metallization is provided for this purpose. The faceted mirror 116 is a second surface mirror, and it is adhered to mirror 118 with a clear adhesive, preferably having an index of refraction near that of the glass to avoid reflections at the adhesive interface. An example of such an adhesive is an ultraviolet cured acrylic adhesive manufactured by the Loctite Corporation of Rocky Hill, Connecticut. This particular product is designated as their 3494 adhesive, and it has an index of refraction of 1.48. The embodiment shown in Figures 24 and 25 provides protection for the faceted mirror and keeps the plane mirror a first surface mirror, which is the common type of mirror in use. The arrangement shown in Figures 24 and 25 could also be implemented with mirror 118 being a second surface mirror.

Figures 26 and 27 are like Figures 24 and 25, and like elements are identified with like reference numbers. The difference lies in the fact that the adhered faceted mirror 124 has the facets formed on the inner face. Here, care must be taken to assure that the clear adhesive is applied so that no air is trapped between the main mirror 118 and auxiliary blindzone-viewing mirror 124 since air bubbles would interfere with the reflections seen. This arrangement provides additional protection for the facets. It should be noted that with this arrangement of using a clear adhesive uniformly applied between the facets and the back surface of mirror 118, mirror 124 becomes a second surface mirror. Additional care must be taken when designing this mirror since the glass and the adhesive may have different indices of refraction. Mirror 124 could also be adhered only along its perimeter, in which case it is optically a first surface mirror in the sense that the angle of a reflected ray is not influenced by the refraction that occurs as the ray passes through 118.

Figures 28 and 29 are also like Figures 24 and 25, and again like elements are denoted by like reference numbers. The difference here is that the faceted blindzone-viewing mirror has been replaced by solid clear plastic element 126 having a spherically concave rear face with a reflective coating 128. It is also adhered to the main viewing mirror 118 with a transparent adhesive, again having an index of refraction near that of the glass and the plastic to minimize reflections at the plane of the adhesive. Mirror surface128 is viewed through window 122 where it is seen as a spherically convex mirror. The advantage of this embodiment is that use of the planar array can be avoided in those applications where there is adequate space behind the main viewing mirror 118 to accommodate the volume of element 126 without interfering with the mirror positioning mechanism.

Figures 30 and 31 show a rearview mirror 130 formed in a transparent material wherein a concave portion is molded integrally with a plane portion. The entire back surface of mirror 130 is coated with reflective material so that mirror 130 is a second surface mirror. Figure 30 is a front view of mirror 130. Area 132 is the region in which concave portion 134 is visible. Figure 31 is an enlarged top sectional view of mirror 130 taken along section line 31-31 in Figure 30. In Figure 30, concave surface 134 appears as a segment of a spherical convex mirror lying in region 132 when viewed from the front. Second surface 136 appears as a plane mirror when mirror 130 is viewed from the front. The advantage of this embodiment is that the use of adhesives is avoided, and it is a single component.

Figures 32 and 33 depict a mirror 138 having a faceted blindzone-viewing portion 140 formed integrally with a plane main viewing portion. The entire back surface of mirror 138 has a reflective coating 142, making it a second surface mirror. Figure 32 is a front view of mirror 138, showing faceted portion 140 and plane portion 144. Figure 33 is an enlarged top sectional view of mirror 138 taken along the section line indicated by 33-33. Faceted portion 140 is formed in the material of which mirror 138 is made. Mirror 138 may be plastic or glass. It may be a molding, or the facets may be pressed into sheet stock. If the material of 138 is a plastic, the front surface may be protected with a hardcoat as previously described. The advantage of this embodiment is that it requires no additional space, and the current mirror glass can be directly replaced with mirror 138.

Preferably, the faceted portion 140 in Figure 32 should have as high a reflectivity as possible, being coated with aluminum or silver. Since the blindzone-viewing portion is a second surface mirror, the first surface will have a reflection of about 4%, which will be faintly visible over the reflection from the blindzone-viewing portion. The two reflections are in different directions, and are of different magnifications. By keeping the reflection from the less than unit magnification mirror as high as possible, the reflection from the first surface is less noticeable. This applies to any of the embodiments utilizing a second surface blindzone-viewing mirror.

Figure 34 shows a truck type of mirror incorporating some of the principles described above. Most truck mirrors are taller than they are wide as indicated in Figure 34. Many of these mirrors use a large bull's-eye convex mirror attached at the lower end to increase the horizontal field of view so that the blindzone may be seen. Figure 34 shows a convex faceted mirror 146 on the lower end of a main unit magnification mirror 148. Mirror 146 has been optimized to view primarily the blindzone. Any of the methods described above may be used to form the mirror of Figure 34.

The passenger's side outside mirror is also subject to restrictions imposed by FMVSS 111. Because that mirror is so far away from the driver, the field of view of a unit magnification mirror of the same size as the mirror on the driver's side would be only about 10°. This would result in a very large blindzone on the passenger's side. For this reason, FMVSS 111 allows a convex mirror having a wider field of view to be used. This of course reduces the size of the images seen in the mirror. FMVSS 111 says that the radius of curvature used on passenger's side mirrors "shall be not less than 34 inches and not more than 65 inches." It also requires that the mirror be inscribed with the statement, "Objects in Mirror are Closer Than They Appear." At a radius of curvature of 1651 mm (65 inches), the magnification is about 0.30, and the field of view is about 27°. A radius of curvature of 1016 mm (40 inches) is in common use. Using the largest possible radius of curvature increases the image size, but it also increases the size of the blindzone.

Returning to Figure 1, lines 150 and 152 define the viewing angle of a 1651 mm radius convex mirror 154. When the driver is looking at mirror 154, the peripheral vision line is approximately shown by line 156. However, because passengers and the vehicle structure block the driver's peripheral vision to the road, the peripheral vision line cannot be used to define the blindzone as on the driver's side. A line 158 extending from the driver's eyes through the right rear door window is about the limit of the driver's vision to the rear. A blindzone then exists between lines 152 and 158, and it is shown crosshatched. This blindzone may be removed by providing an auxiliary blindzone-viewing mirror as in Figure 5, except that such an auxiliary mirror must be placed in the upper right hand corner, as shown in Figure 35.

In Figure 35, a passenger's side mirror 160 has a surface 162 that is a spherically convex mirror having a radius of curvature falling within the requirements of FMVSS 111, and mirror 164 is a less than unit magnification mirror designed to view generally only the blindzone. Mirror 164 should have a field of view encompassing the region between lines 152 and 158, and that will require a field of view in the range of 25 to 30 degrees. If the width for mirror 164 is to be 4.5cm with a viewing angle of 30 degrees and S_T = 140cm, its required radius of curvature calculated from Eq. 7 is 20cm.

While being able to use the largest possible radius of curvature for mirror 164 is an advantage, the main advantage of having a right side blindzone-viewing mirror is that such a mirror unambiguously tells you that you cannot change lanes if a vehicle is visible in that mirror. Without the blindzone viewing mirror, it is necessary to try to judge the position of a vehicle seen in a mirror which has an image size 1/3 of that in direct vision. Mirror 160 can be implemented by any of the arrangements used on the driver's side mirror. And obviously, main viewing mirror 162 which is also a less than unit magnification mirror, may be implemented as a planar array of reflecting facets, with or without the blindzone-viewing mirror.

Figures 55 and 56 show an arrangement similar to that shown in Figures 26 and 27, both of which show a discrete first surface planar array of reflecting facets adhered to the second surface of a first surface plane mirror having a window in the first surface reflective coating through which the planar array is viewed. Figure 55 is a front view of a first surface plane mirror 310 having a faceted mirror 312 adhered to its back surface. The faceted mirror 312 is viewed through a window 314 in the first surface reflective coating 316 on mirror 310. Figure 56 is an enlarged partial sectional view of the mirror of Figure 55 taken along section line 56-56 in the direction of the arrows. Here it is seen that a recess 318 is ground in the back surface of mirror 310, and faceted mirror 312 is adhered in the recess. Again, an adhesive having an index of refraction near that of the glass and the plastic of the discrete mirror is used to prevent reflections at the interface of the glass and the faceted mirror. Having the index of refraction near that of the glass also allows the recess to be rough ground and not polished, since the adhesive will fill all of the surface asperity making the grind marks invisible. The ground recess is shown starting at the left edge and proceeding only far enough to accept the size of the planar array. If the array fills the whole upper corner, the recess is obviously ground accordingly. The advantage of providing the recess is that it allows the faceted discrete mirror to be flush with the back surface of the mirror. Remembering that the discrete mirror can be as thin as 0.5 mm, removing this much from the back of a 2mm thick glass is quite feasible. Hence, the mirror of Figures 55 and 56 can directly replace a standard mirror without requiring any modification to the outside mirror assembly. While a thin first surface faceted mirror is shown in Figures 55 and 56, obviously, a thin second surface faceted mirror may also be used.

So far, all of the mirrors shown have had a constant reflectivity. It is also possible to use the blindzone viewing technology herein disclosed in conjunction with the technology used to provide variable reflectivity mirrors. Various unique combinations of the two technologies combine to provide a new and novel category of mirrors.

Figures 36 and 37 show the generic structure of prior art variable reflectivity mirrors. In general, such mirrors are comprised of a transparent front plate, a rear plate which may or may not be transparent, and a chamber between the two plates which is sealed at their perimeter. Not shown is the manner in which the two plates are held together and their spacing maintained. The chamber is filled with a material that is able to effect a change in the intensity of the reflection from such a mirror. The material may be liquid, gel or solid. Figure 36 is a front view of such a prior art mirror 165 showing a front plate 166 and a perimeter seal 168. Figure 37 is the section indicated by section line 37-37 in Figure 36 in the direction of the arrows. In addition to front plate 166, a rear plate 170 is shown that has a reflective coating 172 applied to its second surface. Perimeter seal 168 is also seen. A chamber 174 exists between the plates. Several materials can be used to fill chamber 174. At present the most extensively used filling is a so-called electrochromic material. This material changes its ionization state when an electric current is passed through it, and in this state it changes its color to a deep bluish green. The material in this state absorbs visible light photons. They are absorbed as light passes through the front plate and into the electrochromic layer and again as the light passes through the rear plate, reflects at coating 172 and exits through the electrochromic material and the front plate 166. The density of the ionized material, and hence the intensity of the light reflected from reflective coating 172, is controlled by the current. Electrically conductive transparent coatings 176 and 178 are applied to the second surface of the front plate 166 and to the first surface of the rear plate 170, respectively. Coatings 176 and 178 are required to obtain uniform current flow through the electrochromic material. A commonly used material for transparent electrically conductive coatings is indium tin oxide, known as ITO. Also indicated in Figures 36 and 37 are wires 180 and 182 connected to the ITO by methodologies not shown, but which are well known in the art.

In Figure 36, mirror 165 is connected electrically in-circuit with a reflectivity control circuit 300 typically comprised of a series interconnected activation switch 302, an electronic control circuit 304, a rear facing light sensor 306 and an ambient light sensor 308. Control circuit 300 is in circuit with mirror 165 via wires 180 and 182 to establish an electric current therein and thus selectively vary the ionization state of the electrochromic material. As the illumination from the rear and the ambient illumination vary, electronic control circuit 304 produces a variation in the current to the electrochromic material thereby altering the reflectivity of the mirror in such a way as to keep the illumination reaching the driver's eyes below the annoyance level. A discussion of the relationship between illumination from the rear and ambient illumination in automatic control of rearview mirrors is found in U. S. Patent 3,601,614 Aug. 24,1971; G.E.Platzer, Jr.

In addition to electrochromics, liquid crystals have been used. Liquid crystals change their ability to polarize light under the influence of an electric field, and when used with a polarizer, the intensity of light passing through such a cell can be controlled by the electric field strength. The liquid crystal mirror controller suffers from a low maximum reflectivity due to an immediate 50% loss due to a polarizer. Furthermore, a loss of power puts it in the minimum reflectivity state.

Another method for controlling reflectivity uses an electroplating process. Here, the chamber is filled with an electrolyte containing ions such as silver which when plated out on either inside surface of the cell produces a reflective surface. The reflectivity is controlled by controlling the amount of silver plated out of the electrolyte. The process is reversible, so the reflectivity can be reduced by removing silver from the surface of the plate chosen to be the mirror.

In the future, additional materials that change their optical transmission in response to an applied electric field or current will probably be discovered, and the teachings of this invention apply to any variable reflectivity mirror.

As with the generic variable reflectivity mirror just described, none of the following mirror configurations will show the manner in which the front and rear plates are held together or how the spacing is maintained. The intent is to delineate the types of mirrors that can be used in a variable reflectivity mirror having a main viewing mirror and an auxiliary blindzone viewing mirror and the unique relationship of the reflective surfaces used in such mirrors.

Figures 38, 39a and 39b show two different configurations, but in a front view they both look the same. Like elements have been given like identification numbers. Figure 38 is a front view of a variable reflectivity mirror 184 that has a plane mirror region 186 and an auxiliary blindzone viewing mirror 187 at the outer end (generally indicated at 189) formed by a planar array of reflecting facets 188 simulating a convex mirror. The advantage of this configuration is that many European and Asian drivers have become accustomed to a mirror with an aspheric mirror at the outer end of the mirror 184, and an aspheric mirror is easily simulated by the planar array.

Figure 39a is a sectional view of Figure 38 taken along line 39-39 in the direction indicated by the arrows showing one way of implementing mirror 184. Here, a planar array of reflecting facets 190 is integral with and on the first surface of rear plate 192. Reflective coatings 194 and 195 are applied to the second surface of the rear plate192 and to the surface of planar array 190 respectively. Transparent electrically conductive coatings 196 and 198 are applied to the second surface of front plate 186 and to the first surface of rear plate 192, respectively. A seal 200 between the front and rear plates 186 and 192 provide a chamber 202 which is filled with one of the electrically active materials capable of changing the intensity of the light reflected from mirror surface194. Note that in Figure 39a the transparent electrically conductive coatings 196 and 198 do not extend in front of planar array 190. While the region between the plates 186 and 192 in front of auxiliary mirror 187 is filled with an electrically active material, a current cannot flow nor can a field exist in that region, and for that reason the reflection from mirror 187 remains unaffected. This is desirable since a convex mirror already has a reduced reflectivity in comparison to a plane mirror, and as shown in SAE Paper 950601, the relative illuminance of a convex mirror is equal to the square of the relative magnification. For example, if the relative magnification of a convex mirror is 0.2, the relative illuminance is 0.04. Dimming such a low magnification mirror is undesirable. If mirror 184 is very large, it is possible that the radius of curvature simulated by planar array 188 may be large enough to produce a relative illuminance which would make it desirable to dim the light reflected from planar array 188. In this case the ITO layers would be extended to the area in front of array 190.

Figure 39b shows mirror 185 which is a variation of the mirror of Figure 39a wherein the planar array of reflecting facets 204 is a second surface mirror on a discrete element 206 whose first surface is adhered to the second surface of a rear plate 208. A reflective coating 210 has been applied to the second surface of rear plate 208 which is similar to coating 194 in Figure 39a. Again, the reflectivity from planar array 204 may be controlled or uncontrolled depending upon the placement of the ITO coating.

A non-dimming mirror in the configuration of Figure 38 is shown generally at 211 in Figures 40 and 41. As in Figure 38, the planar array of reflecting facets 220 is shown at the outer end of this mirror. A plane main viewing mirror 212 is provided by means of second surface reflective coating 214 applied to plane plate 216. An auxiliary blindzone viewing mirror is provided by a discrete element 218 carrying a second surface planar array of reflecting facets 220. The first surface of element 218 is adhered to the second surface of plate 216. Planar array 220 may simulate either a spherical or aspherical convex mirror. The advantage of this non-dimming configuration is that it may be desirable to retain some features of the European and Asian mirrors as described in the discussion of Figure 38. The vast majority of European and Asian mirrors are non-dimming, so it is desirable to be able to provide the mirror of Figures 40 and 41. While a discrete adhered mirror is shown in Figure 41, any of the previously described methods of providing a planar array may be used.

For the US market, use of the blindzone mirror in the upper and outer quadrant of a mirror is preferred for reasons previously described. Therefore, various ways of modifying the variable reflectivity mirror to accept an auxiliary blindzone viewing mirror in this configuration will be shown. Figure 42 shows a variable reflectivity mirror 221 with a plane main viewing portion 222 and a blindzone viewing portion 224 comprised of a planar array of reflecting facets. Figure 43 is a sectional view of the mirror of Figure 42 taken along section line 43-43 and in the direction of the arrows. A front plate 226 covers the entire area defined by the perimeter of the mirror shown in Figure 42. A rear plate 228 is notched out to accept blindzone viewing mirror 224 which is a second surface planar array mirror formed in transparent discrete element 230. The first surface of mirror element 230 is planar, and it is adhered to the second surface of front plate 226. A seal 232 must now cover the perimeter of plate 228, so it will be seen as shown in Figure 42 with a jog around mirror element 230. A reflective coating 234 is applied to the second surface of rear plate 228, and ITO coatings 236 and 238 are applied to the inside surfaces of plates 226 and 228, respectively. Since mirror element 230 is adhered to the second surface of front plate 236, there is no electrically active material in front of the planar array, so the reflection from the planar array does not dim. Conductive leads (not shown), such as in Figures 36 and 37 could be used to place mirror 221 in circuit with a power supply and control circuit.

Figures 44 and 45 show a modification of the mirror of Figures 42 and 43 wherein a variable reflectivity mirror 239 has the planar array mirror element 230 replaced with a solid clear element 240 having a spherically concave rear surface with a reflective coating 242. Like elements in these Figures are identified with like numbers. From the front, element 240 appears as a spherically convex mirror, and as such it performs the function of providing a wide angle view of the blindzone, as does the planar array of Figures 42 and 43.

Figures 47a, 47b and 47c show three alternative configurations 243a, 243b and 243c of a mirror depicted generically in Figure 46 and identified as 243. All of the alternative configurations 243a, 243b and 243c use a planar array and appear the same from the front. In Figure 46, region 244 has a magnification of unity, providing a reflection from a plane mirror. Region 246 has a magnification of less than unity, providing a reflection from a planar array of facets simulating a convex mirror. Also seen in Figure 46 is seal 248 that seals in the electrically active material which dims the reflection from the mirror. In Figures 46 through 47c, like elements will be identified by like numbers. Figures 47a, 47b and 47c are enlarged sectional views taken along section line 47-47 in the direction indicated by the arrows. All three drawings show a front plate 250, a seal 248, a chamber 252 retaining the electrically active dimming material and ITO coatings 254 and 256 on the inside surfaces of the chamber. Figure 47a has a rear plate 258 with an integrally formed planar array 260 having a reflective coating. Planar array 260 may be made dimming or non-dimming depending upon whether or not the ITO coating is used in the region in front of array 260.

Variable reflectivity in both region 244 and 246 of mirror 243 can be accomplished by providing a second seal (not illustrated) around the periphery of region 246 to define two separate chambers (such as chamber 252), each filled with electrochromic material. In addition, separate electrically isolated ITO coatings would be provided in the front and rear plate surfaces within the chamber co-extensively with region 246. Lastly, a separate set of wires would interconnect the additional ITO coatings with a second reflectivity control circuit. Thus arranged, the primary mirror and the auxiliary blindzone viewing mirror could each have a characteristic reflectivity independent of one another.

Figure 47b has a planar array mirror 262 formed in the second surface of rear plate 264. Again, the array may be dimming or non-dimming.

Figure 47c uses a separate element 266 having a planar array mirror 268 formed in its second surface. Its first surface is adhered to the second surface of rear plate 270. This configuration has the advantage of allowing the use of a standard variable reflectivity mirror. However, if dimming of the blindzone mirror is not desired, the ITO coating must not extend in front of mirror 268. Planar arrays 260, 262 and 268 are coated with a reflective surface as described earlier in conjunction with aforementioned embodiments of the invention.

The mirror 271 of Figures 48 and 49 is very similar to the mirror of Figures 46 and 47a. Again, like numbers will be used to identify like elements. The only difference between these mirrors is that the planar array of reflecting facets 272 is integrally formed in the second surface of front plate 274 rather than in the first surface of the rear plate 276. In this configuration, the planar array is non-dimming since the array is in front of the electrically conductive material. Also, since the array is in front of the chamber, the seal 248 does not show behind the array 272 which has its second surface coated with a reflective material. Alternatively, rear plate 276 can be provided by a thin reflective layer deposited directly upon the rear surface of the electrochromic layer.

Figures 50 and 51 show a mirror 275 similar to Figures 46 and 47c, and again like numbers will be used to identify like elements. The difference is that element 266 carrying planar array 268 has been replaced with the concave mirror element 240 of Figure 45 which is now adhered to the second surface of rear plate 270. This configuration is an alternate method to using the planar array of Figure 47c.

Figures 52, 53 and 54 show yet another alternative to producing a blindzone viewing mirror 276 with a flat front face, and in this case it is incorporated with a variable reflectivity mirror. Figure 52 is a front view of the mirror. It has a unity magnification region 278 and a less than unity magnification mirror 280 for viewing primarily only the blindzone. Figure 53 is a sectional view of the mirror 276 of Figure 52 taken along section line 53-53 in the direction of the arrows. A customarily constructed variable reflectivity mirror is indicated by front plate 282, rear plate 284, chamber 286 containing an electrically active material and a chamber seal 288. The upper and outer corner of the variable reflectivity mirror is notched out to provide space for the blindzone viewing mirror 280. Like mirror 240 of Figures 45 and 51, mirror 280 is a segment of a second surface concave mirror. A plastic or metal case 290 supports the variable reflectivity mirror and the concave mirror in such a manner that the first surface of mirror 280 is coplanar with the first surface of front plate 282. Figure 54 is an exploded view of Figure 53 showing the construction of case 290 and how the components fit into it. Case 290 has a sidewall 292 extending around its perimeter, a back wall 294 and a shelf 296 which matches the concave surface of mirror 280. The height of shelf 296 is such that when the variable reflectivity mirror and mirror 280 are in place in the case, the first surfaces of the mirrors are coplanar. These first surfaces may be contiguous or they may be separated by a thin additional wall that may be molded into case 290. Thus, a variable reflectivity mirror and a blindzone viewing mirror are combined to produce a mirror with a flat front face. This same type of structure may be used to combine an ordinary plane non-dimming mirror and a second surface plano-concave blindzone viewing mirror to also have a flat front face.

If any of the mirrors shown which utilize a second surface blindzone viewing mirror are to be used in conjunction with a passenger's side mirror, the first surface of the blindzone viewing mirror must be changed to a spherical surface to match the curvature of the main viewing mirror.

The invention in its broader aspects is not limited to the specific details shown and described, and departures may be made from such details without departing from the principles of the invention and without sacrificing its advantages. For example, the present invention can be applied in other applications such as heavy off-road vehicles and the like where a clear unobstructed wide field of view is required for safe operation, and yet the size of the mirror must be limited.

A mirror assembly 300 utilizing a two zone mirror element 302 of the type previously described as shown in Figure 57. Mirror assembly 300 is made up of a mirror housing 304, a mirror position motor 306 which can be remotely actuated by the vehicle occupant using an electrical switch within the vehicle to position face plate 308. Face plate 308 is provided with a series of posts 310 and a lock on lock lever 312. Posts 310 are adapted to cooperate with a series of apertures 314 and mirror bezel 316. Mirror bezel 316 is a plastic molding adapted to securely retain two zone mirror 302 as illustrated in the Figure a cross-section. Bezel 316 is provided with a series of clips 318 adjacent apertures 314 and bezel 316 for engaging posts 310 on face plate 308. With clips 318 cooperating with posts 310, the lock unlock lever is moved to the lock or unlock position as desired to retain or release the bezel relative to the face plate. In instances when mirror 302 is of the electrochromic or heated variety, an electrical connector not shown in the mirror will be coupled to electrical connector 320 within housing 304.

What is claimed is:

1. A mirror for automotive rearview application comprising a main viewing outside mirror and an auxiliary blindzone viewing mirror, said auxiliary blindzone viewing mirror defining a reflective surface comprised of a planar array of reflecting facets simulating a convex mirror and having a radius of curvature and a magnification less than that of said main viewing outside mirror, wherein said auxiliary blindzone viewing mirror is located generally in an upper and outer quadrant of said main viewing outside mirror, and said radius of curvature of said auxiliary blindzone viewing mirror lies in a plane generally perpendicular to said main viewing outside mirror, and said plane passes through the center point of said auxiliary blindzone viewing mirror so that its viewing angle primarily encompasses the region between the outer limit of the viewing angle of said main viewing outside mirror and the rearward limit of the driver's peripheral vision when said driver is looking at said mirror.

2. The mirror of claim 1 wherein said main viewing mirror having a first surface and a second surface, said second surface incorporating a recess in which said blindzone viewing mirror is adhered such that said blindzone viewing mirror is flush with the second surface of said main viewing mirror.

3. The mirror of claim 2, wherein said auxiliary blindzone viewing mirror is located generally in an upper and outer quadrant of said mirror.

4. The mirror of claim 1 further comprising a reflective layer and an electrochronic layer oriented forward of the reflective layer for selectively varying the intensity of the reflection from at least a portion of said mirror.

5. The mirror of claim 3, wherein said main viewing outside mirror and said auxiliary blindzone-viewing mirror are both first surface mirrors.

6. The mirror of claim 3, wherein said main viewing outside mirror is a first surface mirror and said auxiliary blindzone-viewing mirror is a second surface mirror.

7. The mirror of claim 3, wherein said main viewing outside mirror and said auxiliary blindzone-viewing mirror are both second surface mirrors.

8. The mirror of claim 3, wherein said auxiliary blindzone-viewing mirror is a separate element attached to said main viewing outside mirror.

9. The mirror of claim 3, wherein said main viewing outside mirror and said auxiliary blindzone-viewing mirror are an integral structure.

10. The mirror of claim 9 wherein said mirror is protected with an optically transparent hardcoat.

11. The mirror of claim 3, wherein said reflecting facets are formed in an optically transparent material.

12. The mirror of claim 3, wherein said reflecting facets are squares lying in a plane generally parallel the main viewing outside mirror and each square being a segment of convex mirror.

13. The mirror of claim 12, wherein the facet squares have sides dimensioned in the range of 1.5 mm to 0.5 mm.

14. The mirror of claim 3, wherein said reflecting facets are segments of concentric circular rings.

15. The mirror of claim 14, wherein the width of said rings is in the range 1.5 mm to 0.2mm.

16. The mirror of claim 3, wherein the characteristic reflectivity of said auxiliary blindzone-viewing mirror is greater than the characteristic reflectivity of said main viewing outside mirror.

17. The mirror of claim 3, wherein said main viewing outside mirror is a first surface mirror and said auxiliary blindzone-viewing mirror is attached to a back surface of said main viewing outside mirror, said auxiliary blindzone-viewing mirror, in application, being viewed through a region of said main viewing outside mirror which is devoid of reflective material.

18. A mirror for automotive rearview application comprising:

a main viewing outside mirror and an auxiliary blindzone-viewing mirror, said auxiliary blindzone viewing mirror , said auxiliary blindzone-viewing mirror defining a segment of a convex mirror having a radius of a curvature and a magnification less than that of said main viewing mirror and located behind a first surface of said main viewing outside mirror, wherein said auxiliary blindzone viewing mirror is located generally in an upper and outer quadrant of said main viewing outside mirror, and said radius of curvature of said auxiliary blindzone viewing mirror lies in a plane generally perpendicular to said main viewing outside mirror, and said plane passes through the center point of said auxiliary blindzone viewing mirror so that its viewing angle primarily encompasses the region between the outer limit of the viewing angle of said main viewing outside mirror and the rearward limit of the driver's peripheral vision when said driver is looking at said mirror.

19. The mirror of claim 18, wherein said main viewing mirror is a first surface mirror and said auxiliary blindzone viewing mirror is attached to a back surface of said main viewing mirror and, in application, viewed through a

region of said main viewing outside mirror which is devoid of reflective material.

20. The mirror of claim 18, wherein said auxiliary blindzone-viewing mirror is a second surface mirror.

21. The mirror of claim 18, wherein said main viewing outside mirror and said auxiliary blindzone-viewing mirror are an integral structure.

22. The mirror of claim 18, wherein said main viewing outside mirror and said auxiliary blindzone-viewing mirror are both second surface mirrors.

23. The mirror of claim 18, wherein the characteristic reflectivity of said auxiliary blindzone-viewing mirror is greater than the characteristic reflectivity of said main viewing outside mirror.

24. An auxiliary blindzone-viewing mirror for attachment to an automotive outside rearview mirror wherein said blindzone viewing mirror is comprised of a thin plate in which a planar array of reflecting facets has been formed, said planar array of reflecting facets simulating a convex mirror wherein said auxiliary blindzone viewing mirror is located generally in an upper and outer quadrant of said main viewing outside mirror, and said radius of curvature of said auxiliary blindzone viewing mirror lies in a plane generally perpendicular to said main viewing outside mirror, and said plane passes through the center point of said auxiliary blindzone viewing mirror so that its viewing angle primarily encompasses the region between the outer limit of the viewing angle of said main viewing outside mirror and the rearward limit of the driver's peripheral vision when said driver is looking at said mirror.

25. The mirror of claim 24, wherein said thin plate is optically transparent and said planar array is formed in the second surface of said thin plate, and said thin plate is adhesively attached to said outside rearview mirror.

26. The mirror of claim 24, wherein said thin plate comprises a thermoplastic material.

27. The mirror of claim 25, wherein the front surface of said thin plate is protected with an optically transparent abrasion resistant coating.

28. A mirror adapted for automotive rearview application comprising a main viewing mirror and an auxiliary mirror, said auxiliary mirror defining a reflective surface comprised of a planar array of reflecting facets simulating a convex mirror and having a characteristic magnification less than that of said main viewing mirror, said auxiliary mirror being shaped and positioned for viewing primarily a vehicle in the vehicle blindzone, said mirror having means for selectively varying the intensity of the reflection from at least a portion of said mirror, and said means for selectively varying the intensity of the reflection comprising an electrically modifiable medium intermediate a transparent front plate and a rear plate such that the intensity of the reflection from said mirror varies in response to an electrical signal applied to conductive coatings on said front plate and said rear plate.

29. The mirror of claim 28, wherein said planar array of reflecting facets is defined by the second surface of said front plate.

30. The mirror of claim 28, wherein said planar array of reflecting facets is defined by the first surface of said rear plate.

31. The mirror of claim 28, wherein said planar array of reflecting facets is defined by the second surface of said rear plate.

32. The mirror of claim 28, wherein said planar array of reflecting facets comprises a discrete second surface mirror, and the first surface of said discrete second surface mirror is adhered to the second surface of said front plate.

33. The mirror of claim 28, wherein said planar array of reflecting facets comprises a thin discrete mirror, and the second surface of said front plate incorporates a recess in which said thin discrete mirror is adhered such that the second surface of said thin discrete mirror is flush with the second surface of said front plate.

34. The mirror of claim 28, wherein said planar array of reflecting facets is a discrete second surface mirror adhered to the first surface of said second plate and the first surface of said discrete second surface mirror is coplanar with the first surface of said front plate.

35. The mirror of claim 28, wherein said planar array of reflecting facets comprises a thin discrete mirror, and the first surface of said rear plate incorporates a recess in which said thin discrete mirror is adhered such that the first surface of said thin discrete mirror is approximately flush with the first surface of said rear plate.

36. The mirror of claim 28, wherein said planar array of reflecting facets comprises a discrete second surface mirror adhered to the second surface of said rear plate.

37. The mirror of claim 28, wherein said planar array of reflecting facets comprises a discrete first surface mirror adhered to the second surface of said rear plate.

38. The mirror of claim 28, wherein said electrically conductive coating is selectively deposited to avoid changing the intensity of the reflected light from said planar array of reflecting facets.

39. A mirror adapted for automotive rearview application comprising a main viewing mirror and an auxiliary mirror, said auxiliary mirror defining a transparent solid element having a first surface and a concave reflective second surface appearing as a segment of a convex mirror when viewed from the first surface and having a characteristic magnification less than that of said main viewing mirror, said auxiliary mirror being shaped and positioned for viewing primarily a vehicle in the vehicle blindzone, and said mirror having means for selectively varying the intensity of the reflection from at least a portion of said mirror.

40. The mirror of claim 39, wherein said auxiliary mirror is located generally in the upper and outer quadrant of said mirror.

41. The mirror of claim 39, wherein said main viewing mirror and said auxiliary mirror are both retained in a retaining frame such that the first surface of said auxiliary mirror is retained coplanar with the first surface of said front plate.

42. The mirror of claim 39, wherein the first surface of said main viewing mirror and the first surface of said auxiliary mirror both have the same radius of curvature and are retained in a retaining frame such that the first surface of said auxiliary mirror is tangent to the first surface of said main viewing mirror.

43. A mirror adapted for automotive rearview application comprising a main viewing mirror and an auxiliary mirror, said auxiliary mirror defining a transparent solid element having a first surface and a concave reflective second surface appearing as a segment of convex mirror when viewed from the first surface and having a characteristic magnification less than that of said main viewing mirror, said auxiliary mirror being shaped and positioned for viewing primarily a vehicle in the vehicle blindzone, said mirror having means for selectively varying the intensity of the reflection from at least a portion of said mirror, and said means for selectively varying the intensity of the

reflection is comprised of an electrically modifiable medium intermediate a transparent front plate and a rear plate such that the intensity of the reflection from said mirror varies in response to an electrical signal applied to electrically conductive coatings on said front plate and said rear plate.

44. The mirror of claim 43, wherein the first surface of said auxiliary mirror is adhered to the second surface of said front plate.

45. The mirror of claim 43, wherein the first surface of said auxiliary mirror segment is adhered to the second surface of said rear plate.

46. The mirror of claim 43, wherein said electrically conductive coating is selectively deposited to avoid changing the intensity of the reflected light from said auxiliary mirror.

47. A mirror adapted for automotive rearview application comprising a main viewing mirror and an auxiliary blindzone viewing mirror having a magnification less than that of said main viewing mirror wherein said auxiliary blindzone viewing mirror is located at an outer end of said mirror, said auxiliary blindzone viewing mirror being comprised of a planar array of reflecting facets.

48. The mirror of claim 47, wherein said planar array of reflecting facets simulates a convex mirror.

49. The mirror of claim 47, wherein said planar array of reflecting facets simulates an aspheric convex mirror.

50. A mirror adapted for automotive rearview application comprising a main viewing mirror and an auxiliary mirror, said auxiliary mirror defining a transparent solid element having a first surface and a concave reflective second surface appearing as a segment of a convex mirror when viewed from the first surface and having a characteristic magnification less than that of said main viewing mirror, said auxiliary mirror being shaped and positioned for

viewing primarily a vehicle in the vehicle blindzone, and said main viewing mirror and said auxiliary mirror are both retained in a retaining frame such that the first surface of said auxiliary mirror is retained tangent with the first surface of said main viewing mirror.

51. A mirror adapted for automotive rearview application comprising a first exterior viewing portion characterized by a first reflectivity characteristic and a second exterior viewing surface portion characterized by a second reflectivity characteristic.

52. The mirror of claim 51 wherein said viewing surface portions have different magnification characteristics.

53. The mirror of claim 51, wherein said first reflectivity characteristic is relatively fixed and said second reflectivity characteristic is selectively variable.

54. The mirror of claim 51, wherein both of said reflectivity characteristics are variable, independently of one another.

55. An automotive outside rearview mirror assembly comprising;

a housing adapted to be affixed to the exterior of a vehicle having an enclosed chamber with a rearwardly facing opening;

a mirror adjustment mechanism mounted within the housing enclosed chamber and provided with a remotely positionable face plate; and

a mirror element affixed to the face plate, said mirror element comprising a main viewing outside mirror and an auxiliary blindzone viewing mirror, said auxiliary blindzone viewing mirror defining a reflective surface comprised of a planar array of reflecting facets simulating a convex mirror and having a radius of curvature and a magnification less than that of said main viewing outside mirror, wherein said auxiliary blindzone viewing mirror is located generally in an upper and outer quadrant of said main viewing outside mirror, and said radius of curvature of said auxiliary blindzone viewing mirror lies in a plane generally perpendicular to said main viewing outside mirror, and said plane passes through the center point of said auxiliary blindzone viewing mirror so that its viewing angle primarily encompasses the region between the outer limit of the viewing angle of said main viewing outside mirror and the rearward limit of the driver's peripheral vision when said driver is looking at said mirror.

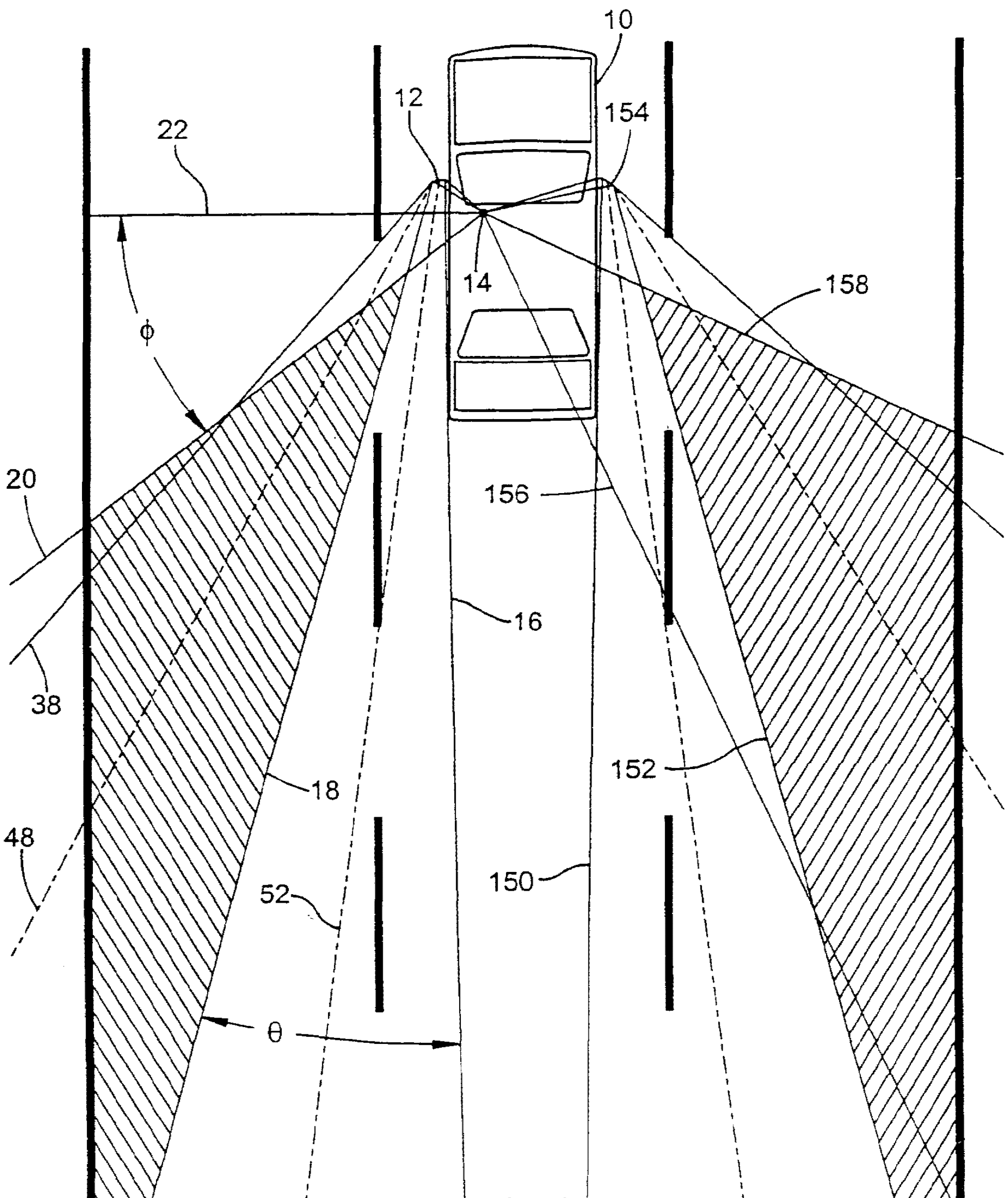


Fig. 1

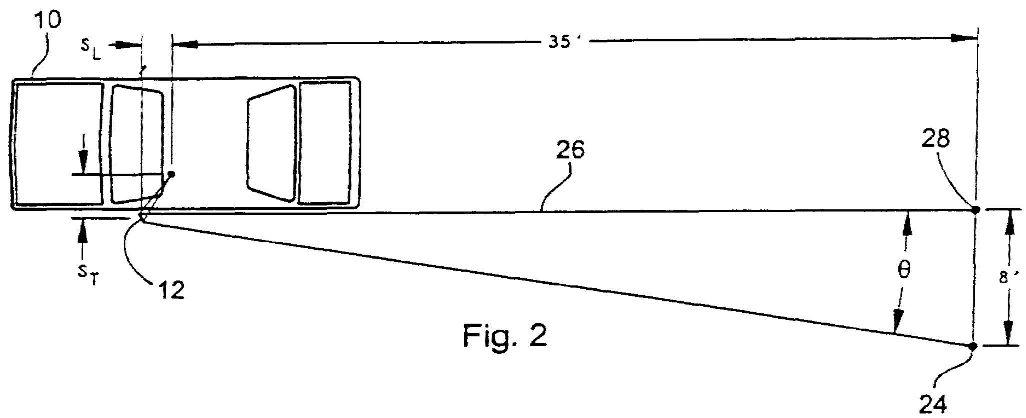


Fig. 2

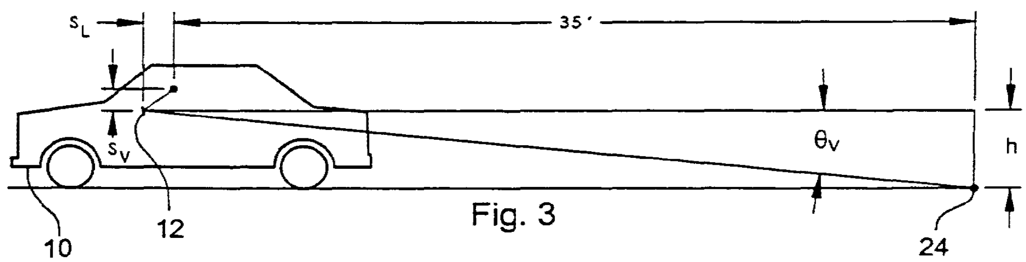
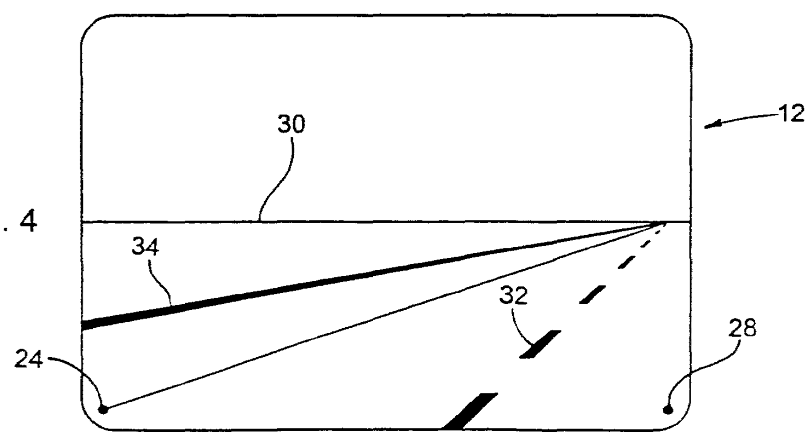


Fig. 3

Fig. 4



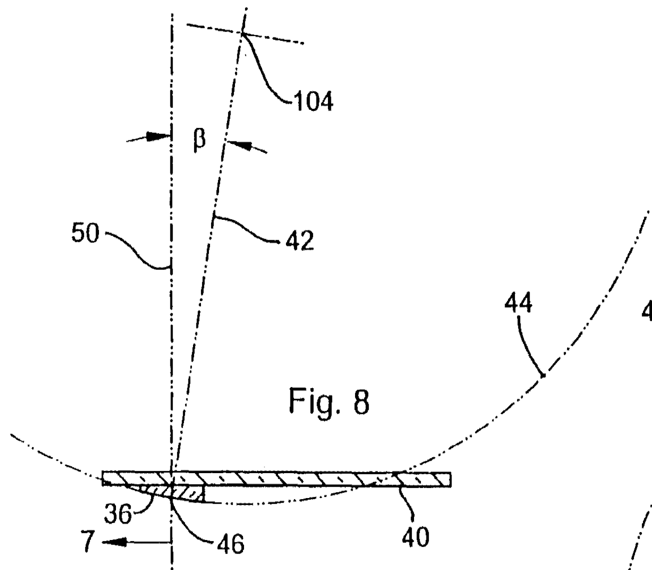


Fig. 8

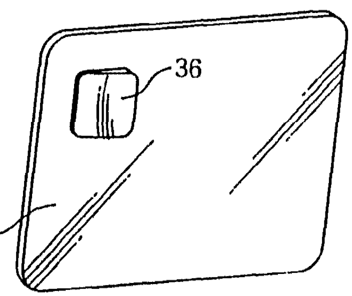


Fig. 5

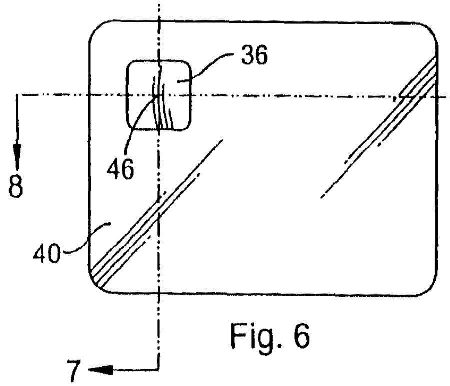


Fig. 6

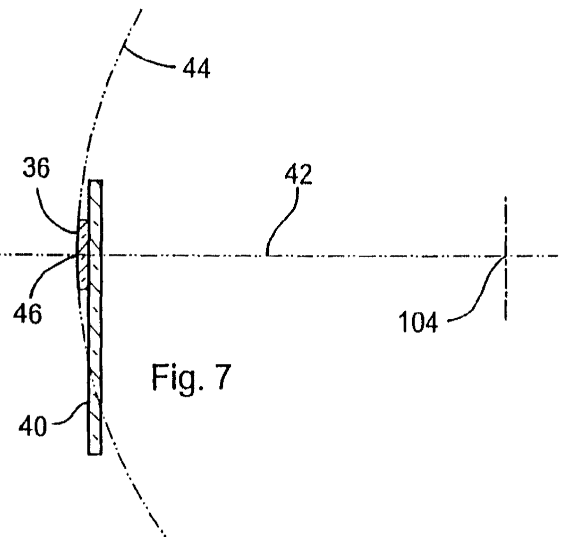


Fig. 7

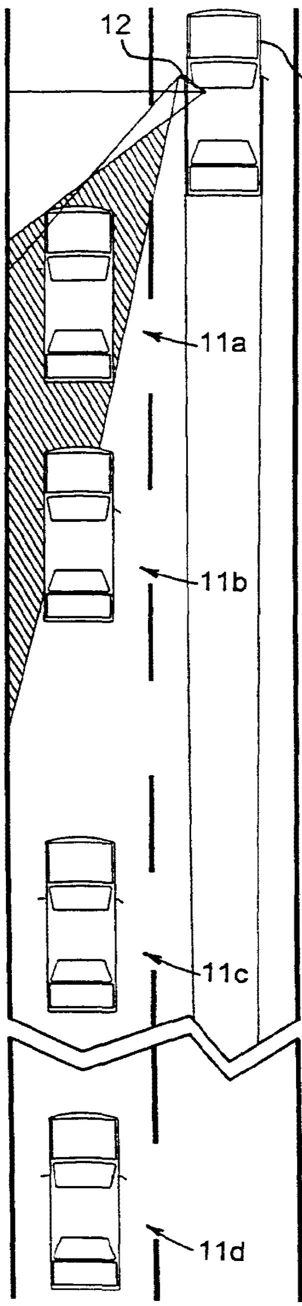


Fig. 9

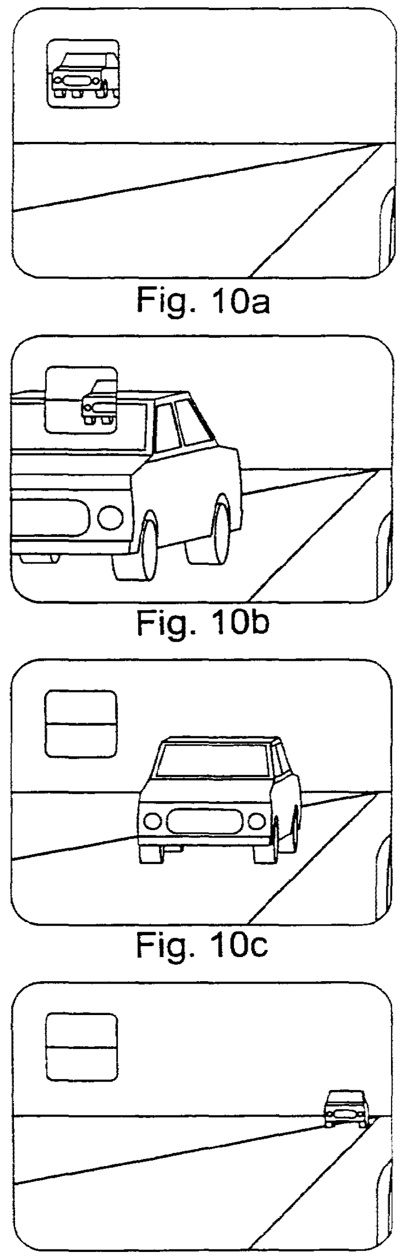


Fig. 10a

Fig. 10b

Fig. 10c

Fig. 10d

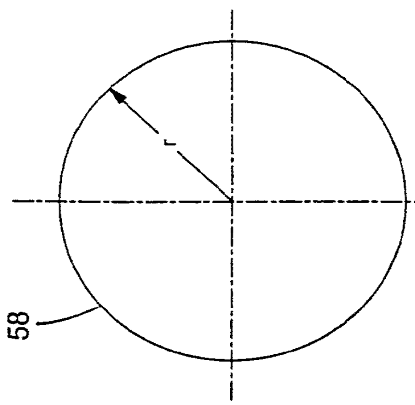


Fig. 13

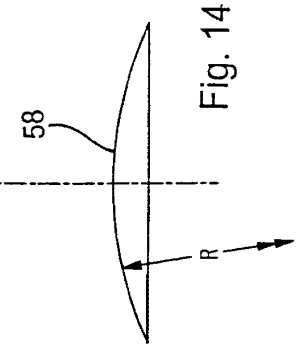


Fig. 14

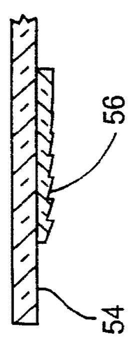


Fig. 12

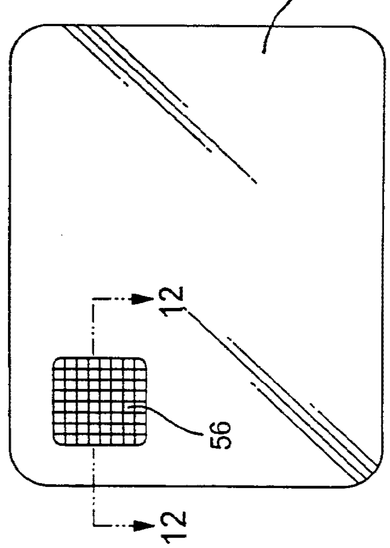
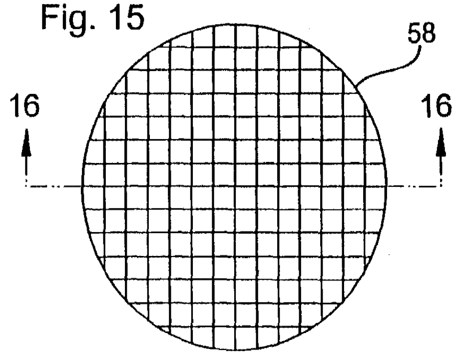


Fig. 11

Fig. 15



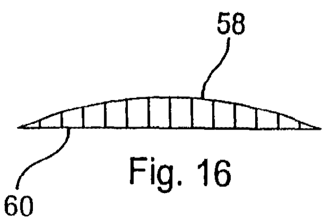


Fig. 16

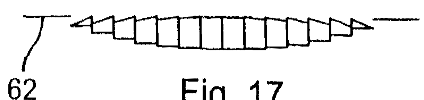


Fig. 17

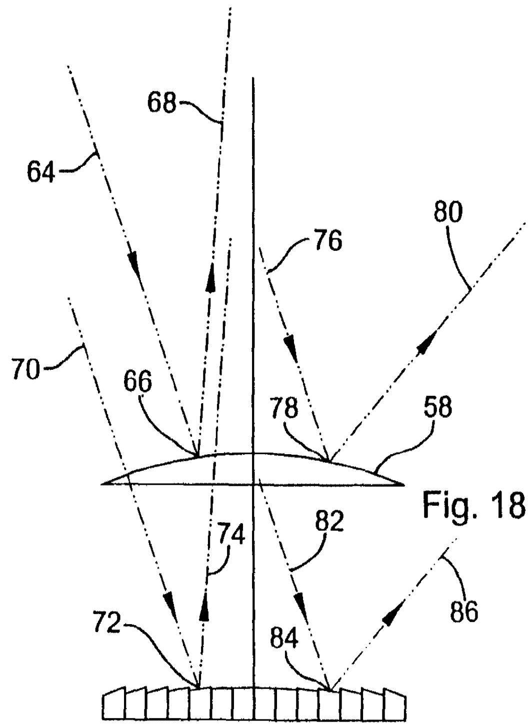


Fig. 18

Fig. 19

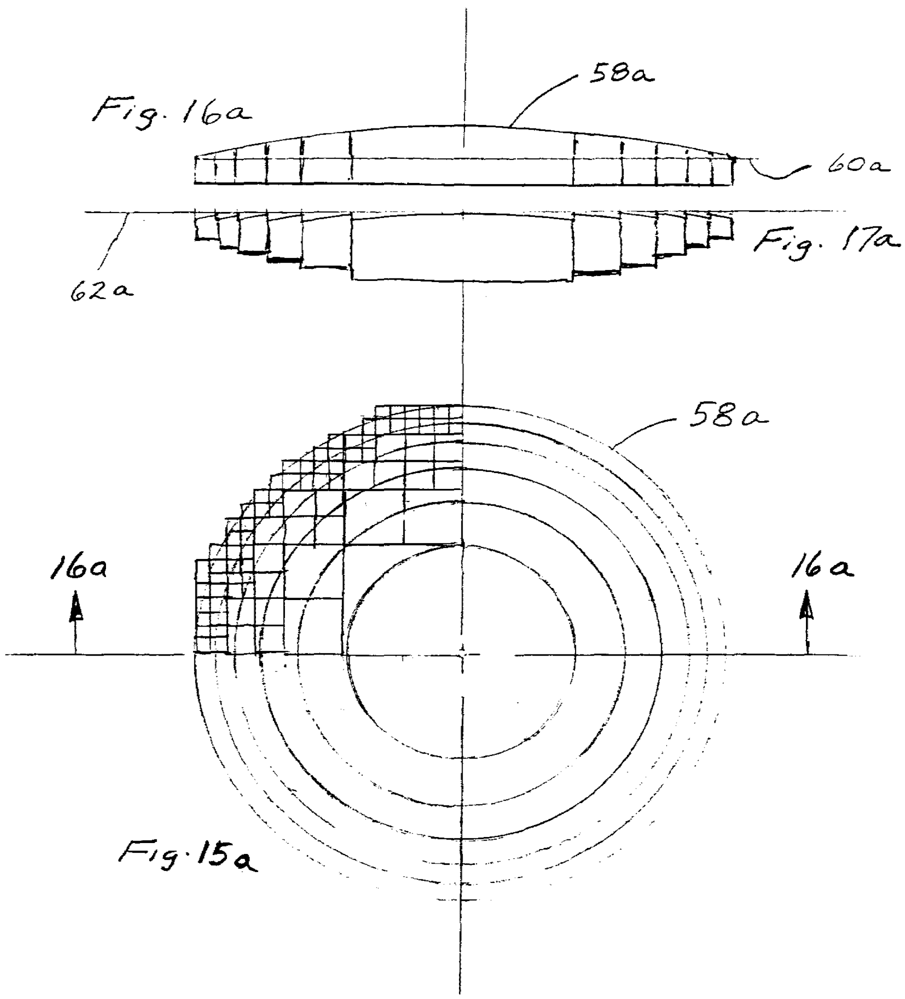
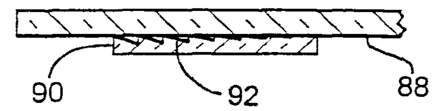

58a
Fig. 16a
60a
Fig. 17a
62a
58a
16a
16a
Fig. 15a

Fig. 21



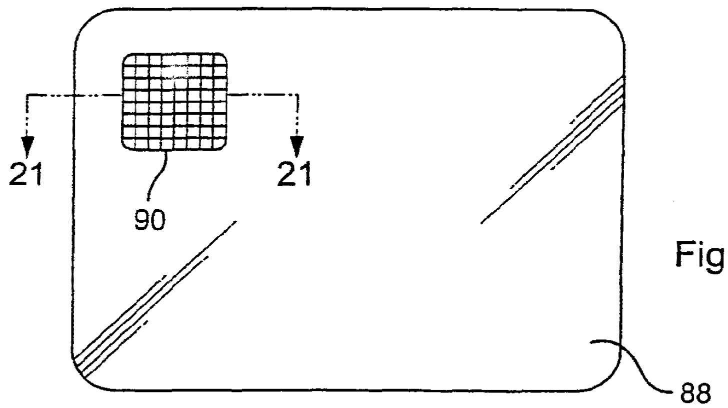
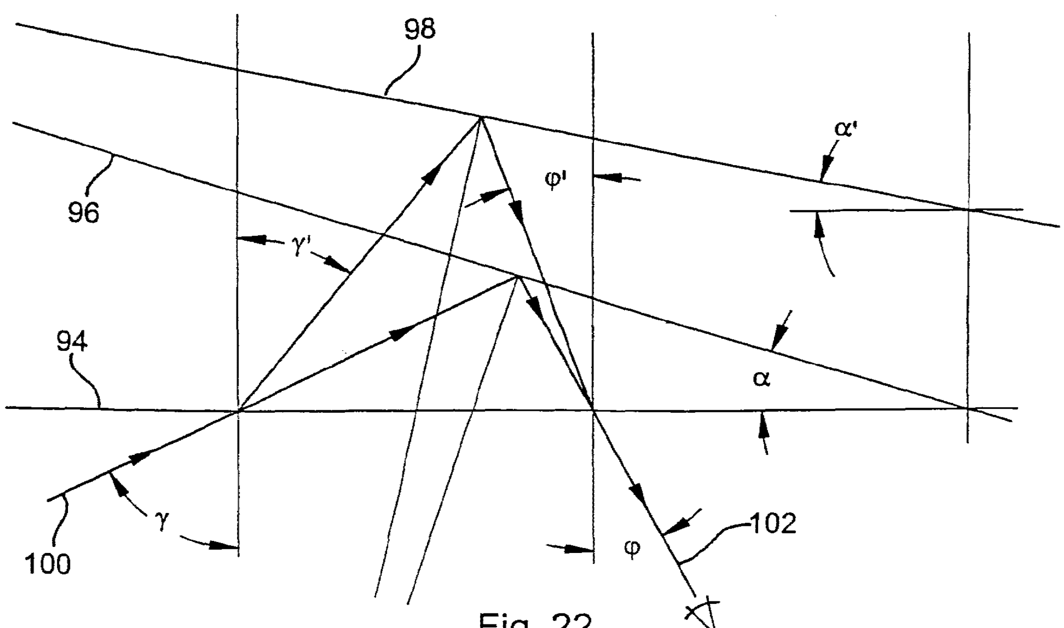


Fig. 20



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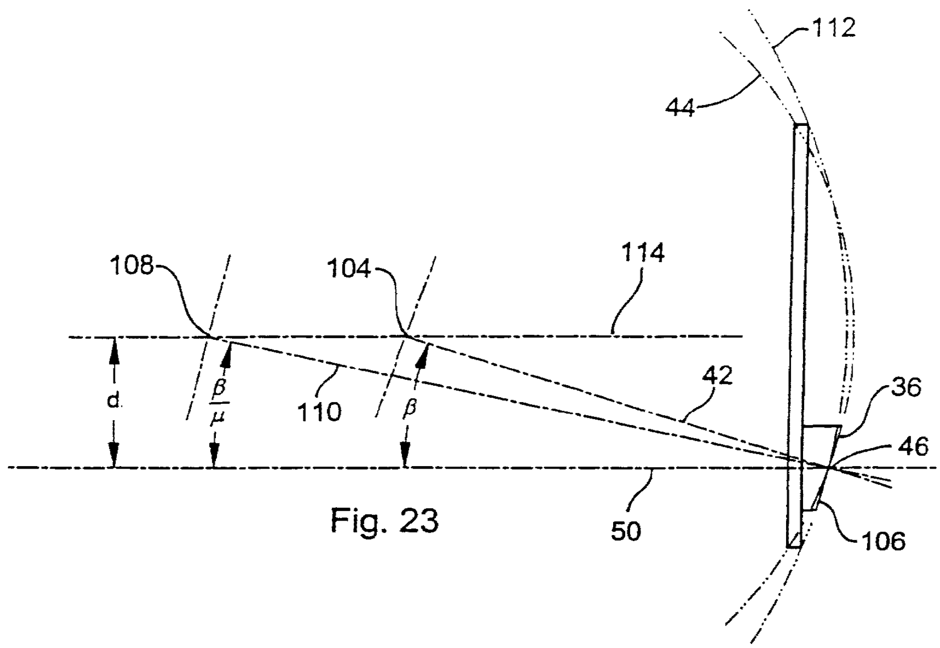

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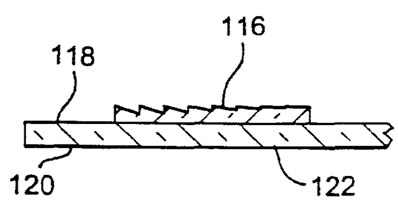

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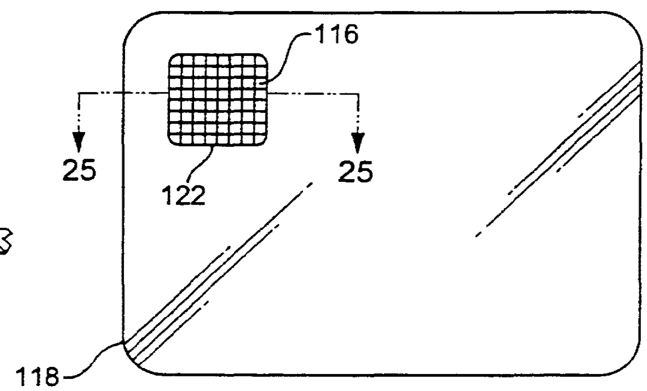

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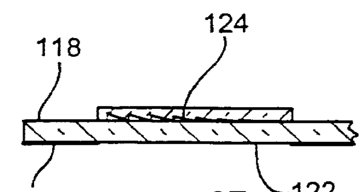


Fig. 27

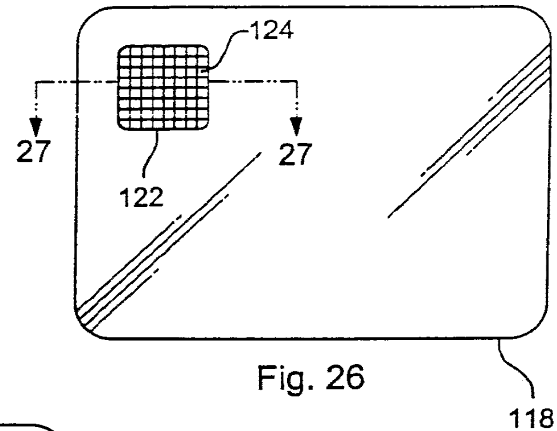
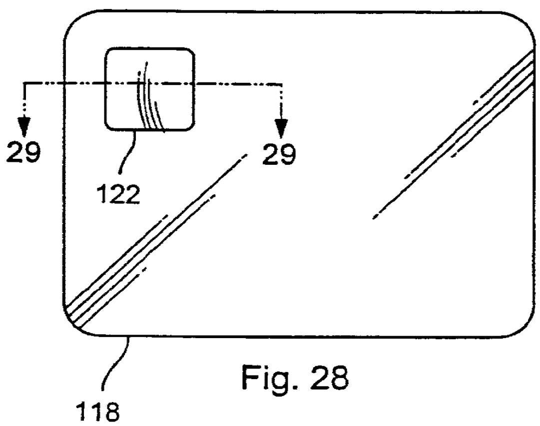


Fig. 26



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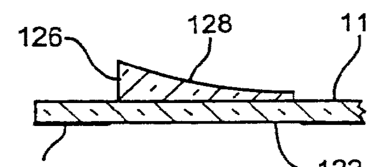

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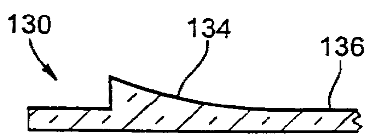

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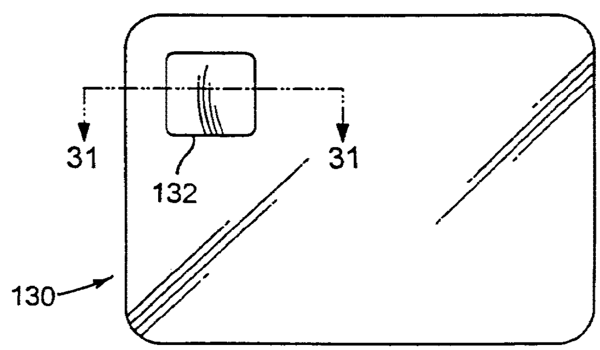

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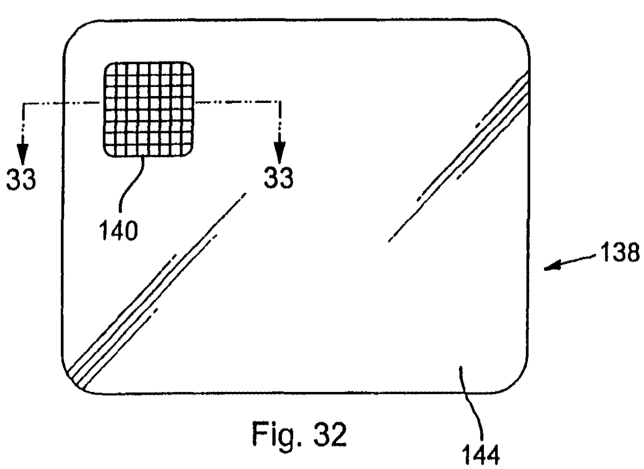


Fig. 32

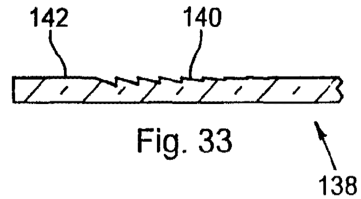
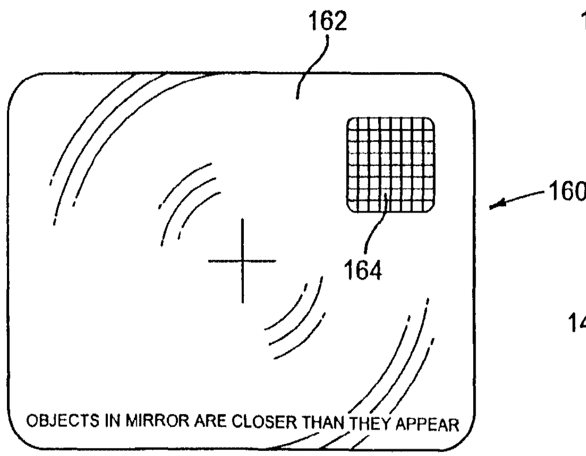


Fig. 33



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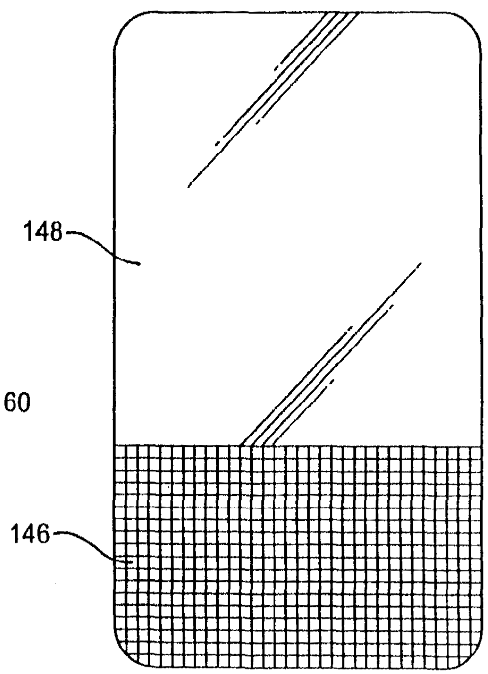
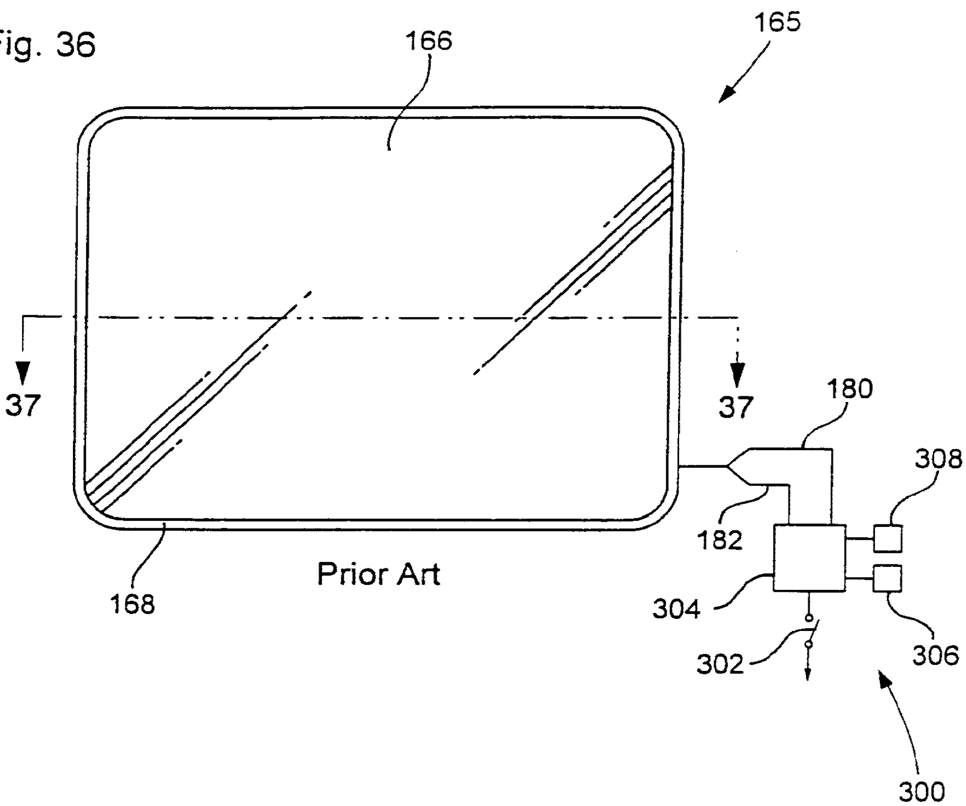
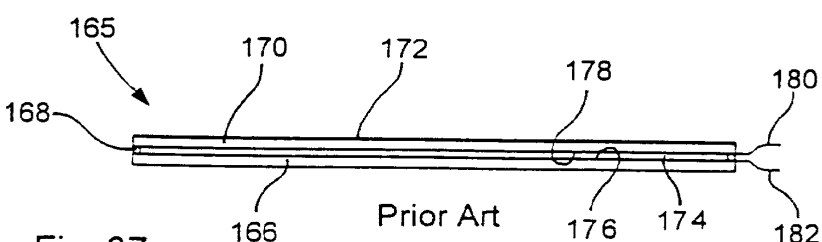


Fig. 34

Fig. 36



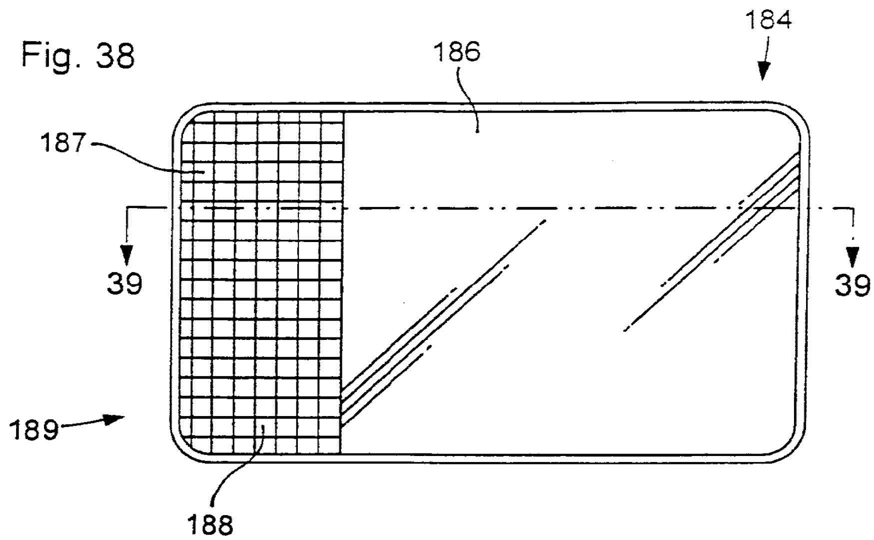
Prior Art



Prior Art

Fig. 37

Fig. 38



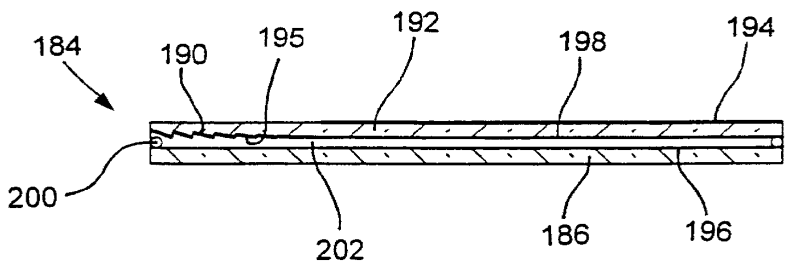


Fig. 39a

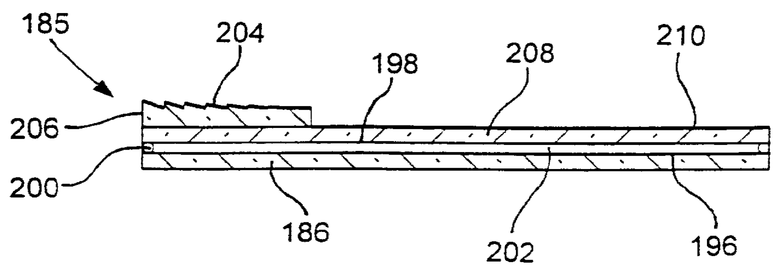


Fig. 39b

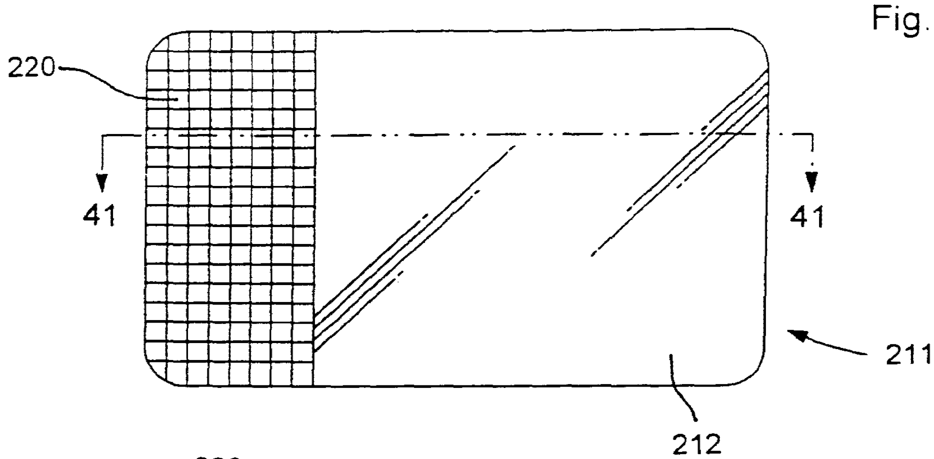


Fig. 40

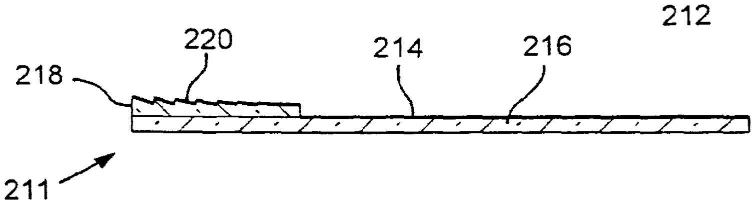


Fig. 41

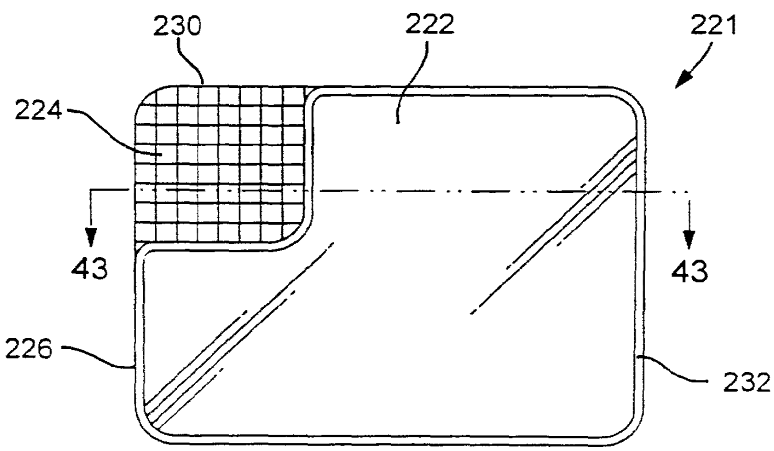


Fig. 42

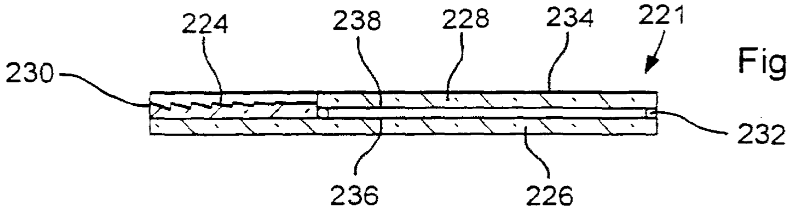
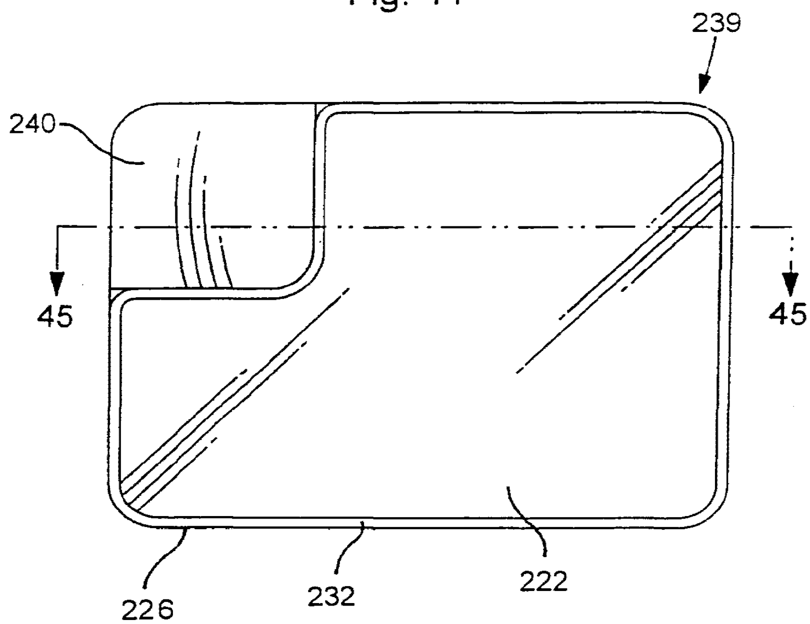
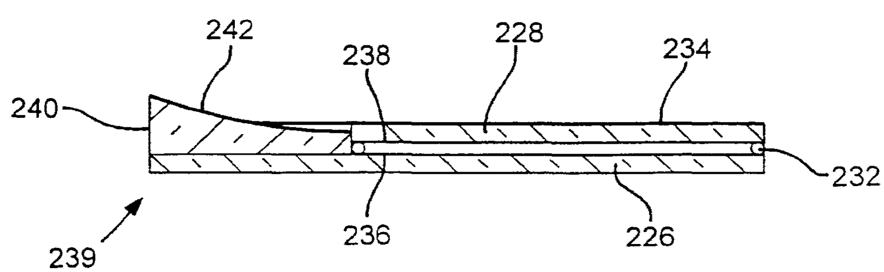


Fig. 43

Fig. 44





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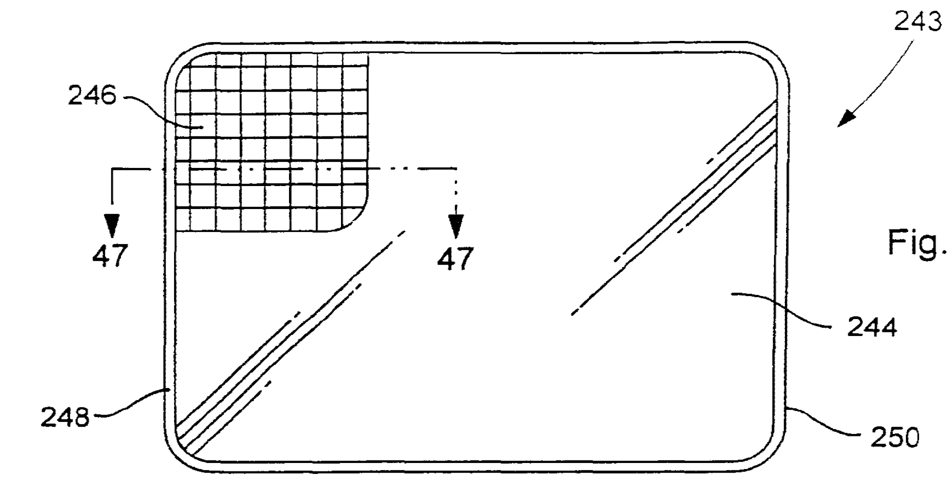

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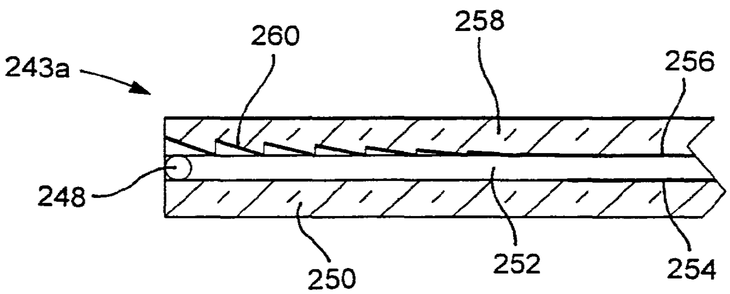


Fig. 47a

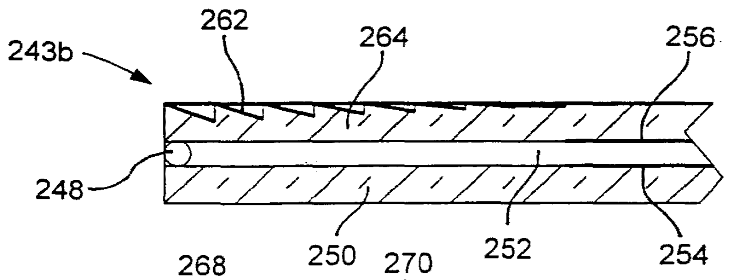


Fig. 47b

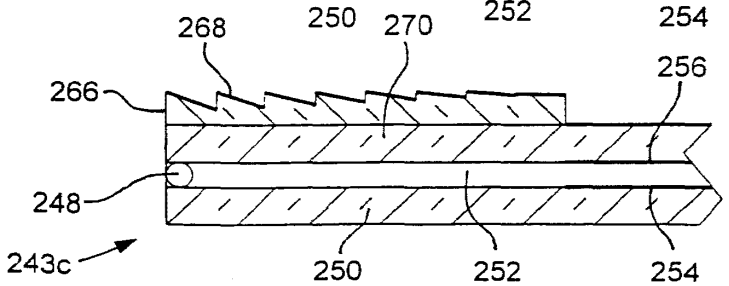


Fig. 47c

Fig. 48

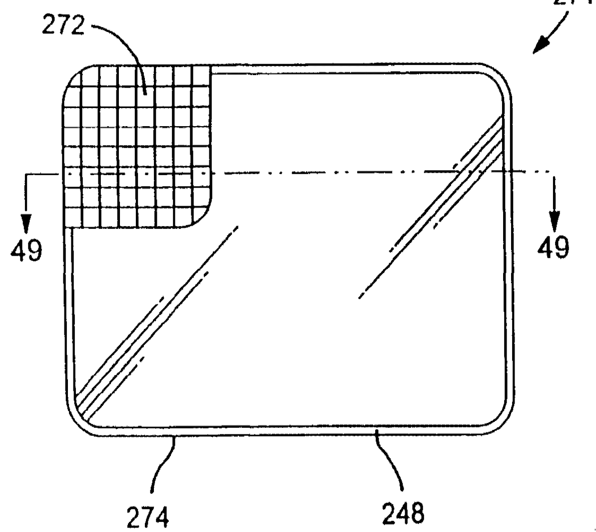
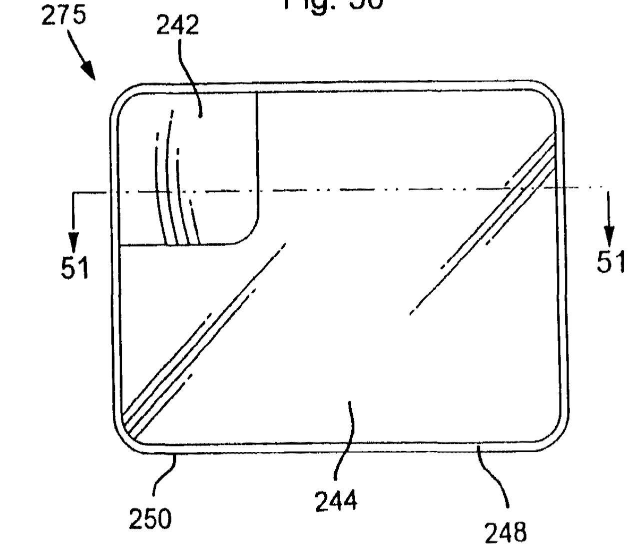


Fig. 50



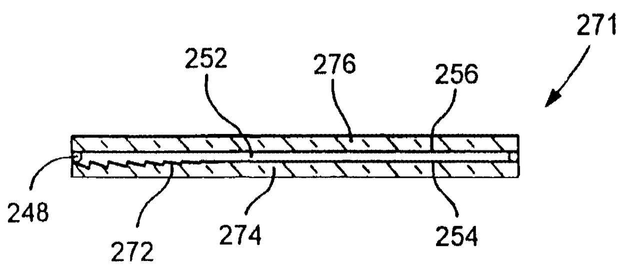


Fig. 49

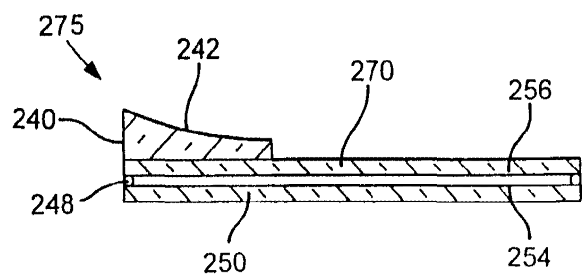


Fig. 51

Fig.54

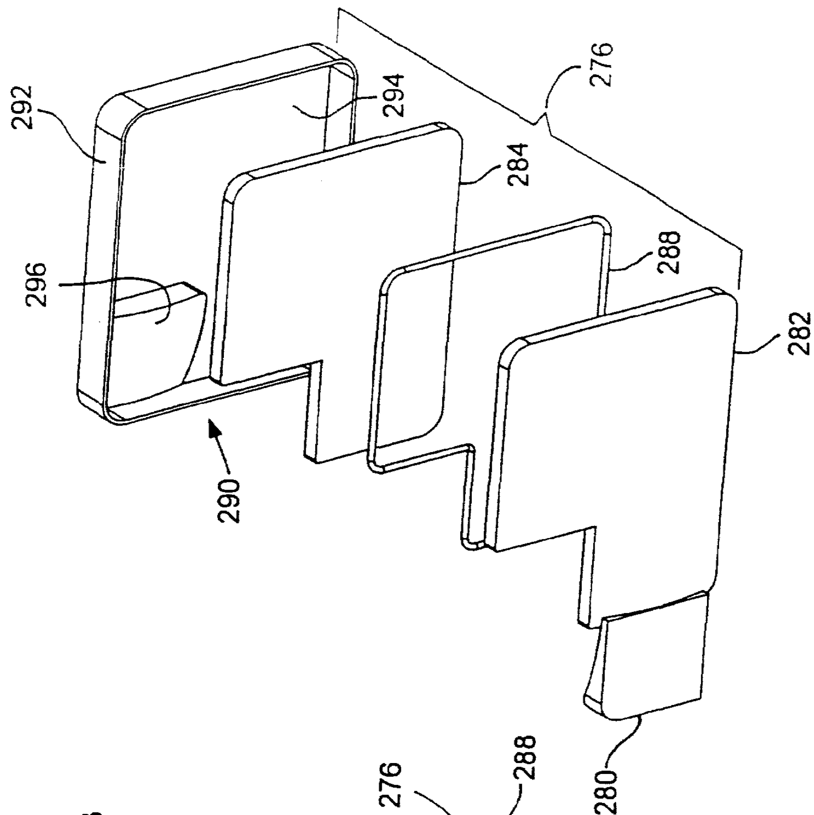


Fig. 52

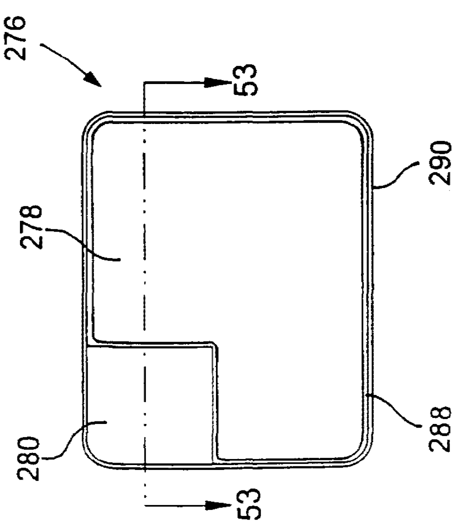


Fig. 53

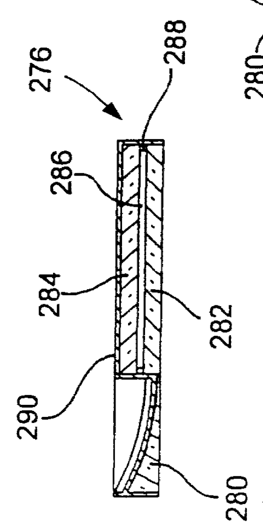
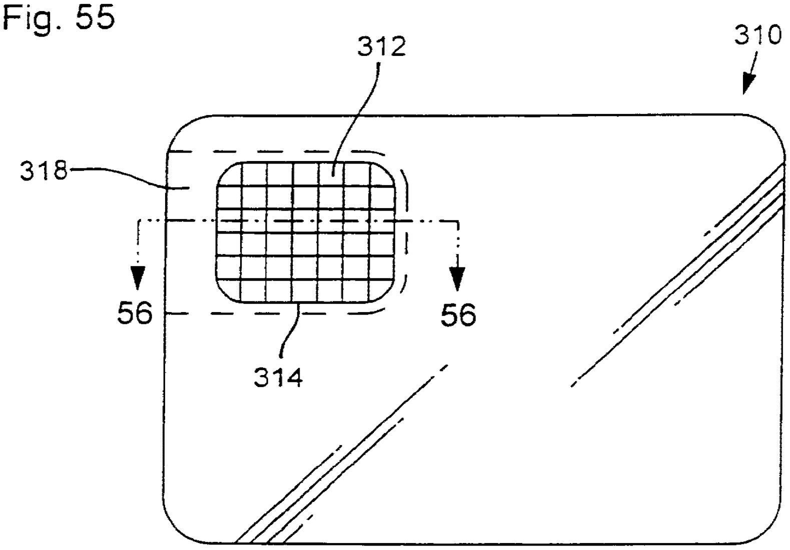


Fig. 55



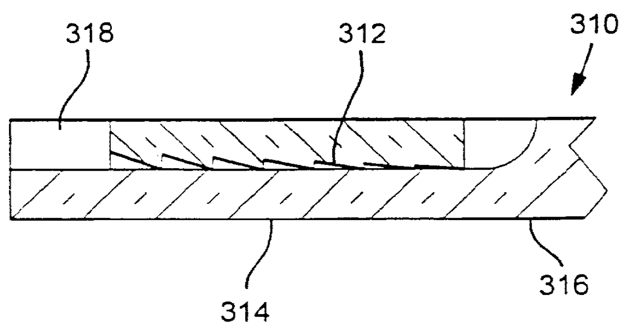


Fig. 56

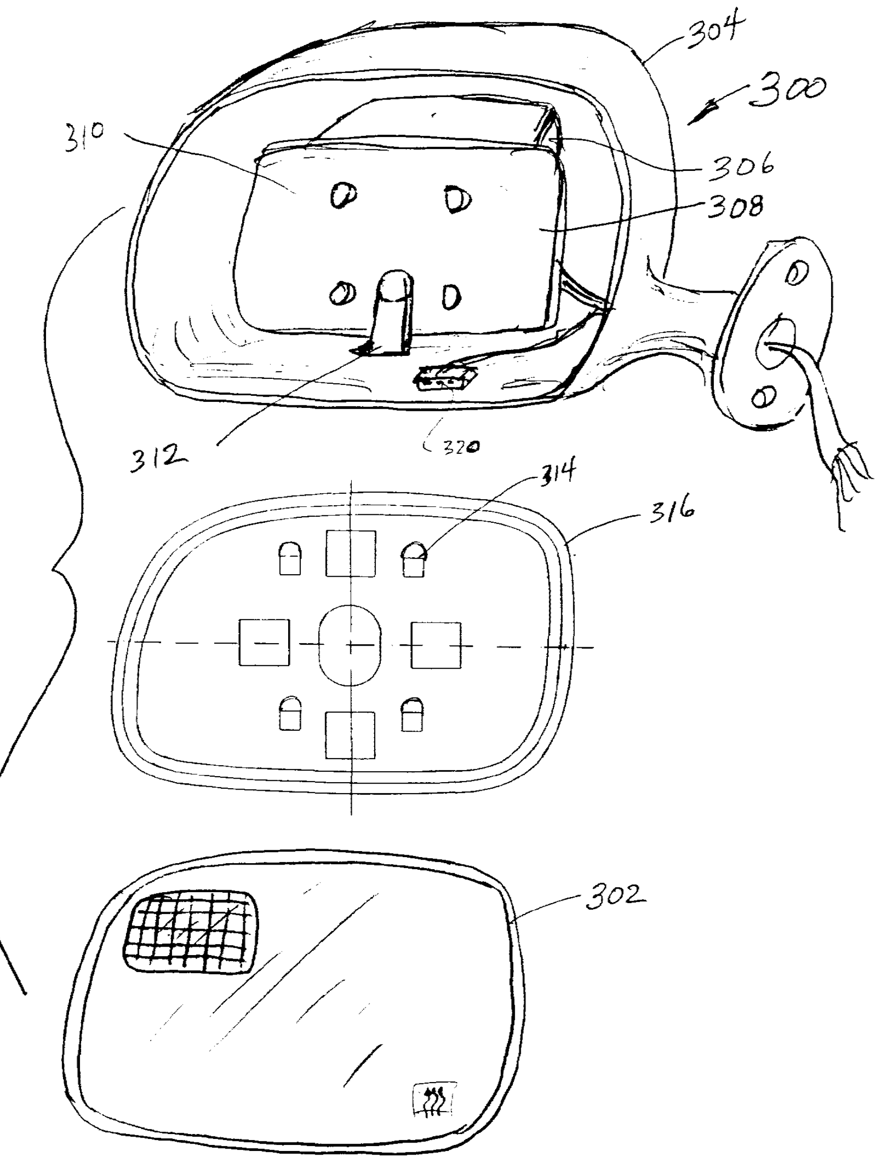


fig. 57

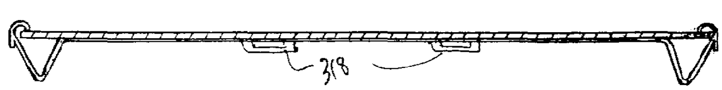


fig. 58

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/13283

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : G02B 5/08
US CL : 359/856, 857, 871, 872
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 359/856, 857, 871, 872

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,436,372 A (SCHMIDT et al.) 13 March 1984 (13.03.1984), whole document.	1-55
Y	US 5,847,889 A (KOMIYAMA et al.) 08 December 1998 (08.12.1998), whole document.	1-55

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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(71) Applicant (*for all designated States except US*): **DONNELLY CORPORATION** [US/US]; 414 East Fortieth Street, Holland, MI 49423 (US).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **MCCABE, Ian, A.** [IE/US]; 16092 Ransom Street, Holland, MI 49424 (US). **HABIBI, Hamid** [IR/US]; 4057 66th Street, Holland, MI 49423 (US). **VARAPRASAD, Desaraju, V.** [US/US]; 1281 Innisbrook Court, Holland, MI 49423 (US). **LYNAM, Niall, R.** [US/US]; 248 Foxdown, Holland, MI 49424 (US).

(74) Agent: **FLORY, Timothy**; Van Dyke, Gardner, Linn & Burkhart, LLP, 2851 Charlevoix Drive SE, Suite 207, P.O. Box 888695, Grand Rapids, MI 49588-8695 (US).

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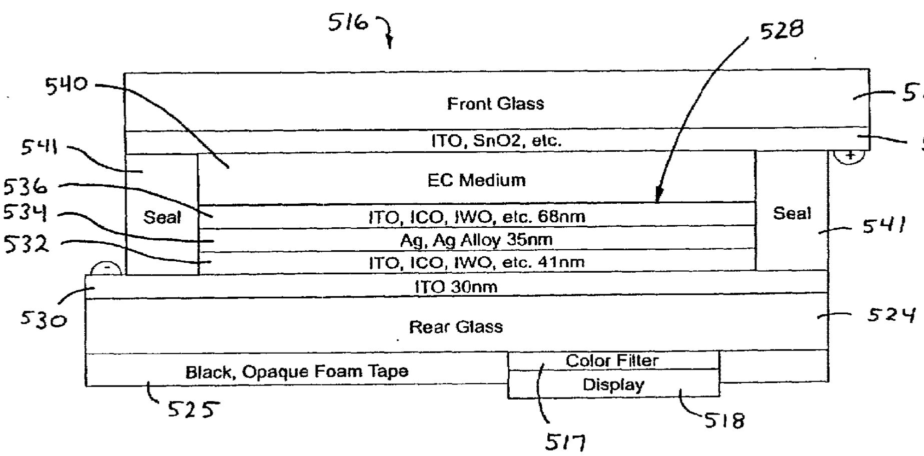
(54) Title: MIRROR REFLECTIVE ELEMENT ASSEMBLY



(57) **Abstract:** A mirror assembly for a vehicle includes a mirror element having at least one substrate that has a forward surface and a rearward surface. The mirror element comprises at least one substantially reflective metallic layer sandwiched between a respective pair of substantially transparent non-metallic layers. Each of the substantially transparent non-metallic layers and the substantially reflective metallic layer have a selected refractive index and a selected physical thickness such that the reflective element is selectively spectrally tuned to substantially transmit at least one preselected spectral band of radiant energy therethrough while substantially reflecting other radiant energy. A radiant energy emitting element is disposed at or near the rearward surface of the at least one substrate. The radiant energy emitting element is configured to emit radiant energy with a peak intensity within the at least one preselected spectral band.

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MIRROR REFLECTIVE ELEMENT ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims priority of U.S. provisional applications, Ser. No. 60/412,275, filed Sep. 20, 2002 by McCabe for ELECTROCHROMIC MIRROR ASSEMBLY (Attorney Docket DON01 P-1011); Ser. No. 60/424,116, filed Nov. 5, 2002 by McCabe for ELECTROCHROMIC MIRROR ASSEMBLY (Attorney Docket DON01 P-1045); and Ser. No. 60/489,816, filed Jul. 24, 2003 by McCabe for ELECTROCHROMIC MIRROR ASSEMBLY (Attorney Docket DON01 P-1099), which are all hereby incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates to a mirror reflective element assembly for a vehicle, such as an electro-optic mirror reflective element assembly, such as an electrochromic interior or exterior rearview mirror reflective element assembly, and, more particularly, to a rearview mirror reflective element assembly which provides transmission of display information or illumination or radiant energy through the reflective element of the mirror reflective element assembly, while providing sufficient reflectance of the reflective element. Aspects of the present invention are equally applicable to interior and exterior mirror reflective element assemblies, as well as to prismatic mirror reflective element assemblies or other mirror reflective element assemblies having a single glass substrate.

BACKGROUND OF THE INVENTION

Variable reflectivity mirror assemblies, such as electrochromic mirror assemblies are known and are widely implemented in vehicles. The reflective element of the mirror assemblies often include two substrates or glass elements. The back or outer surface of the second substrate (commonly referred to as the "fourth surface" of the reflective element) may include a silvered coating to provide reflectance of an image. In embodiments where the mirror assembly may include a display, a window may be formed, such as by sand blasting, laser etching or the like, through the silvered coating, such that display information may be transmitted through the window for viewing by the driver. The window provides a highly transmissive, generally spectrally neutral window for the display. However, the window defines an area of the reflective element that no longer has the reflective coating, such that reflectivity is lost in the window area. Therefore, the size and the quantity of displays that can be provided at the mirror reflective element is limited.

It is known to provide a metallic reflective layer on an inward surface of the second substrate of the electrochromic reflective element (commonly known in the art as a "third surface" of the reflective element), such as disclosed in U.S. Pat. No. 3,280,701, which is hereby incorporated herein by reference. An electrochromic medium may be positioned between the metallic layer and a transparent electrically conductive layer on the inward surface of the first substrate (i.e., the "second surface" of the reflective element). However, there are concerns with the electrochromic medium of such mirror assemblies contacting the metallic layer, since chemical and/or electro-chemical attack on the metallic layer may result in corrosion of the metallic layer.

As disclosed in U.S. Pat. No. 5,724,187, which is hereby incorporated herein by reference, a metallic conductive layer may be disposed on the third surface, with a protective layer, such as a transparent semi-conductive layer of indium tin oxide, disposed on the metallic layer. The electrochromic medium is then positioned between the protective layer and a conductive layer on the inward surface of the first substrate. It is preferable for such designs to include an adhesion layer, such as a second transparent semi-conductive layer, such as indium tin oxide, or another metallic layer, between the metallic layer and the inward surface of the second substrate, in order to enhance adhesion of the metallic layer to the second substrate.

In electrochromic mirror assemblies which include a display that may transmit through the substrates of the reflective element, the metallic layer or coating must be thin enough to be transmissive to allow viewing of the display through the metallic coating. It is known to provide a thinner metallic coating in a display area to provide increased transmissivity (but with a consequently reduced reflectivity) only in the display area or areas of the reflective element, such as disclosed in U.S. Pat. No. 6,356,376, which is hereby incorporated herein by reference. However, such designs have layers or coatings that are relatively thin (often less than 150Å or thereabouts in thickness) and so any variation in metallic layer thickness may lead to a significant variation in light transmission through such thin metallic coatings. Thus, such significantly thin metallic coatings or layers may have a substantially low variability tolerance for the thickness and may require a substantially uniform thickness coating, in order to provide the desired results. Such tolerances and uniformity may be difficult to achieve through sputter coating or other coating processes typically used in the manufacture of such reflective elements. Therefore, such significantly thin metallic coatings may be difficult and costly to manufacture.

An example of a known electrochromic reflective element is shown in FIG. 1. The reflective element includes an electrochromic (EC) medium layer and a metallic reflective layer sandwiched between conductive layers at the front and rear glass substrates. A display is positioned at a rear surface of the rear substrate (the fourth surface of the reflective element). The display emits light through the substrates and layers therebetween so as to be viewable by a person viewing the first surface of the reflective element. Such known reflective elements provide little or no spectrally selective transmission characteristics of visible light, as can be seen with reference to FIG. 1A (which shows the transmissivity of the ITO and silver layers at the rear substrate versus the wavelength of the radiant energy), and may be subject to chemical/electrochemical corrosion through contact with the EC medium.

Sometimes it is desired to have an illumination source and/or a camera or imaging device or sensor at an interior rearview mirror assembly for illuminating and/or capturing images of the interior cabin of the vehicle, such as part of a cabin monitoring system, a driver alertness/drowsiness detection system, an intrusion detection system, a seat occupancy detection system and/or the like. The illumination sources and imaging device, if provided at the interior rearview mirror assembly, are typically positioned around the bezel, chin or eyebrow portion of the mirror casing or at a pod or module associated with the mirror assembly or elsewhere in the vehicle. The illumination sources and imaging device cannot typically be positioned within the mirror casing due to the difficulties encountered in projecting light or illumination through the reflective element to the cabin and allowing light from within the cabin to pass through the reflective element to the imaging device. Typically, such transmissivity of light, even of infrared or near infrared light, through the reflective element may not be achieved utilizing reflective coatings that comprise a metallic layer, such as a thin silver or silver alloy or aluminum or aluminum alloy layer or the like. In such applications, the infrared or near infrared light emitted by the illumination source may reflect back into the cavity of the mirror casing, such that a desired amount of light may not reach the cabin and such that the imaging device may be adversely affected by the reflectant light.

Therefore, there is a need in the art for an electrochromic mirror assembly which provides sufficient reflectivity and sufficient transmissivity to allow for transmission of display information or illumination through the reflective element, and which overcomes the above disadvantages and shortcomings of the prior art.

SUMMARY OF THE INVENTION

The present invention provides an interior or exterior rearview mirror assembly that has a mirror reflective element that may be spectrally tuned to substantially transmit light having a particular wavelength or range of wavelengths, while substantially reflecting other light. The mirror reflective element may comprise a third surface reflective element having a particular combination or stack of at least partially conductive layers (such as semi-conductive layers formed of at least partially conducting inorganic oxides, such as doped or undoped indium oxide, doped or undoped tin oxide, doped or undoped zinc oxide, doped or undoped nickel oxide, and/or doped or undoped tungsten oxide or the like) and metallic layer(s) at the third surface. The mirror assembly is suitable for including a display element which emits and transmits viewable information through the reflective element of the mirror assembly. More particularly, the mirror assembly of the present invention is suitable for including a display on demand (DOD) type of display. The mirror assembly of the present invention provides a particular combination of reflector design or designs suitable for a display on demand type of display which are economical and which match and/or make most beneficial use of a particular light emitting display element and color thereof. The present invention thus provides a spectrally selective transmission of visible light characteristic to the reflective element of the mirror assembly, while maintaining a substantially non-spectrally selective, substantially untinted reflectant characteristic, and while maintaining a relatively high photopic reflectance, such as greater than approximately 60% photopic reflectivity, more preferably greater than approximately 70% photopic reflectivity, and most preferably greater than approximately 80% photopic reflectivity. The spectrally selective transmissivity of the reflective element may thus be selected or tuned to optimize transmission of a particular spectral band or range of light wavelengths at least primarily emitted by the display element.

