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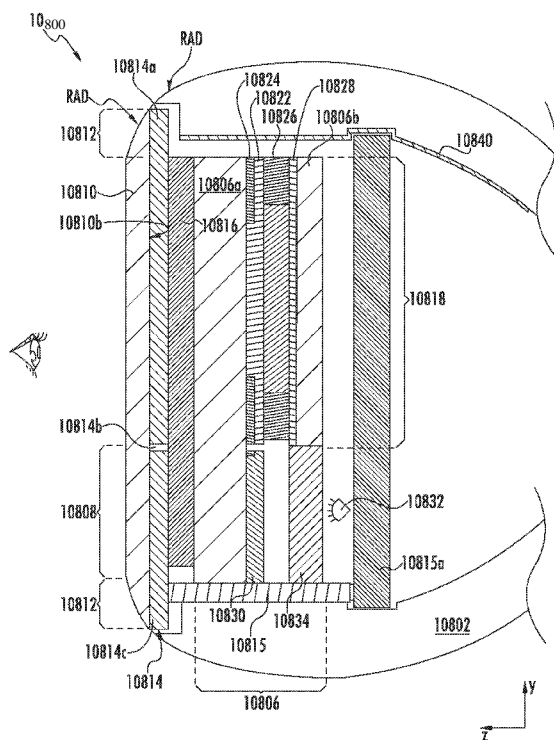


FIG. 51

(57) Abstract: A vehicular rearview assembly that has a rounded outer
perimeter edge to satisfy safety standards and contains an EC element
having a complex peripheral ring, a front surface that is fully observ-
able from the front of the assembly, and a user interface with switches
and sensors that activate and configure, in cooperation with electronic
circuitry of the assembly, pre-defined function(s) or device(s) of the
assembly in response to the user input applied to the user interface. A
complex peripheral ring may include multiple bands the structures of
which is adapted to provide for specified optical characteristics of
light, reflected off of the ring. Electrical communications between the
electronic circuitry, the mirror element, and the user interface utilize
connectors configured to exert a low contact force, onto the mirror ele-
ment, limited in part by the strength of adhesive affixing the EC ele-
ment to an element of the housing of the assembly.

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AUTOMOTIVE REARVIEW MIRROR WITH CAPACITIVE SWITCHES

[0001] This application claims the benefit of U.S. Patent Application No. 12/832,838 filed on July 08, 2010 and titled "Vehicular Rearview Mirror Elements and Assemblies Incorporating These Elements", U.S. Provisional Patent Applications No. 61/450,888 filed on March 09, 2011 and titled "Automotive Rearview Mirror With Capacitive Switches", and U.S. Provisional Patent Application No. 61/467,832 filed on March 25, 2011 and titled "Automotive Rearview Mirror with Capacitive Switches".

[0002] This application is also a continuation-in-part of U.S. Patent Application No. 12/832,838 filed on July 08, 2010, which is a continuation-in-part of U.S. Patent Application No. 12/750,357 filed on March 30, 2010, which is a continuation of U.S. Patent Application No. 12/154,736 filed on May 27, 2008 and now issued as U.S. Patent 7,719,750, which is a continuation of U.S. Patent Application No. 11/477,312 filed on June 29, 2006 and now issued as U.S. Patent 7,379,225, which is a continuation of U.S. Patent Application No. 11/066,903 filed on February 25, 2005 and now issued as U.S. 7,372,611, which in turn claims priority under 35 U.S.C. § 119 to U.S. Provisional Applications Nos. 60/548,472 filed on February 27, 2004, and 60/605,111 filed on August 27, 2004, and 60/614,150 filed on September 29, 2004.

[0003] The U.S. Patent Application No. 11/066,903 is also a continuation-in-part of U.S. Patent Applications Nos. 10/260,741 filed September 30, 2002 and now issued as U.S. 7,064,882 and 10/430,885 filed on May 06, 2003 and now issued as U.S. 7,324,261.

[0004] The disclosure of each of the above-mentioned patent applications is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0005] The present invention generally relates to electro-optic (EO) devices and apparatus incorporating such devices. In particular, the invention relates to electro-optic devices used in architectural windows or vehicular rearview mirror elements.

[0006] Electro-optic rearview mirror elements are becoming more common in vehicular applications with regard to both inside and outside rearview mirrors and mirror assemblies, whether on the driver's or the passenger's side. Such electro-optic rearview mirrors are automatically controlled to vary the reflectivity of the mirror in response to rearward and forward aimed light sensors so as to reduce the glare of headlamps in the image reflected to the driver's eyes. Typical electro-optic elements, when incorporated in vehicular rearview mirror assemblies, will have an effective field of view (as defined by relevant laws, codes and specifications) that is less than the area defined by the perimeter of the element

5 itself. Often, the effective field of view of the element is limited, at least in part, by the construction of the element itself and/ or an associated bezel.

[0007] Typically, a vehicular rearview assembly (for example, an autodimming assembly such as, generally, EO mirror assembly and, in particular, an electrochromic, EC, assembly, or an assembly including a prismatic element) includes a mirror element that is at least partially encased in a casing or housing element, sometimes with a bezel portion of the housing element that encompasses at least a portion of the edge surface of the mirror element and that mechanically cooperates (via snapping elements or other integration mechanism) with the remaining portion of the housing element. Typically, either the mirror element or the assembly itself is spatially (for example, angularly) alterable by the driver (for example, via a pivot assembly) to adjust a rearward field of view associated with the rearview assembly.

15 [0008] Various attempts have been made to provide a mirror element having an effective field of view substantially equal to the area defined by its perimeter. As shown in Fig. 1, depicting a cross-sectional portion of a typical rearview assembly employing an EC element, the subassembly 100 includes an EC mirror element 110, a bezel 112, and a carrier plate 117. The subassembly may further include gaskets 120 and 122 that are placed on either side of the EC element 110 to form a secondary seal around the periphery of the element 110. The EC element 110 includes a front substantially transparent element or substrate 130 typically formed of glass and having a front surface 130a and a rear surface 130b. The EC element 110 further includes a rear element 140, which is spaced slightly apart from the element 130. A seal 146 is formed between elements 130 and 140 about their periphery so as to define a sealed chamber 147 therebetween, in which an EC medium is provided. As known in the art, elements 130 and 140 preferably have electrically conductive layers (serving as electrodes, not shown) on the surfaces facing the chamber such that an electrical potential may be applied across the EC medium. These electrodes are electrically isolated from one another and are separately coupled to a power source (not shown) by means of corresponding bus connectors (connector 148b is shown in a specific implementation, as an electrically-conducting clip). To facilitate attachment of bus connectors to corresponding electrically-conducting layers, elements 130 and 140 are typically mutually offset so that one bus connector may be secured along a bottom edge of one of the elements and another bus connector may be secured to the top edge of the other element. The bus connectors (such as the connector 148b) may be spring clips (similar to those disclosed in commonly-assigned U.S. Patent No. 6,064,509 and 6,062,920) and are configured to ensure that they remain physically and electrically coupled to the electrode layers on the inward-facing surfaces of elements 130 and 140. Alternatively, the bus connectors may include an electrically-conductive member such as a thin-film or foil that electrically extends a corresponding conductive layer to the back of the assembly over an edge surface of at least one of the elements 130, 140 (as discussed, for example, in commonly-assigned U.S. Patent Applications Nos. 12/505,458, 12/563,917). In a specific implementation, such electrical extension may include a portion that wraps around an edge of a corresponding substrate. Once the EC element 110 has been manufactured and bus connectors have been configured, then the mirror subassembly 100 may be formed. As shown in Figs. 1, a bezel 112, the

function of which is to mechanically support the element retained by the bezel, may include a front lip **151** extending over a portion of the front surface **130a** of the front element **130**. While the width D_1 of such lip may vary, it typically extends over a sufficient portion such as 5 mm, for example, of the front surface **130a** to obscure a person's view of the seal **146** and protect the seal **146** from possible degradation caused by ambient UV light.

[0009] Prior to inserting the electrochromic mirror element **110** in the bezel **115**, an optional front gasket **120** may be provided behind the front lip **151** so as to be pressed between the front surface **130a** of the front element **130** and the inner surface of the front lip **151** of bezel **112**. The mirror element **110** is then placed in bezel **112** and an optional rear gasket **122** may be provided along the periphery of the back surface of element **140**. In lieu of, or in addition to front and/or rear gaskets **120**, **122** the bezel/mirror interface area may be filled or potted with a sealing material such as urethane, silicone, or epoxy. A carrier plate **117**, which is typically formed of an engineering grade rigid plastic or a similar material as used for bezel **112**, is then pressed against the rear surface of element **140** with the gasket **122** compressed therebetween. A plurality of tabs (not shown) may be formed inside of the bezel such that carrier plate **117** is snapped in place so as to secure mirror element **110** within the bezel. The carrier plate **117** is typically used to mount the mirror subassembly within an exterior mirror housing. More specifically, a specific positioner (not shown) may also be mounted within the mirror housing and mechanically coupled to the carrier plate **117** for enabling remote adjustment of the position of the mirror subassembly within the housing. Various embodiments with reduced lip of the bezel has been also discussed in prior art.

[0010] While the above-described structures are readily manufacturable, various styling concerns have arisen that often require not only elimination of a conventional bezel but addressing various structural and functional problems generated by such change.

