

DRAWINGS ATTACHED

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(54) IMPROVEMENTS RELATING TO THE MANUFACTURE
OF MIRRORS

- (71) We, **BRITISH AIRCRAFT CORPORATION LIMITED**, a British Company, of 100 Pall Mall, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
- This invention relates to the manufacture of mirrors whose reflecting surface is provided by a metallized film of plastics material, e.g. an aluminized polyester film.
- Such mirrors have many useful properties. They are much lighter than glass mirrors of similar size and are less liable to break if dropped. Owing to the low heat capacity of the film, they are less subject to condensation or "misting-up" in a warm, humid environment. If the metallized film is of good quality and evenly tensioned in all directions the optical properties of the mirror are of a high order. It can, however, be difficult to ensure an even tension throughout the film, in all directions. Film materials are known which have the property that tension can be created in an area of them by application of heat while the periphery of the area is held. This property is more usually expressed by saying that, if the area of film is not restrained, it will shrink upon application of heat. However, it is not easy to heat the material equally all over its surface, and uneven or excessive heating causes uneven shrinkage and consequent distortion.
- According to the present invention a method of manufacturing a mirror comprises securing a metallized film of plastics material against a support which defines the periphery of the mirror, and creating tension in the film by bringing one face of the film substantially into contact with a flat surface heated by means which is under thermostatic control and which produces substantial uniformity in the temperature (and thus in the tension) attained over the whole surface of the film within the periphery of the mirror.

One class of materials having the property that tension can be created in it by heat is polyesters. Another class having this property is polyimides. Polyesters are preferred, for commercial reasons, but polyimides are superior over a wide temperature range and because they will not burn. A convenient polyester is polyethylene terephthalate.

The method operates by bringing every place on the film to substantially the same temperature. For polyethylene terephthalate this should be $180^{\circ} \pm 5^{\circ}\text{C}$. The creation of tension proceeds very rapidly at first and then continues much more slowly. For polyethylene terephthalate, the temperature should be sustained for not less than 3 seconds and not more than 30 seconds.

The preferred film is polyethylene terephthalate 0.001 inch (0.025 mm) thick, and the preferred metallized coating is of aluminium, only about 10^{-6} inch (0.025 μ) thick.

In one particular way of carrying out the invention, the heated flat surface comprises one face of a heat retaining plate, which is itself heated by electric elements in cavities in the plate.

The accuracy of optical reflection from the mirror depends *inter alia* on the absence of scratches on the unmetallized face of the film. Preferably, to guard against scratches, the flat surface comprises one face of a sheet, the other face of the sheet being in heat exchange relationship with a heat retaining plate which is itself heated.

The plate has a much higher thermal capacity than the film, and hence no appreciable drop occurs in the temperature of the plate when the film is brought to the plate. Several seconds may elapse before each place on the film has reached substantially the temperature of the plate. This is because a slight air gap is liable to exist over at least part of the area. This is especially so if there is air trapped, or with only a restricted vent, in a gap between the film and a backing board

forming part of the support. Such air becomes heated and causes the film to bulge towards the plate.

Hence it is desirable to hold the film in contact with the plate for about 10 seconds.

In another particular way of carrying out the invention, the flat surface is the upper surface of the upper run of a moving conveyor belt, and the upper run of the belt is heated substantially uniformly across its width.

Specific examples of methods according to the invention will now be described in more detail, with reference to the accompanying drawings, in which:—

Figure 1 is a perspective view of the front of a mirror;

Figure 2 is a fragmentary cross section of a mirror, in a front-downwards attitude;

Figure 3 is a fragmentary cross section of a heated plate; and

Figure 4 is a perspective view of a mirror being treated by apparatus which includes conveyor belts.

In the example shown, the mirror is rectangular, a typical size being 3 ft. x 2 ft. (0.9 m x 0.6 m). The support for the mirror consists of a rectangular board 2 with a length of extruded metal strip 4 along each edge. As shown most clearly in Figure 2, the strip embraces the edge of the board and includes a bead 6 which actually defines the periphery of the mirror. As shown in Figure 1, the strips 4 may be a single length, notched and bent at each corner, with a butt joint at 8 reinforced internally by a fishplate 10 riveted to the strip as shown in Figure 2.