According to an aspect of the present invention, a mirror assembly for a vehicle comprises a mirror element including at least one substrate having a forward surface facing towards a viewer of the mirror assembly and a rearward surface facing away from a viewer of the mirror assembly. The mirror element comprises at least one substantially reflective metallic layer sandwiched between a respective pair of substantially transparent non-metallic layers. Each of the substantially transparent non-metallic layers and the substantially reflective metallic layer have a selected refractive index and a selected physical thickness such that the reflective element is selectively spectrally tuned to substantially transmit at least one preselected spectral band of radiant energy therethrough while substantially reflecting other radiant energy. A radiant energy emitting element is disposed at or near the rearward surface of the at least one substrate. The radiant energy emitting element is operable to emit radiant energy towards the rearward surface and through the mirror element. The radiant energy emitting element is operable to emit radiant energy with a peak intensity within the at least one preselected spectral band.

Optionally, the at least one preselected spectral band may comprise a preselected band of visible light, while the radiant energy emitting element may be operable to emit visible radiant energy or light with a peak intensity within the preselected spectral band of visible light. The radiant energy emitting element thus may provide a display on demand type of display for viewing of displayed or emitted information through the reflective element.

Optionally, the at least one preselected spectral band may comprise first and second preselected bands of radiant energy, while the radiant energy emitting element comprises first and second radiant energy emitting elements. The first radiant energy emitting element may be operable to emit radiant energy with a peak intensity within the first preselected spectral band of radiant energy and the second radiant energy emitting element may be operable to emit visible radiant energy with a peak intensity within the second preselected spectral band of radiant energy.

Optionally, the at least one preselected spectral band may comprise a preselected band of near infrared radiant energy, while the radiant energy emitting element may be operable to emit near infrared radiant energy with a peak intensity within the preselected spectral band of near infrared radiant energy. The mirror assembly may include an imaging sensor at or near the rear surface that may be sensitive to near infrared radiant energy.

Optionally, the mirror reflective element may comprise an electro-optic or electrochromic mirror element, and may comprise an electrochromic medium sandwiched between a pair of substrates. The non-metallic and metallic layers may be disposed on a third surface (the surface of the rear substrate that opposes electrochromic medium and the front substrate).

Optionally, the mirror reflective element may comprise a prismatic mirror element. The alternating non-metallic and metallic layers may be disposed on a rear surface of the prismatic element or substrate. The radiant energy emitting element may be positioned at a rear layer of the alternating layers and operable to emit radiant energy or light through the layers and the prismatic substrate, such that the information displayed or emitted by the radiant energy emitting element is viewable through the prismatic reflective element by a driver or occupant of the vehicle, while the prismatic reflective element substantially reflects light having other wavelengths or spectral bands. The radiant energy emitting element thus may provide a display on demand type of display to the prismatic mirror element.

According to another aspect of the present invention, an electrochromic mirror assembly for a vehicle comprises an electrochromic mirror element comprising a first substrate having first and second surfaces and a second substrate having third and fourth surfaces. The first and second substrates are arranged so that the second surface opposes the third surface with an electrochromic medium disposed therebetween. The third surface of the second substrate comprises a transflective reflector comprising a first substantially transparent semi-conductive non-metallic layer contacting the electrochromic medium, a second substantially transparent semi-conductive non-metallic layer, and a substantially reflective metallic conductive layer sandwiched between (and electrically in contact/ connection with) the first and second substantially transparent semi-conductive non-metallic layers. When the mirror element is viewed from outside the first surface (such as by a driver or passenger within the vehicle), the mirror element is substantially spectrally untinted (i.e., is substantially spectrally unselective in photopic reflectivity) when no voltage is applied across the electrochromic medium. The mirror element is at least partially spectrally selective in transmission (i.e., is at least partially tinted for transmittant light) and exhibits a spectrally selective transmission characteristic, which is established by the refractive indices and physical thicknesses of the first and second substantially transparent semi-conductive non-metallic layers and the substantially reflective metallic conductive layer. The mirror assembly includes a light emitting or display element disposed at the fourth surface of the second substrate which is operable to emit light having an emitted spectral characteristic through the mirror element. The transflective reflector is configured to exhibit a spectrally selective transmission characteristic so as to substantially transmit light having a spectral band in regions at or near the emitted spectral characteristic and to substantially reflect other light.

Optionally, the second substantially transparent semi-conductive non-metallic layer may contact the third surface of the second substrate. Optionally, the transflective reflector may comprise two or more substantially reflective metallic conductive layers. Each of the two or more substantially reflective metallic conductive layers may be sandwiched between a respective pair of substantially transparent semi-conductive non-metallic layers disposed between the electrochromic medium and the second substrate.

Optionally, the transflective reflector may substantially transmit light or radiant energy having a spectral band in the near infrared region of the spectrum, while the light emitting or display element may emit near infrared light or radiant energy through the transflective reflector. The mirror assembly may include an imaging sensor at the fourth surface that is operable to sense near infrared light.

Optionally, the transflective reflector may substantially transmit light having a first spectral band at a first visible region of the spectrum, and may also substantially transmit light having a second spectral band at a second visible region of the spectrum. The light emitting or display element may emit light that has a peak intensity at or near the first visible region, while the mirror assembly may include a second light emitting element at the fourth surface that may emit light that has a peak intensity at or near the second visible region.

According to another aspect of the present invention, an electro-optic mirror assembly, such as an electrochromic mirror assembly, for a vehicle comprises an electrochromic mirror element comprising a first substrate having first and second surfaces and a second substrate having third and fourth surfaces. The first and second substrates are arranged so that the second surface opposes the third surface, with an electrochromic medium disposed between the second substrate and the first substrate. The mirror element comprises a transflective reflector at the third surface, which comprises at least one conductive metallic reflective layer sandwiched between first and second substantially transparent semi-conductive non-metallic layers. The first substantially transparent semi-conductive non-metallic layer contacts the electrochromic medium. The mirror assembly includes a display element at the fourth surface of the second substrate. A refractive index and a physical thickness of each of the first and second substantially transparent semi-conductive non-metallic layers and the substantially reflective metallic conductive layer are selected such that the transflective reflector is selectively spectrally tuned to substantially transmit at least one preselected spectral band of visible light therethrough while substantially reflecting other visible light. The display element is configured to emit visible light with a peak intensity within the preselected spectral band.

According to another aspect of the present invention, a mirror assembly for a vehicle includes a mirror element and a radiant energy emitting element. The mirror element includes a substrate having a forward surface facing towards a viewer of the mirror assembly and a rearward surface facing away from a viewer of the mirror assembly. The mirror element includes at least one substantially reflective metallic layer sandwiched between a respective pair of substantially transparent non-metallic layers disposed at the rearward surface of the substrate. Each of the substantially transparent non-metallic layers and the substantially reflective metallic layer having a selected refractive index and a selected physical thickness such that the mirror element is selectively spectrally tuned to substantially transmit at least one preselected spectral band of radiant energy therethrough while substantially reflecting other radiant energy. The radiant energy emitting element is operable to emit radiant energy towards the rearward surface and through the mirror element. The radiant energy emitting element is operable to emit radiant energy with a peak intensity within the at least one preselected spectral band.

The substrate may comprises a single substrate. The single substrate may comprise a prismatic or wedge-shaped substrate. The radiant energy emitting element and alternating layers thus may provide for a display on demand type of display for a prismatic (or flat or curved) mirror assembly.

According to other aspects of the present invention, an electrochromic mirror assembly for a vehicle includes an electrically variable mirror element. The mirror element includes a first substrate having first and second surfaces and a second substrate having third and fourth surfaces. The first and second substrates are arranged so that the second surface opposes the third surface. The second substrate includes a conductive stack on the third surface. The conductive stack may comprise a first electrically conductive or semi-conductive layer deposited on the third surface, a reflective or metallic layer of reflective or metallic material on the first electrically semi-conductive layer, and a second electrically conductive or semi-conductive layer on the reflective layer. The mirror element includes an electrochromic medium disposed between the second electrically semi-conductive layer of the second substrate and the electrically semi-conductive coating on the second surface of the first substrate. The thicknesses and materials of the layers are selected to provide or exhibit a spectrally selective visible light transmission characteristic for a particular spectral band or range of wavelengths to provide enhanced transmissivity of the spectral band of light through the reflective element while providing sufficient reflectivity of other light.

In one form, the electrochromic mirror assembly may include a display element positioned at the fourth surface, wherein the display element is operable to emit light through the mirror element for viewing by a driver of the vehicle. The thicknesses of the particular layers of the conductive stack are selected such that the mirror element is spectrally tuned to transmit a predetermined spectral band of light therethrough. The spectral band that is transmittable through the mirror element may be selected to match a spectral band or range of light wavelengths emitted by the display element, such that the mirror element is spectrally tuned for the particular display element positioned at the fourth surface of the mirror element. The mirror element thus may be spectrally tuned to match at least a portion of the transmissive band or range of wavelengths of the mirror element to a particular band or range of wavelengths of the light being emitted by the display element. In one form, the peak transmissivity of the transmissive band of the mirror element is selected to match the peak intensity of the spectral band emitted by the display element. The conductive stack preferably provides at least approximately 60 percent photopic reflectance (preferably as measured in accordance with Society of Automotive Engineers test procedure SAE J964a, which is hereby incorporated herein by reference in its entirety), more preferably at least approximately 70 percent photopic reflectance, and most preferably at least approximately 80 percent photopic reflectance, while providing at least approximately 10 percent transmission, preferably at least approximately 15 percent transmission, more preferably at least approximately 20 percent transmission, and most preferably at least approximately 30 percent transmission, of at least a particular spectral band of light. Preferably, the physical thicknesses of the layers are selected to limit tinting and/or color interference affects as seen in the mirror element (i.e. to provide a neutral reflector) and to spectrally tune the mirror element for a transmission characteristic for providing enhanced transmissivity through the mirror element for a particular spectral band or range of wavelengths, in order to match the transmissivity of the mirror element to the spectral band of emission of light from the display element.

The semi-conductive layers and metallic layer of the conductive stack may be deposited at the third surface via a sputter coating process. The present invention thus may provide a low cost reflective element which provides for sufficient transmission of a particular spectral band or bands of visible light and sufficient reflectance at the third surface of the mirror assembly (with at least 60% photopic reflectance preferred, more preferably, with at least 70% photopic reflectance, and most preferably, with at least 75% photopic reflectance). Preferably, the semi-conductive layers, such as indium tin oxide or the like, sandwiching the metallic layer are formed of the same material. Thus, for example, a conductive stack of alternating layers may comprise a metallic layer of silver sandwiched between two semi-conductive layers of indium tin oxide.

According to another aspect of the present invention, an electro-optic or electrochromic interior rearview mirror assembly comprises an electro-optic or electrochromic mirror reflective element. The electro-optic mirror element provides a substantially reflective mirror element having a first region having a first reflectivity and a first transmissivity and a second region having a second reflectivity and a second transmissivity. The electro-optic mirror element includes a display element positioned at or behind the second region and operable to transmit light through the second region. The first reflectivity is greater than the second reflectivity. Preferably, the second region provides at least approximately 25% transmissivity of light from the display.

Therefore, the present invention provides a mirror reflective element, such as a third surface reflective element or mirror element or a fourth surface reflective element or a prismatic reflective element or the like, which is sufficiently and spectrally selectively transmissive or spectrally tuned to allow a particular spectral range or band of light to pass therethrough from a display at the rear surface of the mirror reflective element. The layers of the reflective element are selected or spectrally tuned to match one or more predetermined or selected spectral bands or ranges of wavelengths and to thus pass the predetermined spectral bands of light therethrough, while being substantially reflective to other spectral bands or wavelengths of light, and do not require windows or apertures formed in the reflective metallic layer of the reflective element.

These and other objects, advantages, purposes, and features of the present invention will become more apparent from the study of the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a conventional electrochromic mirror reflective element;

FIG. 1A is a graphical depiction of the transmissivity of visible light of the conventional electrochromic mirror reflective element of FIG. 1;

FIG. 2 is a perspective view of an interior rearview mirror assembly in accordance with the present invention;

FIG. 3 is a sectional view of the mirror assembly taken along the line III-III in FIG. 2;

FIG. 4 is a sectional view of a second substrate and opaque conductive and reflective layers suitable for use in the mirror assembly of FIG. 2;

FIG. 5 is a front elevation of a second substrate of a reflective element in accordance with the present invention, with a tab-out portion to facilitate electrical connection with the conductive layers;

FIG. 6 is a sectional view of the second substrate taken along the line VI-VI in FIG. 5;

FIG. 7 is a perspective view of another interior rearview mirror assembly in accordance with the present invention, with a display;

FIG. 8 is a sectional view of a reflective element of the mirror assembly taken along the line VIII-VIII in FIG. 7;

FIG. 9 is a sectional view similar to FIG. 6 of a second substrate in accordance with the present invention, which is suitable for use in the mirror assembly of FIG. 7, and includes a tab-out portion to facilitate electrical connection with the conductive layers;

FIG. 10 is a sectional view of another second substrate and transmissive conductive and reflective layer or stack in accordance with the present invention suitable for use in a mirror assembly having a display;

FIG. 11 is another sectional view of a particular embodiment of a reflective element of the present invention;

FIG. 11A is a graphical depiction of the transmissivity of the reflective element of FIG. 11;

FIG. 11B is a graphical depiction of the emission spectrum of the display element for the reflective element of FIG. 11;

FIG. 12 is a sectional view of another particular embodiment of a reflective element of the present invention;

FIG. 12A is a graphical depiction of the transmissivity of the reflective element of FIG. 12;

FIG. 12B is a graphical depiction of the emission spectrum of the display element for the reflective element of FIG. 12;

FIG. 13 is a sectional view of another particular embodiment of a reflective element of the present invention;

FIG. 13A is a graphical depiction of the transmissivity of the reflective element of FIG. 13;

FIG. 14 a sectional view of a particular embodiment of a double stack reflective element of the present invention;

FIG. 14A is a graphical depiction of the transmissivity of the double stack reflective element of FIG. 14;

FIG. 14B is a graphical depiction of the emission spectrum of the display element for the double stack reflective element of FIG. 14;

FIG. 15 a sectional view of another particular embodiment of a double stack reflective element of the present invention;

FIG. 15A is a graphical depiction of the transmissivity of the double stack reflective element of FIG. 15;

FIG. 16 a sectional view of a particular embodiment of a multiple stack reflective element of the present invention;

FIG. 16A is a graphical depiction of the transmissivity of the multiple stack reflective element of FIG. 16;

FIG. 17 a sectional view of another particular embodiment of a multiple stack reflective element of the present invention;

FIG. 17A is a graphical depiction of the transmissivity of the multiple stack reflective element of FIG. 17;

FIG. 18 is a forward facing view of another electro-optic mirror reflective element in accordance with of the present invention;

FIG. 19 is a sectional view of another reflective element in accordance with the present invention, which is capable of transmitting near infrared illumination therethrough;

FIG. 20 is a sectional view of another reflective element in accordance with the present invention;

FIG. 21 is a sectional view of another reflective element in accordance with the present invention;

FIG. 22 is a graphical depiction of the transmissivity of light through the cover and rear substrate of the reflective elements of FIGS. 19-21;

FIG. 23 is a sectional view of another reflective element in accordance with the present invention, which is capable of transmitting near infrared illumination therethrough;

FIG. 24 is a sectional view of another reflective element in accordance with the present invention;

FIG. 25 is a sectional view of another reflective element in accordance with the present invention;

FIG. 26 is a graphical depiction of the transmissivity of light through the rear substrate and IRT stack of the reflective elements of FIGS. 23-25;

FIG. 27 is a graphical depiction of the transmissivity of light through the front substrate and enhanced semi-conductive layers of the reflective element of FIG. 24;

FIG. 28 is a graphical depiction of the transmissivity of light through the front substrate and enhanced semi-conductive layers of the reflective element of FIG. 25;

FIG. 29 is a sectional view of a reflective element similar to the reflective element of FIG. 25, with an anti-reflective stack or layers on a rear surface of the rear substrate in accordance with the present invention;

FIG. 30 is a sectional view of another reflective element in accordance with the present invention; and

FIG. 31 is a graphical depiction of the transmissivity of light through the rear substrate and IRT-DOD stack of the reflective element of FIG. 30; and

FIG. 32 is a sectional view of a prismatic reflective element in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and the illustrative embodiments depicted therein, an electrochromic interior rearview mirror assembly 10 is mounted to a mounting button 12 mounted at an interior surface of a windshield 14 of a vehicle (FIG. 2). Mirror assembly 10 includes a housing or casing 15 and an electrochromic reflective element or mirror element or cell 16 which has electrically variable reflectivity. Reflective element 16 includes first and second glass substrates 22, 24, and provides a third surface reflective element, whereby the reflective coating of the reflective element 16 is deposited on the third surface 24a of the substrates (FIG. 3). An electrochromic medium 40 and a plurality of metallic and non-metallic conductive or semi-conductive layers 28 are disposed between the electrochromic medium 40 and the second substrate 24. The refractive indices and physical thicknesses of the layers are selected to maximize transmission of a particular spectral band of light while substantially reflecting other light to provide a desired degree of photopic reflectance, while also providing the desired degree of conductivity across the layers.

Although shown and described herein as being implemented in an interior rearview mirror assembly of a vehicle, the reflective element or mirror element of the present invention is equally suitable for or applicable to other electro-optic reflective elements, or reflective elements for exterior rearview mirror assemblies for vehicles or for other mirror assemblies, without affecting the scope of the present invention. Also, although shown and described as an electrochromic reflective element, aspects of the present invention may be equally applicable to prismatic reflective elements (such as described below with respect to FIG. 32) or to exterior reflective elements, without affecting the scope of the present invention. Also, the mirror element of the present invention may comprise a substantially flat element or substrate or may comprise a curved element or substrate, such as a convex element or aspheric element or the like, without affecting the scope of the present invention.

Electrochromic reflective element 16 comprises a first or front substantially transparent substrate 22 and a second or rear substantially transparent substrate 24 (which may be glass substrates or the like). The first substrate 22 includes an electrically conductive or semi-conductive layer 26, such as a tin oxide (doped or undoped) or indium tin oxide (ITO) or any other transparent electrically semi-conductive layer or coating or the like (such as indium cerium oxide (ICO), indium tungsten oxide (IWO), or indium oxide (IO) layers or the like or a zinc oxide layer or coating, or a zinc oxide coating or the like doped with aluminum or other metallic materials, such as silver or gold or the like, or other oxides doped with a suitable metallic material or the like), deposited on an inward surface 22a of first substrate 22 (i.e., the second surface 22a of the reflective element 16).

Also, the first (or forward or outermost) surface 22b of front substrate 22 (exposed to the atmosphere exterior of the mirror assembly) may be optionally coated with an anti-wetting property such as via a hydrophilic coating (or stack of coatings), such as is disclosed in U.S. Pat. Nos. 6,193,378; 5,854,708; 6,071,606; and 6,013,372, the entire disclosures of which are hereby incorporated by reference herein. Also, or otherwise, the first (outermost) surface 22b of front substrate 22 may be optionally coated with an anti-wetting property such as via a hydrophobic coating (or stack of coatings), such as is disclosed in U.S. Pat. No. 5,724,187, the entire disclosure of which is hereby incorporated by reference herein. Such hydrophobic property on the first/outermost surface of electrochromic mirror reflective elements (and on the first/outermost surface of non-electrochromic mirror, non-electro-optical conventional reflective elements) can be achieved by a variety of means, such as by use of organic and inorganic coatings utilizing a silicone moeity (for example, a urethane incorporating silicone moeities) or by utilizing diamond-like carbon coatings. For example, long-term stable water-repellent and oil-repellent ultra-hydrophobic coatings, such as described in PCT Application Nos. WO0192179 and WO0162682, the entire disclosures of which are hereby incorporated by reference herein, can be disposed on the first (outermost) surface 22b of front substrate 22. Such ultra-hydrophobic layers comprise a nano structured surface covered with a hydrophobic agent which is supplied by an underlying replenishment layer (such as is described in Classen et al., "Towards a True 'Non-Clean' Property: Highly Durable Ultra-Hydrophobic Coating for Optical Applications", ECC 2002 "Smart Coatings" Proceedings, 2002, 181-190, the entire disclosure of which is hereby incorporated by reference herein).

Second or rear substrate 24 includes at least three layers or coatings defining a reflective and conductive layer or stack or ISI layer or stack 28 (i.e., the combination or stack of a layer of: a semi-conducting coating, such as an ITO layer or the like; a metallic layer, such as a layer of silver, aluminum or an alloy of silver or an alloy of aluminum or other metal or metal alloy; and another layer of a semi-conducting coating, such as an ITO layer or the like, as discussed below, is referred to herein as an ISI stack or layer) on an inward surface 24a of second substrate 24 (or the third surface of the reflective element). Thus, an ISI stack 28 comprises a metallic layer sandwiched between two semi-conducting layers (both of which preferably are the same material, but either of which can be different from the other). In the illustrated embodiment of FIG. 4, ISI layer 28 comprises a first semi-conductive layer 30 disposed on inward surface 24a of second substrate 24, a second semi-conductive layer or adhesion layer 32 disposed on semi-conductive layer 30, a metallic layer or coating 34 disposed on semi-conductive layer 32, and a transparent semi-conductive layer or passivation layer 36 disposed on metallic layer 34. As shown in FIGS. 3 and 4, first semi-conductive layer 30 extends outwardly from the other ISI layers 32, 34 and 36, in order to provide for electrical connection with bus bars 38 of mirror assembly 10. Although referred to herein as an "ISI layer" or an "ISI stack", the conductive and reflective stack or layers of the present invention may comprise materials or coatings other than ITO, ICO, IO, IWO layers or coatings or the like and silver or silver alloy layers or coatings, without affecting the scope of the present invention. For example, a semi-conducting layer of doped zinc oxide, or a semi-conducting layer of cadmium stannate, or a semi-conducting layer of titanium nitride or other titanium compound or the like may be used in the stack, without affecting the scope of the present invention.

As shown in FIG. 3, the first and second substrates 22, 24 are positioned in spaced-apart relationship with one another with an electrochromic medium 40 disposed between semi-conductive layer 26 and semi-conductive layer 36. The electrochromic medium 40 changes color or darkens in response to electricity or voltage applied to or through the semi-conductive layers 26 and 30 at either side of the electrochromic medium. The electrochromic medium 40 disposed between the front and rear substrates 22, 24 may be a solid polymer matrix electrochromic medium, such as is disclosed in U.S. Pat. No. 6,154,306, which is hereby incorporated by reference herein, or other suitable medium, such as a liquid or solid medium or thin film or the like, such as the types disclosed in U.S. pat. application, Ser. No. 09/793,002, entitled VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE, filed Feb. 26, 2001 (Attorney Docket DON01 P-869), and in U.S. Pat. Nos. 5,668,663 and 5,724,187, the entire disclosures of which are hereby incorporated by reference herein, without affecting the scope of the present invention. The electrochromic mirror element may utilize the principles disclosed in commonly assigned U.S. Pat. Nos. 5,140,455; 5,151,816; 6,178,034; 6,154,306; 6,002,544; 5,567,360; 5,525,264; 5,610,756; 5,406,414; 5,253,109; 5,076,673; 5,073,012; 5,117,346; 5,724,187; 5,668,663; 5,910,854; 5,142,407 or 4,712,879, which are hereby incorporated herein by reference, or as disclosed in the following publications: N. R. Lynam, "Electrochromic Automotive Day/Night Mirrors", *SAE Technical Paper Series* 870636 (1987); N. R. Lynam, "Smart Windows for Automobiles", *SAE Technical Paper Series* 900419 (1990); N. R. Lynam and A. Agrawal, "Automotive Applications of Chromogenic Materials", *Large Area Chromogenics: Materials and Devices for Transmittance Control*, C.M. Lampert and C.G. Grandquist, EDS., Optical Engineering Press, Wash. (1990), which are hereby incorporated by reference herein, and in U.S. pat. application, Ser. No. 09/793,002, filed Feb. 26, 2001 by Schofield et al. for VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE (Attorney Docket DON01 P-869), which is hereby incorporated herein by reference. Reflective element 16 may also include a seal 41 positioned around the outer portions of the layers 32, 34, 36 and the electrochromic medium 40 to seal the layers and avoid corrosion of the metallic layer 34.

During operation, a voltage may be applied to reflective element 16 via bus bars 38 positioned around and engaging the outer edges of the semi-conductive layers 26, 30 (FIG. 3). The voltage applied by bus bars 38 is bled from semi-conductive layer 30 and through the layers 32, 34, 36 to the electrochromic medium 40. The ISI layer 28 of the present invention preferably provides for reduced resistance through the layers, which provides for faster, more uniform coloration of the electrochromic medium 40, since the electrons applied via bus bars 38 at semi-conductive layer 30 may bleed through the semi-conductive layers 32, 36 faster due to the enhanced conductivity in the conductive layers 32, 36. Preferably, the ISI layer or stack 28 provides a sheet resistance of less than approximately 10 ohms per square, more preferably less than approximately 5 ohms per square, and most preferably less than approximately 2 ohms per square. Desirably, and particularly for larger area mirrors, the sheet resistance is less than approximately 1 ohm per square, such as in the range of approximately 0.1 to 0.7 ohms per square.

In order to provide enhanced performance of the electrochromic element, each of the layers of the ISI layer or stack has substantial conductivity and none of the layers significantly retard electron/electrical conductivity from one layer to the other throughout the stack, and, thus, do not impede the flow of electrons into the electrochromic (EC) medium. In this regard, it is desirable that one or more of the metallic layers comprises a metallic material (which is preferably a highly reflective material, such as silver or silver alloys or the like) having a specific resistivity of preferably less than approximately $5x10^{-5}$ ohm.cm, more preferably less than approximately $1x10^{-5}$ ohm.cm, and most preferably less than approximately $5x10^{-6}$ ohm.cm. Preferably, such a highly conductive metallic layer or layers is/are sandwiched between two non-metallic, partially conducting layers, preferably formed of a non-metallic material (such as a semi-conducting oxide, such as indium oxide, tungsten oxide, tin oxide, doped tin oxide or the like) having a specific resistivity of less than approximately $1x10^{-2}$ ohm.cm, more preferably less than approximately $1x10^{-3}$ ohm.cm, and most preferably less than approximately $5x10^{-4}$ ohm.cm.

In the illustrated embodiment of FIGS. 3 and 4, first semi-conductive layer 30 is deposited on inward surface 24a of second substrate 24. The semi-conductive layer 30 may be deposited on the glass or substrate 24 via any suitable process. The particular thickness of the conductive layer may vary depending on the particular application of reflective element 16, as discussed below. In the illustrated embodiments of FIGS. 2-4, the semi-conductive layer 30 need not be transparent and may comprise a chromium layer or the like. However, the semi-conductive layer 30 may comprise a generally transparent semi-conductive layer of coating, such as a tin oxide layer, an indium tin oxide (ITO) layer or the like, without affecting the scope of the present invention. In a preferred embodiment, semi-conductive layer 30 may comprise a chromium layer on surface 24a of second substrate 24.

The transparent semi-conductive layers 32 and 36 of ISI layer 28 on second substrate 24 may comprise non-metallic transparent electrically conducting or semi-conducting materials, such as tin oxide, indium oxide, indium cerium oxide, indium tungsten oxide, nickel oxide, tungsten oxide, indium tin oxide, half-wave indium tin oxide, full wave indium tin oxide, doped tin oxides, such as antimony-doped tin oxide and fluorine-doped tin oxide, doped zinc oxides, such as antimony-doped zinc oxide and aluminum-doped zinc oxide, and/or the like. Both of the semi-conductive layers 32, 36 may comprise the same type of material for ease of manufacturing, as discussed below.

Metallic layer or coating 34 comprises a thin film or layer of metal, such as silver, aluminum, or alloys thereof, or the like, with a selected thickness to provide sufficient reflectivity and/or transmissivity, as discussed below. The selected metallic material may comprise silver, but may otherwise comprise a material selected from aluminum, silver alloys, aluminum alloys (such as 6061 or 1100 aluminum alloys or the like), manganese, chromium or rhodium, or any other metallic material which is sufficiently reflective and/or transmissive at a selected thickness. The thickness of metallic layer 34 is preferably selected to be thick enough (such as approximately 60-100 nm or 600-1000Å) to be substantially reflective and not transmissive, such that the ISI layer 28 is substantially opaque or non-transparent.

In a preferred embodiment, the semi-conductive layer 30 comprises indium tin oxide (ITO) and is deposited onto surface 24a of substrate 24 via a hot deposition process, involving, for example, sputter deposition onto a heated substrate, with the heated substrate often being heated to a temperature of greater than about 200°C, sometimes greater than 300°C, as is known in the art. The combination of the semi-conductive layer 30 on the substrate 24 defines a conductive substrate which may be used for various embodiments of the present invention, as discussed below.

The semi-conductive layer 32 of ISI layer 28 may be deposited onto semi-conductive layer 30 via a cold deposition process, such as sputter coating or the like onto an unheated substrate. Preferably, each of the layers 32, 34, 36 of ISI layer 28 is deposited on second substrate 24 by a sputter deposition process. More particularly, the substrate 24 (including the semi-conductive layer 30 already deposited thereon) may be positioned in one or more sputter deposition chambers with either planar or rotary magnetron targets, and with deposition of the layers being achieved by either reactive deposition of an oxide coating by sputtering from a metal target (or from a conductive, pressed oxide target) in an oxygen-rich atmosphere, or by DC sputtering from an oxide target, such as an IO, IWO, ITO or ICO target or the like. For example, the substrate 24 may be sputter coated with two targets in a single chamber, such as by depositing the ITO layer 32 on semi-conductive layer 30, turning or flipping the targets for sputter coating of the metallic layer 34, and then turning the targets back to deposit the second ITO layer or passivation layer 36 on the metallic layer 34. With such a process, it is important that the two ITO layers 30, 34 comprise the same conductive material. Alternately, two targets may be positioned in a row, such that the substrate 24 is moved from one target (for the first ITO coating) to the other (for the metallic coating) and then back to the first (for the second ITO coating). It is further envisioned that three targets may be positioned in a row, with each target depositing the layer in order on the substrate (in which case it would not be as important to have the semi-conductive or ITO layers 32, 36 comprise the same material). Other processes for applying or depositing layers of conductive material or layers and metallic material or layers may be implemented, without affecting the scope of the present invention. In the illustrated embodiment of FIGS. 2 and 3, semi-conductive layer 30 may be deposited or applied to substantially the entire surface 24a of substrate 24, while the outer region or edge of semi-conductive layer 30 and substrate 24 may be masked during the deposition process so that layers 32, 34, 36 do not cover the outer edge of substrate 24 and semi-conductive layer 30.

Because the embodiment of the reflective element of the present invention illustrated in FIG. 4 does not include a display on demand or other type of display transmitting or projecting through the electrochromic reflective element, it is desirable to have a thick metallic or silver layer 34, such as in a range of approximately 60-100 nm (600-1000Å), because the metallic layer does not have to be transmissive of any light therethrough. It is also unnecessary for the second substrate to be transparent. However, it is desirable to avoid tinting or color interference affects as seen in reflection from the reflector (which may arise when stacking layers of conductive coatings and/or metallic coatings on top of one another), because it is desirable to have a neutral or non-colored/non-tinted reflector when no voltage is applied across the electrochromic medium.

Optionally, the metallic layer may be absent or removed at portions, such as to create a local window for placement therebehind of a light emitting display, such as a compass display or PSIR display or other informational display or the like, such as a display of the type disclosed in commonly assigned U.S. Pat. Nos. 6,222,460 and 6,326,900, which are hereby incorporated herein by reference in their entireties, but while maintaining at least the underlying semi-conducting ITO layer at the local window region so that electrical connection through the electrochromic medium at that local region is sustained. In this regard, it is preferable to have an ITO underlayer with a sheet resistance of less than approximately 80 ohms per square, more preferably less than approximately 25 ohms per square, and most preferably less than approximately 15 ohms per square.

In order to avoid such undesirable tinting or color interference affects, such as yellow tinting or other color tinting of the compound or stacked reflective element, as seen in the reflection when the electrochromic reflective element is unpowered, the physical thicknesses of the conductive layers and the metallic layer are selected to provide a desired combination of layer thicknesses to achieve the desired results. For example, the ISI layer 28 may include an adhesion layer or undercoating semi-conductive layer 32 of approximately 100Å +/- 50Å of ITO or the like, a silver layer 34 of approximately 800Å +/- 200Å and a passivation semi-conductive layer 36 of approximately 120Å +/- 25Å of ITO or the like, which provides a desired result with minimal yellow tinting or other color tinting or color interference affects as seen in the reflection.

The range of thicknesses of the layers may be selected to provide a desired untinted affect in the reflection, such that the reflective element may be spectrally tuned to provide a desired reflectant untinted appearance. Testing of various embodiments has shown that the thicknesses of the layers may vary by approximately 25 percent or more from a desired or targeted dimension, yet will still provide the desired results. Such tolerances significantly ease the processing of the ISI layer, since this is well within the capability of typical sputter coating equipment. The layers of the reflective element and ISI stack may be selected such that the reflective element provides a substantially spectrally untinted reflection when viewed by a driver or passenger in the vehicle when no voltage is applied across the electrochromic medium. Also, the layers may be selected and combined to exhibit a spectrally selective transmissive characteristic, which is established by the refractive indices and physical thicknesses of the layers disposed between the electrochromic medium and the third surface of the second substrate.

Although the above embodiment provides a desired neutral color/tint for the reflector, if the passivation layer 36 is increased in thickness, the reflector may become tinted or yellowed. However, if the passivation layer is further increased in thickness to approximately 680Å, then the non-tinting is approximately the same as when the passivation layer has a thickness of approximately 120Å. This periodic change in tinting affect in response to the thicknesses of the layers or coatings of the ISI layer of the present invention allows for selection of different thicknesses of the layers depending on the particular application and desired result of the electrochromic reflective element of the present invention.

Referring now to FIGS. 5 and 6, a reflective element 116 may have alternating layers or an ISI stack or layer 128 comprising a first semi-conductive layer or adhesion layer 132 deposited or sputter coated directly onto surface 24a of second substrate 24, a metallic layer 134 deposited on semi-conductive layer 132, and a second semi-conductive layer or passivation layer 136 deposited on metallic layer 134. The second or rear substrate 24 is masked around substantially the entire outer region 24c of surface 24a during the deposition process, such that the ISI layer 128 is not deposited in the masked region 24c. However, the substrate is not masked over the entire outer edge or region of substrate 24, in order to allow deposition of the ISI layer at a particular area, such that a tab-out portion or area 131 is formed in the ISI layer 128. The tab out area 131 facilitates electrical connection with the conductive coatings 132, 134, 136, such that the first semi-conductive layer 30 of reflective element 16 is not required. In a preferred embodiment of the present invention, the reflective element 116 may include a semi-conductive layer 132 of an ITO coating which has a thickness of approximately 100Å +/- 25Å, a silver layer 134 having a thickness of approximately 900Å +/- 100Å, and a second semi-conductive layer 136 of ITO or the like having a thickness of approximately 120Å +/- 25Å. Such an arrangement of semi-conductive layers and a sandwiched metallic layer provides a neutral reflectance with minimal tinting or color interference affects as seen in reflectance and with the electrochromic medium unpowered.

The opaque ISI layer 28, 128 and the third surface reflective element of the present invention therefore provides an economical, low cost electrochromic reflective element, which provides a neutral color reflection. Typically, for a sputter coating operation, a range of within +/- 5% of a nominal target for uniformity of coating is desired. However, in the present invention, the uniformity tolerance is approximately +/- 25% for each of the coatings or layers from cell to cell. The ISI layer on the second substrate thus may be easy and fast to manufacture due to the thicknesses and the tolerances for the thickness of each particular coating.

Referring now to FIGS. 7 and 8, a mirror assembly 210 in accordance with the present invention (shown as an interior rearview mirror assembly in FIG. 7; however, the reflective element 216 may be implemented at an exterior mirror assembly or other mirror assembly, without affecting the scope of the present invention) may include a display system or element 218 which is operable to provide, emit or display information or light through a mirror element or reflective element 216 of the mirror assembly. The light is emitted through the reflective element 216 at a display area 220 of mirror assembly 210, such that the display information or light is viewable by a driver of the vehicle. The reflective element 216 includes first (or front) and second (or rear) substrates 222, 224, and a conductive and transmissive ISI stack or layer or DOD stack or layer 228 disposed on the inward surface 224a of the second substrate (or the third surface of the reflective element). The second substrate 224 and ISI layer 228 comprise a transflective one way mirror, such as disclosed in commonly assigned U.S. pat. application, Ser. No. 10/054,633, filed Jan. 22, 2002 by Lynam et al. for VEHICULAR LIGHTING SYSTEM (Attorney Docket DON01 P-962), which is hereby incorporated herein by reference. Preferably, the mirror reflective element (behind which the display is disposed so that the information displayed is visible by viewing through the mirror reflective element) of the mirror assembly comprises a transflective mirror reflector, such that the mirror reflective element is significantly transmitting to visible light incident from its rear (i.e., the portion furthest from the driver in the vehicle), while simultaneously the mirror reflective element is substantially reflective to visible light incident from its front (i.e. the position closest to the driver when the interior mirror assembly is mounted in the vehicle). The transflective electrochromic reflective mirror element (such as is disclosed in U.S. pat. application, Ser. No. 09/793,002, entitled VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE, filed Feb. 26, 2001 (Attorney Docket DON01 P-869) and in U.S. Pat. Nos. 5,668,663 and 5,724,187, the entire disclosures of which are hereby incorporated by reference herein) comprises an electrochromic medium sandwiched between the first and second substrates.

The ISI stack or layer 228 includes a conductive metallic layer 234, which is thin enough to be sufficiently transparent or transmissive to allow the display information to be transmitted through the ISI or DOD layer 228 and through reflective element 216 for viewing by the driver of the vehicle. As the thickness of the metallic layer 234 decreases, the transmissivity increases, but the reflectivity decreases. Therefore, a desired thickness of the metallic layer (along with a desired thickness of the other layers of the ISI stack or layer) must be selected to provide sufficient reflectivity and transmissivity, as discussed below. Because the metallic layer 234 is at least partially transmissive, it is desirable to provide an opaque coating or tape or the like 225 on an outer surface 224b of second substrate 224 (or the fourth surface of the reflective element 216). The coating or tape 225 may be a black tape or other color tape or coating.

Display system 218 preferably comprises a display on demand type of display and includes a display element or light emitting device 218a positioned at the back surface 224b of second substrate 224. Display element 218a is operable to emit light, such as in the form of indicia, alphanumeric characters, images, or the like, in response to a control or input. Display element 218a may be a vacuum fluorescent (VF) display element, a light emitting diode (LED) display element, an organic light emitting diode (OLED) display element, a gas discharge display element, a plasma display element, a cathode ray tube display element, a backlit active matrix LCD screen, an electroluminescent display element, a field emission display element or the like, without affecting the scope of the present invention. The particular display element may be selected to provide a desired color to the display. For example, a VF display element may provide a blue-green color or other colors to the information displayed (depending on the phosphor selected for the display), while a light emitting diode display element may provide other colors, such as reds, ambers, or other colors to the information displayed.

Preferably, the display is a display-on-demand type of display, such as of the type disclosed in commonly assigned U.S. Pat. Nos. 5,668,663 and 5,724,187, and/or in U.S. pat. applications, Ser. No. 10/054,633, filed Jan. 22, 2002 by Lynam et al. for VEHICULAR LIGHTING SYSTEM (Attorney Docket DON01 P-962); and Ser. No. 09/793,002, filed Feb. 26, 2001 by Schofield et al. for VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE (Attorney Docket DON01 P-869), which are all hereby incorporated herein by reference. With such a display, it is not only desirable to adjust the display brightness according to ambient lighting conditions, but it is also desirable to adjust the display brightness such that a sufficient contrast ratio is maintained against the variable background brightness of the reflected scene. Also, it may be desirable to compensate for changes in transmission of the electrochromic device effected to control rearward glare sources, so that the display brightness appears to be maintained at a generally constant level.

It is envisioned that the display 218 may include a filter or spectral element 217 positioned between the illumination source or display element 218a of the display 218 and the outer or fourth surface 224b of second substrate 224. The filter 217 may function to filter out light having a wavelength outside of the desired band of light being emitted by the display element or, in other words, the filter or spectral element 217 may transmit a band width of light that substantially matches the particular spectral output of the display or that substantially matches a desired color for the display information. By transmitting only the spectral band which at least generally matches the spectral output of the display device, the filter functions to filter out ghost images of the display, where ambient light may enter the display, such that the display characters may be visible through the reflective element when the display is off.

Because the reflectivity of the metallic layer 234 provides sufficient reflectance over its entire surface (i.e., there are no "windows" formed in or through the metallic layer), mirror assembly 210 may include other displays or multiple display on demand type displays, or other types of displays, such as one or more "display on need" type displays or the like. For example, one or more display on need type displays 213 (FIG. 7) may be provided, such as to indicate to the driver of the vehicle that a door of the vehicle is ajar, or that the driver's seat belt is not fastened, or any other condition or status that may be important to the driver or occupant of the vehicle. The display on need type display or displays may provide indicia, alphanumeric characters, symbols, or the like via one or more light emitting sources (not shown) behind the second substrate in a similar manner as display system 218 discussed above, and may include a filter (also not shown) for filtering out light that is not within the desired spectral band of the particular display system.

In the illustrated embodiment of FIG. 8, ISI or DOD layer or stack 228 includes a first semi-conductive layer 230, a second semi-conductive layer or adhesion layer 232, a reflective and transmissive metallic layer 234 and a semi-conductive or passivation layer 236. Similar to ISI layer 28, discussed above, semi-conductive layer 230 may be deposited or applied to substantially the entire surface 224a of substrate 224, while the outer region or edge of semi-conductive layer 230 and substrate 224 may be masked during the deposition process so that the layers 232, 234, 236 do not cover the outer edge of substrate 224 and semi-conductive layer 230.

Preferably, the physical thicknesses and materials of the metallic layer 234 and the semi-conductive layers 230, 232 and 236 are selected to provide sufficient transmissivity of at least a particular spectral band or range of wavelengths of light which generally matches the peak intensity spectral band of light being emitted by the display. Such spectral tuning or matching of the layers to the display allows the display information to transmit through the reflective element for viewing of the display information by the driver of the vehicle, while also providing sufficient reflectivity over the entire reflective element, and while minimizing the tinting or color interference affects on the reflected image (or targeting such tinting affects toward a desired color). Preferably, the light transmission of the particular spectral band through the reflective element is greater than approximately 15 percent and the reflectivity of the reflective element to other wavelengths of light is greater than approximately 80 percent. More preferably, the light transmission of the particular spectral band is greater than approximately 20 percent, and most preferably greater than approximately 25 percent.

The reflective element 216 is spectrally tuned to maximize transmissivity of a particular desired or targeted range or ranges of wavelengths or spectral bands and to substantially reflect or not transmit other wavelengths of light. The particular choices or thicknesses/materials of the layers is influenced by the spectral emission of the display being used in the mirror assembly. In one exemplary embodiment of the present invention, a transmissive ISI or DOD layer or stack 228 includes a metallic layer 234 of approximately 350Å sandwiched between a semi-conductive passivation layer 236 of approximately 68 nm (680Å) and a semi-conductive adhesion layer 232 of approximately 41 nm (410Å). The adhesion layer 232 is deposited on a semi-conductive layer 230 having a thickness of approximately 30 nm (300Å). In this embodiment, the ISI layer 228 is spectrally tuned for transmission of an orange light (having a peak intensity wavelength in the range of approximately 600 nm) emitting from display device 218a.

In certain conditions, the ambient light intensity within the cabin of the vehicle may be sufficiently high so that reflected light from the mirror reflective element and, in particular, from the display region 220, tends to "wash-out" the display. It is envisioned that this glare may be reduced by taking advantage of the electrochromic function of the mirror assembly. More particularly, the electrochromic medium 240 of the electrochromic mirror reflective element 216 may be colored or darkened in the area of the display by constructing a locally addressable region across the display (as shown at 220, 220a of FIG. 7). This may be achieved by creating a deletion line in the second surface semi-conductive layer 226 at the second surface of the first or front substrate 222 (FIG. 8) and/or in the third surface semi-conductive layer 230 (or a third surface semi-conductive layer of the type shown in FIG. 9 and described below at 332), hence breaking electrical continuity from the rest of the electrochromic cell. An ambient light sensor (not shown) may be used to detect the critical ambient light levels at which "wash-out" is a problem. The addressable region may then be separately colored or darkened to the appropriate level to reduce the glare from the display area in response to the ambient light sensor. Although such a glare problem could be solved by coloring the entire mirror, by localizing the region of coloration to only the display area, the electrochromic mirror assembly of the present invention allows the rest of the mirror reflective area, which does not incorporate the display, to retain full reflectivity while the display area is colored or darkened (such as may be useful when driving by day).

In another exemplary embodiment of the present invention, a transmissive ISI or DOD layer includes a metallic layer 234 of approximately 40 nm (400Å) sandwiched between a semi-conductive passivation layer 236 of approximately 43 nm (430Å) and a semi-conductive adhesion layer 232 of approximately 10 nm (100Å). The semi-conductive adhesion layer 232 is deposited on an adhesion or semi-conductive layer 230 having a thickness of approximately 30 nm (300Å). In this embodiment, the ISI or DOD layer 228 is spectrally tuned for spectrally selective transmission of a blue-green light (having a peak intensity wavelength of approximately 505 nm) emitting from display device 218a.

The thickness of the first semi-conductive layer 230 may be the same for each embodiment described above (and for the particular embodiments discussed below, such as with respect to FIGS. 10-17), in order to provide a common conductive substrate (including the semi-conductive layer 230 already deposited or coated on the surface of the substrate) for the different particular applications of the substrate and ISI layers of the present invention. This may ease the manufacturing of the reflective elements, since the same hot ITO coating or the like may be applied to common substrates for various applications, and then the conductive substrates may be coated with different thickness layers of conductive and metallic coatings for different applications of the reflective element (such as for mirrors having different colored displays).

As discussed above with respect to ISI layer 128, and with reference now to FIG. 9, a second substrate 324 may have an ISI or DOD layer 328 on its inward or forward surface 324a which may include layers 332, 334, 336 which may have a tab-out portion 331 for electrical connections, so as to not require the first conductive layer, without affecting the scope of the present invention. Because the metallic layer 334 is thin and not as conductive as the metallic layer 134, discussed above, the tab-out portion 331 of ISI layer 328 is preferably substantially larger in size or width than the tab-out portion 131 may have been for ISI layer 128. In a particular exemplary embodiment of the substrate 324 and ISI layer 328 of a reflective element as shown in FIG. 9, where the conductive layer 332 is deposited directly on the surface 324a of substrate 324, the ISI layer 328 may include a metallic layer 334 of approximately 35 nm (350Å) sandwiched between a passivation layer 336 of approximately 70 nm (700Å) and an adhesion layer 332 of approximately 70 nm (700Å). This combination or stack of layers on the glass or substrate 324 provides a transflective reflective element which is at least approximately 20 percent transmissive and which is spectrally tuned to pass a particular band of light being emitted by display device 218a of display system 218. In this particular embodiment, the transflective reflective element is spectrally tuned to pass light having a peak intensity wavelength of approximately 605 nanometers, while substantially reflecting other light.

Other thicknesses and materials of the layers may be selected for different displays having different colors or wavelengths of emitted light, without affecting the scope of the present invention. The thicknesses and particular materials of the layers of the ISI or DOD stack and transflective reflector are selected such that their combination provides enhanced or substantial transmissivity of the spectral band or bands corresponding to the spectral band of light emitted by the particular display implemented in the reflective element, while providing substantial reflectance of other visible light.

Referring now to FIG. 10, a second substrate 424 of a reflective element may have multiple layers or a double ISI or DOD layer or stack 428 applied to inward surface 424a. Double ISI layer 428 includes a first semi-conductive layer 430 applied to or deposited on inward surface 424a, a second semi-conductive or adhesion layer 432a deposited on semi-conductive layer 430, a first metallic layer 434a deposited on semi-conductive layer 432 and another semi-conductive layer 436a deposited on metallic layer 434a. Double ISI layer 428 further includes a second metallic layer 434b deposited on semi-conductive layer 436a with another semi-conductive layer 436b deposited on second metallic layer 434b. Therefore, the ISI stack or layer 428 is an alternating stack or combination of dielectric or transparent semi-conductive layers and metallic layers, whereby each metallic layer is sandwiched between a respective pair of conductive or semi-conductive non-metallic layers.

Such an arrangement may be used to provide a desired amount or increased amount of spectrally selective transmission of one or more particular spectral bands of light through the ISI or DOD layers, while increasing the reflectivity or maintaining the reflectivity of the ISI or DOD layers with respect to other spectral bands of light over the single ISI or DOD stack designs discussed above. More particularly, the double stack arrangement (or more layers if desired) provides for increased transmission of a narrower spectral band of light, which allows the reflective element to transmit a high percentage (such as greater than approximately 50 percent transmissivity) of a selected narrow spectral band of light. The narrow spectral band is selected so as to be substantially pinpointed or targeted at the particular peak intensity wavelength or wavelengths of light being emitted by the display device. Such an arrangement is particularly suitable for use with display devices incorporating light emitting diodes, which may emit light within a particular, narrow spectral band. The particular thickness and material for each layer or coating may be selected depending on the particular application and desired results.

For example, in a single ISI or DOD stack design which provides approximately 20-25 percent transmissivity of a particular spectral band or range, the reflectance of the ISI layer may be approximately 60-70 percent with respect to other light. If it is desired that the mirror have approximately 70 percent photopic reflectance or higher and increased transmissivity of a desired spectral band of light, a double ISI or DOD stack may be implemented. One particular embodiment of such a double ISI stack provides a semi-conductive layer (430 and/or 432) of approximately 71 nm (such as a layer 430 of approximately 30 nm (300 Å) and a layer 432a of approximately 41 nm (410 Å) or other combinations) of ITO or the like, a first metallic layer 434a of approximately 41 nm (410Å), a semi-conductive layer 436a of approximately 101 nm (1010Å) of ITO or the like, a second metallic layer 434b of approximately 36 nm (360Å) and a semi-conductive layer 436b of approximately 10 nm (100Å) of ITO or the like. This embodiment provides increased reflectivity of the reflective element to most wavelengths of light, while achieving the desired amount of transmissivity of the particular, targeted spectral band or bands. This is because the two metallic layers 434a, 434b, which are generally planar and parallel to each other, are separated by a distance of the order of approximately 100 nm (1000Å), which gives rise to multiple beam interference of the incident light, resulting in constructive interference at certain wavelengths and destructive interference at other wavelengths. This particular example provides a reflective element which is spectrally tuned to substantially transmit light with a wavelength of approximately 602 nanometers, while substantially reflecting other visible light.

Other materials (with other refractive indices) and other physical thicknesses for the layers may be selected to transmit other desired wavelengths or ranges of wavelengths, without affecting the scope of the present invention. Also, additional repeating layers may be added to form a multiple stack, such as an additional metallic conducting layer and an additional semi-conductive ITO layer (or the like), in order to achieve the desired affect. The repeating and alternating layers form a narrow band ISI stack (which may have seven or nine or more layers of conductive layers and metallic layers), which functions to pass or transmit only such light which corresponds to one or more particular, substantially narrow spectral bands or ranges of wavelengths. The additional layers may provide enhanced performance of the reflective element with only an incremental increase in cost, since the additional layers are preferably deposited onto the other layers as part of the sputter coating process. With each additional set or stack of layers, each of the reflective, metallic layers may be reduced in thickness, which may provide increased transmissivity through the stack for a targeted spectral band, while still providing the desired amount of reflectivity over the reflective element. For example, a nine layer ISI or DOD stack (such as shown in FIG. 17 and discussed below) may provide a reflective element that has a greater than approximately 60 percent transmissivity of one or more particular, narrow spectral bands, and which is tuned or substantially pinpointed to match the emission spectrum from a particular display device (such as a display device including a light emitting diode).

Referring now to FIGS. 11-17, several particular examples of a reflective element or mirror element in accordance with the present invention are shown. The reflective elements of FIGS. 11-17 incorporate the design and functional aspects of the reflective elements discussed above, and are provided as specific examples or embodiments of the present invention. The materials and physical thicknesses of the layers are selected to provide different refractive indices and thicknesses to provide different beam interference of the incident light, thereby resulting in the desired transmissive range for a particular display element. In each embodiment of FIGS. 11-17, the various layers and substrates are given similar reference numbers as shown with respect to the reflective elements shown in FIGS. 2-10, but with each embodiment adding 100 to the reference numbers of the previous embodiment. Clearly, the scope of the present invention includes other combinations of layers that may be implemented to provide for enhanced transmissivity of one or more particular spectral bands of light, while providing substantial reflectance of other light.

With reference to FIG. 11, a reflective element 516 has a front substrate 522 and a rear substrate 524 and a display element 518 at a rear or fourth surface of rear substrate 524. A semi-conductive ITO layer (or the like) 530 of approximately 30 nm is deposited on the forward or third surface of rear substrate 524, while a semi-conductive layer 526 (such as ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 522. An ISI or DOD stack or layer 528 and an electrochromic (EC) medium 540 and seal 541 are provided between the semi-conductive layers 526, 530. ISI layer 528 comprises a substantially transparent semi-conducting non-metallic adhesion layer 532 of approximately 41 nm of ITO, ICO, IWO or the like, a metallic conducting layer 534 of approximately 35 nm of silver or silver alloy or the like, and a substantially transparent semi-conducting non-metallic passivation layer 536 of approximately 68 nm of ITO, ICO, IWO or the like. As shown in FIG. 11A, such a configuration provides a transmissivity of light through reflective element 516 with a peak transmissivity of light having a wavelength of approximately 580 nm. The transflective reflector of the reflective element 516 is thus spectrally tuned to transmit orange light, such as light emitted from an orange vacuum fluorescent display 518, which emits light having a peak intensity of approximately 580 nm, as shown in FIG. 11B. The display 518 may also include a color filter 517, such as discussed above with respect to display 218.

In another particular embodiment similar to that of FIG. 11, an automotive DOD electrochromic mirror cell may include a transparent conductive layer, such as an ITO layer or the like (having, for example, approximately 12 ohms per square resistivity, which is commercially available as an ITO coated substrate), at the innermost, second surface of the front substrate, and a three layer coating or stack deposited on a transparent conductive layer, such as an ITO layer, at the rear substrate, itself deposited on the inner facing third surface of the rear substrate in a front / rear twin substrate laminate cell construction. The ITO layer at the rear substrate layer may have, for example, approximately 80 ohms per square resistivity, and the rear substrate may be a commercially available ITO coated substrate. The three layer stack or layers may be applied to the appropriate ITO coated surface of the rear substrate, such as via sputter coating or the like. For example, the rear glass element or substrate may be placed in a coating mask fixture to mask the perimeter and may be placed in a vacuum deposition system. The transflective third surface reflector/conductor may be made on or applied to the intended surface of the rear substrate (or to the ITO layer on the "third surface") by sequentially depositing first approximately 41 nm of ITO, second approximately 40 nm of silver metal and third approximately 65 nm of ITO onto the ITO layer at the third surface of the rear substrate.

The front and rear substrates are spaced apart using an epoxy perimeter seal (as is known and practiced in the electrochromic mirror art) with the conductive surfaces facing each other and preferably with an offset for the purpose of attaching an electrode clip or busbar. The spacing between the conductive planar surfaces is, for example, approximately 90 μm. After curing of the epoxy seal, the reflective element may be vacuum filled with an electrochromic medium, such as an electrochromic monomer material or the like. After filling the reflective element with the electrochromic monomer, the filling port of the reflective element or cell may be plugged with a UV curable adhesive which may then be cured by exposure to UV radiation. The reflective element or cell may then be cured in an oven to form a solid polymer matrix electrochromic medium.

When such an embodiment was formed and tested, a voltage of approximately 1.2 volts was applied to the reflective element and it was observed to color rapidly and uniformly. The photopic reflectance of the reflective element was initially approximately 67%, with a neutral silvery appearance, and decreased to approximately 7% in less than approximately 8 seconds with the voltage applied. The transmittance of the reflective element in its bleached state was approximately 19% for light having wavelengths between approximately 600 nm and 620 nm. When the voltage was disconnected or stopped, the reflectance of the reflective element substantially uniformly returned to its original value of approximately 67% within about 10 seconds. The DOD stack of the present invention thus may provide for enhanced transmittance of light having a preselected wavelength or range or band of wavelengths, even when in the bleached or colored or darkened state.

It is further envisioned that one or more adhesion enhancement layers or passivation layers, such as a layer or layers of nichrome (NiCr), palladium (Pd), platinum (Pt) or the like, may be applied or disposed at one or both sides of the metallic or silver layer 534, in order to increase the corrosion resistance of the metallic layer and to enhance the adhesion and the mechanical stability of the metallic layer. For example, an adhesion or passivation layer may be applied or disposed between metallic layer 534 and semi-conductive layer 532, and another adhesion or passivation layer may be applied or disposed between metallic layer 534 and semi-conductive layer 536. The adhesion or passivation layer or layers may have a thickness of approximately 0.5 nm to approximately 10 nm or thereabouts. The adhesion or passivation layers may be disposed at one or both sides or surfaces of the metallic layer or layers of any of the reflective element embodiments described herein or of other types of electrochromic reflective elements, without affecting the scope of the present invention. Such adhesion or passivation layers may be applied at the metallic layer or layers of other stacks or layers of the present invention described herein.

With reference to FIG. 12, a reflective element 616 has a front substrate 622 and a rear substrate 624 and a display element 618 at a rear or fourth surface of rear substrate 624. A semi-conductive ITO layer (or the like) 630 of approximately 30 nm is deposited on the forward or third surface of rear substrate 624, while a semi-conductive layer 626 (such as ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 622. An ISI or DOD stack or layer 628 and EC medium 640 and seal 641 are provided between the semi-conductive layers 626, 630. ISI layer 628 comprises an adhesion layer 632 of approximately 10 nm of ITO, ICO, IWO or the like, a metallic layer 634 of approximately 40 nm of silver or silver alloy or the like, and a passivation layer 636 of approximately 43 nm of ITO, ICO, IWO or the like. As shown in FIG. 12A, such a configuration provides a transmissivity of light through the reflective element with a peak transmissivity of light having a wavelength of approximately 500 nm. The reflective element 616 is thus spectrally tuned to transmit light emitted from a blue-green vacuum fluorescent display 618, which may emit light having a peak intensity of approximately 500 nm, as shown in FIG. 12B.

With reference to FIG. 13, a reflective element 616' provides a substantially spectrally neutral transmission characteristic and has a front substrate 622' and a rear substrate 624' and a display element 618' at a rear or fourth surface of rear substrate 624'. A semi-conductive ITO layer (or the like) 630' of approximately 30 nm is deposited on the forward or third surface of rear substrate 624', while a semi-conductive layer 626' (such as ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 622'. An ISI or DOD stack or layer 628' and EC medium 640' and seal 641' are provided between the semi-conductive layers 626', 630'. ISI layer 628' comprises an adhesion layer 632' of approximately 78 nm of ITO, ICO, IWO or the like, a metallic layer 634' of approximately 31 nm of silver or silver alloy or the like, and a passivation layer 636' of approximately 63 nm of ITO, ICO, IWO or the like. As shown in FIG. 13A, such a configuration provides a generally neutral transmission of light through the transflective reflective element for most wavelengths of visible light.

With reference to FIG. 14, a reflective element 716 has a front substrate 722 and a rear substrate 724 and a display element 718 at a rear or fourth surface of rear substrate 724. A semi-conductive ITO layer (or the like) 730 of approximately 30 nm is deposited on the forward or third surface of rear substrate 724, while a semi-conductive layer 726 (such as ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 722. A double stack ISI or DOD stack or layer 728 and EC medium 740 and seal 741 are provided between the semi-conductive layers 726, 730. Double stack ISI layer 728 comprises a semi-conductive adhesion layer 732 of approximately 60 nm of ITO, ICO, IWO or the like, a first metallic layer 734a of approximately 33 nm of silver or silver alloy or the like, a semi-conductive layer 736a of approximately 117 nm of ITO, ICO, IWO or the like, a second metallic layer 734b of approximately 33 nm of silver, silver alloy or the like, and a semi-conductive layer 736b of approximately 86 nm of ITO, ICO, IWO or the like. As shown in FIG. 14A, such a configuration provides a transmissivity of light through the reflective element with a peak transmissivity of light having a wavelength of approximately 650 nm. The reflective element 716 is thus spectrally tuned to transmit red light, such as light emitted from a red light emitting diode display 718, which may emit light having a peak intensity of approximately 650 nm, as shown in FIG. 14B. As can be seen with reference to FIGS. 14A and 11A, the transflective reflector and double stack ISI or DOD layer 728 provide a narrower band of transmissivity for the desired spectral band or range of wavelengths being emitted by the display. Such a configuration thus may provide enhanced reflectivity of light outside of the targeted spectral band.

With reference to FIG. 15, a reflective element 816 has a front substrate 822 and a rear substrate 824 and a display element 818 at a rear or fourth surface of rear substrate 824. A semi-conductive ITO layer (or the like) 830 of approximately 30 nm is deposited on the forward or third surface of rear substrate 824, while a semi-conductive layer 826 (such as ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 822. A double stack ISI or DOD stack or layer 828 and EC medium 840 and seal 841 are provided between the semi-conductive layers 826, 830. Double stack ISI layer 828 comprises a semi-conductive adhesion layer 832 of approximately 23 nm of ITO, ICO, IWO or the like, a first metallic layer 834a of approximately 30 nm of silver or silver alloy or the like, a semi-conductive layer 836a of approximately 204 nm of ITO, ICO, IWO or the like, a second metallic layer 834b of approximately 34 nm of silver, silver alloy or the like, and a semi-conductive layer 836b of approximately 47 nm of ITO, ICO, IWO or the like. As shown in

FIG. 15A, such a configuration provides a transmissivity of light through the reflective element with a peak transmissivity of light having a wavelength of approximately 500 nm. The reflective element 816 is thus spectrally tuned to transmit blue-green light, such as light emitted from a blue-green light emitting diode display 818, which may emit light having a peak intensity of approximately 500 nm. Similar to double stack ISI layer 728 discussed above, the transflective reflector and double stack ISI layer 828 provide a narrower band of transmissivity for the desired spectral band or range of wavelengths being emitted by the display. Such a configuration thus may provide enhanced transmissivity of the preselected or targeted spectral band and enhanced reflectivity of light outside of the targeted spectral band.

With reference to FIG. 16, a reflective element 916 has a front substrate 922 and a rear substrate 924 and a display element 918 at a rear or fourth surface of rear substrate 924. A semi-conductive ITO layer (or the like) 930 of approximately 30 nm is deposited on the forward or third surface of rear substrate 924, while a semi-conductive layer 926 (such as ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 922. A multiple stack ISI or DOD stack or layer 928, EC medium 940, seal 941 and encapsulant 943 are provided between the semi-conductive layers 926, 930. The ISI or DOD stack or layer 928 may be provided on ITO layer 930 so as to have a tab out portion as discussed above with respect to ISI layer 328. The encapsulant 943 is provided along the edges of the tab out portion of reflective element 916, and the seal 941 is provided between the tab out portion and the ITO layer 926 on front substrate 922 and between the ITO layers 924, 926 around ISI layer 928 where there is no tab out portion.

Multiple ISI or DOD stack or layer 928 comprises an adhesion layer 932 of approximately 80 nm of ITO, ICO, IWO or the like, a first metallic layer 934a of approximately 30 nm of silver or silver alloy or the like, a layer 936a of approximately 101 nm of silicon oxide or the like, a layer 934b of approximately 60 nm of titanium oxide or the like, a layer 936b of approximately 95 nm of silicon oxide or the like, a layer 934c of approximately 161 nm of titanium oxide or the like, a layer 936c of approximately 53 nm of silicon oxide or the like, a metallic layer 934d of approximately 50 nm of silver or silver alloy or the like, and a layer 936d of approximately 72 nm of ITO, ICO or the like. As shown in FIG. 16A, such a configuration provides a transmissivity of light through the reflective element with a peak transmissivity of light having a wavelength of approximately 650 nm. The reflective element 916 is thus spectrally tuned to transmit red light, such as light emitted from a red light emitting diode display 918, which may emit light having a peak intensity of approximately 650 nm. The transflective reflector and multiple stack ISI layer 928 provide an extra narrow band of transmissivity for the desired spectral band or range of wavelengths being emitted by the display. Such a configuration thus may provide enhanced reflectivity of light outside of the targeted spectral band. As can be seen in FIG. 16A, reflective element 916 may also transmit spectral bands of light at certain other wavelengths or ranges of wavelengths as well, such as at approximately 410 nm and 470 nm.

With reference to FIG. 17, a reflective element 1016 has a front substrate 1022 and a rear substrate 1024 and a display element 1018 at a rear or fourth surface of rear substrate 1024. A semi-conductive ITO layer (or the like) 1030 of approximately 30 nm is deposited on the forward or third surface of rear substrate 1024, while a semi-conductive layer 1026 (such as ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 1022. A multiple stack ISI or DOD stack or layer 1028, EC medium 1040, seal 1041 and encapsulant 1043 (around a tab out portion of the ISI layer, as discussed above) are provided between the semi-conductive layers 1026, 1030.

Multiple stack ISI or DOD layer 1028 comprises an adhesion layer 1032 of approximately 80 nm of ITO, ICO, IWO or the like, a first metallic layer 1034a of approximately 46 nm of silver or silver alloy or the like, a layer 1034b of approximately 80 nm of titanium oxide or the like, a layer 1036a of approximately 85 nm of silicon oxide or the like, a layer 1034c of approximately 188 nm of titanium oxide or the like, a layer 1036b of approximately 48 nm of silicon oxide or the like, a metallic layer 1034d of approximately 42 nm of silver or silver alloy or the like, and a layer 1036c of approximately 77 nm of ITO, ICO or the like. As shown in FIG. 17A, such a configuration provides a transmissivity of light through the reflective element with two peak transmission bands, namely, a first spectral band having a peak transmissivity of light having a wavelength of approximately 465 nm and a second spectral band having a peak transmissivity of light having a wavelength of approximately 645 nm. The reflective element 1016 is thus spectrally tuned to substantially transmit both blue light, such as light emitted from a blue light emitting diode display 1018a, which may emit light having a peak intensity of approximately 465 nm, and red light, such as light emitted from a red light emitting diode display 1018b, which may emit light having a peak intensity of approximately 645 nm. The transflective reflector and multiple stack ISI layer 1028 provide an extra narrow band of transmissivity for each of the desired spectral bands or ranges of wavelengths being emitted by the displays. Such a configuration thus may facilitate the implementation of different colored display elements, while providing enhanced reflectivity of light outside of the targeted spectral bands.

Referring now to FIG. 18, an electro-optic or electrochromic mirror element 1116 comprises a pair of substrates (a front substrate 1122 is shown in FIG. 18), with an electrochromic medium (not shown in FIG. 18) sandwiched therebetween. Electrochromic mirror element 1116 may comprise a reflective metallic layer or layers and transparent, at least partially conductive layers, such as discussed above, to provide a transflective mirror element. The electrochromic mirror element 1116 includes one or more display elements, such as the three display elements 1118a, 1118b, 1118c shown in FIG. 18, positioned behind the rear substrate and operable to emit or transmit light through the substrates and layers and electrochromic medium for viewing at the front substrate 1122.

The electrochromic mirror element 1116 comprises at least two regions, such as the three regions 1116a, 1116b, 1116c shown in FIG. 18. A central or principle viewing region 1116a provides a respective reflectivity and transmissivity, such as via layers or coatings as described above. One or both side regions 1116b, 1116c also provide a respective reflectivity and transmissivity. In the illustrated embodiment, the display element or elements 1118a, 1118b, 1118c are positioned at the side or display regions 1116b, 1116c. The conductive metallic and semiconductive non-metallic layers may be selected and adjusted so that the transmissivity in the side regions 1116b, 1116c may be greater than the transmissivity in the central region 1116a, while the reflectivity in the central region 1116a may be greater than the reflectivity in the side or display regions 1116b, 1116c. The present invention thus provides greater transmissivity in the display regions to enhance viewing of the displays, while providing greater reflectivity in the central or main region of the mirror element to provide enhanced reflectivity in the principle viewing area.

In the illustrated embodiment, the transmissivity at the display regions may be approximately 25%, while the transmissivity in the central or principle viewing region may be approximately 20%. Likewise, the reflectivity in the central or principle viewing region may be approximately 65%, while the reflectivity in the display regions may be approximately 60%. Other reflective and transmissive characteristics may be achieved without affecting the scope of the present invention.

The difference in the reflectivity and transmissivity between the regions is achieved by selecting different combinations of vapor source and masking of the regions to achieve the desired effect. For example, the thicknesses of different layers of the conductive metallic layer or layers and of the transparent, at least partially conductive layers may be selected or adjusted across the mirror element to achieve a desired amount of transmissivity at the display regions, while maintaining sufficient reflectivity in these regions, and to achieve a desired or optimum or maximum reflectivity at the central or principle viewing area or region of the mirror element. For example, a reflective metallic coating or layer may be thicker at the principle viewing region than at the display region or regions, while a transparent layer or coating may be thinner at the principle viewing region than at the display region or regions. Although shown as having display regions at the side regions of the mirror element, clearly displays and associated display regions providing enhanced transmissivity may be positioned elsewhere around the mirror element, without affecting the scope of the present invention.

Therefore, the reflective element or mirror element of the present invention allows for a display element to be positioned behind the reflective layer and transmits light from the display element through the mirror element, while providing sufficient reflectivity across the entire mirror element and not requiring any windows or thinned areas of reduced reflectivity in the display region. The present invention thus provides a mirror assembly which may include multiple display-on-demand type displays or display-on-need type displays, without adversely affecting the reflective nature of the reflective element. Furthermore, the transmissivity of the ISI or DOD stack or layer or the multiple stack ISI or DOD layers of the transflective reflector of the present invention may match or pinpoint the particular spectral band corresponding to the light emitted by the display element or device, in order to provide improved transmission of the display information or light through the stack (and thus through the reflective element), while providing a desired neutral reflectance over the entire surface of the reflector. The present invention thus may provide a reflective element which has a transmissivity level of greater than at least approximately 20 percent, more preferably at least approximately 30 percent, and most preferably at least approximately 50 percent, for light within a particular narrow spectral band or range of wavelengths, while providing substantial reflectance of light outside of the particular, selected spectral band or range of wavelengths. The reflective element of the present invention also provides for generally uniform thickness of the ISI or DOD layers, since none of the layers have to be etched or masked or reduced in thicknesses to allow for the display to transmit therethrough, thereby enhancing the manufacturing processing of the reflective element.

Optionally, the mirror assembly may include an illumination source for providing illumination, such as near infrared and/or infrared illumination, within the cabin of the vehicle. For example, the illumination source may be directed toward the head of the driver of the vehicle (or the area or location where a typical driver's head would be), and may be used in conjunction with a camera device or imaging device or the like. The imaging device or imaging system may comprise a cabin monitoring system, such as a monitoring system utilizing the principles disclosed in U.S. Pat. Nos. 6,523,964; and 6,302,545, and U.S. pat. applications, Ser. No. 10/372,873, filed Feb. 24, 2003 (Attorney Docket DON01 P-1077); Ser. No. 09/793,002, entitled VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE, filed Feb. 26, 2001 (Attorney Docket DON01 P-869); and Ser. No. 10/054,633, filed Jan. 22, 2002 by Lynam et al. for VEHICULAR LIGHTING SYSTEM (Attorney Docket DON01 P-962), which are hereby incorporated by reference herein. Optionally, the illumination source may be operable to illuminate the head of the driver while the imaging device is operable to capture images of the driver's head, such as for a video conferencing function, a driver alertness detection function (which may detect drowsiness issues, such as unorthodox head movement, nodding, glazed eyes, dilating eyes or other characteristics which may be indicative of driver fatigue or reduced alertness), a seat occupancy detection function, an intrusion detection function or any other desired functions. The illumination source or sources may comprise infrared or near infrared emitting sources, such as light emitting diodes (LEDs) or the like, to minimize the affect on or visibility to the driver of the vehicle, such as disclosed in U.S. Pat. Nos. 6,523,964; and 6,302,545, and U.S. pat. application, Ser. No. 10/372,873, filed Feb. 24, 2003 (Attorney Docket DON01 P-1077), which are hereby incorporated herein by reference. The imaging device thus may be capable of sensing infrared light, and may be particularly sensitive to infrared or near infrared light, and may comprise a CMOS imaging array or the like, such as disclosed in U.S. Pat. Nos. 5,550,677; 5,670,935; 5,760,962; 5,796,094 and 5,877,897, which are hereby incorporated herein by reference.

The interior rearview mirror assembly may provide the illumination source or sources at the bezel or chin or eyebrow of the mirror assembly, or at a module or pod or the like associated with the mirror assembly. Optionally, the mirror assembly may include the illumination source or sources within the mirror casing and behind the electrochromic cell of the mirror assembly, whereby the illumination source may emit near infrared light or radiant energy and project the light through a transflective electrochromic element, which may have sufficient transmissivity in the near infrared range of the spectrum, while limiting transmissivity of light in the visible range and providing a desired amount of untinted photopic reflectance, as discussed below. The illumination source thus may be positioned behind the rear substrate of the electrochromic cell and may project the near infrared illumination through both substrates of the reflective element or cell to sufficiently illuminate or bathe or flood the targeted area with near infrared illumination. The imaging device may also be positioned within the mirror casing and behind the transflective electrochromic element to capture images of the scene illuminated by the near infrared illumination source or sources.

The transflective display on demand type reflective element preferably maintains an untinted, high photopic reflectance of visible light, while also providing sufficient transmissivity of near infrared light or radiant energy (such as within the range of approximately 750 nm to approximately 1100 nm). Preferably, the transflective display on demand element provides at least approximately 30% transmissivity of near infrared light, preferably at least approximately 40%, more preferably at least approximately 60% and most preferably at least approximately 80% transmissivity of near infrared light. Typically, such near infrared transmissivity may not be achieved utilizing reflective coatings or stacks of coatings that comprise or include a metallic layer, such as a thin silver or silver alloy or aluminum or aluminum alloy layer or the like. In such applications, the infrared or near infrared light emitted by the illumination source may reflect back into the cavity of the mirror casing. The present invention overcomes this by providing an infrared or near infrared transmitting stack of dielectric layers or coatings which substantially transmit near infrared light while the transflective element also provides high photopic reflectance of visible light. The transflective element may provide high photopic reflectance and may meet the specifications set forth in SAE J964A, which is hereby incorporated herein by reference. Preferably, the transflective element provides greater than approximately 55%, more preferably greater than approximately 65% and most preferably greater than approximately 75%, of such photopic reflectance.

Referring now to FIGS. 19-22, a transflective electrochromic element or cell 1216 includes a front substrate 1222 and a rear substrate 1224, and an illumination source 1244 and an imaging device 1246 at a rear or fourth surface of rear substrate 1224. A semi-conductive layer or coating (such as ITO, tin oxide or the like) 1230 is deposited on the forward or third surface of rear substrate 1224, while a semi-conductive layer 1226 (such as

ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 1222. An electrochromic medium 1240 and seal 1241 are provided or sandwiched between the semi-conductive layers 1226, 1230, with an electrical connector 1248 positioned at least partially along at least one edge of each of the semi-conductive layers 1226, 1230. The transflective cell 1216 further includes an infrared or near infrared transmitting (IRT) stack or layers 1228, which, in the illustrated embodiment of FIG. 19, is positioned or stacked on the rear surface of the rear substrate 1224. A protective cover or glass sheet 1225 is adhered or secured to the rear surface of the IRT stack 1228, such as via an adhesive layer 1225a, which preferably is an index matching adhesive that matches the index of the protective cover or sheet. The protective cover may comprise glass, or may comprise other transparent or substantially clear materials, such as plastic, polycarbonate, acrylic or the like, without affecting the scope of the present invention.

IRT stack 1228 comprises multiple layers of dielectric layers or coatings across the rear surface of rear substrate 1224 which function as a cold mirror stack that allows near infrared and infrared light or radiant energy to pass therethrough while substantially reflecting visible light. The IRT stack 1228 may comprise layers of titanium oxide alternating with silicon oxide layers. The titanium oxide layers provide a higher refractive index while the silicon oxide layers provide a lower refractive index. The alternating combination of the lower and higher refracting indices of alternating layers provides enhanced near infrared transmissivity, while providing reflectivity of visible light.

In an exemplary embodiment, IRT stack 1228 comprises nineteen such alternating layers having: a first titanium oxide layer approximately 72 nm thick on the rear surface of substrate 1224, a first silicon oxide layer approximately 32 nm thick on the first titanium oxide layer, a second titanium oxide layer approximately 94 nm thick on the first silicon oxide layer, a second silicon oxide layer approximately 110 nm thick on the second titanium oxide layer, a third titanium oxide layer approximately 64 nm thick on the second silicon oxide layer, a third silicon oxide layer approximately 85 nm thick on the third titanium oxide layer, a fourth titanium oxide layer approximately 62 nm thick on the third silicon oxide layer, a fourth silicon oxide layer approximately 128 nm thick on the fourth titanium oxide layer, a fifth titanium oxide layer approximately 60 nm thick on the fourth silicon oxide layer, a fifth silicon oxide layer approximately 98 nm thick on the fifth titanium oxide layer, a sixth titanium oxide layer approximately 57 nm thick on the fifth silicon oxide layer, a sixth silicon oxide layer approximately 94 nm thick on the sixth titanium oxide layer, a seventh titanium oxide layer approximately 54 nm thick on the sixth silicon oxide layer, a seventh silicon oxide layer approximately 77 nm thick on the seventh titanium oxide layer, an eighth titanium oxide layer approximately 36 nm thick on the seventh silicon oxide layer, an eighth silicon oxide layer approximately 83 nm thick on the eighth titanium oxide layer, a ninth titanium oxide layer approximately 58 nm thick on the eighth silicon oxide layer, a ninth silicon oxide layer approximately 97 nm thick on the ninth titanium oxide layer, and a tenth titanium oxide layer approximately 28 nm thick on the ninth silicon oxide layer. Clearly, other thicknesses and combinations of layers may be implemented to achieve the desired levels of transmissivity and reflectivity, without affecting the scope of the present invention. The transflective element thus provides a fourth surface transflective mirror element, with multiple alternating layers of silicon oxide and titanium oxide to enhance the near infrared transmissivity through the ITO layers and substrates.

The transmissivity percentage of such a substrate versus the light wavelength is shown in FIG. 22. As can be seen in FIG. 22, the substrate 1224 and IRT stack 1228 transmit more than 90% of near infrared light, while substantially not transmitting light in the visible range of the spectrum. The transflective element 1216 is thus spectrally tuned to transmit near infrared light emitted from illumination source 1244, and may transmit the near infrared light from the scene back to the imaging sensor 1246. As can be seen in FIG. 22, the transmission is generally constant or flat for the desired wavelengths at an angle of incidence of the light source relative to the substrate between approximately 0 degrees and approximately 50 degrees.

The arrangement shown in FIG. 19 may allow the mirror manufacturer to purchase the rear substrate sheet or material, which may be purchased from a glass or substrate supplier or vendor with the front ITO layer or coating and the cold mirror stack or IRT stack already applied thereto or deposited thereon. The ITO layers and alternating silicon oxide and titanium oxide layers may be deposited on the respective surfaces or layers via any known manner, such as vacuum deposition or the like, and such as disclosed in U.S. Pat. Nos. 5,668,663; 5,724,187; and 6,002,511, which are hereby incorporated herein by reference. This allows the mirror manufacturer to select an appropriate rear substrate, depending on the desired function or application of the mirror assembly, and to assemble the transflective element with the selected substrate. The mirror manufacturer may purchase the substrates, cut out the desired shape for the mirror reflective element and glue or adhere or otherwise join the substrates (with coatings thereon) together (and sandwich the electrochromic medium between the front and rear substrate) to form the desired transflective element.

Prior to deposition, it is desirable / beneficial to clean the substrate using a plasma source or an ion source, such as a linear ion source or the like, which may result in enhanced adhesion of the thin films to the substrate. It is preferable that the substrate cleaning is accomplished in one single pump down cycle of the vacuum coating process. For example, glass substrates can enter a vacuum chamber via a load-lock, and pass under a plasma source, such as a linear ion source or the like, where the surface-to-be-coated is activated/cleaned by exposure to a plasma and/or by ion bombardment or the like. The now plasma activated/ion-bombardment cleaned surface is then coated with an ITO layer, followed by a metallic layer (such as silver), followed by an ITO layer such as described herein. Optionally, and preferably, a three-sided target assembly is used, for example, one side may be a linear ion source, another side may be an ITO target, and the third side may be a silver target. The three-sided target assembly can, for example, rotate (such as clockwise) to first ion clean the substrate, then rotate clockwise again to deposit ITO, then rotate clockwise again to deposit silver, and then rotate counterclockwise to deposit ITO again. Suitable ion sources for such a cleaning purpose include Anode Layer Sources (ALS), Kaufmann sources, gridded sources, non-gridded sources, RF sources and DC glow discharge sources and the like. The most preferred are the linear ion sources of the ALS type, such as are available from Veeco Instruments, Inc. of Colorado and Advanced Energy (AE) of Colorado.

Optionally, and desirably, the substrates 1222, 1224 may have a low absorption characteristic in the near infrared range or band of the energy spectrum, whereby the substrates provide low absorption of near infrared radiant energy, such as at wavelengths of around 880 nm or thereabouts. The substrates thus may provide enhanced transmissivity of such near infrared radiant energy through the transflective electrochromic element or cell. Such low absorption characteristics may be accomplished by selecting a material for the substrates that provides the desired results. For example, the substrates may comprise a borosilicate material, such as the type that is commercially available from Schott Glass Corp. under the name BOROFLOAT™, or may comprise a B270 material or SUPERWHITE™, also commercially available from Schott Glass Corp., or may comprise other materials, such as fused silica or quartz materials or the like, that may also or otherwise provide the desired degree of low absorption of near infrared radiant energy. Other materials may be selected for the substrates of the transflective electrochromic cell, without affecting the scope of the present invention.

Optionally, and with reference to FIG. 20, a transflective element 1216' may provide the IRT stack 1228' on a front surface of the protective cover or glass substrate or sheet 1225. In such an embodiment, the IRT stack 1228' and cover 1225 are adhered or secured to the rear surface of rear substrate 1224' via the index matching adhesive 1225a or the like. The arrangement shown in FIG. 20 allows the IRT stack to be manufactured on a separate glass sheet or protective cover, whereby the mirror manufacturer may purchase the front and rear substrates or sheets (with the ITO layers already applied thereto or deposited thereon) and the third glass sheet or protective cover with the IRT stack already deposited thereon. The protective cover may comprise glass, or may comprise other transparent or substantially clear materials, such as plastic, polycarbonate, acrylic or the like, without affecting the scope of the present invention. The IRT stack and other components of transflective element 1216' may be substantially similar to the IRT stack and components of transflective element 1216 discussed above, such that a detailed discussion of these elements will not be repeated herein.

Optionally, and with reference to FIG. 21, a transflective element 1216" may be substantially similar to transflective element 1216 of FIG. 19, discussed above, and may include a titanium oxide layer or coating 1227 on the rear surface of the front substrate 1222' and between the front substrate 1222' and the ITO layer or coating 1226'. The titanium oxide layer 1227 may function to partially cancel out or compensate for any near infrared reflectivity by the ITO layers of the cell or element to further enhance the performance of the transflective element.

Referring now to FIG. 23, a transflective electrochromic element or cell 1316 includes a front substrate 1322 and a rear substrate 1324, and an illumination source 1344 and an imaging device 1346 at a rear or fourth surface of rear substrate 1324. A semi-conductive layer or coating 1326 (such as ITO, tin oxide or the like) is deposited on the rear or second surface of front substrate 1322. An IRT stack 1328 is applied to or deposited on the front surface of rear substrate 1324, and a semi-conductive layer or coating 1330 (such as ITO, tin oxide or the like) is deposited on IRT stack 1328. An electrochromic medium 1340 and seal 1341 are provided or sandwiched between the semi-conductive layers 1326, 1330, with an electrical connector 1348 positioned at least partially along at least one edge of each of the semi-conductive layers 1326, 1330.

Similar to IRT stack 1228 discussed above, IRT stack 1328 comprises multiple layers of dielectric layers or coatings. IRT stack or cold mirror stack 1328 is deposited on the front surface of rear substrate 1324 and may comprise alternating layers of titanium oxide alternating with silicon oxide layers. The titanium oxide layers provide a higher refractive index while the silicon oxides provide a lower refractive index. The combination of the lower and higher refractive indices of the alternating layers provides enhanced near infrared transmissivity, while providing reflectivity of visible light.

In an exemplary embodiment, IRT stack 1328 comprises nineteen such alternating layers with a twentieth layer of ITO deposited on the outermost IRT stack layer. For example, the IRT stack may comprise a first titanium oxide layer approximately 53 nm thick on the rear surface of substrate 1324, a first silicon oxide layer approximately 57 nm thick on the first titanium oxide layer, a second titanium oxide layer approximately 84 nm thick on the first silicon oxide layer, a second silicon oxide layer approximately 103 nm thick on the second titanium oxide layer, a third titanium oxide layer approximately 58 nm thick on the second silicon oxide layer, a third silicon oxide layer approximately 96 nm thick on the third titanium oxide layer, a fourth titanium oxide layer approximately 64 nm thick on the third silicon oxide layer, a fourth silicon oxide layer approximately 108 nm thick on the fourth titanium oxide layer, a fifth titanium oxide layer approximately 63 nm thick on the fourth silicon oxide layer, a fifth silicon oxide layer approximately 93 nm thick on the fifth titanium oxide layer, a sixth titanium oxide layer approximately 44 nm thick on the fifth silicon oxide layer, a sixth silicon oxide layer approximately 70 nm thick on the sixth titanium oxide layer, a seventh titanium oxide layer approximately 37 nm thick on the sixth silicon oxide layer, a seventh silicon oxide layer approximately 61 nm thick on the seventh titanium oxide layer, an eighth titanium oxide layer approximately 58 nm thick on the seventh silicon oxide layer, an eighth silicon oxide layer approximately 102 nm thick on the eighth titanium oxide layer, a ninth titanium oxide layer approximately 31 nm thick on the eighth silicon oxide layer, a ninth silicon oxide layer approximately 55 nm thick on the ninth titanium oxide layer, and a tenth titanium oxide layer approximately 49 nm thick on the ninth silicon oxide layer. The semi-conductive layer 1330 may comprise an ITO layer approximately 130 nm thick. Clearly, other thicknesses and combinations of layers may be implemented to achieve the desired levels of transmissivity and reflectivity, without affecting the scope of the present invention. The transflective element thus provides a third surface transflective mirror element, with multiple layers of silicon oxide and titanium oxide to enhance the near infrared transmissivity through the ITO layers and substrates.

The transmissivity percentage of such a substrate versus the light wavelength is shown in FIG. 26. As can be seen in FIG. 26, such a rear substrate transmits more than approximately 90% of near infrared light, while substantially not transmitting light in the visible range of the spectrum. The transflective element 1316 is thus spectrally tuned to transmit near infrared light emitted from illumination source 1344, and may transmit the near infrared light from the scene back to the imaging sensor 1346. As can be seen in FIG. 26, the transmission is generally constant or flat for the desired wavelengths at an angle of incidence of the light source relative to the substrate between approximately 0 degrees and approximately 50 degrees.

The arrangement shown in FIG. 23 may allow the mirror manufacturer to purchase the rear substrate sheet or material, which may be purchased from a glass or substrate supplier or vendor with the IRT or cold mirror stack and the front ITO layer or coating already applied thereto or deposited thereon. The ITO layers and silicon oxide and titanium oxide layers may be deposited on the front surface or other layers via any known manner, such as vacuum deposition or the like, and such as disclosed in U.S. Pat. Nos. 5,668,663; 5,724,187; and 6,002,511, which are hereby incorporated herein by reference. This allows the mirror manufacturer to select an appropriate rear substrate, depending on the desired function or application of the mirror assembly, and to assemble the transflective element with the selected substrate. The mirror manufacturer may purchase the substrates, cut out the desired shape for the mirror reflective element and glue, adhere or otherwise join the substrates (with coatings thereon) together (and sandwich the electrochromic medium between the front and rear substrate) to form the desired transflective element.

Optionally, and with reference to FIG. 24, a transflective element 1316' in accordance with the present invention may be substantially similar to transflective element 1316 discussed above, and may include a titanium oxide layer or coating 1327 on the rear surface of the front substrate 1322' and between the front substrate 1322' and the ITO layer or coating 1326'. In an exemplary embodiment, the titanium oxide layer 1327 may be approximately 250 nm thick, while the ITO layer 1326' may be approximately 130 nm thick, but other thicknesses may be implemented to achieve the desired result, without affecting the scope of the present invention. The titanium oxide layer 1327 may function to partially cancel out or compensate for any near infrared reflectivity by the ITO layers of the cell or element. This arrangement provides an enhanced semi-conductive layer or coating on the rear surface of the front substrate. A graphical depiction of the transmissivity of front substrate 1322' versus wavelength of light is shown in FIG. 27. In the illustrated embodiment, the peak transmissivity wavelength is approximately 880 nm. Such a reflective element or cell thus may be particularly suited for use with an imaging device or camera that has a peak sensitivity or response to light having a wavelength of approximately 880 nm.

Optionally, and with reference to FIG. 25, another transflective element 1316" in accordance with the present invention may be substantially similar to transflective element 1316 of FIG. 23, discussed above, and may include an enhanced semi-conductive layer on the rear surface of the front substrate 1322". The enhanced semi-conductive layer includes a titanium oxide layer or coating 1329 deposited on the rear surface of the front substrate 1322", a silicon oxide layer 1327' deposited on titanium oxide layer 1329, and an ITO layer 1326" deposited on silicon oxide layer 1327'. In an exemplary embodiment, the titanium oxide layer 1329 may be approximately 109 nm thick, while the silicon oxide layer 1327' may be approximately 277 nm thick and the ITO layer 1326' may be approximately 130 nm thick. Other thicknesses may be implemented to achieve the desired result, without affecting the scope of the present invention. The titanium oxide layer 1329 and silicon oxide layer 1227' may function to partially cancel out or compensate for any near infrared reflectivity by the ITO layers of the cell or element to enhance the near infrared transmissivity of the front substrate and semi-conductive layers. A graphical depiction of the transmissivity of front substrate 1322" versus wavelengths of light is shown in FIG. 28. In the illustrated embodiment, the peak transmissivity wavelength is approximately 880 nm. Such a reflective element or cell thus may be particularly suited for use with an imaging device or camera that has a peak sensitivity or response to light having a wavelength of approximately 880 nm.

Optionally, and as shown in FIG. 29, a transflective element 1316''' may include the substrates 1322", 1324' and coatings or layers such as described above with respect to transflective element 1316" (FIG. 25), and may further include an anti-reflective (AR) stack or layers 1352 at the rear surface of the rear substrate 1324'. The anti-reflective stack or layers 1352 may be selected to minimize the reflectance of light at a desired or targeted wavelength or range of wavelengths or spectral band to enhance the overall transmissivity at the desired or targeted spectral band. For example, the anti-reflective stack 1352 may be selected to minimize the reflectance of near infrared radiant energy, such as radiant energy having a wavelength of approximately 880 nm or thereabouts, such that the transmission of such radiant energy may be enhanced. In an exemplary embodiment, anti-reflective stack or layers 1352 comprises a layer of titanium oxide 1352a deposited on or disposed at the rear surface of the rear substrate 1324 and a layer of silicon oxide 1352b deposited on or disposed at the titanium oxide layer 1352a. In one embodiment, titanium oxide layer 1352a may have a thickness of approximately 25 nm, while silicon oxide layer 1352b may have a thickness of approximately 205 nm, such that the anti-reflective stack or layers 1352 reduces the reflectance of near infrared radiant energy having a wavelength of approximately 880 nm or thereabouts. Other layers or thicknesses may be selected to achieve other desired results, and may be selected depending on the particular reflective element design and the particular application of the reflective element, without affecting the scope of the present invention. Such anti-reflective surfaces may be applied to or disposed on the rearward surface of other mirror elements of the present invention described herein.

Therefore, the present invention provides a transflective electrochromic element or cell which may allow transmittance of near infrared light through the substrates while providing a desired amount of untinted photopic reflectance, and while also providing the desired degree of conductivity at the conductive or semi-conductive layers. The transflective element may include multiple dielectric layers or coatings on one of the substrates or on a rear cover or glass sheet of the transflective element. The dielectric layers cooperate to enhance transmissivity of infrared or near infrared light through the substrates, while providing the desired level of untinted photopic reflectance. The transflective element thus may allow the mirror assembly to include a near infrared light emitting diode or other near infrared emitting light source to be positioned behind the transflective element and within the mirror casing, whereby the light source may emit or project near infrared light through the transflective element toward and into the cabin of the vehicle. The mirror assembly may also include an imaging device which may be positioned behind the transflective element and may receive or capture images of the interior cabin of the vehicle which is covered by the near infrared light of the light source.

Optionally, and with reference to FIG. 30, it is envisioned that a transflective element 1416 in accordance with the present invention may provide high transmissivity of near infrared radiant energy, while also providing high transmissivity of a particular wavelength or range of wavelengths or spectral band or region of visible light, yet still providing high photopic reflectance of the other visible light and sufficient conductivity. Transflective element 1416 may be substantially similar to the transflective elements 1316, 1316', 1316", discussed above, but may include an infrared transmitting and display on demand stack 1428 (IRT-DOD stack) of alternating titanium oxide layers (or the like) and silicon oxide layers (or the like) that may provide for high transmissivity of near infrared radiant energy and high transmissivity of a desired visible light color, such as, for example, visible light having a wavelength of approximately 430 nm (blue). Different combinations of alternating layers may be selected to provide sufficient transmissivity of near infrared radiant energy and of other desired spectral bands, without affecting the scope of the present invention.

The titanium oxide layers provide a higher refractive index while the silicon oxides provide a lower refractive index. The combination of the lower and higher refractive indices of the alternating layers provides enhanced near infrared transmissivity, while providing high photopic reflectivity of most of the visible light, except the visible light in the desired spectral region or having the desired or selected or targeted wavelength. The transflective element thus may be used with a near infrared light emitting source 1444, which may be used in conjunction with an imaging source or camera 1446, and a display on demand element 1450 that may emit light at the desired or selected wavelength or color (such as, for example, blue light having a wavelength of 430 nm) so that it is viewable through the reflective element by a driver or occupant of the vehicle.

The other elements of the transflective element 1416 may be substantially similar to the transflective elements 1316, 1316', 1316", discussed above, such that a detailed discussion of these elements will not be repeated herein. The similar or common elements are shown in FIG. 30 with similar reference numbers to those of FIG. 24, but with one hundred added to each number. In the illustrated embodiment of FIG. 29, the transflective element 1416 is shown with a titanium oxide (TiO_2) layer or coating 1427 on the rear surface of the front substrate 1422 and between the front substrate 1422 and the ITO layer or coating 1426, similar to transflective element 1316' of FIG. 24. However, other coatings or layers may be deposited on or applied to the front substrate of the transflective element, such as, for example, the other layers discussed above, without affecting the scope of the present invention.

In an exemplary embodiment of the infrared transmitting and visible light transmitting transflective element 1416, the IRT-DOD stack 1428 comprises nineteen such alternating layers with a twentieth layer of ITO 1430 deposited on the outermost IRT-DOD stack or layers. For example, the IRT-DOD stack may comprise a first titanium oxide layer approximately 50 nm thick on the surface of the substrate, a first silicon oxide layer approximately 83 nm thick on the first titanium oxide layer, a second titanium oxide layer approximately 48 nm thick on the first silicon oxide layer, a second silicon oxide layer approximately 159 nm thick on the second titanium oxide layer, a third titanium oxide layer approximately 50 nm thick on the second silicon oxide layer, a third silicon oxide layer approximately 97 nm thick on the third titanium oxide layer, a fourth titanium oxide layer approximately 61 nm thick on the third silicon oxide layer, a fourth silicon oxide layer approximately 104 nm thick on the fourth titanium oxide layer, a fifth titanium oxide layer approximately 59 nm thick on the fourth silicon oxide layer, a fifth silicon oxide layer approximately 84 nm thick on the fifth titanium oxide layer, a sixth titanium oxide layer approximately 35 nm thick on the fifth silicon oxide layer, a sixth silicon oxide layer approximately 65 nm thick on the sixth titanium oxide layer, a seventh titanium oxide layer approximately 46 nm thick on the sixth silicon oxide layer, a seventh silicon oxide layer approximately 76 nm thick on the seventh titanium oxide layer, an eighth titanium oxide layer approximately 48 nm thick on the seventh silicon oxide layer, an eighth silicon oxide layer approximately 175 nm thick on the eighth titanium oxide layer, a ninth titanium oxide layer approximately 19 nm thick on the eighth silicon oxide layer, a ninth silicon oxide layer approximately 61 nm thick on the ninth titanium oxide layer, and a tenth titanium oxide layer approximately 37 nm thick on the ninth silicon oxide layer. The semi-conductive layer 1430 may comprise an ITO layer or the like of approximately 130 nm thick. Clearly, other thicknesses and combinations of layers may be implemented to achieve the desired levels of transmissivity and reflectivity, such as high transmissivity of other colors or spectral regions of the spectrum, without affecting the scope of the present invention. The transflective element thus provides a third surface transflective mirror element, with multiple layers of silicon oxide and titanium oxide to enhance the near infrared transmissivity and particular visible light wavelength or wavelengths through the ITO layers and substrates.

The transmissivity percentage of such a substrate versus the light wavelength is shown in FIG. 31. As can be seen in FIG. 31, such a substrate transmits more than approximately 90% of near infrared light, while substantially reflecting or not transmitting light in the visible range of the spectrum, except for light having a wavelength of approximately 430 nm, which is also highly transmitted (such as at greater than approximately 90% transmissivity) by the substrate and alternating layers of the IRT-DOD stack. The transflective element is thus spectrally tuned to transmit near infrared light that may be emitted from an illumination source 1444, and may transmit the near infrared light from the scene back to an imaging sensor 1446. The transflective element may also transmit light having a desired or targeted wavelength to allow for a colored display element or illumination source or indicator 1450 to be viewed through the transflective element.

Although shown and described as being implemented on a third surface of an electrochromic mirror element, it is envisioned that the layers or stacks of the present invention may be implemented at a fourth surface of the electrochromic reflective element, such as for a fourth surface reflective element, without affecting the scope of the present invention. In such an application, a radiant energy emitting device or element and/or an imaging sensor may be positioned rearward of the stack or layers for emitting or receiving radiant energy through the reflective element. Also, a protective layer or cover may be provided over the rearwardmost layer of the alternating layers and over or around the display element or sensor to protect the layers at the rear of the reflective element.

Also, although shown and described as being implemented in an electrochromic reflective element or cell, the alternating layers or stacks of the present invention may be implemented at a rear surface (second surface) of a prismatic reflective element, without affecting the scope of the present invention. For example, and with reference to FIG. 32, a prismatic reflective element 1516 may comprise a prismatic or wedge-shaped substrate 1522 having a forward or outwardly facing surface 1522a and a rearward surface 1522b opposite the forward surface 1522a. Prismatic reflective element 1522 includes alternating layers or a stack 1528 disposed at rear surface 1522b of prismatic substrate 1522. As shown in FIG. 32, a protective layer or coating 1525 may be applied over the stack 1528. The layers of stack 1528 may comprise alternating layers of metallic and non-metallic layers or coatings, such as layers or stacks similar to the ISI stacks or DOD stacks or IRT stacks or IRT-DOD stacks of the present invention, as discussed above, depending on the particular application of the prismatic reflective element. The particular materials and thicknesses of the layers may be selected to provide the desired transmissivity of a particular selected spectral band or bands of radiant energy through the prismatic reflective element, while providing sufficient reflectivity of other spectral bands of radiant energy.

Prismatic reflective element 1516 may include a display element or radiant energy emitting device or illumination source 1544 positioned at a rear surface of the rearward most layer of stack 1528 and operable to emit radiant energy, such as visible light, near infrared radiant energy or infrared radiant energy through stack 1528 and prismatic substrate 1522. The thicknesses and materials of the layers of stack 1528 may be selected to provide enhanced transmissivity of radiant energy or light within a particular spectral band through stack 1528 and prismatic substrate 1522, while providing sufficient reflectivity of light having wavelengths outside of the selected particular spectral band. The particular spectral band may be selected to match the spectral band of light or radiant energy emitted by radiant energy emitting device 1544, such as in the manners discussed above. Optionally, the prismatic reflective element may include an imaging sensor or the like, such as discussed above with respect to electrochromic reflective element 1316 or 1416, without affecting the scope of the present invention.

The radiant energy emitting element or display element thus may be viewable through the prismatic substrate without requiring windows or the like formed in the reflective layer at the rear of the prismatic substrate. The layers or stacks of the present invention thus may provide an improved display on demand or display on need type of display element for a prismatic reflective element. Although shown as a prismatic or wedge-shaped substrate, the substrate may comprise a substantially flat substrate or may comprise a curved substrate having one or more curved surfaces, without affecting the scope of the present invention.

Although described as being implemented with interior rearview mirror assemblies, it is further envisioned that the layers or stacks of the present invention may be implemented with reflective elements for exterior rearview mirror assemblies, such as exterior electrochromic rearview mirror assemblies or other exterior rearview mirror assemblies, such as exterior rearview mirror assemblies having a single flat substrate or having a curved outer surface or substrate or the like, without affecting the scope of the present invention. For example, an exterior reflective element may have a stack of alternating layers (such as the types discussed above) that may have enhanced transmissivity of visible light that has a spectral band that matches a color output of a turn signal indicator or other indicator or light emitting device positioned behind the reflective element, such as within the casing of the exterior rearview mirror assembly. The indicator may thus be viewable through the reflective element when the indicator is activated, while the reflective element substantially reflects other light over its entire viewing surface. The exterior rearview mirror assembly of the present invention thus may provide an indicator for viewing through the reflective element without requiring a window to be formed in the reflective layer or surface of the exterior reflective element. The present invention thus may provide a display on demand or display on need type of display to an exterior rearview mirror assembly. Optionally, the alternating layers may comprise an IRT stack or IRT-DOD stack, such as described above, and the exterior rearview mirror assembly may include an infrared or near infrared emitting element, and may include an imaging sensor or device or camera, such as for a side or rearward imaging system of the vehicle (such as for a viewing system such as the types disclosed in U.S. Pat. Nos. 5,550,677; 5,670,935 and 6,201,642, which are hereby incorporated herein by reference, or such as for a lane change assist system or side objection detection system or the like, such as the types disclosed in U.S. pat. applications, Ser. No. 10/209,173, filed Jul. 31, 2002 by Schofield for AUTOMOTIVE LANE CHANGE AID (Attorney Docket DON01 P-1016), Ser. No. 10/427,051, filed Apr. 30, 2003 by Pawlicki et al. for OBJECT DETECTION SYSTEM FOR VEHICLE (Attorney Docket DON01 P-1075), which are hereby incorporated herein by reference). The near infrared emitting element or elements may be positioned within the exterior rearview mirror assembly and behind the reflective element and may provide illumination at the side of the vehicle without distracting or adversely affecting the view or vision of drivers of other vehicles at the side of the subject vehicle.

The present invention thus provides mirror reflective elements that provide substantial visible reflectivity, and that may provide substantial transmissivity of near infrared light, and that may also or otherwise provide substantial transmissivity of visible light within a selected spectral band or region or range of wavelengths. The mirror reflective elements of the present invention thus may be spectrally tuned for the desired application, while still providing the desired degree of photopic reflectivity and the desired conductivity on the conductive or semi-conductive layers, such that the electrochromic medium of the mirror cell colors or darkens in a desired manner.

The electrical connectors for the transflective electrochromic cells or elements of the present invention may comprise clip connectors, electrical busbars or the like, such as disclosed in U.S. Pat. Nos. 5,066,112 and 6,449,082, which are hereby incorporated herein by reference. Although shown as having the substrates and connectors offset, clearly the transflective element may comprise a flush element, such as described in U.S. Pat. No. 5,066,112, or such as described in U.S. provisional applications, Ser. No. 60/490,111, filed Jul. 25, 2003 by McCabe et al. for FLUSH ELECTROCHROMIC CELL (Attorney Docket DON01 P-1102); and Ser. No. 60/423,903, filed Nov. 5, 2002 by McCabe for ONE SIDED FLUSH ELECTROCHROMIC CELL (Attorney Docket DON01 P-1032), which are all hereby incorporated herein by reference. Such a flush transflective element may facilitate a no-bezel or bezelless or low bezel mirror casing or assembly, with minimal or no offset between the substrates of the mirror assembly.

As discussed above, the mirror assembly of the present invention may include a display for providing information for viewing by the driver of the vehicle on the reflective element so that the driver can easily see the display. In order to maintain easy viewing of the display, it is desirable to adjust the display intensity in response to ambient light levels (in order to avoid washout during daytime driving conditions and glare during nighttime driving conditions) and in response to the degree of transmissivity of the electrochromic reflective element. For example, in low lighting conditions, such as during the nighttime, the intensity of the display may be dimmed to avoid glare, while in higher lighting conditions, such as during the daytime, the intensity of the display may be increased to provide sufficient visibility of the display to the driver of the vehicle. The mirror assembly may include light sensors for sensing the ambient light in the cabin of the vehicle or at the mirror assembly and may include a control which is operable to automatically adjust the display intensity and/or the transmissivity of the electrochromic medium in response to the ambient light sensors.

Further, automatic dimming circuitry used in electrochromic mirror assemblies utilizing the reflective elements of the current invention may utilize one or more (typically two) photo sensors to detect glaring and/or ambient lighting. For example, a silicon photo sensor such as a TSL235R Light-to-Frequency converter (available from Texas Advanced Optoelectronic Solutions Inc. of Plano, TX) can be used as such photo sensors. Such light-to-frequency converters comprise the combination of a silicon photodiode and a current-to-frequency converter on a single monolithic CMOS integrated circuit.

The mirror assembly or assemblies of the present invention may also include or house a plurality of electrical or electronic devices, such as antennas, including global positioning system (GPS) or cellular phone antennas, such as disclosed in U.S. Pat. No. 5,971,552, a communication module, such as disclosed in U.S. Pat. No. 5,798,688, displays, such as shown in U.S. Pat. Nos. 5,530,240 and 6,329,925, blind spot detection systems, such as disclosed in U.S. Pat. Nos. 5,929,786 or 5,786,772, transmitters and/or receivers, such as garage door openers, a digital network, such as described in U.S. Pat. No. 5,798,575, a high/low head lamp controller, such as disclosed in U.S. Pat. No. 5,715,093, a memory mirror system, such as disclosed in U.S. Pat. No. 5,796,176, a hands-free phone attachment, a video device for internal cabin surveillance and/or video telephone function, such as disclosed in

U.S. Pat. Nos. 5,760,962 and 5,877,897, a remote keyless entry receiver, map lights, such as disclosed in U.S. Pat. Nos. 5,938,321; 5,813,745; 5,820,245; 5,673,994; 5,649,756; or 5,178,448, microphones, such as disclosed in U.S. Pat. Nos. 6,243,003 and 6,278,377, speakers, a compass, such as disclosed in U.S. Pat. No. 5,924,212 or U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), seat occupancy detector, a trip computer, an ONSTAR® system or the like (with all of the above-referenced patents and applications being commonly assigned to Donnelly Corporation, and with the disclosures of the referenced patents and applications being hereby incorporated herein by reference in their entireties).