SUMMARY OF THE INVENTION

[0011] Embodiments of the invention provide vehicular rearview assemblies including electrochromic (EC) elements at least a portion of which is defined by the EC cell. Generally, the front outer peripheral portion of an assembly defines an annulus region having a curvature with a radius of at least 2.5 mm. The EC cell has first and second optically transparent substrates and a seal configured to bound a cavity of said EC cell that contains EC medium. The first substrate of an EC cell a first surface corresponds to a front of the EC element and a second surface has a peripheral ring of material disposed thereon, which peripheral ring conceals the seal from being observed from the front and from being exposed to at least UV light incident through the first substrate. In one embodiment, the first and second substrate cooperate such as to establish a ledge along at least a part of a perimeter of the EC cell. In a specific case, the second substrate has an area that is smaller than the area of the first substrate. An embodiment of the assembly also includes a conductive pad of a capacitive switch disposed on the second

5 surface adjacent to said EC cell. A conductive pad of a capacitive switch may have an opening defined throughout the pad. The EC element further includes an electrically-conductive thin-film layer (such as a TCO layer) disposed over the peripheral ring and a thin-film stack containing a second electrically-conductive layer. In a specific embodiment, the annulus region of the assembly is located along a perimeter of the first surface and has an optically diffusive surface. In a related embodiment, the seal of
10 the EC cell includes a non-conductive portion disposed circumferentially around a perimeter of the EC cell such as to face the EC medium and a conductive portion disposed outside of said non-conductive portion.

[0012] Embodiments of the invention additionally provide an EC element for use in a vehicular rearview assembly that includes a first optically transparent substrate (having a first surface
15 corresponding to a front of the EC element, a second surfaces opposite the first surface, and a first edge surface connecting said first and second surfaces); a second optically transparent substrate (having a third surface, a fourth surface, and a second edge surface connecting said second and third surfaces); and a seal sealably affixing the second and third surfaces to one another and defining a perimeter of a cavity containing an EC medium between said surfaces. Embodiments additionally include a transparent
20 electrode layer on the second surface of the EC element (including a first layer of electrically-conductive material and a ring-shaped layer of a spectral filter material disposed along a perimeter of the cavity and adjoining the first layer of electrically-conductive material and configured to substantially block the seal from at least visible and UV light incident through the first surface); and a reflective electrode layer including a second layer of electrically-conductive material on the third surface. Furthermore,
25 embodiments additionally include a third layer of electrically-conductive material carried on at least one of the second, third, and fourth surfaces such as to have a projection, onto the second surface, that is adjacent to either of normal projections of the transparent electrode layer or the reflective electrode layer onto the second surface. Optionally, the second substrate may have an area that is smaller than an area of the first substrate, the first substrate may be configured to transversely extend beyond the second
30 substrate such as to define a ledge along at least a portion of a perimeter of the second substrate, and the third electrically-conductive layer may be disposed on the ledge and include a layer of the ring-shaped spectral filter material. In a specific embodiment, the layer of the spectral material of the third electrically-conductive layer contains openings therethrough, and the third electrically-conductive layer additionally includes a layer of transparent electrically-conductive material. In particular, the layer of
35 transparent electrically-conductive material of the third electrically conductive layer may include a TCO layer that is substantially co-extensive with the spectral filter material of the third electrically-conductive layer. In another specific embodiment, the EC element has an annulus region having a curvature with a radius of at least 2.5 mm and located along a perimeter of the first surface. Optionally, the annulus region has an optically diffusive surface.

40 [0013] Any embodiment of the EC element is generally configured in a vehicular rearview assembly that additionally contains a carrier having an extended portion disposed along the fourth surface

5 of the EC element and a ridge portion extending substantially transversely to the extended portion along a perimeter thereof. In a specific embodiment, the ridge portion is characterized by a radius of curvature of at least 2.5 mm. The carrier may also include a step portion having a step surface configured to extend along the second surface of the EC element, where the step surface carries a fourth electrically-conductive layer disposed thereon and having a normal projection onto the second surface that is adjacent to either of
10 normal projections of the transparent electrode or the reflective electrode onto the second surface. The step surface additionally carries a graphical layer disposed on top of the fourth electrically-conductive layer and including graphical indicia. The assembly additionally includes an auxiliary device selected from the group consisting of an illumination assembly, a display, a voice activated system, a compass system, a telephone system, a highway toll booth interface, a telemetry system, a headlight controller, a
15 rain sensor, a tire pressure monitoring system, a navigation system, a lane departure warning system, and an adaptive cruise control system. A portion of the illumination assembly is configured to highlight the graphical layer and transmit light through the graphical indicia towards a field of view at the front of the assembly. In a specific embodiment, the second substrate has an area that is smaller than an area of the first substrate, the first substrate is configured to transversely extend beyond the second substrate such as
20 to define a ledge along at least a portion of a perimeter of the second substrate, and the third electrically-conductive layer is disposed on said ledge. Moreover, the fourth electrically-conductive layer is, optionally, electrically extended, through a passage in the extended portion of the carrier to a circuitry at a back of the assembly so as to define a capacitive switch adapted to operate in response to an input applied to a front of the assembly.

25 **[0014]** Embodiments of the invention additionally provide a vehicular rearview assembly including (i) an electrochromic (EC) element (having first and second substrates where the first substrate includes first and second mutually opposing surfaces, corresponds to a front of the rearview assembly, and has a profile that is graded, in a peripheral region along a circumference of the first surface, with a radius of at least 2.5 mm); (ii) a second substrate (having third and fourth surfaces, the third surface
30 having a reflective electrode thereon, the fourth surface corresponding to the back of the assembly, the second and third surfaces facing each other and mutually secured with a ring of seal material so as to define a cavity hosting an EC medium); and (iii) a carrier configured to support the EC element from its back and having an extended portion disposed along the fourth surface and a peripheral portion adapted to protrude transversely from the extended portion so as to accommodate said second substrate on an
35 inboard side of the peripheral portion. The second surface of the EC element generally carries a thin-film stack that includes a transparent electrode and a peripheral ring of material configured to substantially conceal the seal from being visible from the front. In a specific embodiment, a transparent electrode include a TCO layer disposed on top of the peripheral ring. In a related specific embodiment, the second surface additionally includes a second layer of TCO disposed adjacently to the transparent electrode layer
40 along a portion of a periphery of said second surface. At least one of the transparent and reflective electrodes is electrically extended to the back of the assembly through a conductive member. The

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5 peripheral portion defines a step that is substantially parallel to the second surface and that carries a patch of electrically-conductive layer electrically extended, through a passage in the extended portion, to a circuitry at the back of the assembly so as to define a capacitive switch adapted to operate in response to an input applied to the front of the assembly. The patch of the electrically-conductive material has a normal projection onto the second surface that is adjacent to either of normal projections of the
10 transparent electrode or the reflective electrode on the same second surface. In one embodiment, the normal projection of the patch onto the second surface overlaps with the second layer of TCO. Optionally, the second layer of the TCO may be larger than an area of the patch of electrically-conductive material.

[0015] An embodiment of the assembly may additionally include (iv) a graphical layer carrying
15 graphical indicia therein and disposed on top of the patch of electrically-conductive material; and (v) a source of light configured to highlight the graphical layer and transmit light through the graphical indicia towards a field of view at the front of the assembly. Additionally, an area of the first substrate may be larger than an area of the second substrate, and the first substrate may extend transversely beyond the second substrate such as to define a ledge, the light transmitted through said graphical indicia being
20 observable through the ledge.

[0016] Embodiments of the invention also provide a vehicular rearview assembly having a front surface and including a housing system (with a casing defining an inner volume and an aperture, the aperture corresponding to the front of the assembly), an optical system (with a (i) mirror system having a substrate with a first surface and a transfective element disposed behind the first surface with respect to
25 the front of the assembly; (ii) a first source of light positioned behind the transfective element and adapted to transmit light through the transfective element, the aperture of the casing, and the first surface to a field-of-view (FOV) at the front of the assembly), and first and second sensors. The optical system is structurally supported by the housing and at least partially disposed within the volume of the casing such as to have the first surface be unobstructingly observable from the front of the assembly. The first sensor
30 is configured to activate, in response to a first user input, at least one auxiliary device chosen from a group consisting of an interior illumination assembly, a digital voice processing system, a power supply, a global positioning system, an exterior light control, a moisture sensor, an information display, a light sensor, a blind spot indicator, a turning signal indicator, an approach warning, an operator interface, a compass, a temperature indicator, a voice actuated device, a microphone, a dimming circuitry, a GPS
35 device, a telecommunication system, a navigation aid, a lane departure warning system, an adaptive cruise control, a vision system, a rear vision system and a tunnel detection system of the assembly. The second sensor is configured to cause, in response to a second user input, locking of the operation of the first sensor.

[0017] In one embodiment, the first sensor includes a capacitive sensor having a first
40 electrically-conductive pad disposed on a portion of the optical system. In a related embodiment, the second sensor includes a capacitive sensor having an electrically-conductive pad disposed on a surface of

5 said casing behind said first surface. In particular, the first sensor may include a capacitive sensor having a first electrically-conductive pad disposed on a surface of the optical system, and the second sensor may includes a capacitive sensor having an electrically- conductive pad disposed on the same surface on a side of the first electrically-conductive pad. In one embodiment, the electrically-conductive pad of the second switch is spatially distributed on an inner portion of the housing system in electrical cooperation
10 with electronic circuitry at the back of the assembly such as to cause locking of the operation of the first sensor in response to change in angular position of the assembly. In a specific embodiment, the second user input is configured to simultaneously activate said first and second sensors. In one embodiment, the second sensor includes an optical sensor.

[0018] In one embodiment, the optical system further includes an indicator configured to
15 produce, in response to activation of the at least one auxiliary, an optical output observable from the front of the assembly; and optical means for backlighting said indicator with light from a second source of light within the assembly. Optionally, the optical means includes a lightpipe having input and output lightpipe ends, the output end adapted to couple light from the second source of light into the indicator. Optionally, the mirror system includes an optically-transparent ledge defined by two substrates that sandwich said
20 transfective element therebetween, and optical system further includes optical indicia configured to be illuminated from a back of the assembly through the ledge and thereby uniquely identify the first sensor.