A suitable material for the board 2 is polyurethane rigid foam with aluminium foil at both faces. A suitable thickness is $\frac{1}{2}$ inch (12 mm). The strip 4 is of aluminium.

The metallized film 5 of plastics material is cut to a size somewhat larger than the mirror and placed upon the support so as to rest upon the bead 6. For the majority of purposes, the metallized surface is towards the board 2, so that in use reflection takes place at the interface between the film and the metallizing. The thickness of the film is necessarily exaggerated in the drawing.

The film is secured to the strip 4 by folding the film around the side and the back of the strip, and trapping the film in a dovetail-sectioned groove in the rear of the strip. This groove is shown at 12 in Figure 2 and the position of the film at 14. The film is trapped by forcing into the groove, after the film, a length of resilient material, e.g. rubber or polyvinyl chloride, which is of circular section and is an interference fit. This is shown at 16 in Figure 2. Thereupon surplus film is removed by cutting at 18.

At this stage, the film of plastics material is not tight, but simply free of any major wrinkles. In this condition it does not provide a true mirror.

In order to produce a true mirror, two things are necessary, namely that the film should be evenly tensioned, and that the support which defines the periphery of the mirror should be truly in a plane. The purpose of the board 2 is to supply the necessary rigidity to ensure that the latter requirement is satisfied. The board 2 must furthermore be truly flat, and the strip 4 must be accurately made.

The even tensioning is achieved, in this particular example, by placing the mirror, film downwards, on a heated plate, as shown in Figure 3. The main body 20 of this plate is of metal with a flat upper surface. This upper surface has a covering layer 22, of a polytetrafluoroethylene impregnated glass fibre cloth of 120 threads per inch (5 threads per mm) and 0.003 inch (0.075 mm) thickness. This does not deteriorate at the temperature of the plate 20, and has the further advantages that it has a low coefficient of friction with the film, and that, at the temperature of the plate, the surface hardness of the polytetrafluoroethylene is of the same order as that of the film. This cloth need not be adherent to the metal, but simply laid evenly on it. The thickness of the cloth is necessarily exaggerated in the drawing.

The metal plate is kept at an even temperature of 180°C by means of electric heating elements which are accommodated in grooves 24 in the underside of the plate, and which are controlled by a thermostat housed in a recess 26 in the underside of the plate. The grooves, and consequently the elements, are parallel, extending the length of the plate, and spaced sufficiently closely to avoid temperature variations on the upper side of the plate. Uniformity of temperature is also assisted by the presence of a substantial thickness of metal 28 above the groove 24, for example $\frac{1}{2}$ inch (12 mm) thickness. The grooves are closed by strips of asbestos board 30, and there is also a further sheet of asbestos board 32 over the entire underside of the plate.

As an alternative to parallel heated elements, a single element may be accommodated in a groove which first follows the periphery of the plate and then follows a spiral towards its centre.

As mentioned above, the film of the mirror is held substantially in contact with the cloth 22 for about 10 seconds. This process is found to produce even tensioning of the film, without distortion or marking of the unmetallized face.

If the mirror is very large, the plate may be of less area than the mirror. Then the mirror is tensioned in a series of steps by bringing first one area of the mirror and then another substantially into contact with the plate. There must be no gaps between these areas, but overlap is permissible, even to the extent of a corner of an area overlapping several other areas.

As an alternative to the use of a heated

plate, the tension in the mirror may be created by the use of a heated belt, as shown in Figure 4. Mirrors which have been prepared as shown in Figure 2 are supplied, face downwards, on an unheated belt 34, by which they are delivered on to a heated belt 36 from which they pass to a receiving unheated belt 38. The belt 36 is heated by a plate 40 close beneath the upper run of the belt. This plate may be the same as the plate shown in Figure 3, omitting the cloth 22.

Preferably the belt is from 0.001 inch (0.025 mm) to 0.006 inch (0.15 mm) thick. Preferably, to guard against scratches or other marks, the belt 36 is of finely woven glass fibre cloth impregnated with polytetrafluoroethylene.

Other possible materials for the belt are polyester film, and aluminium foil.