The mirror assembly and/or reflective element of the present invention may include a printed circuit board (PCB) which may be attached to its rear surface (e.g. the fourth surface) by, for example, a suitable adhesive or the like. An example of such an arrangement is disclosed in commonly assigned U.S. Pat. No. 5,820,245, which is incorporated in its entirety by reference herein. The PCB optionally may include glare sensing and ambient photo sensors and electrochromic circuitry that automatically dims the reflectivity of the electrochromic mirror element when glare conditions are detected, such as at nighttime or the like. Alternately, the PCB may be snap connected, by a clip or otherwise attached, to a plastic plate that itself is adhered to the electrochromic element.

The printed circuit board may include electronic or electrical circuitry for actuating the variable reflectance of the reflective element and for operating other electrical or electronic functions supported in the rearview mirror assembly. The circuit board may support, for example, light emitting diodes (LEDs) for illuminating indicia on display elements provided on the chin of the bezel of the mirror assembly or display devices provided on the reflective element, or map or dash board lights or the like. The circuit board may be independently supported from the reflective element or in the casing or may be mounted to the reflective element's rear or fourth surface on a separate plate or may be directly adhered to the rear surface by a suitable adhesive. Reference is made to U.S. Pat. Nos. 5,671,996 and 5,820,245, the disclosures of which are hereby incorporated herein by reference in their entireties.

Therefore, the present invention provides a reflective element which provides a combination of substantially transparent, conductive or semi-conductive layers and substantially reflective, conductive metallic layer or layers on one of the surfaces of the reflective element, such as the inward surface (or third surface) of a second substrate of an electrochromic reflective element or a rear surface (or fourth surface) of an electrochromic reflective element or a rear surface of a prismatic reflective element or the like. The reflective element of the present invention provides enhanced manufacturing processing of the reflective element, since the thicknesses of the layers and tolerances associated therewith are sufficiently large enough to be sputter coated or otherwise deposited via a low cost process. The reflective element of the present invention also provides for a reflective and transmissive element which allows transmission of display information through the reflective element, while still providing sufficient reflectance over the entire surface of the reflective element, even in the display area. Accordingly, multiple displays may be positioned on, at or around the reflective element, without loss of reflectivity of the element. The materials and thicknesses of the layers of the reflective element may be selected to spectrally tune the reflective element to allow transmission of one or more particular spectral bands or range of wavelengths, in order to tune the reflective element for use with a particular spectral band of light being emitted by a particular display. The materials and thicknesses of the layers may also be selected to spectrally tune the reflective element to enhance transmissivity of near infrared radiant energy. Also, the thicknesses of one or more layers may be varied across the mirror element to provide regions or areas of increased transmissivity for a display, while maintaining a desired level of reflectivity at the principle viewing area of the mirror element. The mirror element may comprise an electrochromic element or a prismatic element and may be implemented at an interior rearview mirror assembly or an exterior rearview mirror assembly. Optionally, the mirror element may comprise a substantially flat element or may comprise a curved element, such as a convex element or aspheric element or the like.

Changes and modifications in the specifically described embodiments can be carried out without departing from the principles of the invention, which is intended to be limited only by the scope of the appended claims, as interpreted according to the principles of patent law.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A mirror assembly for a vehicle, said mirror assembly comprising:

a mirror element comprising at least one substrate having a forward surface facing towards a viewer of the mirror assembly and a rearward surface facing away from a viewer of the mirror assembly, said mirror element comprising at least one substantially reflective metallic layer sandwiched between a respective pair of substantially transparent non-metallic layers, each of said substantially transparent non-metallic layers and said substantially reflective metallic layer having a selected refractive index and a selected physical thickness such that said mirror element is selectively spectrally tuned to substantially transmit at least one preselected spectral band of radiant energy therethrough while substantially reflecting other radiant energy; and

a radiant energy emitting element at or near said rearward surface of said at least one substrate, said radiant energy emitting element being operable to emit radiant energy towards said rearward surface and through said mirror element, said radiant energy emitting element being operable to emit radiant energy with a peak intensity within said at least one preselected spectral band.

2. The mirror assembly of claim 1, wherein said at least one preselected spectral band comprises a preselected band of visible light, said radiant energy emitting element being operable to emit visible radiant energy with a peak intensity within said preselected spectral band of visible light.

3. The mirror assembly of claim 1, wherein said at least one preselected spectral band comprises a preselected band of near infrared radiant energy, said radiant energy emitting element being operable to emit near infrared radiant energy with a peak intensity within said preselected spectral band of near infrared radiant energy.

4. The mirror assembly of claim 3 including an imaging sensor at or near said rearward surface, said imaging sensor being sensitive to near infrared radiant energy.

5. The mirror assembly of claim 1, wherein said at least one preselected spectral band comprises first and second preselected bands of radiant energy, said radiant energy emitting element comprises first and second radiant energy emitting elements, said first radiant energy emitting element being operable to emit radiant energy with a peak intensity within said first preselected spectral band of radiant energy and said second radiant energy emitting element being operable to emit radiant energy with a peak intensity within said second preselected spectral band of radiant energy.

6. The mirror assembly of claim 5, wherein said first and second preselected bands of radiant energy comprise first and second preselected bands of visible light, said first band being a different band than said second band.

7. The mirror assembly of claim 5, wherein said first preselected band of radiant energy comprises a band of near infrared radiant energy and said second preselected band of radiant energy comprises a band of visible light.

8. The mirror assembly of claim 1, wherein said reflective element comprises at least two substantially reflective metallic layers, each of said at least two substantially reflective metallic conductive layers being sandwiched between a respective pair of substantially transparent non-metallic layers.

9. The mirror assembly of claim 1 including an anti-reflective stack of layers at said rearward surface, said anti-reflective stack being spectrally tuned to minimize reflectance of radiant energy at said preselected spectral band.

10. The mirror assembly of claim 1, wherein said at least one substrate comprises first and second substrates, said first substrate having said forward surface and a second surface opposite said forward surface, said second substrate having said rearward surface and a third surface opposite said rearward surface, said first and second substrates being arranged so that said second surface opposes said third surface, said mirror element comprising an electrochromic medium disposed between said first and second substrates.

11. The mirror assembly of claim 10, wherein said substantially transparent non-metallic layers and said substantially reflective metallic layer are disposed between said electrochromic medium and said third surface, wherein said mirror element comprises a transflective reflector at said third surface.

12. The mirror assembly of claim 10, wherein said substantially transparent non-metallic layers and said substantially reflective metallic layer are disposed at said rearward surface of said second substrate, wherein said mirror element comprises a fourth surface reflective element.

13. The mirror assembly of claim 10, wherein said substantially transparent non-metallic layers comprise substantially transparent semi-conductive non-metallic layers and said substantially reflective metallic layer comprises a substantially reflective conductive metallic layer.

14. The mirror assembly of claim 13, wherein said substantially transparent semi-conductive non-metallic layers and said substantially reflective conductive metallic layer conduct electricity to darken or color said electrochromic medium in response to a voltage being applied to said layers.

15. The mirror assembly of claim 1, wherein said at least one substrate comprises a single substrate, said substantially transparent non-metallic layers and said substantially reflective metallic layer being disposed at said rearward surface of said single substrate.

16. The mirror assembly of claim 15, wherein said single substrate comprises a prismatic substrate.

17. The mirror assembly of claim 1 including at least one adhesion enhancement and passivation layer disposed between said reflective metallic layer and at least one of said transparent non-metallic layers to increase the corrosion resistance of said reflective metallic layer and to enhance the adhesion and the mechanical stability of said reflective metallic layer.

18. An electrochromic mirror assembly for a vehicle, said mirror assembly comprising:

an electrochromic mirror element comprising a first substrate having first and second surfaces and a second substrate having third and fourth surfaces, said first and second substrates being arranged so that said second surface opposes said third surface with an electrochromic medium disposed therebetween;

said third surface of said second substrate comprising a transflective reflector comprising a first substantially transparent semi-conductive non-metallic layer contacting the electrochromic medium, a second substantially transparent semi-conductive non-metallic layer, and a substantially reflecting metallic conductive layer sandwiched between said first and second substantially transparent semi-conductive non-metallic layers, wherein when said mirror element is viewed from outside said first surface, said mirror element is substantially spectrally untinted when no voltage is applied across said electrochromic medium, said mirror element being at least partially spectrally selective in transmission and exhibiting a spectrally selective transmission characteristic, said spectrally selective transmission characteristic being established by the refractive indices and physical thicknesses of said first and second substantially transparent semi-conductive non-metallic layers and said substantially reflective metallic conductive layer; and

a light emitting element disposed at said fourth surface of said second substrate and operable to emit light having an emitted spectral characteristic through said mirror element, wherein said transflective reflector is configured to exhibit a spectrally selective transmission characteristic so as to substantially transmit light having a spectral band in regions at or near said emitted spectral characteristic and to substantially reflect other light having a spectral band outside of said regions.

19. The electrochromic mirror assembly of claim 18, wherein said transflective reflector provides at least 20 percent transmissivity of light at or near said emitted spectral characteristic.

20. The electrochromic mirror assembly of claim 18, wherein said transflective reflector provides at least 10 percent transmissivity of light at or near said emitted spectral characteristic.

21. The electrochromic mirror assembly of claim 20, wherein said transflective reflector provides at least 60 percent photopic reflectance of other light.

22. The electrochromic mirror assembly of claim 20, wherein said transflective reflector provides at least 70 percent photopic reflectance of other light.

23. The electrochromic mirror assembly of claim 20, wherein said transflective reflector provides at least 80 percent photopic reflectance of other light.

24. The electrochromic mirror assembly of claim 18, wherein said transflective reflector provides at least 15 percent transmissivity of light at or near said emitted spectral characteristic and provides at least 60 percent photopic reflectance of other light.

25. The electrochromic mirror assembly of claim 18, wherein said transflective reflector provides at least 30 percent transmissivity of light at or near said emitted spectral characteristic and provides at least 60 percent photopic reflectance of other light.

26. The electrochromic mirror assembly of claim 18, wherein said second substantially transparent semi-conductive non-metallic layer contacts said third surface of said second substrate.

27. The electrochromic mirror assembly of claim 18, wherein said transflective reflector comprises at least two substantially reflective metallic conductive layers, each of said at least two substantially reflective metallic conductive layers being sandwiched between a respective pair of substantially transparent semi-conductive non-metallic layers disposed between said electrochromic medium and said second substrate.

28. The electrochromic mirror assembly of claim 27, wherein said transflective reflector substantially transmits light having said spectral band in the near infrared region of the spectrum, said light emitting element being operable to emit near infrared light through said transflective reflector.

29. The electrochromic mirror assembly of claim 28 including an imaging sensor at said fourth surface that is operable to sense near infrared light.

30. The electrochromic mirror assembly of claim 28, wherein said transflective reflector substantially transmits light having a second spectral band in a visible region of the spectrum, said mirror assembly including a second light emitting element at said fourth surface, said second light emitting element being operable to emit light that has a peak intensity at or near said second spectral band through said transflective reflector.

31. The electrochromic mirror assembly of claim 27, wherein said transflective reflector substantially transmits light having said spectral band at a first visible region of the spectrum.

32. The electrochromic mirror assembly of claim 31, wherein said transflective reflector substantially transmits light having a second spectral band in a second visible region of the spectrum, said mirror assembly including a second light emitting element at said fourth surface, said second light emitting element being operable to emit light that has a peak intensity at or near said second spectral band through said transflective reflector.

33. An electrochromic mirror assembly for a vehicle, said mirror assembly comprising:

an electrochromic mirror element comprising a first substrate having first and second surfaces and a second substrate having third and fourth surfaces, said first and second substrates being arranged so that said second surface opposes said third surface with an electrochromic medium disposed therebetween;

said third surface of said second substrate comprising at least one conductive metallic layer and at least one transparent, at least partially conductive layer, wherein said layers define first and second regions of said transflective reflector, said first region having a first reflectivity and a first transmissivity and said second region having a second reflectivity and a second transmissivity, said second transmissivity being greater than said first transmissivity; and

a display element positioned at said fourth surface of said second substrate and operable to transmit light through said second region of said transflective reflector.

34. The electrochromic mirror assembly of claim 33, wherein said first reflectivity is greater than said second reflectivity.

35. The electrochromic mirror assembly of claim 34, wherein said first reflectivity comprises at least approximately 60%.

36. The electrochromic mirror assembly of claim 33, wherein said first region comprises a generally central region of said electrochromic mirror element and said second region comprises at least one side region of said electrochromic mirror element.

37. The electrochromic mirror assembly of claim 33, wherein said transflective reflector comprises a first substantially transparent semi-conductive layer contacting the electrochromic medium, a second substantially transparent semi-conductive layer, and a substantially reflecting metallic conductive layer sandwiched between said first and second substantially transparent semi-conductive layers.

38. The electrochromic mirror assembly of claim 37, wherein a thickness of at least one of said layers is varied between said first and second regions.

39. The electrochromic mirror assembly of claim 38, wherein each of said first and second transparent semi-conductive layers and said substantially reflective metallic conductive layer of said second region have a selected refractive index and a selected physical thickness such that said transflective reflector is selectively spectrally tuned to substantially transmit at least one preselected spectral band of light therethrough while substantially reflecting other light, said display element being operable to transmit light with a peak intensity within said preselected spectral band through said second region of said transflective reflector.

40. A mirror assembly for a vehicle, said mirror assembly comprising:

a mirror element comprising a substrate having a forward surface facing towards a viewer of the mirror assembly and a rearward surface facing away from a viewer of the mirror assembly, said mirror element comprising at least one substantially reflective metallic layer sandwiched between a respective pair of substantially transparent non-metallic layers disposed at said rearward surface of said substrate, each of said substantially transparent non-metallic layers and said substantially reflective metallic layer having a selected refractive index and a selected physical thickness such that said mirror element is selectively spectrally tuned to substantially transmit at least one preselected spectral band of radiant energy therethrough while substantially reflecting other radiant energy; and

a radiant energy emitting element at or near said rearward surface of said substrate, , said radiant energy emitting element being operable to emit radiant energy towards said rearward surface and through said mirror element, said radiant energy emitting element being operable to emit radiant energy with a peak intensity within said at least one preselected spectral band.

41. The mirror assembly of claim 40, wherein said at least one preselected spectral band comprises a preselected band of visible light, said radiant energy emitting element being operable to emit visible radiant energy with a peak intensity within said preselected spectral band of visible light.

42. The mirror assembly of claim 41, wherein said radiant energy emitting element comprises a display on demand element.

43. The mirror assembly of claim 40, wherein said at least one preselected spectral band comprises a preselected band of near infrared radiant energy, said radiant energy emitting element being operable to emit near infrared radiant energy with a peak intensity within said preselected spectral band of near infrared radiant energy.

44. The mirror assembly of claim 43 including an imaging sensor at or near said rearward surface, said imaging sensor being sensitive to near infrared radiant energy.

45. The mirror assembly of claim 40, wherein said at least one preselected spectral band comprises first and second preselected bands of radiant energy, said radiant energy emitting element comprises first and second radiant energy emitting elements, said first radiant energy emitting element being operable to emit radiant energy with a peak intensity within said first preselected spectral band of radiant energy and said second radiant energy emitting element

being operable to emit radiant energy with a peak intensity within said second preselected spectral band of radiant energy.

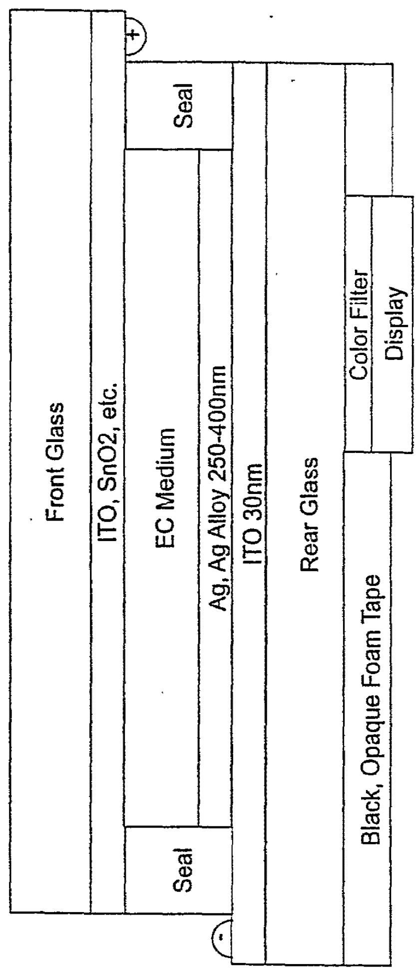
46. The mirror assembly of claim 45, wherein said first and second preselected bands of radiant energy comprise first and second preselected bands of visible light, said first band being a different band than said second band.

47. The mirror assembly of claim 45, wherein said first preselected band of radiant energy comprises a band of near infrared radiant energy and said second preselected band of radiant energy comprises a band of visible light.

48. The mirror assembly of claim 40, wherein said reflective element comprises at least two substantially reflective metallic layers, each of said at least two substantially reflective metallic conductive layers being sandwiched between a respective pair of substantially transparent non-metallic layers.

49. The mirror assembly of claim 40 including an anti-reflective stack of layers at said rearward surface, said anti-reflective stack being spectrally tuned to minimize reflectance of radiant energy at said preselected spectral band.

50. The mirror assembly of claim 40, wherein said single substrate comprises a prismatic substrate.



PRIOR ART

Figure 1

PRIOR ART

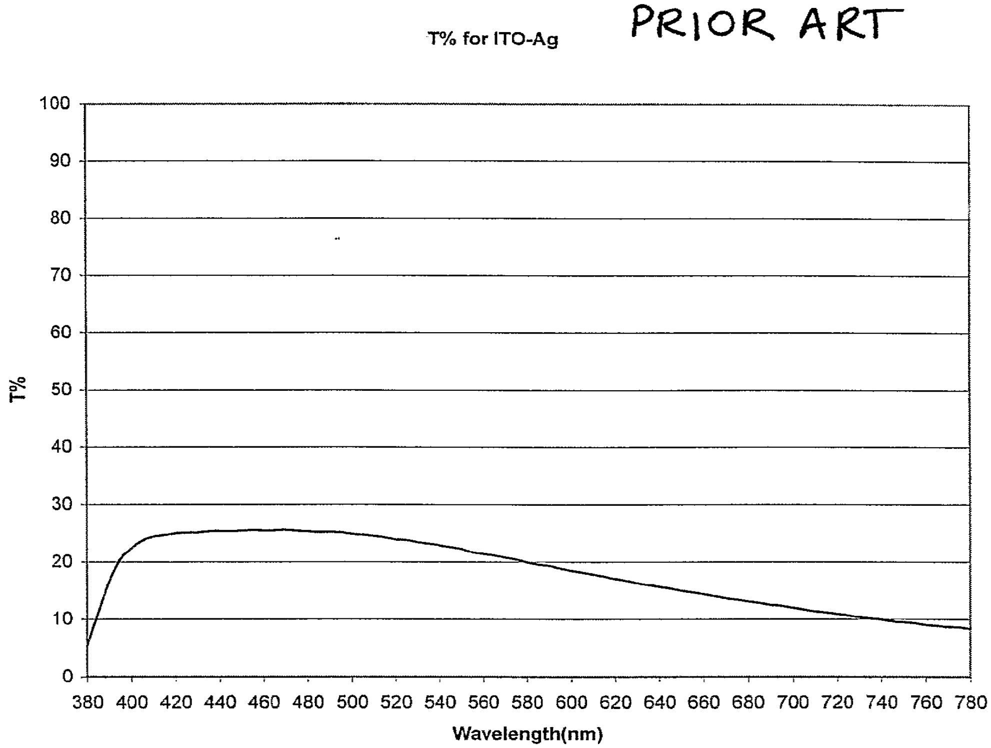


FIG. 1A

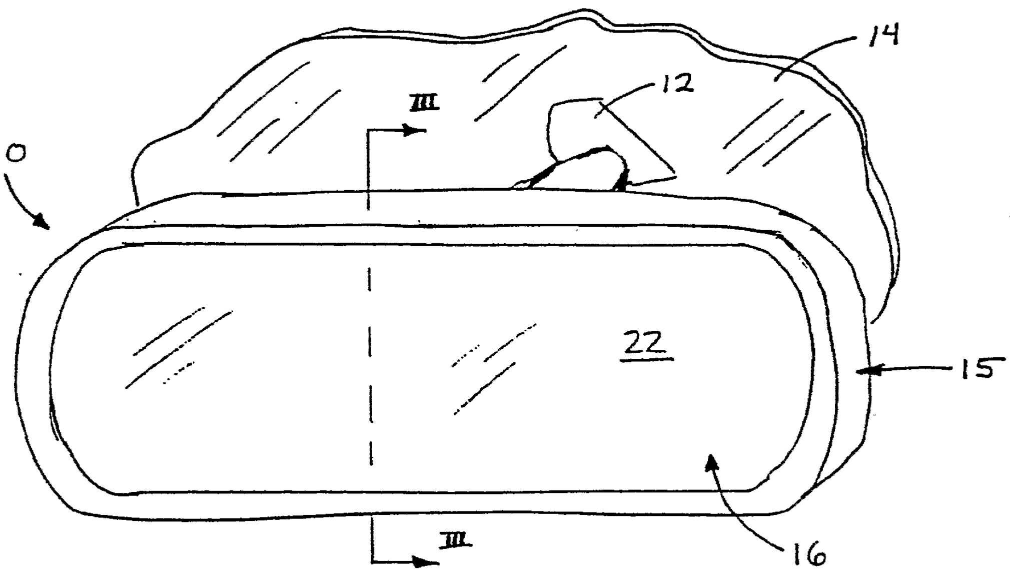


FIG.2

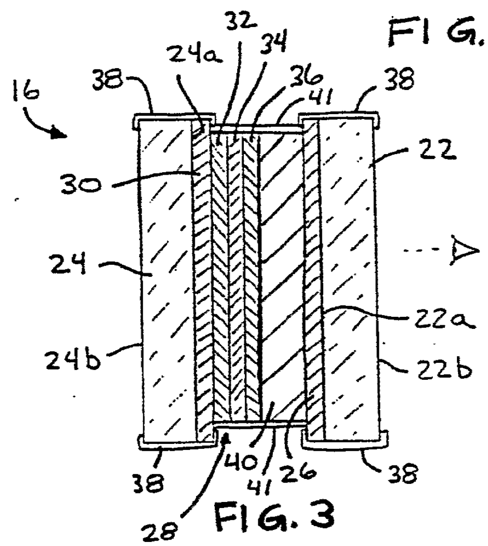


FIG.3

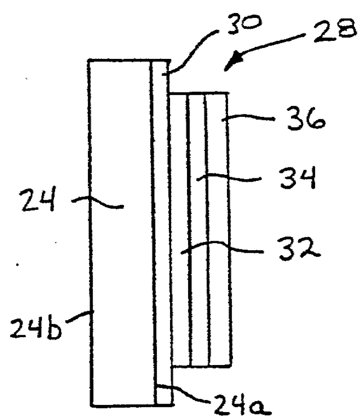


FIG.4

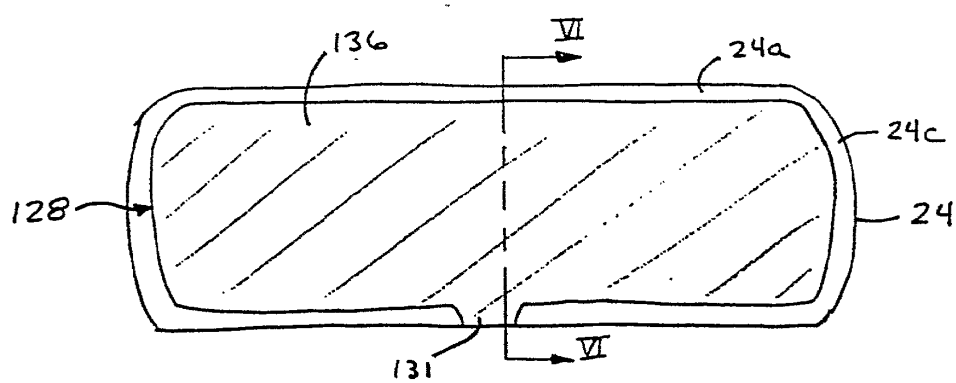


FIG.5

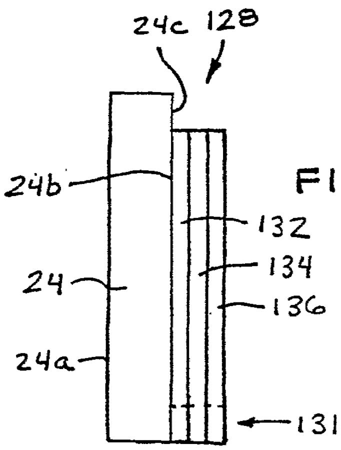


FIG. 6

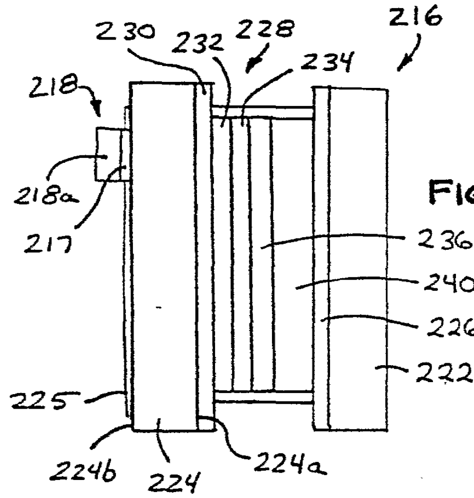


FIG. 8

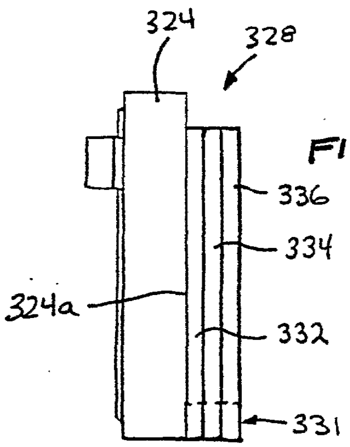


FIG. 9

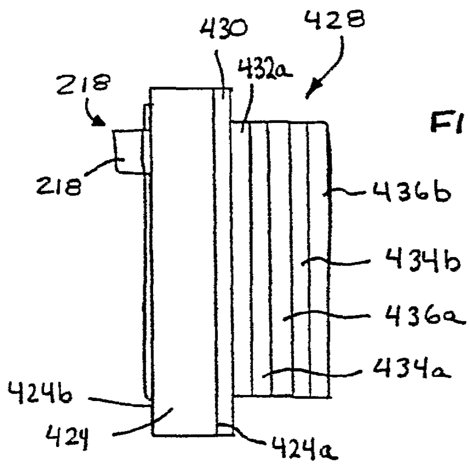


FIG. 10

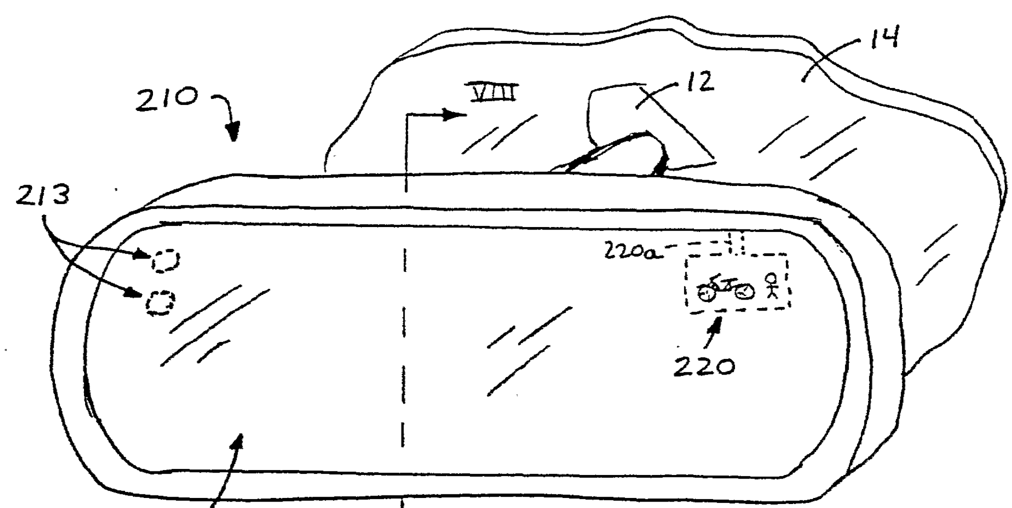


FIG. 7

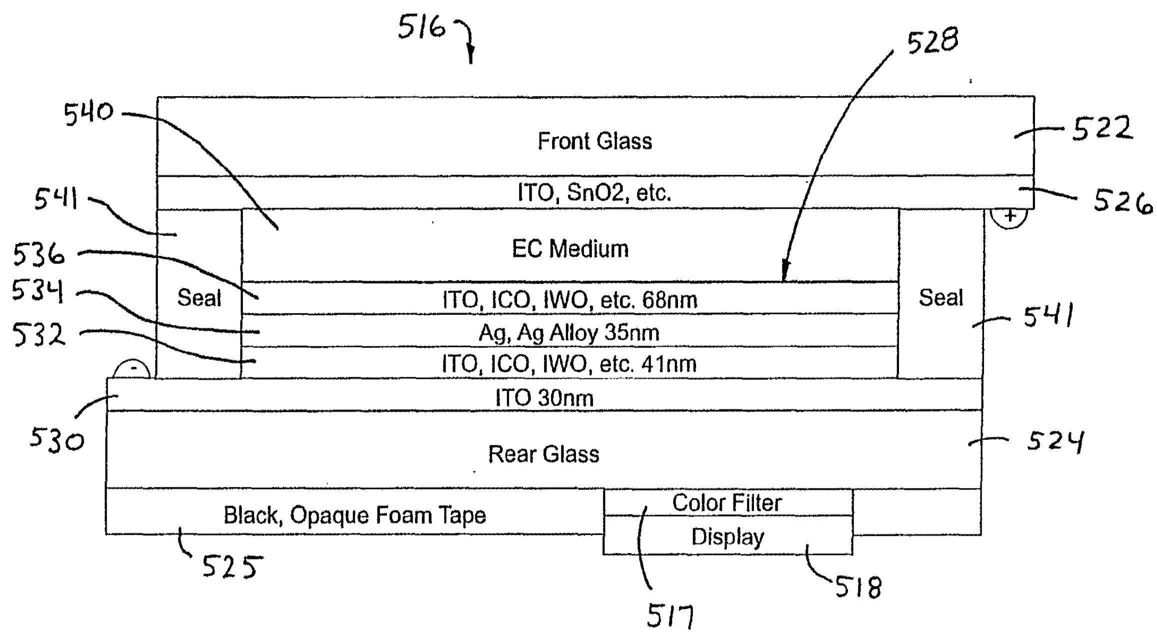

516
528
540
Front Glass
522
541
ITO, SnO2, etc.
526
+
EC Medium
536
534
Seal
ITO, ICO, IWO, etc. 68nm
Seal
532
Ag, Ag Alloy 35nm
541
-
ITO, ICO, IWO, etc. 41nm
ITO 30nm
530
Rear Glass
524
Black, Opaque Foam Tape
Color Filter
Display
525
518
517

Figure 11

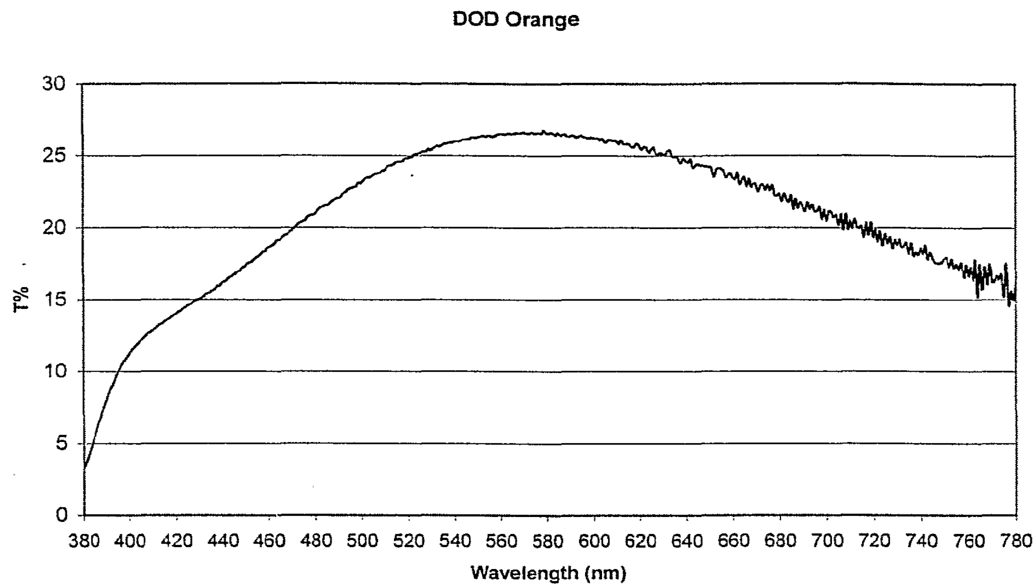


FIG. 11A

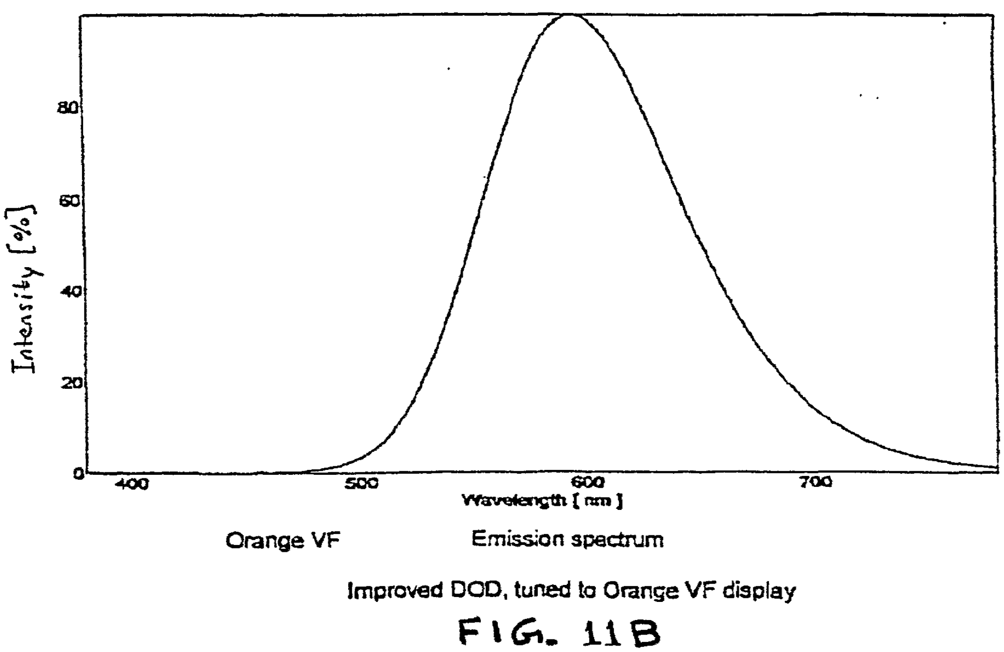
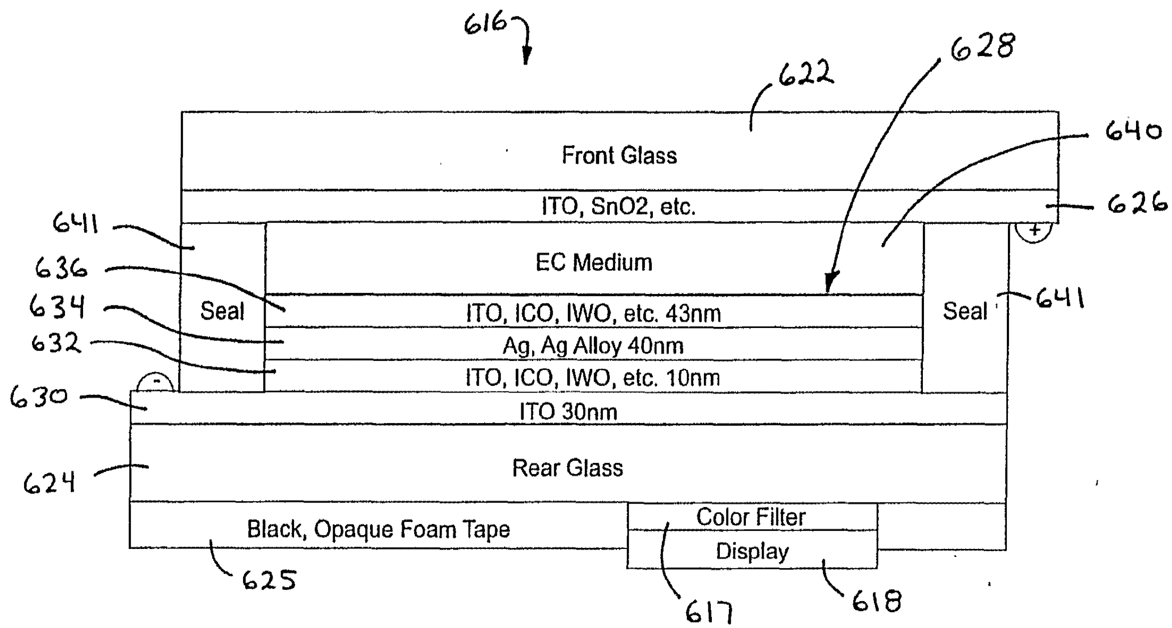


FIG. 11B



616
622
628
640
626
641
636
634
632
630
624
625
617
618
641
Front Glass
ITO, SnO2, etc.
EC Medium
Seal
Seal
ITO, ICO, IWO, etc. 43nm
Ag, Ag Alloy 40nm
ITO, ICO, IWO, etc. 10nm
ITO 30nm
Rear Glass
Black, Opaque Foam Tape
Color Filter
Display
+
-

Figure 12

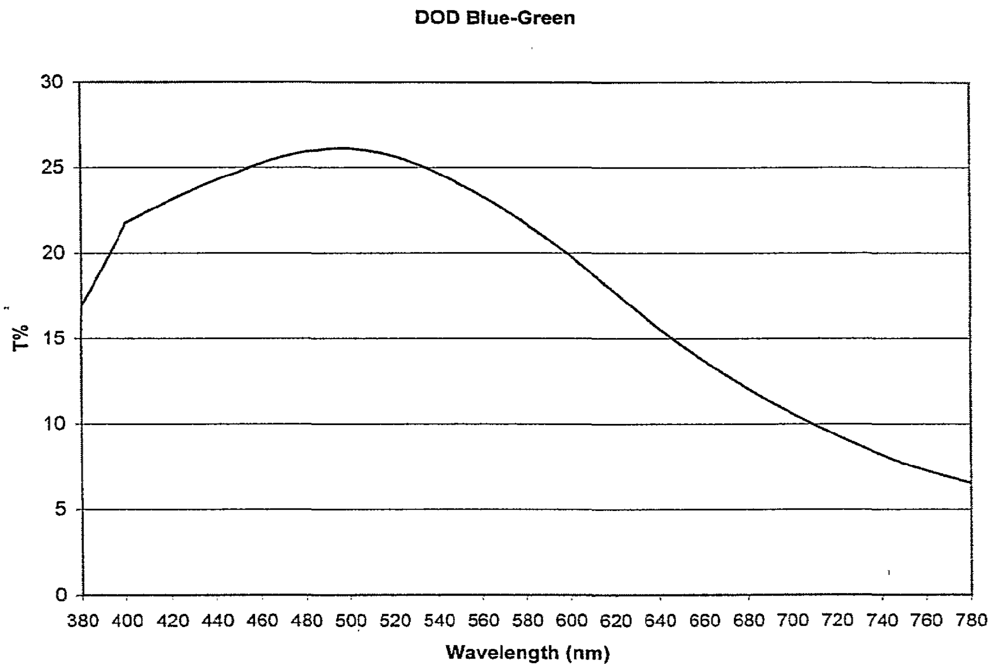
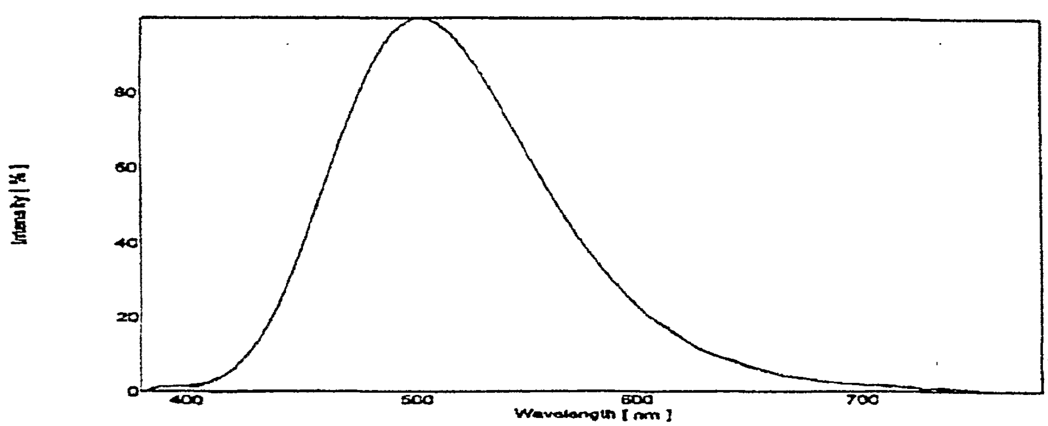


FIG. 12A



Blue-Green VF display: Emission spectrum
Improved DOD tuned to Blue-Green VF display

FIG. 12B

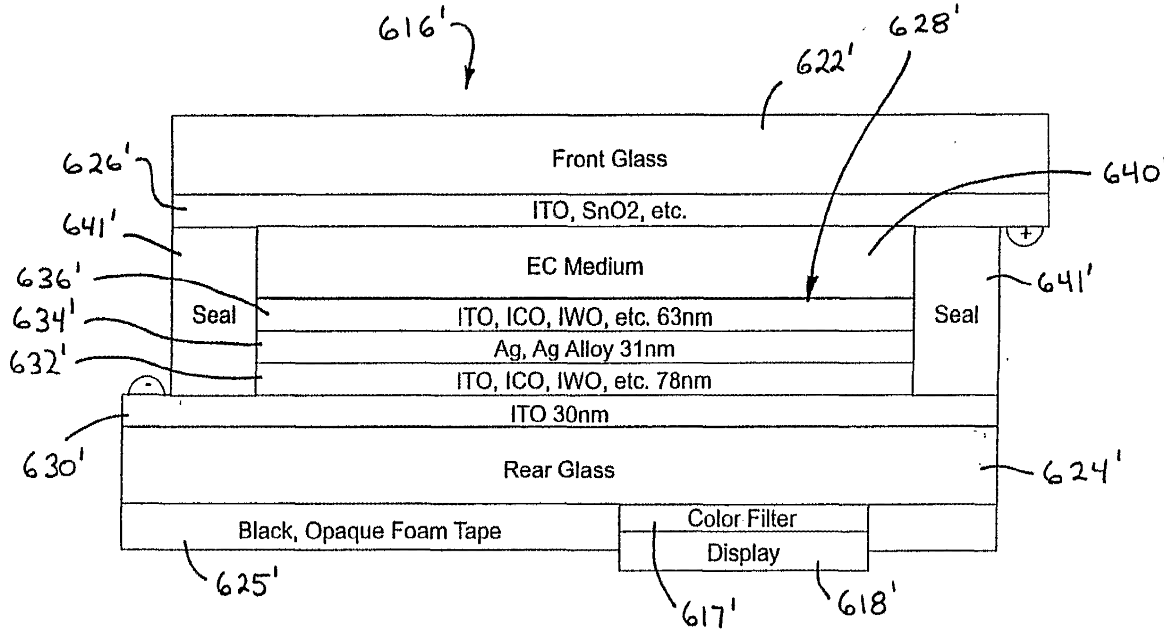

616'
622'
628'
Front Glass
626'
640'
ITO, SnO2, etc.
641'
EC Medium
636'
+
641'
Seal
ITO, ICO, IWO, etc. 63nm
Seal
634'
Ag, Ag Alloy 31nm
632'
ITO, ICO, IWO, etc. 78nm
-
ITO 30nm
630'
Rear Glass
624'
Black, Opaque Foam Tape
Color Filter
Display
625'
617'
618'

Figure 13

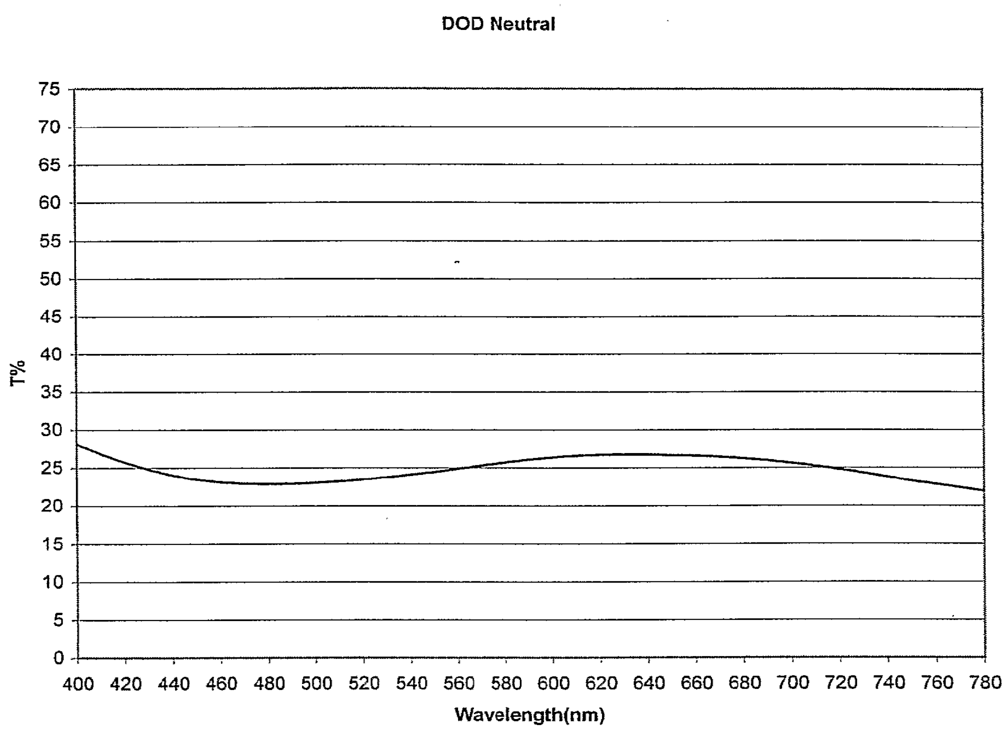

DOD Neutral
T%
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780
Wavelength(nm)

FIG. 13A

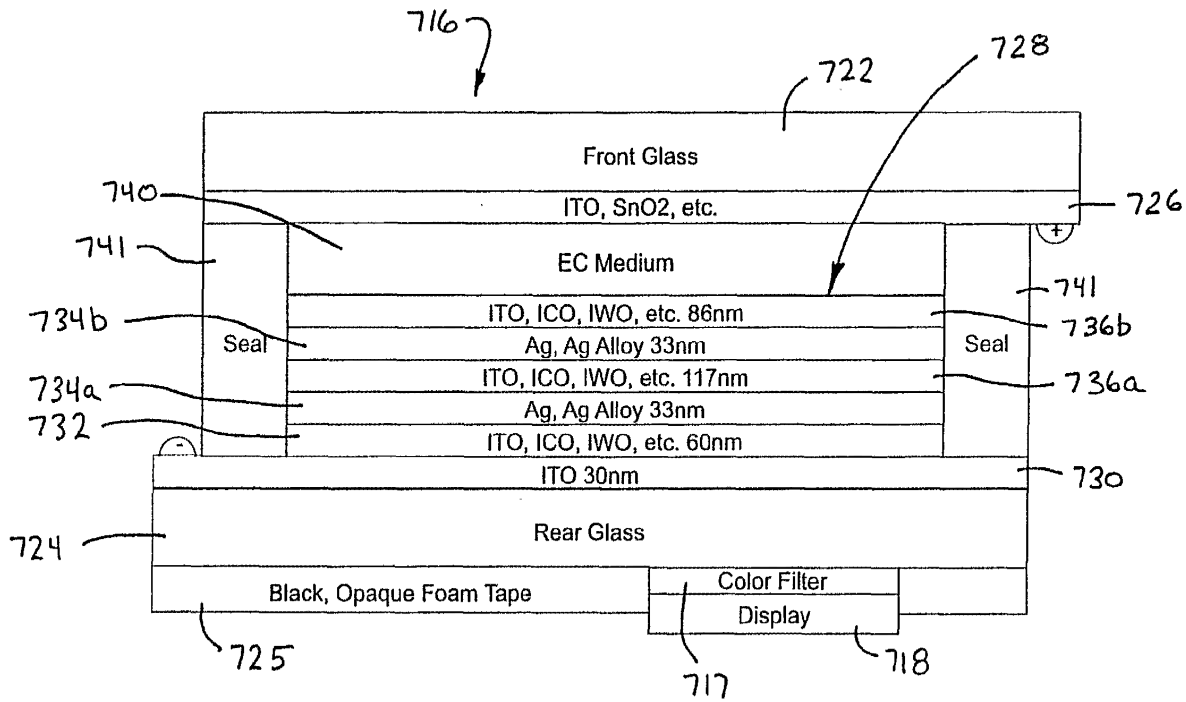

716
722
728
Front Glass
ITO, SnO2, etc.
726
740
741
EC Medium
741
734b
ITO, ICO, IWO, etc. 86nm
736b
Seal
Ag, Ag Alloy 33nm
Seal
734a
ITO, ICO, IWO, etc. 117nm
736a
732
Ag, Ag Alloy 33nm
ITO, ICO, IWO, etc. 60nm
ITO 30nm
730
724
Rear Glass
Black, Opaque Foam Tape
Color Filter
Display
725
717
718

Figure 14

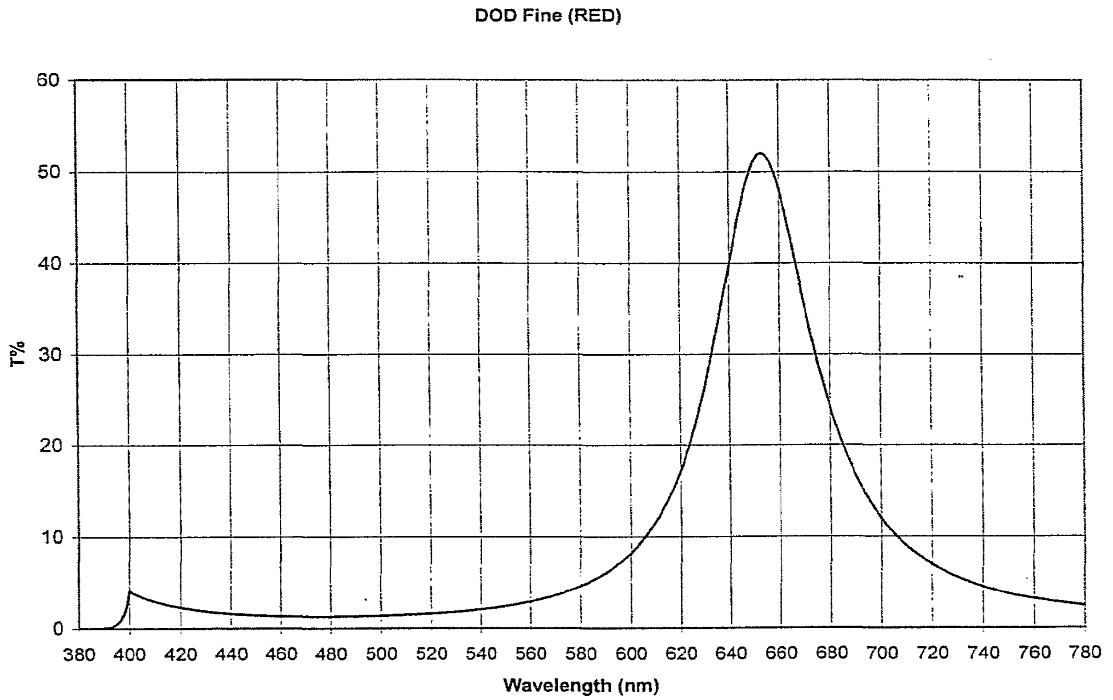


FIG. 14A

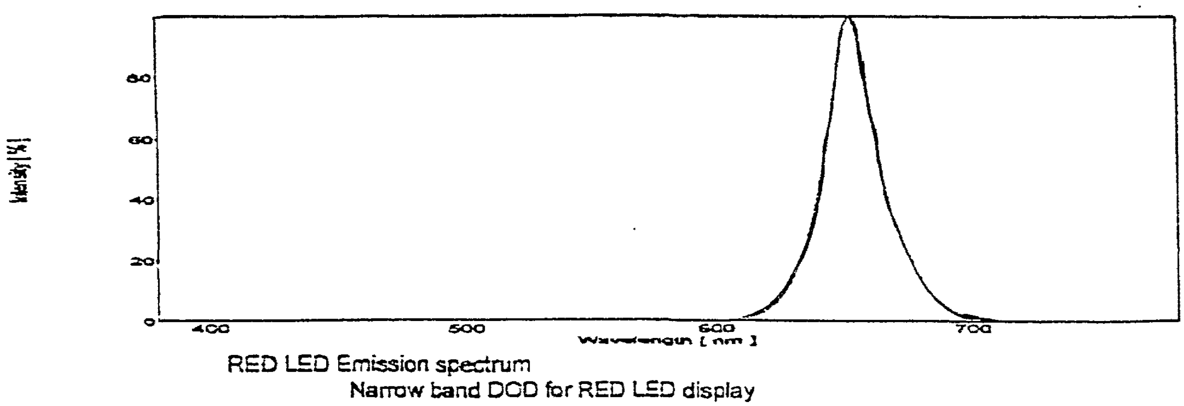


FIG. 14B

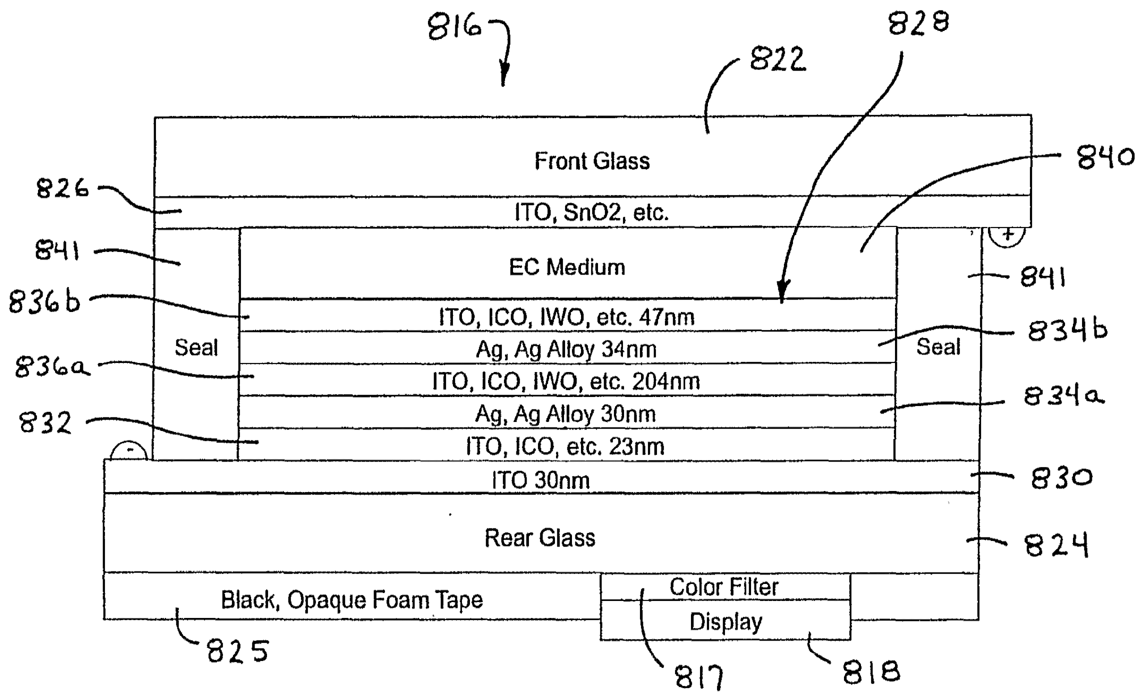

816
822
828
840
Front Glass
826
ITO, SnO2, etc.
841
EC Medium
836b
ITO, ICO, IWO, etc. 47nm
Seal
Ag, Ag Alloy 34nm
Seal
834b
836a
ITO, ICO, IWO, etc. 204nm
Ag, Ag Alloy 30nm
834a
832
ITO, ICO, etc. 23nm
ITO 30nm
830
Rear Glass
824
Black, Opaque Foam Tape
Color Filter
Display
825
817
818

Figure 15

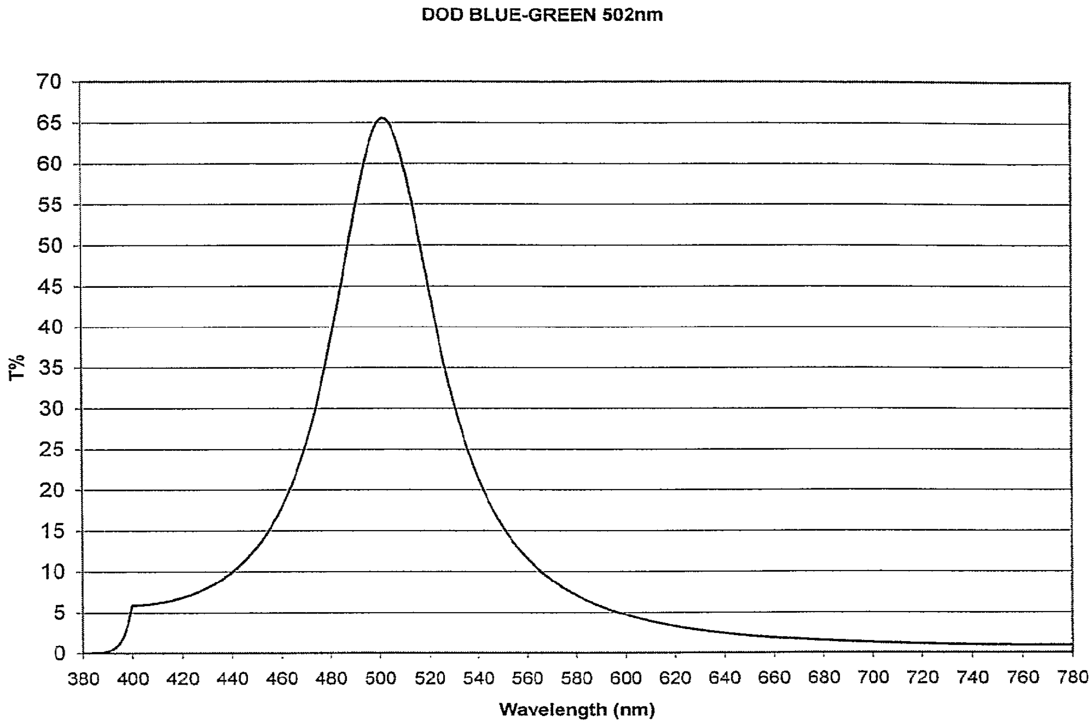

DOD BLUE-GREEN 502nm
T%
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780
Wavelength (nm)

FIG. 15A

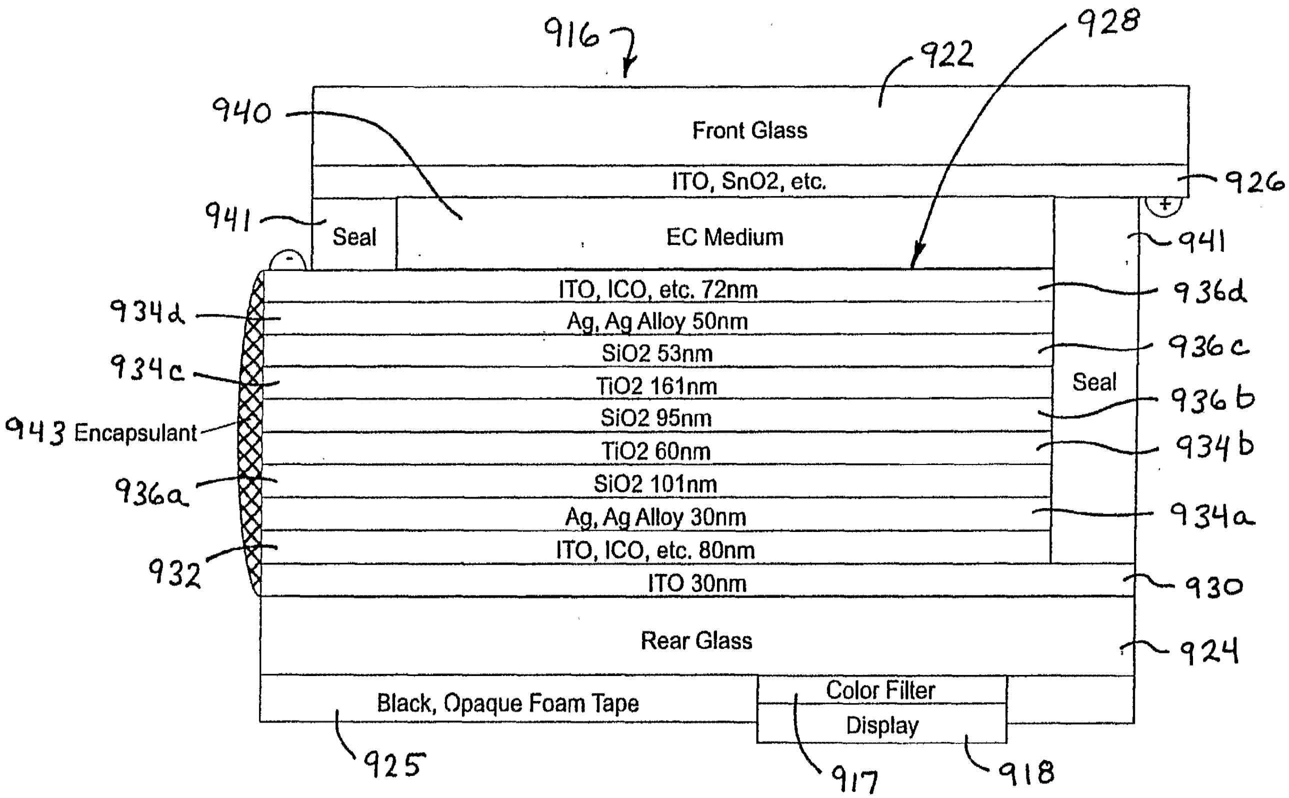

916
922
928
940
Front Glass
ITO, SnO2, etc.
926
941
Seal
EC Medium
941
ITO, ICO, etc. 72nm
936d
934d
Ag, Ag Alloy 50nm
SiO2 53nm
936c
934c
TiO2 161nm
Seal
936b
943 Encapsulant
SiO2 95nm
TiO2 60nm
934b
936a
SiO2 101nm
Ag, Ag Alloy 30nm
934a
932
ITO, ICO, etc. 80nm
ITO 30nm
930
Rear Glass
924
Black, Opaque Foam Tape
Color Filter
Display
925
917
918

Figure 16

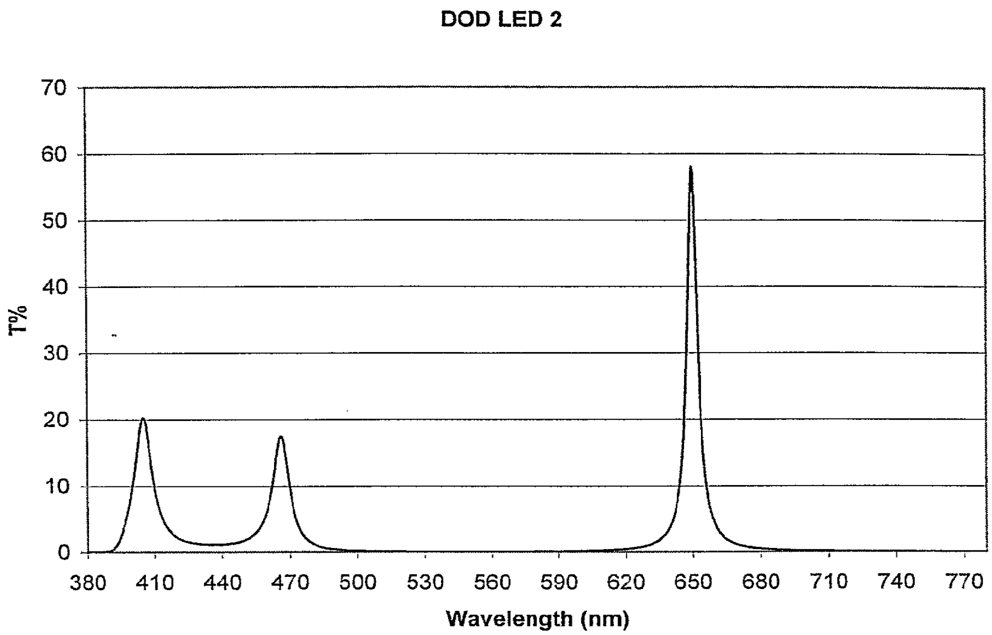

DOD LED 2
70
60
50
40
30
20
10
0
T%
380
410
440
470
500
530
560
590
620
650
680
710
740
770
Wavelength (nm)

FIG. 16A

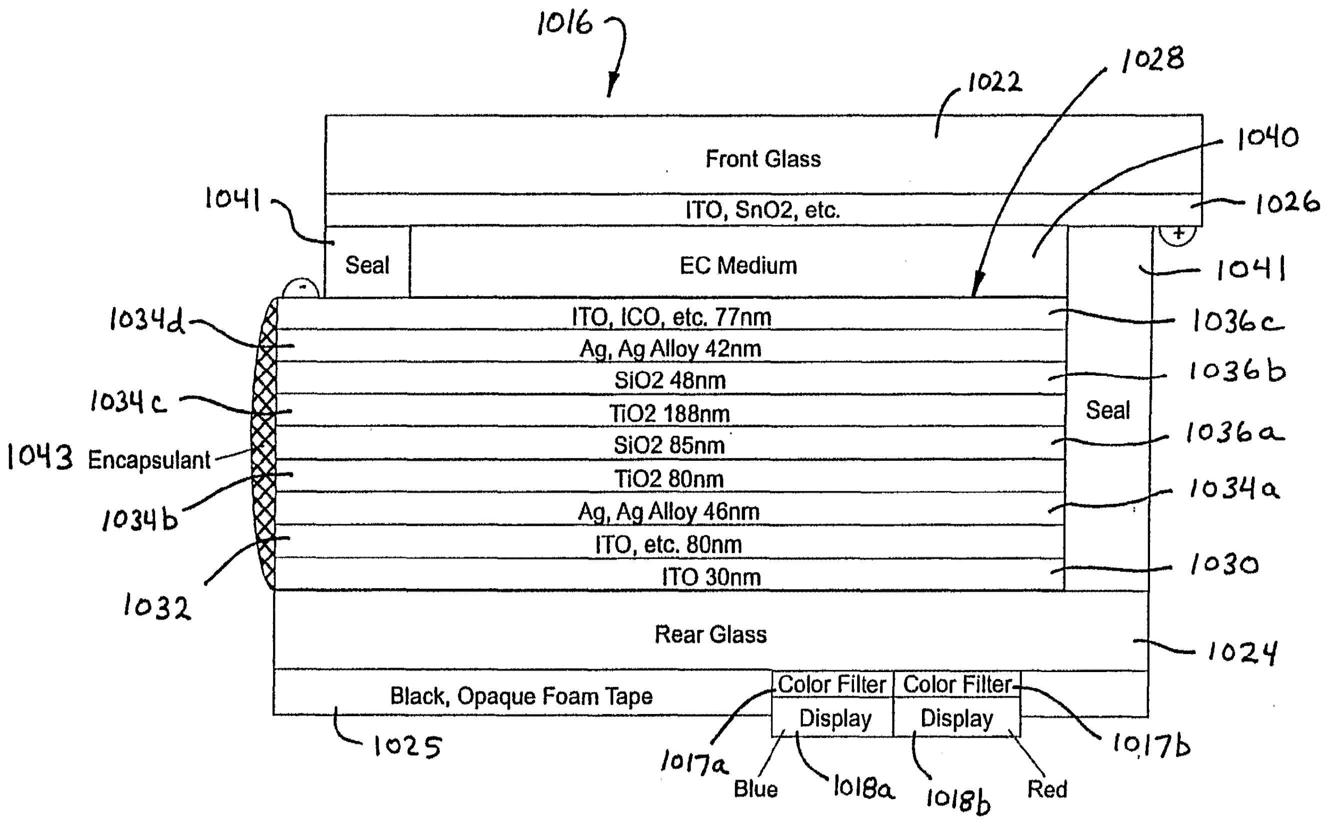

1016
1022
1028
1040
Front Glass
ITO, SnO2, etc.
1026
1041
Seal
EC Medium
+
1041
-
1034d
ITO, ICO, etc. 77nm
1036c
Ag, Ag Alloy 42nm
SiO2 48nm
1036b
1034c
TiO2 188nm
Seal
1043
Encapsulant
SiO2 85nm
1036a
TiO2 80nm
1034b
Ag, Ag Alloy 46nm
1034a
ITO, etc. 80nm
1032
ITO 30nm
1030
Rear Glass
1024
Black, Opaque Foam Tape
Color Filter
Color Filter
Display
Display
1025
1017a
1017b
Blue
1018a
1018b
Red

Figure 17

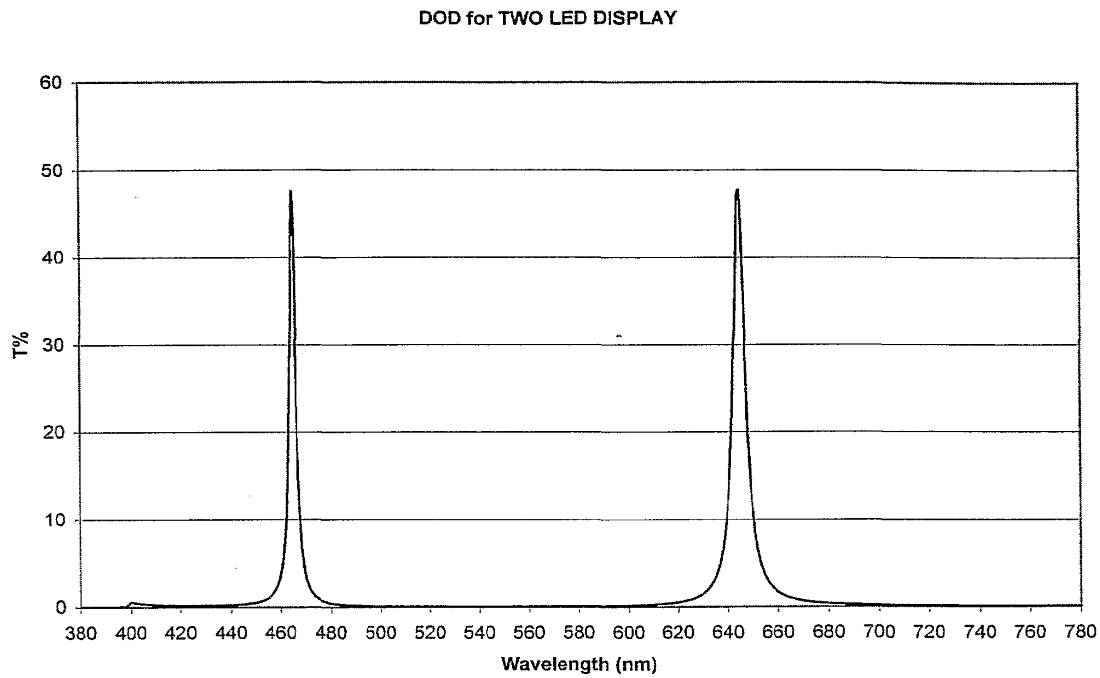

DOD for TWO LED DISPLAY
60
50
40
30
20
10
0
T%
380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780
Wavelength (nm)

FIG. 17A

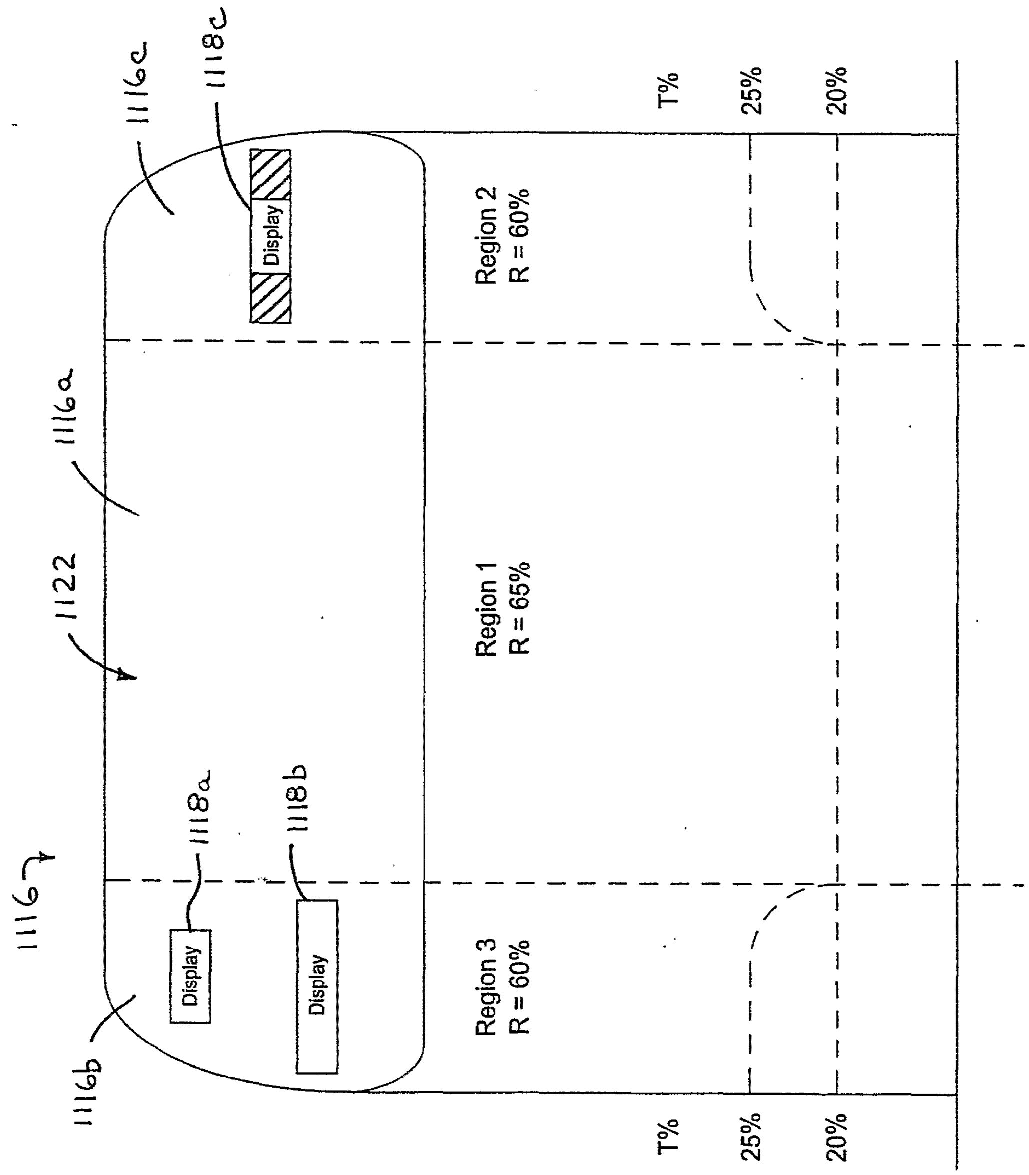

1116
1116a
1116b
1116c
1118a
1118b
1118c
1122
Display
Display
Display
Region 1
R = 65%
Region 2
R = 60%
Region 3
R = 60%
T%
25%
20%
T%
25%
20%

FIG. 18

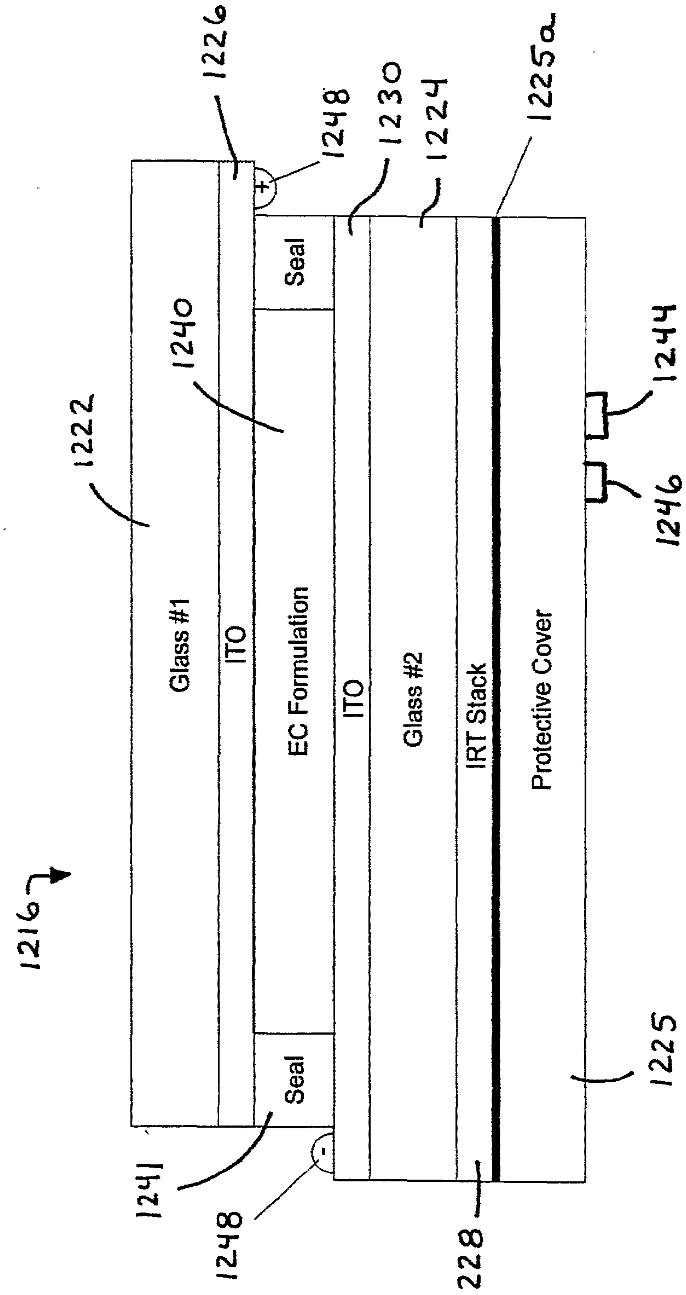

1216
1222
1226
1248
1230
1224
1225a
1240
Glass #1
ITO
Seal
EC Formulation
ITO
Glass #2
IRT Stack
Protective Cover
1244
1246
Seal
1241
1248
1228
1225
+
-

Figure 19

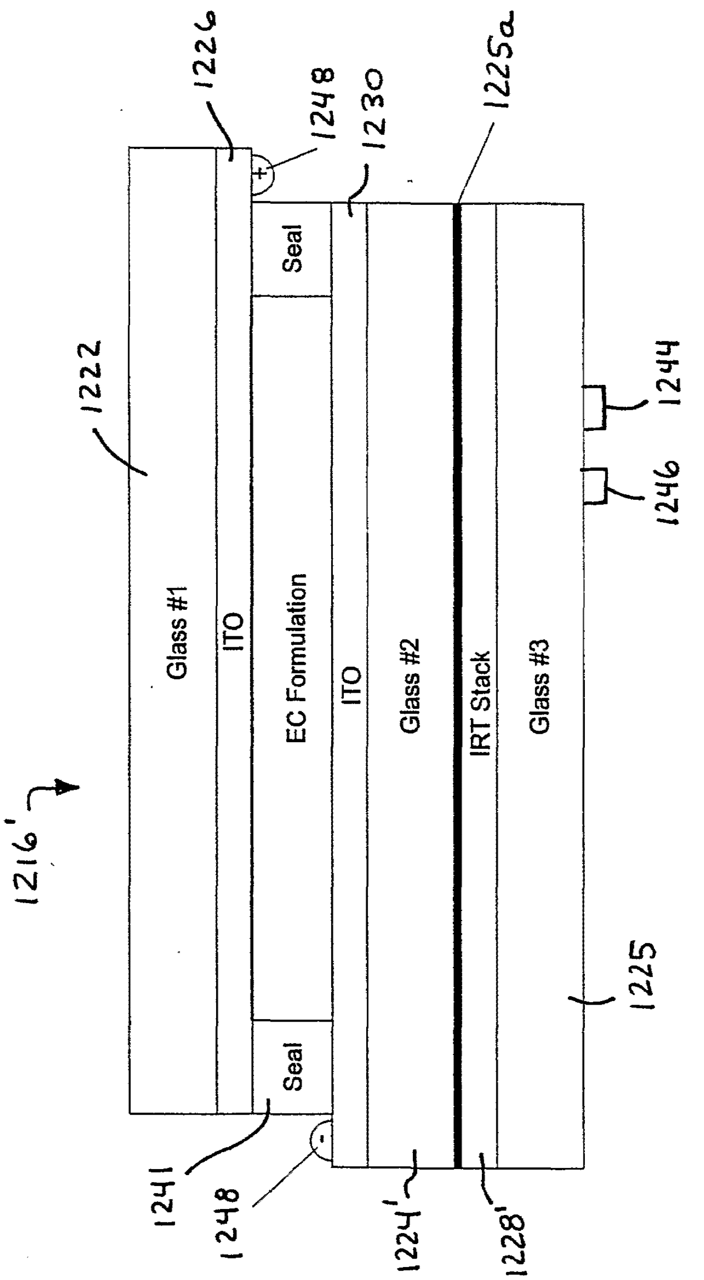

1216'
1222
1226
1248
+
1230
1225a
Seal
Glass #1
ITO
EC Formulation
ITO
Glass #2
IRT Stack
Glass #3
1244
1246
1225
Seal
-
1241
1248
1224'
1228'

Figure 20

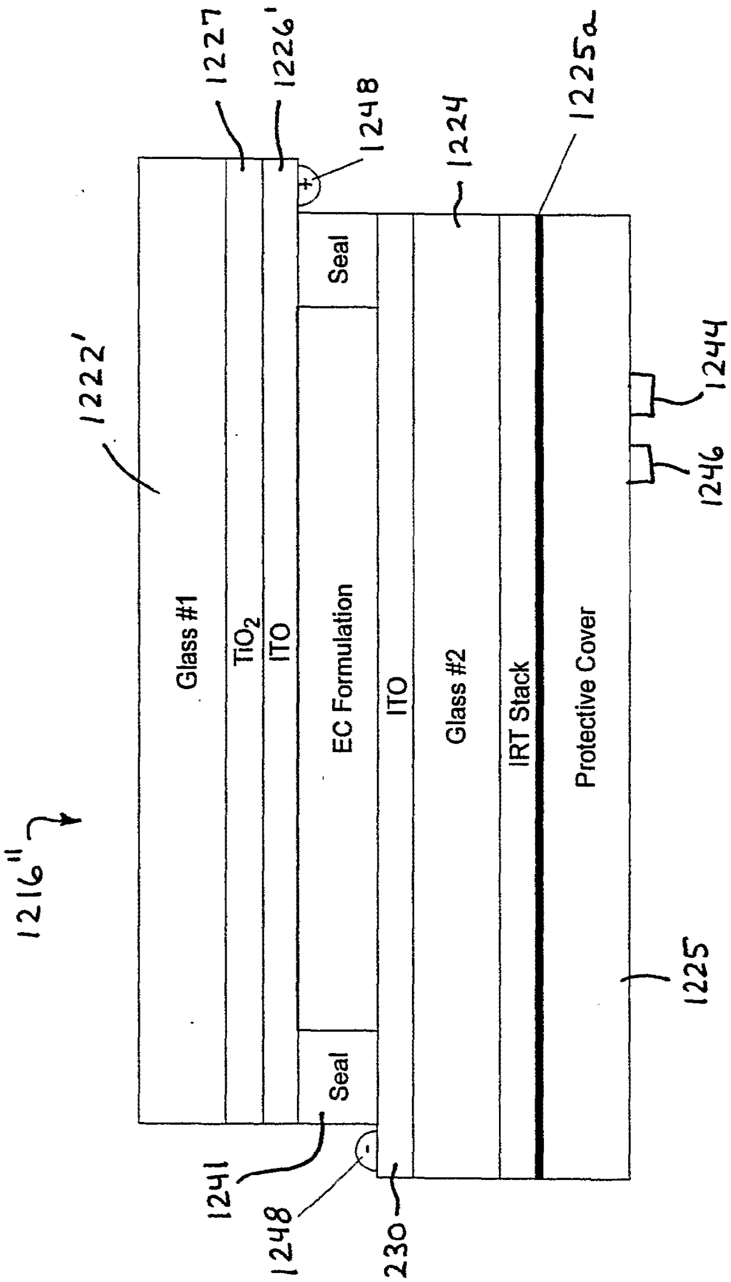

1216''
1222'
1227
1226'
1248
1224
1225a
Glass #1
TiO2
ITO
Seal
EC Formulation
Seal
ITO
Glass #2
IRT Stack
Protective Cover
1244
1246
1225
1241
1248
1230

Figure 21

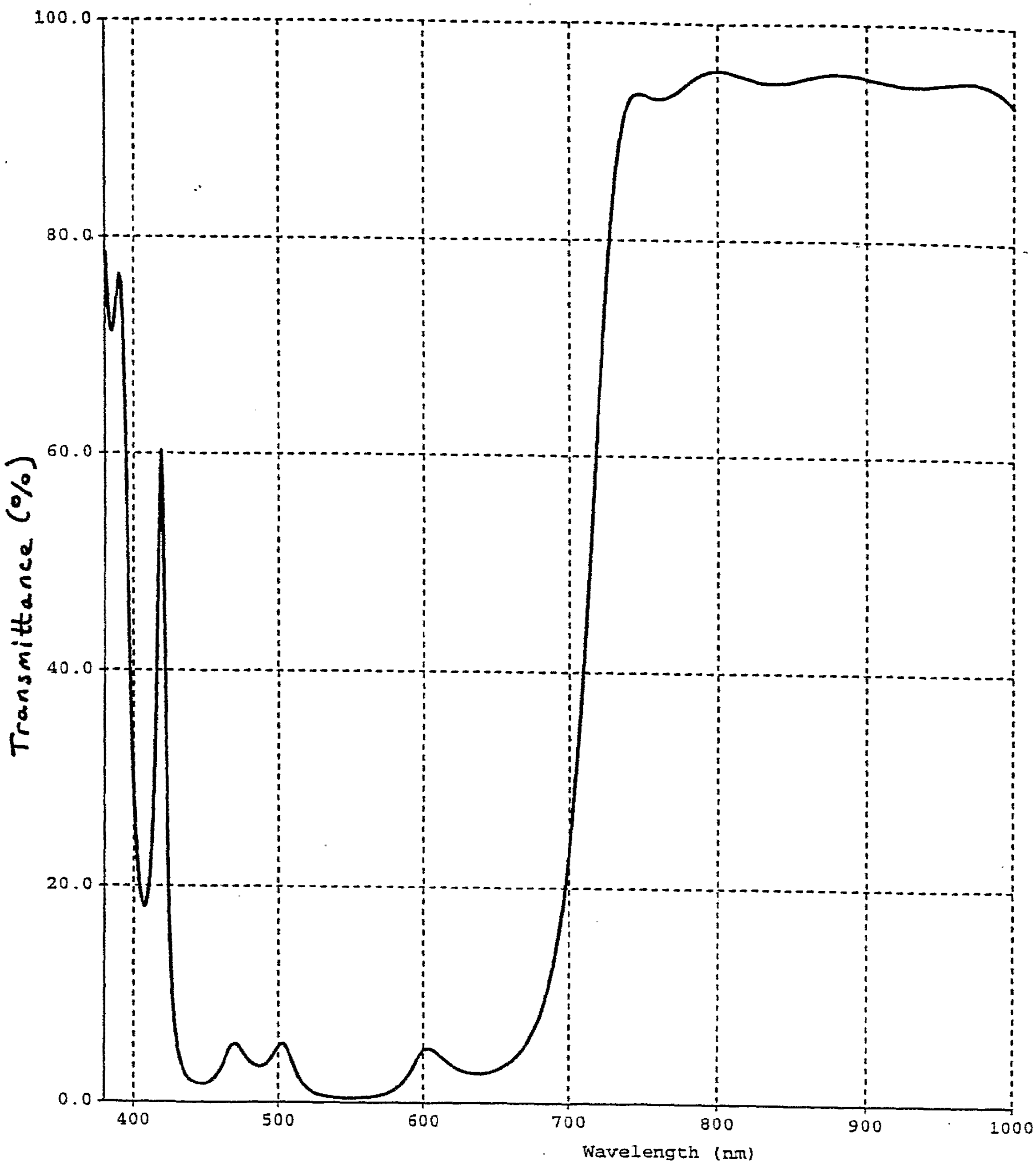

100.0
80.0
60.0
40.0
20.0
0.0
400
500
600
700
800
900
1000
Wavelength (nm)
Transmittance (%)

Figure 22

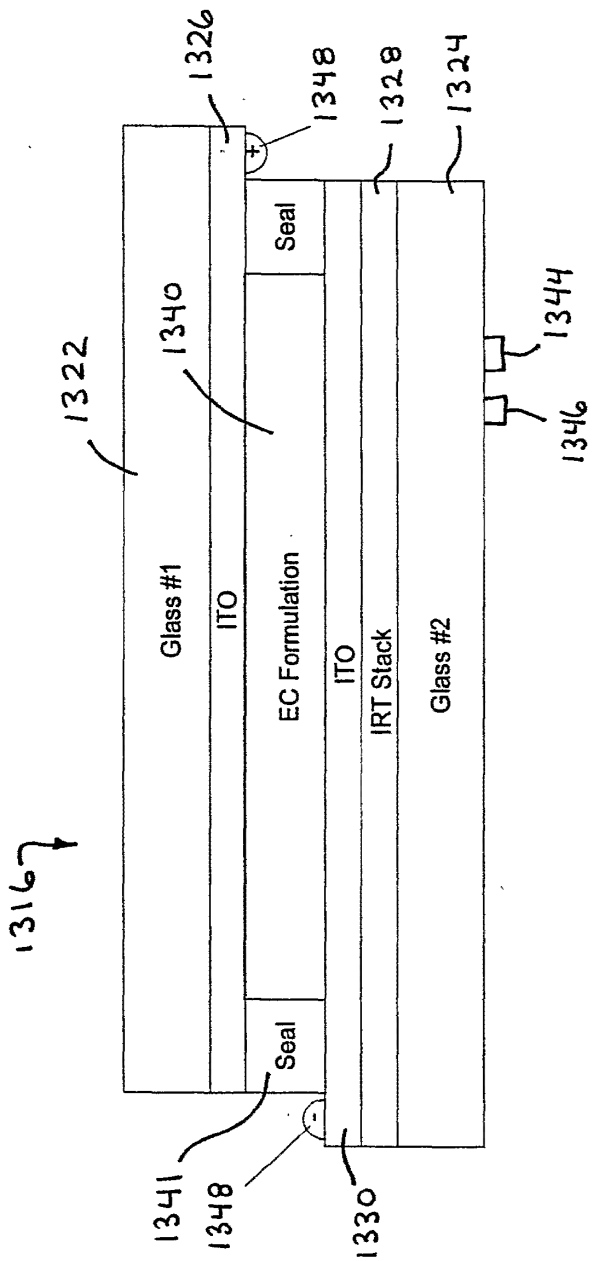

1316
1322
1340
1326
1348
1328
1324
Seal
Glass #1
ITO
EC Formulation
ITO
IRT Stack
Glass #2
1344
1346
Seal
1341
1348
1330

Figure 23

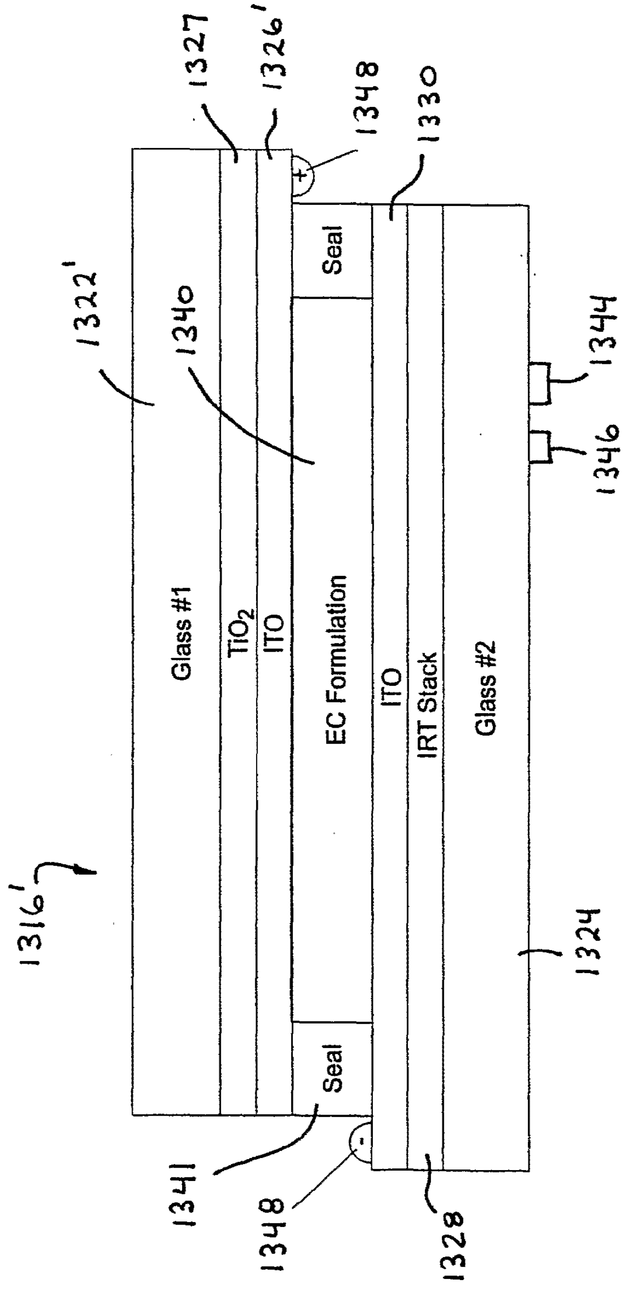

1327
1326'
1348
1330
1322'
1340
Seal
1344
1346
Glass #1
TiO_2
ITO
EC Formulation
ITO
IRT Stack
Glass #2
1316'
1324
Seal
1341
1348
1328

Figure 24

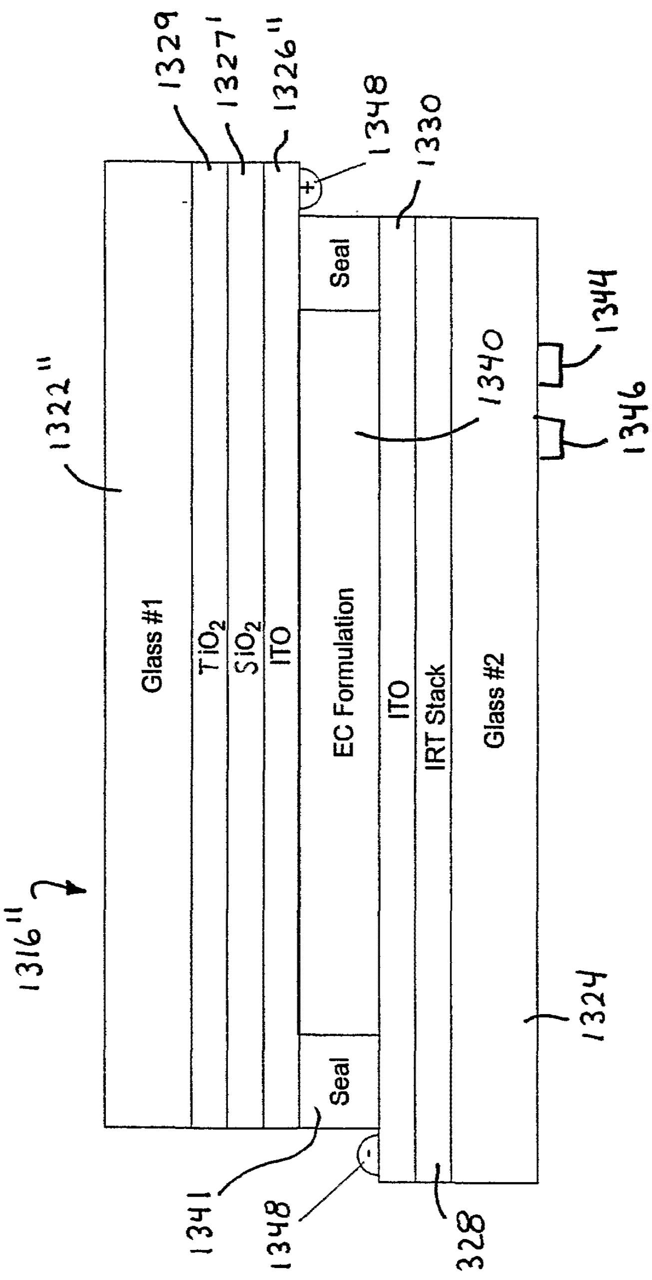

1316''
1322''
1329
1327'
1326''
1348
1330
Seal
1344
1340
1346
Glass #1
TiO_2
SiO_2
ITO
EC Formulation
ITO
IRT Stack
Glass #2
1324
Seal
1341
1348
1328

Figure 25

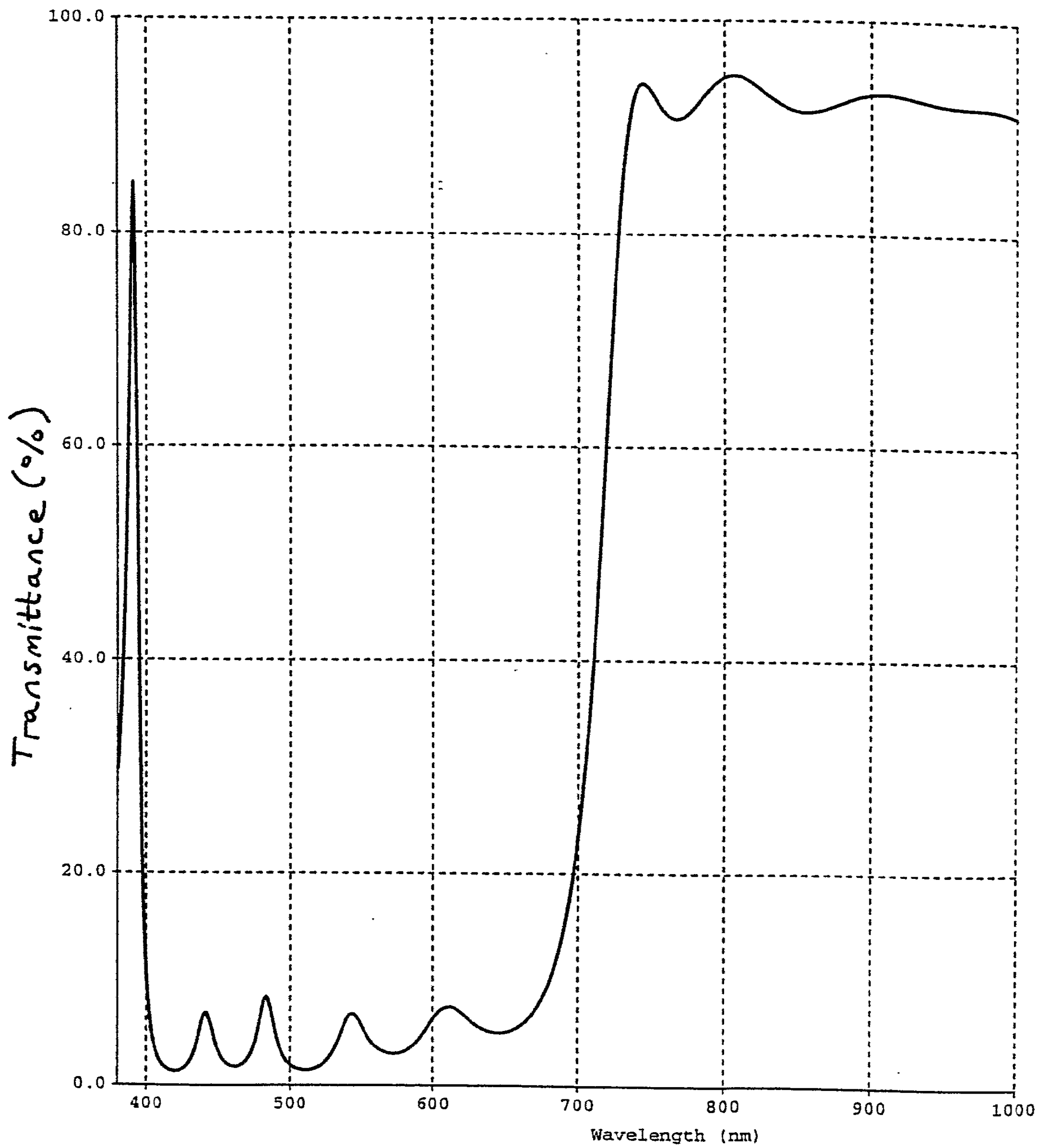

Transmittance (%)
100.0
80.0
60.0
40.0
20.0
0.0
400
500
600
700
800
900
1000
Wavelength (nm)

Figure 26

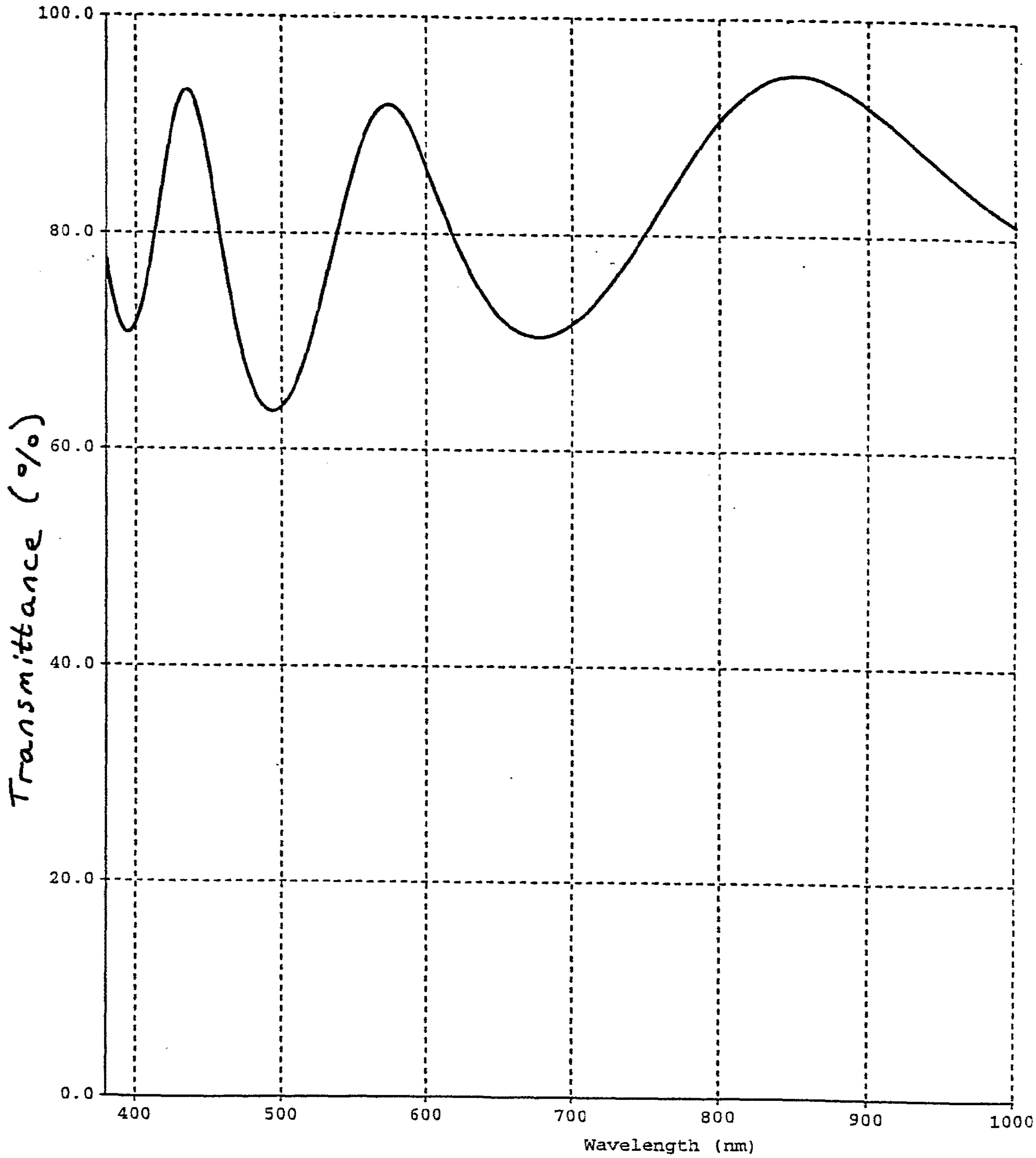

100.0
80.0
60.0
40.0
20.0
0.0
Transmittance (%)
400
500
600
700
800
900
1000
Wavelength (nm)

Figure 27

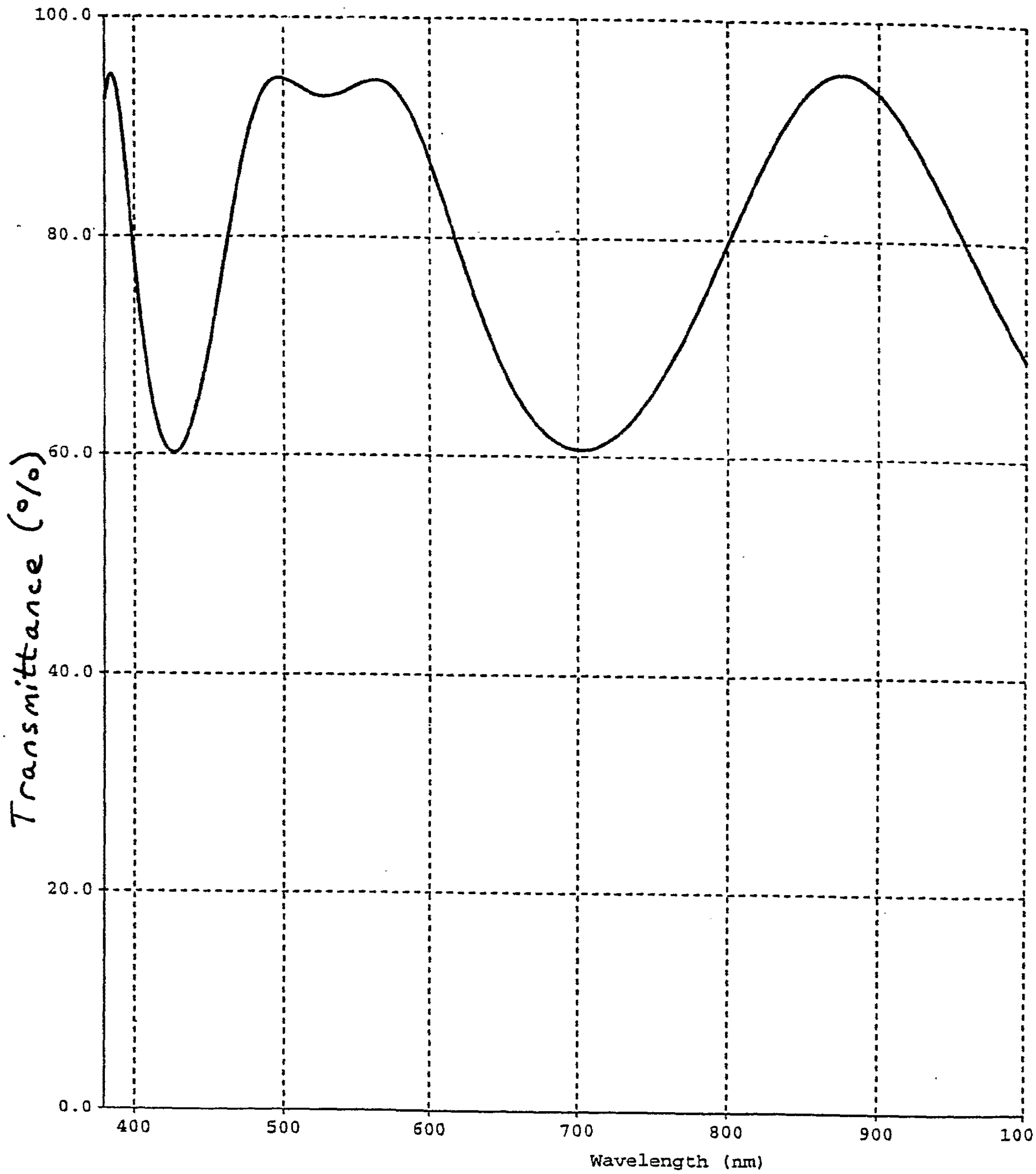

100.0
80.0
60.0
40.0
20.0
0.0
Transmittance (%)
400
500
600
700
800
900
1000
Wavelength (nm)

Figure 28

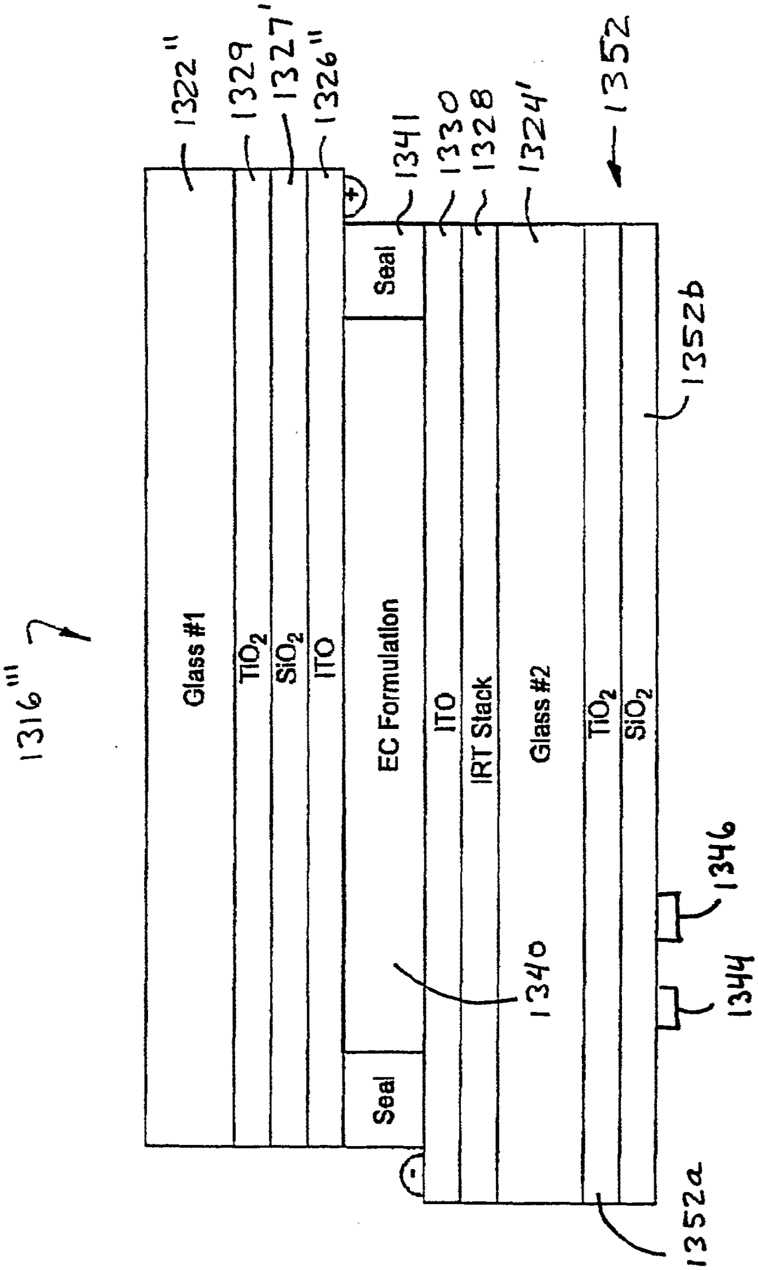

1316'''
1322''
1329
1327'
1326''
1341
1330
1328
1324'
1352
Glass #1
TiO_2
SiO_2
ITO
Seal
EC Formulation
Seal
ITO
IRT Stack
Glass #2
TiO_2
SiO_2
1352b
1340
1346
1344
1352a

Figure 29

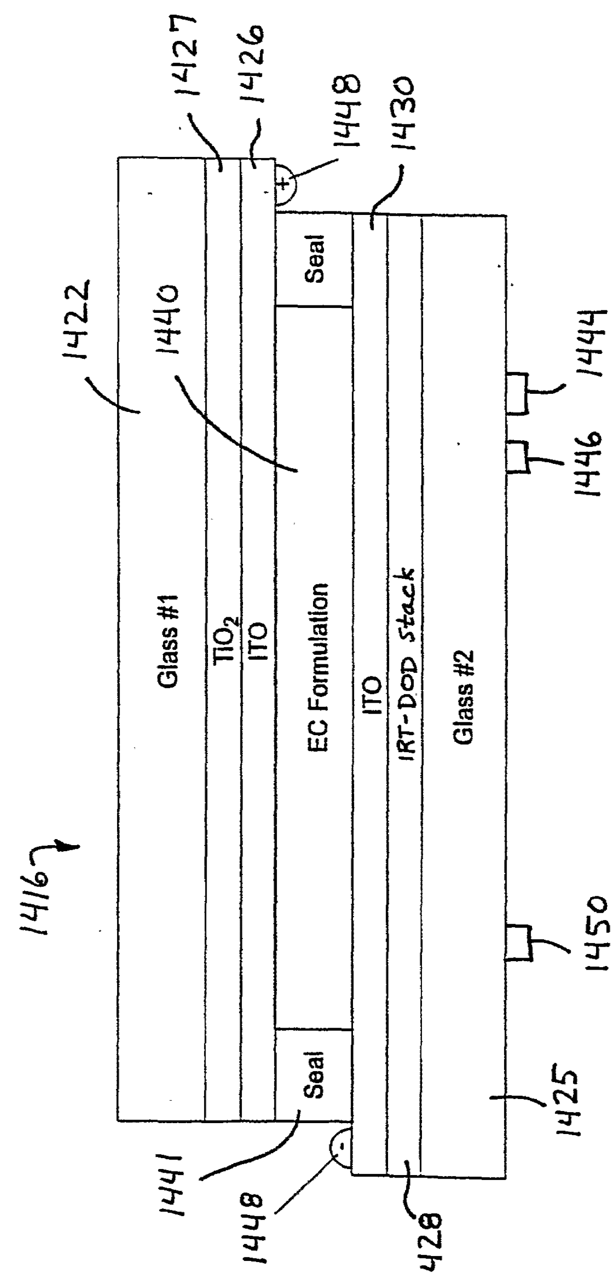

1427
1426
1448
1430
1422
1440
1444
1446
Seal
Glass #1
TiO2
ITO
EC Formulation
ITO
IRT-DOD stack
Glass #2
1416
1450
Seal
1425
1441
1448
1428

Figure 30

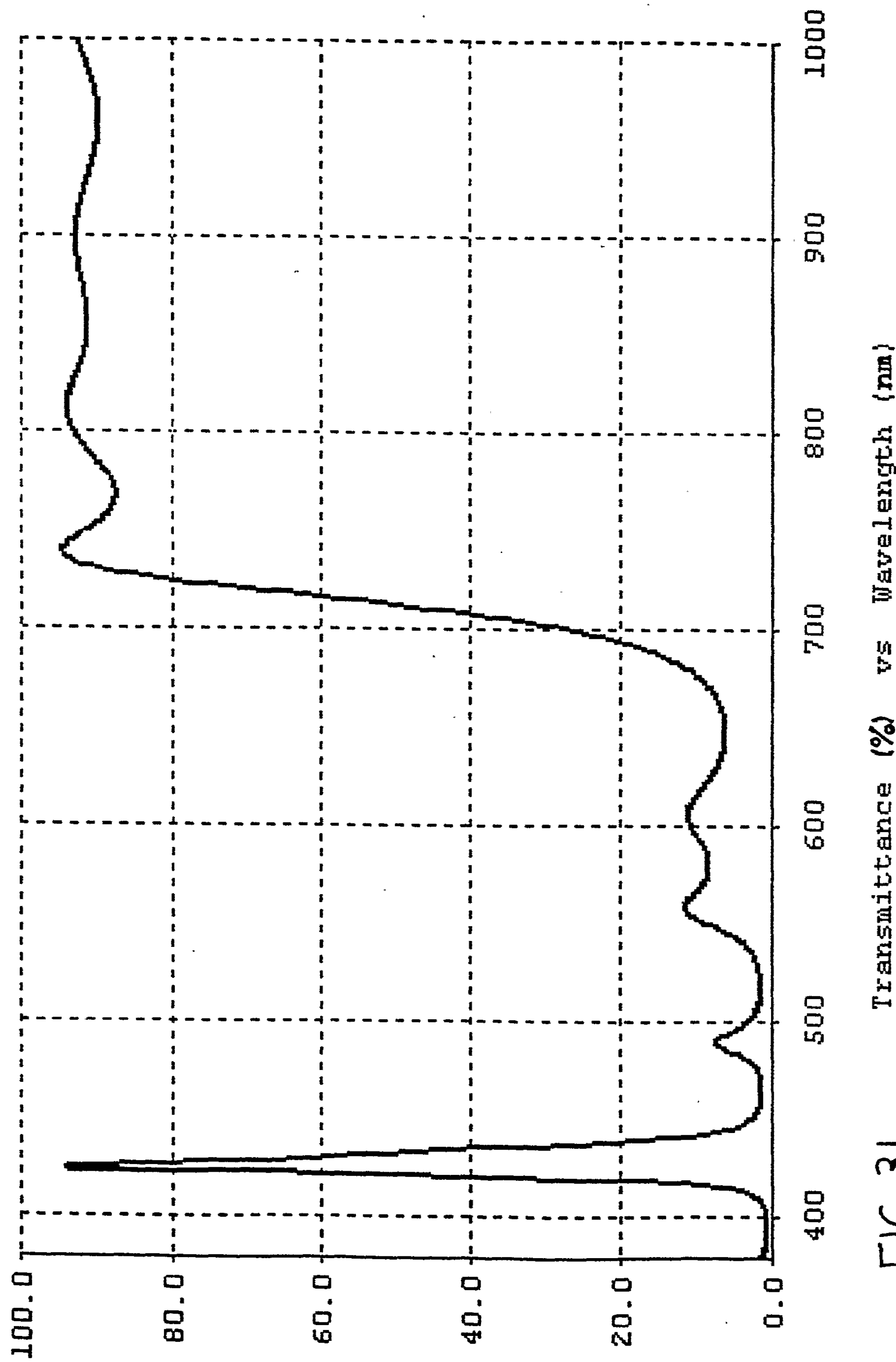

100.0
80.0
60.0
40.0
20.0
0.0
400
500
600
700
800
900
1000
Transmittance (%) vs Wavelength (nm)

FIG.31

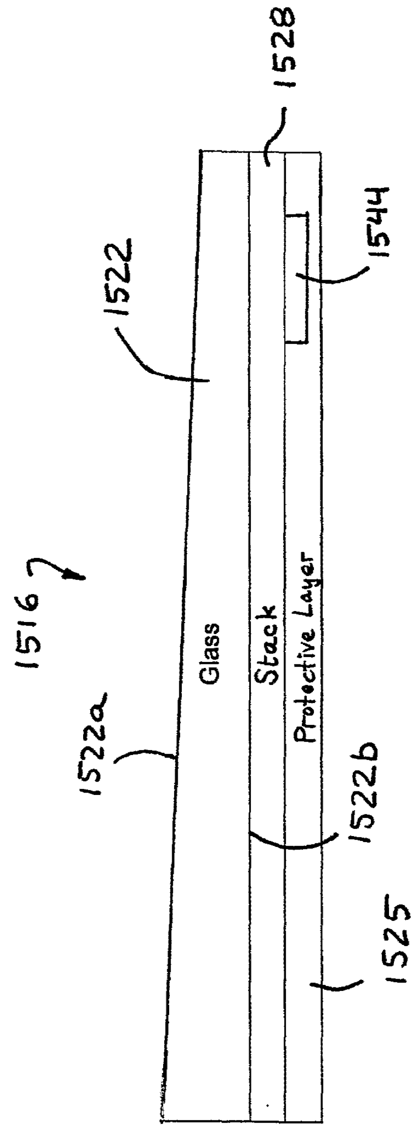

1528
1544
1522
1516
Glass
Stack
Protective Layer
1522a
1522b
1525

Figure 32

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60/477,416	10 June 2003 (10.06.2003)	US
60/492,544	5 August 2003 (05.08.2003)	US

(71) Applicant (*for all designated States except US*): **DONNELLY CORPORATION** [US/US]; 414 East Fortieth Street, Holland, MI 49423 (US).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **BINGLE, Robert, L.** [US/US]; 3102 Crestbrooke Drive, Holland, MI 49424 (US). **CAMILLERI, Joseph** [US/US]; 11537 Eagle Way, Brighton, MI 48114 (US). **WHITEHEAD, Peter, J.** [GB/US]; 345 Sandcastle Drive, Holland, MI 49424 (US). **SCHOFIELD, Kenneth** [GB/US]; 4793 Crestridge Court, Holland, MI 49423 (US).