[0019] In one embodiment, the housing structure is characterized by an annular region around the perimeter thereof, the annular region having a radius of no less than 2.5 mm. Optionally, this annular region is an annular region around the perimeter of the first substrate.

25 [0020] In a specific embodiment, the first substrate of the mirror system includes a laminate of two lites of glass, and the first sensor includes an electrically-conductive pad between said two lites of glass, the electrically-conductive pad being electrically-extended through a connector to an electrical circuitry at a back of the assembly. An outer edge of the laminate is curved at a radius of no less than 2.5 mm around a perimeter of the laminate, and said connector adjoins the curved outer edge.

30 [0021] Embodiments of the invention further provide a vehicular rearview assembly having a front surface and including:

- A housing system including a casing defining an inner volume and an aperture, the aperture corresponding to the front of the assembly;

- An optical system having a mirror system (including (i) a substrate with a first surface and a
35 transfective element disposed behind the first surface with respect to the front of the assembly, where the transfective element is characterized by transmittance that is variable in response to voltage applied to the transfective element; (ii) a reflective optical polarizer disposed across a surface of the transfective element; and (iii) a first source of light positioned behind the transfective element and adapted to transmit light through the transfective element, said reflective optical polarizer, the aperture, and the first
40 surface to a field-of-view (FOV) at the front of the assembly. The reflective optical polarizer may include an optically-anisotropic plastic layer. The optical system is generally structurally supported by the

5 housing and is at least partially disposed within the volume of the housing such as to have the first surface be unobstructingly observable from the front of the assembly; and

- First and second sensors, the first sensor configured to activate (in response to a first user input) an auxiliary device of the assembly, while the second sensor is configured to cause (in response to a second user input) locking of the operation of the first sensor for a period of time defined by the second user input.

10 [0022] In a specific embodiment, the mirror system of the assembly is configured to reflect ambient light, incident from said FOV, with efficiency of at least 55 percent. In a specific embodiment, the optical system of the assembly further comprises a second substrate having an extent smaller than that of the first substrate and coordinated with the first substrate such as to define a ledge a conductive layer
15 disposed behind a pad of the first sensor.

BRIEF DESCRIPTION OF THE FIGURES

20 [0023] Fig. 1 is an enlarged cross-sectional view of a portion of the conventional EO mirror assembly;

[0024] Fig. 2 depicts a controlled vehicle;

[0025] Fig. 3A depicts an assembly incorporating an electro-optic element;

[0026] Fig. 3B depicts an exploded view of an outside rearview mirror;

[0027] Fig. 4 depicts an inside rearview mirror assembly incorporating an electro-optic element;

25 [0028] Fig. 5 is a front elevational view schematically illustrating a rearview mirror system constructed in accordance with the present invention.

[0029] Fig. 6 depicts an exploded view of an interior rearview mirror assembly.

[0030] Figs. 7(A-E) illustrate embodiments of patterning of an eye-hole of a rearview assembly.

[0031] Fig. 7F provides illustration to segregation effects in an EC element.

30 [0032] Fig. 7G shows examples of transmittance changes for EC elements with and without segregation.

[0033] Fig. 7H provides examples of % full scale behavior of the EC element during clearing.

[0034] Figs. 8(A-D) illustrate various modalities pertaining to embodiments of the invention.

Fig. 8A: electrical contacting modalities; Figs. 8(B-D): embodiments of plug configurations.

35 [0035] Fig. 9 shows a bezel-less embodiment having an EC-element based mirror system with a rounded edge.

[0036] Figs. 10(A-C) provide illustrations related to another embodiment having an EC-element based mirror system with a rounded edge.

[0037] Figs. 11-13 show embodiments of invention having a lipless frame of the mirror system.

5 [0038] Figs. 14(A-C) illustrate embodiments with a user interface including an optical interrupter.

 [0039] Fig. 15 schematically shows an embodiment with a user interface having three line-of-sight sensors.

10 [0040] Fig. 16 illustrates an embodiment with a user interface employing an optical reflective sensor.

 [0041] Fig. 17 illustrates an alternative embodiment with a user interface employing an optical reflective sensor.

 [0042] Figs. 18(A, B) show embodiments employing a user interface having an "on-glass" type of capacitive sensor.

15 [0043] Figs. 19(A-C) show embodiments employing a user interface having a "through-glass" type of capacitive sensor.

 [0044] Figs. 20(A, B) show an embodiment employing a user interface having an "in-glass" type of capacitive sensor.

20 [0045] Figs. 20(C-G) show embodiments employing a user interface having a "through-bezel" type of a capacitive sensor or a field sensor.

 [0046] Figs. 21(A-C) illustrate embodiment having a "capacitive conductive bezel" type of user interface.

 [0047] Fig. 22 shows an embodiment where a user interface employs an optical waveguide element.

25 [0048] Fig. 23 illustrates embodiments of a peripheral ring used with rearview assembly of the present invention. Fig. 23A: a single-band peripheral ring; Fig. 23B: a multi-band peripheral ring.

 [0049] Fig. 24A shows a specific embodiment of a mirror system of the invention including a multi-band peripheral ring.

30 [0050] Fig. 24B illustrates a two-lite embodiment of an electro-optic (EO) element having a two-band peripheral ring and a double seal the components of which correspond to the two bands.

 [0051] Fig. 24C illustrates a non-specularly reflecting peripheral ring of an embodiment of invention.

 [0052] Figs. 25(A-D) show various embodiments of a two-band peripheral ring used in a mirror system of a rearview assembly of the invention.

35 [0053] Fig. 26 illustrates a mask construction means used to fabricate an embodiment of a two-band peripheral ring of the invention.

 [0054] Fig. 27 shows an embodiment of a two-band peripheral ring having a non-uniform thickness.

40 [0055] Fig. 28(A, B) illustrate an embodiment of a two-band peripheral ring with a portion that is transfective. A sensor is positioned behind the transfective portion of a two-band peripheral ring.

5 **[0056]** Fig. 28C illustrates transmission and reflection spectra of one embodiment of a transfective thin-film stack used on a second surface of the mirror system of the invention.

[0057] Figs. 29(A-D) illustrate alternative embodiments and uses of a transfective multi-band peripheral ring of the invention.

10 **[0058]** Fig. 30(A-C) show variations in reflectance values as functions of real and imaginary parts of refractive index of a metal layer used for reflectance-enhancement in three corresponding embodiments of the invention.

[0059] Figs. 31(A, B) illustrate a derivation of formula facilitating the determination of a metallic material for reflectance-enhancement in embodiments of the invention.

[0060] Fig. 32A depicts an EC-element structure having a ledge defined by the optical substrates.

15 **[0061]** Figs. 32B and 32C illustrate substrate pairs usable to define an EC-element of Fig. 32A.

[0062] Figs. 33(A, B) schematically illustrate, in cross-sectional views, portions of embodiments of EC-element including a capacitive switch and portions of corresponding carriers of the present invention that have rounded peripheral edges.

20 **[0063]** Figs. 34A depicts a portion of an EC-element embodiment including a capacitive switch and having a front substrate with appropriately ground peripheral edge.

[0064] Figs. 35(A-C) illustrate alternative embodiments of the invention.

[0065] Fig. 36 shows an embodiment of the carrier of the rearview assembly.

[0066] Figs. 37(A-B) and 38 illustrate additional embodiments of the invention.

25 **[0067]** Figs. 39(A, B, C) schematically show a mirror system of the rearview assembly utilizing various embodiments of a capacitive switch.

[0068] Figs. 40(A-C) illustrate portions of embodiments implementing a capacitive switch in coordination with a composite substrate of the mirror system.

[0069] Figs. 41 and 42 illustrate alternative embodiments implementing a capacitive switch in coordination with a composite substrate of the mirror system.

30 **[0070]** Figs. 43 and 44 illustrate additional embodiments implementing a capacitive switch in coordination with a composite substrate of the mirror system.

[0071] Figs. 45(A, B) show pairs of substrates cooperated to implement corresponding embodiments of the invention.

35 **[0072]** Fig. 46(A, B) illustrate, in different views, a notched pair of substrate and an embodiment of the peripheral ring region for use with a mirror system of the rearview assembly.

[0073] Fig. 46C illustrates a notched pair of substrate and another embodiment of the peripheral ring region for use with a mirror system of the rearview assembly.

[0074] Fig. 46D shows a front view of an embodiment of the mirror system containing capacitive switches.

40 **[0075]** Figs. 46(E-J) shows embodiments implementing capacitive switches and corresponding optical indicators.

5 **[0076]** Figs. 47 and 48 illustrate, in different views, a sized-down pair of optical substrates and an embodiment of the peripheral ring region for use with a mirror system of the rearview assembly.

[0077] Fig. 49 is an exploded view of a portion of a rearview assembly employing an embodiment of the invention.

10 **[0078]** Fig. 50A is another exploded view a portion of a rearview assembly employing an embodiment of the invention.

[0079] Fig. 50B is a front view of a carrier and a portion of the backlight system of the portion of Figs. 49 and 50A.

[0080] Fig. 50C provides a cross section corresponding to the view of Fig. 50B.

[0081] Fig. 50D illustrates an embodiment of a lightpipe and a supporting structure.

15 **[0082]** Fig. 51 shows an exemplary embodiment including an EC element, a capacitive switch, and a lock-out switch for use in a rearview assembly of the invention.

[0083] Figs. 52(A-D) illustrate several implementations of a lock-out switch.

