

A METHOD OF FORMING A TRANSMISSIVE SCREEN

The invention relates to a method of forming a transmissive screen and to a transmissive screen so formed.

5 Such a transmissive screen may be used for example in a video projector.

 A transmissive screen for use in a video projector is generally composed of a Fresnel lens and a lenticular lens, and contains a diffusing agent made, for example, of SiO_2 in order to have a diffusing
10 property. The Fresnel lens has a function in which a diverged light from a projection lens is refracted toward a viewer. This Fresnel lens has a lens surface formed on one side of a methacrylic resin plate in which a number of concentric V-shaped grooves are formed and a non-lens surface formed on the other side of the methacrylic resin plate. In
15 general, a hot-press moulding method is employed to produce a Fresnel lens screen. According to the hot-press moulding method, a methacrylic resin plate 3 to 5 mm thick is sandwiched between a metal mould in which V-shaped grooves opposite to the configuration of the Fresnel lens are concentrically engraved on a copper plate of 1 to 3 mm thick
20 and a calendered metal plate, heated and moulded with a pressure. A Fresnel lens screen can be produced by this method. A lenticular lens screen is produced similarly.

 In such a previously proposed manufacturing method, in order to form one surface of a Fresnel lens, one surface of the engraved metal
25 mould is needed, and many metal moulds are required to mass-produce a Fresnel lens. The metal mould costs £6,000 to £10,000 per plane and is thus expensive. Further, the metal mould needs a large number of planes and the metal mould cost increases the cost of production. A life span of the metal mould provides a press-process of about 800 to
30 10000 times, which means a metal mould cost of £6 to £10 per plane. In the moulding-process, a methacrylic resin plate provided as a workpiece must be heated, softened and placed in the condition such that it can be moulded. A moulding temperature must be selected to be high in a range of from 140 to 170°C, and the moulding time required is 1.5 to 2
35 hours per plane. Further, the Fresnel lens screen moulded by the hot-press moulding method must be released from the metal mould at a high temperature of 80 to 100°C, otherwise it cannot be released from

the mould without difficulty. If the moulded Fresnel lens screen is not uniformly released from the mould, the product will be rejected. Furthermore, the metal mould is heated at very high temperature so that the life span of the metal mould is short, which causes the cost of the product to be greatly increased. In addition, the prior-art Fresnel lens screen is thick, which causes a problem of the occurrence of multiple images.

According to the invention there is provided a method of forming a transmissive screen comprising the steps of coating a uniform thickness coating of a liquid UV-curable resin onto one of a UV-transmissive backing film and a mould having a surface complementary to the shape of a lens surface to be formed, applying the other of the mould and the backing film to the exposed face of the coating of UV-curable resin to sandwich the UV-curable resin between the backing film and the mould, conveying the mould on a conveyor while irradiating the UV-curable resin with ultraviolet rays through the backing film, and releasing the moulded transmissive screen thereby formed, comprising cured resin and the backing film, from the mould.

By the method of the invention moulding time can be reduced and continuous mass-production can be made possible. Therefore, a press apparatus and a heating apparatus needed by the previously proposed hot-press system, are not required, which can considerably reduce the cost of the manufacturing facilities. Further, the thickness of the screen can be adjusted to be a desired one so that the transmissive screen can be reduced in weight and thickness.

By reducing the thickness of the screen the occurrence of multiple images can be reduced.

The invention is diagrammatically illustrated by way of example in the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a section of an apparatus in which the method according to the invention can be performed;

Figure 2 is a diagrammatic view of a section of a transmissive screen during manufacture by the method according to the invention;

Figure 3 is a diagrammatic view of a section of a transmissive screen manufactured by the method according to the invention;

Figures 4 to 6 are graphs graphing spectral transmissivity characteristics of a UV-curable resin;

Figure 7 is a schematic diagram used to explain a multiple image;
and

Figure 8 is a schematic diagram showing an example of a
transmission projector incorporating a transmissive screen manufactured
5 by a method according to the invention.

Referring to the drawings, Figure 1 shows apparatus for
continuous manufacture of Fresnel lens screens. The apparatus 1
comprises a base table 2, a conveyor 3 provided on the base table 2, a
resin feeder 4, a doctor blade 5, a pressure roll 6, a metal halide
10 lamp 8 for irradiation by ultraviolet rays 7 and a mould-releasing roll
9. Reference numeral 10 designates resin moulds on each of which there
is formed a lens surface of opposite shape to that of a Fresnel lens to
be formed. The resin moulds 10 are located on the conveyor 3 with a
predetermined spacing. A number of resin moulds 10 are manufactured on
15 the basis of a master metal mould whose one plane is formed by a cut
and mould process so that the manufacturing cost of the resin mould 10
can be reduced. The resin mould 10 can be replaced by a metal mould.
However such a metal mould does not require heating to high temperature
unlike the previously proposed hot pressing manufacturing method so
20 that the life span of the metal mould can be extensive, which can
decrease the cost of the produce.