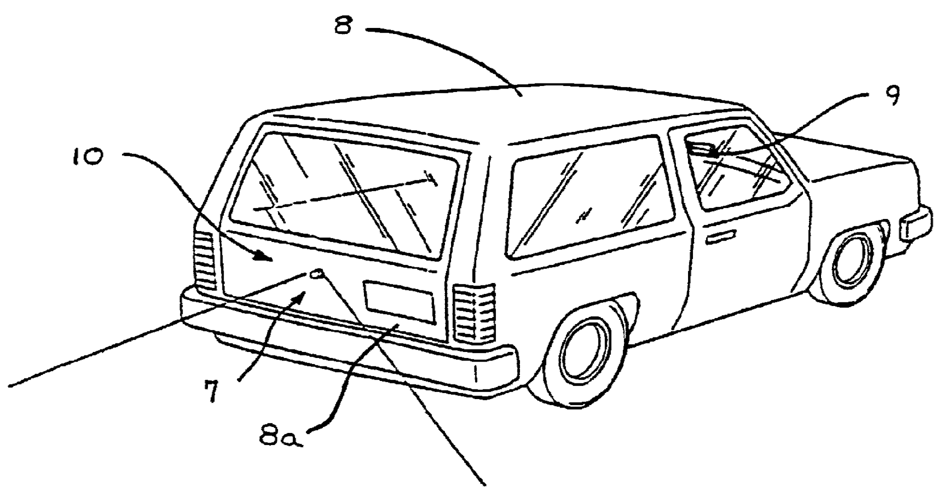
(74) Agents: **VAN DYKE, GARDNER, LINN & BURKHART, LLP** et al.; 2851 Charlevoix Drive, SE, Ste. 207, P.O. Box 888695, Grands Rapids, MI 49588-8695 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: IMAGING SYSTEM FOR VEHICLE



(57) Abstract: An imaging system (7) for a vehicle (8) includes a camera module (10) positionable at the vehicle and a control (9b). The camera module includes a plastic housing (16) that houses an image sensor (18), which is operable to capture images of a scene occurring exteriorly of the vehicle. The control is operable to process images captured by the image sensor. The portions of the housing may be laser welded or sonic welded together to substantially seal the image sensor and associated components within the plastic housing. The housing may include a ventilation portion (15) that is at least partially permeable to water vapor to allow water vapor to pass therethrough while substantially precluding passage of water droplets and/or other contaminants. The housing (110) may be movable at the vehicle between a stored position and an operational position, where the image sensor may be directed toward the exterior scene.

WO 2004/047421 A2

European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

IMAGING SYSTEM FOR VEHICLE

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims priority of U.S. provisional applications, Ser. No. 60/426,239, filed Nov. 14, 2002 by Bingle for CAMERA MODULE FOR VEHICLE (DON01 P-1031); Ser. No. 60/477,416, filed Jun. 10, 2003 by Camilleri for IMAGING SYSTEM FOR VEHICLE (DON01 P-1097); and Ser. No. 60/492,544, filed Aug. 5, 2003 by Whitehead et al. for CAMERA HOUSING FOR VEHICLE IMAGING SYSTEM (DON01 P-1108), which are all hereby incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates to an imaging system for a vehicle and, more particularly, to a camera which may be mounted at an exterior portion of a vehicle for providing an image of a scene exteriorly of the vehicle. The present invention also relates to an imaging system for a vehicle which provides color imaging and a low light imaging capability.

BACKGROUND OF THE INVENTION

The advent of low cost, reliable imaging devices, based on a variety of silicon technologies, and in particular CMOS technology, combined with an improved cost/performance ratio for displays capable of meeting automotive specifications, and an increasing application rate of video monitor displays for automotive navigation systems or as part of the driver interface to a wide variety of vehicle systems, has lead to an increasing use of cameras or imaging sensors designed to give the driver a view of those areas around the vehicle which are not in the normal direct field of view of the driver, typically referred to as "blind spots". These areas include the region close to the front of the vehicle, typically obscured by the forward structure of the vehicle, the region along the passenger side of the vehicle, the region along the driver's side of the vehicle rearward of the driver, and the area or region immediately rearward of the vehicle which cannot be seen directly or indirectly through the rear view mirror system. The camera or imaging sensor may capture an image of the rearward (or sideward or other blind spot area) field of view, and the image may be displayed to the driver of the vehicle to assist the driver in backing up or reversing or otherwise driving or maneuvering the vehicle. The use of electronic cameras in these applications significantly increases the driver's knowledge of the space immediately surrounding the vehicle, which may be of importance prior to and during low speed maneuvers, and thus contributes to the safe completion of such maneuvers.

It is thus known to provide a camera or imaging sensor on a vehicle for providing an image of a scene occurring exteriorly or interiorly of the vehicle to a driver of the vehicle. Such a camera may be positioned within a protective housing, which may be closed about the camera or sensor and secured together via fasteners or screws or the like. For example, a metallic protective housing may be provided, such as a die cast housing of aluminum or zinc or the like. In particular, for camera sensors mounted on the exterior of a vehicle, protection against environmental effects, such as rain, snow, road splash and/or the like, and physical protection, such as against road debris, dirt, dust, and/or the like, is important. Thus, for example, in known exterior camera sensor mounts, a butyl seal, such as a hot dispensed butyl seal, or an O-ring or other sealing member or material or the like, has been provided between the parts of the housing to assist in sealing the housing to prevent water or other contaminants from entering the housing and damaging the camera or sensor positioned therein. However, such housings typically do not provide a substantially water tight seal, and water droplets thus may enter the housing. Furthermore, any excessive vibration of the camera sensor, due to its placement (such as at the exterior of the vehicle), may lead to an undesirable instability of the image displayed to the driver of the vehicle. Also, such cameras or sensors are costly to manufacture and to implement on the vehicles.

Such vehicle vision systems often position a camera or imaging sensor at an exterior portion of a vehicle to capture an image of a scene occurring exteriorly of the vehicle. The cameras, particularly the cameras for rearward vision systems, are thus typically placed or mounted in a location that tends to get a high dirt buildup on the camera and/or lens of the camera, with no easy way of cleaning the camera and/or lens. In order to reduce the dirt or moisture buildup on the lenses of such cameras, it has been proposed to use hydrophilic or hydrophobic coatings on the lenses. However, the use of such a hydrophilic or hydrophobic coating on the lens is not typically effective due to the lack of air flow across the lens. It has also been proposed to use heating devices or elements to reduce moisture on the lenses. However, the use of a heated lens in such applications, while reducing condensation and misting on the lens, may promote the forming of a film on the lens due to contamination that may be present in the moisture or water. Also, the appearance of such cameras on the rearward portion of vehicles is often a problem for styling of the vehicle.

Typically, based on consumer preference and at least a perceived improved ability to extract information from the image, it is desired to present a color image to the driver that is representative of the exterior scene as perceived by normal human vision. It is also desirable that such imaging devices or systems be useful in all conditions, and particularly in all lighting conditions. However, it is often difficult to provide a color imaging sensor which is capable of providing a clear image in low light conditions. This is because conventional imaging systems typically have difficulty resolving scene information from background noise in low light conditions.

Silicon-based cameras may be responsive to light in the visible and near infrared portions of the spectrum. It is known to filter out the infrared portion of the energy available to the camera in order to maintain an appropriate color balance. When this is done, the camera sensitivity may be less than if the near infrared and infrared light was received and used by the camera. Depending on the imaging technology used, the minimum sensitivities currently economically available for automotive cameras are typically in the range of 1 to 2 lux and may maintain a reasonable image quality at light levels at or above such levels. However, the conditions on a dark cloudy night where moonlight is obscured, and/or in rural situations in which there is no source of artificial lighting, may result in a scene illumination as low as about 0.01 lux. While the technology continues to improve the low light sensitivity of silicon based cameras, it is not expected that 0.01 lux capability will become available in the foreseeable future. Other technologies may be capable of such sensitivity, but are not sufficiently cost effective for general application in the automotive industry.

Therefore, there is a need in the art for a camera housing that overcomes the shortcomings of the prior art, and a need in the art for an imaging system that may provide clear, satisfactory images during all driving or lighting conditions, and thus overcomes the shortcomings of the prior art imaging systems.

SUMMARY OF THE INVENTION

The present invention is intended to provide a camera module which includes a camera or image sensor and a circuit board positioned within a housing, which may be laser welded or sonic welded or the like to substantially seal the camera and circuit board within the housing. The housing, preferably molded of a plastic material, may include a plastic molded connector extending therefrom, such that the camera housing and connector are configured as a single unitary module. The camera module may include a heating element for heating a transparent cover at the lens (or for heating the lens itself) of the camera to assist in defogging or defrosting the transparent cover in cold weather conditions. The transparent cover may have a transparent conductive coating (such as an indium tin oxide (ITO) coating or doped tin oxide or a metal grid or the like), preferably on its inner surface, such that contact of a power terminal (connected to or in communication with or powered by a battery or other power source of the vehicle) and a ground terminal of the heating elements at the conductive coating causes heating of the coating to defrost or defog the cover. The heating elements or terminals may be actuated in response to a control or thermostat, which functions to activate and deactivate the heating element at predetermined temperatures sensed by a temperature sensor at or in the camera module or elsewhere at, in or on the vehicle. The present invention thus provides a camera module that maintains the camera or imaging sensor and is substantially impervious to environmental elements, such as rain, snow, dirt, dust, road splash, road debris and the like. The present invention also provides at least partial, and preferably substantial, reduced vibration affects of the camera or image sensor.

According to an aspect of the present invention, a substantially sealed camera module for an imaging system of a vehicle includes a plastic housing, which preferably includes first and second portions. The first and second portions are preferably laser welded or sonic welded together to substantially seal the camera or sensor and associated components within the plastic housing. The laser welded or sonic welded plastic housing provides a substantially hermetic seal to prevent water intrusion or the like into the housing. Alternately, and less preferably, the first and second portions may be adhesively sealed or joined.

The camera module may be incorporated into an imaging system that includes the sensor and a control for processing images captured by the imaging sensor. The camera module may be positioned within a movable housing that is movable relative to the vehicle to move the imaging sensor between an in use or operational position, where the imaging sensor is directed toward the exterior scene, and a storage position, where the housing and the imaging sensor are positioned within a portion of the vehicle.

According to another aspect of the present invention, a vented camera module for a vehicle includes a plastic housing which is configured to receive a camera or sensor therein. The housing of the vented camera module includes a semi-permeable ventilation area, such as a Gore-Tex assembly or area or patch or the like, which is at least partially permeable to water vapor and/or is porous enough to allow transfer of water vapor into and out from the housing, while substantially precluding entry of water droplets, dirt or the like into the housing.

According to another aspect of the present invention, a camera module for a vehicle includes a housing and a transparent cover at a portion of the housing. The transparent cover provides a transparent wall of the housing for the lens and sensor or camera to receive an image therethrough. The cover may be heated to defrost or defog the cover in cold weather conditions or the like. The cover includes a surface (such as an inner surface within the housing) which has a conductive coating, such as a coating of indium tin oxide (ITO), doped tin oxide or the like. The module includes a pair of heater terminals or elements which contact the coating, whereby heating of the cover or coating on the cover (such as the inner surface of the cover) is accomplished by generating a flow of electricity or electrons or current across the coating on the cover via the heater terminals or elements.

In one form, one of the heater terminals may be energized or charged with electricity and the other terminal may be grounded to the vehicle, such that the electrical current travels from the energized or powered terminal across the conductive coating to the grounded terminal, thereby heating the conductive coating and, thus, the transparent cover. Preferably, the heater terminals are spaced apart at generally opposite sides or portions of the transparent cover.

Actuation of the heater terminals may defrost or defog the transparent cover and/or may heat the module housing and interior compartment of the camera module to dry out any moisture within the housing or compartment. In applications where the module includes a ventilation area, such as a vented semi-permeable membrane, such as a Gore-Tex assembly or the like, heating of the compartment may be especially suited for driving moisture out of the compartment or module through the ventilation area to limit or substantially preclude moisture condensing within the module. Optionally, the heater terminals may be actuated or energized in response to a control, which is operable to energize the heater terminals or elements in response to a thermostat and/or temperature sensor positioned at or within the camera module or elsewhere at, in or on the vehicle. Optionally, desiccant material, such as silica gel or the like, may be included in the housing to absorb moisture which may be present within the housing.

According to yet another aspect of the present invention, a camera module for a vehicle comprises a housing, a transparent cover at a portion of the housing, an image sensor, at least one heating element and a control. The image sensor is positioned within the housing and is operable to receive an image of a scene exteriorly of the housing through the transparent cover. The heating element is operable to heat the transparent cover. The control is operable to activate the heating element in response to a temperature sensor. The heating element is activatable to heat the transparent cover to reduce fog and/or ice on the transparent cover.

The present invention also provides a camera housing that is movably positioned at an exterior portion of a vehicle such that the camera may be moved from a stored position to an in-use or exterior or operational position. The camera housing may include a transparent window or panel and may further include a window wiper that functions to wipe dirt and/or moisture or the like from the window or panel as the housing moves the camera between the stored position and the operational position.

According to an aspect of the present invention, a holding device for movably holding an imaging device of a vehicle includes a housing, a transparent panel and a panel cleaning device. The imaging device is operable to capture an image of a scene occurring exteriorly of the vehicle. The housing is movably mountable at an exterior portion of the vehicle and is configured to receive an imaging device therein. The housing is movable relative to the exterior portion of the vehicle to move the imaging device between a stored position, where the imaging device is positioned generally within the portion of the vehicle, and an operational position, where the imaging device is positioned to have a field of view exteriorly of the vehicle. The transparent panel is positioned at least partially across an opening of the housing and generally in the field of view of the imaging device. The panel cleaning device is positionable at the exterior portion of the vehicle and configured to engage the transparent panel to clean the transparent panel as the housing moves the imaging device between the stored position and the operational position.

According to another aspect of the present invention, an imaging system for a vehicle includes an imaging device operable to capture an image of a scene occurring exteriorly of a vehicle, a control operable to process the image captured by the imaging device, and a camera housing device. The housing device includes a housing portion defining a compartment, a transparent panel substantially closing an opening of the compartment, and a panel cleaning device. The housing device is movably mountable on an exterior portion of the vehicle. The imaging device is positioned within the compartment and directed toward the transparent panel. The housing device is movable between a stored position, where the imaging device and the transparent panel are positioned at least substantially within the exterior portion of the vehicle, and an operational position, where the imaging device is directed exteriorly of the vehicle and has a field of view directed through the transparent panel and toward the exterior scene. The panel cleaning device is positionable at the exterior portion of the vehicle and configured to engage the transparent panel to clean the transparent panel as the housing device moves between the stored position and the operational position.

The imaging system may include a display operable to display the image captured by the imaging device. The housing device may be pivotably mountable at the exterior portion of the vehicle, or the housing device may be slidably or otherwise movably mountable at the exterior portion of the vehicle. An outer panel of the housing device may define an exterior cover portion at the exterior portion of the vehicle when the housing device is moved or pivoted to the stored position.

Optionally, the imaging system may comprise a color imaging sensor operable to capture color images of the exterior scene and an infrared imaging sensor operable to capture infrared images of the exterior scene. The control may selectively activate one of the color imaging sensor and the infrared imaging sensor in response to the ambient light intensity present in the exterior scene.

Optionally, the imaging system may include an illumination source positioned within the compartment and directed toward the exterior scene when the housing device is moved to the operational position. The transparent panel and the compartment are positioned generally within the exterior portion of the vehicle when the housing device is moved to the stored position. Optionally, the control may be operable to selectively activate the illumination source and the imaging device when the housing device is moved to the stored position to determine if moisture is present on the transparent panel. The housing device may include a heater element that is selectively operable to heat the transparent panel to reduce moisture present on the transparent panel.

Optionally, the housing device may be movable to selectively position the imaging device in first and second operational positions. The control may be operable to determine a distance to at least one object in the exterior scene in response to processing of images captured by the imaging device when the imaging device is in the first and second operational positions. For example, the control may be operable to selectively move the housing device to position the imaging device at the first operational position in response to the vehicle making an initial approach to a target zone and to position the imaging device at the second operational position in response to the vehicle moving further into the target zone. The imaging device may be directed more downward when in the second operational position relative to the first operational position.

According to another aspect of the present invention, an imaging system of a vehicle includes an imaging device, a holding device and a control. The imaging device is operable to capture images of a scene occurring exteriorly of the vehicle. The holding device is pivotally mountable at a portion of a vehicle and includes a housing having an exterior panel and a transparent panel. The imaging device is positioned within the housing. The transparent panel is positioned at least partially across an opening of the housing and generally in the field of view of the imaging device. The holding device is pivotable relative to the portion of the vehicle to move the imaging device between a stored position, where the imaging device is positioned generally within the portion of the vehicle, and an operational position, where the imaging device is positioned to have a field of view exteriorly of the vehicle. The exterior panel is generally aligned with an exterior surface of the portion of the vehicle and the transparent panel is generally within the portion of the vehicle when the imaging device is in the stored position. The control is operable to process images captured by the imaging device.

The present invention also provides a vehicular imaging system or image capture system which is operable to capture an image of an exterior scene and to display the images at a display of the vehicle. The imaging system is operable to control illumination sources operable to illuminate the exterior scene and/or to control the color processing of the captured images and/or to control the color/monochromatic status or mode of the image capture device or camera of the system, in order to provide or display an optimum color or black and white image at the display which has optimum color representation of the scene or has optimum illumination or visibility or clarity or contrast ratio in the image displayed.

For example, the imaging system may selectively activate visible or infrared or near infrared illumination sources or light emitting diodes (LEDs) in response to a detected ambient light level dropping or decreasing or lowering to a threshold level. The imaging system may also or otherwise selectively switch the imaging sensor from a color mode to a black and white mode in response to the reduced ambient light level. Optionally, the imaging system may apply an infrared contribution correction to the detected levels for each color (such as red, green, blue) detected by the imaging sensor to adjust the color balance of the imaging sensor for better color rendition in the captured images. Optionally, the imaging system may provide visible illumination to the exterior scene and may limit or block infrared and near infrared light present in the illuminated scene to reduce processing requirements to obtain the appropriate color balance in the captured images.

Therefore, the present invention provides a camera module for a vehicle which may be substantially hermetically sealed to limit or substantially preclude water intrusion or the like into the housing of the module, or which may be vented to allow for water vapor to enter or exit the module. The camera housing may also include a heating element which is operable to defrost or defog the transparent cover of the module and/or to heat the compartment of the camera housing to limit or substantially preclude condensation from forming within the module. The heating element may be activated and deactivated at predetermined temperatures in response to a temperature sensor and/or thermostat. The transparent cover of the housing may include a conductive coating on a surface thereof, such that applying an electrical current or flow through or across the coating on the surface of the transparent cover functions to heat the surface of the cover to defrost or defog the transparent cover. The present invention thus provides an environmentally resilient, protected, economical camera module which may be mounted to a vehicle and connected or plugged into a wiring connector of the vehicle.

The present invention thus also provides a camera housing device that is movable or adjustable to move a camera or imaging sensor between an operational position and a stored position. The camera thus may be positioned in a stored position within an exterior portion of the vehicle when not in use. The exterior panel of the camera housing device may provide an exterior cover at the exterior portion of the vehicle to protect the camera and lens from the elements when they are not in use. The housing device may include a transparent panel that substantially encloses the camera and lens within the housing. The housing device may also include a panel cleaning device that may clean the transparent panel to limit or substantially preclude dirt buildup or debris on the panel that may adversely effect the performance of the camera and thus of the imaging system.

The present invention also provides an imaging system that is capable of providing a color image during daytime conditions, and that may provide a black and white image, with or without additional infrared or near infrared illumination provided to the scene, during darkened or nighttime conditions. The imaging system may correct the color image to account for infrared and near infrared illumination that may be present in the exterior scene, in order to provide an image with proper or desired color balance. The present invention thus may provide optimal images to the driver of the vehicle during substantially all types of lighting conditions.

These and other objects, purposes, advantages and features of the present invention will become apparent upon review of the following specification in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a rear perspective view of a vehicle having an imaging system thereon in accordance with the present invention;

FIG. 2 is a plan view of the vehicle of FIG. 1;

FIG. 3 is a perspective view of a camera module in accordance with the present invention;

FIG. 4 is a side elevation of the camera module of FIG. 3;

FIG. 5 is another side elevation of the camera module of FIGS. 3 and 4;

FIG. 6 is an end elevation of the camera module of FIGS. 3-5;

FIG. 7 is a sectional view of the camera module taken along the line VII-VII in FIG. 6;

FIG. 8 is an opposite end elevation of FIG. 6 of the camera module of FIGS. 3-7;

FIG. 9 is a sectional view of the camera module taken along the line IX-IX in FIG. 5;

FIG. 10 is a sectional view of the camera module taken along the line X-X in FIG. 8;

FIG. 11 is another sectional view of the camera module taken along the line XI-XI in FIG. 8;

FIG. 12A is a side elevation of a camera housing portion of the camera module of the present invention;

FIG. 12B is an end elevation of the camera housing portion of FIG. 12A;

FIG. 12C is an opposite end elevation of FIG. 12B of the camera housing portion of FIGS. 12A and 12B;

FIG. 12D is a sectional view of the camera housing portion taken along the line D-D in FIG. 12C;

FIG. 13A is a top plan view of a circuit board useful with the camera module of the present invention;

FIG. 13B is a side elevation of the circuit board of FIG. 13A;

FIG. 14A is another plan view of the circuit board of FIGS. 13A and 13B, with the circuit board folded over itself;

FIG. 14B is a side elevation of the circuit board of FIG. 14A;

FIG. 15A is a side elevation of a connector portion of the camera module of the present invention;

FIG. 15B is an end elevation of the connector portion of FIG. 15A;

FIG. 15C is a sectional view of the connector portion taken along the line C-C in FIG. 15B;

FIG. 15D is another sectional view of the connector portion taken along the line D-D in FIG 15B;

FIG. 15E is an opposite end elevation of FIG. 15B of the connector portion of FIGS. 15A-D;

FIGS. 16A-D are various views of one side or portion of a metallic protective shield for the camera module of the present invention;

FIG. 16E is a sectional view of the protective shield taken along the line E-E in FIG. 16D;

FIG. 17A and 17B are side elevations of an alternate embodiment of another camera module and/or components thereof in accordance with the present invention, with the connector portion being angled;

FIG. 17C is a perspective view of the connector portion of the camera module of FIGS. 17A and 17B;

FIG. 17D is a sectional view of the camera module taken along the line D-D in FIG. 17B;

FIG. 17E is a sectional view of the camera module taken along the line E-E in FIG. 17A;

FIG. 18 is a rear perspective view of a vehicle with a camera housing device in accordance with the present invention positioned thereon and positioned in its in-use or operational position;

FIG. 19 is a side elevation and sectional view of a camera housing device in accordance with the present invention, with the camera housing device positioned so the camera is in its stored position;

FIG. 20 is a side elevation and sectional view similar to FIG. 19, with the camera housing device positioned so the camera is in its operational position;

FIG. 21 is a side elevation and sectional view of another camera housing device in accordance with the present invention, with an illumination source positioned within the camera housing device and movable with the housing device and camera;

FIG. 22 is a side elevation and sectional view of another camera housing device in accordance with the present invention, with the camera housing device being slidable to move the camera between its stored position and operational position, and with the camera housing device shown in the stored position;

FIG. 23 is a side elevation and sectional view of the camera housing device of FIG. 22, with the camera housing device shown in the extended or operational position;

FIG. 24 is a schematic of an image capture device in accordance with the present invention;

FIG. 25 is a block diagram of an imaging system in accordance with the present invention; and

FIG. 26 is a perspective view of an imaging system module in accordance with the present invention, having auxiliary illumination sources.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and the illustrative embodiments depicted therein, an image capture system or imaging or vision system 7 is positioned at a vehicle 8, such as at a rearward exterior portion 8a of the vehicle 8, and is operable to capture an image of a scene occurring interiorly or exteriorly of the vehicle, such as rearwardly of the vehicle, and to display the image at a display or display system 9a of the vehicle which is viewable by a driver or occupant of the vehicle (FIGS. 1 and 2). Imaging system 7 includes a camera module 10, which is mountable on, at or in the vehicle to receive an image of a scene occurring exteriorly or interiorly of the vehicle, and a control 9b that is operable to process images captured by an image sensor 18 of camera module 10. Camera module 10 includes a plastic camera housing 11 and a metallic protective shield or casing 16 (FIGS. 3-12). Camera housing 11 includes a camera housing portion 12 and a connector portion 14, which mate or join together and are preferably laser welded or sonic welded together to substantially seal the housing 11 to substantially limit or prevent water intrusion or other contaminants from entering the housing, as discussed below.

Housing 11 of camera module 10 substantially encases a camera or image sensor or sensing device 18 (FIGS. 7, 9-11, 13A, 13B, 14A and 14B), which is operable to capture an image of the scene occurring exteriorly or interiorly of the vehicle, depending on the particular application of camera module 10. Housing 11 also includes a cover portion 20 at an end of camera housing portion 12. Cover portion 20 provides a transparent cover plate 22 which allows the image of the scene exteriorly or interiorly of the vehicle to pass therethrough and into housing 11 to camera 18, and which may be heated to defrost or defog the cover, as discussed below. Camera module 10 may include the protective shield 16, which substantially encases camera housing portion 12 and a portion of connector portion 14, thereby substantially limiting or reducing electronic noise going into or out of the camera module and/or protecting the plastic housing 11 from damage due to impact or the like with various items or debris that may be encountered at the exterior of the vehicle.

Camera module 10 provides a camera or image capture device 18 for capturing an image of a scene occurring exteriorly or interiorly of a vehicle. The captured image may be communicated to a display or display system 9a which is operable to display the image to a driver of the vehicle. The camera or imaging sensor 18 useful with the present invention may comprise an imaging array sensor, such as a CMOS sensor or a CCD sensor or the like, such as disclosed in commonly assigned U.S. Pat. Nos. 5,550,677; 5,670,935; 5,796,094; and 6,097,023, and U.S. pat. application, Ser. No. 09/441,341, filed Nov. 16, 1999 by Schofield et al. for VEHICLE HEADLIGHT CONTROL USING IMAGING SENSOR (Attorney Docket DON01 P-770), which are hereby incorporated herein by reference. Camera module 10 and imaging sensor 18 may be implemented and operated in connection with various vehicular vision systems, and/or may be operable utilizing the principles of such other vehicular systems, such as a vehicle headlamp control system, such as the type disclosed in U.S. Pat. Nos. 5,796,094; 6,097,023; 6,320,176; and 6,559,435, and U.S. pat. applications, Ser. No. 09/441,341, filed Nov. 16, 1999 by Schofield et al. for VEHICLE HEADLIGHT CONTROL USING IMAGING SENSOR (Attorney Docket DON01 P-770); and Ser. No. 10/427,146, filed Apr. 30, 2003 by Schofield et al. for VEHICLE HEADLIGHT CONTROL USING IMAGING SENSOR (Attorney Docket DON01 P-1091), which are all hereby incorporated herein by reference, a rain sensor, such as the types disclosed in commonly assigned U.S. Pat. Nos. 6,353,392; 6,313,454; and/or 6,320,176, which are hereby incorporated herein by reference, a vehicle vision system, such as a forwardly, sidewardly or rearwardly directed vehicle vision system utilizing principles disclosed in U.S. Pat. Nos. 5,550,677; 5,670,935; 5,760,962; 5,877,897; 5,949,331; 6,222,447; 6,302,545; 6,396,397; 6,498,620; 6,523,964; 6,611,202; and 6,201,642, and/or in U.S. pat. applications, Ser. No. 09/199,907, filed Nov. 25, 1998 by Bos et al. for WIDE ANGLE IMAGE CAPTURE SYSTEM FOR VEHICLE (Attorney Docket DON01 P-676); Ser. No. 10/372,873, filed Feb. 24, 2003 by Schofield et al. for VEHICLE IMAGE CAPTURE SYSTEM (Attorney Docket DON01 P-1077); Ser. No. 10/011,517, filed Nov. 5, 2001 by Bos et al. for INTERIOR REARVIEW MIRROR SYSTEM INCLUDING A FORWARD FACING VIDEO DEVICE (Attorney Docket DON01 P-934); Ser. No. 10/324,679, filed Dec. 20, 2002 by Schofield et al. for VEHICULAR VISION SYSTEM (Attorney Docket DON01 P-1059); Ser. No. 10/047,901, filed Jan. 14, 2002 by Bos et al. for VEHICLE IMAGING SYSTEM WITH ACCESSORY CONTROL (Attorney Docket DON08 P-949); Ser. No. 10/643,602, filed Aug. 19, 2003 by Schofield et al. for VISION SYSTEM FOR A VEHICLE INCLUDING IMAGING PROCESSOR (Attorney Docket DON01 P-1087); and Ser. No. 10/010,862, filed Dec. 6, 2001 by Bos for PLASTIC LENS SYSTEM FOR VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-954), which are all hereby incorporated herein by reference, a trailer hitching aid or tow check system, such as the type disclosed in U.S. pat. application, Ser. No. 10/418,486, filed Apr. 18, 2003 by McMahon et al. for VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-1070), which is hereby incorporated herein by reference, a reverse or sideward imaging system, such as for a lane change assistance system or lane departure warning system, such as the type disclosed in U.S. pat. application, Ser. No. 10/427,051, filed Apr. 30, 2003 by Pawlicki et al. for OBJECT DETECTION SYSTEM FOR VEHICLE (Attorney Docket DON01 P-1075), which is hereby incorporated herein by reference, a traffic sign recognition system, a system for determining a distance to a leading or trailing vehicle or object, such as a system utilizing the principles disclosed in U.S. Pat. No. 6,396,397, which is hereby incorporated herein by reference, and/or the like.

Typically, cameras are best suited for uniform lighting conditions, and typically have a dynamic range of approximately 60 to 70 dB. The lighting extremes which are encountered in automotive applications create challenges for these cameras. For example, a single frame captured by the camera may include sunlight reflecting off concrete pavement and a dark shadow cast by the vehicle or other object. In such a situation, standard dynamic range cameras are limited in their ability to display usable images in both portions of the frame. Either the light area may be washed out, or the shadowed area may be black or darkened.

.Optionally, and preferably, camera 18 may comprise an extended dynamic range camera, which may have a dynamic range of greater than approximately 100 dB, and preferably approximately 100 to 120 dB. The linear dynamic range of the camera or sensor may be extended to above 100 dB by programming a non-linear response curve that generally matches the response of the human eye. By providing such an extended dynamic range camera, the camera module may provide an image which is readable and not washed out or darkened in both the highly lighted areas and the dark areas of each frame of the image captured by the camera. Such a camera thus may provide an image to the display or display system which is readable in both the light and dark regions of each frame.

In a preferred embodiment, the extended dynamic range camera may provide a dynamic range of approximately 62 dB in a linear mode and approximately 110 dB in a non-linear mode. The camera or sensor may have a sensitivity of approximately 5 V/lux.s (if the sensor comprises a monochrome sensor) or approximately 2.7 V/lux.s (if the sensor comprises a color sensor), and may be operable at a frame rate of approximately 30 frames per second. For example, the camera or sensor may comprise a LM9618 Monochrome CMOS Image Sensor or a LM9628 Color CMOS Image Sensor, both of which are commercially available from National Semiconductor. Other suitable cameras or sensors may otherwise be implemented with the camera module, without affecting the scope of the present invention.

Although shown at a rear portion of a vehicle, camera 18 and camera module 10 may be positioned at any suitable location on the vehicle, such as within a rear panel or portion of the vehicle, a side panel or portion of the vehicle, a license plate mounting area of the vehicle, an exterior mirror assembly of the vehicle, an interior rearview mirror assembly of the vehicle or any other location where the camera may be positioned and oriented to provide the desired view of the scene occurring exteriorly or interiorly of the vehicle. The camera module of the present invention is particularly suited for use as an exterior camera module. However, the camera module may be positioned at an interior portion of the vehicle, such as at or in an interior rearview mirror assembly or accessory module at or near an interior rearview mirror assembly, to provide an image of an interior scene or of an exterior scene through a window or windshield of the vehicle, without affecting the scope of the present invention. The image captured by the camera may be displayed at a display screen or the like positioned within the cabin of the vehicle, such as at an interior rearview mirror assembly (such as disclosed in U.S. pat. application, Ser. No. 09/793,002, filed Feb. 26, 2001 by Schofield et al. for VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE (Attorney Docket DON01 P-869), which is hereby incorporated herein by reference), or elsewhere at or within the vehicle cabin, such as by using the principles disclosed in U.S. Pat. Nos. 5,550,677; 5,670,935; 5,796,094; 6,097,023 and 6,201,642, and/or in U.S. pat. application, Ser. No. 09/199,907, filed Nov. 25, 1998 by Bos et al. for WIDE ANGLE IMAGE CAPTURE SYSTEM FOR VEHICLE (Attorney Docket DON01 P-676), which are hereby incorporated herein by reference.

As best shown in FIGS. 7 and 9-12, camera housing portion 12 includes a generally cylindrical portion 12a extending outwardly from a base portion 12b. Camera portion 12 comprises a molded plastic component and may include a pair of heater terminals or elements 30a, 30b insert molded within and/or along the walls of cylindrical portion 12a, as discussed below. Cylindrical portion 12a receives a lens or optic system 24 therein, which functions to focus the image onto camera or sensor 18, which is positioned at a circuit board 26 mounted within the base portion 12b of camera housing portion 12.

Lens system 24 is positioned within cylindrical portion 12a of camera portion 12 so as to receive light from the exterior or interior scene through cover 22 at end 12c of camera portion 12. Lens system 24 is mounted to, such as via threaded engagement with, camera cover or housing 28, which functions to substantially cover or encase camera or sensor 18 to substantially prevent or limit incident light from being received by camera 18 and interfering with the image received by camera 18 through cover 22 and lens system 24. The lens system

24 may be any small lens or lens system which may focus an image of the scene exteriorly of the camera module onto the camera or image sensor 18, such as, for example, the types disclosed in U.S. Pat. No. 6,201,642; and/or in U.S. pat. application, Ser. No. 10/010,862, filed Dec. 6, 2001 by Bos for PLASTIC LENS SYSTEM FOR VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-954), which are hereby incorporated herein by reference. The lens system 24 may provide a wide-angle field of view, such as approximately 120 degrees or more.

Cover portion 20 is mounted at an outer end 12c of camera housing portion 12 opposite from base portion 12b, as shown in FIGS. 7 and 9-11. Cover portion 20 includes an outer circumferential ring or cover retainer 20a, which engages an outer surface of transparent cover 22 and functions to retain transparent cover 22 in position at the end 12c of the cylindrical portion 12a of camera receiving portion 12. Preferably, circumferential ring 20a is laser welded or sonic welded or otherwise joined or bonded to outer end 12c of cylindrical portion 12a of camera receiving portion 12, as discussed below. The laser or sonic welding of the seam substantially seals and secures cover portion 20 onto camera receiving portion 12, and may limit or substantially preclude any water intrusion or contaminant intrusion into the camera receiving portion at the outer end 12c. Preferably, an inner surface 22a of transparent cover 22 includes a transparent conductive coating for heating the cover, as also discussed below.

In the illustrated embodiment, base portion 12b is generally square and defines a generally square mating edge 12e around the base portion 12b for mating and securing to a corresponding edge 14g of connector portion 14, as discussed below. Base portion 12b receives circuit board 26 and camera 18 therein, while a camera housing or shield 28 and lens or lens system 24 extend into cylindrical portion 12a of camera portion 12 to receive the image through transparent cover 22.

Connector portion 14 of housing 11 is a molded plastic component and includes a connector terminal or connector 14a, such as a multi-pin snap-on connector or the like, extending from a base portion 14b. Base portion 14b is formed (such as in a square shape as shown in the illustrated embodiment) to substantially and uniformly mate or connect to base portion 12b of camera housing 12, as can be seen with reference to FIGS. 7 and 9-11. The base portions 12b and 14b mate together and define a pocket or space for receiving and securing circuit board 26 therein. Base portions 14b and 12b may be laser welded or sonic welded together at their mating joint or connection 13. Laser or sonic welding of the joint melts the plastic edges or seams together to substantially hermetically seal housing 11 to prevent water intrusion or other contaminant intrusion into housing 11 of camera module 10. Optionally, and less desirably, the base portions may be otherwise joined or substantially sealed together (such as via suitable adhesives and/or sealants). The module may optionally include a vented portion or semi-permeable membrane to vent the module, as discussed below. The base portions 12b and 14b may further include mounting tabs or flanges 12d, 14f, which extend outwardly from base portion 12b, 14b. Mounting tabs 12d, 14f are generally aligned with one another when the base portions are secured together and include an aperture therethrough for mounting the camera module 10 at or to the vehicle via suitable fasteners or the like (not shown). Although shown as having generally square-shaped mating portions, connector portion 14 and camera portion 12 may have other shaped mating portions or surfaces, without affecting the scope of the present invention.

Multi-pin connector 14a extends from base portion 14b and includes a plurality of pins or terminals 14c for electrically connecting camera module 10 with a connector (not shown) of the vehicle. For example, one end 14d of terminals 14c may connect to circuit board 26, while the other end 14e of terminals 14c connects to the corresponding connector of the vehicle. The corresponding connector may partially receive the ends 14e of pins or terminals 14c at multi-pin connector 14a and may snap together with multi-pin connector 14a via a snap connection or the like. As best shown in FIGS. 15A, 15C and 15D, ends 14d of terminals 14c protrude or extend from connector portion 14, such that the ends 14d may be received within corresponding openings or apertures 26c in circuit board 26 when housing portion 11 is assembled, as discussed below.

As shown in FIGS. 3-11, connector portion 14 may provide a generally straight multi-pin connector extending longitudinally from the base portion of the housing 11. However, other shapes of connectors, such as angled connectors or bent connectors or the like, such as a 90 degree angle connector portion 14' of a camera module 10' (FIGS. 17A-E), discussed below, may be implemented, depending on the particular application of the camera module, without affecting the scope of the present invention.

Optionally, camera module 10 may comprise a substantially hermetically sealed module, such that water intrusion into the module is limited or substantially precluded. Base portion 12b of camera housing portion 12 and base portion 14b of connector portion 14 are correspondingly formed so as to substantially mate or join together at their mating seam 13, whereby the portions may be laser welded or sonic welded together or otherwise joined, while cover portion 20 is also laser welded or sonic welded or otherwise secured and substantially sealed at the opposite end 12c of camera portion 12, in order to substantially seal the camera housing. Laser or sonic welding techniques are preferred so as to join the materials at a state where they are able to re-flow, either via heat, vibration or other means, such that the materials re-flow and cross-link and become a unitary part. Such joining results in a substantially hermetically sealed camera module. Additionally, the pores in the plastic as well as any voids around the insert molded pins and stampings may be sealed with a Loctite material or other suitable sealing material, to further limit or substantially preclude entry of water droplets and/or water vapor into the housing of the substantially sealed module.

Optionally, or alternately, the camera module of the present invention may comprise a vented module, which allows for water vapor to enter and/or exit the housing, while substantially precluding water droplets and the like from entering the housing. The camera portion 12 or connector portion 14 may include a semi-permeable ventilation portion or membrane 15 (FIG. 10), which preferably comprises a material or membrane which is at least partially permeable to water vapor and/or is porous enough to allow for ventilation of water vapor, but does not allow water droplets to pass therethrough, such that water vapor may enter and exit the housing 11, while water droplets and the like are kept outside the housing 11. For example, the ventilation portion 15 may comprise a Gore-Tex material or the like. In such applications where the module comprises a vented module and includes a ventilation portion, it is not necessary that the seams of the housing be laser welded or sonic welded, since the substantially hermetic sealing of the seams of the module would not be critical when the module is vented. Optionally, desiccant material, such as silica gel or the like, may be included in the housing to absorb moisture which may be present within the housing.

Camera housing portion 12 also includes a pair of heating terminals 30a, 30b which extend from within base portion 12b to outer end 12c substantially along/or within the walls of cylindrical portion 12a. Preferably, the terminals 30a, 30b are insert molded within the cylindrical wall of camera portion 12a. As shown in FIGS. 7 and 12D, the ends 30c of terminal portions 30a, 30b extend downward into base portion 12b of camera receiving portion 12, for connection to circuit board 26, as discussed below. The opposite ends 30d of terminals 30a, 30b extend radially inward at outer end 12c of cylindrical portion 12a and may provide arcuate or semicircular contacts at inner surface 22a of transparent cover 22 (FIGS. 7, 12B and 12C). A power or positive terminal 30a may be insert molded along and at least partially within the cylindrical portion 12a and positioned generally along an interior portion of the cylindrical portion 12a, while a ground or negative terminal 30b is insert molded along and partially within cylindrical portion 12a and positioned along an exterior wall or surface of the cylindrical portion 12a (as can be seen in FIGS. 7 and 12D). The exteriorly positioned ground terminal 30b may contact the metallic protective shield 16, discussed below, to ground the shield to the heating device and/or camera module.

Heating device 30 functions to heat inner surface 22a of transparent cover 22, in order to defrost or defog the cover 22. Heating device 30 may also function to heat the inside or interior compartment of housing 11, in order to maintain the temperature within the housing above a threshold temperature to further limit or substantially preclude moisture from condensing within the camera housing. This is especially useful when implemented in a vented module having a semi-permeable membrane or portion, whereby the heater may generate heat to dry out and drive out any moisture within the camera body compartment. The heated camera module thus may substantially preclude moisture from condensing within the module, since the water vapor would otherwise condense on the coldest surface available within the module.

The power heater terminal 30a may be connected to or in communication with the vehicle battery or other power source and may be energizable to provide electrical current to inner surface 22a of transparent cover 22, while the ground terminal 30b provides a ground connection for the heating device. Energization of terminal 30a thus causes electrical current or electrons to flow across the inner surface 22a of cover 22 to ground terminal 30b. Preferably, inner surface 22a of transparent cover 22 includes a transparent conductive coating or layer, such as an indium tin oxide (ITO) coating or a doped tin oxide coating or the like, such as the types of layers or coatings used in electro-optic or electrochromic mirror technology and as disclosed in U.S. Pat. Nos. 5,140,455; 5,151,816; 6,178,034; 6,154,306; 6,002,544; 5,567,360; 5,525,264; 5,610,756; 5,406,414; 5,253,109; 5,076,673; 5,073,012; 5,117,346; 5,724,187; 5,668,663; 5,910,854; 5,142,407 and 4,712,879, which are hereby incorporated herein by reference. Preferably, the conductive coating or layer provides a resistance of less than approximately 80 ohms per square, and more preferably less than approximately 20 ohms per square. The conductive coating generates heat as electrons or electricity flow from contact 30d of power terminal 30a across surface 22a to contact 30d of ground terminal 30b. The contacts 30d are spaced apart at generally opposite sides of the transparent cover 22 and provide for generally uniform and thorough heating of inner surface 22a when electricity is applied to heating terminal 30a. As can be seen in FIGS. 12B and 12C, contacts 30d of terminals 30a, 30b are preferably semicircular or half moon shaped contacts to extend substantially across each side of the cover 22, without interfering with the central region of the cover through which the scene may be viewed by the camera and lens.

Preferably, circuit board 26 of camera module 10 also includes a heater circuit for controlling the heater device 30 and heater terminals 30a, 30b in response to a temperature sensor (not shown). The heater circuit may be operable to actuate the heater device 30, such as via energizing heater terminal 30a, when the temperature at, within or near the camera module (or elsewhere at, in or on the vehicle) drops to a threshold temperature. The control or circuit is also operable to deactivate the heating device at a second predetermined threshold temperature. The heating device thus is operable via a thermostatic circuit which may activate and deactivate the heating device to heat the transparent cover 22 and/or the interior compartment of the housing when the temperature is detected to be low enough to warrant such activation. Such a thermostatic circuit may be operable to activate the heater elements when it is most desirable to heat the transparent cover and/or the interior of the housing and, thus, may limit or substantially preclude fogging or freezing of cover 22 and/or moisture condensing within the housing, while limiting or substantially precluding operation of the heating device in circumstances or situations when heat is not required on the transparent cover or in the housing.

As best shown in FIGS. 13A, 13B, 14A and 14B, circuit board 26 includes a camera mounting circuit board 26a, which is connected to a connector receiving circuit board 26b via a multi-wire ribbon wire 27 or the like. Camera mounting circuit board 26a is mounted or secured to the base portion 12b of camera portion 12, while connector circuit board 26b is mounted or secured to the base portion 14b of connector portion 14. Camera or image sensor 18 is mounted at a surface of camera circuit board 26a, and is substantially encased at circuit board 26a by camera cover 28 and lens 24 (FIGS. 7 and 9-11). As shown in FIGS. 7, 13A and 14A, camera circuit board 26a includes a pair of apertures 26c for receiving ends 30c of heating terminals 30a, 30b. Likewise, connector circuit board 26b includes a plurality of openings or apertures 26d for receiving ends 14d of connector terminals 14c therethrough (FIGS. 7, 10, 11 and 13A). The ends of the pins or terminals may be soldered in place in their respective openings. As shown in FIGS. 9, 11 and 14B, circuit board 26 is folded at ribbon wire 27, such that circuit board 26a generally overlaps circuit board 26b when they are positioned within the base portions 12b, 14b of the camera housing. The circuit board 26 may thus fold to an open position after the separate boards 26a, 26b are secured within their respective base portions of the housing to facilitate soldering of the connector terminals or heater terminals at the respective circuit boards. After all of the connections are made, the housing may be folded to its closed position and laser welded or sonic welded together or otherwise joined or bonded together to substantially seal the circuit board within the housing.

Optionally, the exterior surface 22b of cover 22 (which may be exposed to the atmosphere exterior of the camera module) may be coated with an anti-wetting property such as via a hydrophilic coating (or stack of coatings), such as is disclosed in U.S. Pat. Nos. 6,193,378; 5,854,708; 6,071,606; and 6,013,372, the entire disclosures of which are hereby incorporated by reference herein. Also, or otherwise, the exterior or outermost surface 22b of cover 22 may optionally be coated with an anti-wetting property such as via a hydrophobic coating (or stack of coatings), such as is disclosed in U.S. Pat. No. 5,724,187, the entire disclosure of which is hereby incorporated by reference herein. Such hydrophobic property on the outermost surface of the cover can be achieved by a variety of means, such as by use of organic and inorganic coatings utilizing a silicone moeity (for example, a urethane incorporating silicone moeities) or by utilizing diamond-like carbon coatings. For example, long-term stable water-repellent and oil-repellent ultra-hydrophobic coatings, such as described in PCT Application Nos. WO0192179 and WO0162682, the entire disclosures of which are hereby incorporated by reference herein, can be disposed on the exterior surface of the cover. Such ultra-hydrophobic layers comprise a nano structured surface covered with a hydrophobic agent which is supplied by an underlying replenishment layer (such as is described in Classen et al., "Towards a True 'Non-Clean' Property: Highly Durable Ultra-Hydrophobic Coating for Optical Applications", ECC 2002 "Smart Coatings" Proceedings, 2002, 181-190, the entire disclosure of which is hereby incorporated by reference herein).

In the illustrated embodiment, camera module 10 includes a protective shield or casing 16 which partially encases the plastic housing 11 and functions to limit or reduce electronic noise which may enter or exit camera module 10 and may protect the plastic housing from damage from impact of various items or debris which the camera module may encounter at the exterior portion of the vehicle. The protective shield or casing 16 includes a pair of casing portions 16a (one of which is shown in FIGS. 16A-16E). Each of the casing portions 16a partially encases about half of the plastic housing 11 of camera module 10 and partially overlaps the other of the casing portion 16a, to substantially encase the plastic housing within protective shield 16. Each of the portions 16a includes a slot 16b for receiving the mounting tabs 12d, 14f therethrough for mounting the camera module at the desired location at the vehicle. Each casing portion 16a includes overlapping portions 16c which overlap an edge of the other casing portion 16a to assemble the casing 16 around the plastic housing. The casing portions 16a may be welded, crimped, adhered, banded, or otherwise joined or secured together about the plastic housing 11, in order to encase the housing 11. Preferably, protective shield 16 comprises a metallic shield and contacts ground terminal 30b of heating device 30 at the exterior surface of the cylindrical portion 12a of camera receiving portion 12 and, thus, may be grounded to the heating device and/or the camera module or unit via the ground terminal 30b, as can be seen with reference to FIG. 7. Protective shield 16 may comprise a stamped metal shielding or may be formed by vacuum metalizing a shield layer over the plastic housing 11, or may comprise a foil or the like, without affecting the scope of the present invention.

With reference to FIGS. 17A-17E, a camera module 10' is shown which includes a connector portion 14' of a housing 11' which provides for a 90 degree bend in the connector pins or terminals 14c' to accommodate different mounts or connections to a connector of the vehicle. Other bends or shapes of the molded connector portion may be implemented without affecting the scope of the present invention. The other components of camera module 10' are substantially similar to the respective components of camera module 10, discussed above, such that a detailed discussion of those components will not be repeated herein. The common components are shown in FIGS. 17A-17E with the same reference numbers as assigned to the respective components of camera module 10 of FIGS. 1-16.

Therefore, the present invention provides a sealed camera module which may provide a substantially watertight and substantially hermetically sealed housing about a camera or image sensor of the camera module. The housing components may be laser welded or sonic welded together which substantially seals the plastic housing and substantially precludes water intrusion or the like into the housing at the seams or mating portions of the housing. Because the plastic housing of the camera module of the present invention may be laser welded or sonic welded together to substantially seal the housing, the housing may provide an economical and rugged, environmentally resilient and protective housing for the camera or sensor and circuit board. The unitary housing and connector also makes it easy to install and connect the camera module to a vehicle connector.

Alternately, the camera module of the present invention may comprise a vented camera module, where the housing includes a semi-permeable ventilation or venting portion, such as a Gore-Tex assembly, area or patch or the like, which allows for ventilation of water vapor into and out from the housing, while substantially precluding entry of water droplets or dirt or other contaminants or the like into the housing. The plastic vented module of the present invention thus may also provide an economical and rugged, environmentally resilient and protective housing for the camera or sensor and circuit board.

Additionally, the camera module of the present invention may include a heating device which functions to heat a transparent conductive coating on a transparent cover of the housing, so as to provide heat to the cover to defrost or defog the cover. The heater elements may be insert molded within the plastic housing of the camera module and may plug into a circuit board received within the housing as the camera module is assembled. Preferably, the heating device may be operable in response to a temperature sensor, such that the heating device may be activated when the temperature drops to a threshold temperature and then deactivated after the temperature has been elevated to a second higher threshold temperature. The heating device is thus automatically operable in low temperature levels when it may be desirable to activate the heating device. The heating device may be activated to defrost or defog the transparent cover of the camera module and/or to heat the interior chamber of the camera module to limit or substantially preclude moisture condensing therein. Heating the interior compartment of the camera module may dry out any moisture within the module and may limit or substantially preclude condensation from forming within the module. In applications where the camera module comprises a vented camera module, the heat generated within the vented camera module may also drive out water vapor through the semi-permeable ventilation area to further limit or substantially preclude water vapor from condensing within the camera module.

Referring now to FIGS. 18-20, a camera housing device 110 may house or contain a camera or imaging device 116 and protect the camera from exposure to the elements in applications where the camera may be positioned at a vehicle 8 (FIG. 18) for viewing an area or scene exterior of the vehicle. The camera housing device 110 may be positioned at least partially within an opening 8b at an exterior portion 8a of a vehicle 8 (such as a rearward portion or side portion or elsewhere on the vehicle) . The housing device 110 defines a compartment or cavity 114 for receiving camera or imaging device 116 therein and is operable or movable to move the camera or imaging device 116 between a stored position (FIG. 19) and an operational or extended or in-use position (FIG. 20). The camera 116 and compartment 114 are positioned generally inwardly of an outer panel or flap 118 of housing device 110 at the exterior portion 8a of the vehicle 8 when the housing device and camera are in the stored position. As shown in FIG. 19, the outer panel or flap 118 is positioned generally along the exterior portion 8a of the vehicle a and serves as a cover or flap over the opening 8b when housing device 110 is in its stored position.

Imaging device 116 may be operable in conjunction with a vision or imaging system of the vehicle, such as a reverse or backup aid system, such as a rearwardly directed vehicle vision system utilizing principles disclosed in U.S. Pat. Nos. 5,550,677; 5,760,962; 5,670,935; 5,760,962; 5,877,897; 5,949,331; 6,222,447; 6,302,545; 6,396,397; 6,498,620;

6,523,964; 6,611,202; and/or 6,201,642, and/or in U.S. pat. applications, Ser. No. 09/199,907, filed Nov. 25, 1998 by Bos et al. for WIDE ANGLE IMAGE CAPTURE SYSTEM FOR VEHICLE (Attorney Docket DON01 P-676); Ser. No. 10/372,873, filed Feb. 24, 2003 by Schofield et al. for VEHICLE IMAGE CAPTURE SYSTEM (Attorney Docket DON01 P-1077); Ser. No. 10/011,517, filed Nov. 5, 2001 by Bos et al. for INTERIOR REARVIEW MIRROR SYSTEM INCLUDING A FORWARD FACING VIDEO DEVICE (Attorney Docket DON01 P-934); Ser. No. 10/324,679, filed Dec. 20, 2002 by Schofield et al. for VEHICULAR VISION SYSTEM (Attorney Docket DON01 P-1059); Ser. No. 10/047,901, filed Jan. 14, 2002 by Bos et al. for VEHICLE IMAGING SYSTEM WITH ACCESSORY CONTROL (Attorney Docket DON08 P-949); and Ser. No. 10/643,602, filed Aug. 19, 2003 by Schofield et al. for VISION SYSTEM FOR A VEHICLE INCLUDING IMAGING PROCESSOR (Attorney Docket DON01 P-1087); and Ser. No. 10/010,862, filed Dec. 6, 2001 by Bos for PLASTIC LENS SYSTEM FOR VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-954), which are hereby incorporated herein by reference, a trailer hitching aid or tow check system, such as the type disclosed in U.S. pat. application, Ser. No. 10/418,486, filed Apr. 18, 2003 by McMahon et al. for VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-1070), which is hereby incorporated herein by reference, or an imaging system that may utilize aspects of other imaging or vision systems, such as the types disclosed in U.S. pat. applications, Ser. No. 10/054,633, filed Jan. 22, 2002 by Lynam et al. for VEHICULAR LIGHTING SYSTEM (Attorney Docket DON01 P-962); and Ser. No. 09/793,002, filed Feb. 26, 2001, entitled VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE (Attorney Docket DON01 P-869), which are hereby incorporated herein by reference. The imaging system includes a control or control system or device that is operable to process images captured by the imaging device 116 and a display 115 (FIG. 1) for displaying the captured images to a driver or occupant of the vehicle. The display may be positioned at an interior portion of the vehicle, such as at an interior rearview mirror assembly of the vehicle or accessory module of the vehicle or the like. The display may comprise a video display screen at a mirror assembly, such as the type disclosed in U.S. provisional applications, Ser. No. 60/439,626, filed Jan. 13, 2003 by Hutzel et al. for MIRROR WITH VIDEO DISPLAY SCREEN (Attorney Docket DON01 P-1061); Ser. No. 60/489,812, filed Jul. 24, 2003 by Hutzel et al. for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 P-1100); and Ser. No. 60/492,225, filed Aug. 1, 2003 by Hutzel et al. for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 P-1107), which are hereby incorporated herein by reference, or may comprise other types of displays or display systems, such as, for example, a display on demand type of display, such as the types disclosed in commonly assigned U.S. Pat. Nos. 5,668,663 and 5,724,187, and U.S. pat. applications, Ser. No. 10/054,633, filed Jan. 22, 2002 by Lynam et al. for VEHICULAR LIGHTING SYSTEM (Attorney Docket DON01 P-962); and Ser. No. 09/793,002, filed Feb. 26, 2001, entitled VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE (Attorney Docket DON01 P-869), which are hereby incorporated by reference herein, without affecting the scope of the present invention.

The control may also be operable to move the camera housing device between the operational and stored positions. The method of actuation of the housing to move the housing and camera may be accomplished by a motor, such as via a gear or screw mechanism, or by vacuum compressed air or by magnetic or electromagnetic means, such as in the form of a solenoid or the like. Optionally, the camera housing device 110 may be movable to the operational position in response to an engagement of the reverse gear of the vehicle, or in response to an actuation of a backup aid or other reverse viewing system of the vehicle. Optionally, the camera housing may be moved to the operational position in response to a user input or the like, without affecting the scope of the present invention. The camera housing thus allows for occasional use of the camera and may store and protect the camera when the camera is not in use.

Imaging device or camera 116 may comprise a camera device or other image capturing device, such as a video camera or sensor, such as a CMOS imaging array sensor, a CCD sensor or the like, such as the types disclosed in commonly assigned, U.S. Pat. Nos. 5,550,677; 5,760,962; 6,097,023 and 5,796,094, which are hereby incorporated herein by reference. Such imaging array sensors comprise an array of photo-sensing pixels to sense light present in the field of view of the sensor. The imaging device 116 may comprise a color sensing imaging device, which includes color filters such that the photo-sensing pixels of the imaging device sense particular colors of light from the scene. Optionally, the imaging device may or may not include an infrared filter to filter or attenuate infrared or near infrared light present in the exterior scene. Optionally, the imaging device may provide an infrared sensing capability to provide enhanced performance of the imaging device during nighttime and/or darkened conditions where the visible light intensity is reduced. Optionally, the housing device may include two separate imaging devices, one for sensing color light for daytime lighting conditions and one for sensing infrared light for nighttime or darkened lighting conditions, as discussed below. Alternately, the control may be operable to selectively switch the imaging sensor between a color mode and a monochromatic mode, such as via utilization of principles described below with respect to imaging system 310. The imaging device may have a lens 117 positioned in front of the sensor, and may utilize aspects of an imaging module of the types described above with respect to the camera modules 10, 10' of FIGS. 1-17.

Housing device 110 mounts or attaches the camera 116 generally at the external flap 118, such that the movement of the external flap between its opened position (FIG. 20) and its closed position (FIG. 19) moves the camera between its operational position and its stored position. The reverse aid camera or imaging device 116 is thus mounted behind the flap 118 such that when the camera is not in use it may be retracted into the vehicle exterior portion or body portion 8a, thereby protecting it from the elements, such as dirt or debris or the like, and keeping the lens 117 relatively clean. The outer flap 118 may partially overlap the edges of the opening 8b in exterior portion 8a of vehicle 8 and may be generally aligned with an outer or exterior surface of the exterior portion to provide a generally flush, finished appearance to the exterior portion 8a when the housing device 110 is in the stored or closed position.

As shown in FIGS. 19 and 20, the camera 116 may be mounted in a housing or box or container 119 attached to the flap 118, such that the camera 116 is substantially contained or encased within the compartment 114 defined within the housing 119. The housing device 110 may define compartment or cavity 114 within and between an inner wall or flap 120 and external flap 118, and opposite side walls or flaps 122 (only one side wall shown in FIGS. 19 and 20). The housing 119 of camera housing device 110 may be pivotable about a generally horizontal pivot axis or pin 111 at the exterior portion 8a of the vehicle 8. In the illustrated embodiment, housing device 110 includes a pivot arm or extension 111a extending from inner wall 120. The pivot arm 111a pivotally mounts to a pivot pin 111 and may pivotally move or swing the housing 119 between the stored position and the operational position. The pivot pin or axis 111 may be positioned within the exterior portion 8a of the vehicle 8 and generally adjacent to the edge of the opening 8b in the exterior portion 8a.

Optionally, the housing device may be positioned at a side portion of the vehicle (such that the housing may pivot about a generally vertical pivot axis or the like) or at a generally horizontal portion of the vehicle (such that the housing may pivot about a generally horizontal pivot axis and may have an outer flap that is generally horizontal when in its closed orientation, with the camera and housing positioned generally above or below the closed flap, depending on the particular application) or elsewhere on or in the vehicle, without affecting the scope of the present invention.

Housing 119 may include a clear or transparent glass or plastic window or panel 124 that at least partially closes the compartment 114 and that is positioned generally in front of the camera or imaging device 116 and covers or generally encases the lens 117 of the camera or imaging device 116. The transparent panel 124 may comprise a visible light transmitting panel that may substantially transmit visible light present in the scene to the imaging sensor 116 within housing 119 and behind transparent panel 124. The transparent panel 124 may comprise a substantially clear or transparent panel to provide protection to the lens and imaging sensor within the housing. Optionally, the transparent panel may comprise or provide an optical lens or may have optical qualities or characteristics or properties, whereby the transparent panel may function to serve or augment the lens of the imaging sensor.

Optionally, a wiper blade or wiping or cleaning device 126 may be positioned at the opening 8b of the exterior portion 8a of the vehicle 8 and may engage or wipe the outer surface 124a of the transparent panel 124 as the housing device 110 moves between the stored position and the operational position, in order to brush or clean or wipe debris or dirt or the like from the transparent panel 124. The wiper blade or device 126 may be spring loaded or biased (such as via a flexible spring clip 126a or the like) into engagement or contact with the surface 124a of the window or panel 124 such that as the housing device 110 opens and closes, the wiper 126 engages and wipes and cleans the window 124.

The transparent panel 124 thus may comprise a curved or arcuate panel such that the wiping device 126 generally uniformly engages the outer surface of the transparent panel as the housing device is opened and closed. However, the transparent panel may comprise other forms (and may be a generally flat panel), whereby the wiping device may engage only a desired portion of the panel or may be biased more toward the panel to maintain engagement of the wiping device with the panel during movement of the housing device. Optionally, a washer jet 128 may also be positioned at or near the opening 8b and may be operable to spray washer fluid or the like toward the panel or window 124 to clear dirt from the panel or window and to limit or prevent scratching of the window by the wiper.

Optionally, the housing device 110 may include a heating element that is operable to heat the transparent panel or window 124 to reduce moisture that may be present on the window. For example, window 124 may be heated by conductive strips embedded in the window, or surface mounted conductive strips, or ITO coatings or similar conductive or semi-conductive coatings or the like, such as described above with respect to camera module 10, 10'. The heater thus may heat the window to limit or substantially avoid condensation obscuring the field of view of the camera. Optionally, condensation may be limited by the use of a desiccant substance or by venting the enclosure or the like, without affecting the scope of the present invention.

Optionally, the exterior surface 124a of window 124 may be coated with an anti-wetting property such as via a hydrophilic coating (or stack of coatings), such as is disclosed in U.S. Pat. Nos. 6,193,378; 5,854,708; 6,071,606; and 6,013,372, the entire disclosures of which are hereby incorporated by reference herein. Also, or otherwise, the exterior surface 124a of window 124 may optionally be coated with an anti-wetting property such as via a hydrophobic coating (or stack of coatings), such as is disclosed in U.S. Pat. No. 5,724,187, the entire disclosure of which is hereby incorporated by reference herein. Such hydrophobic property on the outermost surface of the window or panel can be achieved by a variety of means, such as by use of organic and inorganic coatings utilizing a silicone moeity (for example, a urethane incorporating silicone moeities) or by utilizing diamond-like carbon coatings. For example, long-term stable water-repellent and oil-repellent ultra-hydrophobic coatings, such as described in PCT Application Nos. WO0192179 and WO0162682, the entire disclosures of which are hereby incorporated by reference herein, can be disposed on the exterior surface of the window. Such ultra-hydrophobic layers comprise a nano structured surface covered with a hydrophobic agent which is supplied by an underlying replenishment layer (such as is described in Classen et al., "Towards a True 'Non-Clean' Property: Highly Durable Ultra-Hydrophobic Coating for Optical Applications", ECC 2002 "Smart Coatings" Proceedings, 2002, 181-190, the entire disclosure of which is hereby incorporated by reference herein).

In some applications, it may be advantageous and desirable to add additional illumination to the exterior scene being captured by the camera. Accordingly, a camera housing device 110' may house or contain an imaging device or camera 116 and an illumination source or auxiliary light 130 (FIG. 21) that is operable to direct illumination toward the field of view of the camera 116. The illumination source 130 may provide visible light, infrared or near infrared light or may be pulsed to provide pulsed infrared or near infrared light. The auxiliary light 130 may be fixedly positioned on the external bezel portion of the camera housing or of the exterior portion of the vehicle, or optionally, and preferably, may be positioned within the housing and as part of the camera housing device or assembly (such as shown in FIG. 21). In this way, the panel 125 in front of the illumination device 130 may also be cleaned by the same operation or wiper 126 that cleans the transparent panel 124' in front of the camera 116.

Under some conditions, the light from the auxiliary illumination source 130 may be reflected, piped or refracted in or along the compartment and/or transparent panel in such a way that it may interfere with the image captured by the camera. Such interference may be avoided by splitting the clear window (as shown in FIG. 21) such that there is a window or panel 124' in front of the camera and a second window or panel or section 125 in front of the illumination source 130. Optionally, a divider or separating wall or panel or baffle 132 may be positioned between the compartments 114a, 114b that contain the camera 116 and illumination source 130, respectively. In the illustrated embodiment, the camera transparent panel 124' is substantially flat or planar, while the light transparent panel 125 is curved or arcuate. However, the transparent panels 124', 125 may be other shapes, without affecting the scope of the present invention. The separate panels and baffle provide a non-continuous path for the light to travel, so that the light will not have an adverse affect on the images being captured, while still providing for the external surface or surfaces of the panel or panels to be cleaned by the same wiper device. Optionally, by splitting the window into two panels 124', 125, the panel 125 covering the auxiliary light may be colored, such as red, to improve the appearance of the product on the vehicle. The camera housing device 110' is otherwise substantially similar to camera housing device 110, discussed above, such that a detailed discussion of the camera housing device will not be repeated herein.

Optionally, to improve the performance of the camera, the light level or intensity of the light emitted by the auxiliary light may be monitored by a sensor or device or control, and a control circuit may be used to adjust the camera for different light levels. Such a camera adjustment system would enhance the performance of the camera over a wide range of light conditions, and may also be used to control the auxiliary light if desired.

Optionally, when the camera housing is in the closed position, the camera and the auxiliary light may be at least occasionally turned on to illuminate the enclosed cavity and to capture an image of the illuminated enclosed cavity and transparent window. The enclosed cavity provides a known image, and the images captured by the camera in this orientation may be used to examine the window for condensation, dirt or other abnormalities. If condensation is detected on the window, a heater or heating mechanism may be activated to dry or evaporate the moisture from the window. The camera thus may be used to control the heaters that are used to remove condensation from the window. Optionally, if heating the window or cleaning the window does not alleviate a detected abnormality (such as if the same abnormality is detected after two or more openings and closings of the housing device), the control may provide an indication to a user of the imaging system that the transparent window may need to be checked or replaced (in case the abnormality detected is a chip or scratch or crack or the like that may adversely effect the performance of the imaging system).

Because the camera housing device is adjustable and may move the camera, the camera housing device of the present invention may provide the ability to change the field of view. For example, the camera can be moved to the furthest out or fully extended position for an initial approach to a parking zone or target zone or area. As the vehicle further enters the parking zone, the camera can be adjusted or moved to a more vertical angle (by pivoting or moving the housing device partially toward the closed position) to display the proximity of the bumper to any obstacle in the exterior scene. Such an adjustment of the camera position or orientation may also be combined with a change or adjustment of the lens configuration, such as by using a longer focal length for the initial approach (which may provide a less distorted view or image) and a wider angle configuration for the close range viewing to provide a wider field of view to the driver of the vehicle during the back up or reverse driving or maneuvering of the vehicle.

Also, by using the folding adjustment of the camera housing device to adjust the position of the camera, the housing device and camera may be adjustable to provide a different view of the area behind the vehicle. The control of the imaging system may then be operable to process images captured in each of the views and may compare the images to determine distances to objects detected in the exterior scene (such as by utilizing principles disclosed in U.S. Pat. No. 6,396,397; and/or in U.S. pat. application, Ser. No. 10/427,051, filed Apr. 30, 2003 by Pawlicki et al. for OBJECT DETECTION SYSTEM FOR VEHICLE (Attorney Docket DON01 P-1075), which are hereby incorporated herein by reference). By electronic comparison of the images captured between two positions of the camera (capturing at least one image in each of the two views), a distance map can be produced. Such a distance map may then be used to provide additional information about the exterior scene to the driver of the vehicle.

Optionally, the housing may not be restricted to one camera and may instead house or include two cameras for different imaging situations. For example, a standard color camera could be used for daylight conditions, while an infrared camera may be used for night or darkened conditions. The infrared or night camera may comprise a CMOS camera or the like without color or infrared filtering, such that it may be highly sensitive to infrared light that is present in the visibly darkened scene. The control may selectively activate the appropriate camera or imaging sensor in response to the ambient light level or intensity present at the exterior scene, such as in response to an ambient light sensor or in response to a light detection by one or both of the imaging sensors or the like. When the night camera is operated or used, the control may also activate (such as continuously activate or pulse) an infrared or near infrared illumination source at the exterior portion of the vehicle (such as within the compartment of the housing device, as discussed above). Optionally, a single camera or imaging sensor may be switched between a color mode and a monochromatic mode (such as described below with respect to imaging system 310), and an infrared illumination source may be activated when in the monochromatic mode, to enhance the performance of the camera or imaging sensor in various lighting conditions.

Although shown as being positioned at a rearward portion of a vehicle, the camera housing device of the present invention may be positioned elsewhere on the vehicle, such as a forward portion of the vehicle or a sideward portion of the vehicle or a roof portion of the vehicle or the like, without affecting the scope of the present invention. Also, although the camera housing device is shown as being mounted on a nearly vertical body portion of the vehicle, the camera housing device may be mounted or positioned at a nearly horizontal surface (such as may be found in the top of a number plate appliqué or the like), without affecting the scope of the present invention. In such a horizontal mounting application, the flap of the housing device may drop down to expose the clear window and to move the camera into its operational position.

Referring now to FIGS. 22 and 23, a camera housing device 210 holds or contains a camera or imaging device 216 and is movably mounted to an exterior portion 8a of a vehicle. The housing device 210 is movable to move the camera 216 (and associated lens 217) between a stored position (FIG. 22) and an operational position (FIG. 23). Housing device 210 includes a housing portion 219 that defines the cavity or compartment 214 within an outer panel or flap 218, an inner panel 220 and side panels 222 (one side panel is shown in FIGS. 22 and 23). A transparent cover 224 may close a portion of the cavity and may be positioned generally in front of the imaging device, such that imaging device has a field of view through the transparent window or panel and toward the exterior scene, as discussed above. Housing device 210 is generally linearly slidable relative to the exterior portion 8a of the vehicle (such as via a linear motor, an electromagnetic device or solenoid, a pneumatic device and/or the like) to extend outward from the exterior portion of the vehicle when in the operational position, as shown in FIG. 23.

The housing device 210 thus may be generally linearly moved outward and inward relative to the vehicle portion 8a. Accordingly, the transparent panel 224 may be a substantially flat or planar panel, such that the wiper device 226 (such as a wiper blade or the like on a spring or biasing member or the like 226a) may engage and wipe the surface 224a of the panel 224 as the panel is moved along adjacent to the wiper device 226. Optionally, the housing device 210 may be generally tubular or even generally cylindrical in shape, such that the transparent panel is curved, while the wiper device is correspondingly curved to substantially uniformly engage the curved or tubular transparent panel as the housing device is moved between the stored and operational positions. The wiping motion of the wiper on the transparent window or panel may thus be achieved by making the camera housing device a generally tubular construction that slides in and out in a generally linear motion, whereby the wiper can then clean the transparent window as the housing device moves in and out. The housing device 210 may otherwise be substantially similar to the housing device 110, 110', discussed above, such that a detailed discussion of the housing device will not be repeated herein.

Therefore, the present invention provides a camera housing device that contains a camera and lens of an imaging system at or partially within an exterior portion of a vehicle. The camera housing device is movable or adjustable to move the camera between an operational position and a stored position. The camera thus may be positioned in a stored position within an exterior portion of the vehicle when not in use. The exterior panel of the camera housing may provide an exterior cover at the exterior portion of the vehicle to protect the camera and lens from the elements when they are not in use. The housing device may include a transparent panel that substantially encloses the camera and lens within the housing. The housing device may also include a panel cleaning device that may clean the transparent panel to limit or substantially preclude dirt buildup or debris on the panel that may adversely effect the performance of the camera and thus of the imaging system.

Referring now to FIGS. 24-26, an image capture system or imaging or vision system 310 is positioned at an exterior portion of a vehicle, such as at a rearward portion 8a of the vehicle 8 (FIGS. 1 and 2), and is operable to capture an image of a scene occurring exteriorly of the vehicle, such as rearwardly of the vehicle, and to display the image at a display or display system 314 of the vehicle which is viewable by a driver of the vehicle. Image capture system 310 includes an image capture device or camera 316 (such as a camera or camera module of the types described above), which is directed exteriorly of the vehicle and has an exterior field of view which at least partially encompasses a "blind spot" area exteriorly of the vehicle. The images or frames captured by image capture device 316 are displayed at display 314 to assist the driver in viewing the blind spot areas, such as the rearward area immediately behind the vehicle for backing up or otherwise driving or maneuvering the vehicle. The image capture system 310 may include one or more auxiliary illumination sources 318 (FIG. 26), which may be selectively operable to provide illumination within the field of view of the image capture device 316 to enhance the illumination of the exterior scene. The image capture system 310 may also include a control or control system or microcontroller or microprocessor 320 for controlling or adjusting the image capture device and/or the illumination sources in response to the light levels in the general vicinity of the imaging system or in response to the contrast ratio in the captured image. For example, the microcontroller may selectively activate one or more illumination sources or LEDs 318, or may selectively switch the imaging sensor 316 from a color mode to a monochromatic or black and white mode, or may apply an infrared or near infrared contribution correction to the color levels of the pixels of the imaging sensor to adjust the color balance for better color rendition in the captured images, in response to the ambient light levels or contrast ratio, as discussed below.

Image capture system 310 may be positioned at the exterior portion of the vehicle and directed generally exteriorly of the vehicle for capturing images of the exterior scene to assist the driver in maneuvering or driving the vehicle. Image capture system 310 may utilize principles of other vehicle vision or imaging systems, such as a forwardly, sidewardly or rearwardly directed vehicle vision system or imaging system or the like utilizing principles of the systems disclosed in U.S. Pat. Nos. 5,550,677; 5,670,935; 5,760,962; 5,796,094; 5,877,897; 5,949,331; 6,097,023; 6,201,642; 6,222,447; 6,302,545; 6,313,454; 6,320,176; 6,353,392; 6,396,397; 6,498,620; 6,523,964; 6,559,435; and 6,611,202, and U.S. pat. applications, Ser. No. 09/441,341, filed Nov. 16, 1999 by Schofield et al. for VEHICLE HEADLIGHT CONTROL USING IMAGING SENSOR (Attorney Docket DON01 P-770); Ser. No. 10/427,146, filed Apr. 30, 2003 by Schofield et al. for VEHICLE HEADLIGHT CONTROL USING IMAGING SENSOR (Attorney Docket DON01 P-1091); Ser. No. 09/199,907, filed Nov. 25, 1998 by Bos et al. for WIDE ANGLE IMAGE CAPTURE SYSTEM FOR VEHICLE (Attorney Docket DON01 P-676); Ser. No. 10/372,873, filed Feb. 24, 2003 by Schofield et al. for VEHICLE IMAGE CAPTURE SYSTEM (Attorney Docket DON01 P-1077); Ser. No. 10/011,517, filed Nov. 5, 2001 by Bos et al. for INTERIOR REARVIEW MIRROR SYSTEM INCLUDING A FORWARD FACING VIDEO DEVICE (Attorney Docket DON01 P-934); Ser. No. 10/324,679, filed Dec. 20, 2002 by Schofield et al. for VEHICULAR VISION SYSTEM (Attorney Docket DON01 P-1059); Ser. No. 10/047,901, filed Jan. 14, 2002 by Bos et al. for VEHICLE IMAGING SYSTEM WITH ACCESSORY CONTROL (Attorney Docket DON08 P-949); Ser. No. 10/643,602, filed

Aug. 19, 2003 by Schofield et al. for VISION SYSTEM FOR A VEHICLE INCLUDING IMAGE PROCESSOR (Attorney Docket DON01 P-1087); and Ser. No. 10/010,862, filed Dec. 6, 2001 by Bos for PLASTIC LENS SYSTEM FOR VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-954), which are hereby incorporated herein by reference. The imaging system may be operable to captures images of the scene immediately rearward of the vehicle to assist the driver of the vehicle in backing up or maneuvering the vehicle in reverse. The back up assist system may be operable in response to the reverse gear of the vehicle being selected.

Image capture device or camera or imaging sensor 316 may comprise an imaging array sensor or a pixelated imaging array, such as a multi-pixel array such as a CMOS sensor or a CCD sensor or the like, such as the types disclosed in commonly assigned U.S. Pat. Nos. 5,550,677; 5,670,935; 5,796,094; 6,097,023; and 6,498,620, and U.S. pat. applications, Ser. No. 09/441,341, filed Nov. 16, 1999 by Schofield et al. for VEHICLE HEADLIGHT CONTROL USING IMAGING SENSOR (Attorney Docket DON01 P-770); and Ser. No. 09/793,002, filed Feb. 26, 2001 by Schofield et al. for VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE (Attorney Docket DON01 P-869), which are hereby incorporated herein by reference, or such as an extended dynamic range camera, such as the types described above. For example, the imaging sensor may comprise a CMOS camera, such as the OV7930 single chip CMOS color NTSC camera available from OmniVision Technologies Inc. of Sunnyvale, CA. Such color cameras may have the performance characteristics identified above and may additionally provide RGB and/or YCrCb video signals. Preferably, the color video camera operates at a minimum illumination (3000 K) of less than about 5 lux at f1.2, more preferably of less than about 3 lux at f1.2, and most preferably less than about of less than about 2 lux at f1.2. Such CMOS imaging sensors typically may have a peak sensitivity in the near infrared range, such as at approximately 850 nm to 900 nm.

Such pixelated imaging sensors may include a plurality of pixels, with at least some of the pixels masked or covered with a particular color filter, such that the individual pixels function to capture a particular color, such as red, green and blue colors or the like, such as disclosed in U.S. Pat. Nos. 5,550,677; 5,670,935; 5,796,094; 6,097,023; and 6,498,620, referenced above. For example, the imaging sensor 16 may comprise an individual blue or a green or a red color filter over each pixel element of the CMOS multi-pixel element array. The imaging sensor is thus operable to provide color images to the display. Such RGB filters enable the capture of a color image by the CMOS detector, but necessarily result in a reduced or decreased low light level sensitivity for a color camera compared to a monochromatic or black and white camera. Optionally, and preferably, the imaging sensor may be capable of selectively operating in either a color mode, in which a color image may be displayed on display 314, or a monochromatic or black and white mode, in which a monochromatic or black and white image may be displayed on display 314, such as by utilizing aspects of the imaging sensor disclosed in U.S. Pat. No. 6,498,620, which is hereby incorporated herein by reference.

In the illustrated embodiment of FIGS. 26, the image capture device 316 is at least partially contained within an imaging module or camera module 322, which includes imaging sensor or camera 316 and a lens 324 positioned within a housing (such as similar to housing 11 of camera module 10, discussed above) which defines a transparent window 322a (which may comprise an at least substantially transparent glass or polycarbonate or acrylic (or other suitable material) window or panel) at the end of lens 324 (such as described above with respect to camera module 10, 10'). The imaging module 322 may include the circuitry and controls for imaging sensor 316, such as on one or more printed circuit boards 322b (FIG. 26) contained within the housing. The imaging module 322 is shown in FIG. 26 without the housing for purposes of clarity.

As shown in FIG. 26, imaging module 322 may be positioned at or adjacent to a plurality of illumination sources 318 to define an imaging system module 323. The illumination sources 318 may be operable to emit or project illumination in the general direction that the imaging sensor 316 and lens 324 are directed. Preferably, the illumination sources project or emit substantially uniform illumination directly behind the vehicle where the vehicle back up lights do not typically provide adequate illumination. The illumination sources may be selected to provide sufficient intensity over the targeted area to maintain the minimum acceptable contrast ratio (such as about 18 dB) in the displayed images.

The illumination sources 318 may comprise infrared or near infrared emitting light emitting diodes (LEDs) or the like and thus may emit light or energy in the infrared or near infrared range (such as energy having a wavelength of approximately 750 nm or greater). The infrared illumination may be provided via pulsing the illumination sources or generally continuously activating the illumination sources. An exemplary near-infrared emitting LED to use in conjunction with the imaging system of the present invention is available from Lumex Inc. of Palatine, Ill. under the trade name OED-EL-1L2. This is a T-5mm, leaded, clear epoxy - 60 degree LED that emits essentially no visible light but that has a peak spectral emission of about 940 nm. Forward current through such infrared LEDs is typically less than about 150 mA, more preferably less than about 100 mA, and most preferably less than about 80 mA. Power consumption by such infrared LEDs is typically less than about 350 mW, more preferably less than about 250 mW, and most preferably is less than about 150 mW. Such LEDs can be powered by duty cycling, such as by pulse width modulation or by direct current drive (typically via a load dropping resistor in series with the vehicle ignition supply). Other near-infrared light emitting diodes or the like can be used, such as LEDs with a peak light emission intensity at about 730 nm, at about 780 nm, at about 875 nm, and at about 880 nm. Spectral output for such near-infrared LEDs is preferably in the 5 mW/sr to about 35 mW/sr range. Such near-infrared light emitting diodes emit little or no visible light.

The infrared or near infrared illumination thus may provide improved camera pixel responsivity in low light levels, and the projected infrared or near infrared illumination is not readily visible directly behind the vehicle when the illumination sources are activated. The wavelength of the illumination emitted by the illumination sources may be selected to best balance the camera spectral response and to minimize ambient lighting affects in the captured image. Optionally, auxiliary illumination sources may be selected that emit visible light, as discussed below. Optionally, additional visible light sources (such as visible light emitting LEDs or an incandescent source or a neon source or the like) can illuminate on occasions at night when the driver wants to have visible light illumination of the area immediately exteriorly of the vehicle. Optionally, the auxiliary illumination may be provided via activation of modified back up lights, which may provide visible or infrared or near infrared illumination at the area immediately rearward of the vehicle, such as when the vehicle is shifted to the reverse gear.

With reference to FIG. 25, imaging system 310 includes microcontroller 320, which is operable to control imaging sensor 316 and auxiliary illumination sources 318. The microcontroller 320 may receive an input signal from one or more ambient light sensors 326, which are operable to detect the ambient light levels within the exterior scene. The microcontroller may provide an active camera control and may be operable to adjust or control the imaging sensor and/or the illumination sources in response to the ambient light levels present in the exterior scene. Optionally, the microcontroller may process the captured image to determine the contrast ratio in the images. The microcontroller may then adjust or control the imaging sensor and/or the illumination sources in response to the contrast ratio in order to maintain the image display contrast ratio at a minimum acceptable viewing contrast ratio. For example, the microcontroller may activate or increase the illumination output of the illumination sources to increase the contrast ratio in the captured images to a desired or threshold minimum ratio or level, such as approximately 18 dB.

The imaging sensor 316 may receive or capture images via imaging lens 324 and a bandpass filter 328, all of which may be positioned behind the transparent window of camera module 322. The images captured by imaging sensor 316 may be received by an image processor 330 and data translator 332, which may process the images or pixel outputs as desired. For example, the image processor 330 and data translator 332 may be operable to process the images to determine if an object is present in the detected image, such as by utilizing the principles disclosed in U.S. pat. application, Ser. No. 10/427,051, filed Apr. 30, 2003 (Attorney Docket DON01 P-1075), which is hereby incorporated herein by reference, or may process the captured images to extract other information therefrom, without affecting the scope of the present invention. The data translator 332 may also receive inputs 333 pertaining to vehicle data or vehicle status data or the like. The images captured may be displayed at the display or display system 314, and/or the processed images or information derived or extracted from the processed images may be displayed at the display or display system 314.

During normal day time conditions or high ambient light conditions (for example, when the ambient light sensor or sensors 326 detect an ambient light level which is greater than a threshold light level or when the microcontroller determines that the contrast ratio of the captured images is greater than the minimum acceptable viewing contrast ratio), imaging sensor 316 may provide color images which provide a color rendition consistent with the driver's expectations (in other words, consistent with real world colors). The imaging sensor or camera may be switched or set to a color mode when ambient light levels are at or increase to a sufficient level at or above a minimum or threshold level, and thus may capture color images and may provide color images to the display system during such lighting conditions. The camera or system may also include an automatic color balance algorithm which may function to adjust or optimize the colors in the captured image to the visible spectrum of light, as discussed below.

As disclosed in U.S. Pat. Nos. 5,550,677; 5,670,935; 5,796,094; 6,097,023; and 6,498,620, and U.S. pat. applications, Ser. No. 09/441,341, filed Nov. 16, 1999 by Schofield et al. for VEHICLE HEADLIGHT CONTROL USING IMAGING SENSOR (Attorney Docket DON01 P-770); and Ser. No. 09/793,002, filed Feb. 26, 2001 by Schofield et al. for VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE (Attorney Docket DON01 P-869), which are hereby incorporated herein by reference, the pixels of the imaging array sensor 316 may be individually operable to measure a particular color or range of color (such as red, green and blue) in the visible spectrum to determine the color image. Any near infrared radiation or infrared radiation that is received by the pixels may add to the measured value of the particular color that the particular pixel senses or accumulates. This results in a shift in the representation in the color of the captured image and may result in an image having unsatisfactory or unrepresentative color. Optionally, and as discussed below, the band pass filter 328 of the imaging system may comprise an infrared or near infrared filter, which may filter out or substantially block light in the infrared and/or near infrared range of the spectrum, such as light having wavelengths in the approximately 750 to 900 nm, and preferably blocking or reducing transmission of some light in the visible region of the electromagnetic spectrum so that band pass filter 328 passes (i.e. is highly transmitting to) visible wavelengths up to about 650 nm or thereabouts, but has reduced transmission above about 650 nm and, in particular, has substantially reduced transmission in the near infrared region.

In order to correct the color balance in the captured images, the image capture system of the present invention may subtract fixed values from the particular color values (e.g., red, green, blue) of each pixel, such that the imaging system may provide an infrared or near infrared contribution correction in situations where the infrared or near infrared light present in the scene (such as from solar radiation) may otherwise washout or distort or otherwise adversely affect the color balance of the captured images. The offset or subtracted values may be a generally fixed intensity offset or value or may be based on the ambient light levels detected by the ambient light sensor or by a combination of pixels of the imaging sensor or the like.

Optionally, the infrared radiation present in the exterior scene may be measured, such as via an infrared sensor positioned at the lens 324, imaging sensor 316 or window 322a of camera module 322. The measured infrared radiation may be factored into the infrared contribution correction amount to provide an improved and dynamic correction for the pixels. It is further envisioned that the offset for the particular colors (e.g., red, green, blue) may be different between the colors (for example, in certain lighting conditions, there may be more of an offset for one color, such as, for example, red, than the other color or colors, such as green and blue). The imaging system may thus provide a detection of the infrared radiation and may provide a dynamic correction of each pixel color. The imaging system thus may provide a sensor driven offset or correction. The sensor or sensors may comprise an infrared sensor (with a visible light filter) by itself or in combination with a second sensor which senses visible light (with an infrared filter), to determine the infrared level or intensity in the exterior scene.

Optionally, some of the pixels of the imaging array sensor 316 may be unmasked or unfiltered, such that they capture or accumulate the entire spectrum of light (or at least substantially the entire spectrum of light) present in the scene. The unmasked pixels thus are dedicated to sensing the visible and infrared light present in the exterior scene and may provide a basis for determining the offset that is to be applied to the color value of the masked pixels. In such an embodiment, the image capture device would not include an infrared filter, or at least not an infrared filter over the entire pixelated array (however, an infrared filter at the pixel level may be provided, such as an infrared filter at each of the individual color pixels, which also include a mask or filter associated with the particular color that the individual pixel is to capture).

The imaging sensor 316, which may comprise a CCD or CMOS camera or the like, may thus operate sufficiently well with its factory settings at illumination levels between a few lux and several thousand lux (such as may be present in normal indoor lighting conditions). When the available ambient illumination is below these levels, however, the camera may have a difficult time distinguishing features in the captured image as compared to the background noise of the camera, and thus may not be able to maintain the minimum contrast ratio during such low light levels. To address this deficiency, the auxiliary illumination sources 318 may be selectively activated to project auxiliary illumination throughout the field of view of the camera, in order to provide sufficient illumination levels for the camera to operate properly. The illumination sources may be selectively activated or controlled by the microcontroller in response to the ambient light levels detected by ambient light sensor or sensors 326 or by imaging sensor 316 (such as in response to a detection that the ambient light level has dropped or reduced to a threshold reduced light level), or in response to the contrast ratio in the captured image (such as in response to the contrast ratio being less than a desired or threshold amount, such as approximately 18 dB).

Optionally, the auxiliary illumination sources 318 may emit or project or provide visible light to the exterior scene. In such applications where visible light is provided by the auxiliary illumination sources (or where sufficient visible light may be provided by the backup lights or other lights or illumination sources of the vehicle), the band pass filter 328 may comprise an infrared or near infrared filter (or visible light pass filter) and may provide a cutoff or block at approximately 650 nm, such that the near infrared and infrared spectral regions (and preferably a portion of the visible light region of the spectrum) are limited or blocked from the imaging sensor or camera 316. Because greater visible illumination may thus be provided via the illumination sources in low ambient light conditions, while the infrared and near infrared illumination present in the exterior scene may be filtered or substantially blocked, the imaging system may be capable of capturing images during such lighting conditions which may have acceptable color balance, or which may require a reduced amount of processing or color adjustment to achieve the appropriate or acceptable color balance and contrast ratio. The filter pass or cutoff wavelength range may be selected to tailor the filter cutoff wavelength to the particular application (depending on the illumination provided to the exterior scene and the capabilities of the imaging sensor). The imaging system thus may provide improved imaging capabilities in low light conditions, while providing an appropriate color balance and contrast ratio for the images captured in all ambient lighting conditions.

In applications where the auxiliary illumination source or sources comprise infrared or near infrared illumination sources or LEDs, the microcontroller may switch the color camera from the color mode (where the camera captures color images and the display displays color images) to a monochromatic or black and white mode (where the camera captures monochromatic images). The microcontroller may switch the imaging sensor to the black and white mode in response to the ambient light level dropping to the threshold level or in response to the illumination sources being activated. Such a monochromatic mode is preferred in reduced visible lighting conditions and/or when the infrared emitting illumination sources are activated because the automatic color balance algorithm of the imaging system functions to optimize the color in the captured image to the visible spectrum, and may not function as well in such infrared or non-visible lighting conditions. Once the infrared or near infrared illumination is introduced by the illumination sources, the color balance control may be insufficient, which may result in a washed out or distorted image. The black and white image provided by the black and white mode may thus be more pleasing for viewing by the driver of the vehicle during such lighting conditions. The image sensor may quickly switch between the color mode and black and white mode and may provide a smooth transition from one mode to the other.

With reference to FIG. 25, the following illustrates the sequence of events that may trigger or initiate the low-light mode of the imaging system of the present invention. The microcontroller 320 may read or receive an output from one or more ambient light sensors 326, which may be positioned at or near imaging sensor 316 and which may be operable to detect or sense the ambient light present in the exterior scene. The microcontroller may also determine the contrast ratio of the images being captured by the imaging sensor. When the ambient light levels are determined to be below a low-light mode calibrated value or threshold value (or when the contrast ratio drops below the threshold level), the microcontroller may then initiate new commands to the imaging sensor or camera 316, such as via an I2C serial link or the like. The new register commands may consist of defeating the automatic gain, exposure and color modes of the imaging sensor 316. The exposure may be set to maximum frame integration time and the amplifier gain may, for example, be set to ½ maximum. This combination provides an enhanced or optimal signal to noise ratio for such lighting conditions.

The microcontroller may enter the monochromatic or color defeat mode, whereby the microcontroller may select either a single color kill register or a combination of modifying the color matrix registers to negate the color balance of the imaging sensor. The microcontroller may also enable the infrared LEDs via a logic control signal or the like, so that infrared or near infrared illumination is provided to the exterior scene. The low light mode camera settings may then be maintained until one or more of the ambient light sensors returns values or signals to the microcontroller which are above or outside the calibrated or threshold low-light mode range. Once this occurs, the imaging sensor may be set to the color mode and the above mentioned registers may be again updated with new values, and the illumination sources or LEDs may be disabled. The imaging sensor, such as a CMOS camera or the like, may implement the register updates within approximately two frame times (i.e., the time it takes to capture two consecutive frames or images), which may be within approximately 66 ms, depending on the particular imaging sensor used with the imaging system of the present invention.