[0084] Fig. 53 schematically shows positioning of optical indicators operably coordinated with a capacitive switch of an embodiment of the invention.

20 **[0085]** Figs. 54(A-D) depict embodiments of electrical connectors for use with EC-elements and capacitive switches of embodiments of the invention.

[0086] Figs. 55(A-E) illustrate a double-sided connector and its use in an embodiment of the invention.

[0087] Figs. 55(F, G) show an alternative embodiment of an electrical interconnect.

25 **[0088]** Figs. 56(A, B) show a simplified cross-sectional view corresponding to embodiments of an EC-element of the invention.

[0089] Fig. 57 is a contact force vs. displacement plot for the embodiment of Figs. 112(A-C).

[0090] Figs. 58(A-F) show schematically embodiments of a reconfigurable switch.

30 **[0091]** Figs. 59(A-C) show schematically embodiments having transparent switch and/or switch area.

[0092] Fig. 60 shows a characteristic pertaining to a peripheral ring disposed on a textured glass surface.

[0093] Figs. 61(A-D) illustrate schematically process of shaping an edge of a peripheral ring with laser ablation.

35 **[0094]** Fig. 62 shows an SEM image of a laser-ablated edge of a peripheral ring.

[0095] Fig. 63 provides illustration to discussion of galvanic corrosion of a thin-film stack of an embodiment of the invention.

40 **[0096]** Figs. 64(A,B) illustrate thin-film structures for use in an embodiment of the peripheral ring of the EC-element of the vehicular rearview assembly that are optimized for photopically adjusted and scotopically adjusted vision of the user, respectively.

[0097] Fig. 65 illustrates the thin-films structures for use in an embodiment of the peripheral ring of the EC-element of the vehicular rearview assembly that are optimized for both photopically and scotopically adjusted vision of the user.

DETAILED DESCRIPTION OF THE INVENTION

[0098] As used in this description and the accompanying claims, the following terms shall have the meanings indicated, unless the context otherwise requires:

[0099] "Transflective" describes an optical element or component that has a useful non-zero level of transmittance and also has a useful, non-zero level of reflectance in a specified spectral region. In the context of an image-forming reflector, such as a mirror for viewing reflected images, for example, the viewer in front of the mirror may not only observe an image of the ambient objects, formed in reflection from such transflective area but also receive information contained in the displayed image delivered with light from the light source located behind the transflective area of the mirror.

[00100] The spectrum of light reflected (and that of light transmitted) by an embodiment of the mirror system of the invention can be tuned or modified by adjusting the thickness of the reflectance-enhancing layers. The peak reflectance will vary with optical design wavelength and this will result in a change in color gamut of the reflected (and transmitted) light. In discussing color distributions (i.e., spectra of light), it is useful to refer to the Commission Internationale de FEclairage's (CIE) 1976 CIELAB Chromaticity Diagram (commonly referred to the $L^*a^*b^*$ chart or quantification scheme). The technology of color is relatively complex, but a fairly comprehensive discussion is given by F.W. Billmeyer and M. Saltzman in *Principles of Color Technology*, 2nd Edition, J. Wiley and Sons Inc. (1981). The present disclosure, as it relates to color technology and uses appropriate terminology, generally follows that discussion. As used in this application, Y (sometimes also referred to as Cap Y), represents either the overall reflectance or the overall transmittance, depending on context. L^* , a^* , and b^* can be used to characterize parameters of light in either transmission or reflection. According to the $L^*a^*b^*$ quantification scheme, L^* represents brightness and is related to the eye-weighted value of either reflectance or transmittance (also known as normalized Y Tristimulus value) by the Y Tristimulus value of a white reference, Y_{ref} : $L^* = 116 * (Y/Y_{ref}) - 16$. The a^* -parameter is a color coordinate that denotes the color gamut ranging from red (positive a^*) to green (negative a^*), and b^* is a color coordinate that denotes the color gamut ranging from yellow and blue (positive and negative values of b^* , respectively). For example, absorption spectra of an electrochromic medium, as measured at any particular voltage applied to the medium, may be converted to a three-number designation corresponding to a set of $L^*a^*b^*$ values. To calculate a set of color coordinates, such as $L^*a^*b^*$ values, from the spectral transmission or reflectance, two additional parameters are required. One is the spectral power distribution of the source or illuminant. The present disclosure uses CIE Standard Illuminant A to simulate light from

5 automobile headlamps and uses CIE Standard Illuminant D₆₅ to simulate daylight. The second parameter is the spectral response of the observer. Many of the examples below refer to a (reflectance) value Y from the 1931 CIE Standard since it corresponds more closely to the spectral reflectance than L*. The value of "color magnitude", or C*, is defined as $C^* = \sqrt{(a^*)^2 + (b^*)^2}$ and provides a measure for quantifying color neutrality. The metric of "color difference", or ΔC^* is defined as

10 $\Delta C^* = \sqrt{(a^* - a^{*'})^2 + (b^* - b^{*'})^2}$, where (a*, b*) and (a*', b*') describe color of light obtained in two different measurements. Additional CIELAB metric is defined as $\Delta E^* = (\Delta a^{*2} + \Delta b^{*2} + \Delta L^{*2})^{1/2}$. The color values described herein are based, unless stated otherwise, on the CIE Standard D65 illuminant and the 10-degree observer.

15 **[00101]** An optical element such as a mirror is said to be relatively color neutral in reflected light if the reflecting element is configured to have a corresponding C* less than, generally, 20. Preferably, however, a color-neutral optical element is characterized by the C* value of less than 15, and more preferably of less than about 10.

20 **[00102]** As broadly used and described herein, the reference to an electrode or a material layer as being "carried" on a surface of an element refers to such an electrode or layer that is disposed either directly on the surface of an underlying element or on another coating, layer or layers that are disposed directly on the surface of the element.

[00103] The terms "adjacent" and "adjacently" are generally defined as "being in close proximity to but without actually touching", in comparison with the terms "adjoining" and "adjoiningly" that are defined as "located next to another and being in contact at some point or line".

[00104] References throughout this specification to "one embodiment," "an embodiment," "a related embodiment," or similar language mean that a particular feature, structure, or characteristic described in connection with the referred to "embodiment" is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment. It is to be understood that no portion of disclosure, taken on its own and/or in reference to a figure, is intended to provide a complete description of all features of the invention.

[00105] In addition, in drawings, with reference to which the following disclosure may describe features of the invention, like numbers represent the same or similar elements wherever possible. In the drawings, the depicted structural elements are generally not to scale, and certain components are enlarged relative to the other components for purposes of emphasis and understanding. It is to be understood that no single drawing is intended to support a complete description of all features of the invention. In other words, a given drawing is generally descriptive of only some, and generally not all, features of the invention. A given drawing and an associated portion of the disclosure containing a description referencing such drawing do not, generally, contain all elements of a particular view or all features that can be presented in this view in

order to simplify the given drawing and the discussion, and to direct the discussion to particular elements that are featured in this drawing.

[00106] A skilled artisan will recognize that the invention may possibly be practiced without one or more of the specific features, elements, components, structures, details, or characteristics, or with the use of other methods, components, materials, and so forth. Therefore, although a particular detail of an embodiment of the invention may not be necessarily shown in each and every drawing describing such embodiment, the presence of this detail in the drawing may be implied unless the context of the description requires otherwise. In other instances, well known structures, details, materials, or operations may be not shown in a given drawing or described in detail to avoid obscuring aspects of an embodiment of the invention that are being discussed. Furthermore, the described features, structures, or characteristics of the invention may be combined in any suitable manner in one or more embodiments.

[00107] For example, to simplify a particular drawing of an electro-optical device of the invention not all thin-film coatings (whether electrically conductive, reflective, or absorptive or other functional coatings such as alignment coatings or passivation coatings), electrical interconnections between or among various elements or coating layers, elements of structural support (such as holders, clips, supporting plates, or elements of housing, for example), or auxiliary devices (such as sensors, for example) may be depicted in a single drawing. It is understood, however, that practical implementations of discussed embodiments may contain some or all of these features and, therefore, such coatings, interconnections, structural support elements, or auxiliary devices are implied in a particular drawing, unless stated otherwise, as they may be required for proper operation of the particular embodiment.

[00108] The invention as recited in claims appended to this disclosure is intended to be assessed in light of the disclosure as a whole, including features disclosed in prior art to which reference is made.

[00109] *Numbering of structural surfaces.* In describing the order of elements or components in embodiments of a vehicular rearview assembly or a sub-set of a vehicular rearview assembly, the following convention will be generally followed herein, unless stated otherwise. The order in which the surfaces of sequentially positioned structural elements of the assembly (such as substrates made of glass or other translucent material) are viewed is the order in which these surfaces are referred to as the first surface (or surface **I**), the second surface (or surface **II**), the third surface (or surface **III**), and other surfaces (**IV**, **V** and so on), if present, are referred to in ascending order. Generally, therefore, surfaces of the structural elements (such as substrates) of an embodiment of the invention are numerically labeled starting with a surface that corresponds to the front portion of a rearview assembly and that is proximal to the observer or user of the assembly and ending with a surface that corresponds to the back portion of an assembly and that is distal to the user. Accordingly, the term "behind" refers to a position, in space, following something else and suggests that one element or thing is at the back of another as viewed from the front of the rearview assembly. Similarly, the term "in front of" refers to a forward place or position, with respect to a particular element as viewed from the front of the assembly.

