or more of the preceding claims, wherein the panel further comprises a rear shell.

8. Panel according to claim 7, wherein the rear shell is adapted to alternatively assume:

- a switched-off configuration wherein it prevents any backlighting of the panel; and
- a switched-on configuration in which it provides a panel backlighting.

9. Furnishing item comprising a panel according to one or more of the preceding claims.

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EUROPEAN SEARCH REPORT

Application Number
EP 19 21 9450

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 July 2020	Zacchini, Daniela

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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