

LIGHT REFLECTOR APPARATUS AND METHOD OF MAKING SAME

The present invention relates to an improved method of making light reflector apparatus usable, for example, in a photographic electronic flash unit or the like, and to improved light reflector apparatus.

Photographic flash apparatus includes a reflector, a source of light, such as a flash bulb or flash tube, and a housing for mounting the light source and the reflector relative to each other.

The flash apparatus produces a beam of illumination which includes direct illumination from the light source, as well as source illumination reflected from the reflector. In photographic flash apparatus it is commonly intended that the projected light should, as well as possible, be uniformly distributed within an imaginary plane located a particular distance from the flash apparatus. However, in some photographic flash apparatus, non-uniform light patterns may be desirable, as disclosed in U.S. Patent No. 4,304,479. Regardless of the desired light distribution, it is important that the reflector conform accurately to a predetermined shape to provide the desired light distribution, and that both the reflector and the light source are accurately mounted within the flash housing and thus with respect to each other, to prevent skewing of the projected light beam.

It is known in the photographic flash reflector art to make flash reflector apparatus by vacuum depositing aluminium, which serves as the reflector, directly onto a plastics material, which forms at least a portion of the flash housing assembly. In order to have a high reflectivity surface, the aluminium coating is made very thin - about .05 to .075 millimeter. However, with an

electronic flash unit it has been found that when the flash tube is located close to the reflector and/or a high-energy flash tube is employed, heat from the tube can burn such a thin reflector. Also, because there is intimate contact between the reflector and the plastics material, the latter is also heated and may separate from the reflector. This can both change the shape of the reflector, and/or shift the position of the reflector relative to the flash tube, thus creating errors in both light distribution and direction of the projected light beam.

Heating of the reflector and the plastics material is not as severe if the aluminium is made thicker. However, it is not practical in a flash reflector to vacuum deposit a thicker coating of aluminium because the reflectivity of vacuum-deposited aluminium decreases in proportion to its thickness. Furthermore, a thicker coating increases manufacturing time.

An alternative solution has been to adhesively attach an aluminium coated sticker directly onto a plastics material housing. Two advantages achieved with this operation are (1) the sticker and aluminium coating form a thicker reflector, which is, thus, better able to resist burning and to thermally shield the plastics material, and (2) the adhesive for securing the sticker serves as a thermal insulator, which further shields the plastics material. However, this solution adds to reflector manufacturing costs, and further complicates the manufacturing process, in part because precise sticker alignment tolerances must be met.

It is also known in the photographic flash reflector art to pre-shape a highly polished aluminium sheet into a reflector. The pre-shaped reflector is

then attached to a moulded plastics material housing. The sheet, in this case, can be made thicker than the aluminized coating described above, without a reduction in reflectivity, and thus is less susceptible to burning and is more suited to thermally shielding its housing. However, because the reflector and its housing no longer form a unitary structure, the thickness of the aluminium sheet must be controlled precisely, and the housing must include reference mounting surfaces, retaining ribs, fingers and the like, for accurately and securely mounting the reflector. U.S. Patent No. 4,317,625 discloses some assembly requirements which should be met when a pre-shaped reflector is mechanically attached to a housing.

In summary, prior art light reflector apparatus and manufacturing methods therefor, are relatively complex and/or expensive or the apparatus is deficient in use. The present invention seeks to overcome the disadvantages of the prior art.

According to the present invention there is provided a method of making light reflector apparatus said method comprising:

- a) placing a flexible material having a light-reflecting surface adjacent a forming surface having contours arranged to form the light-reflecting surface of the flexible material into a shape for reflecting light into a beam;
- b) enclosing the material in a moulding chamber a portion of which is defined by the forming surface;
- c) injecting liquid plastics material under pressure into the chamber against a rear surface of the flexible material so as to press the light-reflecting surface into intimate contact with the forming surface to shape the material to the contours of the forming surface; and

d) solidifying the plastics material to form a solid housing against the rear surface of the flexible material to maintain the shape.

5 Preferably, discrete zones of the flexible material are clamped against the forming surface. With this step, the flexible material is retained in a shape generally according to that of the forming surface prior to the injection of the liquid plastics material.

10 Advantageously, the forming surface is of area larger than the area of the flexible material and the flexible material is located on the forming surface during placement. Intimate contact created between the light-reflecting surface and the forming
15 surface serves to prevent leakage of the plastics material onto the light-reflecting surface. A shoulder is created at edges of the flexible material which serves to retain the flexible material in its formed shape.