With the employment of the apparatus 1, Fresnel lens screens 11
can be produced according to the following process.

Initially, a UV-curable resin 12, for example, APR resin (trade
25 name, manufactured by Asahi Chemical Industry Co Ltd) or GRANDICK resin
(trade name, manufactured by Dainippon Ink & Chemicals Inc etc), in a
liquid condition is supplied from the resin feeder 4 to the resin
moulds 10 which are being conveyed by the conveyor 3, and the thickness
of the coating is made uniform by the doctor blade 5. The coating
30 thickness of the resin 12 must be properly selected in a range of from
0.10 to 2.50 mm. When the coating thickness is small, the uniformity
of the thickness becomes inferior, whereas, when the coating thickness
is large, the necessary irradiation time by the ultraviolet rays 7 is
extended. In the coating-process, air bubbles must be carefully
35 prevented from entering the resin 12 otherwise pin-holes will be
produced in the screen. For this countermeasure, upon use, after a
viscosity of the UV-curable resin 12 is adjusted to be low in a range

of from 500 cps to 2000 cps, vacuum defoaming is performed prior to the coating-process to remove the bubbles contained in the resin 12, and is then utilized. In the next process, a backing-film (for example, a polyester film acetate film or the like) 13 which is 50 to 300 μ m thick, is transported around the pressure roll 6 and is deposited on a coating surface 14 of the resin 12. The backing film 13 is deposited on the coating surface 14 of the resin in order to isolate the resin 12 from the air (in particular, oxygen).

As shown in Figure 1 and in Figure 2 to an enlarged scale, the resin 12 with the backing film 13 deposited thereon is transported under the metal halide lamp 8 forming an ultraviolet ray light source, so that ultraviolet rays 7 irradiate the resin at an intensity of 2 mW/cm² on the irradiated surface and for an irradiation time of 5 minutes thereby to cure the resin 12. At the completion of the curing-treatment utilizing the ultraviolet rays 7, a Fresnel lens screen 11 is released from the resin mould 10 by the mould-releasing roll 9. Thereafter, the backing film 13 is cut and divided so that the Fresnel lens screen 11 shown in Figure 3 is obtained. Reference numeral 15 denotes a Fresnel lens surface.

While the description above provides that the backing film 13 is deposited on the resin after the resin 12 is coated on the resin mould 10, the Fresnel lens screen 11 can be produced by a method in which the resin 12 of a desired thickness is coated on the backing film 13 and the resultant product is then laid on the resin mould 10 and is irradiated with the ultraviolet rays 7. A resin mould is employed as a mould for the lens in the above-described embodiment, a metal mould may be utilized if desired as mentioned hereinbefore and may be a machined metal mould or a cast metal mould. Instead of a metal mould it is also possible to utilize a mould made of ceramics or a mould made of glass or gypsum. The invention is also applicable to manufacture of a lenticular lens.

An embodiment in which inflammability of the transmissive screen of the invention is improved will be described next. Generally, a video projector screen is required to pass the horizontal burning test of the standard UL-94. For this reason a fire retardant is added to the UV-curable resin 12 with a ratio of 5 to 20 wt% relative to the resin 12, thereby increasing inflammability. As a fire retardant

commercially available on the market, there are known, for example, CR-720, CR-509, CLD (trade names, manufactured by Daihachi Kagaku Kogyosho Kabusiki Kaisha), FIRE GUARD (trade name, manufactured by Teijin Kasei Kabushiki Kaisha), FIRE-ROAD A (trade name, manufactured by Osaka Yuki Kagaku Kogyo Kabushiki Kaisha), UNFLAME (trade name, manufactured by Nippon Oils & Fats Co Ltd) and Kopica (trade name, manufactured by Nippon Yupica Kabushiki Kaisha).

In one experiment CR-509 (trade name) was utilized as the fire retardant, added into the UV-curable resin 12 while varying an added ratio and stirred and mixed thereinto so as to be dispersed uniformly. Thereafter, a test-piece of 0.4 mm thick, 12.7 mm wide and 125 mm long was produced and a burning test was carried out. The test results are represented on the table below. According to the standard of UL-94, 2·2·B, in a case of a test-piece of less than 3.05 mm (0.120-inch) thick, it is required that a burning velocity thereof should not exceed a burning velocity of 76.2 mm per minute (3.0-inch per minute). The test results demonstrate that the above condition can be satisfied by adding the fire retardant of more than 5 wt% to the UV-curable resin 12. In practice, it is preferable that the fire retardant of from 10 to 20 wt% should be added to the resin from a safety standpoint.