Because the imaging system of the present invention may correct for washout or distortion in the color values to account for infrared and near infrared illumination in the exterior scene, and because the imaging system may switch to a monochromatic mode when conditions darken and/or when the illumination sources are activated, the present invention may obviate the need or desirability of providing an infrared filter at the imaging sensor, since such a filter may filter out some of the infrared or near infrared illumination provided by the illumination sources when the imaging system is in the low light mode. However, it is envisioned that such a band pass filter or infrared filter element may optionally be provided at the imaging sensor to attenuate at least some of the infrared radiation that may be present in the exterior scene. For example, an infrared filter may be provided that is highly transmitting (such as an integrated photopic visible transmission of at least about 75% transmitting, more preferably at least about 80% transmitting, and most preferably at least about 85% transmitting) in the visible light region between about 300 nm and 800 nm (where the eye's photopic response is sensitive), and more preferably in the 400 nm to 700 nm spectral range, and that has a lower or reduced transmissivity or is lowly transmitting in the 800 nm to 1100 nm region (at least) with a spectral transmission in the 750 nm to 1100 nm of less than about 5% transmission preferred, less than about 3% more preferred, and less than about 1% most preferred. Such infrared filter elements typically consist of a transparent substrate (typically glass) coated with a multilayer stack (typically at least three layers, more preferably at least five layers, most preferably at least seven layers, and typically deposited by vacuum deposition such as by sputtering or evaporation) of metal oxides and similar dielectric thin film layers that form a broad band visible band pass filter with a sharp spectral cut off around 700 nm or so. Such infrared filters typically operate by light interference, and preferably act as cold mirrors reflecting away near-infrared radiation while being highly transmitting to visible light. An example of an infrared filter element suitable for use with the imaging system of the present invention is available from Maier Photonics, Inc. of Manchester Center, VT under the part designation "p/n SP730/14s". This filter element has a 50% cut-off at +/- 10 nm at normal incidence, and comprises a 1 mm thick soda-lime glass substrate. Alternately, a WBHM infrared filter element available from OCLI of Santa Rosa, CA can be used (which has an average transmission equal to or greater than 80% from approximately 400 nm to 700 nm and an average transmission less than or equal to 2% from approximately 750 nm to 1100 nm). Also, an infrared filter element from Evaporated Coatings, Inc. of Willow Grove, PA comprising a Corning Micro-Sheet Glass 0211 coated with ECI#1010 can be used. This filter element has an average transmission equal to or greater than 85% at 400 nm to 700 nm; a partial transmission of about 80% at 740 nm (+/- 10 nm); a partial transmission of about 50% at 750 nm (+/- 10 nm); and an average transmission of less than about 3% at 780 nm to 1100 nm. Such infrared filter elements are abrasion resistant per MIL-C-675A, which is hereby incorporated by reference herein. Such infrared filters may be disposed in the camera assembly in front of the CMOS or CCD imaging array sensor (either in front of the camera lens or between the camera lens and the video detector array).

However, a problem can arise when a camera equipped with an infrared element as described above is used in conjunction with near infrared light emitting sources such as those also described above. The near infrared cut off of the camera filter may also severely attenuate and/or block the near infrared radiation emitted by the near infrared LEDs (or similar near-infrared emitting sources) such that nighttime illumination may be inadequate to be useful/valued by the driver. In order to avoid such concerns, while still providing such an infrared filter, the infrared filter and illumination sources may be selected such that at least some of the infrared illumination emitted by the illumination sources is not filtered or blocked by the infrared filter. For example, the filter may be selected that may cut out or substantially block radiation having wavelengths above approximately 950 nm, while the illumination source may emit light having wavelengths of approximately 800 nm to 900 nm. Optionally, and as discussed above, the auxiliary illumination sources may be operable to emit or project visible light to provide adequate visible illumination to the exterior scene, whereby the infrared and near infrared light may not be required by the imaging sensor (and thus may be filtered or blocked, such as at a wavelength of approximately 650 nm and above) in order to provide appropriate clarity and color balance in the images captured by the imaging sensor.

Optionally, it is further envisioned that the imaging system may function to remove the infrared filter from in front of the imaging sensor when the infrared illumination sources are activated, such as described in U.S. pat. application, Ser. No. 09/793,002, filed Feb. 26, 2001 by Schofield et al. for VIDEO MIRROR SYSTEMS INCORPORATING AN ACCESSORY MODULE (Attorney Docket DON01 P-869), which is hereby incorporated herein by reference. For example, at nighttime when ambient lighting is low and the infrared emitting illumination sources are activated, the infrared filter element may be moved out of the field of view of the lens so that the detector or camera can view unattenuated infrared radiation from the infrared emitting illumination sources so that the output image in the video display is discernable by the driver. Various means can be used to remove the infrared filter element from the camera field of view during nighttime. For example, an electromechanical mechanism, preferably operated by the microcontroller in response to a photo sensor or ambient light sensor, can automatically move the infrared filter element, such as by electrical command, out of the line of sight or field of view of the imaging sensor when the ambient lighting conditions are low.

Optionally, electro-optic means can be used to prevent color wash out by day while maximizing low light sensitivity by night. For example, an electrochromic infrared filter can be used, such as a filter utilizing the principles disclosed in U.S. Pat. No. 6,426,492, and U.S. pat. application, Ser. No. 10/206,558, filed Jul. 26, 2002 by Bos for ELECTRO-OPTIC FILTER FOR VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-1013), which are hereby incorporated herein by reference. The filter may include a tungsten oxide electrochromic layer that changes from being substantially visible light transmitting and substantially near-infrared transmitting when uncharged (bleached) and transforms to being significantly near-infrared absorbing/reflecting as well as being significantly visible light attenuating when cathodically charged. The degree of near-infrared attenuation and visible light attenuation is proportional to the negative voltage applied to the electrochromic tungsten oxide metal oxide layer, with applied voltages in the 0.1V to about 2.5V range typical. The higher the cathodic voltage applied, the more the near-infrared/visible light attenuation.

Optionally, the imaging system of the present invention may additionally include a plurality of infrared shutters which are in the optical path the imaging array sensor, such as disclosed in U.S. Pat. No. 6,498,620, which is hereby incorporated herein by reference. Each infrared shutter has at least one state in which infrared energy is generally not attenuated to the imaging sensor. In another state, the infrared shutter generally blocks infrared radiation from the array. The state of the infrared shutters may be controlled by the microcontroller, which may control the shutters in response to the ambient light levels in the exterior scene, such as detected by the ambient light sensor or sensors. During periods of high image luminance, the infrared shutters may switch to a state in which the shutters block near infrared radiation from the imaging sensor. However, during low image luminance conditions, the infrared shutters may switch to a state in which the shutters allow the near infrared energy to be transmitted to the imaging sensor. The addition of the near infrared radiation at low luminance levels enhances the image luminance sensed by the imaging sensor. The imaging sensor may also be switched to the monochromatic or black and white mode during such low luminance levels. The infrared shutters may be either electrochromic shutters or liquid crystal shutters, both of which are known in the art.

Although many aspects of the present invention are particularly suitable for applications having a CMOS type image sensor or camera (due to the high infrared sensitivity of CMOS cameras), other types of cameras or sensors may be implemented, such as CCDs, etc., without affecting the scope of the present invention.

Therefore, the present invention provides an imaging system which may provide enhanced imaging during nighttime conditions, while providing optimal color imaging during daytime conditions. The imaging system may determine the ambient light levels at the exterior scene, such as via ambient light sensors or photosensors, which may be associated with the camera or imaging array sensor, or which may be separate ambient light sensors. When the ambient light levels drop below a threshold level, the color mode of the imaging sensor may be turned off, such that the imaging sensor operates in a monochromatic or black and white mode in such low light conditions, thereby providing an enhanced image to the display for viewing by the driver of the vehicle. Also, the illumination sources (which are preferably infrared or near infrared illumination sources or LEDs) may be activated when the ambient light levels are low, so as to provide additional, substantially non-visible light to the exterior scene. Optionally, the illumination sources may be activated to illuminate the targeted area to increase the contrast ratio in the displayed images to a desired amount in response to the contrast ratio falling below a minimum acceptable viewing contrast ratio. Because the imaging sensors may then be operating in a black and white mode, the infrared illumination emitted by the illumination sources will not result in washed out or saturated or distorted color images. Also, because the imaging sensor may have a peak sensitivity in the infrared or near infrared range, and because the illumination sources may be infrared emitting sources, the imaging sensor may be capable of capturing images in very low lighting conditions, whereby the illumination for the imaging sensor is provided by the infrared illumination sources.

Optionally, when the imaging sensor is operating in the color mode, the microcontroller may adjust or correct the color balance via an adjustment of the pixel output for each of the color sensing pixels of the pixelated imaging array sensor. The present invention thus may provide a dynamic color balance adjustment function for a vehicular color exterior-viewing camera, such as one viewing rearward of the vehicle or forward of the vehicle or sideways of the vehicle, such as may be achieved by placing the camera module with integrated auxiliary illumination into an exterior rearview mirror assembly with its field of view directed toward and onto a ground surface adjacent the side body of the vehicle (in this regard, and when auxiliary illumination is required, and when the camera-equipped exterior mirror assembly includes a visible light emitting ground illumination/security light, such as are disclosed in 6,276,821; 6,176,602; 5,823,654; 5,669,699; 5,497,306; and 5,371,659, which are hereby incorporated herein by reference, the ground illumination/security light may optionally be selectively actuated to add additional auxiliary illumination in certain circumstances, such as when about to or first starting to drive the vehicle from a parked position). Preferably, such dynamic adjustment of color balance is achieved by determination of the level of near-infrared radiation incident the camera module and by using this determined level (via a closed-loop or an open-loop control algorithm) to adjust the color balance and/or other characteristics (such as selection of the monochrome or black and white mode) of the video camera system employed. Other camera functions, such as iris function or exposure function, may optionally be similarly dynamically adjusted commensurate with a detected ambient near-infrared or other light level at the camera module. The present invention also finds applicability to interior cabin monitoring systems.

Changes and modifications to the specifically described embodiments may be carried out without departing from the principles of the present invention, which is intended to be limited only by the scope of appended claims, as interpreted according to the principles of patent law.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An imaging system for a vehicle, said imaging system comprising:

a camera module positionable at the vehicle, said camera module comprising a plastic housing and an imaging sensor, said plastic housing including a first portion and a second portion, said first portion and said second portion being one of laser welded and sonic welded together to substantially seal said image sensor and associated components within said plastic housing; and

a control operable to process images captured by said image sensor.

2. The imaging system of claim 1 including a sealing material at said plastic housing to seal the pores of said plastic housing.

3. The imaging system of claim 1 including a heating element operable to heat at least one of a transparent cover of said housing and an interior chamber of said housing.

4. The imaging system of claim 1, wherein said first portion comprises a connector portion and includes a connector at an end thereof and said second portion comprises a camera portion and includes a transparent cover portion for receiving an image therethrough.

5. The imaging system of claim 4, wherein said transparent cover is one of laser welded and sonic welded to said camera portion.

6. The imaging system of claim 1, wherein said camera module is positioned in a movable housing that is movable relative to an exterior portion of the vehicle to move said image sensor between a stored position generally within the portion of the vehicle and an operational position where said image sensor is positioned to have a field of view exteriorly of the vehicle.

7. The imaging system of claim 6, wherein said movable housing comprises a transparent panel, said transparent panel being positioned at least partially across an opening of said housing and generally in the field of view of said image sensor.

8. The imaging system of claim 7, wherein said movable housing comprises a panel cleaning device positionable at the exterior portion of the vehicle and configured to engage an exterior surface of said transparent panel to clean said transparent panel as said housing moves said image sensor between said stored position and said operational position.

9. The imaging system of claim 7, wherein said housing is configured to receive an illumination source, said illumination source being directable toward the exterior scene when said housing moves said image sensor to said operational position.

10. The imaging system of claim 9, wherein said transparent panel is positioned in front of said illumination source.

11. The imaging system of claim 9, wherein said transparent panel comprises a first transparent panel positioned in the field of view of said image sensor and a second transparent panel positioned in front of said illumination source.

12. The imaging system of claim 1 including at least one illumination source, said control being operable to selectively activate said at least one illumination source in response to a detected ambient light level decreasing to a threshold level.

13. The imaging system of claim 12, wherein said control is operable to apply an infrared contribution correction to the detected levels for at least some of the colors detected by said image sensor to adjust a color balance of said image sensor.

14. The imaging system of claim 12, wherein said at least one illumination source comprises a visible light source, said control being operable to limit or block infrared and near infrared light present in the illuminated scene to reduce processing requirements.

15. The imaging system of claim 12, wherein said control is operable to selectively switch said image sensor from a color mode to a black and white mode in response to the reduced ambient light level.

16. The imaging system of claim 1, wherein said housing includes a ventilation portion, said ventilation portion being at least partially permeable to water vapor to allow water vapor

to pass therethrough while substantially precluding passage of at least one of water droplets and contaminants.

17. An imaging system for a vehicle, said imaging system comprising:

a vented camera module, said vented camera module comprising a housing and an image sensor, said housing including a ventilation portion, said housing being configured to receive said image sensor therein, said ventilation portion being at least partially permeable to water vapor to allow water vapor to pass therethrough while substantially precluding passage of at least one of water droplets and contaminants; and

a control for processing images captured by said image sensor.

18. The imaging system of claim 17, wherein said ventilation portion comprises a Gore-Tex area.

19. The imaging system of claim 17 including a heating element operable to heat the interior of said housing to limit condensation from forming within said housing.

20. The imaging system of claim 19, wherein said heating element is selectively activatable in response to a signal from a temperature sensor of said imaging system, said signal being indicative of a threshold temperature within said housing.

21. The imaging system of claim 20, wherein said heating element is selectively deactivatable in response to a second signal from said temperature sensor, said second signal being indicative of a second threshold temperature within said housing.

22. The imaging system of claim 19, wherein said heating element is operable to at least one of (a) dry out moisture within said housing and (b) drive out moisture through said ventilation portion.

23. The imaging system of claim 17, wherein said camera module comprises a movable housing that is movable relative to an exterior portion of the vehicle to move said image sensor between a stored position, where said image sensor is positioned generally within the portion of the vehicle, and an operational position, where said image sensor is positioned to have a field of view exteriorly of the vehicle.

24. The imaging system of claim 23, wherein said movable housing comprises a transparent panel, said transparent panel being positioned at least partially across an opening of said housing and generally in the field of view of said image sensor.

25. The imaging system of claim 24, wherein said movable housing comprises a panel cleaning device positionable at the exterior portion of the vehicle and configured to engage an exterior surface of said transparent panel to clean said transparent panel as said housing moves said image sensor between said stored position and said operational position.

26. The imaging system of claim 17 including at least one illumination source, said control being operable to selectively activate said at least one illumination source in response to a detected ambient light level decreasing to a threshold level.

27. The imaging system of claim 26, wherein said control is operable to apply an infrared contribution correction to the detected levels for at least some of the colors detected by said image sensor to adjust a color balance of said image sensor.

28. The imaging system of claim 26, wherein said at least one illumination source comprises a visible light source, said control being operable to limit or block infrared and near infrared light present in the illuminated scene to reduce processing requirements.

29. The imaging system of claim 26, wherein said control is operable to selectively switch said image sensor from a color mode to a black and white mode in response to the reduced ambient light level.

30. The imaging system of claim 17, wherein said housing comprises a first plastic portion and a second plastic portion, said first plastic portion being one of laser welded and sonic welded to said second plastic portion to substantially seal said image sensor and associated components within said housing.

31. An imaging system of a vehicle, said imaging system comprising:

an imaging device operable to capture images of a scene occurring exteriorly of the vehicle;

a holding device for movably holding said imaging device, said holding device comprising a housing, a transparent panel and a panel cleaning device, said housing being movably mountable at an exterior portion of a vehicle, said imaging device being positioned within said housing, said transparent panel being positioned at least partially across an opening of said housing and generally in the field of view of said imaging device, said housing being movable relative to the exterior portion of the vehicle to move said imaging device between a stored position, where said imaging device is positioned generally within the portion of the vehicle, and an operational position, where said imaging device is positioned to have a field of view exteriorly of the vehicle, said panel cleaning device being positionable at the exterior portion of the vehicle and configured to engage an exterior surface of said transparent panel to clean said transparent panel as said housing moves said imaging device between said stored position and said operational position; and

a control operable to process images captured by said imaging device.

32. The imaging system of claim 31, wherein said housing is pivotably mountable at the exterior portion of the vehicle.

33. The imaging system of claim 31, wherein said housing is slidably mountable at the exterior portion of the vehicle.

34. The imaging system of claim 31, wherein said housing moves said imaging device to said operational position in response to engagement of a reverse gear of the vehicle.

35. The imaging system of claim 31 including a spraying device operable to spray fluid onto said transparent panel.

36. The imaging system of claim 31 including an illumination source that is selectively operable to illuminate the exterior scene.

37. The imaging system of claim 36, wherein said housing is configured to receive said illumination source, said illumination source being directable toward the exterior scene when said housing moves said imaging device to said operational position.

38. The imaging system of claim 37, wherein said transparent panel is positioned in front of said illumination source.

39. The imaging system of claim 38, wherein said transparent panel comprises a first transparent panel positioned in the field of view of said imaging device and a second transparent panel positioned in front of said illumination source.

40. The imaging system of claim 38, wherein said control is operable to selectively activate said illumination source and said imaging device when said imaging device is moved to said stored position to determine if moisture is present on said transparent panel.

41. The imaging system of claim 36, wherein said control is operable to selectively activate said illumination source in response to at least one of (a) said imaging device being in said operational position and (b) a detected ambient light level decreasing to a threshold level.

42. The imaging system of claim 36, wherein said illumination source comprises a visible light source, said control being operable to limit or block infrared and near infrared light present in the illuminated scene to reduce processing requirements.

43. The imaging system of claim 36, wherein said control is operable to apply an infrared contribution correction to the detected levels for at least some of the colors detected by said imaging device to adjust a color balance of said imaging device.

44. The imaging system of claim 31, wherein an outer panel of said housing defines an exterior cover portion at an exterior surface of said exterior portion of the vehicle when said imaging device is moved to said stored position.

45. The imaging system of claim 31 including a display operable to display the image captured by said imaging device.

46. The imaging system of claim 31, wherein said imaging device comprises a color imaging sensor operable to capture color images of the exterior scene and an infrared imaging sensor operable to capture infrared images of the exterior scene, said control selectively

activating one of said color imaging sensor and said infrared imaging sensor in response to the ambient light intensity present in the exterior scene.

47. The imaging system of claim 31, wherein said housing is movable to selectively position said imaging device in first and second operational positions.

48. The imaging system of claim 47, wherein said control is operable to determine a distance to at least one object in response to processing of images captured bŷ said imaging device when in said first and second operational positions.

49. The imaging system of claim 47, wherein said control is operable to selectively move said housing to position said imaging device at said first operational position in response to the vehicle making an initial approach to a target zone and to position said imaging device at said second operational position in response to the vehicle moving further into the target zone, said imaging device being directed more downward when in said second operational position relative to said first operational position.

50. An imaging system of a vehicle, said imaging system comprising:

an imaging device operable to capture images of a scene occurring exteriorly of the vehicle;

a holding device pivotally mountable at a portion of a vehicle, said holding device comprising a housing having an exterior panel and a transparent panel, said imaging device being positioned within said housing, said transparent panel being positioned at least partially across an opening of said housing and generally in the field of view of said imaging device, said holding device being pivotable relative to the portion of the vehicle to move said imaging device between a stored position, where said imaging device is positioned generally within the portion of the vehicle, and an operational position, where said imaging device is positioned to have a field of view exteriorly of the vehicle, said exterior panel being generally aligned with an exterior surface of the portion of the vehicle and said transparent panel being generally within the portion of the vehicle when said imaging device is in said stored position; and

a control operable to process images captured by said imaging device.

51. The imaging system of claim 50, wherein said holding device includes an interior panel that is pivotally mounted at the portion of the vehicle, said interior panel and said exterior panel defining a cavity of said housing for receiving said imaging device.

52. The imaging system of claim 51, wherein said interior panel includes a pivot member that is pivotally attachable to a corresponding pivot portion of the portion of the vehicle.

53. The imaging system of claim 52, wherein said pivot member is pivotally attachable to a corresponding pivot portion of the vehicle that is positioned interiorly of the exterior surface of the portion of the vehicle.

54. The imaging system of claim 50, wherein said holding device includes a cleaning device for cleaning said transparent panel, said cleaning device being positionable at the portion of the vehicle and configured to engage an exterior surface of said transparent panel to clean said transparent panel as said holding device moves said imaging device between said stored position and said operational position.

55. The imaging system of claim 50, wherein said holding device moves said imaging device to said operational position in response to engagement of a reverse gear of the vehicle.

56. The imaging system of claim 50 including an illumination source that is selectively operable to illuminate the exterior scene.

57. The imaging system of claim 56, wherein said holding device is configured to receive said illumination source, said illumination source being directable toward the exterior scene when said holding device pivots said imaging device to said operational position.

58. The imaging system of claim 57, wherein said control is operable to selectively activate said illumination source in response to at least one of (a) said imaging device being in said operational position and (b) a detected ambient light level decreasing to a threshold level.

59. The imaging system of claim 57, wherein said control is operable to selectively activate said illumination source and said imaging device when said imaging device is moved to said stored position to determine if moisture is present on said transparent panel.

60. The imaging system of claim 56, wherein said illumination source comprises a visible light source, said control being operable to limit or block infrared and near infrared light present in the illuminated scene to reduce processing requirements.

61. The imaging system of claim 56, wherein said control is operable to apply an infrared contribution correction to the detected levels for at least some of the colors detected by said imaging device to adjust a color balance of said imaging device.

62. The imaging system of claim 50, wherein said imaging device comprises a color imaging sensor operable to capture color images of the exterior scene and an infrared imaging sensor operable to capture infrared images of the exterior scene, said control selectively activating one of said color imaging sensor and said infrared imaging sensor in response to an ambient light intensity present in the exterior scene.

63. The imaging system of claim 50, wherein said housing is pivotable to selectively position said imaging device in first and second operational positions.

64. The imaging system of claim 63, wherein said control is operable to determine a distance to at least one object in response to processing of images captured by said imaging device when in said first and second operational positions.

65. The imaging system of claim 63, wherein said control is operable to selectively move said housing to position said imaging device at said first operational position in response to the vehicle making an initial approach to a target zone and to position said imaging device at said second operational position in response to the vehicle moving further into the target zone, said imaging device being directed more downward when in said second operational position relative to said first operational position.

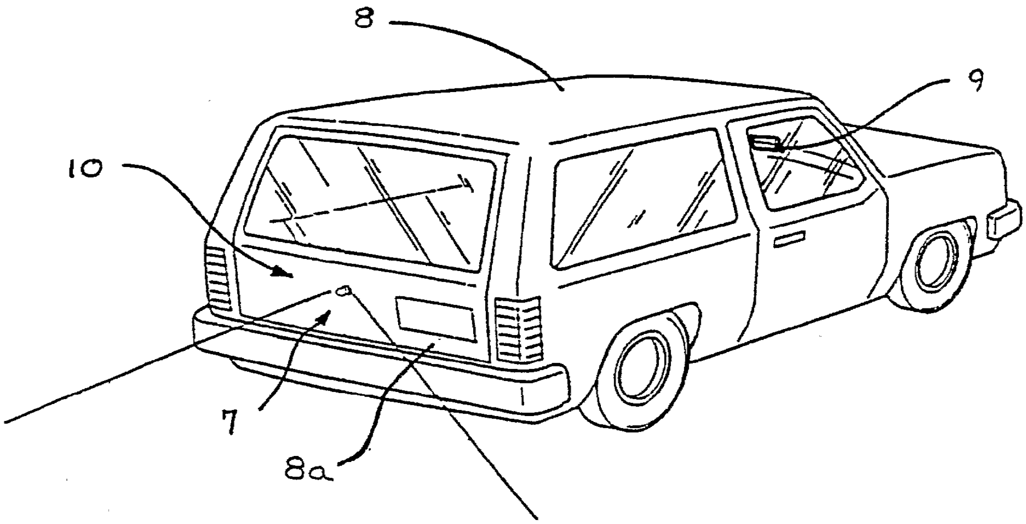


Fig. 1

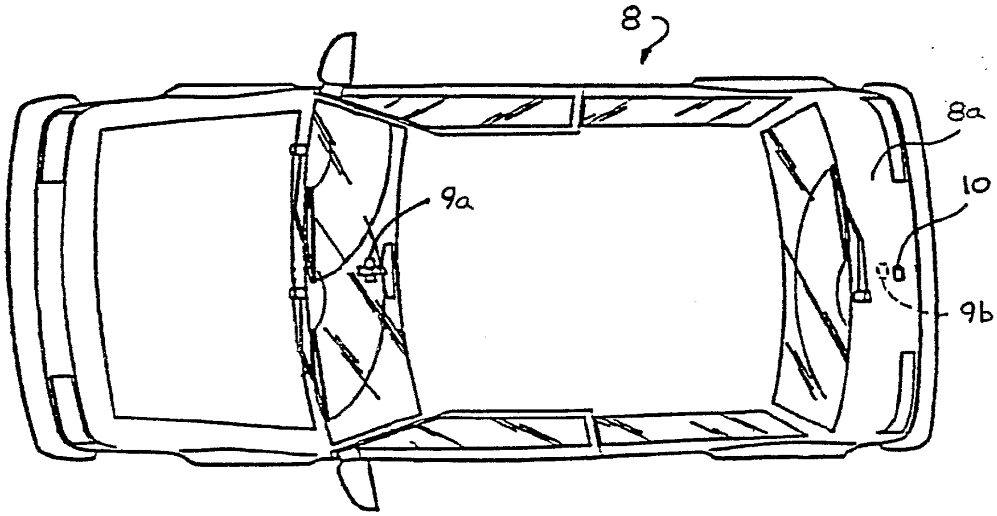


Fig. 2

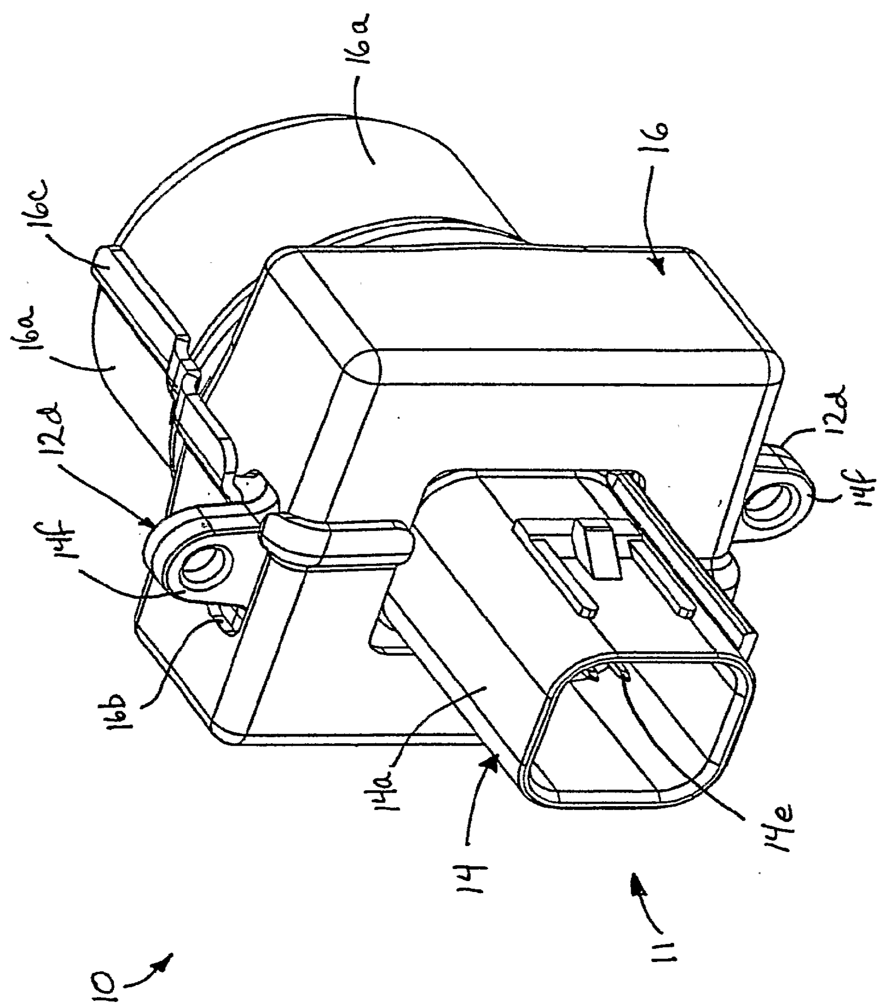
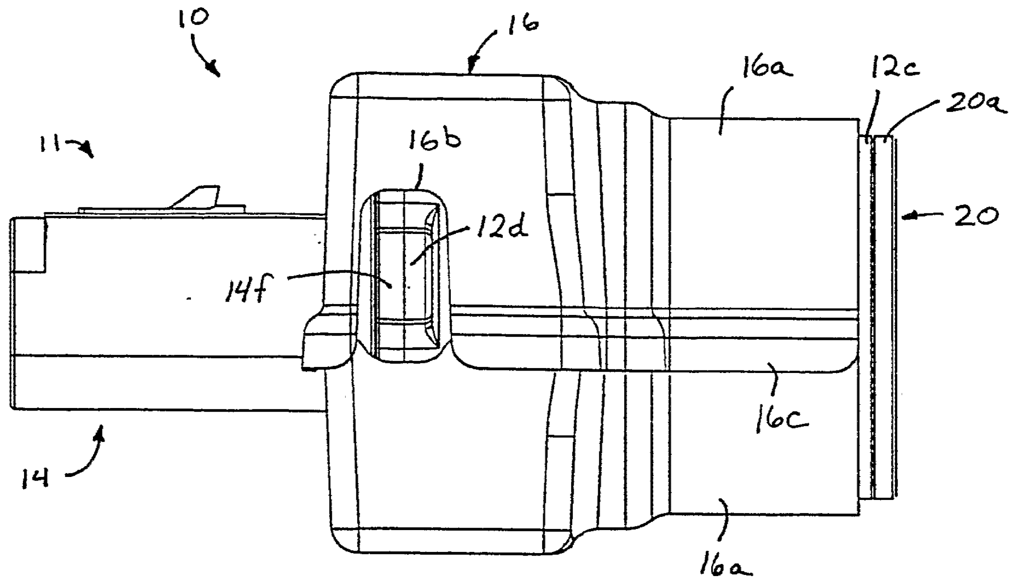


Fig. 3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20a
11
16b
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12d
14f
16c
14
16a

Fig. 4

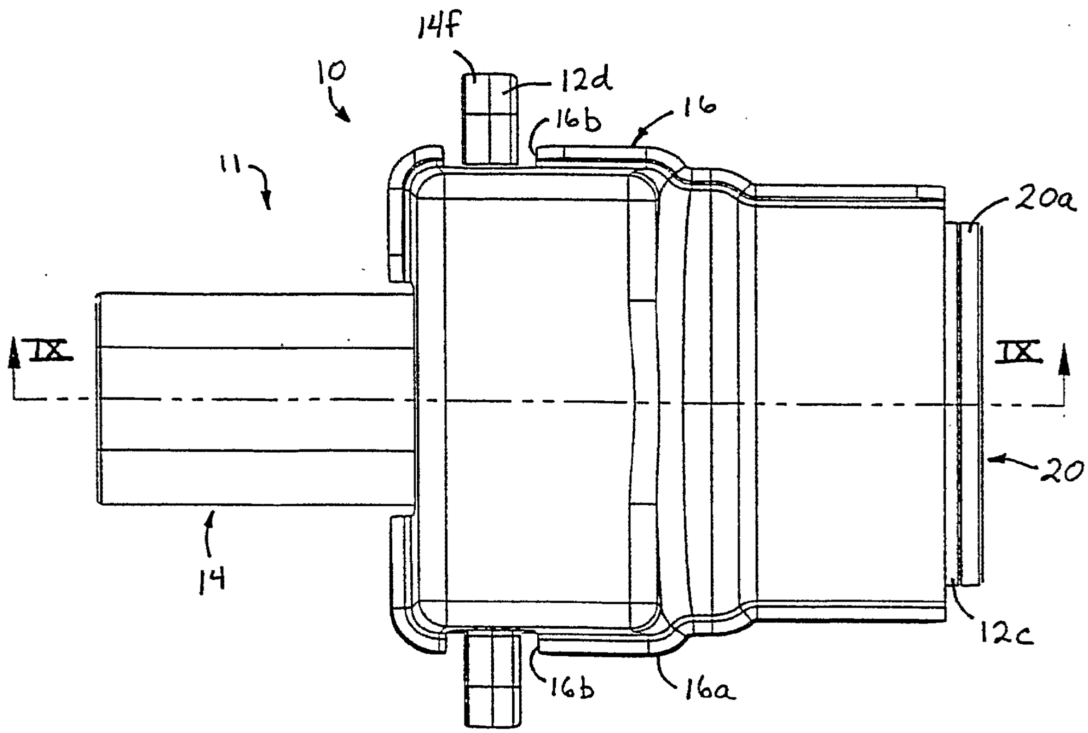
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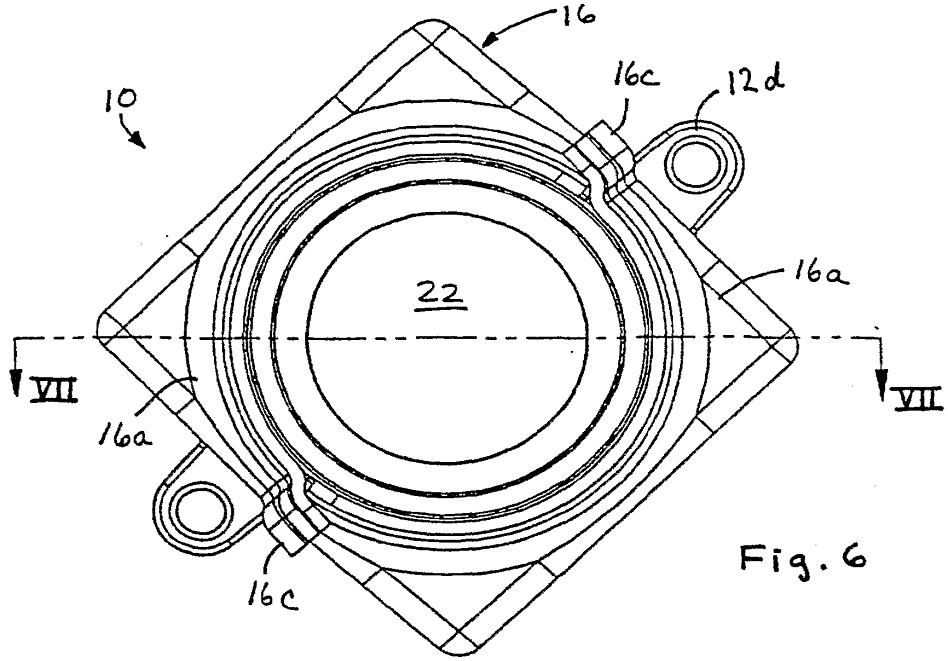
Fig. 5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22
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VII
VII
16a
16c

Fig. 6

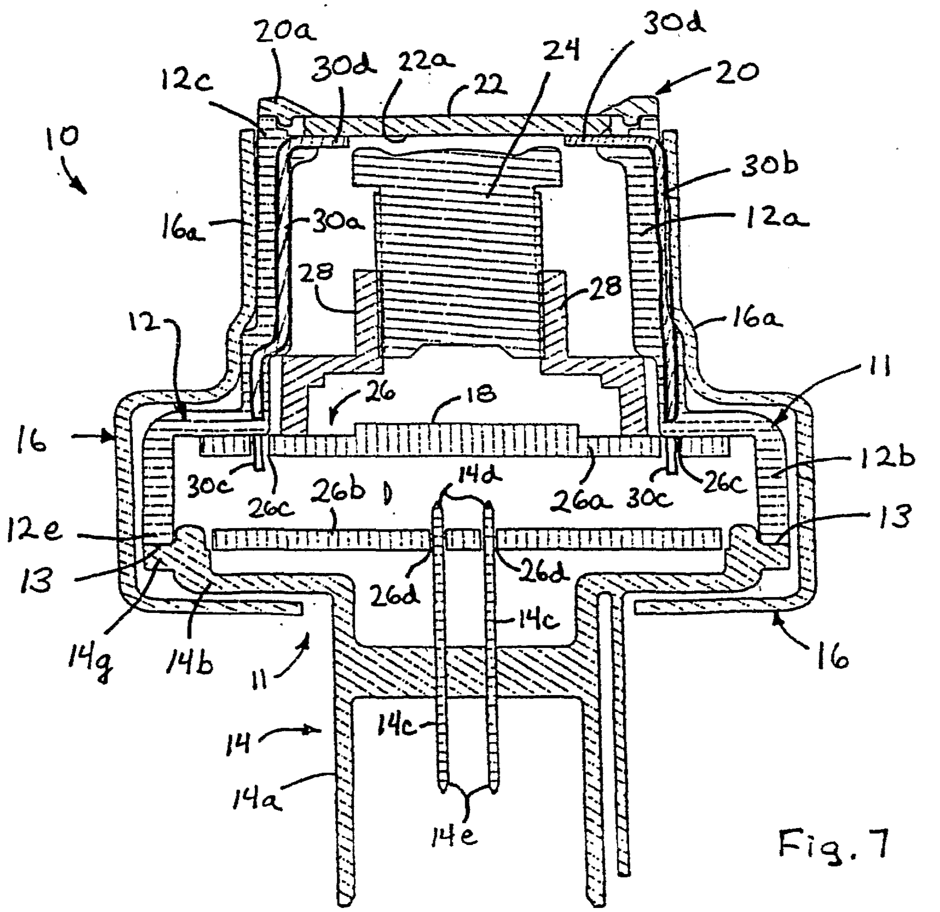
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Fig. 7

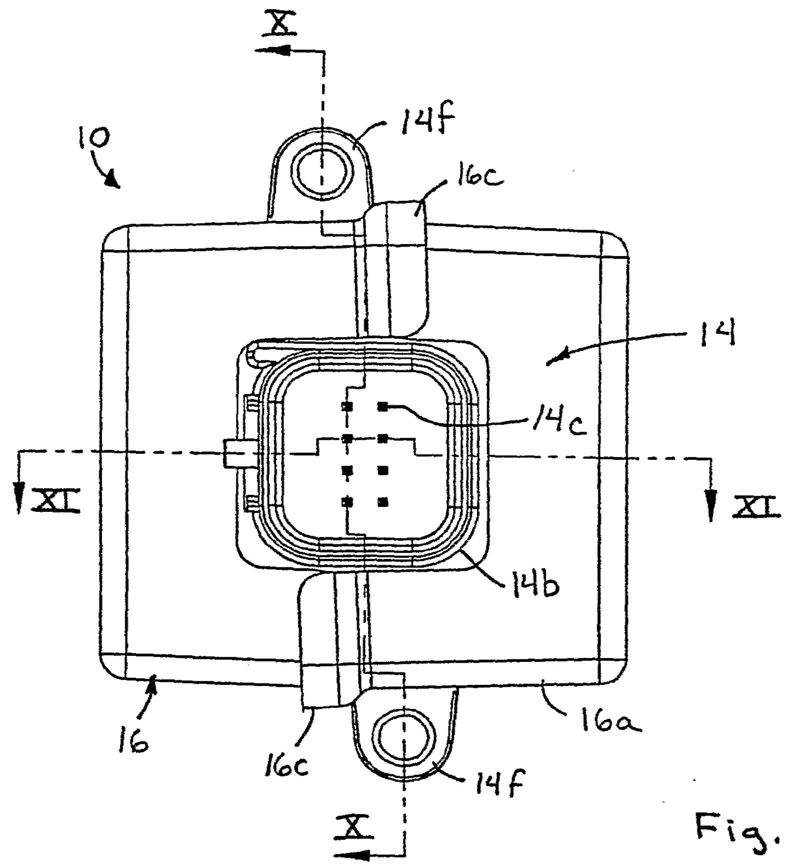
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Fig. 8

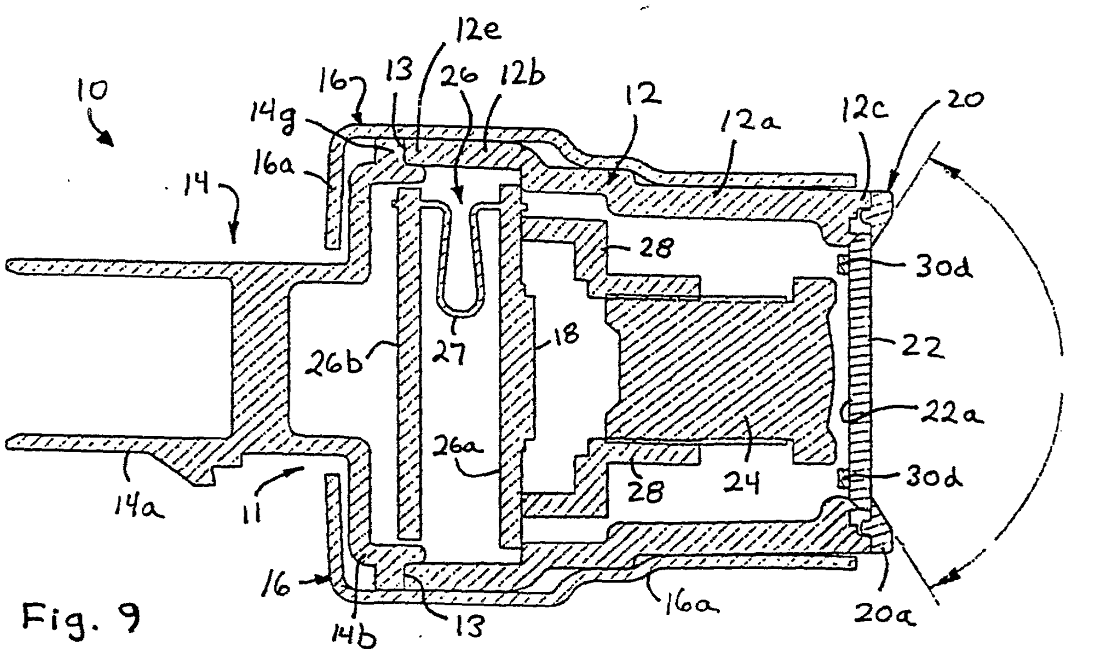
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Fig. 9

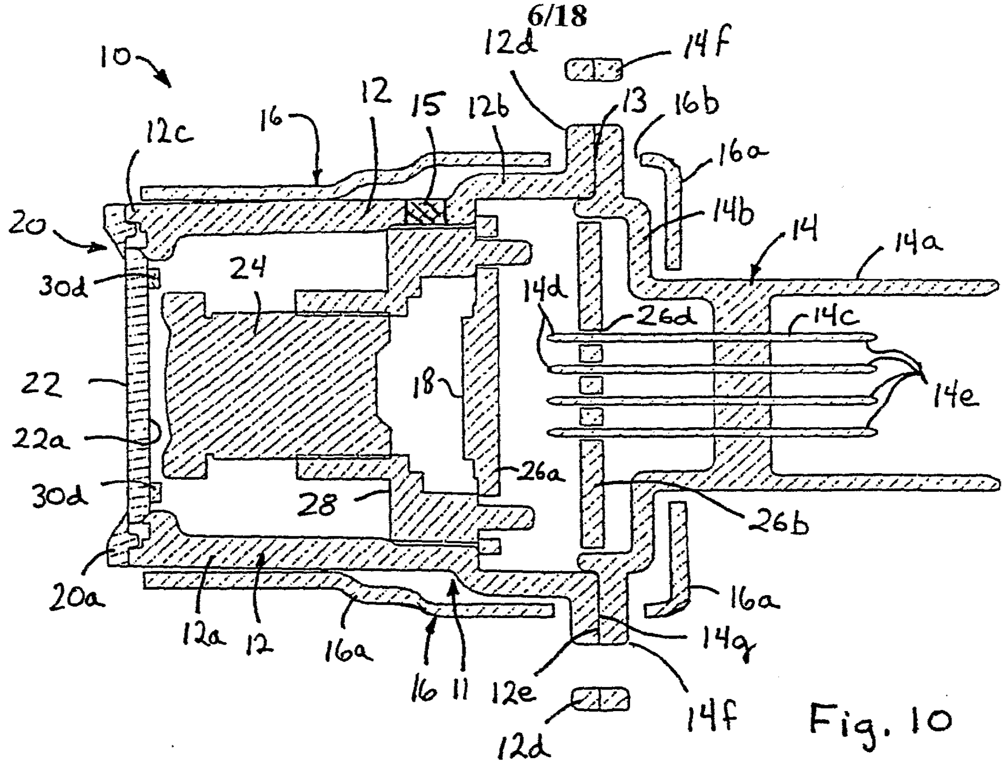
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Fig. 10

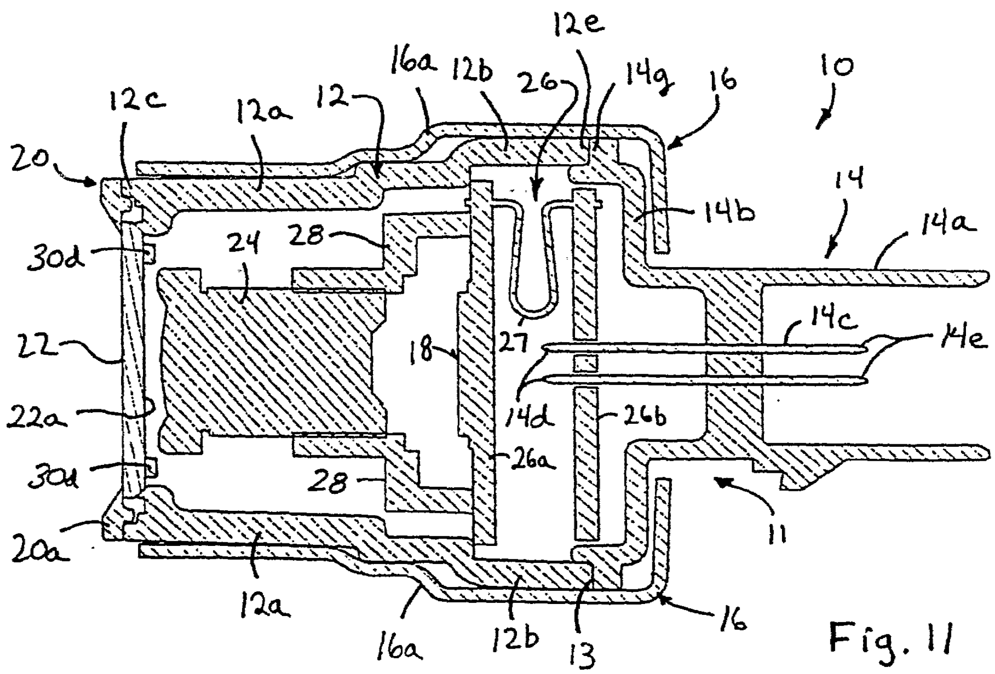
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Fig. 11

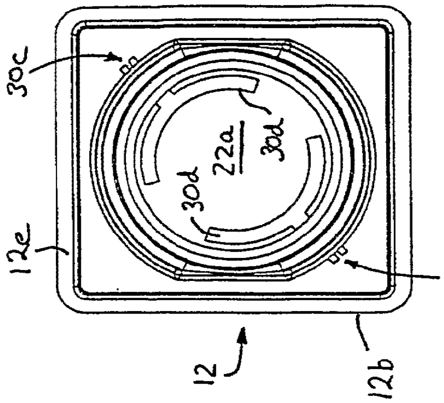

Fig. 12B

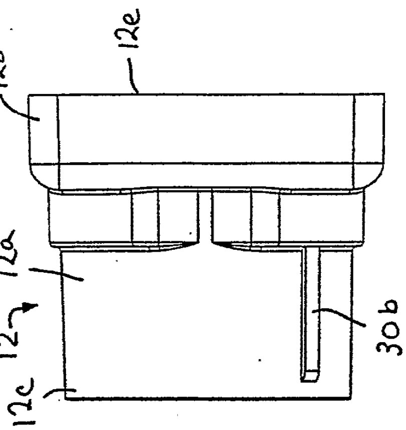

Fig. 12A

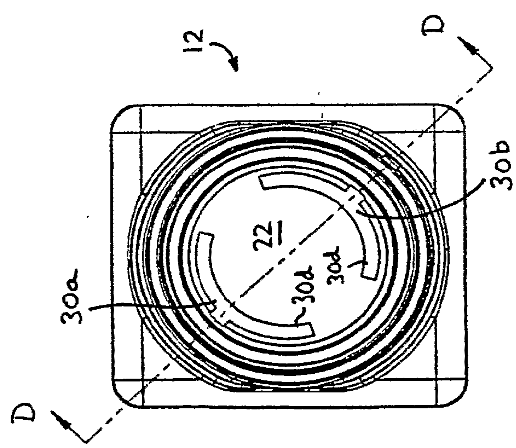

Fig. 12C

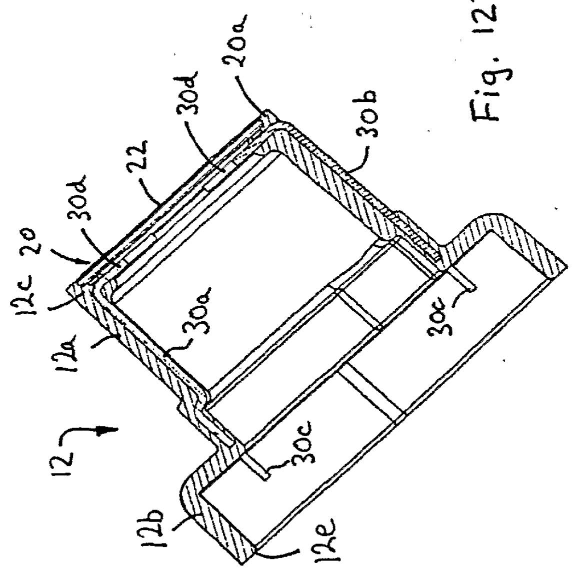

Fig. 12D

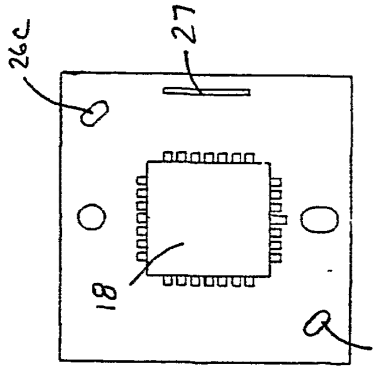

Fig. 14A

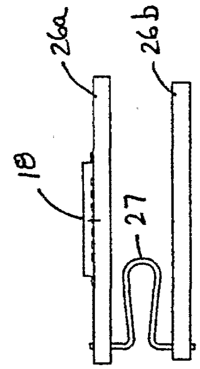

Fig. 14B

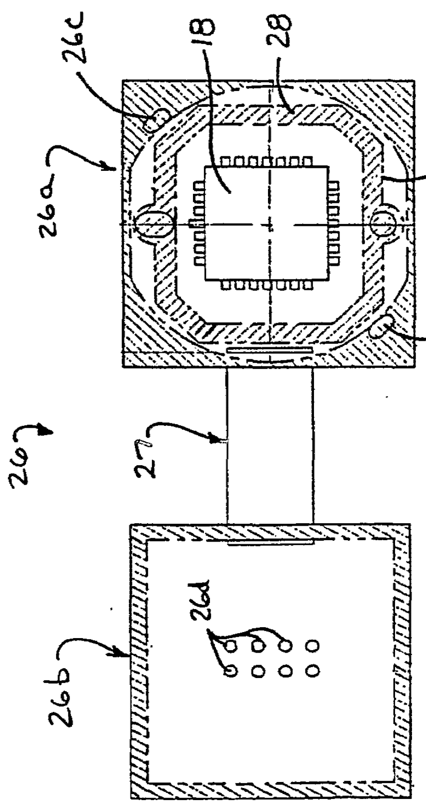

Fig. 13A

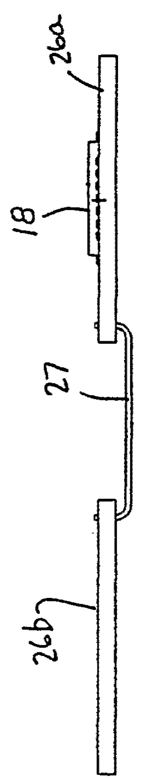

Fig. 13B

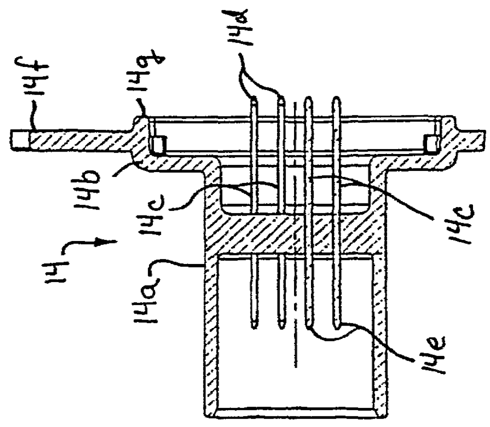

Fig. 15C

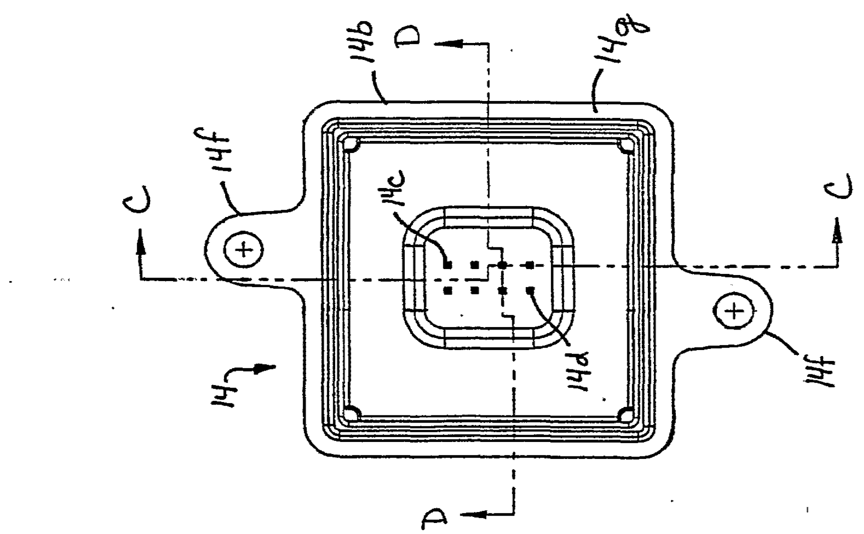

Fig. 15B

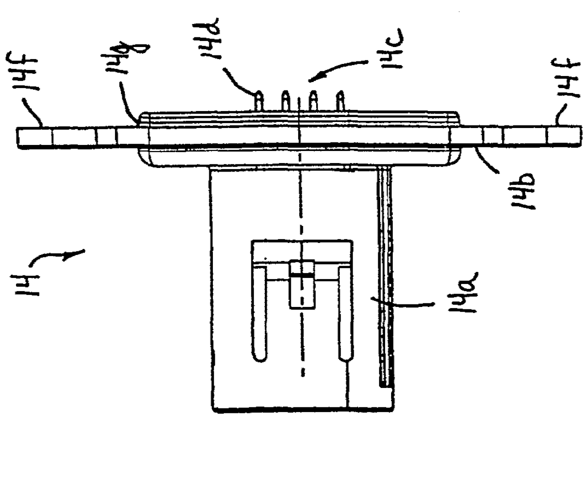

Fig. 15A

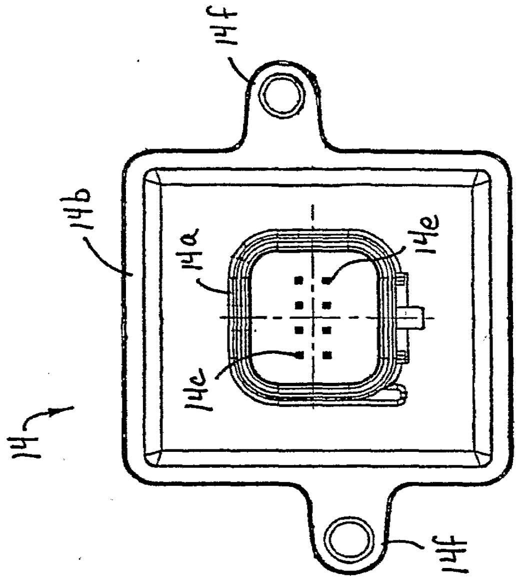

Fig. 15E

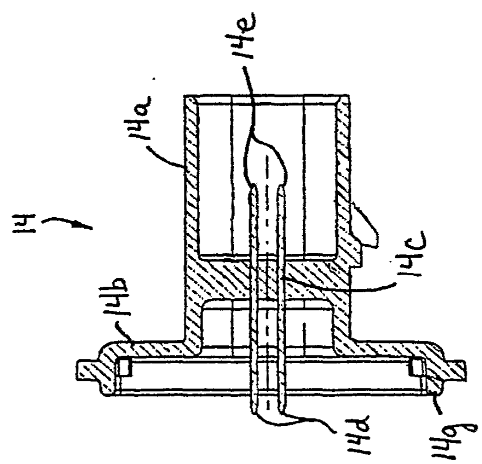

Fig. 15D

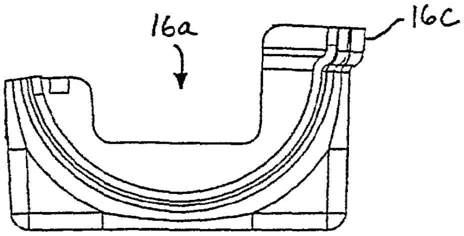

Fig. 16B

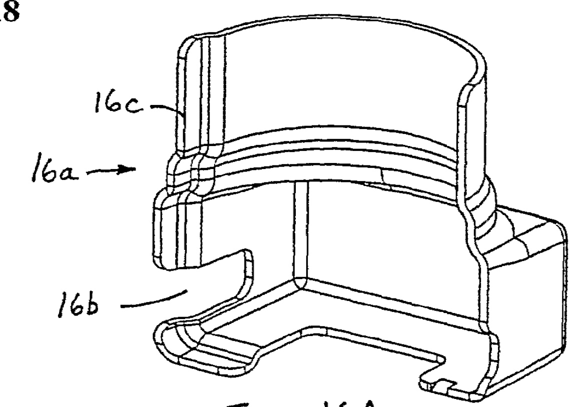

Fig. 16A

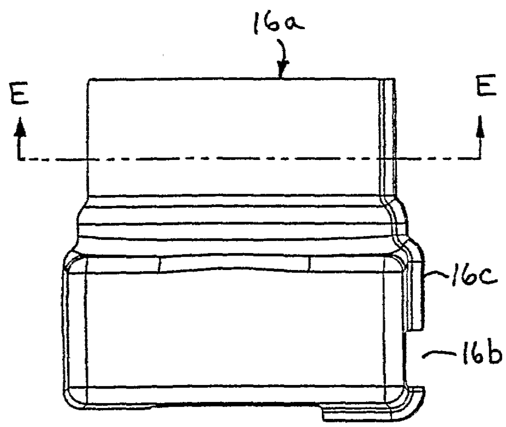

Fig. 16D

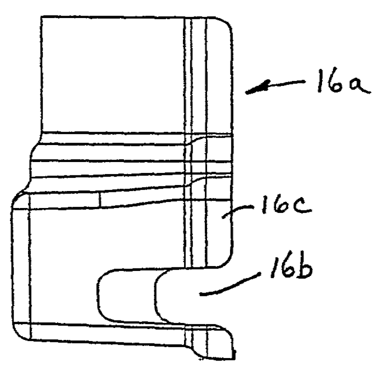

Fig. 16C

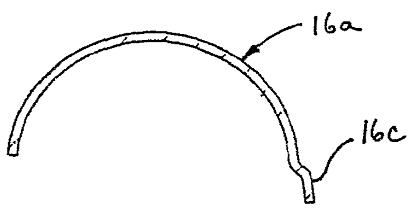

Fig. 16E

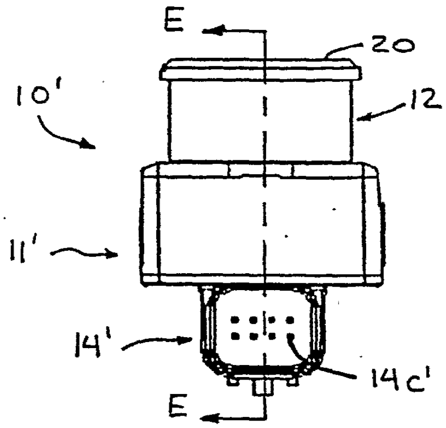

Fig. 17A

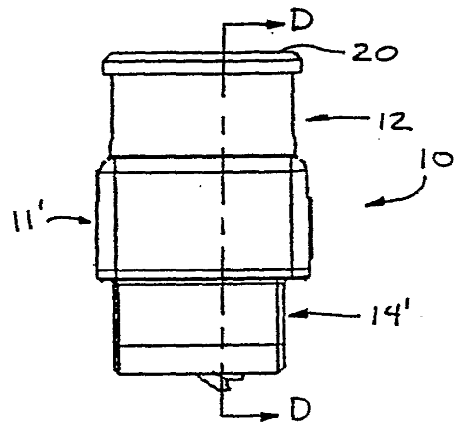

Fig. 17B

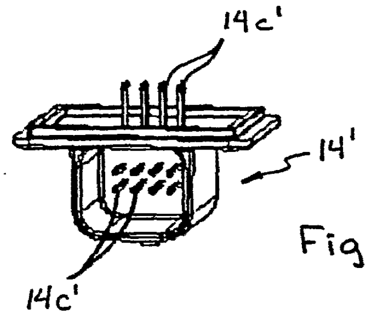

Fig. 17C

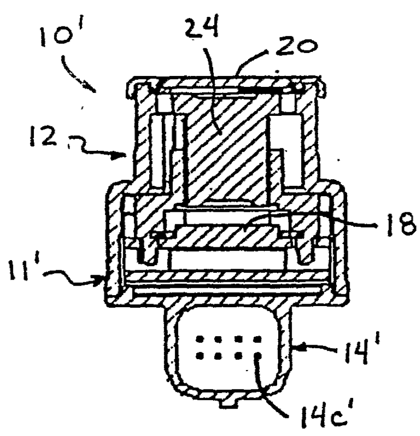

Fig. 17D

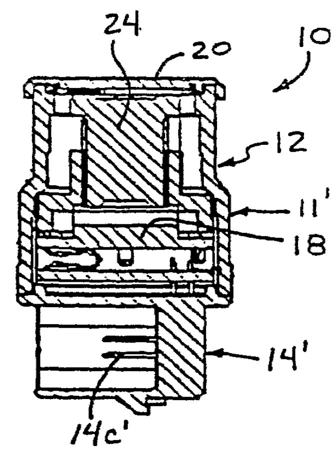

Fig. 17E

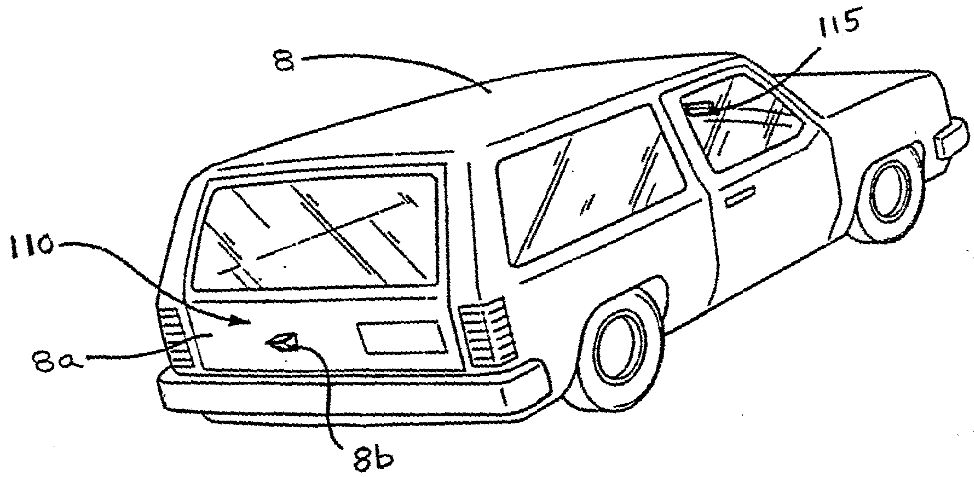

Fig. 18

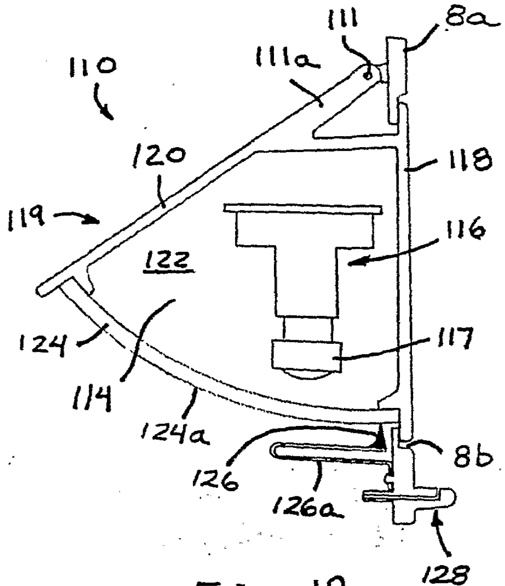

Fig. 19

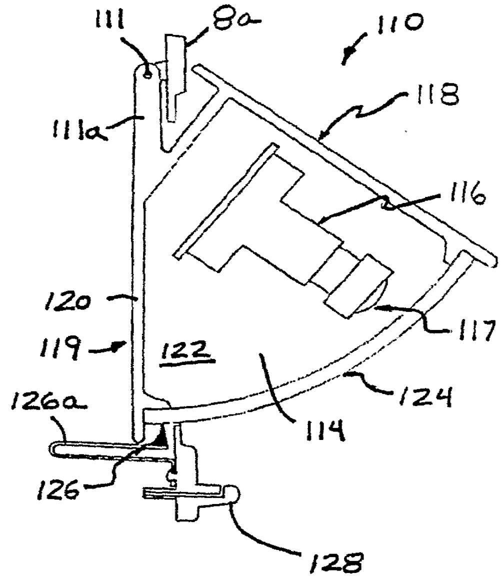

Fig. 20

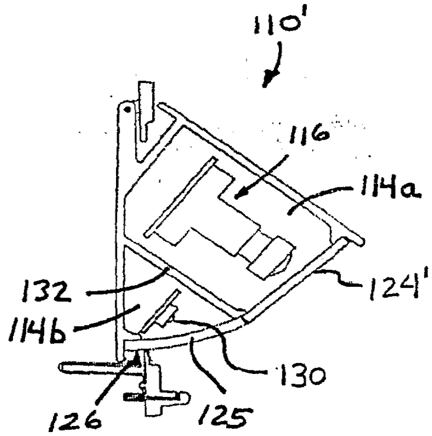

Fig. 21

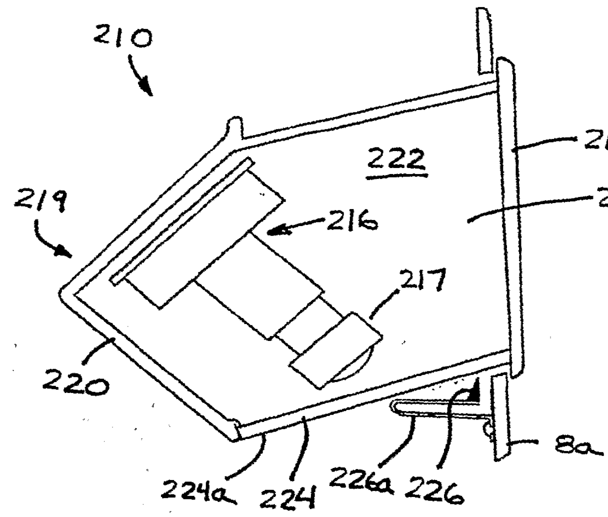
210
218
222
219
214
216
217
220
8a
224a
224
226a
226

Fig. 22

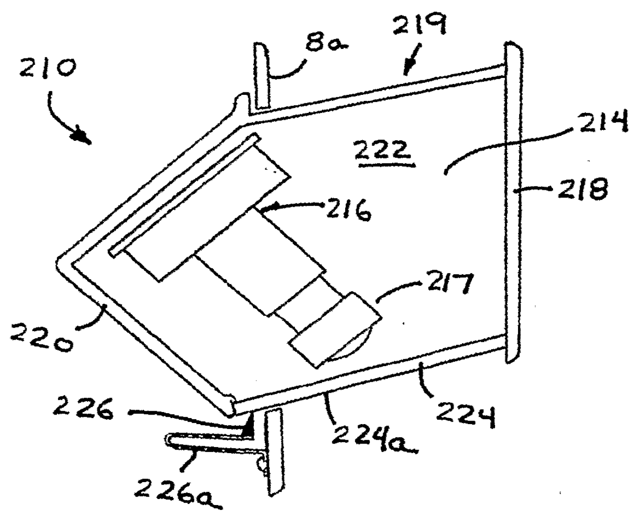
8a
219
210
214
222
218
216
217
220
226
224
224a
226a

Fig. 23

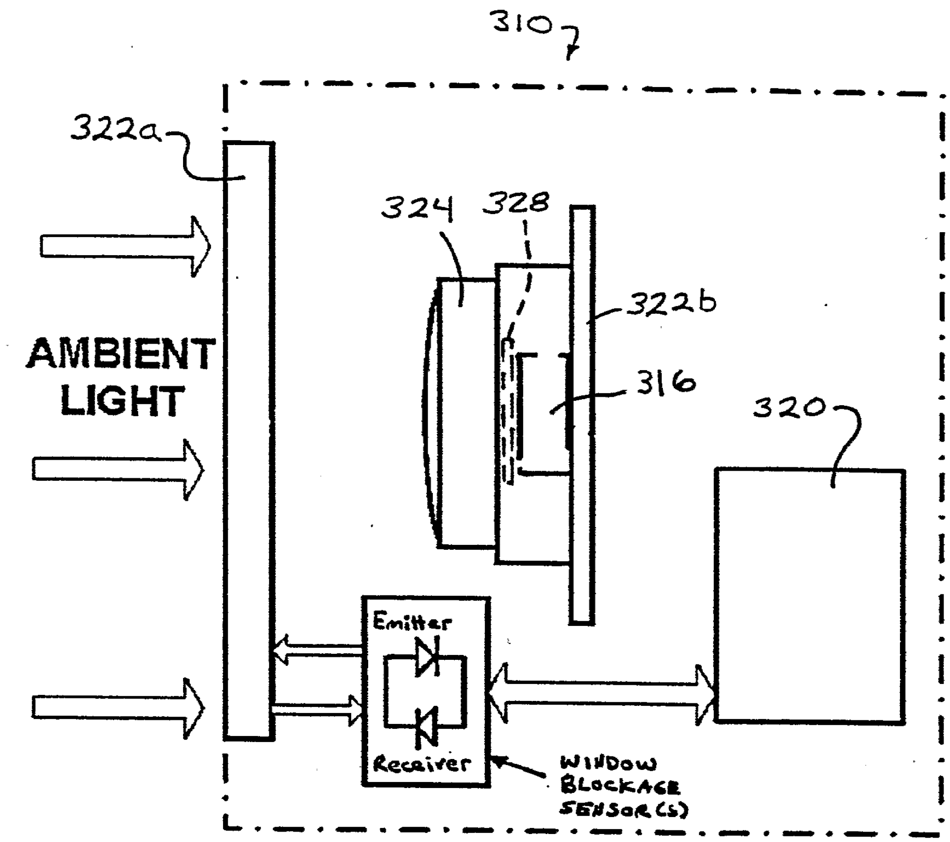
310
322a
324
328
322b
316
320
AMBIENT LIGHT
Emitter
Receiver
WINDOW BLOCKAGE SENSOR(S)

Fig. 24

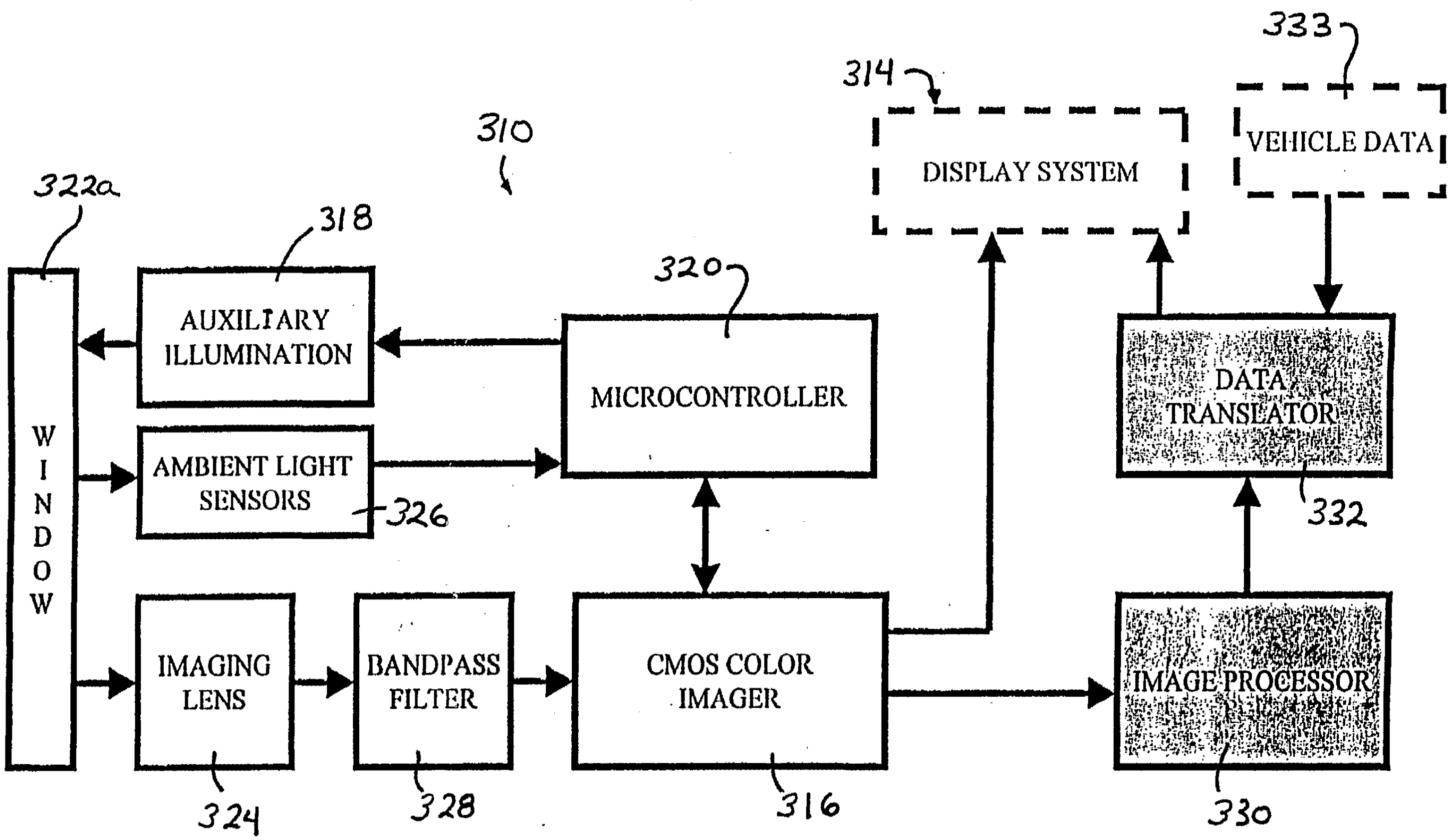
310
322a
318
AUXILIARY ILLUMINATION
320
MICROCONTROLLER
314
DISPLAY SYSTEM
333
VEHICLE DATA
W I N D O W
AMBIENT LIGHT SENSORS
326
DATA TRANSLATOR
332
IMAGING LENS
BANDPASS FILTER
CMOS COLOR IMAGER
IMAGE PROCESSOR
324
328
316
330

Fig. 25

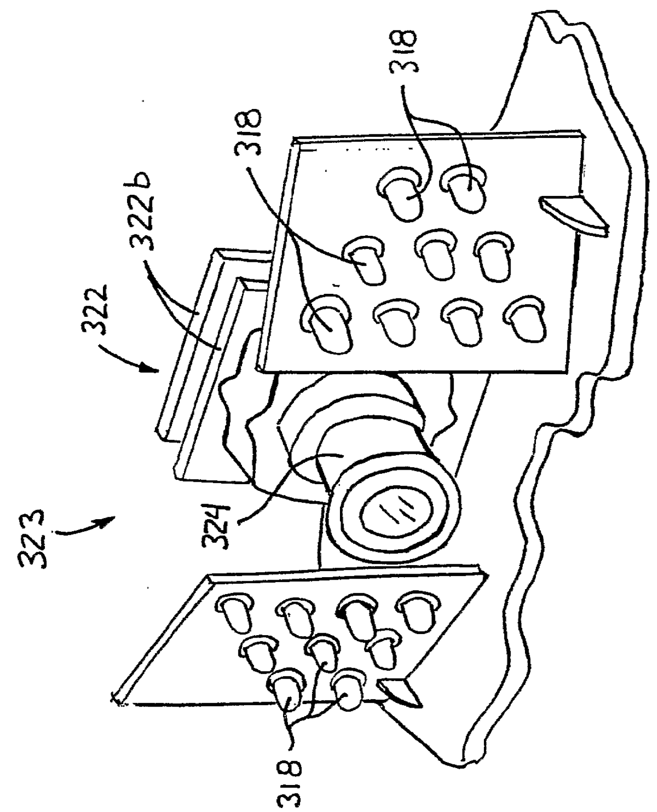

Fig. 26

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(71) Applicant (*for all designated States except US*): **DONNELLY CORPORATION** [US/US]; 414 East Fortieth Street, Holland, Michigan 49423 (US).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **UKEN, John, T.** [US/US]; 7730 Steele Avenue, Jenison, Michigan 49428 (US). **KARNER, Lee** [US/US]; 2974 N. 168th, Holland, Michigan 49424 (US). **HOOK, Richard, R.** [US/US]; 7035 Michael Drive, Hudsonville, Michigan 49426 (US). **LYNAM, Niall, R.** [US/US]; 248 Foxdown, Holland, Michigan 49424 (US).

(74) Agent: **VAN DYKE, GARDNER, LINN & BURKHART, LLP**; FLORY, Timothy A., 2851 Charlevoix Drive, SE, Suite 207, P.O. Box 888695, Grand Rapids, Michigan 49588-8695 (US).

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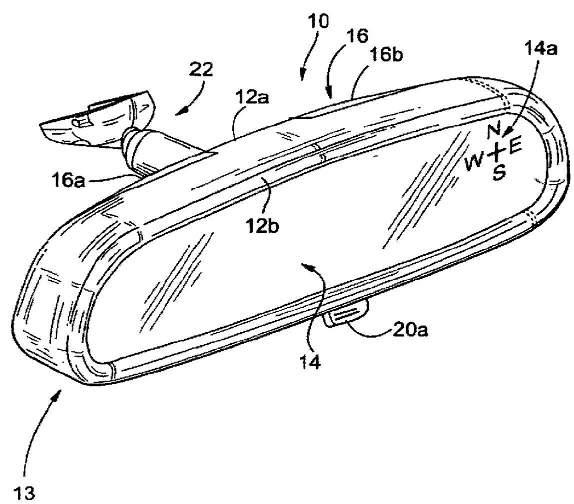
[Continued on next page]

(54) Title: MIRROR ASSEMBLY FOR VEHICLE



(57) Abstract: An interior rearview mirror assembly (10) for a vehicle includes a reflective element assembly portion (13) and at least one cap portion (16) adapted to attach to the reflective element assembly portion. The reflective element assembly portion includes a reflective element (14). The reflective element assembly portion comprises a first molding that encompasses at least a perimeter portion of the reflective element. The first molding is formed by molding a first resinous material having a tool shrinkage factor equal to or greater than about 1%. The cap portion comprises at least one second molding formed by molding a second resinous material having a tool shrinkage factor of less than or equal to about 1%. The cap portion preferably includes internal structure for supporting at least one accessory.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

MIRROR ASSEMBLY FOR VEHICLE

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims benefit of U.S. provisional applications, Ser. No. 60/471,546, filed May 19, 2003 (Attorney Docket DON01 P-1093); Ser. No. 60/525,537, filed Nov. 26, 2003 (Attorney Docket DON01 P-1129); and Ser. No. 60/556,259, filed Mar. 25, 2004 (Attorney Docket DON01 P-1147), which are hereby incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates generally to the field of interior rearview mirror assemblies for vehicles and, more particularly, to interior rearview mirror assemblies which incorporate an accessory or feature, particularly an electronic accessory or feature.

BACKGROUND OF THE INVENTION

The base level mirror for a vehicle is often a prismatic mirror assembly, which may provide a low cost mirror for the vehicle. The mirror assembly is often economically assembled by snapping or inserting the toggle assembly and prismatic reflective element into the casing at the front or bezel portion of the mirror casing substantially immediately after the casing (which may be formed of a hot molded polypropylene or the like) is formed and while the casing is still hot and pliable. As the casing cools, it shrinks to secure the reflective element in place in the casing. Because the reflective element is inserted into the casing while the casing is hot (such as after being freshly molded), the timing for the insertion process may be limited. Thus, it may be difficult to install or insert other accessories or components into the casing before the casing cools and shrinks.

It is often desirable to provide an electronic feature in the mirror assembly, such as a compass sensor and/or compass display, a tire pressure monitoring system and/or display and/or the like. In order to facilitate the addition of accessories or other components in the mirror assembly, the mirror assembly may typically have a casing and a separate bezel portion, which allows the accessory or accessories or the like to be installed into the casing (via its front opening) after it has cooled, and then allows the reflective element and bezel portion to be installed at the front portion of the casing. The bezel portion may be snapped to the casing or may be otherwise attached to the casing via sonic welding or the like to secure the bezel portion to the casing and to secure the components or accessories and the reflective element at or within the mirror casing. Although practical, this involves a less economical two-part, non-unitary casing and bezel design.

It is typically preferred to have the unitarily formed casing and bezel portion so that the reflective element is inserted into the casing while the casing is hot and pliable. However, it is also desirable to provide additional features or functions to the mirror assembly. Therefore, there is a need in the art for an improved mirror assembly which overcomes the shortcomings of the prior art.

SUMMARY OF THE INVENTION

The present invention provides an interior rearview mirror assembly which has one or more cap portions which attach or secure to a rear portion of a mirror holder. The mirror holder comprises part of a reflective element assembly portion comprising a mirror reflective element and a bezel portion or the like that preferably encompasses at least a perimeter portion of the reflective element, thereby at least partially securing the reflective element in the reflective element assembly portion. The cap portion or portions may include one or more electronic accessories or circuitry to provide additional features or functions to the mirror assembly. The additional features or functions may thus be back-loaded into the mirror holder after the mirror holder is formed and after the reflective element is attached at the bezel portion or front portion of the mirror holder.

According to an aspect of the present invention, an interior rearview mirror assembly for a vehicle comprises a mirror holder having a front portion and a rear portion, a reflective element positioned at the front portion of the mirror holder and received at least partially within the front portion of the mirror holder, and at least one cap portion. The rear portion of the mirror holder has at least one opening therethrough and the at least one cap portion is attachable to the rear portion of the mirror holder generally at the at least one opening. The at least one cap portion includes circuitry for at least one accessory. The at least one cap portion provides a rear cover for the mirror holder generally over the at least one opening.

According to another aspect of the present invention, a method of manufacturing an interior rearview mirror assembly portion includes forming a first molding by injection molding a first resinous material in a mold. The first resinous material has a tool shrinkage factor of at least approximately 1%. The first molding is at an elevated temperature when the first molding is removed from the mold. A reflective element is provided and positioned at the first molding before the first molding has cooled to approximately ambient temperature. The first molding at least partially encompasses a perimeter portion of the reflective element to form a reflective element assembly portion. The first molding is allowed to cool and shrink to retain the reflective element at the first molding. A cap portion comprises a second resinous material, which has a tool shrinkage factor of at less than or equal to approximately 1%. The cap portion includes at least one accessory. The cap portion is attached to the reflective element assembly portion after the first molding has cooled and shrunk. The cap portion is attached to the reflective element assembly portion such that the accessory is at least partially within the mirror assembly.

The accessory may comprise a compass sensor and/or display, a tire pressure monitoring system receiver/control circuitry and/or display, an antenna, a garage door opener, or any other accessory and/or accessory display and associated circuitry. For example, the circuitry may comprise compass display circuitry and the reflective element may have at least one port or icon or character etched or otherwise formed thereon, and preferably with an element of the circuitry aligned with / juxtaposed with the at least one port or icon or character etched or otherwise formed on the reflective element. The display circuitry may include at least one illumination source or lighting element for projecting illumination through a corresponding or appropriate port or icon or character on the mirror reflective element.

The cap portion or portions may be detachably attached to the mirror holder or first molding or bezel portion, such as via accessible detents or snaps or the like, and may be detachably removable from the mirror holder or first molding or bezel portion for service or replacement. However, the cap portion may alternatively be non-detachably attached, such as by adhesive attachment or by heat staking or by ultrasonic welding or the like.

Therefore, the present invention provides an interior rearview mirror assembly which may include one or more electronic accessories or features. The accessory or feature may be installed at the rear portion of the mirror holder or bezel portion opposite the reflective element, and may be installed after the reflective element is inserted into the freshly molded or hot mirror holder or bezel portion and after the mirror holder has cooled and shrunk to secure the reflective element. Preferably, the accessory or feature may be mounted or positioned at, within or on one or more cap portions (preferably also with any associated wiring, interconnects and/or connectors and the like) which may be secured to the rear portion of the mirror holder and which may form a rear wall or surface of the mirror holder. The cap portion may be snapped to or attached to the mirror holder (which has the reflective element already inserted/installed therein) after the mirror holder has cooled, such that the assembly may be completed at a facility or assembly line that is remote from the facility or line at which the reflective element and mirror holder are assembled together. The present invention thus facilitates the addition of an electronic accessory or feature into a low cost mirror assembly with minimal additional investment to add the accessory or feature. The present invention may thus easily accommodate various features which may be selected by a customer.

These and other objects, advantages, purposes and features of the present invention will become apparent upon review of the following specification in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front perspective view of an interior rearview mirror assembly in accordance with the present invention;

FIG. 2 is an exploded perspective view of the interior rearview mirror assembly of FIG. 1;

FIG. 3 is an exploded perspective view of another interior rearview mirror assembly in accordance with the present invention;

FIG. 4 is an exploded perspective view of another interior rearview mirror assembly in accordance with the present invention;

FIG. 5 is an exploded perspective view of another interior rearview mirror assembly in accordance with the present invention;

FIG. 6 is a perspective view of a reflective element assembly portion of the mirror assembly of the present invention, with the reflective element removed to show additional details;

FIG. 7 is an opposite perspective view of the reflective element assembly portion of FIG. 6;

FIG. 8 is a perspective view of a cap portion of the mirror assembly of FIG. 5;

FIG. 9 is a perspective view of a cap portion and circuit boards of FIG. 5, as assembled;

FIG. 10 is a rear perspective view of another interior rearview mirror assembly of the present invention;

FIG. 11 is a rear elevation of another interior rearview mirror assembly of the present invention;

FIG. 12 is a front elevation of an interior rearview mirror assembly, having directional heading or compass display in accordance with the present invention;

FIGS. 13A-D are enlarged elevations of customized compass displays in accordance with the present invention;

FIG. 14 is a front elevation of another interior rearview mirror assembly, showing another compass display in accordance with the present invention;

FIG. 15 is a front elevation of another interior rearview mirror assembly, showing another compass display in accordance with the present invention; and

FIG. 16 is a front elevation of another interior rearview mirror assembly, showing another compass display in accordance with the present invention

FIG. 17 is a front elevation of another interior rearview mirror assembly having a compass and temperature display;

FIG. 18 is a front elevation of another interior rearview mirror assembly, having a garage door opening system display and user inputs in accordance with the present invention;

FIG. 19 is a front elevation of another interior rearview mirror assembly, having a compass display and a tire pressure monitoring system display in accordance with the present invention;

FIG. 20 is a front elevation of another interior rearview mirror assembly, having a tire pressure monitoring system display in accordance with the present invention;

FIG. 21 is an enlarged front elevation of another tire pressure monitoring system display in accordance with the present invention;

FIG. 22 is a front elevation of another interior rearview mirror assembly, having a telematics module and display in accordance with the present invention;

FIG. 23 is a front elevation of another interior rearview mirror assembly, having a telematics module and display in accordance with the present invention;

FIG. 24 is a perspective view of a cap portion for an interior rearview mirror assembly in accordance with the present invention;

FIG. 25 is an enlarged perspective view of a light actuator of the cap portion of FIG. 24;

FIG. 26 is a perspective view of another cap portion of the present invention;

FIG. 27 is an upper perspective view of an interior rearview mirror assembly of the present invention, with microphones positioned along an upper cap portion;

FIG. 28 is a sectional view of an interior rearview mirror assembly having a battery in accordance with the present invention;

FIG. 29 is an exploded perspective view of another interior rearview mirror assembly in accordance with the present invention;

FIG. 30 is a rear perspective view of the mounting assembly of the mirror assembly of FIG. 29;

FIG. 31 is a sectional view of the mounting arm and mount of FIG. 30;

FIG. 32 is a rear perspective view of another mounting assembly of the present invention;

FIG. 33A is a sectional view of an electrochromic reflective element assembly portion in accordance with the present invention;

FIG. 33B is a sectional view of another electrochromic reflective element assembly portion in accordance with the present invention;

FIG. 34 is a perspective view of another interior rearview mirror assembly and a windshield accessory module in accordance with the present invention; and

FIGS. 35A-D are perspective views of different accessory modules of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and the illustrative embodiments depicted therein, an interior rearview mirror assembly or modular prismatic rearview mirror assembly 10 for a vehicle includes a reflective element assembly portion 13 including a mirror holder 12 and a reflective element 14 (FIG. 1) positioned at and at least partially within the mirror holder and/or bezel portion, that preferably is molded from a polyolefin material, such as a polypropylene material or the like. Mirror assembly 10 includes a plastic molded cap or cap portion 16, preferably molded from an ABS material, an engineering resin material, such as a filled or unfilled nylon material, or the like (and may be integrally molded with metallic or ceramic materials or inserts or the like to provide mechanical bracing and enhanced structural rigidity). Cap portion 16 is mountable or attachable to a rear portion or open portion 12a of mirror holder 12, and may include an accessory or feature or the like, such as a printed circuit board 18 having an electronic accessory or circuitry thereon or integrated therein or attached thereto. Cap portion 16 may be snapped or otherwise mounted to or attached to the open rear portion 12a of mirror holder 12 to install or back-load the printed circuit board and/or accessory within the mirror holder 12 of mirror assembly 10. Cap portion 16 may be detachably mounted or attached to the mirror holder, such as via accessible detents or snaps or the like, and may be removable or detachable from the rear portion of the mirror holder, such as for service or replacement of the cap portion or one or more accessories of the cap portion.

Various cap portions of the present invention may be provided with different options or accessories, and may be selected to mount to or attach to a universal or common mirror holder to form different mirror assemblies having different content. The present invention thus allows an automobile manufacturer to order or purchase common or standard mirror holders or reflective element assembly portions and different or custom cap portions and to assemble the mirror assembly with the desired cap portion and content at the vehicle assembly plant. The automobile manufacturer may even choose to purchase the mirror holders (which may include the reflective element) from one source and the cap portions from another source, and may complete the mirror assembly at the vehicle assembly plant or at another facility, such as a mirror assembly plant or the like. The present invention thus allows an automobile manufacturer to order or purchase the mirror holder and reflective element (and maybe the toggle assembly and mounting assembly as well, such as shown in FIGS. 6 and 7) from a mirror specialist, and the cap portions and accessories (such as shown in FIG. 9) from an electronics specialist. The cap portion may snap or otherwise attach to the mirror holder to complete the assembly of the rearview mirror assembly.

Because the cap portion or portions may be purchased separately, the present invention lends itself to aftermarket applications or to dealership or consumer customizations/personalizations, where a cap portion having the desired accessories or appearance or design may be purchased and installed to a mirror holder to alter or upgrade the mirror assembly of the vehicle. It is envisioned that such an upgrade could be made to a base mirror that does not originally include any electronic accessories, whereby the cap portion could provide electrical content to the mirror assembly. In such applications, the cap portion may connect to a power source or the like of the vehicle (such as via a wire or cable that extends between the mirror assembly and the headliner or an accessory module of the vehicle when the mirror assembly is installed in the vehicle) or the cap portion may include a battery or self-contained power source to provide power to the accessories and circuitry contained within the cap portion, such as discussed below with respect to FIG. 28.

In an aftermarket application, cap portions may be provided as aftermarket cap portions, and a consumer may purchase a desired cap portion, which may have desired content or features and/or may have a desired color or texture or appearance or the like, and may readily remove the existing cap portion from the mirror of their vehicle and replace it with the new cap portion. For example, the cap portion and/or the mirror holder may have snaps or clasps that may retain the cap portion and the mirror holder together, but that may release or detach such that the cap portion may be detachable from the mirror holder by a user. The cap portion may be pulled or detached from the mirror holder and a new cap portion may be pressed or snapped into place on the mirror holder to provide the vehicle owner with the new cap portion having the desired content or functions or features and/or the desired appearance or the like, as discussed in detail below.

Reflective element 14 may comprise a prismatic reflective element having a wedge shaped prism with a reflective coating on its rear surface, such as described in U.S. Pat. Nos. 6,318,870; 5,327,288; 4,948,242; 4,826,289; 4,436,371; and 4,435,042; and/or U.S. pat. application, Ser. No. 10/709,434, filed May 5, 2004 by Lynam for MIRROR REFLECTIVE ELEMENT (Attorney Docket DON01 P-1152); and/or U.S. provisional application, Ser. No. 60/525,952, filed Nov. 26, 2003 by Lynam for MIRROR REFLECTIVE ELEMENT FOR A VEHICLE (Attorney Docket DON01 P-1130), which are all hereby incorporated herein by reference. Reflective element 14 may include one or more displays which may be laser-etched or otherwise formed thereon, such as via an appliqué or the like on the surface of the reflective element or such as a display on demand type of display (discussed below). The display may include one or more display elements, such as illumination sources, such as vacuum fluorescent (VF) elements, liquid crystal displays (LCDs), light emitting diodes (LEDs), such as inorganic LEDs or organic light emitting diodes (OLEDs), electroluminescent (EL) elements or the like. Optionally, the prismatic reflective element may comprise a display on demand or transflective prismatic element (such as described in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); and/or U.S. provisional application, Ser. No. 60/525,952, filed Nov. 26, 2003 by Lynam for MIRROR REFLECTIVE ELEMENT FOR A VEHICLE (Attorney Docket DON01 P-1130), which are all hereby incorporated herein by reference) so that the displays are viewable through the reflective element, while the display area still functions to substantially reflect light, in order to provide a generally uniform prismatic reflective element even in the areas that have display elements positioned behind the reflective element.

For example, as shown in FIGS. 1-5 and 12, prismatic reflective element 14 may include a compass display 14a and/or other display, such as a passenger side inflatable restraint status display 14b (FIGS. 2-4) or the like, formed or etched on the reflective element. For example, the compass display 14a may include ports 15a, such as icons, characters or directional headings (N, S, E, W), etched or formed in the reflective coating of the reflective element (such as via removing the reflective coating of the reflective element to form a desired port or icon or character and/or such as by utilizing aspects described in U.S. Pat. No. 4,882,565, issued to Gallmeyer, which is hereby incorporated herein by reference) to allow light from corresponding illumination sources or elements 19a (such as light emitting diodes or the like) to pass through the reflective element to illuminate or back light the appropriate port or icon or heading character for viewing by the driver or occupant of the vehicle, such as similar to the compass systems disclosed in U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which is hereby incorporated herein by reference in its entirety, and as discussed below.

As shown in FIG. 5, the reflective element 14 may include an anti-scatter film or sheet or tape 14c applied over its rear surface. The tape 14c may be adhered or otherwise attached to the rear surface of the reflective element so as to limit shattering or scattering of the mirror glass if the vehicle is involved in an accident. Also, the reflective element 14 may include a display appliqué 14d that may be adhered or applied to the rear surface of the reflective element in the general region of the display 14a (and/or at the region of other displays at the reflective element). The display appliqué 14d may comprise a diffusing element or material, such as a white diffusing material with a smoked front or the like, to diffuse the light emitted by the display elements so that a person viewing the display 14a will not readily discern the individual lighting elements or filaments, but will view substantially uniform illumination provided by the lighting elements or filaments.

Interior rearview mirror assembly 10 may include a toggle assembly 20 and a mounting portion 22, which may be pivotally connected to toggle assembly 20 and mounted to the vehicle to provide pivotal movement of the mirror holder and reflective element relative to the vehicle. Toggle assembly 20 may include a toggle member 20a, which may be actuated or moved by a user to adjust the mirror holder and reflective element relative to the vehicle. Optionally, toggle member 20a may comprise a soft touch surface or portion, such as disclosed in U.S. Pat. Nos. 6,318,870 and 6,349,450, which are hereby incorporated herein by reference. Such a soft touch surface or portion preferably comprises a soft touch material (such as a thermoplastic elastomer or other similar thermoplastic materials, such as Santoprene or the like), preferably having a Shore A durometer value of less than about 110 Shore A, more preferably less than about 90 Shore A, and most preferably less than about 70 Shore A, that may be molded over a rigid or harder material or structure, such as by utilizing aspects described in U.S. Pat. No. 6,349,450, which is hereby incorporated herein by reference. The toggle assembly or the mirror holder may also include a pivot joint or pivot element 20b, such as a socket and/or ball member, molded or formed thereon or attached or mounted thereto, in order to provide pivotal movement or adjustment of the mirror assembly relative to the mounting arm or portion. The mounting portion 22 may be mounted to the vehicle, such as to an interior surface of the vehicle windshield or to a header portion of the vehicle or the like, via any mounting arm and button or any other mounting arrangement or construction, such as the types disclosed in U.S. Pat. Nos. 6,499,850; 6,318,870; 6,315,421; 6,227,675; 5,671,996; 5,813,745; 5,673,994; 5,820,097; 5,708,410; 5,680,263; 5,582,383; 5,576,687; 5,555,136; 5,521,760; 5,330,149; 5,100,095; 5,058,851; 4,930,742; 4,936,533; 4,436,371; 4,524,941; 4,435,042; and/or 4,646,210; and/or PCT Publication No. WO 03/095269 A2, published Nov. 20, 2003 for REARVIEW MIRROR ASSEMBLIES; and/or PCT Publication No. WO 03/099614 A1, published Dec. 4, 2003 for MODULAR REARVIEW MIRROR ASSEMBLY, which are hereby incorporated by reference herein, without affecting the scope of the present invention. Optionally, the mirror assembly may be mounted to the vehicle portion (such as to the windshield or headliner of the vehicle) via a substantially plastic or all plastic double ball mounting arrangement, such as described in U.S. Pat. No. 6,318,870 and/or U.S. pat. application, Ser. No. 10/032,401, filed Dec. 20, 2001 by March et al. for INTERIOR REARVIEW MIRROR ASSEMBLY WITH POLYMERIC COMPONENTS (Attorney Docket DON01 P-951), which are hereby incorporated herein by reference. The mounting arrangement may be configured to provide for wiring to the mirror assembly through the mounting arrangement and to or into the mirror assembly, without affecting the scope of the present invention.

During assembly of the reflective element assembly portion, the mounting member or arm may be inserted into the socket portion at the reflective element assembly portion (such as at the reflective element or at a backing plate of the reflective element or at a toggle assembly of the mirror assembly or the like) via an automated device or machine or by a robot. The automatic device or machine may be used to attach or snap the front end of the mounting member to the socket portion at the reflective element.

Optionally, the mirror assembly may provide or include an automatic flip prismatic reflective element, such as described in U.S. Pat. Nos. 6,717,712; 6,568,414; and/or 6,382,806, which are hereby incorporated herein by reference. Because the circuit board and any display elements positioned thereon is/are generally fixedly secured to the cap portion, which in turn is generally fixedly secured to or relative to the mirror holder and reflective element, the circuit board and display elements move with the reflective element during adjustment of the mirror, such that there is substantially no change in the juxtapositioning / alignment of the lighting or display through the prismatic reflective element.

Mirror holder 12 of interior rearview mirror assembly 10 preferably comprises a unitary or one-piece mirror holder (preferably molded from a thermoplastic resin, such as a polyolefin, such as polypropylene or the like), which may be molded or otherwise formed with a bezel portion 12b integrally formed therewith, and which receives the prismatic reflective element therein. As shown in FIGS. 6 and 7, the toggle assembly 20 and mounting portion 22 may be attached to the mirror holder / bezel portion 12, preferably while the mirror holder is still warm and pliable. Although not shown in FIGS. 6 and 7, the reflective element 14 may be attached to or inserted into the mirror holder / bezel portion 12 at around the same time to form a mirror holder assembly that may be attached to the appropriate or desired cap portion, as discussed below. The reflective element and molded portion or bezel portion thus may define a reflective element assembly portion 13 of the mirror assembly 10. The toggle assembly 20 and the prismatic reflective element 14 thus may be secured into place (such as by snapping together) at or in the mirror holder 12 while the molded mirror holder (preferably the freshly molded mirror holder) is still warm and pliable, such as disclosed in U.S. Pat. No. 4,436,371, issued to Wood et al., which is hereby incorporated herein by reference. When the molded mirror holder (preferably the freshly molded mirror holder and thus just exiting the injection molding press, or alternately, and less desirably, a heated mirror holder having been heated, such as in an oven or the like, to make the mirror holder warm and pliable) cools and shrinks, the mirror holder grips around the toggle assembly and the prismatic reflective element to retain the toggle assembly and the reflective element in the reflective element assembly portion.

The material of the mirror holder or bezel portion, and/or of the reflective element assembly portion in totality, may be selected to have a desired linear mold shrinkage or tool shrinkage factor to provide the desired amount or degree of shrinkage as the mirror holder cools and shrinks around the reflective element to secure the reflective element at the mirror holder or bezel portion. For example, at least the bezel material, and preferably the reflective element assembly portion in totality, may have a linear mold shrinkage or tool shrinkage factor of preferably at least about 0.01 cm/cm or about 1%, and more preferably at least about 0.015 cm/cm or about 1.5%. For example, a UV stabilized, general purpose black polypropylene polymeric molding resinous material, such as is commercially available from Huntsman Corp. of Houston, Tex. under the trade name REXENE 17C9A, and having a tool shrinkage factor of 0.018 cm/cm or 1.8%, may be a suitable material for the bezel portion in that it provides a desired degree of shrinkage around the reflective element as the material cools, and after formation of the mirror holder or bezel portion by molding in an injection molding operation and/or after heating an already-molded mirror holder or bezel portion to an elevated temperature (such as greater than 70 degrees Celsius or higher), in order to sufficiently retain the reflective element at the bezel portion.

The linear mold shrinkage or tool shrinkage factors, as known in the material science arts, are determinable by test standards, such as by test standards set by the American Society for Testing and Materials (ASTM), such as the ASTM D 955 (Standard Test Method of Measuring Shrinkage from Mold Dimensions of Thermoplastics), which is hereby incorporated herein by reference, or such as by ISO 294-4, which is hereby incorporated herein by reference. The test measures the shrinkage from the mold cavity to the molded dimensions of thermoplastics when molded by compression or injection molding processes with specified process conditions or parameters.

As shown in FIGS. 2 and 3, the rear portion 12a of mirror holder 12 may have openings or apertures 12c formed therethrough at either or both sides of the toggle assembly to allow for insertion of the accessory or accessories supported by the corresponding cap portions, as discussed below. Optionally, and as shown in FIGS. 4-7, the mirror holder 12' may be substantially open for a unitary cap portion 16" to attach at, as also discussed below.

After the mirror holder and reflective element are assembled together, and maybe after the mirror holder has cooled and shrunk (such as in applications where the reflective element / mirror holder assembly is provided or shipped from a different location than where the cap portion and electrical circuitry or electrical content are from), the cap portion 16 may be attached or secured to the rear portion 12a of mirror holder 12 to complete the assembly of rearview mirror assembly 10. In comparison to the bezel material, the material selected for the cap portion need not have such shrinkage properties as described above, because the cap portion may be fabricated at and supplied from separate operations, locations and/or facilities than the bezel portion. However, the cap portion may be fabricated at the same facility or location, but could by made during a different operation and/or at a different time, without affecting the scope of the present invention. For example, the cap portion preferably is formed by injection molding of a polymeric resinous material having a tool shrinkage factor of less than and preferably substantially less than about 0.01 cm/cm or about 1% (although it may also have higher tool shrinkage factors, without affecting the scope of the present invention), and preferably less than approximately 0.008 cm/cm or about 0.8%. This enables the provision in the cap portion of material properties not readily deliverable by the higher linear mold shrinkage or tool shrinkage factor materials used for the bezel portion.

For example, the cap portion material may have a higher heat stability / higher heat deflection property / higher flexural modulus compared to the reflective element assembly portion, in order to maintain any accessories or elements mechanically attached thereto or therein. Also, the cap portion material may be selected to provide a higher structural strength if desired. For example, the cap portion material may comprise a high temperature ABS material, such as available from BASF or others under the trade name TERLURAN® GRADE-HH106, which has a tool shrinkage factor of around 0.006 cm/cm or 0.6%, or other suitable materials, such as Nylon and preferably a filled Nylon material or the like. Such a material may also provide structural characteristics that are suitable for supporting accessories or the like. For example, the cap portion material may desirably have a heat deflection temperature under load of 0.45 MPa of greater than approximately 100 degrees Celsius (and more desirably, greater than approximately 110 degrees Celsius and most desirably greater than approximately 115 degrees Celsius), as determined by standard testing, such as by ASTM 648 or ISO 75-1/-2 (which are hereby incorporated herein by reference) or the like. Such testing may determine the temperature at which an arbitrary deformation occurs when a specimen of the material is subjected to an arbitrary set of testing conditions or parameters.

The tool shrinkage factor of the resinous material molded to form the cap portion thus is preferably less than the tool shrinkage factor of the resinous material molded to form the bezel portion of the reflective element assembly portion. Also, the flexural modulus of the material that forms the cap portion may preferably be greater than the flexural modulus of the material that forms the mirror holder or bezel portion. Also, the material that forms the cap portion may preferably have a higher heat deflection temperature (such as may be determined by standard testing, such as ASTM D-790, which is hereby incorporated herein by reference) than the material that forms the bezel portion or mirror holder. Such standardized testing may determine the flexural properties or flexural strength of the material via bending or breaking of specimens of the material in accordance with the appropriate test parameters. Desirably, although the polymeric resinous materials used for the bezel portion and the cap portion may be different, the portions may have similar exterior finishes and/or textures. Alternatively, however, the portions may have different finishes and/or textures or the like as discussed below, without affecting the scope of the present invention.

Optionally, and as described above, the mirror holder and reflective element assembly portion may be packaged and moved to another facility and/or the cap portion may be received from another facility to complete the mirror assembly. The appropriate or selected cap portion (with the appropriate associated electrical circuitry/accessory/content) may then be attached to the reflective element / mirror holder assembly, such as at the vehicle assembly line, to assemble the mirror assembly for installation into the appropriate vehicle having the optional content of the mirror assembly, as discussed below. The modular mirror assembly of the present invention thus facilitates assembly of the reflective element assembly portion and of the cap portion at different assembly locations, whereby the two portions may be joined or assembled together at a different location, such as at the vehicle assembly plant, to complete the mirror assembly. The cap portion may attach to the reflective element assembly portion via a snap together connection or other type of connection, and may removably or detachably attach, so that the cap portion may be removed from the reflective element assembly portion if desired. However, the cap portion may alternatively be non-detachably attached, such as by adhesive attachment or by heat staking or by ultrasonic welding or the like, without affecting the scope of the present invention. The cap portion may attach to the reflective element assembly portion via any manner, such as, for example, utilizing aspects described in U.S. Pat. No. 6,402,331, which is hereby incorporated herein by reference. Thus, the present invention encompasses customization/selection of material properties for the cap portion to be different from material properties selected for the reflective element assembly portion so that decorative finishes and/or functional properties may be customized/delivered to be the same or different for one or both of the portions.