20 The present invention also resides in light reflector apparatus for reflecting light from a source into a beam and manufactured by a method as recited in any of the preceding three paragraphs. Such apparatus includes flexible material having a reflective surface
25 and formed into the desired shape, and a plastics material housing in intimate contact with the other surface of the flexible material.

The housing may have shoulders engaging edges of the flexible material for retaining the flexible
30 material in its formed shape.

Advantageously, the housing includes two apertures together bounding a bridge portion of the housing. The bridge portion is resiliently flexible and integral with the remainder of the housing at its ends. The bridge portion serves to retain a light source, which extends through one of said apertures, in contact with the reflective surface of the flexible material.

In a detailed description of preferred embodiments of the present invention presented below, reference is made to the accompanying drawings, in which:

Fig. 1 is a schematic view of an injection moulding machine for use in manufacturing light reflector apparatus according to the present invention;

Fig. 2 is an exploded, perspective view of moulding sections of the injection moulding machine of Fig. 1;

Fig. 3 illustrates a light-reflecting flexible sheet which is to be shaped into a reflector for light reflector apparatus according to the present invention;

Figs. 4 to 7 are cross-sectional views of the sheet of Fig. 3, and the upper and lower moulding sections of Fig. 2, during various stages of an injection moulding operation;

Fig. 8A is a perspective view, a portion of which is cut away, of trough-shaped light reflector apparatus manufactured in accordance with the present invention.

Fig. 8B is an enlarged perspective view of the lower left-hand corner of the light reflector apparatus shown in Fig. 8A; and

Fig. 9 is an end view of a second preferred embodiment of light reflector apparatus, manufactured in accordance with the present invention, for an electronic flash unit.

The ensuing description is directed to a particular type of light reflector apparatus, namely light reflector apparatus for a photographic flash device, and a method of its manufacture, in accordance with the present invention. However, it is to be understood that the invention is applicable to other light reflector apparatus, for example, as used in automobile headlights, flashlights, searchlights, and photographic chemical flash apparatus.

Fig. 1 schematically shows an injection moulding machine 10, which is to be used in the manufacture of light reflector apparatus, according to the present invention. Generally, the equipment 10 includes an injection unit 12 and a clamping unit 14.

The injection unit 12 includes a hopper 22 in which pelletized plastics material is loaded. The hopper 22 funnels the pelletized plastics material into a heated extruder 24 wherein the plastics material is converted to a liquid state. The extruder 24 feeds liquid plastics material through a check valve 26 into a shooting pot 28, which contains an injection piston 30. The piston 30, under control of motorized drive means 32, forces the liquid plastics material through a shut-off nozzle 34 into the clamping unit 14.

The clamping unit 14 contains a mould 36 into which the liquid plastics material is injected. The mould 36 comprises female and male moulding sections 38 and 40, respectively. The section 38, which is mounted on a stationary platen 42, is connected to the shut-off nozzle 34 for receiving liquid plastics material from the injection unit 12.

The section 40 is mounted on a movable platen 44, which is driven by a ram 46 into a moulding position. Rails 48 support the platen 44 and align the platens 42 and 44, to provide accurate mould

alignment. The clamping unit 14 may also include an ejector (not shown) for removing the moulded part from the mould 36 after the liquid plastics material cools.

The injection moulding machine 10 described above is conventional and is available from a variety of sources, one of which is Husky Injection Molding Systems Ltd, Bolton, Ontario, Canada.

A light reflector apparatus in accordance with the present invention and for use in an electronic flash unit will now be described. The reflector apparatus includes a metallic reflector and a plastics material housing supporting the reflector. The reflector apparatus is shaped like a trough for reflecting light impinging on the reflector out through the mouth of the trough. Preferably, the reflector is shaped so that, with the light source in predetermined position, the reflected light is concentrated into a beam. An elongate flash tube is disposed in the base of the trough and the ends of the trough have openings through which respective ends of the flash tube protrude.

The plastics material housing is formed and unified with the reflector by an injection moulding operation. The reflector is shaped into its trough-like configuration in response to the injecting of liquid plastics material into a mould. The plastics material is allowed to solidify to form the housing, which maintains the contour of the reflector formed during the moulding operation.