5 **[00110]** The present disclosure refers to U.S. Patents Nos. 4,902,108; 5,128,799; 5,151,824; 5,278,693; 5,280,380; 5,282,077; 5,294,376; 5,336,448; 5,448,397; 5,679,283; 5,682,267; 5,689,370; 5,803,579; 5,808,778; 5,818,625; 5,825,527; 5,837,994; 5,888,431; 5,923,027; 5,923,457; 5,928,572; 5,940,201; 5,956,012; 5,990,469; 5,998,617; 6,002,511; 6,008,486; 6,020,987; 6,023,229; 6,037,471; 6,049,171; 6,057,956; 6,062,920; 6,064,509; 6,084,700; 6,102, 546; 6,111,683; 6,111,684; 6,129,507; 10 6,130,421; 6,130,448; 6,132,072; 6,140,933; 6,166,848; 6,170,956; 6,188,505; 6,193,378; 6,193,912; 6,195,194; 6,222,177; 6,224,716; 6,229,435; 6,238,898; 6,239,898; 6,244,716; 6,246,507; 6,247,819; 6,249,369; 6,255,639; 6,262,831; 6,262,832; 6,268,950; 6,281,632; 6,291,812; 6,313,457; 6,335,548; 6,356,376; 6,359,274; 6,379,013; 6,392,783; 6,399,049; 6,402,328; 6,403,942; 6,407,468; 6,420,800; 6,426,485; 6,429,594; 6,441,943; 6,465,963; 6,469,739; 6,471,362; 6,504,142; 6,512,624; 6,521,916; 15 6,523,976; 6,471,362; 6,477,123; 6,521,916; 6,545,794; 6,587,573; 6,614,579; 6,635,194; 6,650,457; 6,657,767; 6,774,988; 6,816,297; 6,861,809; 6,968,273; 6,700,692; 7,064,882; 7,287,868; 7,324,261; 7,342,707; 7,417, 717; 7,663,798; 7,688,495; 7,706,046 and D410,607. The present application also refers to the International Patent Applications Nos. PCT/W097/EP498; PCT/W098/EP3862, U.S. Patent Applications Nos. 60/360,723; 60/404,879; 11/682,121; 11/713,849; 11/833,701; 12/138,206; 20 12/154,824; 12/370,909; 12/563,917; 12/496,620; 12/629,757; 12/686,019; 12/774,721, and U.S. Provisional Patent Application No. 61/392,119 filed on October 12, 2010. The disclosure of each of the abovementioned patent documents is incorporated herein by reference in its entirety. All these patent documents may be collectively referred to herein as "Our Prior Applications".

[00111] Although EC-elements for use in vehicular mirror systems and rearview assemblies 25 incorporating such elements and systems have been taught in detail in Our Prior Applications, the following provides an overview of subject matter sufficient to build upon when considering embodiments of the present invention. Referring initially to Fig. 2, there is shown a controlled vehicle **200** having a driver's side outside rearview mirror **210a**, a passenger's side outside rearview mirror **210b** and an inside rearview mirror **215**. Details of these and other features will be described herein. Preferably, the 30 controlled vehicle comprises an inside rearview mirror of unit magnification. A unit magnification mirror, as used herein, refers to a mirror with a plane or flat reflective element producing an image having perceived angular and linear sizes equal to those of the object. Deviations from unit magnification resulting from conventional processing of components of an inside rearview mirror and ways of reducing or eliminating such deviations have been addressed, e.g., in U.S. U.S. 7,688,495, the teachings of which 35 include modified thin-film deposition techniques resulting in reduced warp of a mirror substrate upon a surface of which a transparent layer of conductive oxide has been disposed. A prismatic day-night adjustment rearview mirror which in at least one associated position provides unit magnification is considered to be a unit magnification mirror. Preferably, each outside mirror comprises not less than 126 cm of reflective surface and is located so as to provide the driver a view to the rear along an associated 40 side of the controlled vehicle. Preferably, the average reflectance of any mirror, as determined in accordance with SAE Recommended Practice J964, OCT84, is at least 35 percent (40 percent for many

5 European Countries). In embodiments where the mirror element is capable of operating at multiple reflectance levels, the minimum reflectance level in the day mode shall be at least 35 percent (40 percent when mirror is fabricated according to European standards) and the minimum reflectance level in the night mode shall be at least 4 percent.

10 [00112] With further reference to Fig. 2, the controlled vehicle 200 may comprise a variety of exterior lights, such as, headlight assemblies 220a, 220b; foul condition lights 230a, 230b; front turn-signal indicators 235a, 235b; taillight assembly 225a, 225b; rear turn signal indicators 226a, 226b; rear emergency flashers 227a, 227b; backup lights 240a, 240b and center high-mounted stop light (CHMSL) 245.

15 [00113] As described in detail herein, the controlled vehicle may comprise at least one control system incorporating various components that provide shared functions with other vehicle equipment. An example of one control system described herein integrates various components associated with automatic control of the reflectivity of at least one rearview mirror element and automatic control of at least one exterior light. Such systems may comprise at least one image sensor within a rearview mirror, an A-pillar, a B-pillar, a C-pillar, a CHMSL or elsewhere within or upon the controlled vehicle. Images acquired, or
20 portions thereof, by a sensor may be used for automatic vehicle equipment control. The images, or portions thereof, may alternatively or additionally be displayed on one or more displays. At least one display may be covertly positioned behind a transfective, or at least partially transmissive, electro-optic element. A common controller may be configured to generate at least one mirror element drive signal and at least one other equipment control signal.

25 Exterior and Interior Rearview Assemblies.

[00114] Turning now to Figs. 3a and 3b, various components of a typical outside (or exterior) rearview mirror assembly 310a, 310b are depicted. An EO mirror element may comprise a first substrate
30 320a, 320b secured in a spaced apart relationship with a second substrate 325 via a primary seal 330 to form a chamber there between. At least a portion of the primary seal is left void to form at least one chamber fill port 335. An EO medium is enclosed in the chamber and the fill port(s) are sealingly closed via a plug material 340. Preferably, the plug material is a UV-curable epoxy or acrylic material. Also shown is a spectral filter material 345a, 345b located near the periphery of the element. Generally, this
35 optical thin-film spectral filter material 345a, 345b is circumferentially disposed in a peripheral area, next to a corresponding perimeter-defining edge, of either of the first and the second surface of the system, and is configured as a ring. Such ring of the spectral filter material is interchangeably referred to herein as a peripheral ring. The electrical clips 350, 355 are preferably secured to the element, respectively, via first adhesive material 351, 352. The element is secured to a carrier plate 360 via second adhesive material 365.
40 Electrical connections from the outside rearview mirror to other components of the controlled vehicle are preferably made via a connector 370. The carrier is attached to an associated housing mount 376 via a

5 positioner 380. Preferably, the housing mount is engaged with a housing 375a, 375b and secured via at least one fastener 376b. Preferably, the housing mount comprises a swivel portion configured to engage a swivel mount 377a, 377b. The swivel mount is preferably configured to engage a vehicle mount 378 via at least one fastener 378b. Additional details of these components, additional components, their interconnections and operation are discussed below.

10 **[00115]** With further reference to Fig. 3a, the outside rearview mirror assembly 310a is oriented such that a view of the first substrate 320a is shown with the spectral filter material 345a positioned between the viewer and the primary seal material (not shown). A blind spot indicator 385, a keyhole illuminator 390, a puddle light 392, a turn signal 394, a photo sensor 396, any one thereof, a subcombination thereof or a combination thereof may be incorporated within the rearview mirror
15 assembly such that they are positioned behind the mirror element with respect to the viewer. Preferably, the devices 385, 390, 392, 394, 396 are configured in combination with the mirror element to be at least partially covert as discussed in detail within various references incorporated by reference herein. Additional details of these components, additional components, their interconnections and operation are further discussed in reference to Fig. 65, below.

20 **[00116]** Turning now to Fig. 4, there is shown an inside (or interior) rearview mirror assembly **410**, as viewed when looking at the first substrate **420**, with a spectral filter material or peripheral ring **445** positioned between the viewer and a primary seal material (not shown). The mirror element is shown to be positioned within a movable housing **475** and combined with a stationary housing **477** on a mounting structure **481**. The mirror housing **477** (which may include a bezel portion) supports not only
25 opto-electronic components and devices such as a reflective element and an information display, but various assembly function actuators such as button and keys. Commonly assigned U.S. Patents 6,102,546; D 410,607; 6,407,468; 6,420,800; and U.S. Patent application serial number 09/687,743, the disclosures of which are incorporated in their entireties herein by reference, describe various bezels, cases, and associated button constructions for use with the present invention. Examples of mounting structures
30 such as structures having means for angular alignment of the mirror element with respect to the viewer (such as a ball-and-socket pivoting mechanism) are disclosed in, for example, the commonly-assigned U.S. Patent Application No. 12/832,838.

[00117] A first indicator **486**, a second indicator **487**, operator interfaces **491** and a first photo sensor **496** are positioned in a chin portion **490** of the movable housing. Operator interfaces **491** are
35 configured to control any of functional systems or modalities of the assembly such as, for example, an illumination assembly, a display, mirror reflectivity, a voice-activated system, a compass system, a telephone system, a highway toll booth interface, a telemetry system, a headlight controller, and a rain sensor, to name just a few. Generally, however, operator interfaces **491** can be incorporated anywhere in the associated vehicle, for example, in the mirror case, accessory module, instrument panel, overhead
40 console, dashboard, seats, center console. Some of the operator interfaces **491** may include a switch (not shown) such as a proximity switch, for example. Suitable switches for use with the present invention are

5 described in detail in commonly assigned U.S. Patents 6,407,468 and 6,420,800, 6,471,362, 6,614,579, 6,614,579, the disclosures of which are incorporated in their entireties herein by reference. Various indicators for use with the present invention that attest to the status of any of the functional systems or modalities of the assembly are described in commonly assigned U.S. Patents 5,803,579, 6,335,548, and 6,521,916, the disclosures of which are incorporated in their entireties herein by reference.