TABLE

Containing amount of fire retardant (wt%)	Burning time of 76.2 mm	Burning Velocity (mm/minute)	Appearance	Curing time
0	57 seconds	80.2	-	-
5	1 minute and 27 seconds	52.6	not changed	not changed
10	2 minutes and 36 seconds	29.6	not changed	not changed
20	extinguished halfway	-	not changed	not changed

As shown in the table, regardless of the addition of the fire retardant into the resin 12, the curing time is not changed, and the

screen can be produced under exactly the same curing condition as that of the case where the fire retardant is not added to the resin. Then, with respect to the samples made of the resin 12 in which the fire retardant is added as in the above-mentioned embodiment, the change of transmissivity was measured while the added amount of the fire retardant was being varied. The measured results are represented in Figure 4 to 6. Figure 4 shows measured results in which the added amount of the fire retardant is zero, Figure 5 shows measured results in which the added amount of the fire retardant is 5 wt%, and Figure 6 shows measured results in which the added amount of the fire retardant is 10 wt%, respectively. From these graphs, it is to be noted that, even when the fire retardant is added to the resin (Figures 5 and 6), the spectral transmissive characteristics of UV-curable resins are not substantially changed as compared with the case where the fire retardant is not added to the resin (Figure 4). Therefore, even when the screen is produced under the condition that the fire retardant is added to the resin, colour and physical changes are not found in the resultant screen. Although the thickness of the screen must be increased so as to conform to the UL-94 Standard as with prior-art screens, the thickness of the screen can be decreased without causing any problem from an inflammability standpoint. Simultaneously, it becomes possible to solve a problem of multiple images occurring due to the reflection on the lens surface because the screen has a large thickness. More specifically, as shown in Figure 7, in order to obtain the same inflammability level, a thickness t_2 of a prior-art screen in which the fire retardant is not added must be increased. Whereas, in the screen 11 of the invention, its thickness t_1 can be reduced. Therefore, in the case of the present screen 11, a distance L_1 in which a real image and a ghost cannot be distinguished from each other can be reduced as compared with a distance L_2 of the example of the prior art, whereby the degree of multiple images is reduced. In Figure 7, reference numeral 16 designates a light source and 17 a light.

Figure 8 shows a transmission projector utilizing a transmissive screen of the invention. In Figure 8, it will be seen that a transmission projector 19 comprises a transmissive screen 20, red, green and blue cathode ray tubes 21 (only one cathode ray tube is shown in the figure) each being provided as a video source, a mirror 22 to

reflect visual image lights from the cathode ray tubes 21 on the transmissive screen and a cabinet 23 to accommodate these elements therein. The transmissive screen 20 is formed as shown in Figure 3, its lens surface 15 faces the viewer and the backing film 13 faces the inside of the cabinet 23.

According to previously known transmission screen manufacturing methods, there are problems in the case of a Fresnel lens screen, for example, 1016 to 1143 mm (40 to 45-inches), since it is thick (3 to 5 mm) and heavy (1.5 to 2 kg). By the method of the invention, it is possible to obtain a screen of 0.6 to 2 mm thick and which weighs 200 to 300 g. Therefore, as compared with the prior art, a screen made by the method of the invention can be reduced in thickness and in weight to about 1/5. Thus, the thickness of the screen can be reduced so that it is possible to solve a problem of multiple images occurring due to the reflection on the lens surface when the lens is a Fresnel lens of short focal length. Further, since the screen can be made very thin, it is possible to obtain a rewind-type transmission screen. According to the manufacturing method of the invention, the manufacturing time can be considerably reduced as compared with that of the example of the prior art so that the manufacturing method of the invention can be suited to mass-production. Furthermore, it is possible to provide an unmanned automated line on the basis of the invention.

CLAIMS

1. A method of forming a transmissive screen comprising the steps of coating a uniform thickness coating of a liquid UV-curable resin onto one of a UV-transmissive backing film and a mould having a surface complementary to the shape of a lens surface to be formed, applying the other of the mould and the backing film to the exposed face of the coating of UV-curable resin to sandwich the UV-curable resin between the backing film and the mould, conveying the mould on a conveyor while irradiating the UV-curable resin with ultraviolet rays through the backing film, and releasing the moulded transmissive screen thereby formed, comprising cured resin and the backing film, from the mould.
2. A transmissive screen formed by the method of claim 1.