Optionally, one or more accessory modules or blocks (such as discussed below) may be attached to or inserted or plugged into the cap portion and/or mirror assembly, such as at the vehicle assembly line, to provide a desired or selected or customized optional feature or accessory to the mirror assembly. The accessory module may insert or attach to the mirror assembly or cap portion utilizing aspects described in U.S. Pat. Nos. 6,672,744; 6,402,331; 6,386,742; and 6,124,886, and/or U.S. pat. application, Ser. No. 10/739,766, filed Dec. 18, 2003 by DeLine et al. for MODULAR REARVIEW MIRROR ASSEMBLY (Attorney Docket DON01 P-1119), which are hereby incorporated herein by reference. The accessory module may include circuitry and display elements and user inputs, and may plug into the cap portion or mirror assembly in a manner whereby mechanical and electrical connections are preferably simultaneously made as the module is inserted into the cap portion or mirror assembly, such as by utilizing aspects described in U.S. Pat. No. 6,669,267, and/or U.S. pat. application, Ser. No. 10/727,731, filed Dec. 3, 2003 by Lynam et al. for EXTERIOR ACCESSORY MODULE FOR VEHICULAR MODULAR DOOR (Attorney Docket DON01 P-1124), which are hereby incorporated herein by reference. The mirror assemblies thus may be customized to particular work orders or selected options at the vehicle assembly line via insertion or attachment of the appropriate accessory module, such that the cap portion and the reflective element assembly portion may comprises common or universal components for two or more options offered for the particular mirror assembly or vehicle application.

The modular mirror assembly of the present invention thus may provide fully assembled mirror assemblies to a vehicle assembly plant and line, where the cap portion and selected content are attached to the reflective element assembly portion at a remote location, such that different mirror assemblies are provided for different options or applications. Optionally, the modular mirror assembly may provide a universal or common reflective element assembly portion to a vehicle assembly plant, and a selected cap portion (with the appropriate or desired or selected optional content) may be attached to the reflective element assembly portion at the vehicle assembly line to customize the mirror assembly for the particular selected option or application. Optionally, the modular mirror assembly of the present invention may provide a universal reflective element assembly portion and a partially or substantially universal (at least universal as to two or more selectable options) cap portion, whereby the selected accessory module may be inserted into or attached to the cap portion and/or mirror assembly at the vehicle assembly line to complete the mirror assembly and to provide the desired or selected option or feature to the mirror assembly.

As shown in FIG. 2, cap portion 16 may comprise two separate cap portions 16a, 16b, or a cap portion 16' (FIG. 3) may have two cap portions 16a', 16b' joined together by a connecting portion or wire channel 16c. One or both of the cap portions 16a, 16b may have an accessory or circuit board 18a, 18b attached thereto. The circuit board or boards may snap or otherwise affix or secure to the cap portion or portions. As shown in FIG. 2, the cap portions may have retainers or pillars extending from an interior surface for retaining and supporting the circuit board or boards thereon. Optionally, the cap portion may comprise a unitary cap portion 16" (FIGS. 4, 5, 8-11, 24 and 26) substantially covering the rear portion of the mirror holder (opposite the reflective element) and receiving or supporting one or more printed circuit boards thereon. The cap portion may receive the mounting portion 22 between the side portions of the cap portion 16' (FIG. 3) or through an opening 25a in the cap portion 16" (FIGS. 4, 8-11, 24 and 26) as the cap portion is attached to the mirror holder. For example, the mounting portion 22 may be threaded through the opening 25a in the cap portion as the cap portion is moved toward and into engagement with the bezel portion during the mirror assembly process. The mirror assemblies 10' and 10" (with cap portions 16' and 16", respectively) may be substantially similar to and may have substantially similar components and accessories as mirror assembly 10 (with cap portions 16a, 16b), such that a detailed description will not be repeated for the different mirror assemblies. The common or similar components of the mirror assemblies are referred to in FIGS. 2-11 with the same reference numbers.

The cap portion 16 or portions 16a, 16b may be positioned at openings 12c of mirror holder 12 such that the accessories or circuitry supported by the cap portions are positioned generally within mirror holder 12. The cap portions may snap onto the rear portion 12a of mirror holder 12 and generally cover the openings 12c in mirror holder 12. Optionally, the unitary cap portion 16" may snap onto or otherwise secure to the mirror holder and generally cover or define the rear portion of the mirror assembly when so assembled. The cap portion or portions thus support the circuit board or circuit boards and associated circuitry and/or accessories at or within the mirror assembly.

Optionally, the circuit boards or accessories may be provided at, within or on the cap portions at a cap portion manufacturing facility or electrical accessory manufacturing facility, such that the cap portion and circuitry assemblies are provided as a unit to the mirror assembly facility or plant. The cap portion and circuitry units may then be snapped or otherwise affixed to the mirror holder or reflective element assembly portion of an appropriate mirror assembly having features or components or displays corresponding to the cap portion and circuitry units, as discussed below. The assembly or back-loading of the cap portions to the mirror holder and reflective element assembly portion thus may be performed remote from the molding tool for molding the mirror holder, since the cap portions may be mounted to the mirror holder after the mirror holder has cooled and shrunk.

Each cap portion may support one or more desired accessories or circuit boards for providing the desired feature to the mirror assembly. The cap portions, and corresponding accessory or feature or electrical content, may be selected and attached to a universal or common mirror holder to provide different features to the mirror depending on the options selected for a particular application or vehicle. Optionally, the cap portions may be selected/configured to have accessories contained/supported therein to correspond to and be aligned with/juxtapositioned with one or more displays of a particular or respective reflective element secured in the common mirror holder and/or may correspond with a particular mirror holder for applications where the accessory includes buttons or controls which may extend through openings or recesses in the mirror holder for access thereto by the driver or occupant of the vehicle, as discussed in detail below.

The cap portion or cap portions may be snapped or otherwise secured to the rear portion 12a of mirror holder 12, such as generally at and covering corresponding openings

12c through the rear portion 12a of mirror holder 12. The opening or openings 12c may be at either or both sides of the toggle assembly and mounting portion of the mirror assembly. The cap portion may snap over or otherwise interconnect with the respective opening via a plurality of hooks or snap clasps (which may extend from the cap portion or the mirror holder) engaging a plurality of corresponding slots or the like at the other of the cap portion and the mirror holder. The cap portion may be formed to provide an exterior surface which may substantially match the exterior surface of the mirror holder to provide a finished appearance to the mirror assembly when the cap portions are attached to the mirror holder and thus form the rear or back portion of the mirror holder and/or it may provide a contrast or distinctive aesthetic or functional appearance or finish. The mirror holder and the cap portions may be formed of a polypropylene material or a talc-filled polypropylene material or the like, or preferably the mirror holder is formed of a molded polyolefin, while the cap portion is formed of a molded engineering resin, such as ABS or a Nylon or the like. Optionally, the cap portion may comprise a metallic material or may comprise a polymeric molding overcoated with a metallic layer or coating, and may have ribs or ripples to provide enhanced rigidity of the cap portion, without affecting the scope of the present invention.

Optionally, the cap portion may have a different color or texture (such as a chrome or colored or textured surface or the like) than the mirror holder or bezel portion to provide a two-tone configuration to the mirror assembly. Optionally, the cap portion and/or the mirror holder may have a decorative finish, and may be painted or plated, such as electroplated or the like, or may have a film or an in mold film or coating thereon to provide the desired surface to the cap portion and/or the mirror holder. For example, the cap portion (or the mirror holder) may provide a contrast or accent color or may be chrome plated or may be brushed aluminum or the like or may provide an angle variant color (where the perceived color may change depending on the viewing angle) or may provide various colors or patterns or textures or the like as may be desired by a consumer (for example, certain colors or patterns or textures may be provided to target different demographics, such as for targeting teenagers or other age groups or genders or the like). Optionally, the cap portion or bezel portion may have a fabric cover (such as, for example, leather or cloth or denim or other cover material or the like) at and substantially over at least a portion or the entirety of its exterior surface to provide a desired appearance or texture or the like. Optionally, the cap portion and/or the mirror holder or bezel portion may have a soft touch surface, such as a soft touch surface and material similar to that described above (preferably having a Shore A durometer value of less than about 110 Shore A, more preferably less than about 90 Shore A, and most preferably less than about 70 Shore A) with respect to the toggle tab and/or similar to the types described in U.S. Pat. Nos. 6,318,870 and/or 6,349,450, which are hereby incorporated herein by reference. For example, either the mirror holder or the cap portion may have such a soft touch surface independent of the other, or both may have such a soft touch surface or neither may have a soft touch surface. Although the cap portion may be finished with a metallized reflective finish, such as a chrome or chrome-plated finish, the bezel portion desirably may not be chrome or chrome-plated or the like, in order to reduce reflections or glare at the bezel portion around the reflective element, and thus not be specularly reflecting.

It is further envisioned that the cap portion or bezel of the interior or exterior mirror assembly may include a personalization element, such as a logo or text or pattern or other indicia, thereon as desired by the consumer to provide highly personalized and unique mirror assemblies for the particular consumers that purchase the vehicles or the mirror assemblies, such as described in U.S. provisional applications, Ser. No. 60/553,842, filed Mar. 17, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1143); and Ser. No. 60/563,342, filed Apr. 19, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1153), which are hereby incorporated herein by reference. For example, the cap portion may include a school logo and colors, such as, for example, the letters "MSU" in green and white print/background, to provide a desirable appearance to the personalized mirror assembly for a particular consumer, such as, for example, a student or graduate of Michigan State University. Optionally, the cap portion may include other text or logos or brand names or other types of identifying indicia, such as, for example, "FORD" to identify the vehicle manufacturer, or "TOMMY HILFIGER" to identify the vehicle owner's clothing preference or the like, or other text or messages or images or trademarks or colors or patterns or indicia or the like to provide a desired appearance or identification or message or statement or advertisement or logo or sponsorship identification or style or brand identification on the interior or exterior mirror assembly. The mirror assemblies may thus be assembled to have the desired or personalized cap portion with the desired or personalized logo or color or message or indicia thereon to provide the desired or personalized finish or appearance of the interior or exterior mirror assembly.

In an aftermarket application, various cap portions as described above may be provided as aftermarket interior or exterior mirror cap portions. A consumer may then purchase a desired cap portion, which may have desired content or features and/or may have a desired color or texture or appearance or the like, and may readily remove the existing cap portion from the interior or exterior mirror assembly of their vehicle and replace it with the new cap portion. For example, the cap portion and/or the mirror holder or reflective element assembly portion (such as the mirror support arm for an interior rearview mirror assembly or a mirror mount for an exterior rearview mirror assembly) may have snaps or clasps that may retain the cap portion and mirror holder/mount/bezel together, but that may release or detach such that the cap portion may be detachable from the mirror assembly by a user/consumer. The cap portion may be pulled or detached from the mirror assembly and a new cap portion (with the desired content therein and/or personalized text or indicia or colors or the like thereon) may be pressed or snapped into place on the mirror assembly to provide the vehicle owner with the new cap portion having the desired content or functions or features and/or the desired or personalized appearance or the like.

Optionally, the modular mirror assembly of the present invention may provide customizing of other visible or viewable portions of the mirror assembly as well. For example, the flip tab or toggle tab 20a (or a rotary knob or the like depending on the type of toggle assembly of the particular mirror assembly) may be removably attached to the toggle assembly, such that the tab may be selected or replaced as desired. The tab may threadedly attach to a threaded stud or bolt or nut or the like at the toggle assembly (or may detachably attach via other means, such as snaps, twist-on connections, a bayonet connection or the like), such that a desired tab may be readily attached to the toggle assembly to provide the desired tab for the mirror assembly. The selectable or replaceable or customized toggle tabs may provide various styles, sizes, shapes, appearances, textures, touches/feels (such as a soft touch material or the like), colors, patterns, indicia (such as logos or icons or the like as described below with respect to the center port 15c of the compass display 14a in FIGS. 13A-D). The customer/consumer thus may select the desired toggle tab for attachment to the mirror assembly (such as a tab that matches or is associated with the selected cap portion and/or bezel portion and/or reflective element ports (discussed below) or the like) to customize the mirror assembly. The customization and selection or replacement of the toggle tab may occur at the reflective element assembly portion assembly plant or at the mirror assembly plant or at the vehicle assembly plant or at the vehicle dealership or at any other aftermarket facility or the like, without affecting the scope of the present invention. The custom tab may thus be selected and attached or replaced at the mirror assembly to provide a custom appearance without having to retool or mold a different toggle assembly.

Optionally, the bezel portion 12 may be molded of a universal or standard color, finish and/or material, such as a black plastic material or black polypropylene or the like, and an outer rim portion or perimeter trim portion element may attach to a forward edge of the bezel portion (at the viewable side of the reflective element) to provide a desired appearance and/or functionality of the bezel portion of the mirror assembly to the driver and passenger of the vehicle. The bezel portion 12 may be formed to have a recess or trough or lip or the like around its perimeter portion (such as at 12b in FIG. 2), and the desired trim portion element may be selected and snapped to or pressed into or otherwise received in / attached to the perimeter portion of the bezel portion to provide the desired appearance/functionality to the mirror assembly. The attachable trim portion element may provide various styles, appearances, textures, touches/feels (such as a rubber or elastomeric material or soft touch material or the like), colors, patterns, indicia (such as logos, icons or the like as described below with respect to the center port 15c of the compass display 14a in FIGS. 13A-D). The customer thus may select the desired trim portion element for attachment to the bezel portion of the mirror assembly (such as a trim portion element that matches or is associated with the selected cap portion and/or toggle tab and/or reflective element ports (discussed below) or the like) to customize the mirror assembly. The trim portion element may be selected to provide a soft material or an impact absorbing material, and may have a Shore A durometer hardness that is less than that of the bezel portion or mirror holder. The customization and selection or replacement of the trim portion element may occur at the reflective element assembly portion assembly plant or at the mirror assembly plant or at the vehicle assembly plant or at the vehicle dealership or at any other aftermarket facility or the like, without affecting the scope of the present invention. The bezel portion thus may be formed as a universal or common bezel portion, and the viewable rim of the bezel portion (such as around the perimeter of the reflective element and viewable by a driver of the vehicle when the mirror is installed in the vehicle) may be selected or replaced to provide the desired or customized appearance and/or feel of the mirror assembly.

Optionally, the cap portion, or one of the cap portions, such as the cap portion 16b on the side of the mirror assembly, such as the side which will be toward the passenger side of the vehicle when the mirror assembly is installed in the vehicle, may include an electrical connector for connecting the accessory or circuit board or boards 18a, 18b to a vehicle wiring harness or power source of the vehicle. Optionally, the circuit board 18b at the cap portion may include a multi-pin connector 24 for connecting to a corresponding multi-pin connector of the vehicle wire harness. In such applications, an opening (such as opening 25b of cap portion 16" in FIGS. 4, 5 and 8-11) of sufficient size may be provided in the cap portion (or optionally in the mirror holder) to allow the connector on the wire harness to insert therethrough for connection to the connector on the circuit board 18b. The circuit board 18b or connector 24 may be substantially supported at the cap portion to provide sufficient support of the connector when a corresponding connector of the wire harness is pushed into engagement with connector 24.

For example, the cap portion or mirror holder may have a connector formed therein, whereby the wire harness may then connect to or plug into the connector at the rear of the mirror assembly. The connector may be formed as a selected or appropriate connector (such as a six pin or eight pin connector or the like) depending on the accessories of the cap portions. Optionally, the connector may be formed with an insert in the mold or tool for forming the cap portion, such that an appropriate insert may be placed in the mold or tool to form the desired or appropriate connector on that particular cap portion. In the illustrated embodiment of FIGS. 4, 5 and 8-11, the connector 24 of the circuit board includes a plurality of pins 24a for connecting to a connector or plug, and the cap portion 16" has an opening 25b formed therethrough so that the connector or plug may readily connect to the circuit board, and may snap or otherwise be fastened or secured thereto, such as via clasps or the like at the plug and/or at the cap portion 16".

In applications where both cap portions 16a, 16b support an accessory or circuit board, the circuit board 18a on the cap portion 16a (or the circuit board on one side of the unitary cap portion) opposite the connector 24 may be connected to the other circuit board 18b and/or connector 24 via one or more connecting wires 26, in order to provide power and/or control to the accessory on cap portion 16a. The connecting wire or wires 26 may extend between the cap portions 16a, 16b within the mirror holder 12 or may extend along the rear surface of the mirror holder 12, without affecting the scope of the present invention. As shown in FIG. 3, cap portion 16' of an interior rearview mirror assembly 10' may comprise a single cap portion having a wire channel or connector 16c extending between opposite end caps or end portions 16a', 16b'. The connecting wire (not shown in FIG. 3) may extend between the circuit boards 18a, 18b or accessories supported on the end portions 16a', 16b' and may be routed within the wire channel 16c or between the channel 16c and the rear portion 12a of the mirror holder 12. Optionally, and as shown in FIGS. 4, 5, 8-11, 24 and 26, a mirror assembly 10" may have the single or unitary cap portion 16" in accordance with the present invention, and a connecting wire between two circuit boards or accessories may extend along the cap portion to electrically connect the circuit boards or accessories together.

As shown in FIG. 2, printed circuit board 18b may include circuitry 19 for a compass display 14a and/or other accessory display, such as a passenger side inflatable restraint display 14b or the like, at reflective element 12. More particularly, circuit board 18b may include compass display circuitry 19 having a plurality of illumination sources 19a which are individually illuminated or illuminated in combination to project illumination through respective openings in circuit board 18b to illuminate one or more of the ports or direction characters 15a etched or formed in reflective element 14, such as in the manner disclosed in U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which is hereby incorporated herein by reference in its entirety. The compass display thus may be controlled or actuated by a microcontroller or microprocessor of the cap portion of the mirror assembly. The controller may drive or energize the illumination sources (such as light emitting diodes or the like) directly, without the need for additional display drivers. The direct energization of the illumination sources of the display thus avoids the need for other controllers or drivers within the cap portion or the mirror assembly or the vehicle.

When the cap portion 16b (or cap portion 16" or the like) and circuit board 18b are attached to or juxtaposed with the mirror holder 12, circuit board 18b may be pressed or urged toward the rear surface of reflective element 14 such that the illumination sources 19a (such as light emitting diodes or the like) at the circuit board may generally align with the appropriate ports or characters or icons formed in the reflective element 14, as discussed below. For example, and as best shown in FIGS. 8 and 9, the cap portion may include guide members or posts 25c for engaging corresponding guide members or tabs or holes or notches or recesses 18c of the circuit board for guiding the circuit board into the appropriate position and orientation on the cap portion as the circuit board is attached or snapped to the cap portion. The cap portion may then attach to the mirror holder / bezel portion via engagement and guiding of corresponding tabs and holes and the like, which function to position the cap portion in the desired location relative to the bezel portion, such that the circuit board (and any illumination devices or the like positioned thereon) is/are properly aligned with any associated display ports or switches or the like at the mirror holder / bezel portion / reflective element.

As shown in FIGS. 4 and 5, a seal or sealing member or layer 17 or the like may be applied to the rear surface of reflective element 14 or to the forward face 18d of circuit board

18b to substantially seal the interface between the circuit board 18b and the reflective element 14, in order to limit or substantially preclude light from one of the illumination sources from illuminating a port or character or icon at the reflective element other than the respective port or character or icon aligned with that illumination source and opening. The seal 17 may comprise an opaque material, and may comprise a white (or other color) silicone gasket or the like, to diffuse and/or reflect light. The seal 17 may be at least partially and preferably substantially flexible or resilient to compress and seal against the reflective element and the circuit board to limit or substantially preclude light leakage from one illumination source to one of the other ports or characters of the display.

The circuit board may also include a connecting wire 28 which may connect to a compass pod or module 30 or other accessory or accessory module or the like for communication of compass heading or control information to the compass display circuitry 19 at the circuit board or for communication of other control information between the accessory module and the circuit board of the cap portion. For example, the connecting wire 28 may extend from the cap portion and the rear of the mirror assembly to the compass module 30, which may be attached to the mounting arm or mounting button of the mirror assembly or otherwise positioned or mounted at or near the mirror assembly. Compass module 30 may include the compass circuitry (which may include calibration circuitry, a microprocessor and the like) and magnetoresponsive compass sensors (such as magnetoresistive sensors, magneto-capacitive sensors, magnetoinductive sensors or the like or a flux gate sensor or the like), such as described in U.S. Pat. Nos. 6,513,252 and 5,802,727, and/or U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which are hereby incorporated herein by reference in their entireties. The compass pod may also include an ambient light sensor, whereby the intensity of the compass display (and other displays of the mirror assembly) may be adjusted in response to the detected ambient light levels. Optionally, the compass system may utilize principles disclosed in U.S. Pat. Nos. 5,924,212; 4,862,594; 4,937,945; 5,131,154; 5,255,442; and/or 5,632,092, which are hereby incorporated herein by reference.

Although shown and described as having a separate compass pod that may mount to the mirror mounting portion of the mirror assembly that in turn mounts to the likes of a mirror mounting button on the windshield (such as described in U.S. Pat. Nos. 6,648,478; 5,708,410 and/or 5,576,687, which are hereby incorporated herein by reference) to remain generally stationary, it is envisioned that a compass pod or module or compass circuitry and sensors may be positioned in a post or arm of a single ball mounting arrangement such that the sensors and circuitry are generally fixedly positioned relative to the mounting button and the vehicle. A wire may be routed along the generally fixed mounting arm (via and through the single ball joint) and to the display elements or illumination sources, such as in a manner similar to that shown in FIG. 34, or a wire may be routed along the mounting arm and through the single ball and into the mirror casing or a wire or conductor may be routed or positioned along the arm and ball in any other manner to communicate electrical signals and the like to the circuitry and/or illumination sources of the cap portion, without affecting the scope of the present invention. The wire may provide slack to allow for the adjustment and movement of the mirror holder/cap portion about the single arm to avoid pulling at the wire during adjustment of the mirror.

The compass circuitry 19 on circuit board 18b may also include a button or switch or control or may be in communication with a button or control 23 (FIGS. 8, 10 and 11), such as at the rear of the cap portion 16" or at the rear of the mirror holder, for actuating a calibration or zone function of the compass circuitry. In the illustrated embodiment, the button 23 may include an inward protrusion 23a (FIGS. 8 and 24) that extends forwardly from the cap portion 16" or inwardly toward the button or switch or control on the circuit board when the cap portion 16" is attached to the circuit board. The button 23 may comprise a flexible tab 23b integrally formed with and extending partially along the cap portion 16". When a user presses at the button 23, the tab 23b flexes and the protrusion 23a is moved toward and urged against the button or switch on the circuit board 18b to actuate the switch to control or activate/deactivate the associated function of the compass circuitry (or other circuitry or accessory or the like that may be associated with the switch on the circuit board). Although shown and described as being integrally formed with the single cap portion 16" in FIGS. 8, 10, 11 and 24, the button/flexible tab or flip actuation tab member may be integrally formed on one of the side cap portions 16a, 16b or end portions 16a', 16b' of cap portion 16' or the like, or on other types of casings or housings or the like, without affecting the scope of the present invention.

Optionally, an additional illumination source or lighting element may be provided on the circuit board 18b for projecting illumination through a corresponding port or icon or character 15b formed on the reflective element 14 to indicate that the compass system is in the calibration mode or zone setting mode. Optionally, the calibration mode may be indicated by a light emitting diode (LED) at the center port 15c of the display. For example, a dual-color LED may be provided at the center port, where illumination in one color (such as, for example, red) indicates that the compass system is in the calibration mode. Once the compass system is calibrated, however, illumination may be provided in the other color (such as, for example, blue). Thus, when the compass system is not in the calibration mode, the other color (such as blue) indication color may be provided. Optionally, the calibration mode could be indicated without a dedicated illumination source or light emitting diode or the like (because such an indicator would be used very rarely in the life of the part). For example, the center illumination source or LED (which may be activated to provide an anchor point or focal point for the display, as discussed below) may be flashed or otherwise modulated or adjusted when the system is in the calibration mode, or other similar types of indication may be provided to convey to the driver that the compass is in its calibration mode.

The circuit board 18b may also have an ambient light sensor or photocell (not shown) for detecting the ambient light level at the mirror assembly, whereby the circuitry may adjust the intensity of the display in response to the detected ambient light levels. A corresponding opening in the mirror holder 12 or at the rear of the cap portion 16 (such as opening 25d in cap portion 16" of FIGS. 8, 10 and 11) may allow the ambient light sensor to detect the ambient light levels through the opening. The light sensor may alternately be positioned at the compass pod or module 30, without affecting the scope of the present invention.

The compass display 14a (FIGS. 1-5 and 12) thus may include a plurality of direction indicating ports 15a (such as four such ports formed to represent the cardinal directional points or "N", "E", "S" and "W" or the like) and may include an additional port 15b for a calibration indicator or light source, such as described in U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which is hereby incorporated herein by reference in its entirety. Compass display 14a may further include a center port 15c etched or otherwise formed at a central region of the display 14a. Center port 15c may provide an opening or port for a rearward facing photosensor positioned at the circuit board to receive light therethrough to determine the ambient light at or in the vehicle cabin (or a glare sensor for determining glare at the mirror assembly for controlling an exterior electrochromic mirror assembly or cell or the like as discussed below) when the mirror assembly is assembled and positioned in the vehicle, such as discussed below.

Optionally, center port 15c may align with an illumination source or light emitting diode at the circuit board to provide a visible center indicator or central anchor or focal point at the central region of the display 14a such that a person may readily identify the center of the compass display. For example, when one of the directional heading indicators at ports

15a are illuminated or energized, the indicator or light source at center port 15c may also be energized to provide a visible central anchor point for a person to recognize as the central region of the display. The provision of an extra illumination source or port that is central to the rosette N-E-S-W indicia thus helps to serve as a reference point for the driver, in order to aid the driver's cognitive association of the cardinal direction point that is intended to be communicated when any one (or combination of two) of the N, E, S, W icons or ports are illuminated.

Optionally, the light emitting diodes aligned with the directional indicating ports 15a may be one color, while the light emitting diodes at the central port 15c and/or at the calibration indicating port 15b may be another color or colors. For example, the directional indicating ports 15a may be illuminated or back lit via blue indicators or light emitting diodes or the like, while the central port 15c may be illuminated or back lit via a red or amber indicator or light emitting diode or the like, so that a person viewing the compass display in darkened conditions may readily discern which indicator is indicative of the central region of the display and thus where the center of the display is, such that the person may readily recognize which directional indicating port is illuminated, without having to look to see whether it is an "N" or an "E" or the like.

Optionally, the center port may be illuminated whenever the vehicle is on or powered, in order to provide substantially continuous illumination of the center port. Preferably, the center port is illuminated at a lower light output intensity than that of the respective cardinal N, E, S, W ports, so as to serve as a subtle eye point, but not to be confused with an actual directional indication. For this reason, a color contrast as well as an intensity contrast may be desirable.

In such applications where the center port is illuminated or back lit, an ambient sensor may be positioned elsewhere in the mirror assembly, such as elsewhere in the cap portion, and may be a forwardly facing sensor (i.e. toward the windshield when the interior rearview mirror assembly is normally mounted in the interior cabin of a vehicle) and may receive light through a port or opening 25d in the cap portion. Alternatively, the ambient sensor may be facing downwardly or upwardly when installed in the vehicle, without affecting the scope of the present invention. The ambient sensor may be generally aligned with or juxtaposed at the port or opening or may receive the ambient light via a light pipe or the like, without affecting the scope of the present invention.

Optionally, and with reference to FIGS. 13A-D, the center port 15c of the compass display 14a (or other port or display area of the reflective element) may provide a graphic depiction of a desired image, such as a logo of the vehicle manufacturer or other desired image. For example, the center port 15c may be etched (such as by laser etching or ablation or by sandblasting or the like) or otherwise formed to provide the letters "FORD" or may be etched or otherwise formed in a pattern similar to the design or designs indicative of the manufacturer, such as the Chevrolet "bowtie" or the like. Optionally, other designs or patterns or text or logos or indicia or the like may be provided at the center port 15c (or elsewhere on the reflective element) to provide a desired image or logo. In the illustrated embodiments of FIGS. 13A-D, the central port is formed to be indicative of the vehicle manufacturer, such as for Dodge (FIG. 13A), Honda (FIG. 13B) or Jeep (FIG. 13C), or Subaru (FIG. 13D). However, the central port may be formed to be indicative of other vehicle manufacturers or entities or sponsors or indicia or trademarks or emblems or signature items, or representations of a certain political views, religious beliefs, tribal affiliations, community ties, collegiate affiliations, allegiances and/or advocacy (such as, for example, a "peace" sign or other symbol or text or the like) or other views, affiliations, beliefs, etc., or other custom ports or icons may be formed elsewhere on the reflective element to convey other information or logos or the like, without affecting the scope of the present invention.

The desired image or logo may be indicative of the vehicle manufacturer, or may be selected by the user or vehicle owner to provide a customized interior rearview mirror assembly, such as described above with respect to the different logos or colors or textures or appearances or touch/feel provided on the cap portion or bezel portion of the mirror assembly, without affecting the scope of the present invention. For example, a person may select the logo or mascot of their alma mater to be etched at the center of the compass display (or elsewhere on the reflective element) to customize the mirror assembly for that particular person or owner. The customized or selected port may be at the central port of the compass display or may at or incorporated into another display at the reflective element or may be elsewhere at the reflective element and separate from any other information display, without affecting the scope of the present invention. Optionally, the light source or indicator positioned at the circuit board behind the custom port may be selected to match the color that may be typically associated with the selected logo, such as a green or red or blue indicator or light emitting diode or the like for the school color or the like. Other forms of customized logos or indicia or the like may be etched or otherwise formed at the reflective element, without affecting the scope of the present invention.

Optionally, and with reference to FIGS. 14-16, an interior rearview mirror assembly 10''' may include an intuitive heading instructional icon element or display 14a' at the reflective element 14', such as the types described in U.S. provisional application, Ser. No. 60/553,517, filed Mar. 16, 2004 by Schofield for MIRROR ASSEMBLY (Attorney Docket DON01 P-1145), which is hereby incorporated herein by reference. The compass display 14a' may be associated with or controlled or adjusted by a compass system and/or a navigational system, such as a compass and/or navigational system of the types described in U.S. Pat. Nos. 6,678,614; 6,477,464; 5,924,212; 4,862,594; 4,937,945; 5,131,154; 5,255,442; and/or 5,632,092, and/or U.S. pat. applications, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076); Ser. No. 10/645,762, filed Aug. 20, 2003 by Taylor et al. for VEHICLE NAVIGATION SYSTEM FOR USE WITH A TELEMATICS SYSTEM (Attorney Docket DON01 P-1103); and Ser. No. 10/422,378, filed Apr. 24, 2003 (Attorney Docket DON01 P-1074); and/or PCT Application No. PCT/US03/40611, filed Dec. 19, 2003 by Donnelly Corporation et al. for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1123(PCT)), which are all hereby incorporated herein by reference.

Display 14a' includes a plurality of characters or icons or letters 15a (such as N, E, S, W as shown in FIGS. 14-16) formed or etched in the reflective coating or layer of the reflective element 14' and includes an arrow or direction pointer 15d at each of the characters 15a. The display 14a' may also include a central port 15c through the reflective coating or layer reflective element 14' behind which may be positioned an illumination source as described above or a glare sensor, such as a photo sensor or the like, such as a glare sensor and/or an ambient light sensor and electrochromic automatic dimming circuitry described in U.S. Pat. Nos. 4,793,690 and 5,193,029, and U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which are all hereby incorporated herein by reference. The arrows of direction pointers may point generally upward when the mirror assembly is mounted in the vehicle with the reflective element facing generally rearward and opposite to the direction of forward travel of the vehicle. The arrows or pointers thus may be representative of the direction of forward travel of the vehicle. As shown in FIGS. 14-16, the direction pointers of display 14a' may comprise generally triangular shaped icons or pointers 15d positioned outward from the characters 15a and opposite the characters from the center or port 15c of the display (such as shown in FIG. 14), or the direction pointers of the display may comprise arrows 15d' positioned next to the characters 15a (such as shown in FIG. 15), or the direction pointers of the display may comprise arrows 15d" positioned inward of the characters 15a and between the respective characters and the center or port 15c (such as shown in FIG. 16).

The compass/navigation system may be operable to energize one or more illumination sources positioned at and rearward of a respective one of the characters 15a and corresponding direction pointer 15d to illuminate or back light the respective character and direction pointer. For example, the compass/ navigation system may be operable to illuminate or back light a particular character and adjacent direction pointer to indicate to an occupant of the vehicle the direction that the vehicle is currently heading. For example, if the character "W" and the arrow or direction pointer next to the "W" are illuminated, then the display indicates that the vehicle is heading west. The intuitive heading instructional icon element or display thus may provide reinforcement to a viewer that when the character (such as "W" or other character) is illuminated, it is done so to indicate that the vehicle is traveling in the direction (such as west or other direction) indicated by the character. This is reinforced by the illumination of the corresponding arrow or direction pointer that points upward so as to be representative of pointing in the direction of forward travel of the vehicle. A person viewing the display thus will not misinterpret the illumination of the characters to be indicative of a driving or turning instruction (such as an instruction to turn the vehicle right or east to follow a programmed route) in connection with the navigation system.

Optionally, the display may function as a display for providing both an indication of the directional heading of the vehicle and an indication of which direction the vehicle should be turned in order to follow a programmed route or path. For example, only a particular direction pointer may be illuminated or back lit to indicate that the vehicle is heading in the direction indicated by the non-lit character next to the illuminated pointer, while a different character (separate from the illuminated pointer) may be illuminated or back lit to indicate that the vehicle is to be turned in that direction to follow a programmed route to a desired destination. The compass/navigation system and display thus may clearly display to a driver of the vehicle which direction the vehicle is heading at that time via the directional arrows, while the compass/navigation system and display may also be operable to provide driving or turning instructions to a driver of the vehicle to instruct the driver as to which direction the driver is to turn to follow a particular route to a desired destination. For example, the compass/navigation system may be associated with a global positioning system and/or telematics system of the vehicle, and may generate and display driving instructions to the driver of the vehicle as the vehicle is driven along a generated route, such as by utilizing aspects described in U.S. Pat. Nos. 6,678,614 and 6,477,464, and/or U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076); Ser. No. 10/645,762, filed Aug. 20, 2003 by Taylor et al. for VEHICLE NAVIGATION SYSTEM FOR USE WITH A TELEMATICS SYSTEM (Attorney Docket DON01 P-1103); and Ser. No. 10/422,378, filed Apr. 24, 2003 (Attorney Docket DON01 P-1074); and/or PCT Application No. PCT/US03/40611, filed Dec. 19, 2003 by Donnelly Corporation et al. for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1123(PCT)), which are all hereby incorporated herein by reference.

During operation, the compass/navigation system thus may be operable to energize an illumination source positioned at and rearward of/behind a respective one of the characters to provide a driving instruction to the driver of the vehicle that is separate from the directional heading indication also provided by illumination or back lighting of the arrows or pointers of the display. For example, if the vehicle is heading generally west, the compass/ navigation system may illuminate or back light the arrow next to the "W" to indicate to the driver of the vehicle that the vehicle is traveling generally in that direction. If the programmed route for the vehicle involves an upcoming right turn onto a generally northbound road, the compass/navigation system may then illuminate or back light the letter "N" to indicate to the driver of the vehicle that the driver should turn the vehicle to head north.

It is further envisioned that the illuminated character may be altered or adjusted as the vehicle gets closer to the turning point or intersection, such as by flashing the illumination source or intensifying the illumination source or changing the color of the illumination as the vehicle approaches the desired or appropriate turning point or intersection. It is also further envisioned that arrows pointing sideways may be provided at one or more of the characters of the display (or elsewhere at the display), and the appropriate arrow may be illuminated or back lit to indicate that the driver is to turn right or left to stay on the desired course or route. In such an embodiment, illumination or back lighting of the character may be indicative of the directional heading of the vehicle, while illumination or back lighting of the arrows may be indicative of the driving instructions to the driver of the vehicle.

The intuitive display elements thus provide a clear indication as to which direction the vehicle is presently traveling by providing a directional heading arrow or pointer at each of the compass heading characters. The driver of the vehicle thus will not likely become confused as to the meaning of the illuminated characters or letters. The compass/navigation system and display of the present invention also may provide point-to-point driving instructions and the present directional heading of the vehicle with the same display or display icons/characters.

Optionally, the compass display may include a temperature display or another type of information display with an LED array at or near the compass display ports or icons. One or more control buttons or inputs (such as at the rear side of the mirror assembly) may be provided to allow the driver or occupant of the vehicle to select or actuate the calibration or zone or temperature display functions. The circuit board may be in communication with a temperature sensor or system, such as via a connecting wire or the like, to receive an electronic signal indicative of the temperature to be displayed. Optionally, the cap portions and circuit boards may support or provide a compass and/or temperature display utilizing vacuum fluorescent displays and filters to display the compass heading and/or temperature via two or more characters or letters or numbers. For example, and as shown in FIG. 17, a compass heading display 32a and a temperature display 32b may be provided or formed at a display region 32c of a reflective element 14" of a mirror assembly. The displays may comprise alphanumeric characters or the like to convey the directional heading information and temperature information to the driver of the vehicle.

Optionally, the circuit board may also or otherwise include circuitry for another accessory and/or display at the reflective element. The other display circuitry may illuminate or project information via illuminating ports or icons or characters or the like which are etched or otherwise formed on the reflective element, such as in a similar manner as described above. The display circuitry and associated control circuitry may be positioned at the circuit board. Optionally, some of the circuitry may be positioned outside of the mirror assembly, such as at an accessory pod or module, and may be in communication with the circuitry of the circuit board via a connecting wire or the like, such as described above with respect to the compass circuitry.

Optionally, the illumination sources utilized to back light or illuminate the display icons or characters may emit a desired color of light, such as a blue colored or tinted light or other color as may be desired. In many mirror applications, a blue light is typically preferred because it provides high visibility of the display during high lighting or daytime conditions, but may not be as favorable during low light or nighttime conditions. Optionally, a control or multiplexer may be operable to change the color of the display in response to an ambient light sensor or the like. For example, the control may deactivate a blue illumination source and activate an amber or red illumination source (or other color) when the ambient light level drops to a threshold level. The nighttime color may be selected to provide enhanced viewing of the displays and may be selected to generally match the lighting color scheme or signature color of the particular vehicle in which the display is implemented. Optionally, the colors may be ramped on and off, such that in intermediate lighting conditions, both colors may be provided and mixed, in order to provide a gradual change from one color to the next as the ambient light levels increase or decrease. Optionally, the control may activate a second illumination source (a nighttime illumination source that may be directed toward and through the same port as a daytime illumination source) in parallel with the daytime illumination source (such as a blue illumination source), which may remain activated so that the colors of the illumination sources are mixed during nighttime or darkened conditions.

As also shown in FIGS. 2-5, one of the circuit boards, such as circuit board 18a supported by cap portion 16a (FIG. 2) or circuit board 18a supported by cap portion 16" (FIGS. 4 and 5) or the like, may include an accessory or circuitry 21 and associated manual inputs or controls or buttons 21a for providing manual control of the circuitry or accessory 21. For example, circuitry 21 may comprise circuitry for a garage door opening device or system, such as a universal garage door opener or the like. With reference to FIG. 2, one or more buttons 21a (and/or one or more lights or illuminated buttons or controls) may extend or project from circuitry 21 and may extend at least partially through or may be accessible through corresponding openings or holes 21b in mirror holder 12. Optionally, and as shown in FIGS. 4 and 5, one or more buttons 21a' may be provided at a circuit board 18a, and may be positioned or received in a recessed area 21b' along the bezel portion or mirror holder 12 and/or in a recessed area 25e along the cap portion 16", such that the buttons may be secured in place between the mirror holder and cap portion when the cap portion is attached to or secured to the mirror holder. The buttons 21a, 21a' may be readily accessible by the driver or occupant of the vehicle to actuate or control the circuitry 21, such as to actuate a transmitting device to open or close a garage door, such as utilizing the principles disclosed in U.S. Pat. Nos. 6,396,408; 6,362,771; 5,798,688 and 5,479,155; and/or U.S. pat. application, Ser. No. 10/770,736, filed Feb. 3, 2004 by Baumgardner et al. for GARAGE DOOR OPENING SYSTEM FOR VEHICLE (Attorney Docket DON01 P-1135), which are hereby incorporated herein by reference.

Optionally, and as shown in FIG. 18, a garage door opener display 34 may be provided at the reflective element of the mirror assembly for displaying a Homelink® icon (or other icon or indicia indicative of such a system) at the buttons or inputs 21a , 21a' for the garage door opener system, such as might be useful as an indicator to assist a user when training or operating in a learning mode of a trainable garage door opener (such as by intermittently illuminating or modulating/flashing/blinking an LED or the like behind a Homelink® icon or the like when in the learning mode) and/or as an indicator for company brand promotion/feature illustration promotion, such as by constantly illuminating the LED or the like, such as when a trainable garage door opener is not in the training or learning mode. The garage door opener display 34 may have an illumination source (such as a light emitting diode or the like) that may be activated or energized to back light or otherwise illuminate the display as desired. The display elements and circuitry and user inputs may be added to or attached to the cap portion as a module so that the desired feature or content may be readily added to a corresponding cap portion to provide the desired feature or content to the appropriate mirror assembly.

Because it is desirable that the mirror holder be a universal mirror holder for mirror assemblies having various accessories or no accessories, it is envisioned that the openings 21b in mirror holder 12 for the input controls 21a of accessory 21 (and/or other openings for other user inputs or buttons or switches or the like for other accessories or the like) may be formed in the mirror holder via inserts positioned in the mirror holder mold or tool for mirror holders which require such openings. The inserts may be removed from the tool to provide molding of a mirror holder without such openings for applications where no such accessory and associated controls or buttons is selected. Similarly, the recessed regions 21b' in the mirror holder and/or the cap portion may be formed via inserts placed in the molds during the forming of the mirror holder or cap portion. The different mirror holders may thus be molded or formed using the same tool, yet may receive different cap portions having or supporting different accessories or features.

In the illustrated embodiment, the buttons 21a are positioned at the mirror assembly so that user actuation of the buttons requires a generally vertical upward force (when the mirror assembly is installed in the vehicle) to move the button or input upwardly to actuate the electronic switch. Optionally, however, the buttons or inputs may be positioned at the mirror assembly so that actuation of the button or switch or input may be accomplished by a generally horizontal force or movement, such as a generally horizontal force toward the mirror assembly or in the direction of travel of the vehicle. For example, the user inputs may be positioned in a gondola or pod or attachment or extension of the cap portion that extends outwardly (such as downwardly or upwardly or sidewardly) from the cap portion so as to be viewable and readily accessible by the driver of the vehicle. The user inputs may be positioned within the gondola or pod so that pressing the user inputs generally horizontally actuates the switch (such as an electronic switch at the printed circuit board within the cap portion of the mirror assembly). The cap portion or attachment may include mechanical elements or structure for mechanically translating the generally horizontal movement of the input to a generally vertical actuation of an electronic switch, or the electronic switch may be oriented at the circuit board to be responsive to the generally horizontal actuation movement, without affecting the scope of the present invention. Preferably, such gondola or pod may extend upward or toward the passenger side of the mirror assembly (when the mirror assembly is installed in the vehicle) to limit or reduce any interference with the forward field of view of the driver of the vehicle.

Although shown and described as having buttons such as shown in FIGS. 2-5 and 10, it is envisioned that the mirror assembly may include buttons or inputs of the types described in U.S. provisional applications, Ser. No. 60/553,517, filed Mar. 16, 2004 by Lindahl et al. for MIRROR ASSEMBLY (Attorney Docket DON01 P-1145); and Ser. No. 60/535,559, filed Jan. 9, 2004 by Lindahl for MIRROR ASSEMBLY (Attorney Docket DON01 P-1134), which are hereby incorporated herein by reference. For example, the buttons may be integrally molded in the cap portion or bezel, or the buttons may extend downward through openings in the cap portion or bezel or between the cap portion and bezel when the cap portion is attached to the bezel, without affecting the scope of the present invention.

Optionally, the cap portions and circuit boards may support one or more other accessories and/or corresponding displays at or within the mirror holder, such as a tire pressure monitoring system and display 36, 36' (FIGS. 19-21), whereby the display may indicate when a tire pressure has dropped below a set or preselected tire pressure. For example, a particular light source may be energized or activated to back light or illuminate an icon 36a indicative of one of the tires of the vehicle when the pressure in that tire drops below the threshold tire pressure. The individual light sources may be individually energized, such as in a similar manner as the directional heading indicators discussed above and/or described in U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which is hereby incorporated herein by reference. The display may include an iconistic display that may be laser etched or otherwise formed on the reflective element (such as described above), and may provide for illumination (via one or more illumination sources at the circuit board of one of the cap portions) of one or more icons 36a representative of a particular tire of the vehicle. Optionally, and as shown in FIG. 21, the tire pressure display 36' may be printed on a screen and placed at and generally aligned with a window formed in the reflective layer of the prismatic reflective element, without affecting the scope of the present invention. The display may further provide for illumination of an additional icon or character 36b or may provide a different color illumination when a puncture is detected at one of the tires of the vehicle. Optionally, the tire pressure monitoring display 36' may include a digital display 36c (or other type of character or alphanumeric display) for indicating the tire pressure of one of the tires. The tire pressure monitoring system may utilize principles disclosed in U.S. Pat. Nos. 6,124,647; 6,294,989; 6,445,287; 6,472,979; and/or 6,731,205, which are hereby incorporated herein by reference.

The tire pressure display thus may be controlled or actuated by a microcontroller or microprocessor of the cap portion of the mirror assembly. The controller may drive or energize the illumination sources (such as light emitting diodes or the like) directly, without the need for additional display drivers. The direct energization of the illumination sources of the display thus avoids the need for other controllers or drivers within the mirror assembly or the vehicle. The tire pressure monitoring system display 36, 36' may utilize aspects of the compass display disclosed in U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which is hereby incorporated herein by reference in its entirety.

Optionally, the cap portion may include circuitry and user inputs associated with a telematics system, such as ONSTAR® or the like. For example, a circuit board may include circuitry for the telematics system and may be attached to or mounted to a cap portion, such as a circuit board similar to circuit board 18a described above. The cap portion and/or mirror holder may include a recess or opening for one or more user inputs to be positioned when the mirror assembly is assembled, so that the user inputs may be readily accessible by a driver of the vehicle when the mirror assembly is installed in the vehicle. As shown in FIG. 22, the user inputs or buttons 38 may extend along a lower portion of the mirror assembly and may be readily viewable and accessible at the lower portion of the mirror assembly by a driver of the vehicle. The user inputs 38 may comprise a keypad or the like that is positioned within corresponding notches or recesses along the opposed or mating edges of the mirror holder and the cap portion, such as described above with respect to user inputs 21a' of FIGS. 4 and 5. A telematics display 40 may be etched or otherwise formed in the reflective element 14 to indicate to a user the function of the user inputs 38. The display 40 may include one or more icons or images or characters 40a or the like that may be etched or formed in the reflective element and backlit by respective illumination sources. The illumination source or sources may be activated during low ambient lighting conditions (such as dusk or night, such as when ambient lighting is less than, for example, about 200 lux) to illuminate the display 40 so a user can see the function of the user inputs (which may also be illuminated or backlit or the like) during low lighting conditions, such as at nighttime. Optionally, individual illumination sources may be provided at each icon or port 40a to independently illuminate or back light the respective icon, such as in response to actuation of a respective one of the user inputs (such as in a manner as described above with respect to the individual directional icons of the compass display). Optionally, and with reference to FIG. 23, the display 40' may be positioned at a window 42 of the reflective element 14 and may be viewable through the reflective element window.

The cap portions of the present invention thus may provide a desired content, such as a garage door opening system and respective user inputs or a telematics feature and respective user inputs, to a particular mirror assembly. The desired system may be provided to the cap portion as a module, such as a garage door opening system module (which may include the transmitter and circuitry and user inputs) or a telematics module (which may include the circuitry and user inputs and display elements), and the module may be attached to or snapped to or mounted to the cap portion, such as at a cap portion assembly facility or at the vehicle assembly facility. Although shown as a garage door opening system module or a telematics module, clearly, the cap portion may include or incorporate other modules or displays or the like, such as, for example, a passenger side air bag status display (typically on the lower passenger side corner or area of the reflective element) or other displays, or a rear-facing sensor (which may align with an opening or port or window formed in the reflective element when the cap portion is attached to the mirror holder), or other types of displays or systems or modules, without affecting the scope of the present invention. Optionally, the user inputs or buttons or switches or the like may be positioned in the cap portion or in the bezel portion (or between the cap portion and bezel portion), or the cap portion may include an eyebrow portion or gondola portion or underbrow portion or chin portion or attachment (that may extend or protrude partially outward and/or partially around the bezel portion, and that may extend upwardly or downwardly or sidewardly therefrom) in which the inputs may be positioned, such that the inputs are contained at or in the cap portion and readily viewable and/or accessible at a desired location around the bezel portion.

The desired cap portion (with the desired features or content) may be readily attached to a common or universal mirror holder (which may include the reflective element and toggle and mounting assembly, which may be assembled at a mirror holder assembly facility) to assemble the mirror assembly, such as at a mirror assembly facility. The mirror holder may be adapted to partially receive the user inputs therein, and/or the reflective element contained in the mirror holder may have a particular display or displays formed thereon. The display icons or ports or windows formed in the reflective layer of the reflective element may generally align with the respective display elements or illumination sources of the circuitry within the cap portion when the cap portion is attached to the mirror assembly, such as described above with respect to the compass display. In applications where different modules may be provided that provide different display information at the reflective element, the reflective element may be selected to have the appropriate ports or icons or the like that correspond with the particular module, or the reflective element may have a window or windows formed in the desired or appropriate locations or may comprise a transflective prismatic reflective element (such as described in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); and/or U.S. provisional application, Ser. No. 60/525,952, filed Nov. 26, 2003 by Lynam for MIRROR REFLECTIVE ELEMENT FOR A VEHICLE (Attorney Docket DON01 P-1130), which are hereby incorporated herein by reference), such that the display elements (which may be illuminated alphanumeric characters or icons or indicia or the like) of the modules may be viewable through the reflective element to view the information being displayed by the display elements. The present invention thus provides for various mirror assemblies having different features or electronic content, while providing common or universal mirror holders and cap portions, where different circuitry or circuit boards or modules may be attached to the cap portion to provide the desired content to the mirror assembly.

Optionally, the cap portion or portions and circuit board or boards may support one or more other accessories or features at or within the mirror holder, such as one or more electrical or electronic devices or accessories. For example, and as can be seen in FIGS. 24-26, illumination sources or lights, such as map reading lights 46 or one or more other lights or illumination sources (which may be positioned at or aligned with openings formed in the bottom of the mirror holder to direct illumination generally downward to illuminate the console of the vehicle), such as illumination sources of the types disclosed in U.S. Pat. Nos. 6,690,268; 5,938,321; 5,813,745; 5,820,245; 5,673,994; 5,649,756; 5,178,448; 5,671,996; 4,646,210; 4,733,336; 4,807,096; 6,042,253; and/or 5,669,698, and/or U.S. pat. applications, Ser. No. 10/054,633, filed Jan. 22, 2002 (Attorney Docket DON01 P-962); and/or Ser. No. 10/745,056, filed Dec. 22, 2003 by Lynam et al. for LIGHT MODULE FOR INTERIOR REARVIEW MIRROR ASSEMBLY (Attorney Docket DON01 P-1122); and/or U.S. provisional application, Ser. No. 60/500,858, filed Sep. 5, 2003 by Kulas et al. for

INTERIOR REARVIEW MIRROR ASSEMBLY (Attorney Docket DON01 P-1112), which are hereby incorporated herein by reference, may be included with the cap portion 16". The illumination source or sources 46 may be attachable to or positionable at or molded into the cap portion and may connect to a circuit board 47 of the cap portion 16". The illumination sources and/or the circuit board may be connected to one or more buttons or inputs 48 for activating and deactivating the illumination sources.

Optionally, and with reference to FIG. 26, the circuitry 47a may comprise a stamped circuit that is molded into and/or along the cap portion, with the electrical connections between the lights and buttons and power source being made via stamped connectors or terminals molded into the cap portion (such as terminals of the type described in U.S. Pat. No. 6,227,689, which is hereby incorporated herein by reference) and extending between the lights 46 and/or inputs/buttons (not shown in FIG. 26) and/or the power source/circuit board 47. The illumination sources 46 and inputs 48 may be positioned at recesses in and along a forward edge or portion of cap portion 16" and may be partially received in corresponding recesses along the rearward edge of the corresponding mirror holder to secure the illumination sources and buttons at the mirror assembly.

As best shown in FIGS. 24 and 25, the light actuators or buttons 48 may comprise a push button actuator having a user actuating portion 48a at a lower end of a body portion 48b. The actuator 48 may comprise any known switch or button assembly, or may be of the type described in U.S. pat. application, Ser. No. 10/447,641, filed May 29, 2003 by Adams for ELECTRICAL SWITCH (Attorney Docket DON01 P-1081), which is hereby incorporated herein by reference. Body portion 48b may be slidably mounted to or positioned in or at the cap portion 16" and may slide between an activated position, where the switch closes the circuit to activate the light source, and a deactivated position, where the switch opens the circuit to deactivate the light source. The actuator 48 includes a torsional spring 49 wrapped around a shaft 48c protruding from body portion 48b. One end 49a of the spring 49 engages a stop 50a extending from the cap portion 16", while the other end 49b is movable around a detent 50b as the switch body 48b is moved between the activated and deactivated positions. For example, when the switch is in the lowered or deactivated position, the spring may bias the switch downward (which may open the circuit) via engagement with the stop 50a. When the switch is pressed upward, the end 49b may move upward around the detent 50b and may rest within a recess 50c of the detent 50b when the switch is released to retain the switch in the raised or activated position (which may close the circuit). When the switch is again pressed upward by a user, the end 49b may move upward and out from the recess 50c and may move downward around the detent 50b as the switch is urged or moved downward in response to the biasing forces of the spring 49. The actuator 48 thus provides a low cost actuating device that only has a few components and, thus, is less costly and less complicated and more durable than many multiple component switches in use today.

Optionally, the cap portion may provide circuitry or power for a light or illumination source, such as a map reading light or the like, and a desired or appropriate lighting capsule or module (including the light source and user input or button or switch) may be plugged into the mirror assembly (such as described in U.S. pat. applications, Ser. No. 10/054,633, filed Jan. 22, 2002 (Attorney Docket DON01 P-962); and Ser. No. 10/745,056, filed Dec. 22, 2003 by Lynam et al. for LIGHT MODULE FOR INTERIOR REARVIEW MIRROR ASSEMBLY (Attorney Docket DON01 P-1122), which are hereby incorporated herein by reference). The circuit board of the cap portion may include prongs or connectors or the like at a lower portion of the circuit board, and the lighting capsule may be inserted through an opening in the cap portion and/or mirror holder and may engage and connect to the prongs or connectors to electrically connect the light to the circuit board. The lights thus may be readily inserted into or connected to the circuit board of the cap portion if desired or appropriate to provide the desired feature or content to the cap portion and the mirror assembly.

Optionally, the mirror assembly may include a white light emitting diode, or a cluster of LEDs may be provided, as a map/reading light or light module. Optionally, the cap portion or bezel portion may include illumination sources, such as light emitting diodes or the like, that may be embedded in the rim of the bezel portion or the lower portion of the cap portion to emit or project illumination toward the desired area of the vehicle cabin. The illumination sources may be switched on locally, such as via user inputs or switches or buttons as described above, or may be activated/deactivated/controlled by a control or system remote from the mirror assembly, such as via a vehicle electronic or communication system, and may be connected via a hard wire or via various protocols or nodes, such as Bluetooth, SCP, UBP, J1850, CAN J2284, Fire Wire 1394, MOST, LIN and/or the like, depending on the particular application.

Optionally, the illumination sources may comprise modular light sources, and may comprise one or more incandescent light sources or light emitting diodes or the like, such as described in U.S. pat. applications, Ser. No. 10/054,633, filed Jan. 22, 2002 (Attorney Docket DON01 P-962); and Ser. No. 10/745,056, filed Dec. 22, 2003 by Lynam et al. for LIGHT MODULE FOR INTERIOR REARVIEW MIRROR ASSEMBLY (Attorney Docket DON01

P-1122), which are hereby incorporated herein by reference. Optionally, the light emitting diodes may be operable to individually emit illumination in different colors as desired, so as to provide mood lighting or the like. The illumination sources may be controlled via a user input at the lights or a separate or remote control device, such as a vehicle electronic or communication system, and may be connected via a hard wire or via various protocols or nodes, such as Bluetooth, SCP, UBP, J1850, CAN J2284, Fire Wire 1394, MOST, LIN and/or the like (which may also control the exterior mirror or mirrors of the vehicle), and may provide ramped activation and/or deactivation to provide theater like lighting or the like if desired.

Optionally, the cap portion may include or incorporate or receive other modules as selected or desired to customize the mirror assembly. For example, the cap portion and/or reflective element assembly portion may receive a microphone array module, a garage door opening system module, a telematics user access button/input module, and/or the like. The modules may be provided at the vehicle assembly plant or at the mirror assembly plant, and may be inserted or plugged into the cap portion or mirror assembly to provide the desired content to the mirror assembly. The modules and the cap portion may include connectors that provide both electrical and mechanical connection so that the modules are electrically connected to the appropriate circuitry as they are inserted or received into or snapped to or attached to the cap portion. An operator at the vehicle assembly plant thus may readily connect the appropriate module to the cap portion or to the mirror assembly to provide the desired content for that particular mirror assembly. For a base mirror that may not include such content, a blank module or plug may be inserted into or attached to the cap portion or mirror assembly, so as to fill or conceal any opening in the mirror assembly that otherwise may receive an electronic module or accessory. The modules may also be readily removed and replaced to ease repair and replacement of the accessory or circuitry, and to ease replacement or changeover to a different accessory or module, if a different option is desired, such as an aftermarket module or the like.

Optionally, the cap portion or portions and the circuit board or boards of the present invention may also or otherwise include other accessories, such as microphones 51 (such as shown in FIGS. 5 and/or 27). The microphones may comprise analog microphones or digital microphones or the like, and may be positioned at or aligned with one or more openings formed in the top and/or bottom of the cap portion or the mirror holder. The microphones, such as microphones of the types disclosed in U.S. Pat. Nos. 6,243,003; 6,278,377; and/or 6,420,975, and/or in PCT Application No. PCT/US03/308877, filed Oct. 1, 2003 by Donnelly

Corp. et al. for MICROPHONE SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1111(PCT)), may be provided for interfacing with a vehicle telematics system or the like. Optionally, the cap portion or portions and the circuit board or boards may also or otherwise include other accessories, such as a telematics system, speakers, antennas, including global positioning system (GPS) or cellular phone antennas, such as disclosed in U.S. Pat. No. 5,971,552, a communication module, such as disclosed in U.S. Pat. No. 5,798,688, a voice recorder, a blind spot detection system, such as disclosed in U.S. Pat. Nos. 5,929,786 and/or 5,786,772, and/or U.S. pat. applications, Ser. No. 10/427,051, filed Apr. 30, 2003 (Attorney Docket DON01 P-1075); and Ser. No. 10/209,173, filed Jul. 31, 2002 (Attorney Docket DON01 P-1016), transmitters and/or receivers, such as for a garage door opener or a vehicle door unlocking system or the like (such as a remote keyless entry system), a digital network, such as described in U.S. Pat. No. 5,798,575, a high/low headlamp controller, such as a camera-based headlamp control, such as disclosed in U.S. Pat. Nos. 5,796,094 and/or 5,715,093, a memory mirror system, such as disclosed in U.S. Pat. No. 5,796,176, a hands-free phone attachment, a video device for internal cabin surveillance (such as for sleep detection or driver drowsiness detection or the like) and/or video telephone function, such as disclosed in U.S. Pat. Nos. 5,760,962 and/or 5,877,897, a remote keyless entry receiver, a seat occupancy detector, a remote starter control, a yaw sensor, a clock, a carbon monoxide detector, status displays, such as displays that display a status of a door of the vehicle, a transmission selection (4wd/2wd or traction control (TCS) or the like), an antilock braking system, a road condition (that may warn the driver of icy road conditions) and/or the like, a trip computer, a tire pressure monitoring system (TPMS) receiver (such as described in U.S. Pat. Nos. 6,124,647; 6,294,989; 6,445,287; 6,472,979; and/or 6,731,205), an ONSTAR® system and/or the like (with all of the above-referenced patents and PCT and U.S. patent applications being commonly assigned to Donnelly Corporation, and with the disclosures of the referenced patents and patent applications being hereby incorporated herein by reference in their entireties). The accessory or accessories may be positioned at or on the cap portions and thus positioned at or within the mirror holder and may be included on or integrated in a printed circuit board positioned within the mirror holder.

Optionally, the cap portion or portions of the present invention may include one or more attachments, such as attachments of the types described in U.S. Pat. Nos. 6,690,268 and/or 6,428,172, which are hereby incorporated herein by reference. The attachment or attachments, such as a pen holder or display screen or the like, may be incorporated into the cap portion or may be removably attached to the cap portion and, thus, may be removable if not desired for the particular mirror application, without affecting the scope of the present invention. The desired attachment may be selected for the particular application of the cap portion and mirror assembly, and may provide additional features to the cap portion and mirror assembly as may be desired or selected for the particular mirror application.

Optionally, the cap portion or portions may include a conversation mirror that may flip up or out from the cap portion to allow the driver of the vehicle to view a person in the rear seat (such as a child in the rear seat) to see and talk to the person in the rear seat without having to adjust the reflective element of the mirror assembly. The conversation mirror may be pulled out when desired or may be spring loaded to pop up or out when actuated or depressed, or may be electronically controlled to extend out from the cap portion when an input is actuated, without affecting the scope of the present invention.

Optionally, a blind spot detection or side object detection system or circuitry and corresponding display or indicator may be provided on one of the cap portions and on the reflective element for indicating to the driver or occupant of the vehicle that another vehicle may be in a lane adjacent to the subject vehicle. The indicator may comprise any iconistic type of display which may indicate that another vehicle has been detected and/or that the subject vehicle is changing lanes toward the detected object or vehicle. The side object detection and warning system may utilize the principles disclosed in U.S. pat. applications, Ser. No. 10/427,051, filed Apr. 30, 2003 (Attorney Docket DON01 P-1075); and Ser. No. 10/209,173, filed Jul. 31, 2002 (Attorney Docket DON01 P-1016), which are hereby incorporated herein by reference.

Optionally, the side object detection system may be operable to detect objects or other vehicles at one or both sides of the subject vehicle and to detect and identify a lane marker or lane markers at one or both sides of the vehicle, such as disclosed in U.S. pat. application, Ser. No. 10/427,051, filed Apr. 30, 2003, incorporated above. The side object detection system may be further operable to provide a visible and/or audible warning to the driver of the subject vehicle in response to the detection of another object or vehicle at a side of the subject vehicle and in response to the position or movement of the subject vehicle relative to the lane markers. The use of lane marker detection integrated with such side object detection systems can be used to reduce false positives (where the system detects a vehicle in the adjacent lane when there is no vehicle in the adjacent lane) significantly and enable longer distances of detection, which in turn improves response time for system warnings from high speed target vehicles. In known or conventional side object detection systems, the systems do not track lane markings. Known radar systems are incapable of lane tracking due to the nature of the technology, and conventional vision systems do not currently include this functionality. This forces the detection zone of such known side object detection systems to be static or non-changing regardless of any curvature in the road, and does not allow for higher warning functionality based on the lane position of the subject vehicle.

It is envisioned that the side object detection system (which may have components and/or circuitry on a cap portion or portions of the interior rearview mirror assembly, or on or at or in the mirror assembly or on or at or in an accessory module or pod mounted to or positioned at or near the mirror assembly or positioned elsewhere in the vehicle) may utilize lane marking detection and recognition to allow the side object detection system to determine or adjust a detection zone or target zone or area based on the lane markings of the adjacent lane. Such lane marking detection may accommodate a non-linear detection zone when the subject vehicle is turning or on a curve. This may provide a longer detection distance because non-linear lanes may cause false positives in a static detection zone, whereas a dynamic zone may facilitate a better area of interest at greater distances, since it may avoid tracking trailing vehicles (such as in the same lane as the subject vehicle) on sharp curves. Such a side object detection system may also allow higher human/machine interface (HMI) processing.

Known side object detection systems may be specified to warn when a vehicle is in the blind spot or will be in a short amount of time. This may force the system to warn the driver of a detected object even when a driver is not intending to make a lane change toward the detected object. This can be a source of annoyance to the driver, and it emphasizes the effect of false positives from detection of infrastructure, shadows, miscellaneous road clutter and the like. However, if the side object detection system requires the above condition or detection and also requires a close proximity to or movement toward the lane markers or adjacent lane (i.e. the subject vehicle is moving toward the lane markers and thus toward the adjacent lane) prior to providing a warning, then the system may only provide such a warning when actual danger is present (i.e. the subject vehicle is changing lanes toward an adjacent lane which is occupied by a detected vehicle or object).

Such a side object detection system may provide a large reduction of false positives over current side object detection systems, and the warning may thus represent a heightened level of risk for the current maneuver, instead of a heightened level of risk for a potential maneuver. The side object detection system thus may reduce annoyance, improve perceived reliability, and improve overall detection distances, which in turn may improve the predictive nature of the system to reduce latencies based on human response. The side object detection system, or circuitry and/or display of the side object detection system, may be incorporated into one or more cap portions mounted at the interior rearview mirror assembly, or may be incorporated into the rearview mirror assembly or an accessory module or pod positioned at or near the rearview mirror assembly. The display may be at the reflective element of the mirror assembly and may be an iconistic display of the subject vehicle and a detected object adjacent to the subject vehicle, or any other type of display, and may provide an audible signal to the driver of the vehicle, without affecting the scope of the present invention.

Optionally, the cap portion or portions may include a display element, such as a video display element or the like, that may slide out or flip up or down from the cap portion to provide a video screen that is viewable by the driver of the vehicle, such as a video display screen of the type described in PCT Application No. PCT/US03/40611, filed Dec. 19, 2003 by Donnelly Corporation for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1123(PCT)), which is hereby incorporated herein by reference. The video display screen may be operable to display information to the driver of the vehicle, and may be incorporated into or may be in communication with a vision system or imaging system of the vehicle, such as a rearwardly directed vehicle vision system utilizing principles disclosed in U.S. Pat. Nos. 5,550,677; 5,760,962; 5,670,935; 6,201,642; and/or 6,717,610, and/or in U.S. pat. application, Ser. No. 10/010,862, filed Dec. 6, 2001 by Bos for PLASTIC LENS SYSTEM FOR VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-954), which are hereby incorporated herein by reference, a trailer hitching aid or tow check system, such as the type disclosed in U.S. pat. application, Ser. No. 10/418,486, filed Apr. 18, 2003 by McMahon et al. for VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-1070), which is hereby incorporated herein by reference, a cabin viewing device or system, such as a baby viewing or rear seat viewing camera or device or system or the like, such as disclosed in U.S. Pat. Nos. 5,877,897 and 6,690,268, which are hereby incorporated herein by reference, a video communication device or system, such as disclosed in U.S. Pat. No. 6,690,268, which is hereby incorporated herein by reference, and/or the like. Optionally, the video display screen may also or otherwise serve as a screen for a navigation system of the vehicle or the like, such as a GPS-based navigation system, such as is known in the automotive art.

Optionally, the mirror assembly may include a heating device or element for heating the display element or the area around the display element. At low temperatures, it may be desirable to heat the display element, such as a liquid crystal display (LCD) element or the like (or such as a video screen display or illuminated display or the like), in order to enhance the performance and response of the display element in such low temperatures or cold conditions or environments. The display element may comprise any type of display element or light emitting element, such as a vacuum fluorescent (VF) display element, a light emitting diode (LED) display element (such as an inorganic LED display element or an organic light emitting diode (OLED) display element or a high intensity, high efficiency LED display element, such as disclosed in U.S. Pat. Nos. 6,690,268 and 6,428,172 and in U.S. pat. application, Ser. No. 10/054,633, filed Jan. 22, 2002 (Attorney Docket DON01 P-962), which are hereby incorporated herein by reference), a multi-pixel, dot-matrix liquid crystal display element, an electroluminescent display element, a backlit display element, such as a back lit iconistic display (such as disclosed in U.S. Pat. Nos. 6,642,851; 6,501,387 and 6,329,925, which are hereby incorporated herein by reference), a display element backlit by an incandescent light source, or a backlit liquid crystal display (LCD), a video display screen (such as the type described in PCT Application No. PCT/US03/40611, filed Dec. 19, 2003 for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1123(PCT)), which is hereby incorporated herein by reference) or the like, without affecting the scope of the present invention.

The heating device may be operable to heat the reflective element at the area of the display element or may heat the display element itself. For example, the rear surface of the reflective element may have a transparent conductive coating or layer, such as an indium tin oxide (ITO), a tin oxide (TO) or the like (such as transparent conductive layers of the types suitable for use in electrochromic cells and such as described in U.S. Pat. Nos. 6,690,268; 5,668,663; 5,724,187; 5,140,455; 5,151,816; 6,178,034; 6,154,306; 6,002,544; 5,567,360; 5,525,264; 5,610,756; 5,406,414; 5,253,109; 5,076,673; 5,073,012; 5,117,346; 5,910,854; 5,142,407 and 4,712,879, and/or in U.S. pat. application, Ser. No. 10/054,633, filed Jan. 22, 2002 (Attorney Docket DON01 P-962), and/or in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corporation et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); PCT Application No. PCT/US03/35381, filed Nov. 5, 2003 by Donnelly Corporation et al. for ELECTRO-OPTIC REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1116(PCT)); and/or in PCT Application No. PCT/US03/036177, filed Nov. 14, 2003 by Donnelly Corporation et al. for IMAGING SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1118(PCT)); and/or U.S. provisional applications, Ser. No. 60/531,838, filed Dec. 23, 2003 by Bareman for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1132); Ser. No. 60/553,842, filed Mar. 17, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket

DON01 P-1143); and Ser. No. 60/563,342, filed Apr. 19, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1153), which are hereby incorporated herein by reference), applied thereto or deposited thereon in at least the area at which the display element may be positioned. An electrical current may then be applied to the transparent conductive layer (such as via a pair of terminals contacting opposite portions of the transparent conductive layer or the like) to energize the conductive layer and to heat the conductive layer. For example, the transparent conductive coating or layer may generate heat as electrons or electricity flow from a contact of a power terminal across the surface or coating or layer to a contact of a ground terminal. The contacts may be spaced apart at generally opposite sides of the transparent conductive layer and may provide for generally uniform and thorough heating of the transparent conductive layer when electricity is applied to the heating or power terminal.

The display element may be positioned behind the reflective element and transparent conductive coating and may be next to or urged against or optically coupled to the transparent conductive coating on the rear surface of the reflective element. When the electrical current is applied across the transparent conductive layer, the resistivity in the conductive layer causes the conductive layer to be heated, which functions to heat the display element to enhance the performance of the display element during low temperature conditions. Optionally, other types of heating devices may be implemented at or against the display element and/or the reflective element, or may be positioned at the printed circuit board upon which the display element may be mounted, without affecting the scope of the present invention.

Optionally, for example, a heating device may be implemented at or near a display (such as a video display screen displaying, for example, driver information such as navigational information or a view of an interior or exterior scene, such as a curb side view such as is now being required for certain vehicles in Japan, or a parking/reversing view or the like) to heat the display or display area at least initially upon start up of the vehicle in extremely cold conditions. When the vehicle is in a cold climate (such as, for example, in northern Minn. in the winter time where the temperature may drop to around thirty degrees below zero), the heater may be activated on the first ignition cycle of the vehicle or when the vehicle is first turned on or the like and when the temperature is below a threshold temperature. The heating device may include a thermometer or thermistor or the like to determine the ambient temperature at the vehicle or at or near the display, and the heater may be activatable in response to an output of the thermometer. Optionally, if the temperature is below a threshold temperature, the heater may be operable in a "quick heat mode" to rapidly heat the display so that it works properly very quickly after start up of the vehicle. The heater may be operable at a higher than normal power dissipation during the quick heat mode to provide rapid heating or thawing or defrosting of the display when the vehicle ignition is first turned on during winter or cold conditions, but after the initial rapid heating phase is completed, the heater may operate at a lower power dissipation level more suited for ongoing heating during the driving event. This is particularly useful when the display is associated with a back up aid or reverse vision system or the like (such as those described in U.S. Pat. Nos. 5,550,677; 5,760,962; 5,670,935; 6,201,642; 6,717,610; 5,877,897 and 6,690,268, and/or in U.S. pat. applications, Ser. No. 10/010,862, filed Dec. 6, 2001 by Bos for PLASTIC LENS SYSTEM FOR VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-954), and Ser. No. 10/418,486, filed Apr. 18, 2003 by McMahon et al. for VEHICLE IMAGING SYSTEM (Attorney Docket DON01 P-1070), and/or in PCT Application No. PCT/US03/40611, filed Dec. 19, 2003 for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1123(PCT)), which are hereby incorporated herein by reference), where it is important for the display to be fully operational at the start up of the vehicle so it provides a proper or desired display of the rearward field of view of the camera as the vehicle is initially backed out of its parking space or driveway or the like.

The heating device and the construction of the mirror assembly thus may provide heating of a display or display element (such as, for example, heating of a slide out display screen such as the type described in PCT Application No. PCT/US03/40611, filed Dec. 19, 2003 for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1123(PCT)), which is hereby incorporated herein by reference), such as for a backup aid or rear vision system or the like, during cold temperatures to enhance the performance of the display during such cold temperatures. The heating device may provide intimate heating of the display medium, such as for a liquid crystal display element or the like, to enhance the performance of the display element. The heating device may provide such intimate heating of the display medium while not interfering with or heating other components or circuitry of the mirror assembly. The heating device may be included in the construction of the mirror assembly itself, such as a transparent conductive layer across the display screen or element or reflective element or such as a wire grid or other heating element or the like at or near the display area, to intimately heat the display element or display medium without substantially heating other components and circuitry in the vicinity of the display element. Optionally, the heating device may be activated/deactivated/controlled in conjunction with the heating elements for the exterior rearview mirrors of the vehicle (in such applications where the exterior rearview mirrors may be heated or defrosted, such as when a rear window defroster/defogger is actuated or the like). The heating device may utilize or incorporate aspects of heating devices used to heat and defrost exterior rearview mirror reflective elements, such as the heating means described in U.S. Pat. No. 5,446,576, issued to Lynam et al., which is hereby incorporated herein by reference, such as a positive thermal coefficient (PTC) heater element that is continuously connected to voltage ignition, but that principally only operates at low temperatures, such as less than about 10 degrees Celsius or lower. Optionally, a separate temperature controller, such as a thermistor, may be provided at or near the display in the interior rearview mirror assembly that powers the heater element at low temperatures.

Optionally, it is envisioned that the cap portion or portions may include a shielding element or sleeve or the like to provide shielding from external fields and unwanted radiation fields. The shielding may comprise a thin metal or foil member or sleeve or sheet or the like that is placed over and along an interior surface or portion of the cap portion (such that the shielding is within the mirror assembly and thus not readily visible when the mirror assembly is assembled). The shielding may be attached to the cap portion or portions so as to be retained thereto during the mirror assembly process. The shielding material/sheet preferably has a magnetic and/or electromagnetic permeability appropriate for shielding the accessories and the like within the cap portion and mirror assembly from external fields and unwanted radiation fields and the like.

Optionally, the cap portion or portions may include a hands free phone attachment to allow a driver of the vehicle to use a cellular or mobile telephone via circuitry and microphones and speakers of the mirror assembly and/or vehicle. The cap portion or portions may include a connector, such as a plug or socket type of connector or telephone docking device or the like, for a user to plug their mobile telephone into, which would connect the mobile telephone to a communication system or the like of the mirror assembly or vehicle.

Optionally, and as shown in FIG. 28, the cap portion or portions 16 may house or include a battery 52 for providing power to one or more electronic accessories or to a circuit board 58 of the cap portion or mirror assembly (such as, for example, described in U.S. Pat. No. 6,690,298, which is hereby incorporated herein by reference). The accessory or accessories of the mirror assembly thus may be powered by the battery such that the mirror assembly or circuitry of the cap portion may not have to connect to the power source of the vehicle. The battery may be contained within the cap portion and at or near an exterior or outer portion of the cap portion and may be readily accessible by a user to facilitate changing of the battery when desired or necessary. For example, the battery 52 may be within a recess 54 of cap portion 16 and may be contained therein via a trap door or panel or door 56 that may cover battery 52 and recess 54 when closed. Panel 56 may be opened and may be removable or may be hingedly attached or otherwise movably attached to cap portion 16 to facilitate access to recess 54 and battery 52. For example, panel 56 may be molded with cap portion 16 and may be hingedly attached to cap portion 16 via a living hinge 56a along an edge of panel 56. Other means for storing a battery and selectively accessing the battery may be implemented, without affecting the scope of the present invention. The various accessories and electronic content and directly driven or energized displays may function via power from the battery or internal power source of the cap portion.

Optionally, and with reference to FIGS. 29-32, an interior rearview mirror assembly 60 may include a bezel portion 62 of a mirror casing, a reflective element 64 and a cap portion or rear portion 66 of the mirror casing. The mirror assembly 60 may include a mounting arrangement or mounting assembly 68 for pivotally or adjustably mounting or attaching the mirror assembly to the vehicle, such as to a windshield of the vehicle or the like. The mounting assembly 68 may include a mounting arm 70 having a ball member 70a at one end and an attachment end or mounting end 70b opposite to the ball member 70a. Ball member 70a may be pivotally received within a socket 72 that may be positioned at or formed with or established at or attached to an attachment plate 74 at the reflective element 64. When so positioned, attachment end 70b may extend from attachment plate 74 and may insert through an opening 66a in rear casing portion 66. The attachment end 70b may then attach or mount to a mounting portion or base portion or mounting base 76, which in turn may be attached or mounted to the vehicle or to a mounting button or the like (not shown) at the windshield or headliner or overhead console of the vehicle.

In the illustrated embodiment, attachment end 70b is a threaded stud or end, and is secured to or mounted to the mounting or base portion 76 via insertion of the threaded end 70b through an opening 76a (FIG. 31) in mounting portion 76 and tightening a female fastener or nut 78 onto threaded end 70b. The mounting arm 70 thus may have a narrow end for insertion through the opening 66a in rear casing portion 66, such that the opening in the rear casing portion may be smaller than is typically required (because typically the ball end of the mounting arm is inserted through the opening in the rear casing and snapped into the socket at the attachment plate). The mounting arm may be inserted into the socket of the attachment plate, which may be attached to the reflective element at the bezel portion, and then may be inserted through the opening in the rear casing portion or cap portion as the rear casing portion or cap portion is moved toward and into engagement with the bezel portion, such that the attachment end of the mounting arm extends or protrudes from the rear casing portion or cap portion after the mirror is assembled. The attachment end may then be attached or secured to the mounting portion or base portion via the nut or other type of fastener. As shown in FIG. 29, the mirror assembly may also include a circuit board 80 (with circuitry and/or accessories such as those described above), which may be attached to the attachment plate 74 or which may be attached to the cap portion for mirror assemblies of the types described above.

Although shown as having a threaded attachment end for securing the mounting arm to a mounting base via a nut or the like, it is envisioned that the mounting arm may have other forms of attachment ends for fixedly or pivotally or adjustably mounting the mounting arm to a mounting base or the like, without affecting the scope of the present invention. For example, the attachment end may provide a female fastener which may threadedly receive a male fastener or screw or bolt or stud, or the attachment end may provide a bayonet type fastener, or the attachment end and mounting base may cooperate to provide a snap together attachment or the like, or the attachment end and mounting base may otherwise attach or secure together, such as via adhesive or welding, such as ultrasonic welding or the like. Optionally, the attachment end may attach to or receive another ball member, which may be received within a socket at the mounting base, in order to provide a double ball mounting arrangement. The mounting arm, socket and/or mounting base may comprise plastic or polymeric materials, or may be die cast or otherwise formed, without affecting the scope of the present invention.

Optionally, and as shown in FIG. 32, the ball member 70a of mounting arm 70 may be received in a socket 72' attached to or positioned at or formed with or established at a toggle assembly 82, such as for a prismatic reflective element. The toggle assembly may be any type of toggle assembly, such as described above, and may be attached to or mounted to the mirror holder or the mirror casing, whereby the attachment end of the mounting arm may extend or protrude from the mirror casing when the toggle assembly and mounting arm are mounted therein or attached thereto. The attachment end may then connect or attach to the appropriate connector or attachment (such as to the mounting base 76 via a fastener or nut 78 as shown in FIG. 32) as described above to adapt the mirror assembly for the particular application.

The mounting arrangement of the present invention thus may provide a pre-established pivot element or member, such as a ball joint, at the attachment plate of the reflective element or at the toggle assembly or the like, whereby other attachments or mounting elements may be attached to the other end of the mounting arm to provide the desired attachment or mounting arrangement for the particular application of the mirror assembly. The mounting arm and ball member may be inserted within the socket and then the backing plate or toggle assembly (at which the socket may be formed) may be attached or secured to the reflective element with the pre-established pivot joint or element. The ball member of the mounting arm may already be inserted or snapped into the socket when the backing plate or toggle assembly is attached to or juxtaposed with the reflective element, such that the ball member need not be rammed into the socket when the socket is positioned at or juxtaposed with the reflective element, which avoids the impact or shock to the reflective element that typically occurs when a ball member is rammed into a socket that is at or attached to or juxtaposed with a reflective element.

The other end of the mounting arm may then be attached, such as via a snap together arrangement or a threaded fastener or the like, to another mounting portion or base portion or the like at the vehicle. Optionally, the other portion may have a second pivot element or member, such as a ball member, already received within a socket at a mounting base, and the end of the mounting arm may readily attach to the end of the other ball member to mount the mirror assembly in the vehicle. For example, the attachment end of the mounting arm extending from the reflective element assembly may threadedly attach to a corresponding attachment end of another ball member extending from a socket at a base portion at the vehicle. The mounting arrangement thus may provide a single or double ball mounting arrangement without the need to press or ram the ball member or ball members into the respective socket after the socket is attached to or positioned at the reflective element. The mounting arrangement also avoids the impact or shock of ramming the opposite ball member into the respective socket at the mounting base or button.

Because the pivot element or member, such as a ball member or ball members, is/are already inserted into their respective sockets so that the pivot joints are pre-established at the reflective element and mounting base, the ball member(s) do not have to be rammed or snapped into place in their respective sockets during installation of the mirror assembly, which substantially reduces the stresses at the reflective element to substantially limit or reduce cracking of the reflective element during installation of the mirror assembly. The mounting arrangement thus may substantially reduce the stresses at the reflective element during the installation processes.

Also, because the mounting arm may have an attachment end opposite a ball member, the ball member may be received or pre-established in any suitable or corresponding socket of a substantially universal bezel portion or reflective element assembly portion, whereby the attachment end of the mounting arm may be attached to any corresponding connector or attachment at the vehicle to complete the installation process for the respective mirror assembly. The present invention thus may provide a substantially universal and pre-established ball joint or pivot joint at the reflective element (and thus lends itself to provision of a universal reflective element assembly portion) that does not require attachment or insertion of the ball member at a later time (after the socket portion is positioned at or established at or juxtaposed with the reflective element), and may provide the capability of adapting or configuring the mounting arm to fixedly or pivotally or adjustably attach to a particular mounting base or vehicle portion or console or the like for the particular mirror application. The mounting arrangement may be suitable for applications with the cap portion and mirror holder assemblies as described above, or may be suitable for applications with other types of mirror assemblies, such as a mirror assembly of the type shown in FIG. 29, without affecting the scope of the present invention.

Optionally, and as shown in FIG. 31, the mounting arm 70 may comprise a hollow mounting arm that provides a wiring channel or passageway 70c therethrough. One or more wires or cables or the like thus may be routed through the mounting arm to provide power and/or control to the circuitry and accessories within the mirror assembly. As can be seen in FIGS. 30 and 31, the wires may route along and within the mounting base 76 and through the mounting arm and into the mirror casing or housing. Optionally, the attachment end of the mounting arm may include a connector and may plug into or connect to a corresponding connector at the mounting base or the like to establish mechanical and electrical connections (such as via utilizing aspects described in U.S. Pat. Nos. 6,672,744; 6,669,267; 6,402,331; 6,386,742; and 6,124,886, and/or U.S. pat. application, Ser. No. 10/739,766, filed Dec. 18, 2003 by DeLine et al. for MODULAR REARVIEW MIRROR ASSEMBLY (Attorney Docket DON01 P-1119), and Ser. No. 10/355,454, filed Jan. 31, 2003 by Schofield et al. for VEHICLE ACCESSORY MODULE (Attorney Docket DON01 P-1050), which are hereby incorporated herein by reference) as the mirror assembly is mounted within the vehicle. The mounting arm may include wiring therethrough to electrically connect the connector or attachment end to the circuitry within the mirror assembly.

As shown in FIGS. 29 and 30, the mounting base 76 may have a hollow body portion 76b that may extend along the interior surface of the windshield and that may extend generally downwardly from an attaching portion 76c of mounting base 76. The attaching portion 76c may attach to the mounting button or other attachment element (not shown) positioned at or attached to the interior surface of the windshield or the headliner or an overhead console of the vehicle to position the mounting base at the desired or appropriate location at the vehicle. As shown in FIG. 29, the mounting base 76 may include a cover plate 76d that may encase or enclose the body portion 76b to provide a finished appearance to the mounting base 76 along the windshield. Optionally, the body portion 76b may include or receive one or more electronic elements or accessories, such as a rain sensor or the like (such as a rain sensor of the types described in commonly assigned U.S. Pat. Nos. 6,516,664; 6,320,176; 6,353,392; 6,313,454; 6,341,523; and 6,250,148; and/or in U.S. pat. applications, Ser. No. 10/355,454, filed Jan. 31, 2003 by Schofield et al. for VEHICLE ACCESSORY MODULE (Attorney Docket DON01 P-1050); and Ser. No. 10/348,514, filed Jan. 21, 2003 by Lynam for RAIN SENSOR MOUNTING SYSTEM (Attorney Docket DON01 P-1057), which are all hereby incorporated herein by reference), that may be positioned at the windshield and that may be optically coupled to the windshield, depending on the particular application. In such embodiments, the cover plate 76d may include one or more openings or apertures at which the rain sensor camera or sensing device may be positioned.

Although the mirror assembly may include a prismatic reflective element, it is envisioned that the cap portion or portions may include controls or circuitry for controlling electro-optic or electrochromic reflective elements, such as electrochromic reflective elements of one or more exterior rearview mirror assemblies of the vehicle. The circuitry or controls may control the dimming of the exterior mirrors, such as in a known manner, such as described in commonly assigned U.S. Pat. Nos. 5,140,455; 5,151,816; 6,178,034; 6,154,306; 6,002,544; 5,567,360; 5,525,264; 5,610,756; 5,406,414; 5,253,109; 5,076,673; 5,073,012; 5,117,346; 5,724,187; 5,668,663; 5,910,854; 5,142,407 and/or 4,712,879, which are hereby incorporated herein by reference. Optionally, the cap portion or portions may include one or more photo-sensors, such as an ambient light photo-sensor and a glare sensor, and the controls or circuitry may control the exterior electro-optic or electrochromic reflective elements in response to such photo-sensors.

Optionally, the exterior rearview mirror assemblies of the vehicle may comprise electrochromic mirror reflective element assemblies, while the sensors and electronic circuitry for glare detection and ambient light detection may be positioned inside the vehicle, such as at an interior electrochromic rearview mirror assembly. In applications where the exterior mirror assemblies comprise passenger and/or driver side electrochromic exterior rearview mirror assemblies, such as may be implemented in large vehicles, such as SUVs and the like, the electrochromic controls and circuitry may be contained within the exterior rearview mirror assemblies or the exterior electrochromic reflective element assemblies may be slaved off of the controls and circuitry of an associated electrochromic interior rearview mirror assembly of the vehicle. Optionally, it is envisioned that such sensors and electronic circuitry may be positioned at or near or incorporated into an interior prismatic rearview mirror assembly having a prismatic reflective element. The circuitry and the glare sensor and/or ambient light sensor (such as a photo sensor or the like, such as a glare sensor and/or an ambient light sensor and electrochromic automatic dimming circuitry of the types described in U.S. Pat. Nos. 4,793,690 and 5,193,029, and U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which are all hereby incorporated herein by reference) thus may be positioned at or in or near or incorporated into the added feature prismatic interior rearview mirror assembly. The sensors may be positioned at or within the prismatic interior rearview mirror assembly such that the glare sensor is directed generally rearwardly (in the direction opposite to the forward direction of travel of the vehicle), such as through a bezel portion of the prismatic interior rearview mirror assembly, while the ambient sensor may be directed generally forwardly (in the direction of travel of the vehicle) or downwardly toward the floor of the vehicle when the mirror assembly is installed in the vehicle.

It is further envisioned that the sensors and/or control circuitry may be provided at, on or within a cap portion of the interior rearview mirror assembly and, thus, may be provided as an option for vehicles that offer the electrochromic exterior rearview mirror assemblies with a base or prismatic interior rearview mirror assembly. The appropriate cap portion (with electrochromic control circuitry and sensors and the like incorporated therein) may be selected and attached to the interior rearview mirror reflective element assembly portion to provide glare and light sensing capability and electrochromic reflective element assembly control capability to the interior rearview mirror assembly. Optionally, the cap portion may include the glare sensor in a location therein that may extend downward or outward from the cap portion so that the glare sensor may be directed generally rearward toward the rear of the vehicle when the mirror assembly is installed in the vehicle. For example, the cap portion may include a gondola or pod extending therefrom for housing the sensor or sensors and/or control circuitry. Alternately, the cap portion may include the glare sensor at a location therein that may align with a view port or the like through the reflective element, such as for applications where, for example, the mirror assembly includes a compass/display system or other display system, such as the types described herein and/or the types disclosed in U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076), which is hereby incorporated herein by reference. In such applications, the ambient sensor may provide a dual function of providing an input to the control circuitry for controlling the exterior electrochromic reflective element assemblies and providing an input to the control circuitry for the display element of the interior rearview mirror assembly. The cap portion may include the ambient light sensor in a location and orientation whereby the ambient light sensor is directed generally forwardly in the direction of travel of the vehicle when the mirror assembly is installed in the vehicle.

Optionally, the electrochromic controls and glare/ambient light sensors thus may be provided in a cap portion (such as in a protrusion therefrom, such as a gondola or the like) and, thus, may be provided as an option for use with a common bezel and prismatic reflective element assembly. The present invention thus provides for optional controls and circuitry and sensors for optional accessories, such as electrochromic exterior rearview mirror assemblies, while providing a common bezel and prismatic reflective element and mounting attachment. The desired or appropriate cap portion (with the desired or appropriate controls/sensors/circuitry) may be selected for a particular application and may be snapped onto or otherwise attached to the common bezel and prismatic reflective element assembly. The assembled mirror assembly may then be installed in the appropriate vehicle with the exterior electrochromic mirror assemblies. The present invention thus may provide added feature prismatic interior rearview mirror assemblies, where the desired content of the mirror assemblies may be selected and provided on a respective optional cap portion while the rest of the mirror assemblies comprise common components.

Although shown and described as having a prismatic reflective element, the interior rearview mirror assembly of the present invention may optionally have an electro-optic or electrochromic mirror assembly. The electrochromic mirror element of the electrochromic mirror assembly may utilize the principles disclosed in commonly assigned U.S. Pat. Nos. 6,690,298; 5,140,455; 5,151,816; 6,178,034; 6,154,306; 6,002,544; 5,567,360; 5,525,264; 5,610,756; 5,406,414; 5,253,109; 5,076,673; 5,073,012; 5,117,346; 5,724,187; 5,668,663; 5,910,854; 5,142,407 and/or 4,712,879, which are hereby incorporated herein by reference, and/or as disclosed in the following publications: N. R. Lynam, "Electrochromic Automotive Day/Night Mirrors", *SAE Technical Paper Series* 870636 (1987); N. R. Lynam, "Smart Windows for Automobiles", *SAE Technical Paper Series* 900419 (1990); N. R. Lynam and A. Agrawal, "Automotive Applications of Chromogenic Materials", *Large Area Chromogenics: Materials and Devices for Transmittance Control*, C.M. Lampert and C.G. Granquist, EDS., Optical Engineering Press, Wash. (1990), which are hereby incorporated by reference herein; and/or as described in U.S. pat. application, Ser. No. 10/054,633, filed Jan. 22, 2002 (Attorney Docket DON01 P-962), which is hereby incorporated herein by reference. Optionally, the electrochromic circuitry and/or a glare sensor and circuitry and/or an ambient light sensor and circuitry may be provided on one or more circuit boards at the cap portion or portions of the mirror assembly.

Optionally, the electrochromic reflective element may include one or more displays, such as for the accessories or circuitry described above. The displays may be similar to those described above, or may be of types disclosed in U.S. Pat. Nos. 5,530,240 and/or 6,329,925, which are hereby incorporated herein by reference, and/or may be display-on-demand or transflective type displays, such as the types disclosed in U.S. Pat. Nos. 6,690,298; 5,668,663 and/or 5,724,187, and/or in U.S. pat. application, Ser. No. 10/054,633, filed Jan. 22, 2002 (Attorney Docket DON01 P-962); and/or in U.S. provisional application, Ser. No. 60/525,952, filed Nov. 26, 2003 by Lynam for MIRROR REFLECTIVE ELEMENT FOR A VEHICLE (Attorney Docket DON01 P-1130), and/or in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)), which are all hereby incorporated herein by reference.

Optionally, and with reference to FIG. 33A, a reflective element assembly portion 84 may hold or receive or comprise an electrochromic reflective element assembly or cell 86, which includes a front substrate 88 and a rear substrate 90 and an electrochromic medium 92 sandwiched therebetween. In the illustrated embodiment, the reflective element assembly or cell 86 comprises a front substrate 88 that is larger than the rear substrate 90 so as to create a relief region or overhang region or ledge 93 around the perimeter of the reflective element assembly, such as described in PCT Application No. PCT/US03/35381, filed Nov. 5, 2003 by Donnelly Corporation et al. for ELECTRO-OPTIC REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1116(PCT)); and/or in U.S. provisional applications, Ser. No. 60/553,842, filed Mar. 17, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1143); and Ser. No.

60/563,342, filed Apr. 19, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1153), which are hereby incorporated herein by reference.

The larger front substrate 88 allows the bezel portion or molding 94 to be molded around the electrochromic reflective element assembly and allows the bezel portion to shrink and directly stress the front substrate 88 without placing the interpane seal 96 under the hoop stresses and shear stresses that typically occur with conventional electrochromic cells or reflective element assemblies (where the front and rear substrates are offset one to another such that any bezel shrinkage typically places the front substrate in shear stress relative to the rear substrate, potentially leading to failure of the seal therebetween that protects the electrochromic medium from the outside environment) when the bezel portion cools and contracts around the cell. The bezel portion or molding 94 thus may be formed around the reflective element assembly or cell, and the cap portion (not shown in FIG. 33A) may be provided at a later step after the bezel portion has cooled around the reflective element assembly (such as described above) to provide a modular electrochromic mirror assembly in accordance with the present invention. Optionally, the bezel portion may be formed of a soft polymer or impact absorbing material (such as a soft touch material as described above, and/or preferably having a Shore A durometer value of less than about 110 Shore A, more preferably less than about 90 Shore A, and most preferably less than about 70 Shore A) at or around the perimeter of the front substrate 88 or of the front or first surface 88b of the front substrate 88, or a soft or impact absorbing trim portion or element may be provided at or around the perimeter of the front substrate 88, without affecting the scope of the present invention.

The front substrate 88 includes a transparent conductive coating or layer 89 (such as an indium tin oxide (ITO), a tin oxide (TO) or the like) on its rear surface 88a (the second surface of the cell), while the rear substrate 90 includes a metallic conductive coating or layer or layers or stack of coatings or layers 91 on its front surface 90a (the third surface of the cell), such as is generally done with electrochromic reflective element assemblies, and such as by utilizing aspects described in U.S. Pat. Nos. 6,690,268; 5,668,663; 5,724,187; 5,140,455; 5,151,816; 6,178,034; 6,154,306; 6,002,544; 5,567,360; 5,525,264; 5,610,756; 5,406,414; 5,253,109; 5,076,673; 5,073,012; 5,117,346; 5,910,854; 5,142,407 and 4,712,879, and/or in U.S. pat. application, Ser. No. 10/054,633, filed Jan. 22, 2002 (Attorney Docket DON01 P-962), and/or in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by

Donnelly Corporation et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); PCT Application No. PCT/US03/35381, filed Nov. 5, 2003 by Donnelly Corporation et al. for ELECTRO-OPTIC REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1116(PCT)); and/or in PCT Application No. PCT/US03/036177, filed Nov. 14, 2003 by Donnelly Corporation et al. for IMAGING SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1118(PCT)); and/or U.S. provisional applications, Ser. No. 60/531,838, filed Dec. 23, 2003 by Bareman for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1132); Ser. No. 60/553,842, filed Mar. 17, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1143); and Ser. No. 60/563,342, filed Apr. 19, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1153), which are hereby incorporated herein by reference.

As shown in FIG. 33A, the metallic conductive coating or layer or layers 91 may be removed from (or not disposed at) a perimeter region 90b of the front surface 90a of rear substrate 90, and the interpane seal 96 may be disposed around the masked or uncoated perimeter region, in order to electrically isolate the conductive coatings 91 from the perimeter edge of the rear substrate 90, such as described in U.S. provisional applications, Ser. No. 60/553,842, filed Mar. 17, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1143); and Ser. No. 60/563,342, filed Apr. 19, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1153), which are hereby incorporated herein by reference. The conductive coatings or layers 91 may provide a tab out region (not shown in FIG. 33A) along the front surface of the rear substrate to provide for electrical connection between the third surface coating 91 and the perimeter edge of the substrate (such as described in U.S. provisional applications, Ser. No. 60/553,842, filed Mar. 17, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1143); and Ser. No. 60/563,342, filed Apr. 19, 2004 by Bareman et al. for METHOD OF MANUFACTURING ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1153), which are hereby incorporated herein by reference. A conductor or electrical connector 100 may connect to the conductive coating 89 via a solder or conductive strip 101 around the overhang region, while a second conductor or electrical connector (not shown in FIG. 33A) may connect to the conductive coating 91 via connection to the tab out region. The reflective element assembly may include a reflective perimeter region around the perimeter of the reflective element assembly or may have an opaque or blackened or darkened perimeter region, such as by utilizing the principles described in U.S. Pat. No. 5,066,112, which is hereby incorporated herein by reference, in order to at least partially conceal the seal 96 from being readily viewable by the driver of the vehicle.

Optionally, and with reference to FIG. 33B, a reflective element assembly portion 84' may hold an electro-optic reflective element assembly 86, such as an electrochromic reflective element assembly or cell, and may include a mounting or attachment plate 98 positioned at the rear surface of the reflective element assembly 86 (the fourth surface of the cell). The bezel portion or molding 94' may be molded or formed around the reflective element assembly 86 and around or at the attachment plate 98 to retain the attachment plate 98 and the reflective element assembly 86 within the bezel portion or molding 94'. As can be seen in FIG. 33B, the mounting plate 98 may include protrusions or recesses or the like 98a at least partially around its perimeter edge to facilitate mechanical connection and securement of the bezel portion 94' (such as by snap on or snap in) to the mounting plate 98 when the bezel portion 94' is molded around the mounting plate 98. The attachment plate 98 may include a pivot joint or element 102 established or formed thereon. The reflective element assembly portion 84' may be otherwise substantially similar to reflective element assembly portion 84, discussed above, such that a detailed description of the reflective element assembly will not be repeated herein. The components that are common with the reflective element assemblies 84 and 84' are shown with the same reference numbers in FIGS. 33A and 33B.

Therefore, the reflective element assembly portion may be formed or molded with the molding or bezel portion molded or formed around the larger front substrate to contain the reflective element assembly or cell within or at the bezel portion. The pivot element or joint 102 may be formed or established at the rear of the reflective element assembly, such as in the manners described above, and the mounting arm 104 may extend generally rearwardly from the pivot joint. The cap portion may then receive the mounting arm through an opening or the like in the cap portion such that the mounting arm extends from the cap portion after the cap portion is attached to or snapped to the reflective element assembly portion. The electrical connectors of the reflective element assembly portion may connect to the appropriate electrical connectors or terminals or circuitry of the cap portion as the cap portion is assembled to or attached to the reflective element assembly portion, such as in the manners described above, in order to provide electrical power and/or control to the electrochromic cell.

The electrochromic reflective element assembly portion of the present invention thus may comprise a standard or universal or common reflective element assembly or cell and mirror holder or bezel portion, which may then be attached to a customized or selected or desired cap portion, as described above. Optionally, the reflective element assembly portion may be customized as well. For example, a selected bezel material may be molded around a common reflective element assembly or cell. The reflective element assembly portion may be formed by placing an electrochromic cell into a mold cavity (such as face down into the mold cavity with the rear surface of the rear substrate facing upward), and the plastic piece or mounting plate (preferably with a pivot element or member already established therein or thereon) may be inserted into the mold or placed generally at or on the rear surface of the rear substrate of the reflective element assembly or cell (i.e. the fourth surface of the cell). The mounting plate may be generally smaller than the profile of the rear substrate and may include the pivot element or socket formed thereon (or such pivot components may be added or attached or molded later). Optionally, the mounting plate may include electronic circuitry and the like, such as for making the electrical connection to the electrical connectors of the cell and/or for providing other electronic content or features or functions as may be desired (such as display elements for displaying information through the cell to a driver of the vehicle or the like, or such as ports or aperture for aligning with display elements of the cap portion so that information may be displayed or projected through the apertures in the mounting plate and through the cell to a driver of the vehicle). The bezel portion or molding may then be molded (such as via injection molding or reaction injection molding of a desired or selected or appropriate material into the mold cavity) to form the bezel portion around the perimeter of the front substrate (such as described above).

Optionally, the electrochromic reflective element assembly portion may be readily customized by injection molding a selected material into the mold to form the bezel portion of a selected or customized material. For example, the material may be selected to be a desired color, or may be selected to have desired properties, such as, for example, a soft touch or desired feel or appearance or finish or the like. The present invention thus may provide a common cell and attachment or mounting plate (and pivot element or joint), but may readily customize the appearance and/or feel of the bezel portion or molding to provide a particular, selected and customized reflective element assembly portion, while utilizing the same molding tool or mold to form the customized molding or bezel portion. Optionally, the reflective element assembly or cell and attachment or backing plate may comprise standard or common components for multiple mirror assemblies, and may be placed in desired or appropriate molds for molding the appropriate bezel portion for a particular mirror application. The customized reflective element assembly portion may then be attached to the desired or selected or customized cap portion as described above, and the electrical connections of the electronic circuitry and the like at the plate of the reflective element assembly portion may be made to the corresponding or appropriate connectors or circuitry of the cap portion as the cap portion is attached to the reflective element assembly portion. Although shown and described as molding a bezel portion around the perimeter region of a larger front substrate (which is larger than the rear substrate) of an electrochromic reflective element assembly or cell, it is envisioned that the bezel portion or molding may be molded or formed around other types of electrochromic reflective element assemblies or cells (such as flush cells or offset or staggered cells or the like), and/or may be molded or formed around prismatic reflective elements and the like, without affecting the scope of the present invention.

Optionally, and such as described in PCT Publication No. WO 03/095269 A2, published Nov. 20, 2003 for REARVIEW MIRROR ASSEMBLIES, which is hereby incorporated by reference herein, an electro-optic rearview mirror assembly portion may comprise an electro-optic reflective element assembly or unit or cell, such as an electrochromic reflective unit or cell (whose reflectivity is variable in response to an electrical voltage applied thereto), and an electrical circuit for controlling operation of the mirror cell in response to one or more one light sensors. The interior mirror assembly portion may also comprise at least one pivot element or member, such as a ball and socket member, which allows angular adjustment of the mirror reflective element when the mirror assembly is mounted in the vehicle. Optionally, the ball member may include a plurality of electrical contacts on an exposed surface thereof for sliding engagement by respective counter-contacts over a range of angular movement of the mirror unit for supplying power to the electrical circuit from a vehicle electrical system external to the mirror assembly. Optionally, other means for providing electrical power and/or control to the circuitry/accessories of the mirror assembly may be provided (such as a wire or cable along an exterior surface or portion of the mounting arm or member or the like), without affecting the scope of the present invention.

Optionally, a prismatic mirror assembly portion and cap portion of the present invention may include electrochromic drive circuitry for controlling the exterior electrochromic reflective elements of the exterior rearview mirror assemblies of the vehicle, such as described above. The cap portion may include a glare sensor and an ambient sensor to determine the glare levels and ambient light levels and the control circuitry may adjust the dimming of the exterior mirrors accordingly. The glare sensor may receive the light through an aligned port in the reflective element or may receive light via a light pipe or the like, without affecting the scope of the present invention. The cap portion thus may provide electrochromic control circuitry for applications where the vehicle may have exterior electrochromic mirror assemblies, while the interior rearview mirror assembly may comprise a base or prismatic mirror that may otherwise not include such control circuitry. The cap portion of the present invention thus may provide a low cost conversion of an interior rearview mirror to provide electrochromic mirror control for the exterior rearview mirrors of the vehicle.

Optionally, and with reference to FIGS. 34 and 35A-D, an interior rearview mirror assembly 110 may be attachable or mountable to a windshield accessory module 112, which may be attachable or mountable to an interior surface of the windshield of a vehicle, such as at a mounting button or the like. Windshield accessory module 112 may include a body portion 114 that extends generally along the windshield and may include a head portion 116 at the upper end of the body portion 114 generally above the mirror assembly 110 and viewable by a driver of the vehicle when the windshield accessory module 112 and mirror assembly 110 are mounted in a vehicle, such as in a similar manner as described in U.S. pat. application, Ser. No. 10/355,454, filed Jan. 31, 2003 by Schofield et al. for VEHICLE ACCESSORY MODULE (Attorney Docket DON01 P-1050), which is hereby incorporated herein by reference. Windshield accessory module 112 may include one or more accessories or circuitry therein, and may include one or more user interface controls or inputs and/or a display or indicator or indicators or the like at the head portion that are readily viewable and/or accessible above the mirror assembly, such as discussed below and as shown in FIGS. 35A-D and/or as described in U.S. pat. application, Ser. No. 10/355,454, filed Jan. 31, 2003 by Schofield et al. for VEHICLE ACCESSORY MODULE (Attorney Docket DON01 P-1050), which is hereby incorporated herein by reference. As shown in FIGS. 34 and 35A, a wiring or cabling conduit 118 may extend upward from the body portion 114 and along the windshield 111 to conceal and route the wiring harness between the headliner of the vehicle and the windshield accessory module 112.

Preferably, the windshield accessory module may be configured to attach to a typical mounting button or the like for an interior rearview mirror assembly, and may include a replica of the mounting button or the like for the mirror assembly to mount thereto. The accessory module thus may attach to the existing button on the windshield and the mirror assembly may be attached to the button on the accessory module in the same manner. The mirror assembly may comprise a modular mirror assembly as described above, or may comprise other types of prismatic or electro-optic or electrochromic mirror assembly, without affecting the scope of the present invention. As shown in FIG. 34, a wiring harness 119 and connector or plug 119a may extend from accessory module 112 and plug into the back of the mirror casing or cap portion, such as in a similar manner as described above. The accessory module thus may provide an aftermarket addition to add additional electronic content or accessories, without having to replace the mirror assembly. The accessory module of the present invention thus may provide the desired accessories or options, while providing the vehicle manufacturer and/or the customer the freedom to select any mirror assembly. Optionally, for aftermarket applications, the windshield accessory module may be battery-operated and may include a battery compartment for receiving and connecting to a battery or power source or the like.