10 [00118] A first information display **488**, a second information display **489** and a second photo sensor **497** are incorporated within the assembly behind the mirror element with respect to the viewer. As described with regard to the outside rearview mirror assembly, it is preferable to have devices **488**, **489**, **497** at least partially covert. For example, a "window" may be formed in third and/or fourth surface coatings of the associated mirror element and configured to provide a layer of a platinum group metal
15 (PGM) (i.e. iridium, osmium, palladium, platinum, rhodium, and ruthenium) only on the third surface. Thereby, light rays impinging upon the associated "covert" photo sensor "glare" will first pass through the first surface stack, if any, the first substrate, the second surface stack, the electro-optic medium, the platinum group metal and, finally, the second substrate. The platinum group metal functions to impart continuity in the third surface conductive electrode, thereby reducing electro-optic medium coloring
20 variations associated with the window.

[00119] The rearview assembly **410** may additionally include at least one illumination assembly a (not shown) that preferably comprises a reflector, a lens, and an illuminator (not shown). Most preferably there are two illumination assemblies with one generally positioned to illuminate a front passenger seat area and the second generally positioned to illuminate a driver seat area. There may be only one or may
25 be additional illuminator assemblies such as one to illuminate a center console area, overhead console area, or an area between the front seats. Various illumination assemblies and illuminators for use with the present invention are described in commonly assigned U.S. Patents 5,803,579, 6,335,548, and 6,521,916, the disclosures of which are incorporated in their entireties herein by reference.

[00120] The rearview assembly **410** may additionally include at least one or more light sensors, the preferred embodiments of which are described in detail in commonly assigned U.S. Patents 5,923,027
30 and 6,313,457, the disclosures of which are incorporated in their entireties herein by reference. For example, the glare sensor and/or ambient sensor automatically control the reflectivity of a self-dimming reflective element as well as the intensity of information displays and/or backlighting. The glare sensor is used to sense headlights of trailing vehicles and the ambient sensor is used to detect the ambient lighting
35 conditions that the system is operating within. In another embodiment, a sky sensor may be incorporated positioned to detect light levels generally above and in front of an associated vehicle, the sky sensor may be used to automatically control the reflectivity of a self-dimming element, the exterior lights of a controlled vehicle and/or the intensity of information displays.

[00121] Fig. 5 shows a front elevational view schematically illustrating an interior mirror
40 assembly **510** and two exterior rearview mirror assemblies **210a** and **210b** for the driver side and passenger side, respectively, all of which are adapted to be installed on a motor vehicle in a conventional

5 manner and where the mirrors face the rear of the vehicle and can be viewed by the driver of the vehicle to provide a rearward view. As mentioned above, the interior rearview assembly **410** and exterior rearview assemblies **210a** and **210b** may incorporate light-sensing electronic circuitry of the type illustrated and described in the Canadian Patent No. 1,300,945, U.S. Patent No. 5,204,778, U.S. Patent No. 5,451,822, U.S. Patent No. 6,402,328, or U.S. Patent No. 6,386,713 and other circuits capable of sensing glare and ambient light and supplying a drive voltage to the electro-optic element. The disclosure of each of these patent documents is incorporated herein by reference in its entirety.

[00122] Rearview assemblies **410**, **210a**, and **210b** are essentially similar in that like numbers identify components of the inside and outside mirrors. These components may be slightly different in configuration, but they function in substantially the same manner and obtain substantially the same results as similarly numbered components. For example, the shape of the front glass element of inside rearview assembly **410** is generally longer and narrower than outside rearview assemblies **210a** and **210b**. There are also some different performance standards placed on inside assembly **410** compared with outside assembly **210a** and **210b**. For example, a mirror of the inside assembly **410** generally, when fully cleared, should have a reflectance value of about 70 percent to about 85 percent or even higher, whereas the outside mirrors often have a reflectance of about 50 percent to about 65 percent. Also, in the United States (as supplied by the automobile manufacturers), a mirror of the passenger-side assembly **210b** typically has a spherically bent or convex shape, whereas a mirror of the driver-side assembly **210a** and a mirror of the inside assembly **410** are presently required to be flat. In Europe, a mirror of the driver-side assembly **210a** is commonly flat or aspheric, whereas a mirror of the passenger-side assembly **210b** has a convex shape. In Japan, both outside mirrors typically have a convex shape. While the focus of the invention is generally towards exterior mirrors, the following description is generally applicable to all mirror assemblies of the present invention including inside mirror assemblies. Moreover, certain aspects of the present invention may be implemented in electro-optic elements used in other applications such as architectural windows, or the like, or even in other forms of electro-optic devices.

[00123] An embodiment of a rearview mirror of the present invention may include a housing having a bezel **544**, which extends around the entire periphery of each of individual assemblies **410**, **210a**, and/or **210b** (or at least a portion of the periphery) and structurally supports an edge surface of an optical element of a corresponding assembly. However, as discussed below, the scope of the present invention also includes embodiments having no bezel. When present, a front lip of the bezel **544** that extends onto the first surface of the optical element visually conceals and protects the buss connector and the seal. A wide variety of bezel designs are well known in the art, such as, for example, the bezel taught and claimed in above-referenced U.S. Patent No. 5,448,397.

[00124] Fig. 6 illustrates an exemplary exploded view **6400** of the exemplary interior rearview assembly. As shown, the mirror assembly comprises a reflective element **6405** within a bezel **6455** and a mirror casing **6456**. Bezel **6455** can be adapted to be like any of bezels taught in Our Prior Applications, for example in U.S. Patents Nos. 11/066,903 and 10/430,885. A mirror mount **6457** is included for

5 mounting the mirror assembly within a vehicle. It should be understood that a host of accessories may be incorporated into the mount **6457** and/or onto the plate frame carrier **6421** in addition to a power pack adjuster, such as a rain sensor, a camera, a headlight control, an additional microprocessor, additional information displays, compass sensors, etc. These systems may be integrated, at least in part, in a common control with information displays and/or may share components with the information displays.

10 In addition, the status of these systems and/or the devices controlled thereby may be displayed on the associated information displays.

[00125] The mirror assembly is shown in Fig. 6 to further comprise third information display **6426** with third information display backlighting **6437**, **6438**, **6439**; first and second microphones **6460**, **6461**; and includes other known options such as a first reflector with a first lens; a second reflector with a second lens; a glare sensor; an ambient light sensor; first, second, third, and fourth operator interfaces **6490**, **6491**, **6492**, **6493** with first, second, third, and fourth operator interface backlighting **6490a**, **6491a**, **6492a**, **6493a**; a circuit board **6495** having a compass sensor module **6499**; and a daughter board **6498** with an input/output bus interface **6497**.

[00126] Preferably, the illumination assemblies with associated a light source of the assembly are constructed in accordance with the teachings of commonly assigned U.S. Patents **5,803,579** and **6,335,548**, as well as U.S. Patent application serial number **09/835,278**, the disclosures of which are incorporated in their entireties herein by reference.

[00127] Preferably, the glare light sensor and the ambient light sensor are active light sensors as described in commonly assigned U.S. Patents **6,359,274** and **6,402,328**, the disclosures of which are incorporated in their entireties herein by reference. The electrical output signal from either or both of the sensors may be used as inputs to a controller on the circuit board **6440** or **6495** to control the reflectivity of reflective element **6405** and/or the intensity of third information display backlighting. The details of various control circuits for use herewith are described in commonly assigned U.S. Patents **5,956,012**; **6,084,700**; **6,222,177**; **6,224,716**; **6,247,819**; **6,249,369**; **6,392,783**; and **6,402,328**, the disclosures of which are incorporated in their entireties herein by reference.

[00128] Although the compass sensor module **6499** of the embodiment **6505** is shown to be mounted circuit board **6495** in Fig. 6, it should be understood that the sensor module may be located within mount **6457**, an accessory module **6458** positioned proximate mirror assembly **6400** or at any location within an associated vehicle such as under a dashboard, in an overhead console, a center console, a trunk, an engine compartment, etc. Commonly assigned U.S. Patents **6,023,229**, **6,140,933**, and **6,968,273** as well as commonly assigned U.S. Patent Application **60/360,723**, the disclosures of which are incorporated in their entireties herein by reference, described in detail various compass systems for use with the present invention.

[00129] Daughter board **6498** is in operational communication with circuit board **6495**. Circuit board **6495** may comprise a controller **6496**, such as a microprocessor, and daughter board **6498** may comprise an information display. The microprocessor may, for example, receive signal(s) from the

5 compass sensor module 6499 and process the signal(s) and transmit signal(s) to the daughter board to control a display to indicate the corresponding vehicle heading. As described herein and within the references incorporated by reference herein, the controller may receive signal(s) from light sensor(s), rains sensor(s) (not shown), automatic vehicle exterior light controller(s) (not shown), microphone(s), global positioning systems (not shown), telecommunication systems (not shown), operator interface(s),
10 and a host of other devices, and control the information display(s) to provide appropriate visual indications.

[00130] Controller 6496 (or controllers) may, at least in part, control the mirror reflectivity, exterior lights, rain sensor, compass, information displays, windshield wipers, heater, defroster, defogger, air conditioning, telemetry systems, voice recognition systems such as digital signal processor-based
15 voice-actuation systems, and vehicle speed. The controller 6496 (or controllers) may receive signals from switches and/or sensors associated with any of the devices described herein and in the references incorporated by reference herein to automatically manipulate any other device described herein or described in the references included by reference. The controller 6496 may be, at least in part, located outside the mirror assembly, or may comprise a second controller elsewhere in the vehicle or additional
20 controllers throughout the vehicle. The individual processors may be configured to communicate serially, in parallel, via Bluetooth protocol, wireless communication, over the vehicle bus, over a CAN bus or any other suitable communication.