It will be obvious to those having skill in the art and from the disclosure that follows that any of a variety of shapes for light reflector apparatus can be formed using the teachings of the invention.

Referring now to Fig. 2, the female and male moulding sections, 38 and 40, form respectively the rear and front surfaces of the light reflector

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apparatus.

The male moulding section 40, which serves to form a forwardly facing surface of the light reflector apparatus, includes a projecting mandrel 56 having a
5 generally elliptically curved, centrally located front-forming surface 57, which forms the trough shape of the reflector apparatus, and a pair of opposed end-forming surfaces 58 and 59, which form end walls at corresponding ends of the trough shape.

10 Each end-forming surface is comprised of two corresponding planar sections 58a, 58b and 59a, 59b, respectively. The sections 58a, 58b and 59a, 59b serve to orientate corresponding side walls of the reflector apparatus at an angle for reflecting light.
15 For this purpose, the sections 58a and 59a are obtuse, and the sections 58b and 59b are approximately perpendicular to the longitudinal axis of the trough.

The female moulding section 38, which forms a rearwardly facing housing surface of the light
20 reflector apparatus, includes a fixed, centrally located portion 65, and a pair of opposed side draws 67 and 69, which are mounted to respective ends of the central portion 65, for relative movement in the direction of the arrows A, to close and open the
25 female portion of the mould 36. The centrally located portion 65 of the female moulding section 38 corresponds to the front-forming surface 57 of the male section 40. Likewise, the side draws 67 and 69 of the female section 38 correspond respectively to
30 the end-forming surfaces 59 and 58 of the male moulding section 40.

The centrally located portion 65, and the side draws 67 and 69 include a plurality of depending inwardly facing shutoffs and holddown pads 70. The
35 pads 70 have clamping surfaces 70a, the contours of which are chosen to provide clamping of a

light-reflecting flexible sheet (Fig. 3) about the mandrel 56 in discrete predetermined zones when the mould 36 is closed.

5 Referring now to Fig. 3, there is shown a
light-reflecting flexible sheet 72 which is to be
shaped by the mandrel 56 into a reflector during an
injection moulding operation. Preferably, the sheet
72 is aluminium. In a photographic flash application,
10 its front surface, denoted 73, is highly polished to
a mirror-like finish for reflecting light. Its back
surface, denoted 75, need not be specially treated.
In the illustrative embodiment, the sheet 72 may have
a thickness of about .33 millimeter.

15 The sheet 72 of Fig. 3 is cut from flat
sheet stock into a blank suitable for shaping into
the aforementioned trough-like configuration.
Central portion 77 forms the trough of the reflector,
and mating pairs of end flaps 79 and 80 form a
reflector end wall, at each end of the trough. For a
20 reason made apparent below, the sheet 72 is somewhat
smaller than corresponding portions of the forming
surfaces of the mandrel 56.

Reference is now made to Figs. 4 to 7
which are cross-sectional views of the mould 36 at
25 various stages of manufacture. In manufacturing the
flash reflector apparatus, the central portion 77 of
the sheet 72 is first located on the front-forming
surface 57 of the mandrel 56. A pin 82 on the surface
57, and a receiving eccentric pinhole 84 in the sheet
30 72 can be used for locating the sheet 72 on the
forming surface 57. The polished, light-reflecting,
front surface 73 faces the mandrel 56, as shown in
Fig. 4.

35 To assist in shaping the sheet 72 to the
contour of the mandrel 56, it is beneficial to pre-bend
and prefold the sheet 72 prior to positioning it on the

mandrel 56. This may be done manually or by automatic equipment (not shown) along bend lines, shown by the dashed lines 72a of Fig. 3. In the prebending of the sheet 72, it is preferred that its polished surface 73 is slightly open, that is, less concave, relative to the contour of the mandrel 56. This prevents scuffing of the surface 73 as the sheet 72 is brought into intimate contact with the mandrel 56.

Next, as is shown in Fig. 5, the male moulding section 40 is moved into its moulding position, under the influence of the ram 46 (Fig. 1). When the mould 36 is closed, the holddown pads 70 engage the back surface 75 of the sheet 72 and clamp isolated small zones of its polished surface 73 to corresponding areas on the front-forming surface 57 and the end-forming surfaces 58 and 59 of the mandrel 56.