It is desirable that any given point in the film should remain on the belt for about 10 seconds.

To assist heating of the mirror film at places where there is a slight air gap between the film and the belt, the belt may be perforated. This will enable heated air from beneath the upper run of the belt to flow through the perforations and assist the flow of heat from the plate to the film.

As an alternative to the use of a heated plate 40, the belt 36 may itself incorporate heating means.

In any event, the belt requires to be heated substantially uniformly across its width, so that every part of the film of the mirror reaches the same maximum temperature.

To minimise the effect of trapped air, there is preferably, as shown in Figure 2, at least one hole 42 in the board 2. This hole should not be too large, as a subsidiary function of the board 2 is to ensure that, if something should press against the film, the film is prevented from becoming stretched beyond its elastic limit.

If the film is heated by placing on a plate, as described in relation to Figure 3, it may be desirable to apply some downward pressure to the mirror support, particularly at the corners, to assist uniform heating. With a moving belt this is found to be unnecessary, as the slight tendency of the belt to sag under the weight of the mirror will ensure that the corners of the film are adequately heated.

A refinement is to repeat the heating treatment. This is more likely to be desirable when placing the mirror on a plate.

A further step for enhancing the tension in

the film is to apply heat to each in turn of the side faces of the mirror, that is to say the faces marked 44 in Figure 2. This may be done by holding the mirror in a vertical plane and applying each side face in turn to a heated plate such as shown in Figure 3.

WHAT WE CLAIM IS:—

1. A method of manufacturing a mirror comprising securing a metallized film of plastics material against a support which defines the periphery of the mirror, and creating tension in the film by bringing one face of the film substantially into contact with a flat surface heated by means which is under thermostatic control and which produces substantial uniformity in the temperature (and thus in the tension) attained over the whole surface of the film within the periphery of the mirror.

2. A method according to claim 1, in which the flat surface comprises one face of a heat retaining plate which is itself heated by electric elements in cavities in the plate.

3. A method according to claim 1, in which the flat surface comprises one face of a sheet, the other face of the sheet being in heat exchange relationship with a heat retaining plate which is itself heated.

4. A method according to claim 3, in which the sheet is of glass fibre cloth impregnated with polytetrafluoroethylene.

5. A method according to any preceding claim, in which the flat surface is of less area than the mirror, and tension is created in the film in a series of steps, by bringing first one area of the film, and then another, substantially into contact with the flat surface.

6. A method according to claim 1, in which the flat surface is the upper surface of the upper run of a moving conveyor belt, and the upper run of the belt is heated substantially uniformly across its width.

7. A method according to claim 6, in which the upper run of the belt is heated by passing over a plate which is itself heated by electric elements in cavities in the plate.

8. A mirror which has been made by a method according to any of claims 1 to 7.

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Preferably the belt is from 0.001 inch (0.025 mm) to 0.006 inch (0.15 mm) thick. Preferably, to guard against scratches or other marks, the belt 36 is of finely woven glass fibre cloth impregnated with polytetrafluoroethylene.

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If the film is heated by placing on a plate, as described in relation to Figure 3, it may be desirable to apply some downward pressure to the mirror support, particularly at the corners, to assist uniform heating. With a moving belt this is found to be unnecessary, as the slight tendency of the belt to sag under the weight of the mirror will ensure that the corners of the film are adequately heated.

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2. A method according to claim 1, in which the flat surface comprises one face of a heat retaining plate which it itself heated by electric elements in cavities in the plate.

3. A method according to claim 1, in which the flat surface comprises one face of a sheet, the other face of the sheet being in heat exchange relationship with a heat retaining plate which is itself heated.

4. A method according to claim 3, in which the sheet is of glass fibre cloth impregnated with polytetrafluoroethylene.

5. A method according to any preceding claim, in which the flat surface is of less area than the mirror, and tension is created in the film in a series of steps, by bringing first one area of the film, and then another, substantially into contact with the flat surface.

6. A method according to claim 1, in which the flat surface is the upper surface of the upper run of a moving conveyor belt, and the upper run of the belt is heated substantially uniformly across its width.

7. A method according to claim 6, in which the upper run of the belt is heated by passing over a plate which is itself heated by electric elements in cavities in the plate.

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