[00131] Exterior light control systems as described in commonly assigned U.S. Patents 5,990,469; 6,008,486; 6,130,421; 6,130,448; 6,255,639; 6,049,171; 5,837,994; 6,403,942; 6,281,632; 6,291,812;
25 6,469,739; 6,399,049; 6,465,963; 6,587,573; 6,429,594; 6,379,013; 6,871,809; 6,774,988 and U.S. Patent Applications serial numbers 09/847,197; and 60/404,879, the disclosures of which are incorporated in their entireties herein by reference, may be incorporated in accordance with the present invention.

[00132] Moisture sensors and windshield fog detector systems are described in commonly assigned U.S. Patents 5,923,027 and 6,313,457, the disclosures of which are incorporated in their
30 entireties herein by reference. Commonly assigned U.S. Patent 6,262,831, the disclosure of which is incorporated herein by reference in its entirety, describes power supplies for use with the present invention.

[00133] It is contemplated that the present invention would be useful in inside or outside rearview mirrors having electro-optic mirror elements, convex mirror elements, aspheric mirror elements, planar
35 mirror elements, non-planar mirror elements, hydrophilic mirror elements, hydrophobic mirror elements, and mirror elements having third surface and fourth surface reflectors. It is further contemplated that the present invention will be useful on mirrors that are transfective, or that have a third or fourth surface mirror element with patterns of lines (sometimes referred to as "jail bars") thereon to optimize the effect of visible light. Further, the present invention is useful with mirrors having first surface or fourth surface
40 heaters, anti-scratch layers, and circuit boards including flexible circuit boards, and circuit board and heater combinations, such as heaters having embedded or integrated non-heater functions such as signal

5 ellipses and signal diffusants, locating holes or windows for light pass-through. The present invention is also useful with potted or snap-attached or elastomeric bezels, and useful with carriers having an ultra-flat front surface. Also, additional options can be integrated into the mirrors including signal lighting, key lights, radar distance detectors, puddle lights, information displays, light sensors and indicator and warning lighting, retainers with living hinges, and integrated housings for receiving and supporting said
10 components. Still further, it is conceived that the present mirror can include a manually folding or power folding mirrors, extendable mirrors, and mirrors with a wide field of view, and with information on the mirror such as "object in mirror is closer than may appear" or other indicia, such as "heated" or "auto-dim". Still further, the present invention is useful with a blue glass mirror or "blue chemical" darkening mirror. Still further, efficiencies can be had by incorporating the present concepts with mirrors having an
15 electrochromic mirror subassembly with front and rear glass mirror elements with edges having a "zero offset" (i.e. less than an average of about 1 mm, or more preferably, less than about 0.5 mm difference between perfect alignment of edges of the mirror elements), an edge seal, including clear reflective or opaque edge seals, and/or second surface chrome or a chrome bezel. Generally, however, the rear glass element of an EC mirror subassembly can be smaller than the front glass element and disposed such as to
20 be concealed behind the front element as viewed from the front of the assembly. In a specific embodiment, the circumference of the rear glass element is smaller than that of the front glass element.

[00134] Although the present invention is further generally described as being used in connection with EC devices such as mirrors and architectural windows, those skilled in the art will understand that various aspects of the present invention may be employed in the construction of other electro-optic
25 devices or devices including a prismatic element.

[00135] It is appreciated that a typical exterior rearview assembly (such as that of Figs. 3A, 3B) may contain substantially the same auxiliary devices as those described in reference to Figs. 4 and 6. Details of the housing / casing of an exemplary exterior rearview assembly is taught in, for example, U.S. Patent Application 12/832,838 and may comprise an attachment member and a telescoping extension
30 having a single arm with a linear actuator for extending and retracting the telescoping extension from within the associated vehicle. The telescoping extension may be additionally configured such that the housing may be folded inward toward the associated vehicle and outward away from the associated vehicle. Various positioners and carriers that providing a secure structure for supporting and moving of the associated reflective element are described in U.S. Patent Nos. 6,195,194 and 6,239,899, the
35 disclosures of which are incorporated herein in their entirety by reference. In at least one embodiment, an exterior rearview mirror assembly is provided with a heater for improving the operation of the device and for melting frozen precipitation that may be present. Examples of various heaters are disclosed in U.S. Patent Nos. 5,151,824, 6,244,716, 6,426,485, 6,441,943 and 6,356,376, the disclosures of each of these Patents are incorporated in their entirety herein by reference.

40 [00136] In at least one embodiment, either an external or an internal rearview assembly is equipped with an electrical circuitry comprising a light source such as a turn signal light, a keyhole

5 illuminator, or an outside door area illuminator, as taught in U.S. Patent No. 6,441,943, the entire disclosure of which is incorporated in its entirety herein by reference, an information display, an antenna, a transceiver, a reflective element control, an outside mirror communication system, a remote keyless entry system, proximity sensors, and interfaces for other apparatus described herein. U.S. Patent Nos. 6,244,716, 6,523,976, 6,521,916, 6,441,943, 6,335,548, 6,132,072, 5,803,579, 6,229,435, 6,504,142, 10 6,402,328, 6,379,013, and 6,359,274 disclose various electrical components and electrical circuit boards that may be employed in one or more embodiments, the disclosures of each of each of these U.S. Patents are incorporated herein in their entireties by reference.

[00137] In at least one embodiment, the reflectance of the reflective element of either the exterior or interior rearview assembly can be varied (for example, via autodimming). Such variable-reflectance 15 reflective element may be configured to define a convex element, an aspheric element, a planar element, a non-planar element, a wide field of view element, or a combination of these various configurations in different areas to define a complex mirror element shape. The front surface of the first substrate of the reflective element, that corresponds to the front of the assembly, may comprise a hydrophilic or hydrophobic coating to improve the operation. The reflective element may comprise transfective 20 properties such that a light source, or information display, may be positioned behind the element and project light rays therethrough. Attachment of the reflective element to a carrier / portion of the housing structure is arranged, in at least one embodiment, via a double-sided adhesive tape. The reflective element may comprise an anti-scratch layer, or layers, on the exposed surfaces of the first and, or, second substrates. The reflective element may comprise area(s) that are devoid of reflective material, such as 25 etched in bars or words, to define information display area(s). Examples of various reflective elements are described in U.S. Patent Nos. 5,682,267, 5,689,370, 6,064,509, 6,062,920, 6,268,950, 6,195,194, 5,940,201, 6,246,507, 6,057,956, 6,512,624, 6,356,376, 6,166,848, 6,111,684, 6,193,378, 6,239,898, 6,441,943, 6,037,471, 6,020,987, 5,825,527, 6,111,684 and 5,998,617, the disclosures of each of these Patents are incorporated in their entireties herein by reference.

30 [00138] Plethora of teachings describing various configurations of an EC element or a prismatic element for use in a vehicular rearview assembly is provided in Our Prior Applications. U.S. 2010/0321758, for example (in reference to Figs. 6A through 16 therein), teaches different implementations of electrically-conductive layers (such as, e.g., a layer of transparent conductive oxide performing as a transparent electrode preferably disposed on the second surface of the EC-cell, and a 35 thin-film stack including reflective and conductive layers aggregately performing as a reflecting electrode of the third surface of the EC-cell). U.S. 2010/0321758 also discusses numerous incarnations of electrical interconnects between the electrically-conductive layers (such as TCO layers, or IMI layers, or combinations thereof, for example) and the electrical circuitry of the assembly (see, e.g. Figs. 6-16, 22-34 and associated descriptions in U.S. 2010/0321758), EC-cavity perimeter sealing members, and means for 40 concealing such electrical interconnects and sealing members from being optically accessible from the front of the assembly.

5 **[00139]** As another example, the commonly-assigned U.S. Patent No. 7,372,611 and the U.S. 2010/0321758 discuss (in reference to Tables 3F and 3G contained therein, for example) various thin-film structures configured on the second surface of an EC-element of the rearview assembly to provide a peripheral ring that not only has high reflectance but also assures color matching between the peripheral area of the rearview mirror and the major portion of the viewing area (located within the peripheral area of the mirror). In particular, the taught structures include a thin-film stack in which a dielectric layer is sandwiched between the metallic thin-film and the layer of the TCO, such as, for example, (i) a sequence of a metallic thin-film, a film made of a low-index material, and a film of the TCO; and (ii) a thin-film stack containing a metallic thin film, a high/low/high index dielectric stack, and a layer of TCO. However, the optical properties of the peripheral ring may benefit from a different positioning of the dielectric layers. For example, in a basic case where the second surface of the EC element carries, in a peripheral region, a layer of chrome (500 Å) and a layer of ITO (1490 Å) on top of the chrome layer, the resulting stack has a reflectance of 56.0% ($a^* = -1.6$, $b^* = -3.0$). However, the addition of high- and low-index dielectric layers between the second surface of the front glass substrate and the Cr-layer (thus yielding the following enhanced structure: Glass / TiO_2 (534 Å, index of 2.45) / SiO_2 (848 Å) / Cr (500 Å) / ITO, increases the reflectance to 79.2% ($a^* = -3.4$, $b^* = 1.6$). The achieved reflectance enhancement is further tunable by increasing the index contrast between the high- and low-index layers. (Decreasing the index contrast achieves the opposite effect). For instance, in the previous example of the enhanced structure, the replacement of the TiO_2 layer with SnO_2 (601 Å) and the SiO_2 layer with Al_2O_3 (741 Å) yields an overall reflectance of the peripheral area of 66.2% ($a^* = -4.8$, $b^* = 1.4$). In addition, the thickness of the high- and low-index layers can be used to tune the color to yield an improved color match between the peripheral ring area and to the rest of the mirror element. For example, if a bluer hue is preferred in the above-defined enhanced structure, the thickness of the TiO_2 layer can be reduced to 506 Å and the thickness of the SiO_2 layer can be reduced to 801 Å to yield a 78.9% reflectance with an a^* value of -3.3 and a b^* value of -0.6. Generally, a reduction of reflectance value of the peripheral ring is observed for significant deviation of the dielectric layers from nominal quarter-wave thickness. The choice of the dielectric layers may be based on a variety of properties including, but not limited to, conductivity, index of refraction, extinction coefficient, UV cutoff, chemical durability and environmental stability.