As is shown in Fig. 5, the sheet 72 is now shaped according to the general contour of the mandrel 56. Non-clamped areas of the sheet 72 may not be in intimate contact with the forming surface 57. Fig. 5 also illustrates that, because the sheet 72 is smaller than the mandrel 56, border, or peripheral, portions of the front-forming surface 57, and the planar sections 58b, 59b of the end-forming surfaces 58 and 59 of the mandrel 56, denoted 86, are not covered by the sheet 72.

After the mould 36 is closed, heated, liquid plastics material, denoted 88 (Figs. 6 and 7), is injected under pressure through the nozzle 34 into the female moulding section 38 against the back surface 75 of the sheet 72. The plastics material 88 spreads across the back surface 75 and lips around outer edges, denoted 90, of the sheet 72 against the uncovered peripheral portions 86 of the mandrel 56. Pressure relief means (not shown) are provided for removal of air trapped

in the mould 36.

As the mould 36 fills with plastics material 88, the sheet 72 is subjected to progressively increasing forces on its back surface 75. These forces press

5 the light-reflecting surface 73 of the sheet 72 into intimate contact with the mandrel 56, as shown in Figs. 6 and 7. The intimate contact between the sheet 72 and the mandrel 56 shapes the light-reflecting, front surface 73 precisely
10 according to the contour of the mandrel 56. Such contact also seals the boundary between the edges 90 of the sheet 72 and the mandrel 56. Thus, plastics material 88 is prevented from leaking
15 between the mandrel 56 and the sheet 72 onto the light-reflecting, front surface 73. By selectively clamping the sheet 72 to the mandrel 56 prior to injecting the plastics material 88 into the mould 36, flash reflector apparatus can be made having a wide variety of shapes with the light-reflecting surface
20 73 being free of plastics material. Fig. 6 illustrates the mould 36 when it is partially filled with plastics material 88, and Fig. 7 illustrates the mould 36 when it is completely filled with the plastics material.

Next, the plastics material 88 is caused to
25 harden by cooling it. The plastics material 88 is cooled quickly by passing water through the female moulding section 38 by means not shown.

To open the mould 36, the male moulding section 40 is withdrawn from the female section 38.

30 The side draws 67 and 69 are then moved away from their respective ends of the central portion 65 to open the female portion of the mould 36.

Figs. 8A and 8B illustrate the flash reflector apparatus after it is removed from the mould
35 36. The reflector apparatus is in the form of an open trough and comprises a reflector lining the

inner face of the trough and a hardened plastics material housing 91 supporting the reflector. The reflector consists of the sheet 72, which is now shaped according to the contour of the mandrel 56.

5 The housing 91 comprises a concave supporting body 92, overlying the back surface 75 of the sheet 72, and a lip 94, integral with the body 92, and contiguous with and surrounding the outer edges 90 of the sheet 72. The lip 94 traps the sheet 72 against the body 92, so
10 that the sheet 72 is maintained in the shape caused by the contour of the mandrel 56 during the moulding operation. Openings 96 in the supporting body 92 expose those areas of the back surface 75 of the sheet 72 which were clamped by the holddown pads 70 while
15 the mould 36 was closed.

An electronic flash unit 100 having a light reflector apparatus 102, manufactured in accordance with the teachings of the present invention, is shown in Fig. 9. Elements of light reflector apparatus 102
20 similar to elements of light reflector apparatus of Fig. 8 are identified by like numerals. An opening 104 in the base of each flash end wall 105 adjacent the trough of the light reflector apparatus serves to receive a flash tube 106.

25 The tube 106 is supported at each end by a resilient, plastics material bridge 108. As viewed from the end of the light reflector apparatus, each bridge 108 extends from one side of the reflector apparatus to the other side, and is integrally
30 attached at each end to an end wall 105. The bridge 108, which includes a cradle-shaped central portion 109 for supporting the tube 106, resiliently biases the tube 106 against the light-reflecting surface 73 of the sheet 72. The bridge 108 can accommodate
35 variations in tube diameter, and assures centring of

the tube 106 in the base of the trough. Each opening 104 and bridge 108 is provided by appropriate formation of the mould 36. The bridge is bounded by two openings, one of which is the opening 104 and the other is an opening 104'. The openings 104, 104' are formed by pads (not shown) on the side draws 67 and 69 which exclude liquid plastics material during the moulding process.