As shown in FIG. 35A, windshield accessory module 112 may include or may be associated with a garage door opening system, and head portion 116 may include one or more user actuatable inputs 120a-c for controlling or actuating the garage door opening system. Head portion 116 may also include an icon or indicia 122 or the like, which may be illuminated or back lit via a light source in head portion 116 to indicate to the user of the garage door opening system that the system is activated or that the button or input was successfully actuated. The garage door opening system may comprise a trainable garage door opening system and/or may utilize principles disclosed in U.S. Pat. Nos. 6,396,408; 6,362,771; 5,798,688 and 5,479,155; and/or U.S. pat. application, Ser. No. 10/770,736, filed Feb. 3, 2004 by Baumgardner et al. for GARAGE DOOR OPENING SYSTEM FOR VEHICLE (Attorney Docket DON01 P-1135), which are hereby incorporated herein by reference.

Optionally, and with reference to FIG. 35B, the windshield accessory module 112' may also or otherwise include or be associated with a telematics system or cellular telephone system or the like. The head portion 116' thus may provide user inputs 124a, 124b, 124c for actuating the system, placing a telephone call and ending a telephone call, respectively. The head portion 116' may also include a microphone 126 for receiving voice or audio signals from within the cabin of the vehicle, such as via a microphone system of the types described in U.S. Pat. Nos. 6,243,003; 6,278,377; and/or 6,420,975, and/or in PCT Application No. PCT/US03/308877, filed Oct. 1, 2003 by Donnelly Corp. et al. for MICROPHONE SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1111(PCT)), which are hereby incorporated herein by reference. In the illustrated embodiment of FIG. 35B, the head portion 116' includes user inputs and/or indicators 120a', 120b', 120c' for controlling and actuating the garage door opening system and/or for indicating successful operation of the garage door opening system, such as described above.

Optionally, and with reference to FIG. 35C, the windshield accessory module 112" may also or otherwise include or be associated with a tire pressure monitoring system. The head portion 116" may include a display 128 that includes a pressure display 128a for displaying the tire pressure of a particular tire of the vehicle and indicators or light sources 128b for indicating which tire the display 128a is showing the pressure for. Head portion 116" may also include a reset button or input 128c for resetting the tire pressure monitoring system. The tire pressure monitoring system may comprise any tire pressure monitoring system, and may utilize the principles described in U.S. Pat. Nos. 6,124,647; 6,294,989; 6,445,287; 6,472,979; and/or 6,731,205, which are hereby incorporated herein by reference. The head portion 116" may also include one or more user inputs and/or indicators 120a", 120b", 120c" for controlling and actuating the garage door opening system and/or for indicating successful operation of the garage door opening system, such as described above.

Optionally, and with reference to FIG. 35D, the windshield accessory module 112"' may also or otherwise include or be associated with a navigational system for providing instructions to the driver to follow to arrive at a desired or input destination. The head portion 116"' may include a display screen or display device 130 for providing directional heading or driving instructions to the driver. For example, the display device 130 may display the next step to follow and may indicate how far the vehicle has to travel until it arrives at the next turn or intersection. The head portion 116"' may also include one or more user inputs or buttons 132 for controlling the navigational display and/or for scrolling through the instructions being displayed by the display device 130. The navigational system may be associated with or controlled or adjusted by a global positioning system of the vehicle and/or a telematics system of the vehicle and/or a compass system of the vehicle, and may utilize principles such as used in the compass and/or navigational systems of the types described in U.S. Pat. Nos. 6,678,614; 6,477,464; 5,924,212; 4,862,594; 4,937,945; 5,131,154; 5,255,442; and/or 5,632,092, and/or U.S. pat. application, Ser. No. 10/456,599, filed Jun. 6, 2003 by

Weller et al. for INTERIOR REARVIEW MIRROR SYSTEM WITH COMPASS (Attorney Docket DON01 P-1076); Ser. No. 10/645,762, filed Aug. 20, 2003 by Taylor et al. for VEHICLE NAVIGATION SYSTEM FOR USE WITH A TELEMATICS SYSTEM (Attorney Docket DON01 P-1103); and Ser. No. 10/422,378, filed Apr. 24, 2003 (Attorney Docket DON01 P-1074); and/or PCT Application No. PCT/US03/40611, filed Dec. 19, 2003 by Donnelly Corporation et al. for ACCESSORY SYSTEM FOR VEHICLE (Attorney Docket DON01 FP-1123(PCT)), which are all hereby incorporated herein by reference. As shown in FIG. 35D, head portion 116''' may also include one or more user inputs and/or indicators 120 for controlling and actuating the garage door opening system and/or for indicating successful operation of the garage door opening system, such as described above.

The desired accessory module or content may be used with any mirror assembly and, for aftermarket applications, may be used with an existing mirror assembly in the vehicle. The existing mirror assembly may be removed from the mounting button and the windshield module may be attached to the windshield button and the mirror assembly may be attached to the button of the module. Optionally, and particularly for aftermarket applications, the accessory module may include a power source or battery for providing power to the electronic accessories contained within the module and/or within an associated mirror assembly.

Although certain examples of the controls and/or displays that may be provided at the head portion of the windshield accessory module are shown in FIGS. 35A-D and described above, clearly other displays and/or user inputs and/or accessories or functions or features may be provided within or at the windshield accessory module, without affecting the scope of the present invention. The desired features or content may be provided on a circuit board and may include display elements and/or display screens or panels or the like. The circuit board and associated display elements and circuitry and inputs (or appropriate or selected or desired display elements and the like) may be mounted to or attached to or snapped into a common or universal body or base portion to convert or form the desired windshield electronics module for the particular application. If the screen or circuitry is larger than the standard head size of the module, a larger cap portion (such as shown in FIGS. 35B and 35D) may be implemented to contain and conceal the circuitry and the like within the head portion. The windshield electronics module or accessory module of the present invention thus provides various modules with the desired features or content, while utilizing common or universal components.

The windshield electronics module of the present invention thus eases assembly of various modules having varied content, and eases disassembly and repair of the modules. Optionally, however, the module may be sealed to contain the circuit board and display elements therewithin, without affecting the scope of the present invention. The components of the module, such as the telematics controls and the like, may be associated with other components and/or circuitry and/or systems of vehicle, such as a vehicle electronic or communication system, and may be connected via a hard wire or via various protocols or nodes, such as Bluetooth, SCP, UBP, J1850, CAN J2284, Fire Wire 1394, MOST, LIN and/or the like, depending on the particular application.

Therefore, the present invention provides a modular prismatic interior rearview mirror assembly which may have features, such as electronic accessories and/or displays or the like. The accessories or circuitry may be attached to one or more cap portions which may snap or otherwise affix or secure or mount to the rear portion of the mirror holder or bezel portion or reflective element assembly portion. The mirror holder may receive the reflective element, which may be a prismatic reflective element or an electro-optic or electrochromic reflective element, soon after the mirror holder is formed or heated, such that the reflective element may be installed to the mirror holder without a separate bezel portion. The cap portions and associated accessories and/or circuitry may be mounted to the mirror holder after the reflective element is installed and after the mirror holder has cooled and shrunk. The cap portion of the present invention thus avoids the increased costs associated with a two piece mirror holder having a separate bezel portion which is secured to the mirror holder to secure the reflective element at the mirror holder. The cap portions may be selected to have accessories and/or circuitry corresponding to openings in the mirror holder and/or to displays or display icons or the like at the reflective element. The cap portion may be selected to be formed of a different material than the bezel portion or molding, so as to provide the desired material properties and characteristics to both the bezel portion and the cap portion.

Changes and modification in the specifically described embodiments may be carried out without departing from the principles of the present invention, which is intended to be limited only by the scope of the appended claims as interpreted according to the principles of patent law.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An interior rearview mirror assembly for a vehicle comprising:

a reflective element assembly portion;

at least one cap portion, said at least one cap portion adapted to attach to said reflective element assembly portion;

said reflective element assembly portion including a mirror reflective element, said reflective element assembly portion comprising a first molding that encompasses at least a perimeter portion of said reflective element, said first molding being formed by molding a first resinous material having a tool shrinkage factor equal to or greater than about 1%;

said reflective element assembly portion comprising at least one pivot element, said pivot element providing adjustability of said reflective element when said reflective element assembly portion is mounted within the interior cabin of the vehicle; and

said at least one cap portion including at least one accessory, said at least one cap portion comprising at least one second molding formed by molding a second resinous material having a tool shrinkage factor of less than or equal to about 1%.

2. The interior rearview mirror assembly of claim 1, wherein said at least one cap portion comprises a single cap portion substantially encasing a rear portion of said mirror assembly and having an aperture therethrough, wherein a mounting member extends from said pivot element and through said aperture when said cap portion is attached to said reflective element assembly portion.

3. The interior rearview mirror assembly of claim 1, wherein said at least one cap portion comprises a pair of cap portions attachable at corresponding portions of said reflective element assembly portion.

4. The interior rearview mirror assembly of claim 3, wherein each of said cap portions supports at least one accessory having circuitry, said circuitry of said cap portions being connected via a connecting cable.

5. The interior rearview mirror assembly of claim 4, wherein said cap portions are connected via a connecting member.

6. The interior rearview mirror assembly of claim 1, wherein said reflective element is received into said first molding while said first molding is warm and pliable.

7. The interior rearview mirror assembly of claim 1, wherein said at least one accessory includes circuitry operable to control a display at said reflective element.

8. The interior rearview mirror assembly of claim 7, wherein said display comprises at least one of a compass display, a tire pressure monitoring display, a telematics display, a navigation system display, a garage door opening system display, a temperature display, a supplemental inflatable restraint system status display, and an object detection display.

9. The interior rearview mirror assembly of claim 1, wherein at least one illumination source is positioned to align with at least one port formed on said reflective element when said cap portion is attached to said reflective element assembly portion.

10. The interior rearview mirror assembly of claim 7, wherein said display comprises a compass display.

11. The interior rearview mirror assembly of claim 10, wherein said circuitry is in communication with compass circuitry.

12. The interior rearview mirror assembly of claim 11, wherein said compass circuitry is positioned at an accessory module positioned at a mounting portion of said mirror assembly.

13. The interior rearview mirror assembly of claim 1, wherein said at least one accessory comprises an accessory module insertable at least partially into said cap portion.

14. The interior rearview mirror assembly of claim 13, wherein said accessory module includes at least one user input for selectively actuating an accessory of the vehicle.

15. The interior rearview mirror assembly of claim 13, wherein insertion of said accessory module into said cap portion interconnects said accessory module to said cap portion both mechanically and electrically.

16. The interior rearview mirror assembly of claim 15, wherein said accessory module is inserted into said cap portion after said cap portion is attached to said reflective element assembly portion.

17. The interior rearview mirror assembly of claim 1, wherein said cap portion includes a connector for connecting to a vehicle wiring harness.

18. The interior rearview mirror assembly of claim 1, wherein said at least one cap portion is detachably attached to said reflective element assembly portion.

19. The interior rearview mirror assembly of claim 1, wherein said at least one cap portion is detachably attached to said reflective element assembly portion via at least one mechanical interconnect.

20. The interior rearview mirror assembly of claim 1, wherein said first molding comprises a bezel portion of said mirror assembly.

21. The interior rearview mirror assembly of claim 1, wherein said first molding comprises a backing plate at said reflective element.

22. The interior rearview mirror assembly of claim 1, wherein said first resinous material has a tool shrinkage factor equal to or greater than about 1.5%.

23. The interior rearview mirror assembly of claim 1, wherein said first resinous material comprises a polyolefin material.

24. The interior rearview mirror assembly of claim 1, wherein said second resinous material has a tool shrinkage factor of less than or equal to about 0.8%.

25. The interior rearview mirror assembly of claim 1, wherein said second resinous material has a tool shrinkage factor of less than or equal to about 0.6%.

26. The interior rearview mirror assembly of claim 1, wherein said second resinous material comprises one of an ABS material and a NYLON material.

27. The interior rearview mirror assembly of claim 1, wherein said first molding has a first color and said second molding has a second color, said first color being different than said second color.

28. The interior rearview mirror assembly of claim 1, wherein said first molding has a first exterior finish and said second molding has a second exterior finish, said first exterior finish being different than said second exterior finish.

29. The interior rearview mirror assembly of claim 1, wherein said pivot element comprises a ball joint.

30. The interior rearview mirror assembly of claim 29, wherein a mounting member connects to said reflective element assembly portion by said ball joint.

31. The interior rearview mirror assembly of claim 30, wherein said mounting member comprises a second ball joint connecting to a mirror attachment member, said mirror attachment member being adapted to attach the interior rearview mirror assembly to an interior portion of the vehicle.

32. The interior rearview mirror assembly of claim 2, wherein said pivot element comprises a ball joint.

33. The interior rearview mirror assembly of claim 1, wherein said reflective element comprises a prismatic reflective element and said pivot element is actuated by a toggle element.

34. The interior rearview mirror assembly of claim 1, wherein said reflective element comprises a prismatic reflective element.

35. The interior rearview mirror assembly of claim 1, wherein said reflective element comprises an electro-optic reflective element assembly.

36. The interior rearview mirror assembly of claim 1, wherein said reflective element assembly portion comprises a first sub-assembly and said cap portion comprises a second sub-assembly, said second sub-assembly being attached to said first sub-assembly to assemble said mirror assembly.

37. A method of manufacturing an interior rearview mirror assembly, said method comprising:

forming a first molding by injection molding a first resinous material in a mold, said first resinous material having a tool shrinkage factor of at least approximately 1%, said first molding being at an elevated temperature when said first molding is removed from the mold;

providing a reflective element;

positioning said reflective element at said first molding before said first molding has cooled to ambient temperature, said first molding at least partially encompassing a perimeter portion of said reflective element to form a reflective element assembly portion;

allowing said first molding to cool and shrink to retain said reflective element at said first molding;

providing a cap portion comprising a second resinous material, said second resinous material having a tool shrinkage factor of at less than or equal to approximately 1%, said cap portion including at least one accessory; and

attaching said cap portion to said reflective element assembly portion after said first molding has cooled and shrunk, said cap portion being attached to said reflective element assembly portion such that said accessory is at least partially within said mirror assembly.

38. The method of claim 37, wherein said cap portion includes a printed circuit board therein, said accessory comprising circuitry at said printed circuit board.

39. The method of claim 38 including forming a display region at said reflective element, said circuitry including at least one display element that generally aligns with at least a portion of said display region when said cap portion is attached to said reflective element assembly portion.

40. The method of claim 39, wherein at least one of said cap portion and said first molding include guide portions to guide said cap portion into engagement with and

attachment to said first molding to align said at least one display element with a display port formed in said reflective element.

41. The method of claim 37, wherein said reflective element assembly portion is fabricated as a first sub-assembly and said cap portion and at least one accessory is fabricated as a second sub-assembly.

42. The method of claim 41, wherein said first sub-assembly is fabricated at a first assembly location and said second sub-assembly is fabricated at a second assembly location.

43. The method of claim 42, wherein said first assembly location is remote from said second assembly location.

44. The method of claim 43, wherein said second sub-assembly is attached to said first sub-assembly at a third assembly location.

45. The method of claim 44, wherein said third assembly location is remote from said first and second assembly locations.

46. The method of claim 37, wherein said first resinous material has a tool shrinkage factor of at least approximately 1.5%.

47. The method of claim 37, wherein said first resinous material comprises a polyolefin material.

48. The method of claim 37, wherein said second resinous material has a tool shrinkage factor of less than or equal to approximately 0.8%.

49. The method of claim 37, wherein said second resinous material has a tool shrinkage factor of less than or equal to approximately 0.6%.

50. The method of claim 37, wherein said second resinous material comprises one of an ABS material and a NYLON material.

51. The method of claim 37, wherein said first molding has a first color and said cap portion has a second color, said first color being different than said second color.

52. The method of claim 37, wherein said first molding has a first exterior finish and said cap portion has a second exterior finish, said first exterior finish being different than said second exterior finish.

53. The method of claim 37, wherein said reflective element assembly portion includes a pivot element for providing adjustability of said reflective element when said reflective element assembly portion is mounted within the interior cabin of the vehicle.

54. The method of claim 53, wherein said pivot element comprises a ball joint, said mirror assembly including a mounting member pivotally attached to said reflective element assembly portion via said ball joint.

55. The method of claim 54, wherein said mounting member extends through said cap portion when said cap portion is attached to said reflective element assembly portion.

56. The method of claim 55, wherein said mounting member comprises a second ball joint connecting to a mirror attachment member, said mirror attachment member being adapted to attach the interior rearview mirror assembly to an interior portion of the vehicle.

57. The method of claim 37, wherein said reflective element comprises a prismatic reflective element and said pivot element is attached to a toggle assembly of said reflective element assembly portion.

58. The method of claim 37, wherein said reflective element comprises a prismatic reflective element.

59. The method of claim 37, wherein said reflective element comprises an electro-optic reflective element assembly.

60. An interior rearview mirror assembly for a vehicle comprising:

a reflective element assembly portion;

said reflective element assembly portion including an electro-optic reflective element, said reflective element assembly portion comprising a first molding that encompasses at least a perimeter portion of said reflective element, said first molding being formed by molding a first resinous material having a tool shrinkage factor equal to or greater than about 1%;

at least one cap portion, said at least one cap portion adapted to attach to said reflective element assembly portion, said at least one cap portion comprises at least one second molding formed by molding a second resinous material having a tool shrinkage factor of less than or equal to about 1%;

said reflective element assembly portion comprising at least one pivot element, said pivot element providing adjustability of said reflective element when said reflective element assembly portion is mounted via a mounting member within the interior cabin of the vehicle; and

said at least one cap portion including electro-optic circuitry for controlling said reflective element assembly, said at least one cap portion providing electrical connection of said electro-optic circuitry to said reflective element assembly when said cap portion attaches to said reflective element assembly portion.

61. The interior rearview mirror assembly of claim 60, wherein said reflective element assembly comprises a pair of substrates with conductive coatings on opposed surfaces of substrates and an electrochromic medium disposed between said conductive coatings.

62. The interior rearview mirror assembly of claim 61 including a pair of connectors connected to respective ones of said conductive coatings, said connectors extending from said first molding for connection to said cap portion when said cap portion is attached to said reflective element assembly portion.

63. The interior rearview mirror assembly of claim 61, wherein said pair of substrates comprises a front substrate and a rear substrate, said front substrate having a first dimension thereacross and said rear substrate having a second dimension thereacross and juxtaposed with said first dimension, said first dimension of said front substrate being larger than said second dimension of said rear substrate.

64. The interior rearview mirror assembly of claim 60 including a mounting plate with said pivot element established thereon, said mounting plate being positioned at a rear surface of said reflective element assembly.

65. The interior rearview mirror assembly of claim 64, wherein said first molding at least partially encompasses said mounting plate to attach to said mounting plate and to substantially secure said mounting plate relative to said reflective element assembly.

66. An interior rearview mirror assembly for a vehicle comprising:

a reflective element assembly portion;

said reflective element assembly portion including a mirror reflective element, said reflective element assembly portion comprising a first molding that encompasses at least a perimeter portion of said reflective element;

at least one trim element adapted to attach to said first molding, said at least one trim element extending at least partially around a front portion of said reflective element assembly portion when attached to said first molding;

at least one cap portion, said at least one cap portion adapted to attach to said reflective element assembly portion, said at least one cap portion including at least one accessory; and

said reflective element assembly portion comprising at least one pivot element, said pivot element providing adjustability of said reflective element when said reflective element assembly portion is mounted within the interior cabin of the vehicle.

67. The interior rearview mirror assembly of claim 66, wherein said first molding is formed by molding a first resinous material having a tool shrinkage factor equal to or greater than about 1%.

68. The interior rearview mirror assembly of claim 66, wherein said at least one cap portion comprises at least one second molding formed by molding a second resinous material having a tool shrinkage factor of less than or equal to about 1%.

69. The interior rearview mirror assembly of claim 66, wherein said at least one trim element comprises a material having a Shore A durometer hardness that is less than a Shore A durometer hardness of said first molding.

70. The interior rearview mirror assembly of claim 66, wherein a portion of said at least one trim element is received at least partially within a portion of said first molding.

71. The interior rearview mirror assembly of claim 66, wherein said first molding has a first exterior finish and said at least one trim element has a second exterior finish, said first exterior finish being different than said second exterior finish.

72. The interior rearview mirror assembly of claim 71, wherein said cap portion has a third exterior finish, said third exterior finish being different than at least one of said first and second exterior finishes.

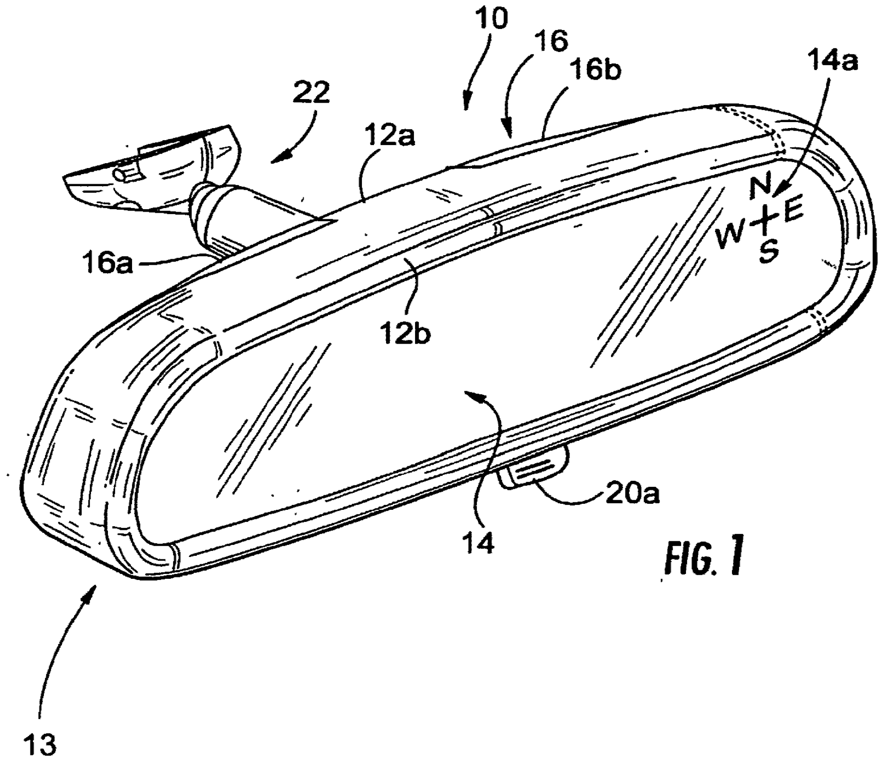
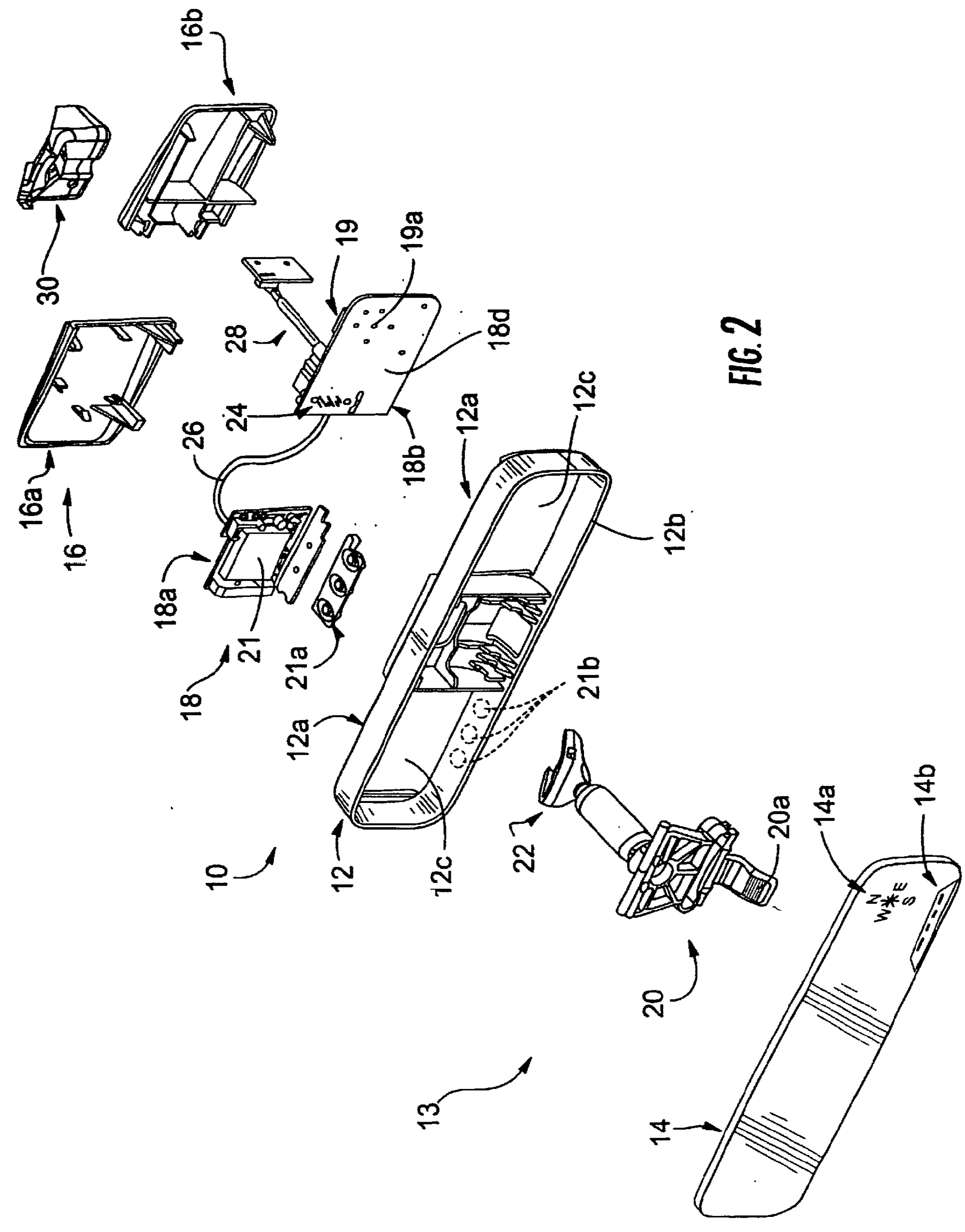


FIG. 1


10
12
12a
12a
12b
12c
12c
13
14
14a
14b
16
16a
16b
18
18a
18b
18d
19
19a
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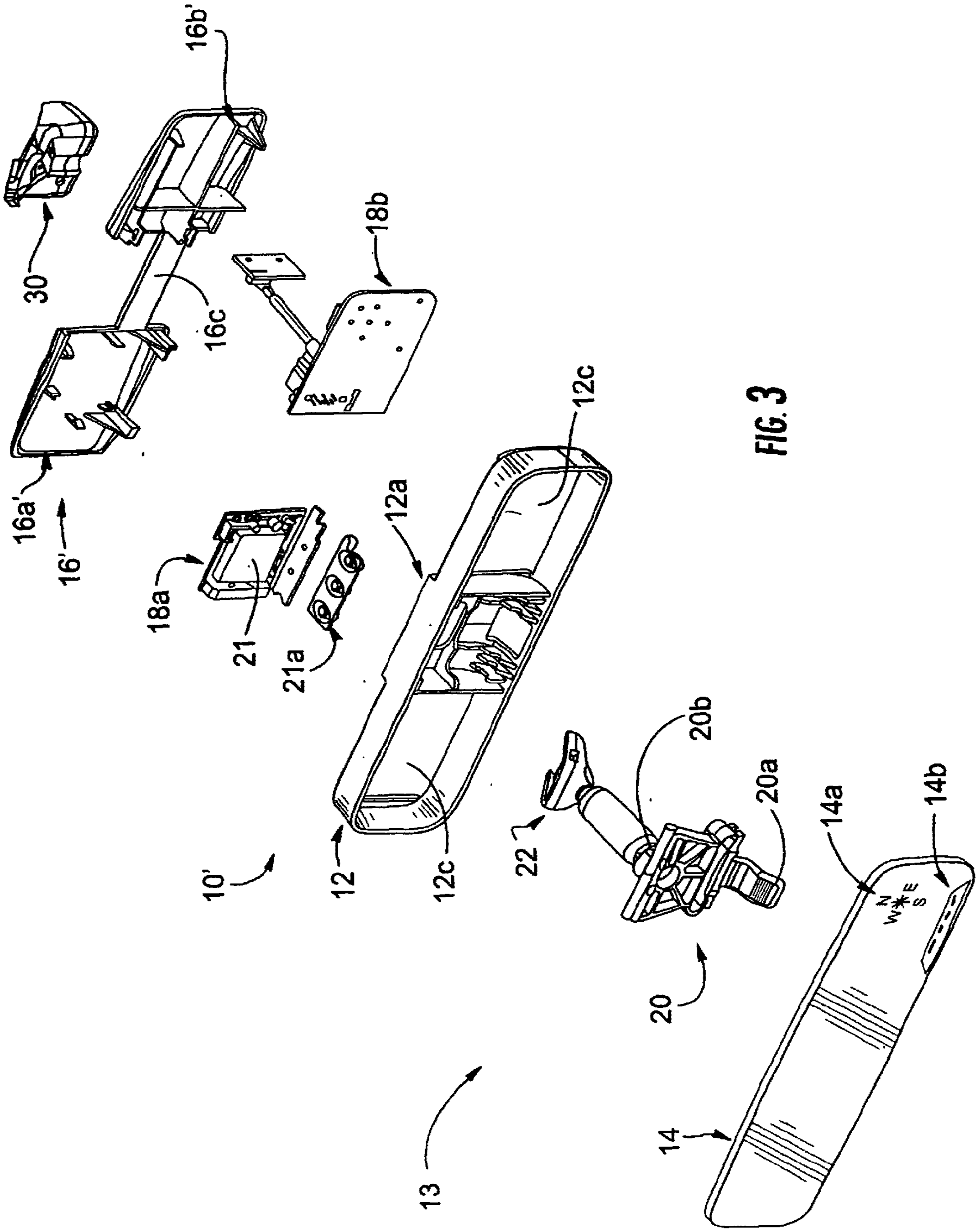
20a
21
21a
21b
22
24
26
28
30
N
W
E
S

FIG. 2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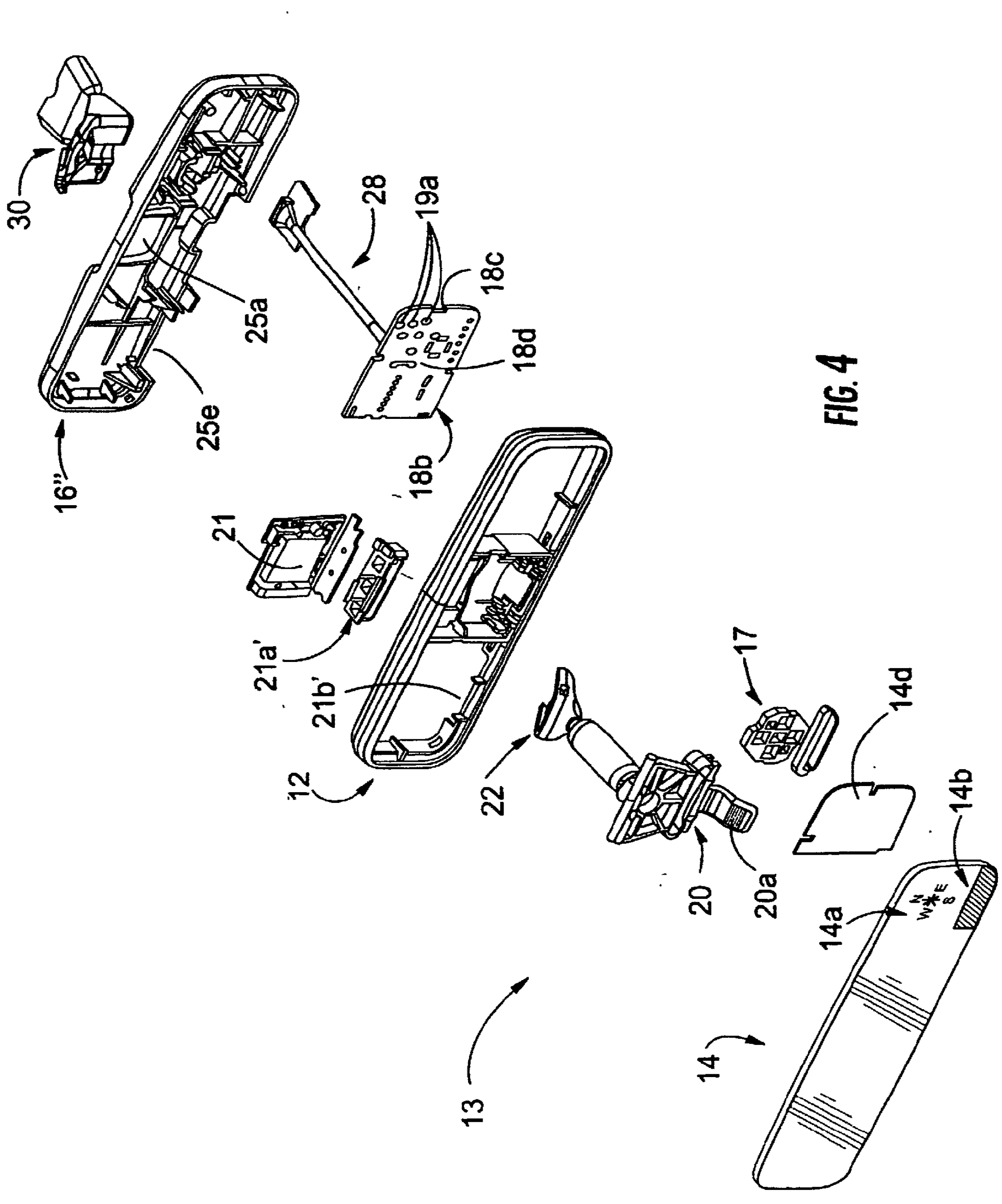
30
16c
18b
12c
16a'
16'
18a
21
21a
12a
20b
20a
22
12
12c
10'
14a
14b
N
W
E
S
20
14
13

FIG. 3


30
16"
25e
25a
28
19a
18c
18d
18b
21
21a'
21b'
12
22
17
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20a
14b
14a
N
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E
S
14
13

FIG. 4

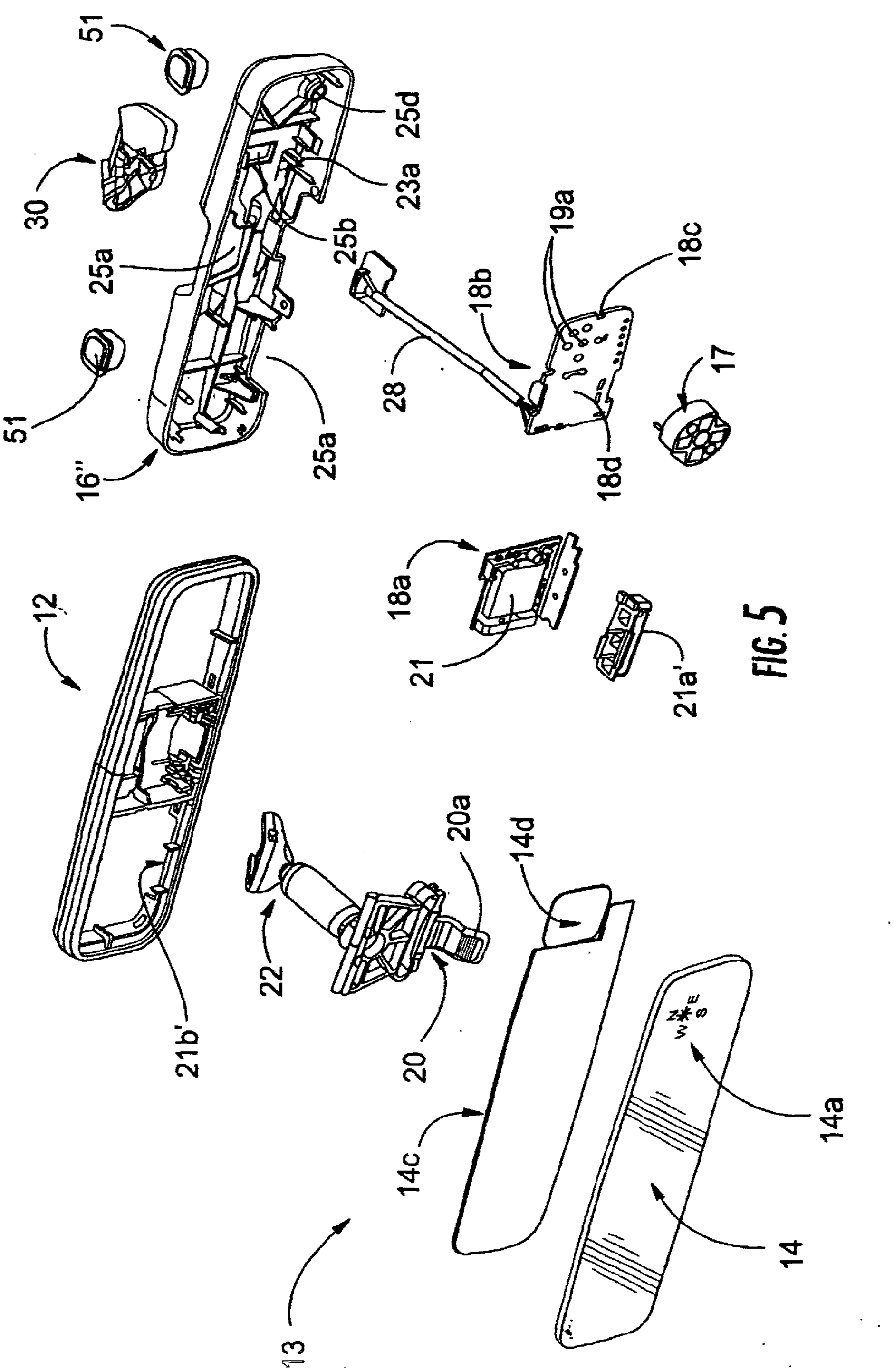
51
30
25d
23a
25a
25b
19a
18c
18b
51
28
17
16"
25a
18d
12
18a
21
21a'
20a
14d
22
21b'
20
14a
14c
14
13

FIG. 5

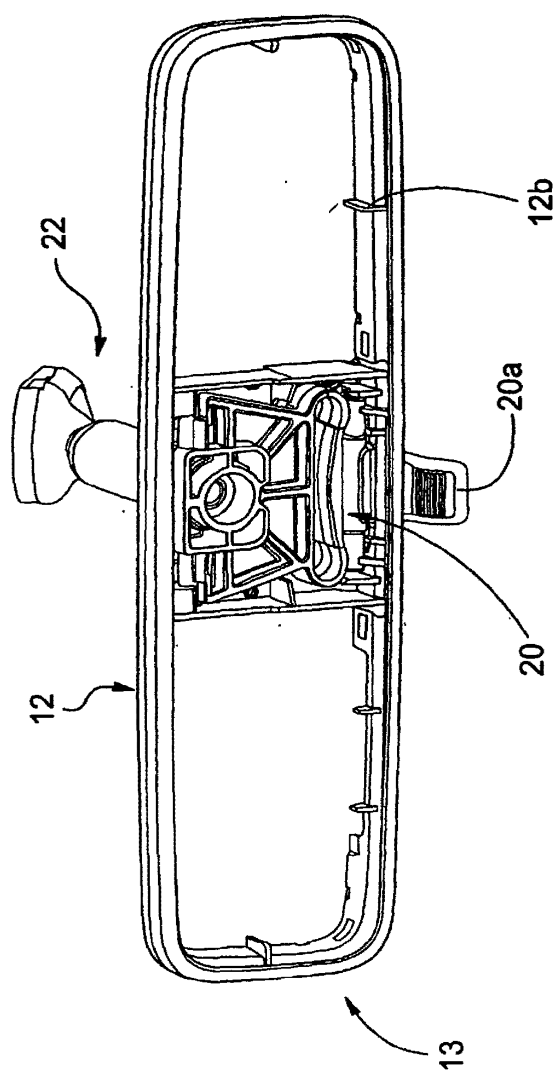

FIG. 6

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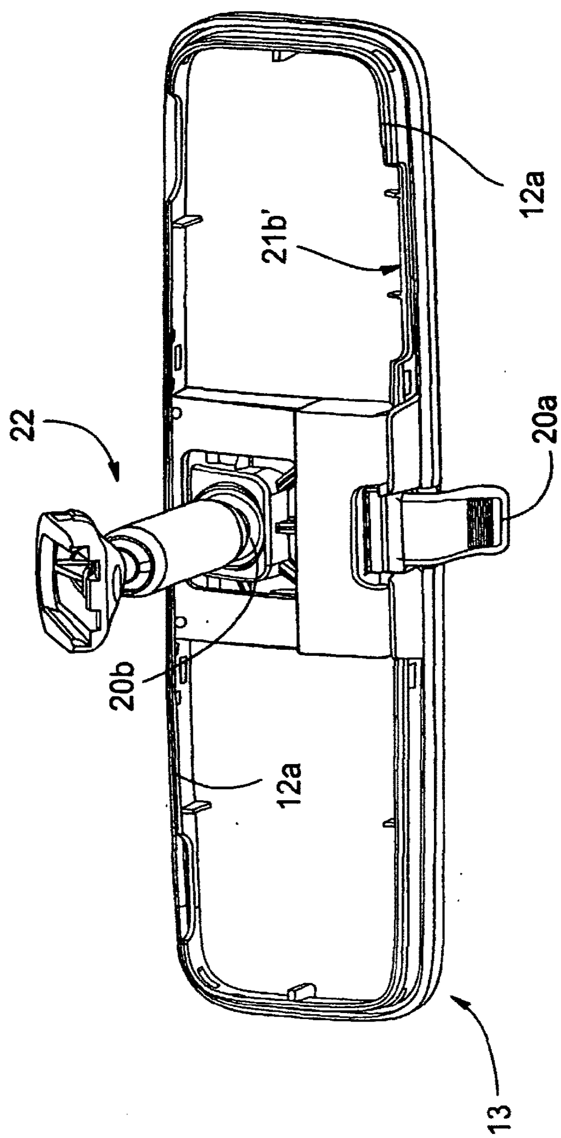

FIG. 7

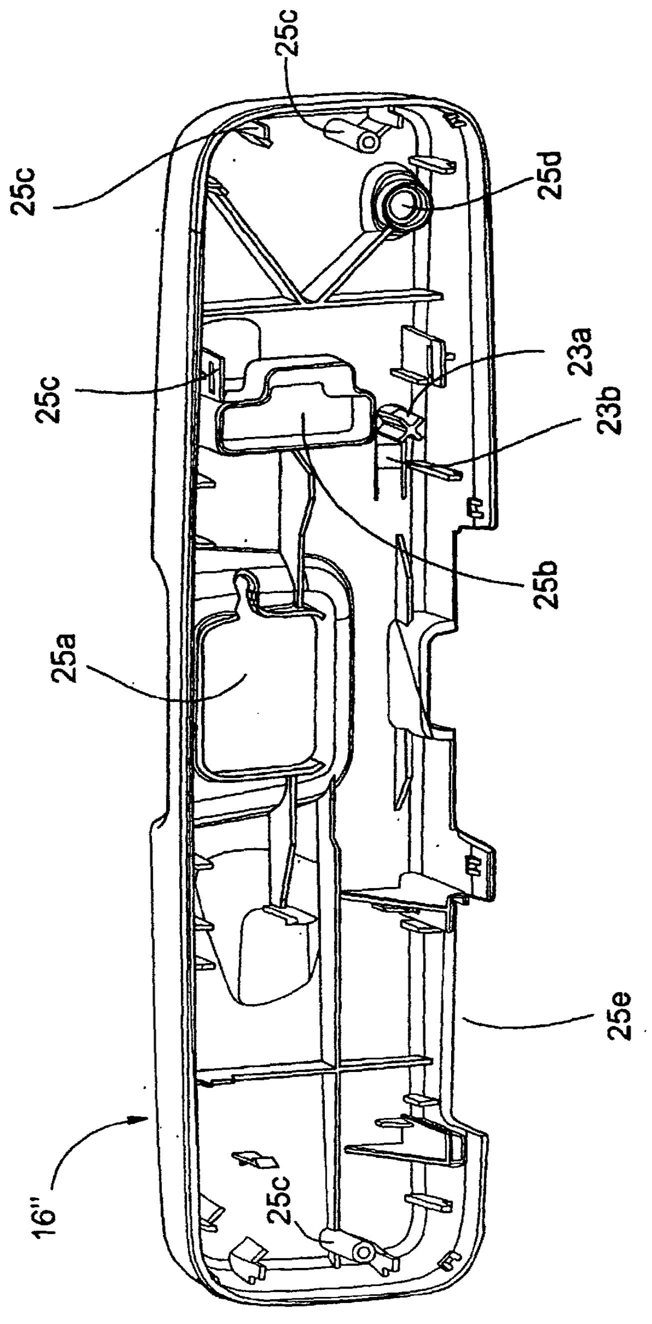

FIG. 8

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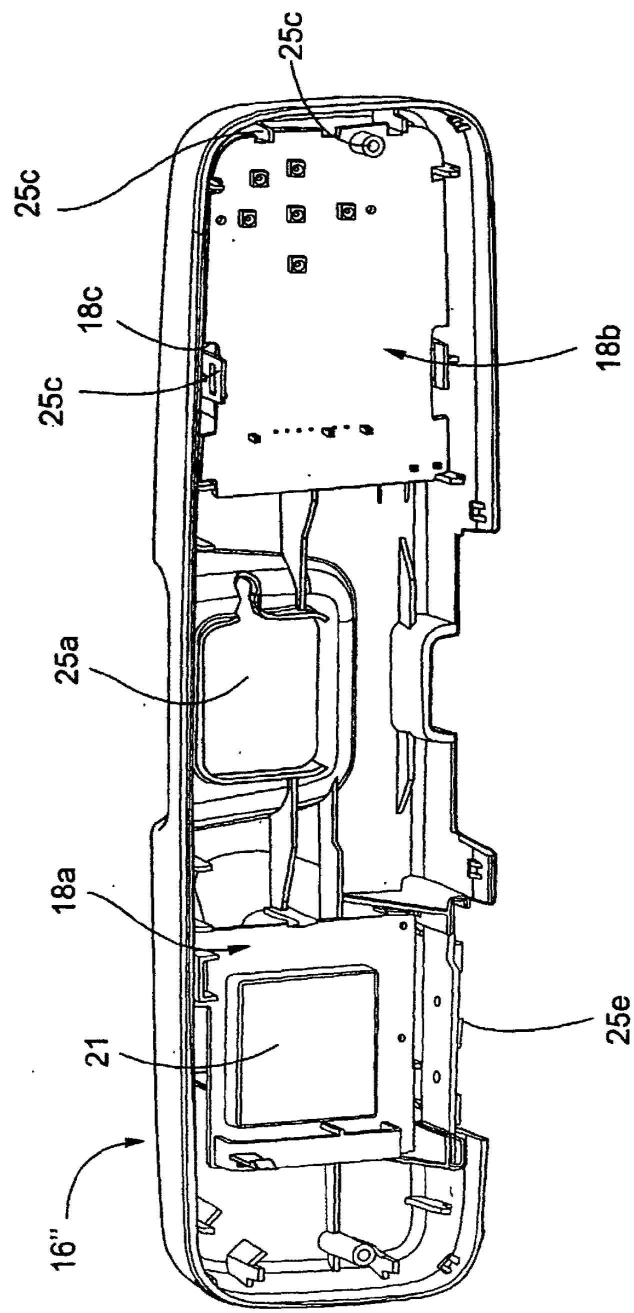

FIG. 9

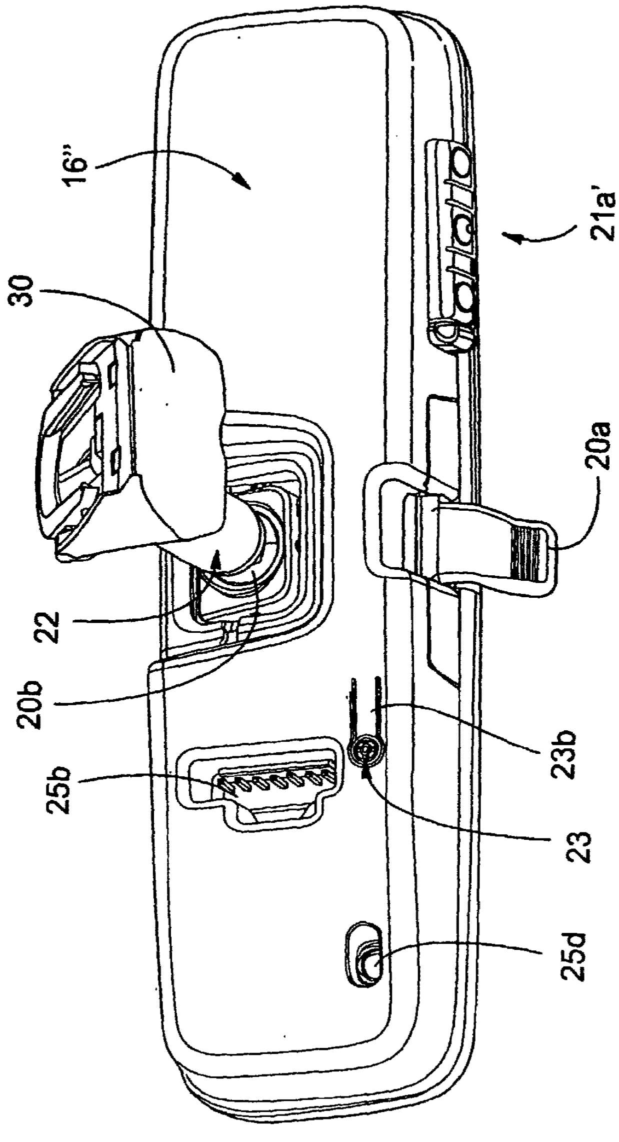

FIG. 10

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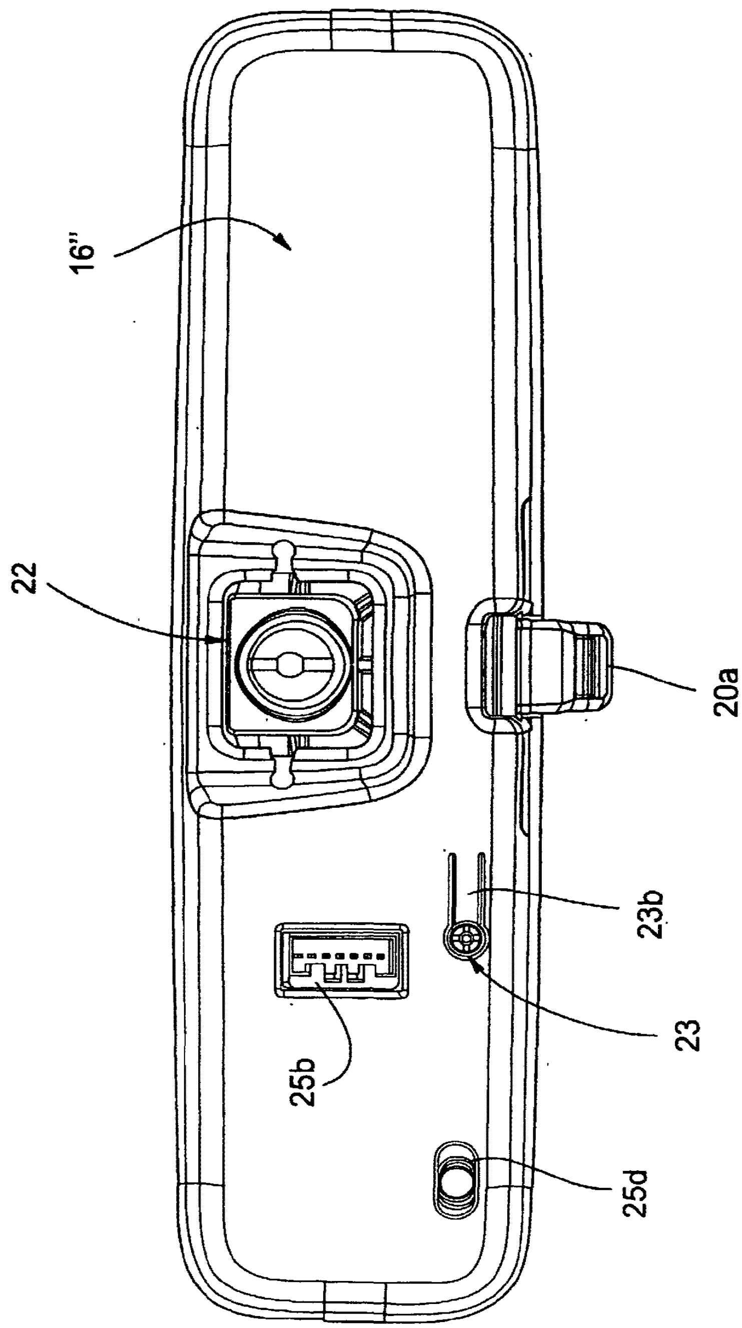

FIG. 11

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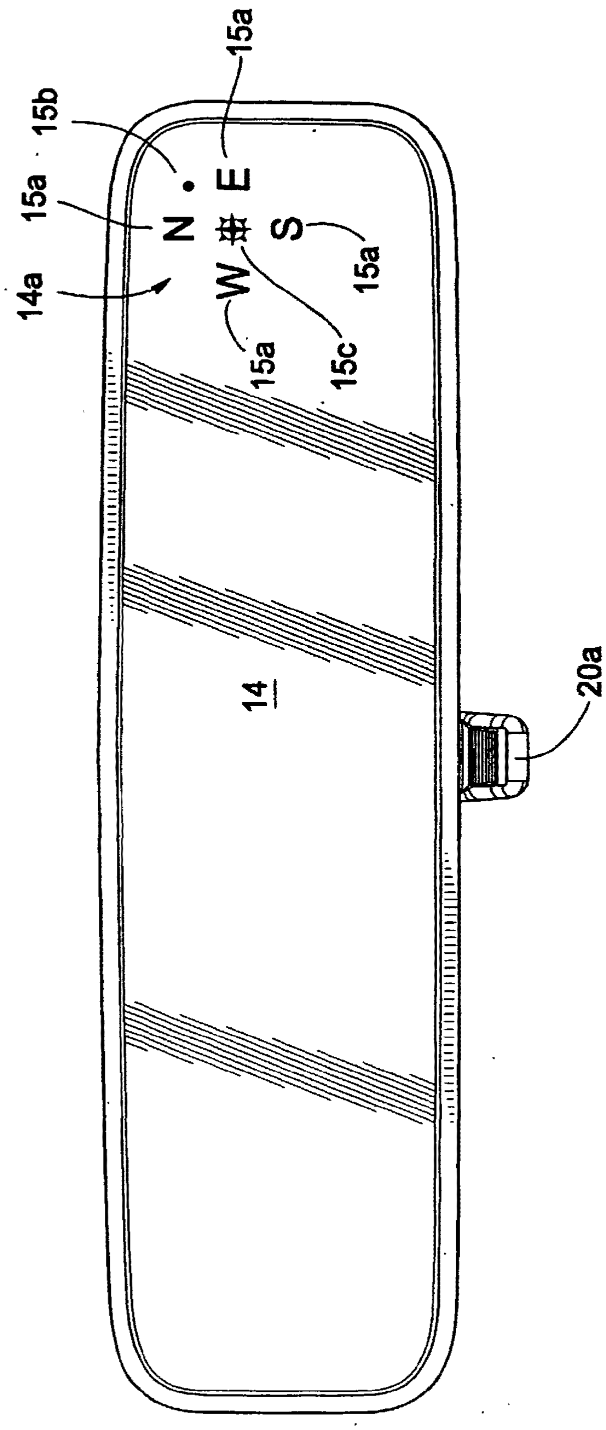

FIG. 12

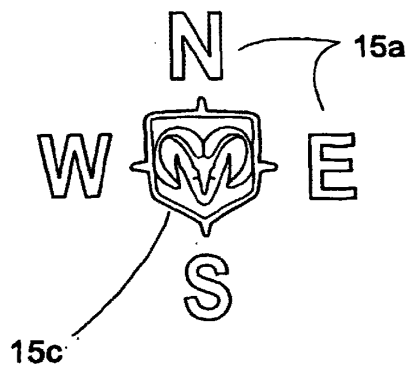

FIG. 13A

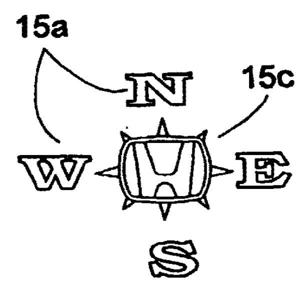

FIG. 13B

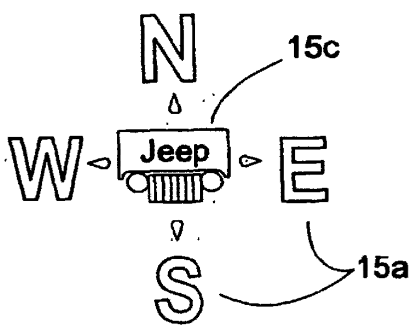

FIG. 13C

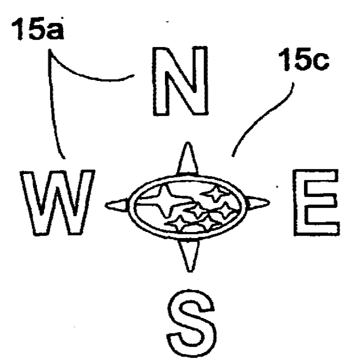

FIG. 13D

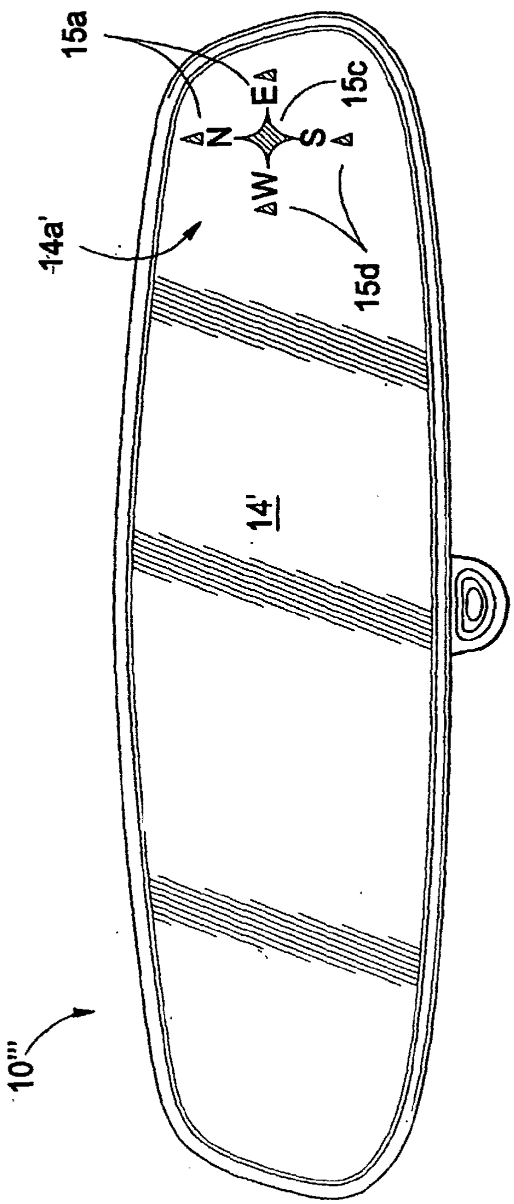

FIG. 14

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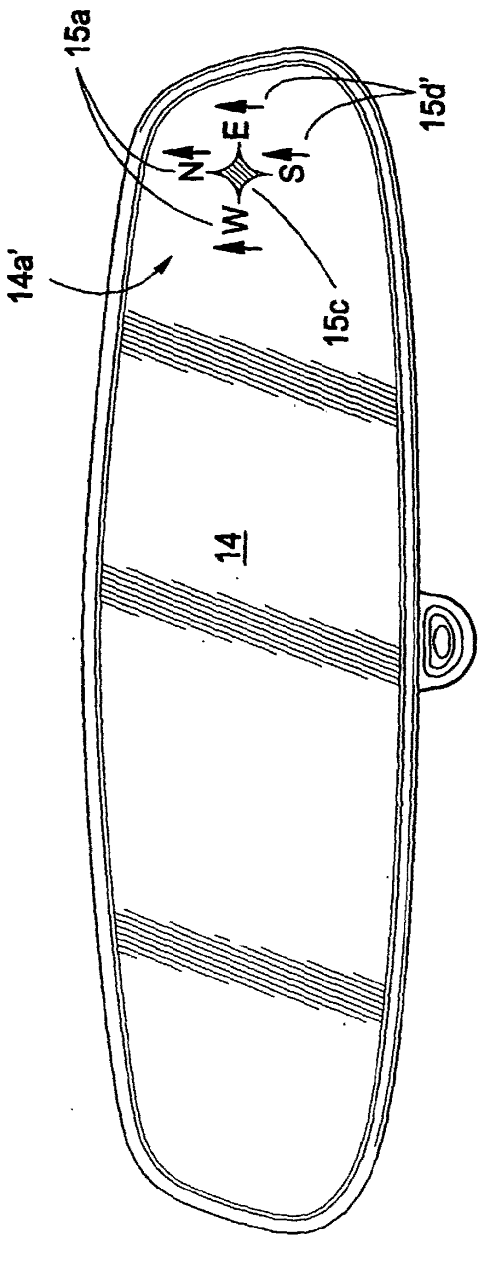

FIG. 15

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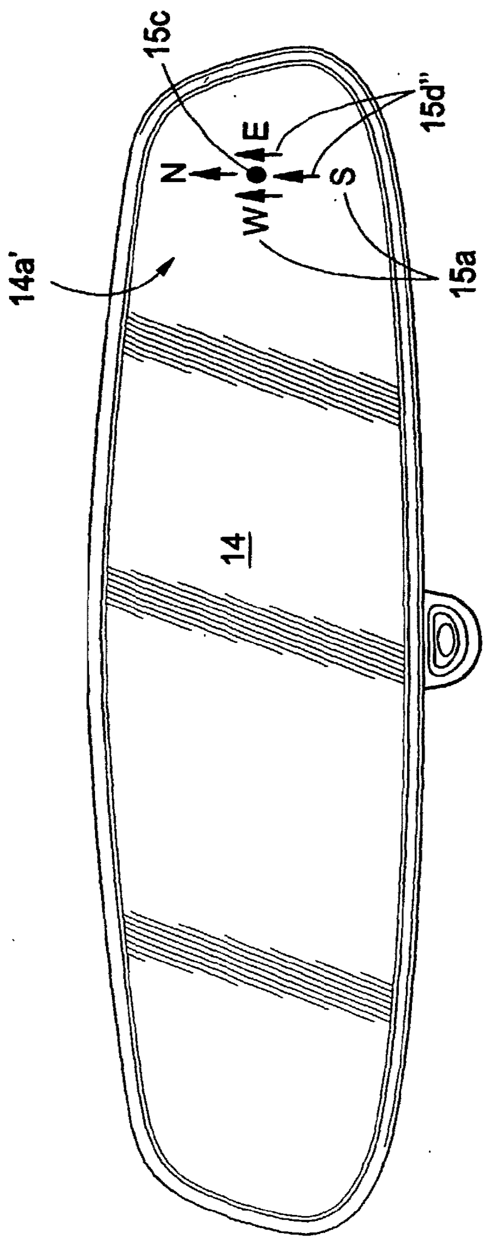

FIG. 16

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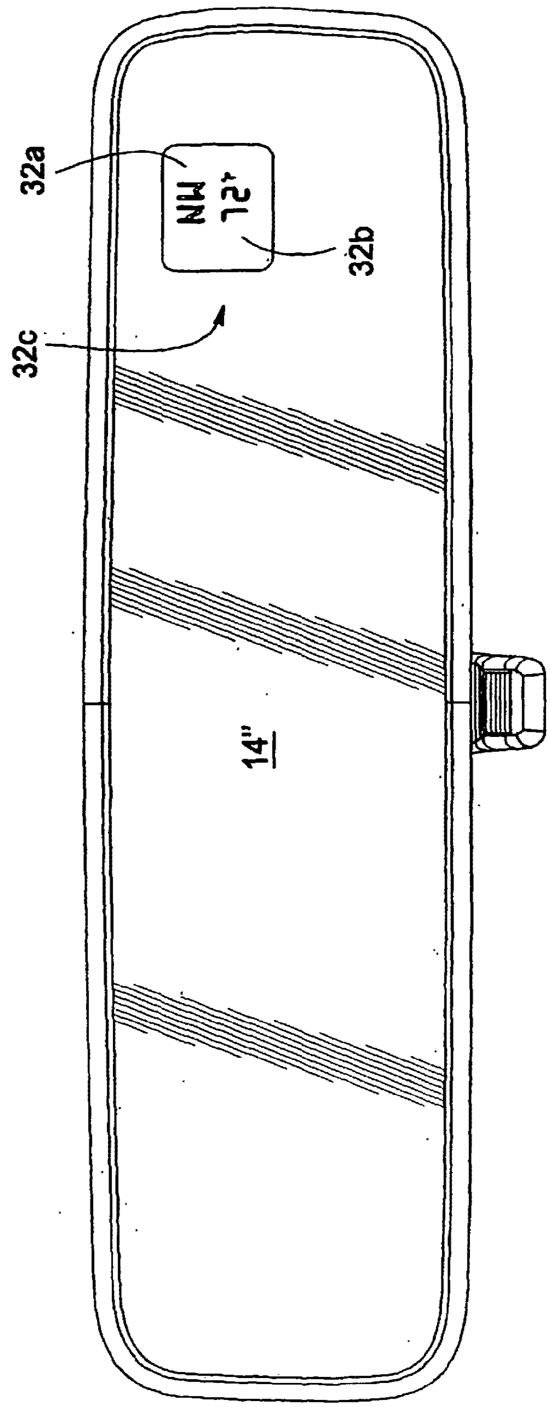

FIG. 17

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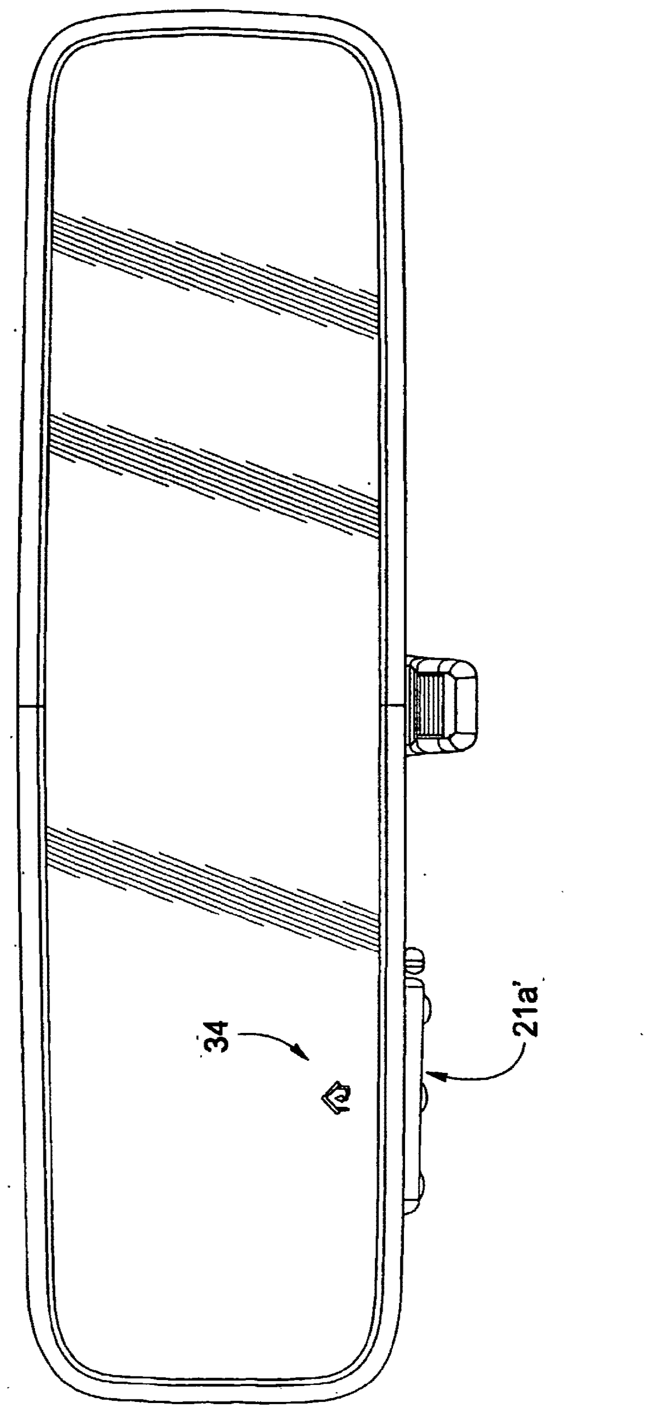

FIG. 18

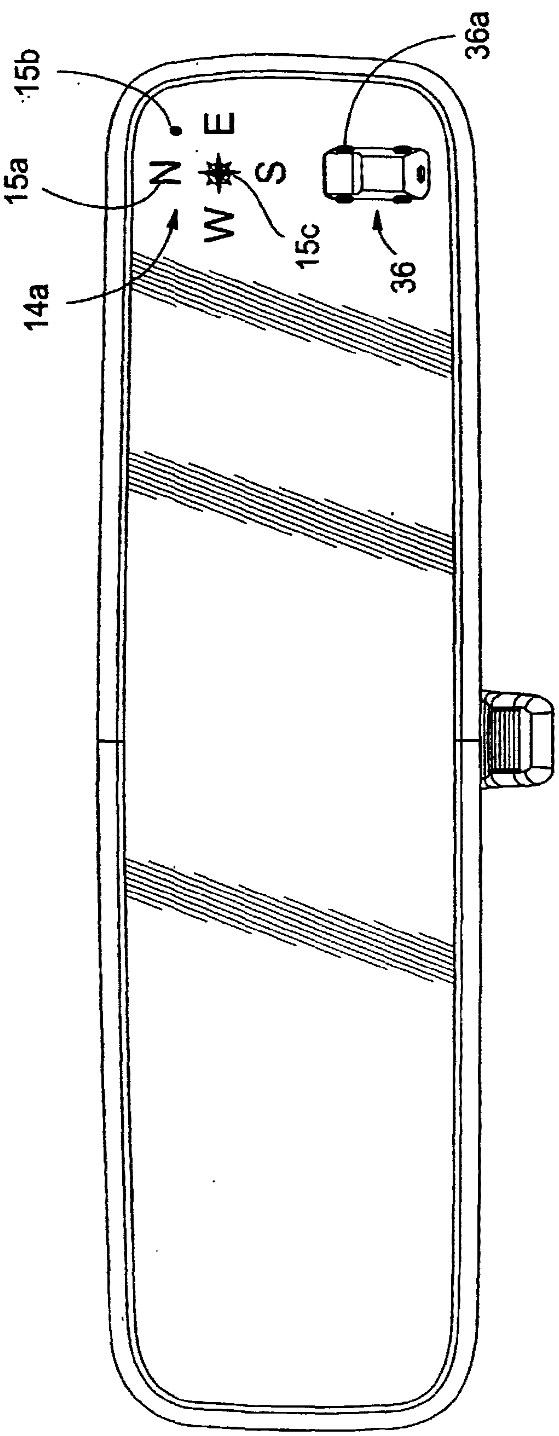

FIG. 19

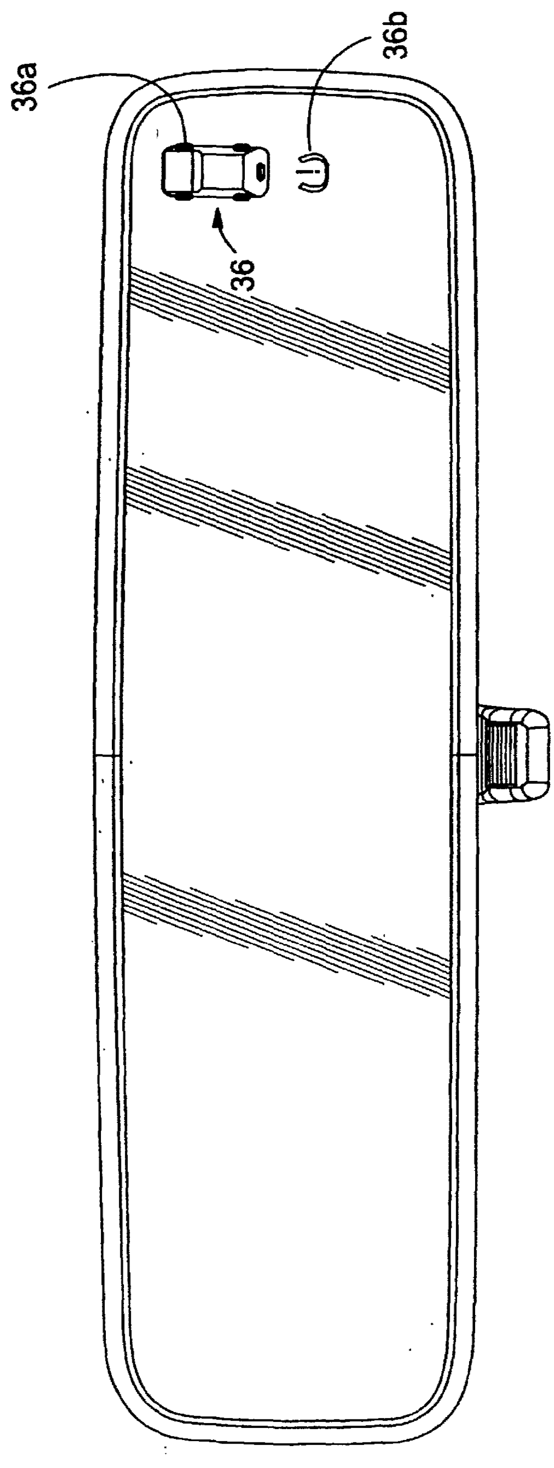

FIG. 20

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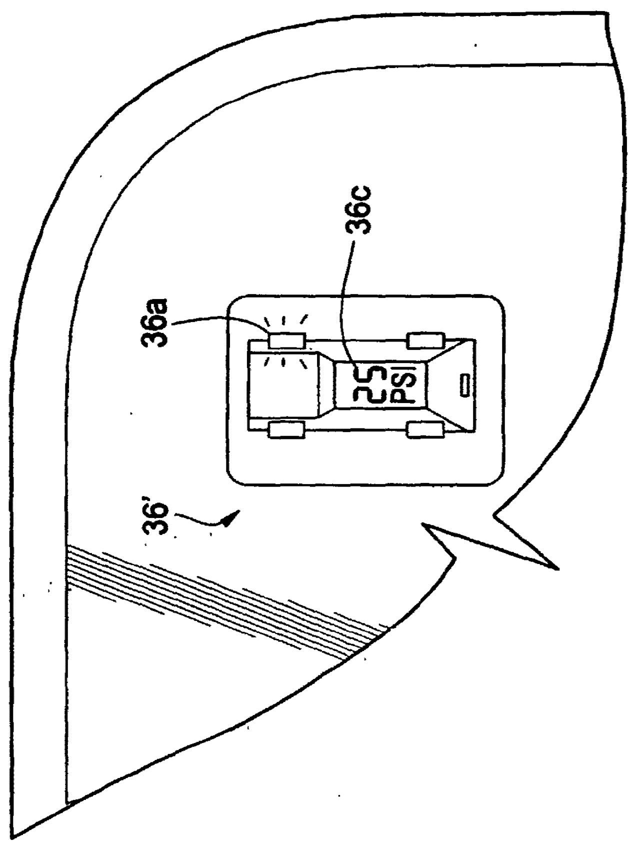

FIG. 21

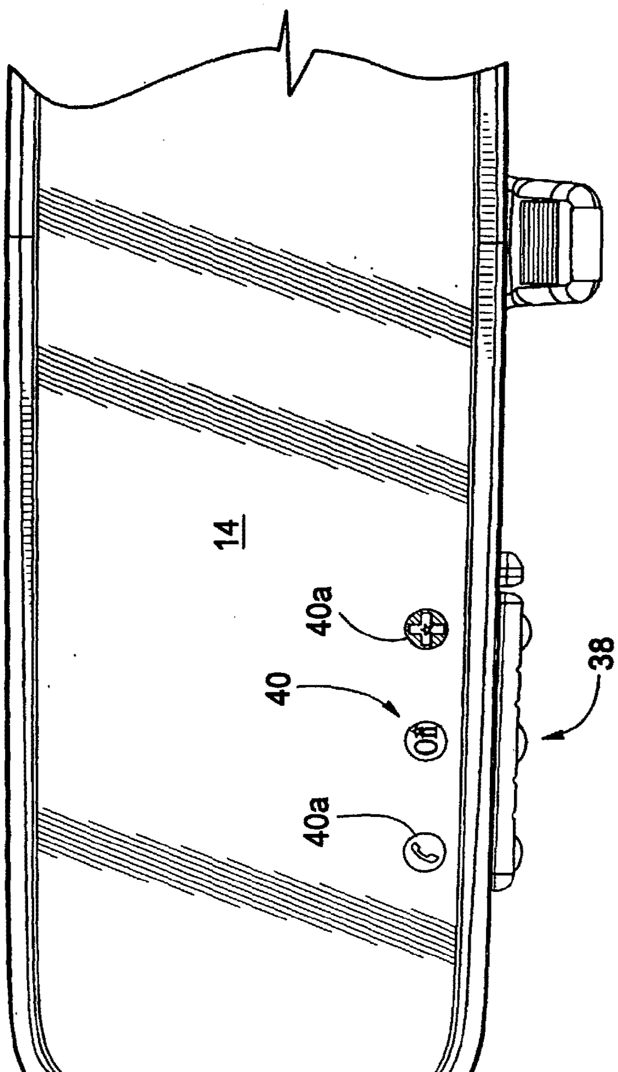

FIG. 22

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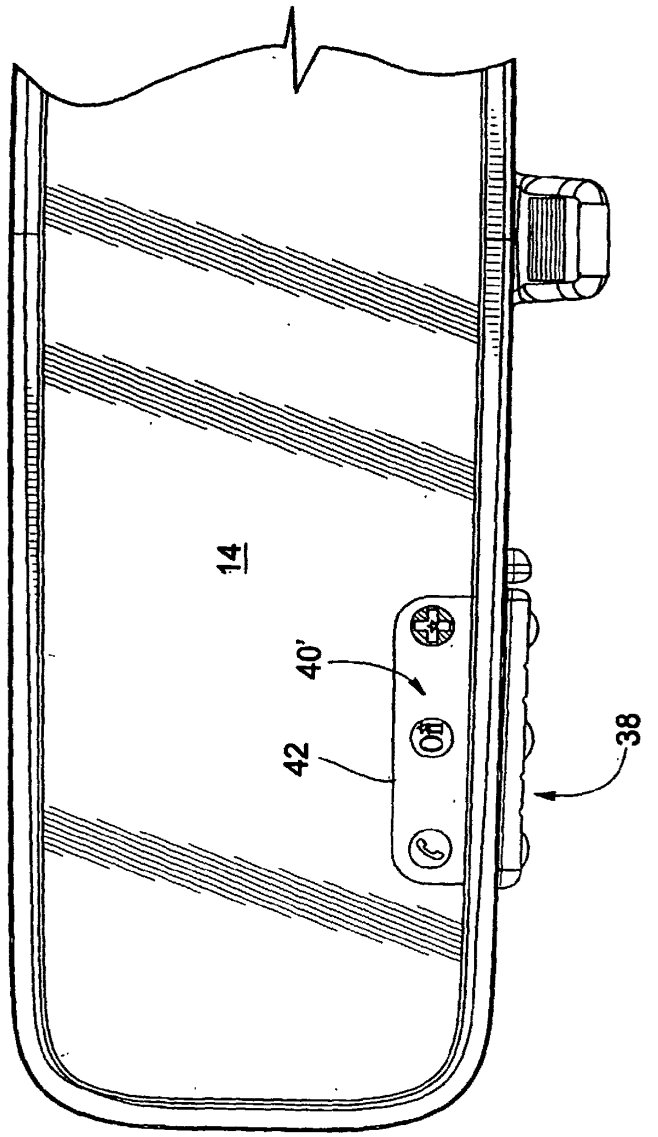

FIG. 23

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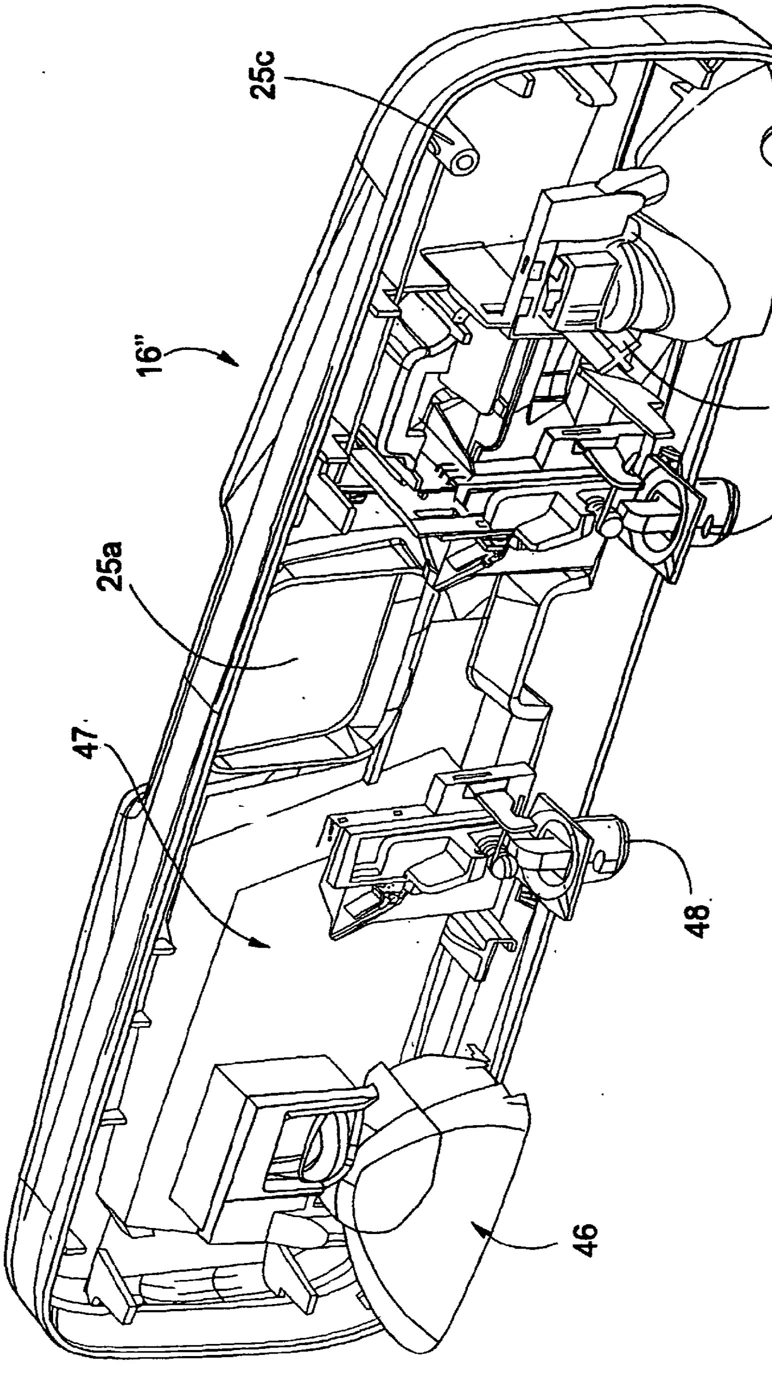

FIG. 24

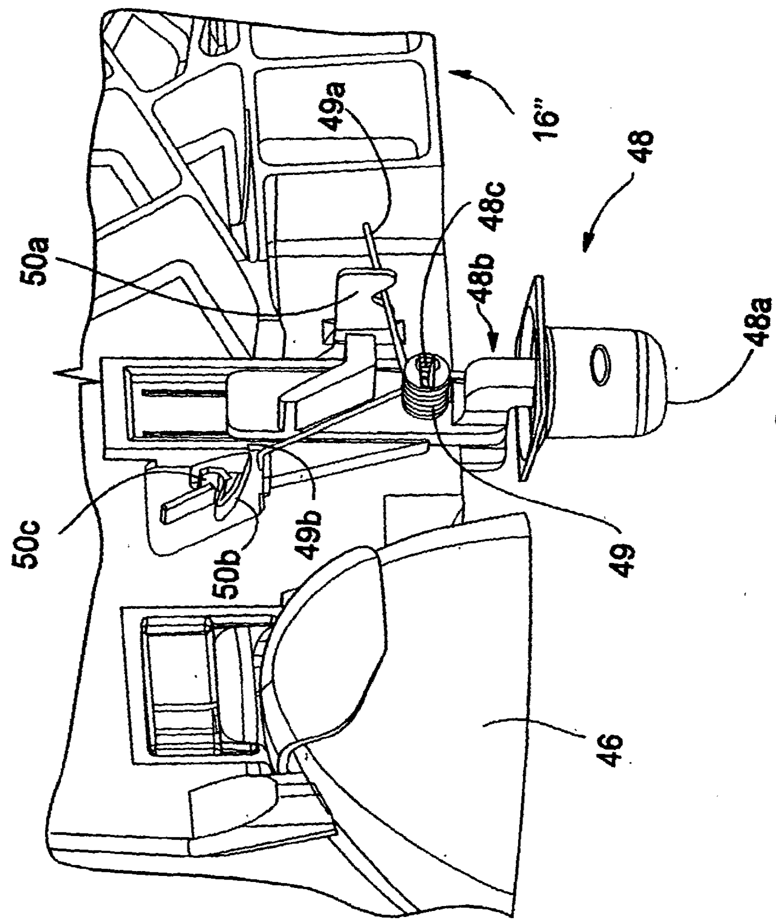

FIG. 25

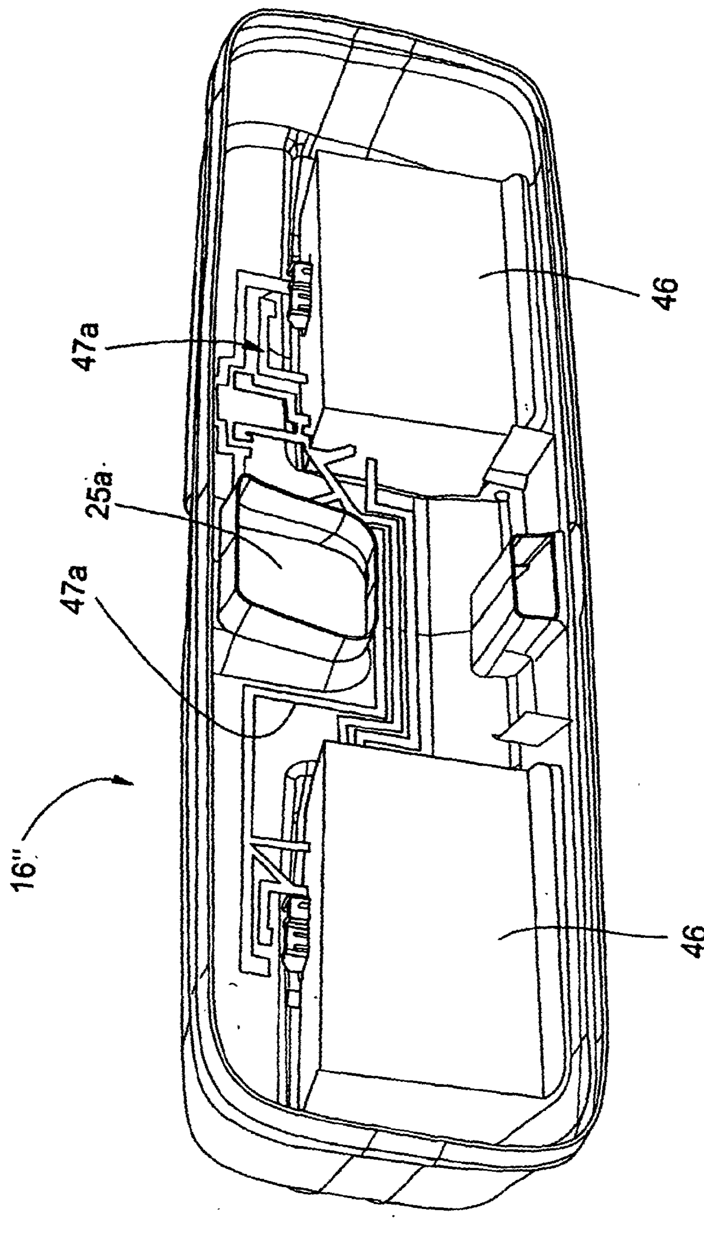

FIG. 26

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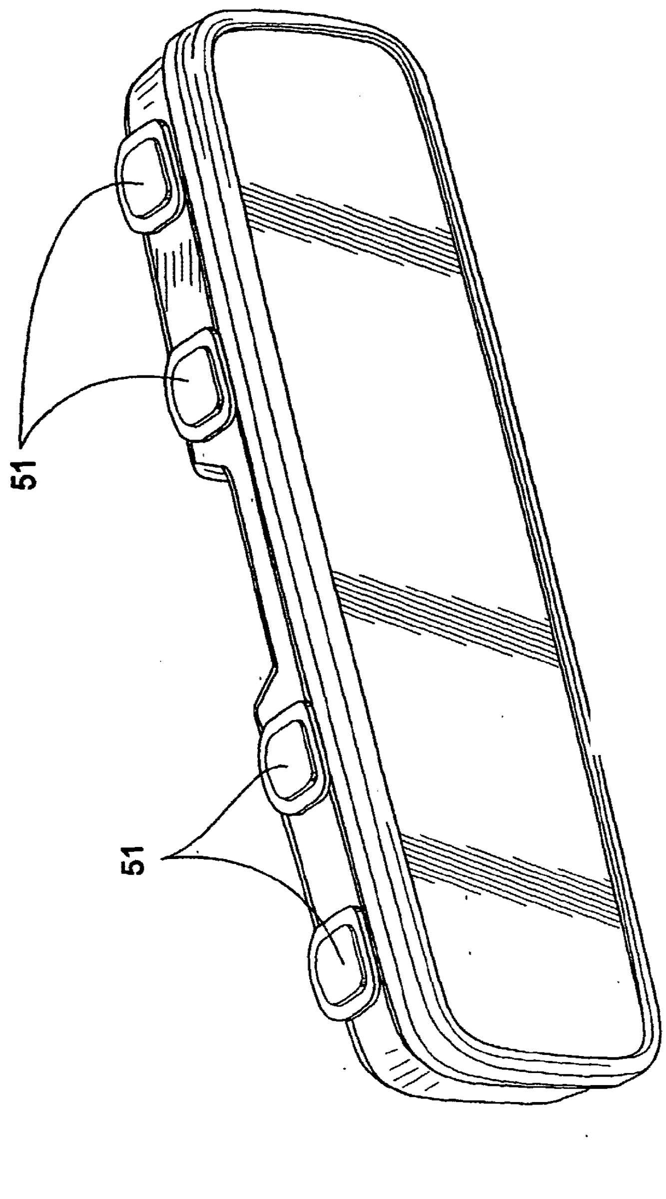

FIG. 27

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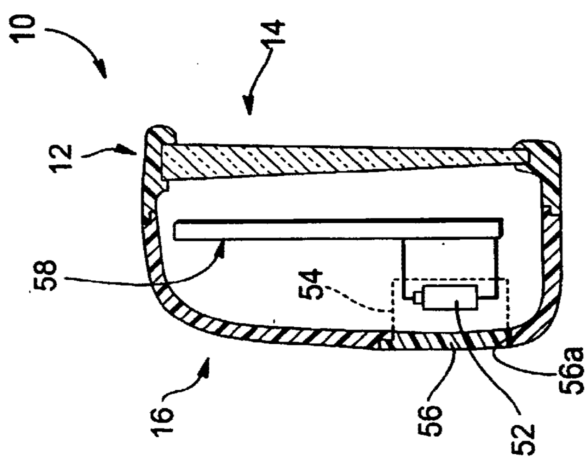

FIG. 28

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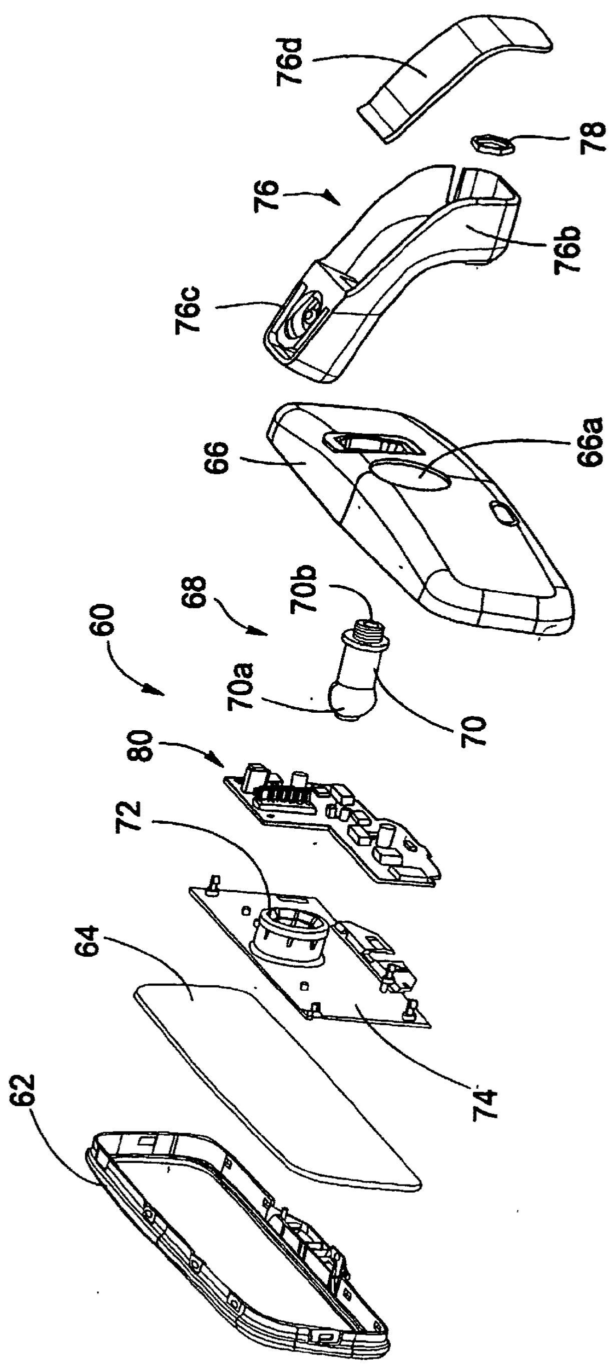

FIG. 29

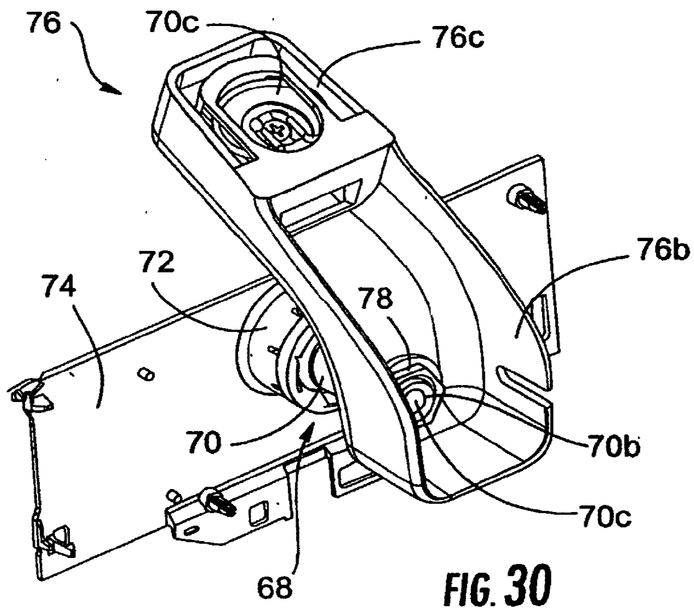
76
70c
76c
76b
74
72
78
70
70b
70c
68

FIG. 30

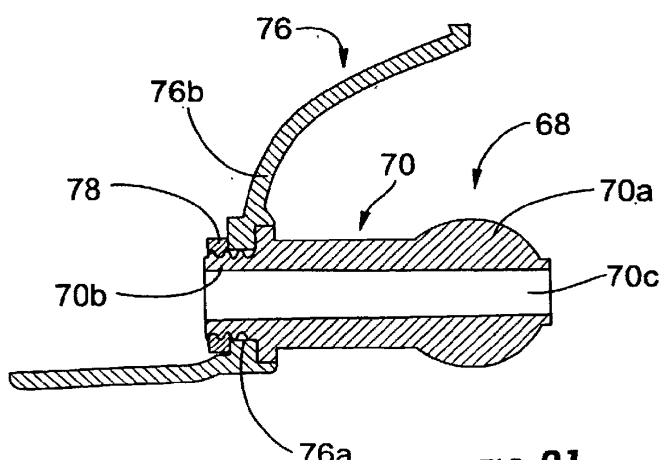
76
76b
68
70
78
70a
70b
70c
76a

FIG. 31

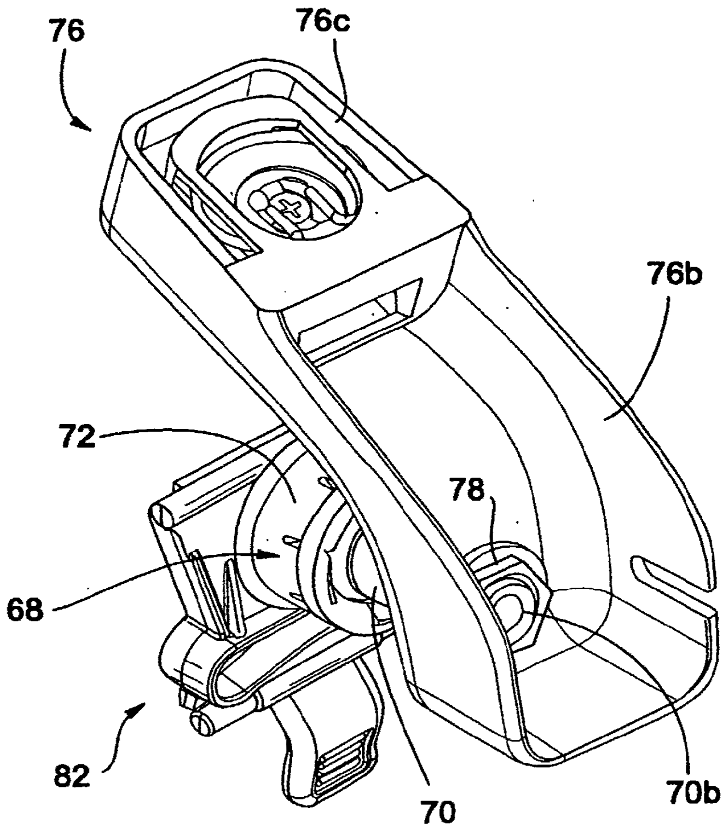

FIG. 32

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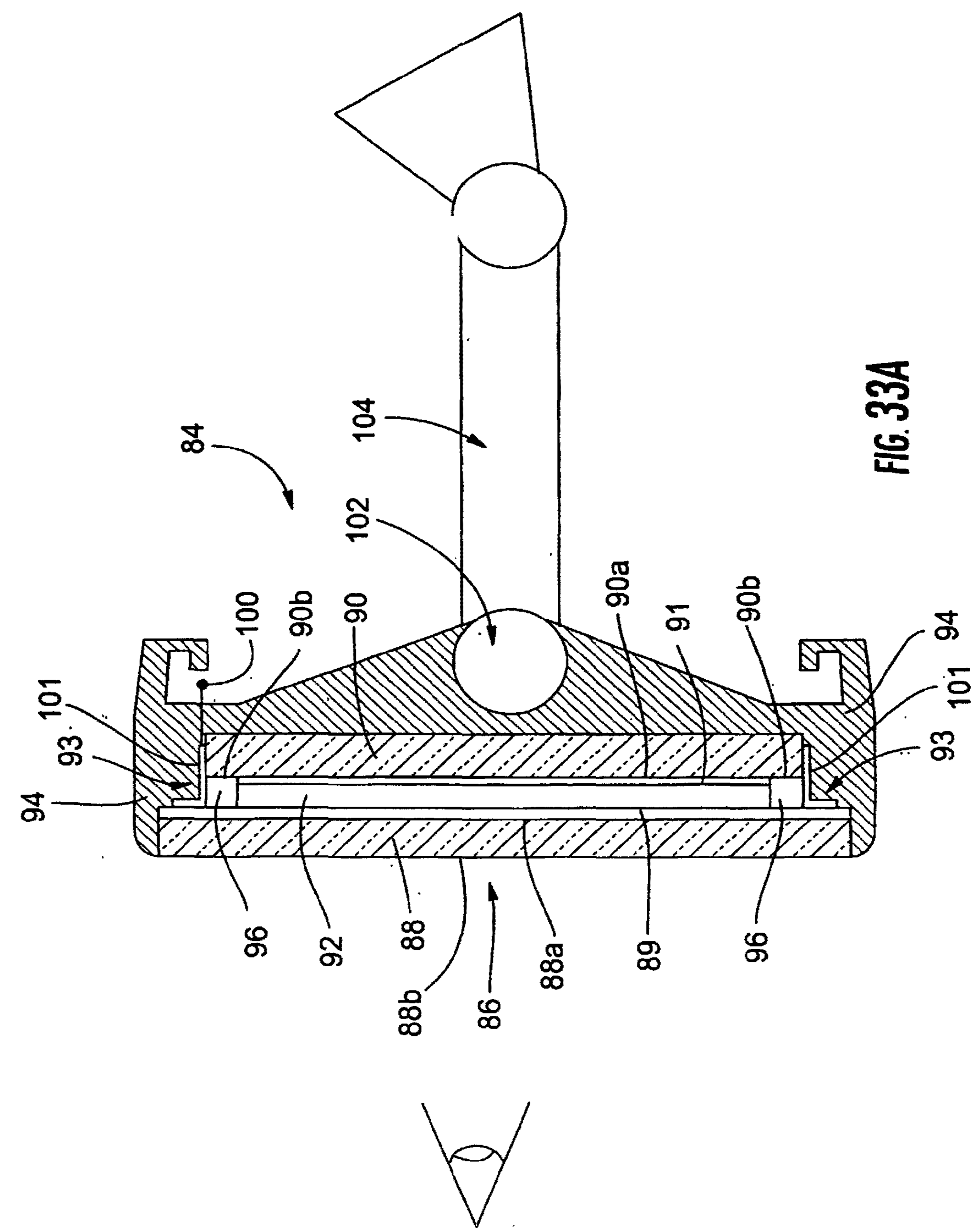
84
104
102
100
90b
90
90a
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94
96
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88b
86
88a
89
96

FIG. 33A

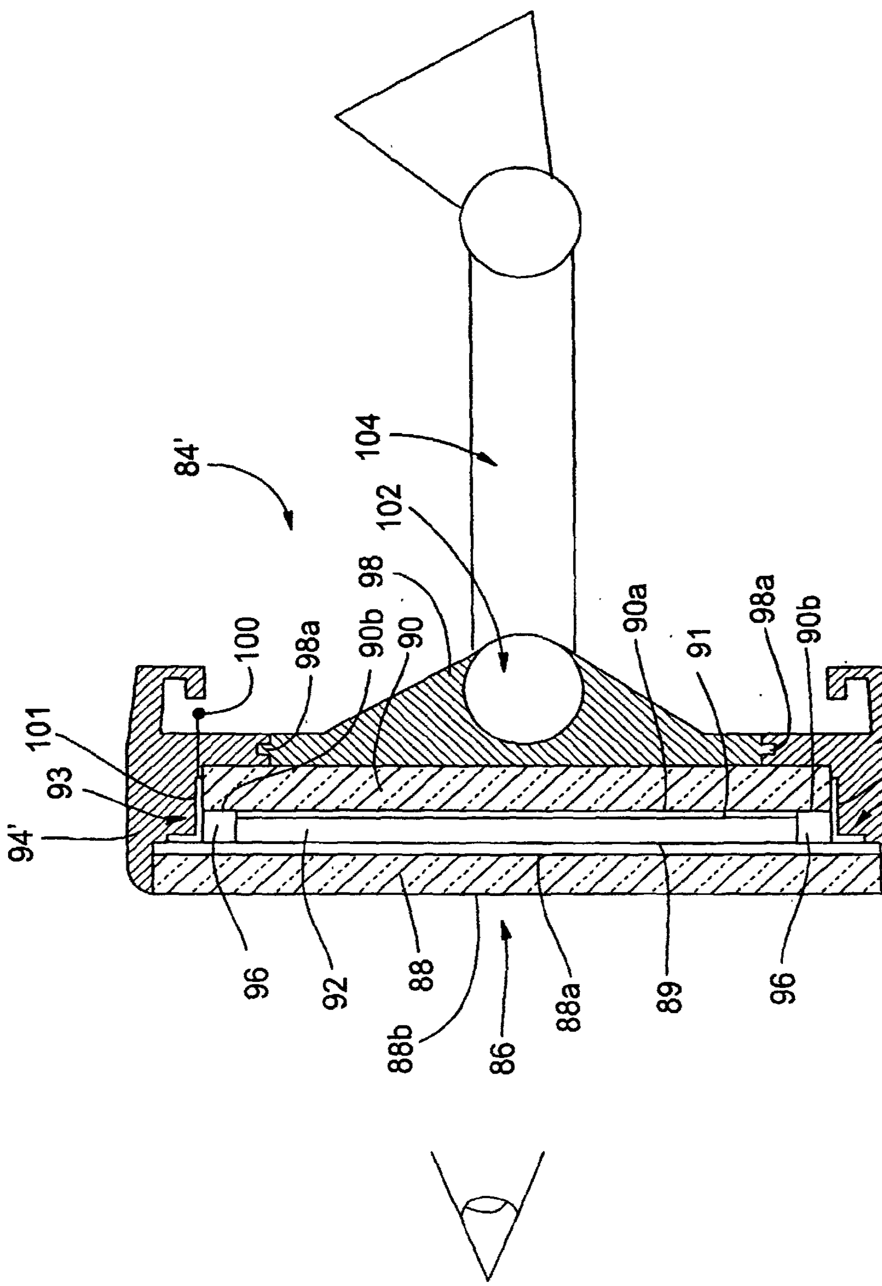

FIG. 33B

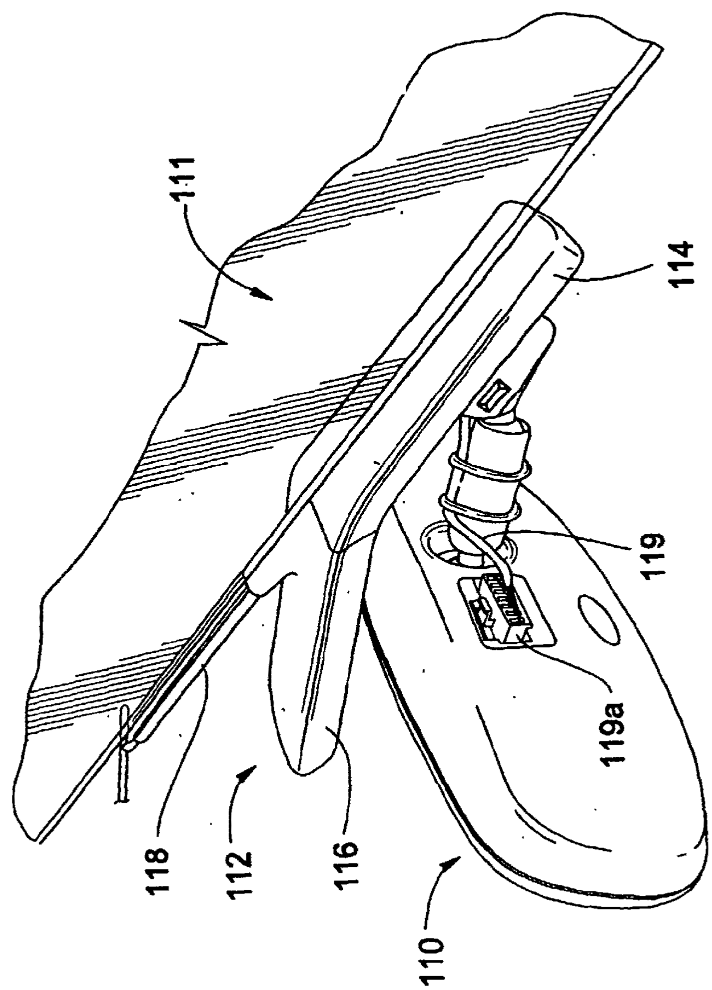

FIG. 34

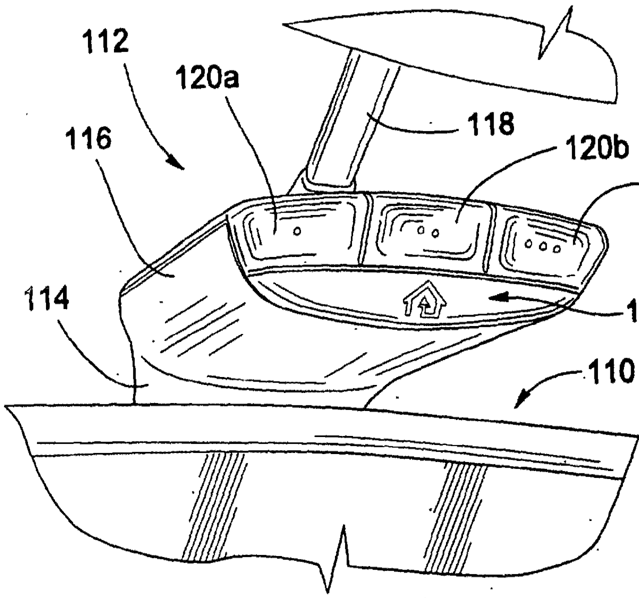

FIG. 35A

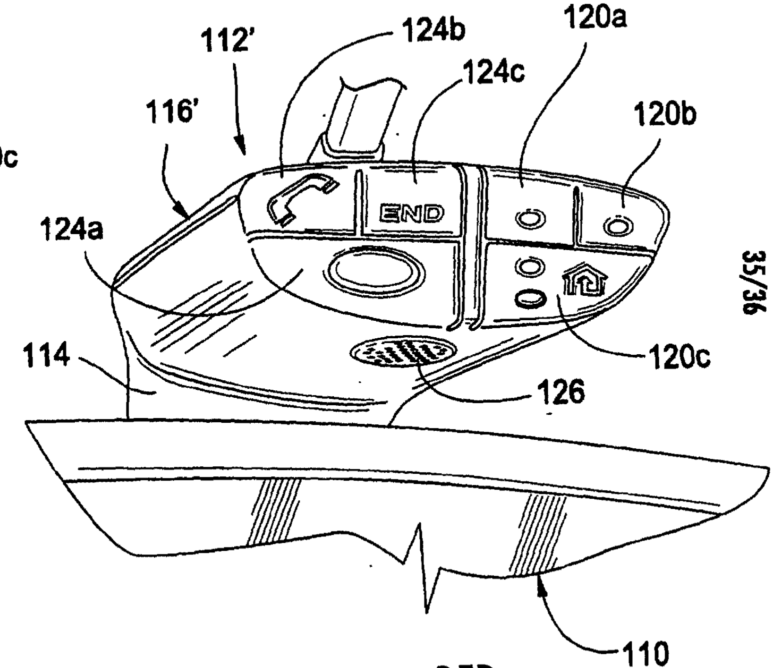

FIG 35B

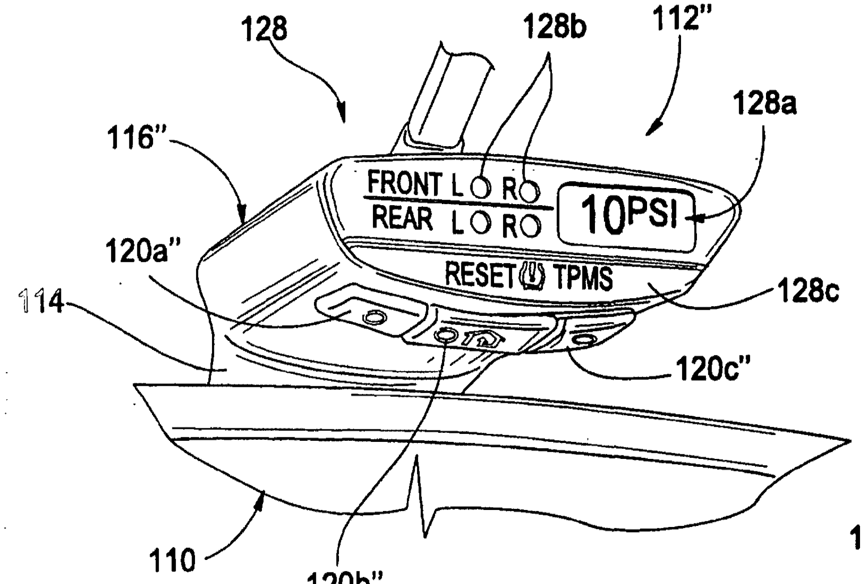

FIG. 35C

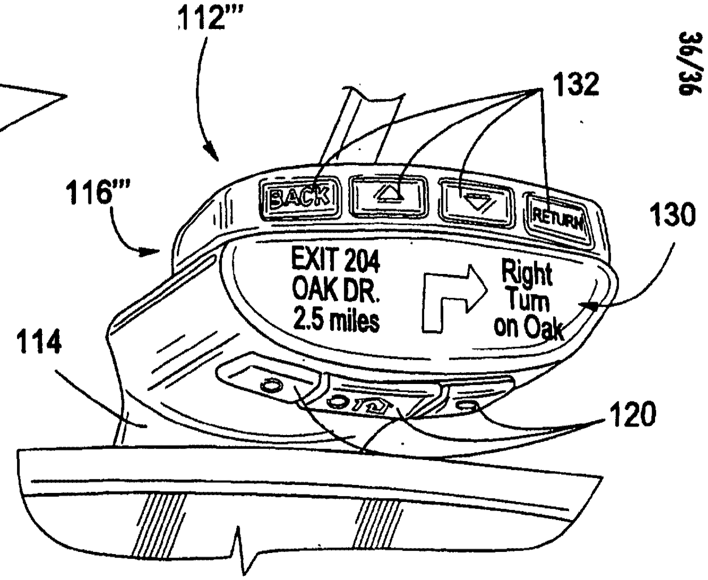

FIG. 35D

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(71) Applicant *(for all designated States except US)*: **DONNELLY CORPORATION** [US/US]; 414 East Fortieth Street, Holland, Michigan 49423-5368 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BAUR, Michael J.** [US/US]; 5089 Reis Circle, Fayetteville, New York 13966 (US). **MCCABE, Ian A.** [IE/US]; 16092 Ransom Street, Holland, Michigan 49424 (US). **HABIBI, Hamid** [IR/US]; 4057 66th Street, Holland, Michigan 49423 (US). **LYNAM, Niall R.** [US/US]; 248 Foxdown, Holland, Michigan 49424 (US).