The underlying supporting body 92 includes an aperture 110 located to expose the back surface 75 of a portion of the sheet 72 adjacent the tube 106. The aperture 110 can be formed by clamping this area of the surface 75 by a holddown pad (not shown) in the female moulding section 38. The aperture 110 provides an area for electrically connecting a trigger transformer (not shown) for applying a tube triggering voltage directly to the sheet 72. Thus, the sheet 72 serves both as a light reflector and as a tube trigger electrode. U.S. Patent No. 3,484,597 discloses a reflector for an electronic flash unit that also serves as a tube trigger electrode.

Polycarbonate M39-6823, sold by the Mobay Chemical Company of Pittsburgh, Pennsylvania under the trademark Merlon, is a plastics material ideally suited to this manufacturing operation. This polycarbonate, heated to about 290°C and pressurized at about 45 kilograms per square centimeter for the moulding operation, has a high viscosity and, thus, a low flow rate. This is advantageous as it serves to further assure that the plastics material does not leak to between the polished surface 73 and the mandrel 56, as the plastics material is injected into the mould 36. It has been found that the location at which plastics material 88 is injected into the mould 36 against the surface 75 is not particularly critical.

By using a coolant, the plastics material is hardened sufficiently within less than 20 seconds to allow the mould 36 to be opened. Full curing of the plastics material probably occurs within about 24 hours. Upon hardening, this polycarbonate has a high creep resistance and thus maintains the reflector in its desired shape.

A further advantage of this polycarbonate is that it is relatively clear. Thus, it more readily
10 dissipates heat produced resulting from a light flash.

A still further advantage offered by its clarity is that this polycarbonate can be used for making a flash covering window (not shown). The mould 36 can be configured for making the window integral
15 with the housing 91. Conveniently, the window is connected to the housing 91 by plastics material hinges so as readily to be swung into a tube-covering position. A further feature is that flash diffusing means such as a fresnel lens or the like can be placed
20 within the window-forming portion of such a mould so that the window can be moulded around or integrally with the lens.

Reference is directed to our copending divisional Application No. 8524732.

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Claims

1 A method of making light reflector apparatus
said method comprising:

a) placing a flexible material having a

5 light-reflecting surface adjacent a forming surface
having contours arranged to form the light-reflecting
surface of the flexible material into a shape for
reflecting light into a beam;

b) enclosing the material in a moulding chamber a

10 portion of which is defined by the forming surface;

c) injecting liquid plastics material under pressure
into the chamber against a rear surface of the
flexible material so as to press the light-reflecting
surface into intimate contact with the forming surface

15 to shape the material to the contours of the forming
surface; and

d) solidifying the plastics material to form a solid
housing against the rear surface of the flexible
material to maintain the shape.

20 2 A method as claimed in claim 1, including
clamping discrete zones of the flexible material
against the forming surface whereby the flexible
material is retained in a shape generally according to
that of the forming surface prior to the injection of
25 the plastics material.

3 A method as claimed in claim 1 or 2, wherein
the forming surface is of area larger than the area of
the flexible material and the flexible material is
located on the forming surface during placement,

30 intimate contact created between the light-reflecting
surface and the forming surface serving to prevent
leakage of the plastics material onto the
light-reflecting surface, whereby a shoulder is
created at edges of the flexible material serving to
35 retain the flexible material in its formed shape.



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4 A method of manufacturing a light-reflecting apparatus substantially as hereinbefore described with reference to Figs 1 to 7 of the accompanying drawings.

5 Light reflector apparatus for reflecting light from a source into a beam, manufactured by a method as claimed in any one of claims 1 to 4, including flexible material having a reflective surface and formed into the desired shape, and a plastics material housing in intimate contact with the other surface of the flexible material.

6 Light reflector apparatus as claimed in claim 5, wherein the housing has shoulders engaging edges of the flexible material for retaining the flexible material in its formed shape.

15 7 Light reflector apparatus as claimed in claim 5 or 6, wherein the housing includes two apertures together bounding a bridge portion of the housing, the bridge portion being resiliently flexible and integral with the remainder of the housing at its ends, the bridge portion serving to retain a light source, which extends through one of said apertures, in contact with the reflective surface of the flexible material.

20 8 A light reflector apparatus substantially as hereinbefore described with reference to and as illustrated in Figs 8A and 8B of the accompanying drawings.

25 9 An electronic flash apparatus including a light reflector apparatus as claimed in any of claims 5 to 8 and substantially as hereinbefore described with reference to and as illustrated in Figs 8A and 30 8B as modified by Fig 9 of the accompanying drawings.