(74) Agent: **VAN DYKE, GARDNER, LINN & BURKHART, LLP**; Timothy A. Flory, 2851 Charlevoix Drive Se, P.o. Box 888695, Grand Rapids, Michigan 49588-8695 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

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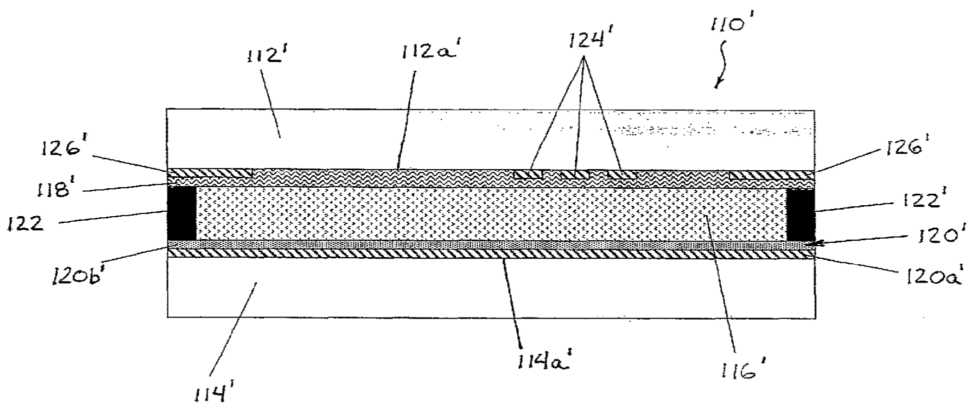
Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

[Continued on next page]

(54) **Title:** VEHICLE MIRROR ASSEMBLY WITH INDICIA AT REFLECTIVE ELEMENT



(57) **Abstract:** A rearview mirror assembly for a vehicle includes a reflective element (110) having at least one substrate (114) with a reflective coating (120) thereon. A specularly reflective indicia reflector (124) is established to form indicia or information at the reflective element. The indicia reflector provides a visible contrast to the main mirror reflector so that the indicia or information is subtly viewable by a person viewing the mirror assembly. The reflective element reflects light incident thereon over the surface coated by the reflective coating of the main mirror reflector, including the area at which the indicia reflector is established.

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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
— *of inventorship (Rule 4.17(iv))*

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VEHICLE MIRROR ASSEMBLY WITH INDICIA AT REFLECTIVE ELEMENT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. provisional applications, Ser. No. 60/681,250, filed May 16, 2005 (Attorney Docket DON01 P-1221); Ser. No. 60/690,400, filed Jun. 14, 2005 (Attorney Docket DON01 P-1225); Ser. No. 60/695,149, filed Jun. 29, 2005 (Attorney Docket DON01 P-1227); Ser. No. 60/730,334, filed Oct. 26, 2005 (Attorney Docket DON01 P-1250); Ser. No. 60/750,199, filed Dec. 14, 2005 (Attorney Docket DON01 P-1260); Ser. No. 60/774,449, filed Feb. 17, 2006 (Attorney Docket DON01 P-1269); and Ser. No. 60/783,496, filed Mar. 18, 2006 (Attorney Docket DON01 P-1272), which are all hereby incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

[0002] The present invention relates to rearview mirror assemblies and, more particularly, to an interior or exterior rearview mirror assembly having information displayed at the mirror assembly.

BACKGROUND OF THE INVENTION

[0003] Interior and exterior mirrors for vehicles typically comprise a substrate having a first surface facing a viewer of the mirror and a second, reflecting surface opposite the first surface. Often, such mirrors may comprise electro-optic reflective element assemblies, which have first and second substrates, whereby the reflecting surface is typically at the third surface of the reflective element assembly (the front surface of the rear substrate) or at the fourth surface of the reflective element assembly (the rear surface of the rear substrate). It is common to include information created on the reflective element substrate, such as safety messages (for example, an exterior rearview mirror may include the message "objects in mirror are closer than they appear" or the like) or other information or indicia. Examples of such indicia are described in U.S. Pat. Nos. 5,189,537 and 5,825,527, which are hereby incorporated herein by reference in their entireties.

[0004] Such indicia or information is typically created by removal of the reflective coating or layers at the respective surface of the substrate, such as by sand blasting or laser ablating the reflective coating, or by overlaying or overcoating a material onto one of the layers or coatings, such as by screening of materials, such as ink or epoxy, onto the layers or coatings at the respective substrate surface (such as described in U.S. Pat. No. 5,189,537, which is hereby incorporated herein by reference). Such indicia or information thus provides a marked, highly visible and definite indicia or information conveyance that is readily discernible and viewable by a person viewing the mirror assembly.

SUMMARY OF THE INVENTION

[0005] The present invention provides a display of information or indicia at a reflective element by applying or disposing or otherwise forming or establishing indicia or the like by establishing a layer of a material that is different from the reflective material that is coated on the respective substrate to define the reflective surface of the reflective element (such as a layer of reflective material that has a distinctly higher or lower reflectivity than that of the layer of reflective material it is coated over or under). The indicia or information is visible to the viewer of the mirror assembly without unduly detracting from or interfering with the functionality of the reflective element.

[0006] According to an aspect of the present invention, a rearview mirror assembly for a vehicle includes a reflective element having a substrate with a reflective coating thereon. A layer of material is established to form indicia or information at the reflective element. The layer of material provides a visible contrast between the reflective coating and the layer of material so that the indicia or information is viewable by a person viewing the mirror assembly. The reflective element reflects light incident thereon over the coated surface, including the area at which the layer of material is disposed, and the indicia so created (such as for example, a vehicle brand name or logo) is subtly visible to the viewer by contrast with the adjacent main reflector coating reflective property, so that the presence of the indicia or logo is visible but subtle and non-obtrusive.

[0007] The layer of material may comprise a reflective material or a transparent material, and may be discernible due to a contrast in color or reflectance or due to an interference effect or difference in refractive index or the like. The reflective element may comprise an electro-optic reflective element assembly or cell, such as an electrochromic reflective element or cell, and may have the reflective coating at the third or fourth surface of the cell (the front surface of the rear substrate or the rear surface of the rear substrate). The layer of material may be disposed or established over the reflective coating or under the reflective coating. The layer of material may be established to provide indicia or a logo or the like, or to provide an information message or the like at the mirror reflective element. The invention may also be applicable to non-electro optic mirrors such as conventional chromium or titanium mirror reflectors or to blue mirror reflectors (as are commonly known in the automotive mirror art).

[0008] Therefore, the present invention provides a mirror reflective element that includes an information message or indicia established at the reflective element that does not unduly detract from or interfere with the functionality of the reflective element. The reflective element provides a desired amount of reflectance of visible light incident thereon over the reflective area of the mirror, including the area or region that includes the indicia or information, maintaining at least about 35 percent reflectivity (as measured using SAE J964a), more preferably at least about 40 percent reflectivity, and most preferably at least about 45 percent reflectivity, in the region or regions where the indicia is established. The reflective element and indicia layer thus provide a watermark-type effect at the reflective element, which allows the vehicle manufacturer or mirror manufacturer to provide a brand name or emblem or logo or the like at the reflective element without unduly affecting the reflectance of the reflective element over the viewable reflective surface of the reflective element.

[0009] These and other objects, advantages, purposes and features of the present invention will become apparent upon review of the following specification in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a front elevation of a reflective element of a rearview mirror assembly in accordance with the present invention;

[0011] FIG. 2 is a rear elevation of the reflective element of FIG. 1;

[0012] FIG. 3 is a sectional view of a reflective element of the present invention;

[0013] FIG. 4 is a sectional view of a rear substrate of a reflective element of the present invention;

[0014] FIG. 5 is a sectional view of another rear substrate of a reflective element of the present invention;

[0015] FIG. 6 is a sectional view of a reflective element of the present invention;

[0016] FIG. 6A is a sectional view of another reflective element of the present invention;

[0017] FIG. 6B is a sectional view of another reflective element of the present invention;

[0018] FIG. 7 is a sectional view of another reflective element of the present invention, with a display element at a patterned element at the fourth surface of the reflective element;

[0019] FIG. 8 is a sectional view of another reflective element of the present invention, with a display element at a transflective element at the fourth surface of the reflective element;

[0020] FIG. 9 is a sectional view of another reflective element of the present invention, with a display element module at the fourth surface of the reflective element;

[0021] FIG. 10A is a sectional view of another reflective element of the present invention, with a display element at the rear of the reflective element;

[0022] FIG. 10B is a plan view of the display element of FIG. 10A;

[0023] FIG. 10C is a sectional view of the display element of FIGS. 10A and 10B;

[0024] FIG. 10D is a sectional view of another reflective element of the present invention, with a display element at the rear of a transflective electro-optic reflective element;

[0025] FIG. 10E is a sectional view of another reflective element of the present invention, with a display element at the rear of a non-electro-optic reflective element;

[0026] FIG. 10F is a plan view of the display element of FIG. 10E;

[0027] FIG. 10G is a sectional view of the display element of FIGS. 10E and 10F;

[0028] FIG. 10H is a sectional view of another reflective element of the present invention, with a display element at the rear of a transflective electro-optic reflective element;

[0029] FIG. 10I is a sectional view of another reflective element of the present invention, with a display element at the rear of a transflective reflective element;

[0030] FIG. 11 is a plan view of another reflective element of the present invention;

[0031] FIG. 12 is a plan view of another reflective element of the present invention, with a wide angle mirror portion;

[0032] FIG. 13 is a sectional view of the wide angle mirror portion of the reflective element of FIG. 12;

[0033] FIG. 14 is a sectional view of a curved non-electro-optic reflective element of the present invention;

[0034] FIG. 15A is a plan view of a non-electro-optic reflective element having a perimeter band formed thereon in accordance with the present invention;

[0035] FIG. 15B is a sectional view of the non-electro-optic reflective element of FIG. 15A;

[0036] FIG. 16 is a plan view of another non-electro-optic reflective element having a perimeter band formed thereon in accordance with the present invention;

[0037] FIG. 17 is a perspective view of a rear substrate of a mirror reflective element for an exterior rearview mirror of the present invention, as viewed from the front or third surface of the rear substrate;

[0038] FIG. 18 is a perspective view of the rear substrate of FIG. 17, as viewed from the rear or fourth surface of the rear substrate;

[0039] FIG. 19 is a sectional view of the rear substrate of FIGS. 17 and 18, with the third and fourth surface wrap-around coatings thereon;

[0040] FIG. 20 is a perspective view of the rear substrate of FIGS. 17-19, as viewed from the front or third surface of the rear substrate, and showing the transflective mirror layer or layers disposed thereon;

[0041] FIG. 21 is a sectional view of a mirror reflective element, incorporating the rear substrate of FIG. 20 in accordance with the present invention;

[0042] FIG. 22 is a sectional view of another mirror reflective element in accordance with the present invention;

[0043] FIG. 23 is a graph depicting optical properties of a coated rear substrate in accordance with the present invention;

[0044] FIG. 24 is a graph depicting optical properties of a mirror cell in accordance with the present invention;

[0045] FIG. 25 is a graph depicting optical properties of a coating of the present invention;

[0046] FIG. 26 is a table listing the initial performance characteristics of samples of electrochromic cells in accordance with the present invention;

[0047] FIG. 27 is a table similar to the table of FIG. 26, but listing the performance characteristics of the samples after 50,000 cycles;

[0048] FIG. 28 is a sectional view of a reflective element assembly in accordance with the present invention;

[0049] FIG. 29 is a sectional view of another reflective element assembly in accordance with the present invention;

[0050] FIG. 30 is a partial sectional view of a mirror assembly in accordance with the present invention;

[0051] FIG. 30A is another partial sectional view of the mirror assembly of FIG. 30;

[0052] FIG. 30B is a partial sectional view of another mirror assembly in accordance with the present invention;

[0053] FIG. 31 is a rear plan view of a reflective element assembly of the present invention;

[0054] FIG. 32 is a perspective view of another mirror reflective element assembly in accordance with the present invention; and

[0055] FIG. 33 is front plan view of another mirror reflective element assembly in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0056] Referring now to the drawings and the illustrative embodiments depicted therein, a reflective element 10 (FIGS. 1 and 2) for a rearview mirror assembly, such as for an interior or exterior rearview mirror assembly for a vehicle, may comprise an electro-optic reflective element assembly or cell, such as an electrochromic reflective element or cell. The reflective element 10 includes a front substrate 12 and a rear substrate 14 (FIGS. 1-3). The rear reflective element substrate 14 is spaced from front reflective element substrate 12, and the cell includes an electrolyte or monomer composition or electrochromic medium 16 and conductive or semi-conductive layers 18, 20 (described below) sandwiched therebetween. An epoxy seal material 22 or the like, is applied between the substrates to define the cavity for the electrochromic medium and to adhere the substrates together. Reflective element assembly 10 includes a reflectant indicia layer 24 disposed or otherwise formed at the rear surface 12a of the front substrate 12 or the front surface 14a of rear substrate 14, whereby the reflectant indicia layer 24 is viewable through the front substrate 12 by a driver of the vehicle, yet does not interfere with the reflectance of the reflective element assembly.

[0057] The rearview mirror assembly may comprise an electro-optic or electrochromic reflective element or cell, such as an electrochromic mirror assembly and electrochromic reflective element utilizing principles disclosed in commonly assigned U.S. Pat. Nos. 6,690,268; 5,140,455; 5,151,816; 6,178,034; 6,154,306; 6,002,544; 5,567,360; 5,525,264; 5,610,756; 5,406,414; 5,253,109; 5,076,673; 5,073,012; 5,117,346; 5,724,187; 5,668,663; 5,910,854; 5,142,407; 4,824,221; 5,818,636; 6,166,847; 6,111,685; 6,392,783; 6,710,906; 6,798,556; 6,554,843 and/or 4,712,879, and/or U.S. pat. applications, Ser. No. 10/054,633, filed Jan. 22, 2002 by Lynam et al. for VEHICULAR LIGHTING SYSTEM (Attorney Docket DON01 P-962); and/or Ser. No. 11/021,065, filed Dec. 23, 2004 (Attorney Docket DON01 P-1193), and/or International Pat. Publication Nos. WO 2004/098953, published Nov. 18, 2004; WO 2004/042457, published May 21, 2004; and WO 2003/084780, published Oct. 16, 2003, which are all hereby incorporated herein by reference in their entireties, and/or as disclosed in the following publications: N. R. Lynam, "Electrochromic Automotive Day/Night Mirrors", *SAE Technical Paper Series* 870636 (1987); N. R. Lynam, "Smart Windows for Automobiles", *SAE Technical Paper Series* 900419 (1990); N. R. Lynam and A. Agrawal, "Automotive Applications of Chromogenic Materials", *Large Area Chromogenics: Materials and Devices for Transmittance Control*, C. M. Lampert and C. G. Granquist, EDS., Optical Engineering Press, Wash. (1990), which are hereby incorporated by reference herein in their entireties. The thicknesses and materials of the coatings on the substrates of the electrochromic reflective element, such as on the third surface of the reflective element assembly, may be selected to provide a desired color or tint to the mirror reflective element, such as a blue colored reflector, such as is known in the art and/or such as described in U.S. Pat. Nos. 5,910,854 and 6,420,036, and in PCT Application No. PCT/US03/29776, filed Sep. 9, 2003 by Donnelly Corp. et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)), which are all hereby incorporated herein by reference in their entireties.

[0058] Optionally, use of an elemental semiconductor mirror, such as a silicon metal mirror, such as disclosed in U.S. Pat. Nos. 6,286,965; 6,196,688; 5,535,056; 5,751,489; and 6,065,840, and/or in U.S. pat. application, Ser. No. 10/993,302, filed Nov. 19, 2004 by Lynam for MIRROR REFLECTIVE ELEMENT FOR A VEHICLE (Attorney Docket DON01 P-1186), which are all hereby incorporated herein by reference in their entireties, can be advantageous because such elemental semiconductor mirrors (such as can be formed by depositing a thin film of silicon) can be greater than 50 percent reflecting in the photopic (SAE J964a measured), while being also substantially transmitting of light (up to 20 percent or even more). Such silicon mirrors also have the advantage of being able to be deposited onto a flat glass substrate and to be bent into a curved (such as a convex or aspheric) curvature, which is also advantageous since many passenger-side exterior rearview mirrors are bent or curved.

[0059] As shown in FIG. 3, the rear surface 12a of front substrate 12 may have a transparent conductive layer 18 disposed thereon. The transparent conductive layer 18 may comprise any suitable transparent conductive coating or layer, such as an indium tin oxide (ITO) or doped (antimony or fluorine doped) tin oxide or doped zinc oxide (such as aluminum-doped zinc oxide) or an ITO/thin Ag/ITO stack or an ITO/thin Al/ITO stack or a thin (preferably, less than about 200 angstroms in physical thickness; more preferably less than about 150 angstroms thick; most preferably less than about 125 angstroms thick; and greater than about 75 angstroms thick, more preferably greater than about 85 angstroms thick and most preferably greater than about 100 angstroms thick) coating of silver (or a silver alloy) sandwiched between ITO or doped zinc oxide layers or a thin coating of aluminum (or an aluminum alloy) sandwiched between ITO or doped zinc oxide layers or a thin coating of platinum or palladium (or an alloy thereof) sandwiched between ITO or doped zinc oxide layers or a thin coating of ruthenium (or a ruthenium alloy) sandwiched between ITO or doped zinc oxide layers, or such as the conductive layers described in U.S. Pat. Nos. 6,690,268; 5,668,663; 5,142,406; 5,442,478 and 5,724,187, and/or in U.S. pat. applications, Ser. No. 10/054,633, filed Jan. 22, 2002 by Lynam et al. for VEHICULAR LIGHTING SYSTEM (Attorney Docket DON01 P-962); Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); Ser. No. 10/528,269, filed Mar. 17, 2005 (Attorney Docket DON01 P-1109); Ser. No. 10/533,762, filed May 4, 2005 (Attorney Docket DON01 P-1116), and/or in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); and/or

PCT Application No. PCT/US03/35381, filed Nov. 5, 2003 by Donnelly Corp. et al. for ELECTRO-OPTIC REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1116(PCT)), which are hereby incorporated herein by reference in their entireties. Note that double-silver stacks (as such term is commonly known and used in the heat mirror-coated art) may be used as a transparent conductor layer. Transparent conductor layers useful in the present invention thus may comprise conductive material such as tin oxide (SnO_2) doped with antimony or fluorine, indium oxide, indium oxide and tin (In_2O_3Sn) (preferably 5-15 percent Sn), zinc oxide (ZnO), zinc oxyfluoride, zinc oxide and indium (ZnO:In), zinc oxide and aluminum (ZnO:Al), cadmium stannate ($Cd_2\ SnO_4$), cadmium stannite ($CdSnO_3$), cadmium oxide (CdO), copper sulfide (Cu_2S), titanium nitride (TiN), or titanium oxynitride (TiO_xN_{1-x}) to provide electrical contact to the electrochromic medium and/or for other layers/elements useful in the present invention.

[0060] In the illustrated embodiment, the reflective element 10 comprises a third surface reflective element, and the front surface 14a of rear substrate 14 includes a metallic reflective layer or coating or coatings 20 disposed thereon. The metallic reflective coatings 20 may comprise any suitable metallic layer or layers, such as silver or chromium or rhodium or aluminum or the like, and/or such as the layer or layers of the types described in U.S. Pat. Nos. 6,690,268; 5,668,663 and 5,724,187, and/or in U.S. pat. application, Ser. No. 10/054,633, filed Jan. 22, 2002 by Lynam et al. for VEHICULAR LIGHTING SYSTEM (Attorney Docket DON01 P-962); Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); Ser. No. 10/528,269, filed Mar. 17, 2005 (Attorney Docket DON01 P-1109); Ser. No. 10/533,762, filed May 4, 2005 (Attorney Docket DON01 P-1116), and/or in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); and/or PCT Application No. PCT/US03/35381, filed Nov. 5, 2003 by Donnelly Corp. et al. for ELECTRO-OPTIC REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1116(PCT)), which are hereby incorporated herein by reference in their entireties.

[0061] As shown in FIG. 3, the indicia reflector or indicia layer 24 may be disposed or established over a portion of the third surface metallic conductive layer 20. For example, the metallic reflective layer may comprise silver or aluminum or the like or alloys thereof, and may provide at least approximately 80 percent or more reflectivity of light incident thereon. The indicia metallic reflector 24 may comprise a metallic material that has a reduced reflectivity of light incident thereon as compared to the reflectivity of the metallic reflective layer 20. For example, the indicia metallic reflector 24 may comprise chromium or titanium or the like or alloys thereof, and thus may provide reflectivity in the range of approximately 35 percent to approximately 65 percent. The reduced reflectivity of light incident on the indicia metallic reflector 24 provides a contrast between the indicia reflector and the reflective coating 20, such that the indicia metallic reflector is discernible by a person viewing the reflective element, yet still provides reflectivity at the indicia area so as to not unduly affect the functionality of the reflective element. Optionally, the indicia reflector may comprise a dielectric coating, such as a transparent conductive coating, such as an ITO or doped tin oxide or doped zinc oxide (such as with an aluminum dopant) or the like, whereby the interference effect caused by the ITO adds a slight but discernible color tint at the indicia reflector so that the indicia is discernible by a person viewing the reflective element, yet still provides reflectivity at the indicia area so as to not unduly affect the functionality of the reflective element. Examples of various interference effects of ITO or other transparent conductive materials are described in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); and/or PCT Application No. PCT/US03/35381, filed Nov. 5, 2003 by Donnelly Corp. et al. for ELECTRO-OPTIC REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1116(PCT)); and/or PCT Application No. PCT/US2004/015424, filed May 18, 2004 by Donnelly Corp. et al. for MIRROR ASSEMBLY FOR VEHICLE (Attorney Docket DON01 FP-1150(PCT)); and/or U.S. pat. applications, Ser. No. 11/226,628, filed Sep. 14, 2005 (Attorney Docket DON01 P-1236); Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); Ser. No. 10/528,269, filed Mar. 17, 2005 (Attorney Docket DON01 P-1109); Ser. No. 10/533,762, filed May 4, 2005 (Attorney Docket DON01 P-1116); and/or Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); and/or U.S. provisional applications, Ser. No. 60/692,113, filed Jun. 20, 2005 (Attorney Docket DON01 P-1224); Ser. No. 60/677,990, filed May 5, 2005 (Attorney Docket DON01 P-1219); Ser. No. 60/653,787, filed Feb. 17, 2005 (Attorney Docket DON01 P-1207); Ser. No. 60/642,227, filed Jan. 7, 2005 (Attorney Docket DON01 P-1199); Ser. No. 60/638,250, filed Dec. 21, 2004 (Attorney Docket DON01 P-1198); Ser. No. 60/624,091, filed Nov. 1, 2004 (Attorney Docket DON01 P-1184), and Ser. No. 60/609,642, filed Sep. 14, 2004 (Attorney Docket DON01 P-1171), which are hereby incorporated herein by reference in their entireties.

[0062] As can be seen with reference to FIG. 4, the indicia reflector may be established over the reflective layer 20 at the front surface 14a of the rear substrate 14 so that the rear substrate with the indicia reflector established thereon may be readily assembled with the front substrate, electro-optic medium and seal in a suitable manner. Optionally, and as shown in FIG. 5, the indicia metallic reflector 24' may be applied to or established at a portion or region of the front surface 14a of the rear substrate 14, and the metallic conductive layer 20' may be disposed or established over substantially the rest of the front surface 14a and over the indicia metallic reflector 24', so that the indicia metallic reflector 24' is behind the reflective layer 20 and between at least one layer 20 and the rear substrate. For example, the indicia layer 24' may comprise a layer of chromium (such as about 2000 angstroms thick), and the reflective coating may comprise a layer of silver (such as about 600 angstroms thick). The presence of the thicker layer of chromium underneath the thin layer of silver provides a subtle viewable indicia layer at the reflective element, without adversely effecting the functionality of the reflective element. Optionally, materials for the layer may be selected to provide a difference in the reflectivity and/or color of the reflective coating or layer and the indicia layer to provide a discernible contrast so that the indicia is discernible by a person viewing the reflective element, yet still provides reflectivity at the indicia area so as to not unduly affect the functionality of the reflective element. Optionally, the indicia layer or reflector may be disposed or established at either side of a fourth surface reflective coating at the rear surface of the rear substrate in a similar manner to provide the desired discernibility of the indicia at the reflective element, without affecting the scope of the present invention.

[0063] The indicia reflector or layer may be established via any suitable means. For example, the indicia reflector may be disposed, such as by sputter coating or the like, at a masked area of the substrate surface to dispose the material at the desired location. Optionally, the indicia layer may be coated or screened onto the substrate surface or onto the reflective coating, such as by a screen/coat/strip process (where a resist pre-deposition is screened or printed onto the substrate, and the indicia layer (such as chromium or the like) is coated onto the substrate and the resist post deposition of the indicia layer material is washed away, whereby the indicia layer material remains at the screened or printed areas). Other means for applying or establishing or forming the indicia layer onto the substrate surface (or onto a reflective coating on the substrate surface) may be implemented without affecting the scope of the present invention.

[0064] Optionally, a light source or indicator may be positioned behind the indicia layer, such as at a circuit board within the mirror, to illuminate or backlight the indicia layer to further enhance viewing of the indicia, particularly in low lighting conditions, such as at nighttime. Optionally, the illumination source or light source behind the indicia may be selected to match the color that may be typically associated with the selected logo (such as discussed below), such as a green or red or blue indicator or light emitting diode or the like for the school color or the like. Other forms of customized logos or indicia or the like and associated illumination sources and the like may be established at the reflective element, without affecting the scope of the present invention.

[0065] Although shown and described as an exterior rearview mirror assembly, the reflective element of the present invention may be suitable for use with an interior rearview mirror assembly, where the reflective element and a housing of the mirror are pivotally or adjustably mounted to an interior portion of a vehicle, such as via a double ball mounting or bracket assembly or the like.

[0066] Optionally, the indicia layer may provide a graphic depiction of a desired image, such as a logo of the vehicle manufacturer or other desired image. For example, the indicia may be established or otherwise formed to provide the letters "FORD" or may be established or otherwise formed in a pattern similar to the design or designs indicative of the manufacturer, such as the Chevrolet "bowtie" or the like. Optionally, other designs or patterns or text or logos or indicia or the like may be provided at the reflective element to provide a desired image or logo. For example, the indicia layer may be formed to be indicative of other vehicle manufacturers or entities or sponsors or indicia or trademarks or emblems or signature items, or representations of a certain political views, religious beliefs, tribal affiliations, community ties, collegiate affiliations, allegiances and/or advocacy (such as, for example, a "peace" sign or other symbol or text or the like) or other views, affiliations, beliefs, etc., or other custom ports or icons may be formed elsewhere on the reflective element to convey other information or logos or the like, without affecting the scope of the present invention (and such as described in U.S. pat. application, Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193), and/or PCT Application No. PCT/US2004/015424, filed May 18, 2004 by Donnelly Corp. et al. for MIRROR ASSEMBLY FOR VEHICLE (Attorney Docket DON01 FP-1150(PCT)), which are hereby incorporated herein by reference in their entireties).

[0067] The desired image or logo may be indicative of the vehicle manufacturer, or may be selected by the user or vehicle owner to provide a customized interior or exterior rearview mirror assembly, such as described above with respect to the different logos or colors, without affecting the scope of the present invention. For example, a person may select the logo or mascot of their alma mater to be established at a desired location at the reflective element to customize the mirror assembly for that particular person or owner. The customized reflective element may provide the desired logo or indicia or the like, without unduly affecting the functionality of the reflective element.

[0068] Optionally, and as shown in FIGS. 1 and 2, the reflective element 10 may include a perimeter metallic band 26, such as the types described in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for ELECTROCHROMIC MIRROR ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); and/or PCT Application No. PCT/US03/35381, filed Nov. 5, 2003 by Donnelly Corp. et al. for ELECTRO-OPTIC REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1116(PCT)); and/or U.S. pat. applications, Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); Ser. No. 10/528,269, filed Mar. 17, 2005 (Attorney Docket DON01 P-1109); Ser. No. 10/533,762, filed May 4, 2005 (Attorney Docket DON01 P-1116); Ser. No. 11/226,628, filed Sep. 14, 2005 (Attorney Docket DON01 P-1236); and/or Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); and/or U.S. provisional applications, Ser. No. 60/692,113, filed Jun. 20, 2005 (Attorney Docket DON01 P-1224); Ser. No. 60/677,990, filed May 5, 2005 (Attorney Docket DON01 P-1219); Ser. No. 60/653,787, filed Feb. 17, 2005 (Attorney Docket DON01 P-1207); Ser. No. 60/642,227, filed Jan. 7, 2005 (Attorney Docket DON01 P-1199); Ser. No. 60/638,250, filed Dec. 21, 2004 (Attorney Docket DON01 P-1198); Ser. No. 60/624,091, filed Nov. 1, 2004 (Attorney Docket DON01 P-1184), and Ser. No. 60/609,642, filed Sep. 14, 2004 (Attorney Docket DON01 P-1171), which are hereby incorporated herein by reference in their entireties. The perimeter band metallic material may be selected to provide a desired band color, such as due to interference effects or material colors and/or reflectances and/or refractive indices. Optionally, the material for the perimeter band may be selected so that the appearance or color of the perimeter band may substantially match or contrast the appearance or color of the indicia layer or reflector, depending on the desired appearance of the reflective element. For example, a combination or stack of oxides comprising materials having different high and low refractive indices may be stacked upon one another to provide alternating refractive indices to spectrally tune the metallic band and/or the indicia reflector or layer to the desired colors or tints or appearances (such as utilizing principles described in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for ELECTROCHROMIC MIRROR ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)), and/or Ser. No. 10/528,269, filed Mar. 17, 2005 (Attorney Docket DON01 P-1109), which are hereby incorporated herein by reference in their entireties).

[0069] Optionally, and with reference to FIG. 6, a reflective element assembly or cell 110 for a rearview mirror assembly, such as for an interior or exterior rearview mirror assembly for a vehicle, includes a front substrate 112 and a rear substrate 114 spaced from front reflective element substrate 112, with an electrolyte or a cured monomer composition or electrochromic medium 116 sandwiched therebetween. The front substrate 112 has a transparent conductive coating or layer 118 disposed on its rear surface 112a (typically referred to as the second surface of the reflective element assembly) and the rear substrate 114 has a metallic conductive coating or layer 120 disposed on its front surface 114a (typically referred to as the third surface of the reflective element assembly), such as described above. As can be seen in FIG. 6, the indicia 126 is locally deposited or established or disposed at the second surface of the front substrate at the desired location and/or pattern (and with the ITO coating adjacent to or over the indicia), while the metallic conductive coating 120 is deposited or established or disposed over substantially the entire third surface of the rear substrate so as to be behind and surrounding the indicia as viewed by the driver when the mirror assembly is installed at the vehicle. An epoxy seal material 122 or the like, is applied between the substrates to define the cavity for the electrochromic medium and to adhere the substrates together. Reflective element assembly 110 includes a reflective perimeter or border band 126 and a reflectant indicia layer 124 disposed or otherwise formed or established at the rear or second surface 112a of the front substrate 112.

[0070] Indicia layer 124 may be established during the same coating process as the perimeter band 126 and may be established on the rear surface of the substrate, so that the transparent conductive layer 118 is disposed or established onto the perimeter band 126 and indicia layer 124 and over the rear surface 112a of front substrate 112. For example, the rear surface of the front substrate may be masked to define the perimeter border and the desired indicia or form. The mask may be etched or cut or punched to provide the desired indicia or logo or the like (which may appear in a reverse image manner when the mask is placed on the rear surface of the front substrate). The etched mask thus may be placed at or on the rear surface of the front substrate and the desired reflective material (such as described below) may be disposed onto the rear surface of the substrate in the unmasked or uncovered areas. The reflective indicia may be formed so as to be located at the electrochromic portion of the mirror (radially inward from the seal and perimeter or border band), so as to be readily viewable by the driver of the vehicle and so as to be visibly effected by the darkening of the electrochromic medium and the corresponding dimming of the electrochromic mirror, as discussed below.

[0071] Preferably, metallic conductive coating 120 comprises a substantially highly reflective material with a high degree of reflectivity of light incident thereon. For example, the third surface coating 120 may comprise aluminum or silver or their alloys (or other similar or suitable metallic compositions and the like), and may provide greater than about 80 percent reflectivity of light incident thereon (as measured using SAE J964a) and more preferably greater than about 90 percent reflectivity of light incident thereon. Preferably, the reflective indicia 124 (and the reflective perimeter band 126) comprises a lower or reduced reflectivity of light incident thereon than that provided by the third surface reflective coating. For example, the reflective indicia 124 may comprise chromium or titanium or nickel or molybdenum or ruthenium or their alloys or other similar or suitable metal (such as a stainless steel or a nickel based alloy, such as Hastelloy C), and may provide about 65 percent reflectivity of light incident thereon, and more preferably less than about 55 percent reflectivity of light incident thereon (such as between about 35 percent reflectivity to about 65 percent reflectivity of light incident thereon).

[0072] Indicia layer 124 may also comprise a speculary reflective layer, preferably such as a mirror-reflective thin film of chromium, ruthenium, silver, silver alloy, aluminum, aluminum alloy or other metal or metal alloy. Thus, and preferably, the indicia layer material comprises a metallic material such that is locally provides a mirror-like reflection at the second surface of the front substrate that is subtly discernible against the third surface mirror reflector at the third surface of the rear substrate of the electrochromic reflective element. Such a specular or mirror-like reflective material may be attained from a sputtered or vacuum deposited metallic thin film coated onto the substrate. The indicia coating or coatings or layer(s) may be disposed onto the substrate surface at the desired location and pattern with the transparent electrically conductive coating of the second surface of the front substrate (such as ITO or other transparent electrically conductive coatings, such as doped tin oxide or doped zinc oxide such as ZnO:Al or the like) deposited over the glass surface and over the indicia material (so that the reflection off the indicia layer(s) is unaffected by the ITO disposed therebehind and thus more metallic or "silvery" in hue and is substantially spectrally neutral rather than being spectrally reflecting/tinted), or the ITO coating may be deposited onto the second-surface surface of the front substrate with the indicia coating material disposed onto the ITO-coated surface at the desired location and pattern (so that the reflection off the indicia layer(s) is/are seen through the ITO and so an interference spectral character to such reflectivity may be imparted), depending on the particular application and desired appearance/effect of the mirror reflective element assembly.

[0073] Although shown as a mirror reflective element having the front substrate 112 larger than the rear substrate, such as for a frameless mirror reflective element for an exterior rearview mirror assembly, the mirror reflective element with indicia may comprise other types of reflective elements, such as a flush reflective element for an interior or exterior rearview mirror assembly or an offset construction such as is known in the electro-optic mirror art, without affecting the scope of the present invention. For example, and as shown in FIG. 6A, a reflective element 110' (preferably an exterior vehicular mirror element) may have a front substrate 112' that is substantially flush with the rear substrate 114', with a reflective indicia or logo 124' (and optionally and preferably a perimeter border band 126' as well) established at the second surface 112a' of front substrate 112'. The front substrate 112' is spaced from the rear substrate 114' with an electrochromic medium 116' disposed therebetween and sealed by a perimeter seal 122'. The logo or indicia 124' (locally established inboard of the perimeter edge or border of the front substrate on its second surface) and border band 126' (at and substantially circumscribing the second-surface perimeter edge or border region of the front substrate) preferably comprise the same metallic reflecting layer, such as sputtered chromium or the like or have distinctly different reflectivity (such as chromium for indicia 124' and ruthenium for border band 126'), and are preferably established via the same coating process as described above. Reflective element 110' includes a transparent conductive coating 118' at the second surface 112a' (such as disposed or established over the perimeter border band 126' and indicia 124', such as described above), which may comprise an ITO coating or a doped zinc oxide (such as ZnO:Al) coating (such as the types discussed below) or other suitable transparent conductive coating or layer or material.

[0074] The third surface reflective coating or layers 120' at the third surface 114a' of rear substrate 114' may comprise any suitable material or materials or layers to provide the desired reflectivity and/or transreflectivity at the third surface of the mirror reflective element. For example, the third surface coatings 120' may comprise a layer of chromium 120a' at the third surface 114a' of rear substrate 114', with a layer of ruthenium 120b' disposed over the layer of chromium 120a'. In such an application, the indicia 124' may comprise chromium and the front-most layer 120b' of third surface reflector 120' may comprise ruthenium (that typically is about 5-20 percent or so more reflecting than chromium, depending on the deposition conditions employed), or both may be similar or identical materials (e.g. chromium or ruthenium). Even with the same materials, the indicia is still discernible due to a contrast between the indicia 124' at the second surface and the coatings or layers 120' at the third surface (due to the optical properties such as refractive index and spectral absorption of the electro-optic EC medium disposed between the second and third surfaces). In the illustrated embodiment, the ITO layer 118' is disposed over the indicia 124', but optionally the ITO layer may be disposed at the second surface with the indicia disposed over the ITO at the desired location or pattern. If the ITO is established at the second surface before the indicia, the indicia may be colored or tinted due to the optical interference effect or coloring caused by the ITO (when the ITO is between the substrate and the indicia and thus the indicia is viewed through the ITO coating by a person viewing the mirror reflective element). Such an arrangement may provide a gold-tinted or blue-tinted or other color tint to the indicia, dependent principally on the thickness of the ITO (or other transparent conductive material) used, which may be preferred depending on the particular application of the mirror assembly and desired effect or appearance of the mirror assembly. Optionally, indicia layer(s) 124' may be formed of a metallic metal coating (such as of gold or a gold alloy) that is itself spectrally selective in reflectivity so as to be tinted in reflection.

[0075] Optionally, and as shown in FIG. 6B, a mirror reflective element 110" (preferably an exterior vehicular mirror element) may be substantially similar to mirror reflective element 110' as described above, and may include a third surface coating or layers 120" at a rear surface 114a" of the rear substrate 114" that comprises a layer of chromium 120a" disposed at the third surface of the rear substrate, with a layer of silver 120b" disposed over the layer of chromium 120a" and a layer of aluminum zinc oxide 120c" (ZnO:Al) disposed over the layer of silver 120b". The third surface reflector thus comprises a different material and specular reflectivity as compared to the chromium indicia 124', whereby the indicia may be more readily discernible by a person viewing the reflective element when the reflective element is in its "day" state due to the contrast between the much more highly reflecting third surface main mirror reflector (typically a silver or silver-alloy metal coating that has a specular first-surface reflectivity, as measured in accordance with SAE J964a, that is at least about 80%R and often at least about 90%R) and the less highly reflecting second-surface indicia/logo reflecting coating or layer (for example, an evaporated chromium coating that has a reflectivity of about 45-55%R or a sputtered chromium coating that has a reflectivity of about 55-65%R). Other stacks or layers of metallic conductive reflective or transflective coatings or layers may be implemented to achieve the desired reflectivity and transmissivity at the third surface of the reflective element, while providing a desired degree of discernibility of the indicia, while remaining within the spirit and scope of the present invention. The indicia material and third surface reflector material and arrangement of the indicia and ITO coatings may be selected to achieve the desired color and reflectivity differential of the indicia relative to the third surface reflector, depending on the particular application and desired effect of the mirror assembly.

[0076] Because the reflective indicia that is locally established in a pattern on the second surface of the front substrate is desirably less reflective than the third surface reflective coating on the rear substrate (when the mirror is in its "day" or undimmed state or high reflectance state) or, less desirably, vice versa, and is surrounded by and backdropped by the third surface reflective coating (which preferably provides a higher reflectivity background to the indicia), the indicia is subtly (such as via the differences in reflectivities of the materials used) discernible by a person viewing the reflective element when the EC medium is unpowered and is in its high reflectance state. The viewability and discernibility of the indicia may be subtle when the reflective surface of the rear substrate is at its highly reflective state or when the electrochromic medium is not darkened. Thus, during the unpowered state of the electrochromic mirror, the indicia may be subtly viewable and discernible by a person viewing the mirror assembly. However, when the electrochromic mirror is powered to darken the electrochromic medium and thus to dim the mirror (such as in response to a glare sensor or the like located at the mirror assembly or elsewhere in the vehicle), the reflectivity of light provided by the third surface reflective coating is reduced (due to the darkening of the electrochromic medium in front of the third surface reflective coating), so that the indicia becomes more visible or more discernible to a person viewing the mirror. In other words, the indicia may be enhanced and more readily viewable and discernible as the mirror is darkened and the reflectivity of the third surface reflective coating is limited or reduced by the darkening of the electrochromic medium.

[0077] Optionally, the third surface metal reflector on the third surface of the rear substrate of the cell, the perimeter reflective border band around the edge border of the second surface of the front substrate, and the indicia (also on the second surface but inward of the border band) may be reflective materials, and may comprise substantially the same metallic or reflective material, so that all three have similar or closely similar reflective properties, and may all have substantially the same optical properties, such as reflectivity level and refractive index/k-value. By so choosing, the optical contrast between the third surface reflector coating and the second surface perimeter border is substantially reduced and essentially eliminated such that the viewer barely sees or notices the presence of the second surface border band when the electrochromic cell is not powered (i.e. is undimmed and is in its bleached state), and the presence of the border reflective band is only discernable when the electrochromic medium dims when the cell is powered. Also, the presence of the indicia (such as an ANTI-GLARE indicia or AUTODIM indicia or the like) on the second surface is subtly noticeable to a viewer because its optical properties substantially match those of the third surface reflector coating (for example, chromium may be used for the indicia and ruthenium for the third surface reflector for an exterior mirror element, or chromium may be used for the indicia and silver or a silver-alloy may be used for the third surface reflector for an interior mirror element), such that the viewer subtly sees or notices or discerns the presence of the second surface indicia when the electrochromic cell is not powered (i.e. is undimmed and in its bleached state), but the presence of the indicia on the second surface becomes appreciably discernable when the electrochromic medium dims when the cell is powered, and in such circumstances provides a "surprise and delight" benefit to the consumer.

[0078] This is particularly advantageous when an AUTODIM or similar automatic dimming indication logo/indicia is used. When the likes of an electrochromic automatic dimming interior mirror element dims in reflectivity at night when rear-approaching glaring headlights are detected, the driver is often unaware of and thus unappreciative of the anti-glare benefits of this feature. In accordance with the present invention, the AUTODIM logo/indicia on the second surface of the front substrate becomes plainly visible once the electro-optic EC medium is powered at night when the mirror element is subject to and is being illuminated by incident light from approaching headlights that are sufficiently intense to cause the automatic glare detection circuitry to power the electro-optic EC medium. And the more intense the glare detected, the darker the electro-optic EC medium dims and the more the second-surface logo/indicia stands out, and so the continuously variable reflectivity feature of such automatic electrochromic mirror assemblies is conveyed to the driver. Note that, for example, the third surface reflector coating and the second surface perimetal border reflector band (if present) and the second surface indicia may all three comprise chromium thin films or all three may comprise ruthenium thin films or all three may comprise rhodium thin films or all three may comprise Hastelloy C-276 thin films or all three may comprise molybdenum thin films or all three may comprise aluminum (or aluminum alloy) thin films or all three may comprise aluminum/palladium alloy thin films or all three may comprise silver (or silver alloy) thin films, or all three may comprise sub-sets of these or other suitable coatings or films.

[0079] Thus, the indicia may optionally be selected to provide information that may be relevant to the driver of the vehicle during night driving when the EC medium dims or darkens in response to detected incident glaring conditions. For example, the logo/indicia may provide a notice or indication to the driver that the electrochromic mirror assembly is powered and thus in an active mode or darkened or dimmed mode, in order to provide a visual reinforcement or communication to the driver that the mirror assembly is working in the desired and designed manner, and is delivering glare protection. Such an information display logo or indication is thus desirable, since customers may not otherwise readily recognize that the electrochromic mirror is properly dimming, and thus may not otherwise fully appreciate the benefits provided by the automatic mirror dimming feature. For example, the indicia can read "AUTODIM" or "ANTI-GLARE" or "EC" or "NIGHT" or may be an icon, such as a representation of a headlamp with a cross or "X" superimposed thereon, indicating that the glare or reflection of the light from the headlamps is being reduced or dimmed by the mirror. Optionally, the logo/indicia may convey other information, such as an automaker brand or personalization information, to the driver that stands out when the EC medium dims.

[0080] The indicia material of the present invention thus may provide a reflective logo that is faintly visible/discernible to the driver when the EC mirror is in its "day" state (where the EC medium is not darkened or colored), but becomes plainly or substantially visible/discernible when the EC mirror dims to its "night" state (when the EC medium is darkened or colored to reduce glare at the reflective element). For example, the reflective logo may be locally coated or established at the second surface of the front substrate and may have a reflectivity of about 55 percent of light incident thereon, while the main or primary mirror reflector established at the third surface of the rear substrate may have a reflectivity of about 70 percent of light incident thereon. Thus, in the "day" state, the driver can discern the lower reflectivity of the logo against the distinctly higher or brighter reflectivity of the main mirror reflector behind the logo; whereby the logo is subtly but distinctly visible/discernible at the mirror reflective element while the mirror reflectivity of light incident thereon is sustained across the viewing surface, even at the location where the logo is disposed or established. Because a person's eyes typically can discern a difference in reflectivity of about 5 percent, and can more readily discern a difference in reflectivity of about 10 percent or more, the difference in reflectivity between the logo and the third surface mirror reflector is readily discernible by the driver of the vehicle when the mirror is in its "day" state.

[0081] When the mirror changes to its "night" or antiglare state, the reflectivity of the primary mirror reflector is substantially reduced (due to the darkening or coloring of the EC medium), while the reflectivity of the logo (established at the second surface and thus in front of the EC medium) is substantially unaffected by the activation of the EC mirror. Thus, when the EC mirror dims, the logo "stands-out" or becomes plainly or substantially visible or discernible at the reflective element. The indicia or logo may be selected to convey the desired message or information or display to the viewer. For example, the logo may comprise the term "AUTODIM" or "ANTI-GLARE" or the like to indicate to the driver that the EC mirror has such a feature. Optionally, the logo may comprise a personalized logo, such as a sports logo or college logo or the like (which may be selected by the user or owner of the vehicle) or a vehicle logo, such as "FORD" or "GM" or the like, depending on the particular application and desired display or appearance of the mirror assembly.

[0082] The indicia material and the third surface reflector material may comprise similar materials or may comprise different reflective materials, depending on the desired appearance and effect of the reflective element. For example, the indicia material may be selected as a gold or bronze colored or tinted material (such as a gold or gold alloy or the like) to provide a desired spectral appearance. Such a colored or tinted indicia material may be more readily discernible at the reflective element since it is backdropped and surrounded by the specularly reflective mirror reflector at the third surface. The third surface mirror reflector may comprise any suitable reflective or transflective material or materials, such as an ISI (ITO - silver - ITO) stack of layers or layers including other metallic materials, such as silver alloys and the like, such as the other materials discussed herein), and provides a specularly reflective (and optionally transreflective) mirror reflector behind and around the indicia as viewed by a driver of the vehicle.

[0083] Note that the degree of subtly that the logo/indicia is discernible to the driver when the electrochromic (EC) medium is not powered (i.e., the EC mirror element is in its high or "day" reflectance state) can be determined by the choices made for the logo/indicia metallic reflecting layer and those of the third surface reflector (or fourth surface reflector) metallic main mirror reflecting layer. For example, a chromium or similar lower reflecting (typically with a first-surface reflectivity in the about 45%R to about 65%R range) metal coating choice for the logo/indicia will be more discernible if the main mirror reflector (that preferably is on the third surface rather than on the fourth surface) is a high reflecting reflector [such as a silver mirror coating (or a silver alloy) with a first-surface reflectivity of at least about 80%R (and often greater than about 90%R)] than it would be if the main mirror reflector is a medium reflecting reflector [such as a ruthenium mirror coating (or a ruthenium alloy or a platinum or palladium metal or alloy) with a first-surface reflectivity in the about 65%R to about 75%R range, typically]. Also, should the metallic logo/indicia overcoat the transparent conductor coating (such as ITO or AZO) of the second surface (and thus be located behind the transparent conductor coating when the mirror reflective element is viewed by a person at the vehicle), the metallic logo/indicia may be less subtly discernible than if the metallic logo/indicia undercoats the transparent conductor coating (because the metallic logo/indicia is subject to optical interference effects and has a spectrally selective reflectivity so as to be color tinted in reflectance when the metallic logo/indicia overcoats and is thus located behind the transparent conductor coating).

[0084] Particularly for an exterior mirror, a user typically cannot discern that the EC function is working, since there is no feedback to the user when the EC function is operating to dim or darken the mirror reflection. The increased viewability of the indicia when the EC medium is darkened provides a visual prompt to the user to reinforce to the consumer the value of the feature, particularly for exterior mirror applications, such that the consumer may recognize the value and functionality of the feature and may increase the use the EC feature, thereby enhancing safety. Although it is known to provide LEDs or the like to interior mirror assemblies, the indicia of the present invention provides a similar function, but with reduced costs and complexity of the mirror assembly, since no additional electronic LED or the like is needed to convey the indication that the EC mirror is powered.

[0085] Although shown and described as having a third surface reflective coating, the reflective element may have a fourth surface reflective coating, without affecting the scope of the present invention. Optionally, and as shown in FIG. 6, the third surface reflective metallic coating may be disposed over the perimeter edge or edges of the rear substrate so as to provide a wraparound portion at the perimeter edge or edges for electrical connection of electrical connectors at the fourth surface 114a of the reflective element assembly 110 to the conductive coatings 118, 120, such as by utilizing aspects described in U.S. pat. applications, Ser. No. 11/226,628, filed Sep. 14, 2005 (Attorney Docket DON01 P-1236); and/or Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193), which are hereby incorporated herein by reference in their entireties.

[0086] Also, although shown and described with the perimeter band and indicia being formed directly on the rear surface of the front (first) substrate and with the transparent conductive coating disposed over the perimeter band and indicia, the transparent conductive coating may first be disposed over the rear surface of the front substrate with the perimeter band and indicia then being disposed onto the transparent conductive coating, without affecting the scope of the present invention. Such an arrangement may be desired if a color or tint of the perimeter band and indicia, such as due to the interference effect of the transparent conductive coating between the perimeter band / indicia and the substrate surface, such as described above and by utilizing aspects described in U.S. pat. applications, Ser. No. 11/226,628, filed Sep. 14, 2005 (Attorney Docket DON01 P-1236); and/or Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); and/or U.S. provisional applications, Ser. No. 60/692,113, filed Jun. 20, 2005 (Attorney Docket DON01 P-1224); Ser. No. 60/677,990, filed May 5, 2005 (Attorney Docket DON01 P-1219); Ser. No. 60/653,787, filed Feb. 17, 2005 (Attorney Docket DON01 P-1207); Ser. No. 60/642,227, filed Jan. 7, 2005 (Attorney Docket DON01 P-1199); Ser. No. 60/638,250, filed Dec. 21, 2004 (Attorney Docket DON01 P-1198); Ser. No. 60/624,091, filed Nov. 1, 2004 (Attorney Docket DON01 P-1184), and Ser. No. 60/609,642, filed Sep. 14, 2004 (Attorney Docket DON01 P-1171), which are hereby incorporated herein by reference in their entireties.

[0087] The indicia and the perimeter band or coating may be established onto the substrate surface, such as onto the rear surface of the front substrate via the same coating operation and with the same material. The indicia thus may be established without additional coating processes, since the indicia is established by using the same mask and coating that normally would be utilized for establishing the perimeter coating or band. The indicia is thus established at the substrate surface in a highly economical manner. For example, a substrate may be provided and a mask (with an outer portion defining the perimeter band and with the indicia formed or cut through the mask) may be placed on the substrate surface (such as the rear surface of the front substrate). The desired metallic layer material may be disposed at the substrate surface so as to be established at the unmasked perimeter band and indicia regions via a single deposition process or the like. The perimeter band and the indicia thus may be readily established in an economical manner without multiple steps or processes and with the same material so that the indicia may substantially match the perimeter band in appearance or color or tint or discernibility.

[0088] Although shown and described as an electro-optic or electrochromic reflective element assembly or cell, the reflective element may comprise a single substrate with a reflective coating at its rear surface, without affecting the scope of the present invention. The indicia layer may be disposed or established at the rear of the reflective coating so as to be discernible through the substrate and reflective coating, or may be disposed or established between the reflective coating and the rear surface of the substrate, such as in a similar manner as described above. The mirror assembly may comprise a prismatic mirror assembly or other mirror having a single substrate reflective element, such as a mirror assembly utilizing aspects described in U.S. Pat. Nos. 6,318,870; 6,598,980; 5,327,288; 4,948,242; 4,826,289; 4,436,371; and 4,435,042; and PCT Application No. PCT/US04/015424, filed May 18, 2004 by Donnelly Corporation et al. for MIRROR ASSEMBLY FOR VEHICLE (Attorney Docket DON01 FP-1150(PCT)); and U.S. pat. application, Ser. No. 10/933,842, filed Sep. 3, 2004 (Attorney Docket DON01 P-1166), which are hereby incorporated herein by reference in their entireties. Optionally, the prismatic reflective element may comprise a conventional prismatic or flat reflective element or prism, or may comprise a prismatic or flat reflective element of the types described in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for MIRROR REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); U.S. pat. applications, Ser. No. 10/528,269, filed Mar. 17, 2005 (Attorney Docket DON01 P-1109); Ser. No. 10/709,434, filed May 5, 2004 by Lynam for MIRROR REFLECTIVE ELEMENT (Attorney Docket DON01 P-1152); Ser. No. 10/933,842, filed Sep. 3, 2004 by Kulas et al. for INTERIOR REARVIEW MIRROR ASSEMBLY (Attorney Docket DON01 P-1166); Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); and/or Ser. No. 10/993,302, filed Nov. 19, 2004 by Lynam for MIRROR REFLECTIVE ELEMENT FOR A VEHICLE (Attorney Docket DON01 P-1186), and/or PCT Application No. PCT/US2004/015424, filed May 18, 2004 by Donnelly Corp. et al. for MIRROR ASSEMBLY FOR VEHICLE (Attorney Docket DON01 FP-1150(PCT)), which are all hereby incorporated herein by reference in their entireties, without affecting the scope of the present invention. A variety of mirror accessories and constructions are known in the art, such as those disclosed in U.S. Pat. Nos. 5,555,136; 5,582,383; 5,680,263; 5,984,482; 6,227,675; 6,229,319; and 6,315,421 (the entire disclosures of which are hereby incorporated herein by reference in their entireties), that can benefit from the present invention. The subtle contrast indicia of the present invention may be established on any of a first, second, third or fourth surface of a laminate-type electro optic mirror cell or on any of a first or second surface of a single-substrate mirror element.

[0089] Optionally, a mirror reflective element may include a display element that emits or projects illumination through a pattern or indicia formed or established at the reflective element. For example, and with reference to FIG. 7, a mirror reflective element 210 for a rearview mirror assembly, such as for an interior or exterior rearview mirror assembly for a vehicle, includes a front substrate 212 and a rear substrate 214 spaced from front reflective element substrate 212, with an electrolyte or a cured monomer composition or electrochromic medium 216 sandwiched therebetween. The front substrate 212 has a transparent conductive coating or layer 218 (such as an ITO layer, such as a ½ wave ITO layer or a doped tin oxide layer or a doped zinc oxide layer or a light transmissive metal oxide/metal/metal oxide stack such as ITO/Ag/ITO or ZnAlO/Ag/ZnAlO or ZnAlO/Al/ZnAlO or ITO/Ag/ZnAlO or the like) disposed on its rear surface 212a (typically referred to as the second surface of the reflective element assembly) and the rear substrate 214 has a metallic conductive coating or layer 220 disposed on and substantially over its front surface 214a (typically referred to as the third surface of the reflective element assembly), such as described above. An epoxy seal material 222 or the like, is applied between the substrates to define the cavity for the electrochromic medium and to adhere the substrates together. In the illustrated embodiment, reflective element assembly 210 includes a reflective perimeter or border band 226 disposed or otherwise formed or established at the rear or second surface 212a of the front substrate 212, such as described above.

[0090] Reflective element 210 includes a display element 230 located rearward of the reflective element and directed at a pattern or indicia 232 formed or established at the rear surface 214b of rear substrate 214 (commonly referred to as the fourth surface of the reflective element). The pattern 232 may comprise the likes of a pattern of stars or dots, a pattern of bars or bar segments, portions of which may be connected or unconnected to each other, or other patterns or indicia or the like. The pattern or indicia 232 may comprise any suitable material (such as chromium, molybdenum or tungsten or the like) and may provide a decorative or light management effect that is viewable and discernible by the driver of the vehicle (or other person viewing the mirror) when the display element 230 (such as a light source, such as a light emitting diode (LED) or the like) is activated. For example, the pattern 232 may be formed to indicate that the turn signal of the subject vehicle is activated, such as for exterior mirror applications for indicating to a driver of an adjacent vehicle that the turn signal of the subject vehicle is activated. The indicia or pattern or structure established at the fourth surface of the reflective element thus may break up or direct light from the display element and/or may obscure or hide the presence of the display element from direct view by a person viewing the reflective element, so as to provide a desired appearance or direction of the light passing through the reflective element for viewing by the driver of the vehicle or other person within or outside of the vehicle. Optionally, the pattern may be thin film coating or a thick film coating, such as a printed pattern or painted pattern, such as a paint or ink or lacquer, or such as an adhesively applied or "stick-on" element or appliqué or the like. For example, the pattern or indicia may be printed or painted or coated or otherwise applied or disposed at a portion of the rear surface of the reflective element, or may be coated or applied or formed or otherwise established on a Mylar shape (or other substrate or the like) that may be adhered to the rear surface of the reflective element, thereby avoiding coating the entire rear surface or substantially the entire rear surface of the reflective element.

[0091] The third surface conductive coating 220 may comprise a transflective coating or layer or other suitable third surface reflective and conductive coatings. In the illustrated embodiment, the third surface conductive coating 220 comprises a layer of a transparent conductive material 220a (such as ITO or the like) over substantially the entire front surface 214a of the rear substrate 214, and a reflective coating or layer 220b (or multiple coatings or layers), such as a layer of chromium/rhodium or chromium/ruthenium or molybdenum/chromium or an ITO/silver/ITO stack of layers or the like. A window or aperture 234 is formed or established in the reflective coating or coatings 220b (such as by laser ablating or etching the reflective coating 220b to remove the coating 220b at the window area [or by masking the metallic transflective coating 220b while it is being deposited onto the transparent conductive layer 220a], while maintaining the transparent conductive coating 220a at the window area).

[0092] As shown in FIG. 7, the reflective element 210 may include a fourth surface conductor 236a and wrap-around coating 236b that wraps around and over a perimeter edge 214c of rear substrate 214 and over a third surface conductive wraparound coating 220c at the perimeter edge 214c, in order to provide electrical conductivity between the fourth surface conductor 236a and the third surface conductive and reflective coating 220b. Preferably, the indicia or pattern 232 is formed or established during the same coating process that establishes the fourth surface conductor 236a and wrap-around coating 236b and thus may comprise the same material as the fourth surface conductor 236a and wrap-around coating 236b (such as chromium or molybdenum or tungsten or Hastelloy or ruthenium or rhodium or other suitable conductive material). Alternately, the pattern or indicia 232 may comprise a different material and may be established via a different coating or forming or establishing process.

[0093] For example, and with reference to FIG. 8, the reflective element 210' may include a transflective coating or layer or appliqué 232' established at the fourth surface 214b' of the reflective element 214' and at the display element 230 and generally opposite the window area 234 at the third surface reflective coating 220b. The transflective coating 232' thus may provide a reflective appearance at the window area 234, while allowing light from display element 230 to pass through the transflective coating 232' and through the reflective element 210' for viewing by a person viewing the mirror reflective element assembly. The transparent conductive coating 220a may be disposed over substantially the entire front surface 214a' of rear substrate 214', while the third surface reflective coating or reflector 220b may have an aperture 234 established therein, such as described above.

[0094] Optionally, and with reference to FIG. 9, the reflective element 210" may include a display module 229 that may be attached or adhered or established at the rear surface 214b" of rear substrate 214" and generally opposite the window area 234 formed in the third surface reflective coating 220b (that is disposed on the transparent conductive layer 220a [such as a layer or coating of ITO or the like, such as a layer of 80 ohms/sq. ITO or the like] at the front surface 214a" of rear substrate 214"). The display module 229 includes a housing 229a, a light source or display element 230" (such as a light emitting diode or other suitable light source) and a transflective window element 232". The housing 229a may include electrical connectors 229b for electrically connecting the display module 229 to a power source or circuitry of the mirror assembly. Preferably, display module 229 may be attached to the rear surface 214b" of rear substrate 214" via an optical index matching adhesive 229c, such as an optical epoxy or optical acrylic (such as utilizing aspects of the reflective element described in U.S. pat. application, Ser. No. 10/993,302, filed Nov. 19, 2004 (Attorney Docket DON01 P-1186), which is hereby incorporated herein by reference in its entirety. The housing 229a may mount or receive the display element 230" such that the light is emitted at an angle through the transflective window and the reflective element (such as, for example, for a blind spot system indicator whose light output is directed into the vehicle cabin so as to be seen by the driver of the host vehicle) to enhance viewability and discernibility of the display (or to reduce the viewability or discernibility of the display, such as by directing the light output away from the cabin of the vehicle so that the light output is not readily discernible by the driver of the host vehicle) to a person viewing the reflective element at an angle. The housing 229a may have a polished or reflective or otherwise shaped or formed inner surface to enhance directing of the light toward and through the reflective element when the display module 229 is attached to the fourth surface of the reflective element. Optionally, the display module may include a pattern or indicia formed on a window element, which may or may not comprise a transflective window element, in order to provide the desired pattern or appearance of the display.

[0095] Reflective elements 210' and 210" of FIGS. 8 and 9 may be otherwise substantially similar to the reflective element 210 and other reflective elements described above, such that a detailed discussion of the reflective elements will not be repeated herein. The common or similar elements of the reflective elements are shown in FIGS. 8 and 9 with the same reference numbers as used in FIG. 7 with respect to reflective element 210.

[0096] Optionally, and with reference to FIGS. 10A-C, a mirror reflective element 250, such as an exterior mirror reflective element, includes a glass substrate 252, a transflective mirror reflector 254 and a display element, such as a turn signal indicator 256, at the rear of the substrate 252 and behind the transflective mirror reflector 254. The mirror reflective element may comprise a single glass substrate (such as glass substrate 252 shown in FIG. 10A), or may comprise an electro-optic reflective element assembly or cell, such as an electrochromic reflective element assembly or cell (such as electro-optic reflective element assembly 250' of FIG. 10D, discussed below, which includes a front substrate 252' and a rear substrate 253' with an electro-optic medium 255' disposed therebetween). In the illustrated embodiment, the transflective mirror reflector 254 is disposed at the rear surface of the substrate 252. However, the transflective mirror reflector may be disposed at the front surface of the substrate, without affecting the scope of the present invention. Turn signal indicator 256 is disposed at the rear of the reflective element substrate and transflective reflector and is operable to emit or project light therethrough for viewing by a person viewing the reflective element, and preferably for viewing by a person viewing the reflective element at an angle with respect to the reflective element.

[0097] Turn signal indicator 256 includes a transparent or translucent optical plastic block 258 and a light control film 260. As shown in FIG. 10A, optical plastic block 258 is disposed at the rear of the substrate 252 and at the rear of the transflective mirror reflector 254, with the light control film 260 disposed between optical plastic block 258 and transflective mirror reflector 254. Optical plastic block 258 may comprise a transparent plastic material, such as, for example, an acrylic or polycarbonate or polystyrene material or the like, formed such as by injection molding, casting or the like. Turn signal indicator 256 includes a plurality of illumination sources 262, such as light emitting diodes or the like, located at the rear of optical plastic block 258 and generally at or aligned with a plurality of apertures or passageways or pipeways 259 formed through block 258 and through which light passes without passing through the optical plastic material of the block itself. However, because of the physical laws of refraction, and because of the angles involved, some of the light generated and emitted by each individual light source or light sources 262 passes through the pipeways and some of the light enters the optical plastic material of the block and exits other points or areas of the block so that the block effectively glows.

[0098] Thus, when the light sources are activated, a person viewing the reflective element will see the five beams of relatively intense light that passes through the pipeways and a less intense but visibly appreciable illumination of the block itself around the light beams. In order to limit or substantially preclude light leaking or passing through the sidewalls of the block so as to be viewable through the reflective element outside of the block shape or footprint (such as an arrow or chevron or the like), the outer walls 258a of the block 258 may be specularly or diffusely reflective or absorbing (such as via a coating or surface finish or the like at the outer walls of the block). Optionally, the rest of the reflective element backing may have an opaque coating or paint or the like (such as an dark or otherwise substantially opaque coating or paint or tape or the like) disposed or applied over the rear of the reflective element except at the display region (the area at which the light control film is disposed).

[0099] Thus, light emitted by the light sources may pass through the pipeways in the block and through the block material itself at the rear of the reflective element, whereby the block provides a continuous shape (such as an arrow or chevron shape or footprint) around the series of illumination sources so as to provide an illuminated shape emanating from the block and through the mirror reflective element. Light control film 260 may comprise any suitable film and may function as microlouvers, so as to preferentially direct light that is received from one angle whereby the light is redirected or controlled to another direction. An example of a suitable light control film or material is disclosed in U.S. Pat. No. 5,481,409 (which is hereby incorporated herein by reference in its entirety), and may comprise a light control film manufactured by the 3M Company of Minn., such as the light control film commercially available under the trade name LCF-P (light control film - polycarbonate). Such a film comprises a thin plastic film enclosing a plurality of closely spaced, light black colored microlouvers. A preferred light control film is approximately 0.75 mm thick or thereabouts, and the angled microlouvers are spaced approximately 0.127 mm apart. The microlouvers may be in various angular positions to provide a particular viewing angle, such as from as narrow as about a 48 degree angle to as wide as about a 90 degree angle. Thus, the light control film controls or directs the light emitted by the illumination sources 262, including the light beams passing through the pipeways in the block as well as the other light emanating from the block material itself, in a desired or appropriate or predetermined angle with respect to the mirror substrate, and helps assure that the driver of the host vehicle is largely unaware or not bothered by actuation of the through-the-mirror reflector turn signal indicating light sources.

[00100] The likes of 3M Light Control Film comprises a thin plastic film containing closely spaced dark or black or light absorbing microlouvers. When used as described herein, the film simulates a tiny Venetian blind, wherein the microlouvers allow for controlled transmission of the light emitted by the indicator light sources (that are disposed behind the transflective mirror element) along the axis of the microlouvers so that the light is seen by drivers overtaking the host vehicle in a side-lane blind spot area but the line of sight from the driver of the host vehicle to the turn signal indicator's emitted light beam is substantially blocked by the microlouvers. Examples of light directing or regulating filters or baffle assemblies can be found in U.S. Pat. Nos. 4,906,085 and 5,313,335, the entire disclosures of which are hereby incorporated by reference herein.

[00101] Although shown and described as a turn signal indicator, and with the pipeways allowing the light beams to pass through the block at an outward angle and the light control film directing the light at an outward angle away from the vehicle (so as to be principally viewable by a driver of a vehicle approaching or overtaking the subject vehicle while being substantially not viewable or discernible by the driver of the subject vehicle), the display element may comprise other types of indicators or displays or illuminated indicia, such as a blind spot detector system alert or an information display or an approach light or the like. The angle of the pipeways and of the light control film may be selected depending on the particular application of the display element. For example, for a blind spot detector alert, the block and light control film may be constructed and arranged so as to direct light toward the driver of the subject vehicle. Optionally, a display element or display elements at a rearview mirror may have a block and light directing film that direct light at different angles so as to provide two different displays or indicators at the mirror. For example, the block and light directing film may direct illumination from one or more illumination sources or LEDs outward away from the vehicle for a turn signal indicator, and may direct illumination from one or more other illumination sources or LEDs inward or toward the vehicle for a blind spot detector alert, so that two distinct displays or display types are provided at the reflective element of the mirror assembly. The two distinct displays may be provided by a single display element or module or may be provided by separate display elements at the rear of the reflective element.

[00102] As shown in FIGS. 10A and 10C, pipeways 259 are formed with recesses 259a at the rear or back of the block 258 and angled pipeways 259b between the recesses 259a and the front of the block 258. The recesses 259a are configured to receive or partially receive the illumination sources 262, which may be mounted to or established on a printed circuit board 264 or the like disposed at or attached to the optical plastic block 258. Although shown in FIG. 10A as being loosely positioned at or received in the recesses 259a, it is desirable to have the illumination sources or LEDs snugly fit in or contacting, and preferably optically coupled to, the transparent block 258 so that the illumination from the illumination sources is emitted or projected into the block when the illumination sources are activated.

[00103] Optionally, and with reference to FIG. 10D, the mirror reflective element may comprise a transflective electro-optic mirror reflective element 250', which includes a glass front substrate 252', a glass rear substrate 253', and a display element or turn signal indicator 256' at the rear of the rear substrate 253'. The mirror reflective element 250' comprises an electro-optic, such as electrochromic, reflective element assembly or cell with an electro-optic medium 255' (such as electrochromic medium) disposed between the front and rear substrates 252', 253'. Rear substrate 253' includes a transflective mirror reflector 254' disposed at its front surface (the third surface of the reflective element assembly or cell), while front substrate 252' includes a transparent conductor 257' disposed at its rear surface (the second surface of the reflective element assembly or cell). The electro-optic medium 255' is disposed between the substrates and is in contact with the transparent conductor 257' and transflective mirror reflector 254' and contained between the substrates via a perimeter seal 261'. The electro-optic mirror construction may be of an offset construction or a flush or frameless construction or design, such as utilizing aspects of various mirror constructions and designs, such as described herein.

[00104] Turn signal indicator 256' is disposed at the rear of the rear substrate 253' and is operable to emit or project light therethrough for viewing by a person viewing the reflective element, and preferably for viewing by a person viewing the reflective element at an angle with respect to the reflective element, such as in a similar manner as described above. Although shown in FIG. 10D as having a third surface transflective mirror reflector 254', the transflective mirror reflector may be disposed at the rear of the rear substrate 253' (at the fourth surface of the reflective element assembly or cell), with the turn signal indicator 256' disposed at the fourth surface transflective mirror reflector at the rear surface of the rear substrate. As described above, the turn signal indicator 256' includes a transparent or translucent optical plastic block 258', a light control film 260', and a plurality of illumination

sources 262 (preferably LEDs) on a printed circuit board 264. Turn signal indicator 256' may be substantially similar to turn signal indicator 256, described above, such that a detailed discussion of the turn signal indicators need not be repeated herein. The similar elements of the turn signal indicators not specifically addressed above with respect to turn signal indicator 250' are referenced with like numbers in FIGS. 10A and 10D.

[00105] When manufacturing a printed circuit board (PCB), it is least expensive and thus desirable to vertically or axially place the LEDs or chips. However, one could choose to have the LEDs put in and angled relative to the plane of the circuit board. The present invention allows for flat placement of the LEDs on the circuit board or substrate or chip, while still providing an angled direction of light emitted by the LEDs. The LEDs are thus substantially vertically oriented on the circuit board (so light emitted by the LEDs would be substantially vertical), but the emitted light is piped through the hollow tubes or pipeways in the block at or near the desired angle or direction for viewing of the lights by a person viewing the reflective element. Some of the emitted light would also leak into and through the transparent walls of the tubes and block to provide the substantially solid, continuous illumination or glow in the desired or appropriate shape around the illumination sources.

[00106] The angled pipeways 259b through optical plastic block 258, 258' are angled so that light from illumination sources 262 passes through the pipeways at an angle relative to the substrate 252 or substrates 252', 253', such as at an outward angle (such as for a turn signal indicator application) so as to direct or guide the light outward away from the side of the vehicle when the mirror reflective element is mounted at a vehicle, such as at a driver or passenger-side exterior rearview mirror of a vehicle, so as to be generally not viewable or discernible by the driver or occupant of the vehicle. For example, for a turn signal indicator application, the pipeways and/or light control film preferably function to angle the light emitted by the illumination sources outwardly away from the subject vehicle such that a driver of an overtaking vehicle would see the display, but the driver of the subject vehicle would not readily see or discern the display at the mirror reflective element. The pipeways and/or light control film may be constructed and/or arranged so as to be angled outward for a turn signal indicator (such as shown in FIGS. 10A and 10D and described above), but could be otherwise angled inward or downward for other applications (such as for a blind spot detector alert or an approach light or the like) or could have multiple angles, as discussed below.

[00107] Preferably, the optical plastic block 258, 258' is formed to be generally arrow-shaped with illumination sources 262 disposed therealong. As can be seen with reference to FIGS.

10A and 10D, the light control film 260, 260' may function to direct or guide the light generally along the same angle as the angled pipeways 259b (as shown in FIG. 10D), or the light control film may function to direct or guide the light at a different angle than the angle of the angled pipeways 259b (as shown in FIG. 10A), without affecting the scope of the present invention. By providing the angle of transmission of the light control film as a different angle as compared to the angle of the pipeways through the block, more of the light emitted from the illumination sources and passing through and along the pipeways may reflect back off of the light control film and/or transmit through the walls, and/or couple through the walls of the pipeways/tubes and into the block, thereby enhancing the illumination of the block when the illumination sources are activated and effectively creating a substantially solid illuminated block, such as a solid continuous illuminated chevron or arrow shape or indicia or the like, as opposed to a series of five or seven individual separated discontinuous light sources that are chevron shaped but not forming a solid continuous arrow.

[00108] Optionally, the optical plastic block may be formed without any passageways or pipeways or the plastic block may have pipeways extending only partially through the block depending on the desired appearance of the display element at the reflective element. Optionally, the illumination sources or LEDs may be located at different areas at the block, such as at a side of the block (and generally at or aligned with pipeways or at the sidewall of the block), depending on the particular application and desired appearance of the display element at the reflective element.

[00109] Optionally, and with reference to FIG. 10E, 10F and 10G, a mirror reflective element 250", such as an exterior mirror reflective element, includes a glass or optical plastic substrate 252" (such as, for example, a substrate having a thickness of about 2 mm to about 2.5 mm or thereabouts), a transflective mirror reflector 254" (such as an aluminum-doped silicon or an ISI stack, such as an ITO/silver/ITO stack or the like) and a display element, such as a turn signal indicator 256", at the rear of the substrate 252" and behind the transflective mirror reflector 254". Turn signal indicator 256" includes a light transmitting optical plastic block 258" (that may be specularly light transmitting so as to be clear or that may be rendered diffusely light transmitting should diffuse light transmission be desired) and a light control film 260" (such as a light control film as described above). Turn signal indicator 256" includes a plurality of illumination sources 262", such as light emitting diodes or diode lasers or incandescent sources or the like, located at the rear of optical plastic block 258" and generally at or aligned with a plurality of recesses or receiving portions 259" for the light

sources at an outer or rearward surface of block 258". The plurality of illumination sources 262 (preferably LEDs) may be established on a printed circuit board 264" or may be on a flexible polymeric substrate, such as an extruded plastic flat flexible cable with TPU, PVC or PBT insulation and flat copper connectors (such as is available from 3M Corporation of Minneapolis, MN as FFCe harnesses).

[00110] As shown in FIG. 10E, optical plastic block 258" is disposed at the rear of the substrate 252" and at the rear of the transflective mirror reflector 254", with the light control film 260" disposed between optical plastic block 258" and transflective mirror reflector 254". As also shown in FIG. 10E, turn signal indicator 256" may include a light absorbing wall or coating or material 257" established at and around block 258" to limit or substantially preclude light from passing through the sidewalls of block 258" to other areas of or at the rear of the reflective element. The light absorbing wall or coating or material 257" may comprise any suitable light absorbing material or layer or element, such as a dark or opaque wall or coating established around the block 258", such as a dark plastic or a black or dark-colored paint, or it may be a light reflecting but substantially non-light transmitting material or layer so that any stray light incident on such walls is reflected back into the body of block 258". The turn signal indicator 256" may be purchased by the mirror element sub-assembly manufacturer (such as from a low cost manufacturer such as in the Far East) and provided as a modular unit having the block and light control film within a light absorbing element/structure and with the printed circuit board and illumination sources at the rear surface of the block, and with any connectors/covers, etc., so that all the mirror element sub-assembly manufacturer need do is attach (either mechanically or adhesively, preferably with optical coupling) the bought-in or separately purchased/supplied module to the rear of the mirror element. One option is to use the likes of a PVB (polyvinyl butyral) laminating clear light transmitting film or a silicone laminating film or the like and to use the likes of an autoclave or a vacuum lamination technique (such as is described in U.S. provisional applications, Ser. No. 60/732,245, filed Nov. 1, 2005 (Attorney Docket DON01 P-1251); and Ser. No. 60/759,992, filed Jan. 18, 2006 (Attorney Docket DON01 P-1264), which are hereby incorporated herein by reference in their entireties) to optically attach the turn signal indicator module at the rear of the mirror element. Optionally, a light absorbing coating or material or opacifying material or coating may be established over the rear surface of the reflective element at locations other than where the turn signal indicator is located to limit or substantially preclude light transmission through the reflective element at regions surrounding the turn signal indicator. In such an application, an opacifying layer or element

may be disposed at the rear of the reflective element and may have an opening or aperture or window established at the desired or appropriate location for the turn signal indicator to be located.

[00111] As shown in FIG. 10G, optical plastic block 258" is generally wedge-shaped or angled at its outer or rearward surface (the surface opposite from the rear of the reflective element and that has the recesses or receiving portions 259" for receiving the illumination sources 262" therein), so that the principal light axis from the illumination sources is directed at an angle relative to the rear surface of the reflective element. For example, the block may preferably be formed with its rear surface (at which the light sources mount) at an angle of about 2 degrees to about 12 degrees or thereabouts (more preferably, at an angle of about 3 degrees to about 8 degrees or thereabouts and most preferably at an angle of about 3.5 degrees to about 5.5 degrees or thereabouts) relative to the front surface of the block (and hence to the rear surface of the mirror element to which the block engages/attaches). Note also that the front surface of the block may be convex contoured to generally match the local (concave) contour of the rear of the mirror element if it is a bent (such as a convex or an aspheric) exterior mirror element. Thus, when the reflective element is mounted at a vehicle as part of an exterior mirror assembly and is adjusted by a typical driver for rearward viewing at the side of the vehicle, the principal light axis of the illumination sources is directed away from the driver and principally into the overtaking area or adjacent lane or blind spot area so as to be readily viewable by a driver of an overtaking vehicle. Note that the angle for the rear surface of block 258" may generally match the light control angle of light control film 260", or may be somewhat different so that light control film 260" somewhat masks the presence of the individual light sources from view by an observer (whether lit or not lit). Note also that a heater pad (not shown) may be present and may have a chevron or other shaped cut out (or alternatively, a light transmitting, optionally light diffuser) portion that matches and juxtaposes where optical plastic block 258" is positioned to the rear of the reflective element.

[00112] Optionally, and with reference to FIG. 10H, the mirror reflective element may comprise transflective electro-optic mirror reflective element 250'", which includes a glass front substrate 252'", a glass rear substrate 253'", and a display element or turn signal indicator 256'" at the rear of the rear substrate 253'". The mirror reflective element 250'" comprises an electro-optic, such as electrochromic, reflective element assembly or cell with an electro-optic medium 255'" (such as electrochromic medium) disposed between the front and rear substrates 252'", 253'". Rear substrate 253'" includes a transflective mirror reflector 254'" (such as a thin transflective silver or silver-alloy or aluminum or aluminum-alloy or

metal oxide/metal/metal oxide transflective coating stacks such as ITO/Ag/ITO or AZO/Ag/AZO) disposed at its front, inner-facing surface (the third surface of the reflective element assembly or cell), while front substrate 252''' includes a transparent conductor 257''' (such as ITO or AZO or doped tin oxide) disposed at its rear surface (the second surface of the reflective element assembly or cell). The electro-optic medium 255''' is disposed between the substrates and is in contact with the transparent conductor 257''' and transflective mirror reflector 254''' and contained between the substrates via a perimeter seal 261'''. The electro-optic mirror construction may be of an offset construction or a flush or frameless construction or design, such as utilizing aspects of various mirror constructions and designs, such as described herein. The mirror reflective element may include a heater pad disposed at its rear surface, and the heater pad may have an aperture or window or hole established at the display area for the turn signal indicator to project or emit light therethrough.

[00113] As shown in FIG. 10H, turn signal indicator 256''' includes an optical plastic block 258''', light control film 260''', a plurality of illumination sources 262''' and a printed circuit board 264''', such as in a similar manner as described above. Mirror reflective element 250''' includes a molded backplate 270''' attached or adhered to the rear surface of rear substrate 253''' with actuator mounting elements 270a''' for mounting the mirror reflective element to a mirror actuator of the exterior mirror assembly, such as in a known manner. Backplate 270''' includes a receiving pocket 270b''' molded or formed at a desired or appropriate location at the backplate for receiving the turn signal indicator 256''' therein. As can be seen in FIG. 10H, the light control film 260''' and optical block 258''' may be received within pocket 270b''' with illumination sources 262''' and printed circuit board 264''' established at the outer or rearward surface of block 258'''. Preferably, the turn signal indicator 256''' may be provided as a modular unit (including the block, light control film, illumination sources and printed circuit board assembled together into a unitary module) and inserted into or received in the pocket 270b''' at the rear of the mirror reflective element (and held therein, such as mechanically or adhesively). However, rather than being provided as a preassembled module, the block, light control film and illumination sources (preferably LEDs) on the printed circuit board may be provided individually and assembled to the mirror reflector individually. Optionally, the mirror reflective element may include a diffuser or diffusing window or layer and/or the block itself may be diffusing or slightly diffusing of the light passing therethrough.

[00114] The backplate 270''' thus has a pocket 270b''' surrounding an aperture formed through the backplate and receiving the turn signal indicator 256''' therein. The aperture and pocket

thus may be arrow-shaped or chevron-shaped and may receive a correspondingly shaped or formed turn signal indicator. The pocket 270b''' is defined by walls extending rearward or outward from the backplate to substantially encase or surround the optical block 258''' when inserted into the pocket 270b'''.

[00115] Thus, the backplate may be attached or adhered to the rear surface of the reflective element and the turn signal indicator may be inserted into or slid into the pocket. The turn signal indicator desirably may be provided as a modular unit (including the block, light control film, printed circuit board and illumination sources) that is readily inserted into the pocket and electrically connected to electrical circuitry of the reflective element and/or mirror assembly. The turn signal indicator module thus may be purchased and provided as a separate modular unit that is readily installed or attached at the rear of the reflective element, such as at the mirror manufacturer's assembly facility or plant.

[00116] Optionally, the light control film may be diffusing or partially diffusing, or the turn signal indicator may include a separate diffuser or the block itself may comprise a diffusing material. Optionally, a diffuser is not included, and optionally, the turn signal indicator may not include the light control film. The turn signal indicator may be mechanically attached or secured at the pocket and may include or provide optical coupling of the block and/or light control film with the rear surface of the reflective element, such as via an optical adhesive or the like. Optionally, the individual elements of the turn signal indicator may be inserted into or established in the pocket to assemble the turn signal indicator in the pocket.

[00117] Optical plastic blocks 258", 258''' may be otherwise substantially similar to blocks 258, 258', described above, such that a detailed description of the optical blocks need not be repeated herein. Similar to optical plastic block 258, described above, optical plastic blocks 258", 258''' may comprise a transparent plastic material, such as, for example, an acrylic or polycarbonate or polystyrene material or the like, formed such as by injection molding, casting or the like. Also, and similar to the optical blocks described above, optical block 258", 258''' may be generally arrow-shaped to provide a substantially solid illuminated arrow at the reflective element when the illumination sources are activated. As can be seen in FIGS. 10E, 10G and 10H, blocks 258", 258''' may be wedge-shaped, and may have narrower or thinner outer leg portions as compared to a thicker center or arrow head portion. Optionally, and as can be seen in FIGS. 10E, 10G and 10H, the illumination sources may be located at recesses 259", 259''', without pipeways formed through the block as described above. The block may be substantially transparent and may diffuse the light passing therethrough.

[00118] Note that one advantage of the embodiments above is that light sources such as LEDs can be axially mounted onto PCBs and any angling of their orientation to the rear of the reflective element is via the angling of the rear surface of the optical block. This facilitates economy of manufacture as the PCB manufacturer may use automatic chip placement machines to axially (i.e. generally perpendicular to the surface of the PCB substrate) insert the likes of surface-mount LEDs (and without the need to insert at an angle or to angle the LEDs in a post-insertion operation). Also, though illustrated as a turn signal indicator, the advantages of the above embodiments may also be achieved with a blind spot detection system indicator (and where the angling of the rear surface of the optical block and of the light control film is towards the driver/cabin of the host vehicle when the reflective element is mounted in the exterior mirror assembly of the host vehicle). Also, a combined turn signal/blind spot indicator may be formed with portions of the optical block (and of the optical control film, if present) angled away from the cabin of the host vehicle for the turn signal function and towards the cabin of the host vehicle for the blind spot detection indicator function. Also, such angling of the rear surface of the optical block is also applicable should light transmitting channels or tubes be created at least partially through the block, such as shown in FIGS. 10A, 10C and 10D (and note that should such channels or tubes be present, the rest of the block may be formed of a light absorbing material, such as of a dark-pigmented polymeric material or of a light diffusing material).

[00119] Also, note that optionally, the optical control film may be disposed at the rear surface of the optical block (rather than disposed between the block 258, 258', 258" or 258'" and the rear surface of the mirror reflective element such as shown in FIGS. 10A, 10D, 10E and 10H), while remaining within the spirit and scope of the indicator of the present invention. For example, and as shown in FIG. 10I, the turn signal indicator 256"" includes an optical plastic block 258"", with a light control film 260"" established (such as via adhering or otherwise attaching) at its rear surface, and with a plurality of illumination sources 262"" and a printed circuit board 264"" at the rear of the block and film. Optionally, and desirably, the indicator 256"" includes an opaque wall or tape or material 257"" at and around the optical block 258"", such as described above. As can be seen in FIG. 10I, the light control film 260"" has its micro louvers 260a"" at about zero degrees (i.e., generally perpendicular to the plane of the light control film) so as to direct the principle beam axis 261"" of the light emitted by the illumination sources at the desired or appropriate angle established by the angling of the rear surface of the block relative to its front surface and so have the light beam emitted by the light sources pass through the block 258"" and through the substrate 252"" of

the reflective element 250"" to exit at an angle. Because the light control film 260"" is established at the rear surface of the block 258"", the block may not include recesses to receive the light sources, but optionally, the light control film may be laminated (at an angle) between a lower block portion (that has an angled rear face) and an upper block portion, and with such recesses provided in the upper block portion. The block can optionally include light transmitting pipeways therethrough (such as pipeways described above with respect to blocks 258, 258', 258", 258"').

[00120] As shown in FIG. 10I, the rear surface of the block may be angled relative to the forward surface of the block at the rear of the reflective element, and may be substantially flat or planar, with the light control film established thereat, and with the illumination sources and printed circuit board located at the rear of the light control film so as to direct or emit illumination through the light control film and through the transparent block and further through the transflective reflective element at an angle set by the slanted rear face of the block. The angle of the rear surface of the block and the angle of the micro louvers thus may be selected to provide the desired angle of the principle beam axis of the light emitted by the indicator. However, and as shown in FIG 10I, it is desirable in such a configuration to use light control film with zero degree louvers. Turn signal indicator 256"" may be otherwise substantially similar to the turn signal indicators 256, 256', 256", 256"' described above, such that a detailed discussion of the turn signal indicators need not be repeated herein. Although shown in FIG. 10I as being established at a rear of a substrate 252"" of a non-electro-optic transflective reflective element, the indicator 256"" (with the light control film established at the rear of the optical block) may be implemented at the rear of an electro-optic reflective element, such as described above with respect to indicators 256' and 256"', and the indicator may be received or inserted into a pocket at a backplate or the like of the reflective element).

[00121] Placement of the light control film on the angled rear surface of the optical block is advantageous when the light control film (such as 3M's Vikuiti™ ALCF-P or LCF-P) is used where the louver angle is zero degrees and where on-axis vertically incident light from the light sources is highly transmitted but where off-axis light is cut-off by the embedded micro louvers. Such zero degree louvered light control film is used for privacy filters for laptop computer screens and ATM screens, and so is economically available. By being able to purchase and use zero angle louvered light control film as shown in FIG. 10I, but by using the likes of an angled optical block to support the light control film at an angle in front of the light sources that are similarly angled and supported, economical assembly can be enhanced [or, alternatively, by using a mechanical support to mutually support and angle the light

control film/light sources relative to the plane of the rear of the mirror reflective element, so that light emitted by the light sources is generally aligned with or on-axis with the light transmission axis between the louvers, and so that the light beam passed through the light control film impinges on the mirror reflective element and passes therethrough with its principal beam axis directed away (for a turn signal indicator) from the vehicle body side and away from direct view by a driver of the host vehicle to which the exterior mirror reflective element is attached].

[00122] Economy of assembly and supply can be achieved by utilizing the embodiment such as shown in FIG. 10H. The combination of a mirror backplate that is adapted to receive a turn signal indicator module (or a blind spot indicator module or an approach light module) in combination with a transflective mirror reflective element can optimize the cost for the mirror assembly supplier as follows. The mirror assembly supplier (which may be the Tier 1 supplier to the automaker) can make or procure the transflective mirror element. Separately, the mirror assembly supplier can make or procure the mirror backplate. Separately, the mirror assembly supplier can make or procure the turn signal module (or its sub-components). Then, the mirror assembly supplier (or a sub-assembly supplier thereto) can take the transflective mirror element and attach a heater pad to its rear (with an aperture or a light transmitting window, preferably a light diffuser and transmitter, created therein that matches, for example, the chevron shape and dimensions of the turn signal indicator module that will be used). Then the backplate (that is modified to receive the turn signal module such as is shown in FIG. 10H) can be attached (such as via a tape adhesive or the like). Then the turn signal indicator module may be inserted into the pocket at the backplate, and any cap or cover may be attached and the assembly of the mirror element with indicator feature is achieved.

[00123] There are several benefits to using a transflective mirror reflector for such a through-the-mirror-reflective element turn signal feature (or other indication or lighting feature). Currently, the likes of a General Motors GMT 800 driver-side exterior mirror assembly is equipped with an electrochromic mirror element that has a signal light area formed in its reflective coating by removing a portion of the reflective coating and aligning the signal light with this signal light area. The portion removed is laser ablated to leave lines devoid of reflective material separated by lines of the reflective material in a non-transflective mirror reflector that is deposited onto the third surface of the electrochromic mirror element used (such as is disclosed in U.S. Pat. No. 6,111,683, the entire disclosure of which is hereby incorporated by reference herein).

[00124] The embodiment illustrated in FIG. 10H and disclosed herein has several advantages and improvement over these existing through-the-mirror-reflective element turn signal electrochromic mirrors. For example, use of a third surface transflective mirror reflector instead of a third surface mirror reflector where holes/apertures/jail-bar lines/ablations/micro-ablations or the like are created has the benefit that there are no consumer viewable openings such as holes/apertures/jail-bar lines/ablations/micro-ablations present in the mirror reflector's coating(s). Thus, should the automaker or consumer elect not to use the turn signal feature, the turn signal module may be left out but the common backplate [where the receiving structure for the turn signal module/components can be economically created during the injection molding of the backplate from a polymeric resin (such as ABS or PC/ABS or the like)] and heater pad may still be used. This is because with a transflective reflector, there are no visible holes or ablations or lines of the like visible to the consumer that betray that there is now no turn signal indicator present. Thus, use of a third surface transflective mirror reflector in such an electrochromic through-the-mirror-reflective element turn signal feature allows the Tier 1 mirror maker and/or the automaker elect to supply a base or turn-signal featured electrochromic mirror assembly using a common assembly process.

[00125] As a further advantage, use of a third surface transflective mirror reflector has the advantage that there is no need to align the light sources (such as the 5 or 7 LEDs in a turn signal chevron) of the turn signal unit/module with holes or apertures in the mirror reflector. And by having the receiving structure/elements for the turn signal module be molded into the plastic backplate itself, the turn signal alignment and positioning to the rear of the mirror element is accurately established in the precise attachment of the backplate to the rear of the mirror element (an operation that the mirror element sub-assembly maker has to do in any event so that the mirror sub-assembly correctly receives the mirror element-positioning actuator).

[00126] Thus, and in accordance with embodiments above, a transparent or substantially transparent optical plastic block may be formed in the general shape of an arrow so that the arrow is viewable and discernible by a person viewing the reflective element. The light emitted through the pipeways in the block and through the light control film may be viewed (such as at or near the angle of the directed or guided light) as relatively intense points of light or light sources when the illumination sources are activated, while the transparent block (preferably in the shape of an arrow or other suitable shape or form) will be viewable as a solid shape (such as an arrow shape or the like) around the light sources to provide an image of the arrow and not just the individual points of light. When the illumination sources are

activated, light emitted by the illumination sources is guided through and along the angled pipeways through the block and may be refracted or guided or controlled by light control film so as to be directed in a desired direction, such as outwardly away from the vehicle. Thus, the illumination sources and the illuminated block are readily viewable by a driver of another vehicle adjacent or approaching the subject vehicle, while the illumination is not readily viewable or discernible by the driver of the subject vehicle.

[00127] The transflective mirror reflector (such as at the rear of the single substrate or at the front surface of the rear substrate of the electro-optic reflective element assembly or cell) may comprise any suitable transflective mirror reflector or coating or layer or layers, such as those described herein. For example, and in a preferred embodiment, the transflective mirror reflector may comprise a silicon material or a doped silicon material or the like, preferably having a refractive index (as measured at the sodium D line) of at least about 3 or thereabouts. For example, good results have been achieved by sputtering from a silicon-aluminum sputtering target (e.g. 95% / 5% Si:Al) or the like. In such an embodiment, a sputter coating of a physical thickness (sputtered in an argon atmosphere) of about 200 to 300 angstroms or thereabouts exhibits a first surface reflectivity of about 60-65 %R photopic reflectivity (as measured per SAE J964a), and a second surface reflectivity of about 50-55 %R, and a photopic transmission of around 18 to 20 %T or thereabouts. The coating may be deposited or disposed on a flat or substantially flat substrate (and optionally, subsequently bent in a glass bender thereafter), or may be deposited or disposed on a curved substrate, such as a curved substrate of the type shown in FIG. 14 and discussed below. Other transflective mirror reflectors may be implemented depending on the particular application. Optionally, the substrate may include a reflective perimeter band around its perimeter, such as described below with respect to FIG. 14, so that a single substrate mirror reflective element may be used at an opposite side of the vehicle (such as the passenger-side of the vehicle) in conjunction with an electro-optic reflective element assembly implemented at the other side of the vehicle (such as the driver-side of the vehicle) that may include such a perimeter reflective band to provide a frameless reflective element, such as described herein.

[00128] Optionally, and particularly for exterior mirror applications, the reflective element may include a broader perimeter band at the area or region where a display element is located. For example, and with reference to FIG. 11, an exterior mirror reflective element 310 may include a perimeter band 326 around the perimeter or border of the reflective element. The perimeter band 326 has a broader band portion 326a along a perimeter portion of the reflective element 310 and along an area that has one or more display elements 330.

The display elements 330 may comprise illumination sources or light sources, such as light emitting diodes (LEDs) or the like, and may be positioned behind the rear surface of the reflective element and directed to emit illumination through the reflective element and through the broader band portion 326a of perimeter band 326. The broader band portion 326a may have one or more windows or ports 327a formed or established through the band portion and generally at or aligned with the display elements 330, or the perimeter border band 326 (or at least the broader band portion 326a of perimeter band 326) may be passively transflective (such as a band formed or established by a layer of a silicon material or the like) to allow light from the display element or elements 330 to pass through the reflective element and the perimeter band (optionally, the perimeter band may have a higher transmissivity characteristic than the electro-optic area of the reflective element to enhance viewability and discernibility of the light emitted by the display elements) so as to be viewable by a person viewing the reflective element. For example, and such as is described in U.S. Pat. No. 6,065,840, which is hereby incorporated herein by reference in its entirety, a sputtered silicon thin film (with a physical thickness in a range of about 300 angstroms to about 450 angstroms) can have a photopic reflectivity greater than at least about 50 percent, and more preferably greater than at least about 55 percent of light incident thereon, and having a transmission value greater than at least about 15 percent, and more preferably greater than at least about 20 percent of light incident thereon.

[00129] Optionally, the reflective element 310 may include a photo sensor 340 for sensing light at the reflective element. In the illustrated embodiment, the photo sensor 340 is located at and behind the perimeter band 326, and at a broader region 326b of perimeter band 326. The photo sensor 340 may be directed or angled or oriented so as to be facing generally upward or skyward to detect light above the reflective element. The perimeter band portion 326b may have a window or port 327b formed therethrough to allow light to pass through the perimeter band portion 326b to the photo sensor 340.

[00130] The reflective element 310 may comprises a transflective or display on demand type of reflective element with a perimeter seal around the perimeter of the reflective element and, thus, around the perimeter of the electro-optic area of the mirror reflective element. The perimeter band may be disposed (such as on the second surface of the front substrate as described above) around the perimeter of the substrate so as to conceal the perimeter seal (such as described in PCT Application No. PCT/US03/29776, filed Sep. 19, 2003 by Donnelly Corp. et al. for ELECTROCHROMIC MIRROR ASSEMBLY (Attorney Docket DON01 FP-1109(PCT)); and/or PCT Application No. PCT/US03/35381, filed Nov. 5, 2003

by Donnelly Corp. et al. for ELECTRO-OPTIC REFLECTIVE ELEMENT ASSEMBLY (Attorney Docket DON01 FP-1116(PCT)); and/or U.S. pat. applications, Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); Ser. No. 10/528,269, filed Mar. 17, 2005 (Attorney Docket DON01 P-1109); Ser. No. 10/533,762, filed May 4, 2005 (Attorney Docket DON01 P-1116); Ser. No. 11/226,628, filed Sep. 14, 2005 (Attorney Docket DON01 P-1236); and/or Ser. No. 11/021,065, filed Dec. 23, 2004 by McCabe et al. for ELECTRO-OPTIC MIRROR CELL (Attorney Docket DON01 P-1193); and/or U.S. provisional applications, Ser. No. 60/692,113, filed Jun. 20, 2005 (Attorney Docket DON01 P-1224); Ser. No. 60/677,990, filed May 5, 2005 (Attorney Docket DON01 P-1219); Ser. No. 60/653,787, filed Feb. 17, 2005 (Attorney Docket DON01 P-1207); Ser. No. 60/642,227, filed Jan. 7, 2005 (Attorney Docket DON01 P-1199); Ser. No. 60/638,250, filed Dec. 21, 2004 (Attorney Docket DON01 P-1198); Ser. No. 60/624,091, filed Nov. 1, 2004 (Attorney Docket DON01 P-1184), and Ser. No. 60/609,642, filed Sep. 14, 2004 (Attorney Docket DON01 P-1171), which are hereby incorporated herein by reference in their entireties). The display elements 330 and/or photo sensor 340 may be positioned outboard of the perimeter seal so that they are not located in the electro-optic area of the reflective element. Because the display elements and/or photo sensor are positioned at the perimeter band area, they are not invasive of the electro-optic function of the reflective element. Thus, the display elements may be positioned at the reflective element for emitting illumination through the reflective element, without the extra complexities of the electro-optic or electrochromic transflective function. Also, the photo sensor may be positioned at the reflective element for receiving light external to the reflective element, without having to form a window or aperture in the reflective coatings of the transflective reflective element.

[00131] Optionally, and with reference to FIGS. 12 and 13, a mirror reflective element 310' may include a wide angle or auxiliary mirror or reflector 350 at a perimeter region or corner region of the reflective element to provide a rearward wide angle view to the driver of the vehicle. The wide angle reflector may be established at the reflective element and behind the fourth surface of the reflective element, such as by utilizing aspects of the reflective elements described in U.S. Pat. No. 6,315,419 and/or U.S. pat. publications, Pub. No. US 2002/0105741, published Aug. 8, 2002; and/or US 2003/0117731, published Jun. 26, 2003; and/or International Pub. No. WO 01/81956, published Nov. 1, 2001, which are all hereby incorporated herein by reference in their entireties. The wide angle reflector may be positioned at a perimeter region of the reflective element so as to provide a wide angle