35 **[00140]** As yet another example, the transparent conductive material (TCO) used in various embodiments may be fluorine-doped tin oxide, doped zinc oxide, indium zinc oxide (IZO), indium tin oxide (ITO), ITO/metal/ITO or insulator/metal/insulator (IMI) and may further include the materials described in above-referenced U.S. Patent No. 5,202,787, such as TEC 20 or TEC 15, available from Libbey Owens-Ford Co. of Toledo, Ohio. Material compositions of a transparent electrode and its opto-electronic characteristics such as sheet resistance affecting the speed and uniformity of coloration (or darkening) of the EC-medium of the EC element of the assembly are discussed in details in U.S. 2010/0321758 and other patent documents from Our Prior Applications.

5 **[00141]** A resistive heater may be disposed in the back of the mirror element to heat the mirror and thereby clear the mirror of ice, snow, fog, or mist. The resistive heater may optionally be a layer of ITO, fluorine-doped tin oxide or may be other heater layers or structures known in the art. Examples of the mirror heater are taught, for example, in U.S. Patent Application S/N 12/686,019.

[00142] Examples of various electrical circuits are taught in the above-referenced Canadian
10 Patent No. 1,300,945 and U.S. Patent Nos. 5,204,778, 5,434,407, 5,451,822, 6,402,328, and 6,386,713.

[00143] Optical concealment of the sealing material and electrical interconnects affixed to electrically-conductive layers of the EC-element may be assured by appropriate shaping of an edge of the first surface of the EC-element, or by configuring a peripheral ring of spectral filter material, as discussed in Our Prior Applications (see, e.g., Figs. 14-16B of U.S. 2010/0321758). Yet another way to conceal the
15 seal is to use a seal material that is transparent as disclosed in commonly assigned U.S. Patent No. 5,790,298, the entire disclosure of which is incorporated herein by reference.

[00144] It is appreciated that embodiments of the present invention draw on the teachings in our Prior Applications and that any of the features of a rearview assembly described in Our Prior Applications can be used with embodiments of the present invention as long as operability of these embodiments is
20 preserved.

Peripheral Ring and Sealing Material.

[00145] U.S. Patent Application Publication No. 2010/0321758 offered (in reference to Figs. 17,
25 18, and 21 therein), a detail discussion of structural and operation coordination of various features of a typical EC-element based mirror and rearview assembly containing such a mirror. The discussion included a description of disposition of a spectral filter material (referred to as a peripheral ring) that is configured to obstruct a sealing material, a plugging material, and/or electrical connections associated with the EC-element from being optically accessible from the front of the assembly, as well as
30 harmonious configuration of various thin-film layers (such as electrically-conductive and reflective layers on the second and third surfaces of the EC-element facilitating fabrication of the EC-element. The discussion additionally included descriptions of methods of fabrication of the EC-element incorporating various notches, cuts-out and "windows" in optical thin-film layers of the EC element in a rearview assembly containing a source of light in order to accommodate a light source, information display, a
35 photo sensor, or a combination thereof in the assembly to selectively transmit a particular spectral band or bands of wavelengths towards the field of view in the front of the assembly to provide required information to the user. To this end, U.S. Patent Application Publication No. 2010/0321758 discussed (in reference to Figs. 19 and Tables 1-4 therein) considerations related to structural elements of the EC-element and the assembly (in particular, thin-film optical structures and related methods of fabrication)
40 that define spectral characteristics of ambient light reflected by the optical system of the assembly and

5 light transmitted through the EC-element-based mirror system of the assembly from a general light source (such as a display behind said mirror system) towards the FOV in the front of the assembly, and provided various examples of optical structures for use in such mirror elements that possess the required spectral and dimensional characteristics.

10 Considerations of Aesthetic Appearance and Styling-

[00146] As discussed in Our Prior Applications, in configuring a rearview assembly - whether the issue concerns coating a surface of an EC-element or a prismatic element (either of which may be forming a basis for a mirror element of the assembly), or formation of a peripheral ring on the first or
15 second surface to mask the seal and/or plug material and contact areas, or whether the issue concerns shaping a perimeter of the mirror element - the aesthetics of appearance of the resulting assembly product plays a critical role in how successful the product is on the market. While the aesthetics of the rearview assembly is not a tangible concept and is generally guided by customer preferences, satisfying these preferences is not a trivial task, and devising satisfactory solutions often involves non-trivial balancing of
20 design and functionality of the resulting embodiments. Such balancing, in turn, poses manufacturing problems that has to be addressed.

[00147] Various examples of such problems involving operational coordination of structural elements of a rearview assembly (such as housing, casing, mounting elements, including as well as devoid of bezels) configured to address the aesthetic concerns were discussed in reference to Figs. 39, 40,
25 42-61 of U.S. 2010/0321758.

[00148] As another example, appearance of the front edge of the assembly plays a special role in assuring that the user's perception of the mirror is satisfying. Following the practical consideration and the current trend in users' preferences in appearance of the vehicular rearview assemblies, the edge of the first substrate should be configured to be optically diffusive for at least two reasons.

30 [00149] 1) In majority of cases, glass substrates of a mirror element of a rearview assembly are produced through scribing and breaking process that generally results in a reflective perimeter edge having specular reflective properties and reflecting about 4 percent of the incident light. (It is understood that this reflectivity level is inevitably increased if the specularly reflecting edge is overcoated with a peripheral ring of material such as Chrome.) The smooth specular reflective edge can give a bright or
35 shiny appearance to the glass edge in many ambient light conditions, which is generally aesthetically objectionable.

[00150] 1) Moreover, if the edge of a mirror element is chipped or cracked and is overcoated with a reflective peripheral ring of spectral filter material (such as chromium, for example), the chipping becomes extremely visible and stands out like a beacon scattering incident light in all different directions.
40 This shortcoming becomes particularly aggravated if a chip or a crack extends onto the perimeter of the first or second surface. Similarly, if the perimeter and/or edge is chipped after the chrome peripheral ring

5 coating is applied, the chip visually stands out in reflected light as a dark void on otherwise a smooth bright surface.

[00151] It is appreciated that both the specularly reflecting edge and imperfections associated with chipping of the edge of the mirror element become especially problematic in embodiments having either a narrow bezel or no bezel at all, because in such embodiments the chipping are not concealed. At
10 least for the reasons discussed above it is preferred, therefore, to configure the first substrate so as to improve both the mechanical quality and the visual appearance of the edge of the mirror element in order to produce a high quality mirror. Both of these goals may be achieved by modifying the surface properties of the edge of the first substrate. Required modifications are produced, for example, by re-shaping the edge either after the coating has been applied to the edge or, preferably, right after the mirror
15 substrates are cut to shape. Re-shaping may be performed by grinding, sanding, or seaming the edge with flat or contoured wheels containing abrasive particles or with a moving belt coated with abrasive particles. Depending on a configuration of the carrier and whether or not a bezel component extends onto the first surface of the mirror element, a light edge treatment that removes as little as 0.005" - or as much as 0.010" to 0.075"- of the front edge of the first may be all that is necessary to achieve a desired result.

[00152] Abrasive materials include but are not limited to diamond, silicon carbide or oxides of aluminum, cerium, zirconium and iron in the size range of about 100 to 1200 mesh. The size of the particles used affects the roughness of the finished glass edge. The larger the abrasive particle the rougher the surface that is created. Generally 80 to 120 mesh size abrasive particles produce a very rough surface, 300 to 500 mesh size particles produce a smooth surface and 600 mesh and above produce a near
20 polished finish. The abrasive particles can be embedded in a metal, resin or rubber medium. An example of abrasives loaded in metal or resin binder are diamond wheels available from GlassLine Corp., 28905 Glenwood Rd., Perrysburg, OH 43551 or Salem Corp., 5901 Gun Club Rd., Winston-Salem, NC 27103. An example of abrasives loaded in a rubber binder are Cratex M or Cratex F wheels available from Cratex/Brightboy Abrasives Co., 328 Encinitas Blvd. Suite 200, Encinitas, CA 92024. Abrasive coated
25 belts are available from 3M Corp., St. Paul, MN 55144. Modification of the surface properties of the edge not only increases the mechanical durability of the edge by removing the micro-cracks but also makes the edge optically diffusive. The re-shaping is generally done in the presence of a coolant to remove the heat generated during grinding or seaming. The edge can also be reshaped by rubbing the glass against a substrate flooded with an abrasive slurry loaded with particles such as diamond, silicon
30 carbide or oxides of aluminum, cerium, zirconium and iron. Equipment for edge polishing using the abrasive slurry method is available from SpeedFam Co., Kanagawa, Japan. Alternatively, the edge can be reshaped by cutting or blasting the edge with a high pressure liquid containing abrasive particles of diamond, silicon carbide or oxides of aluminum, cerium, zirconium and iron. Equipment for frosting glass using this method is available from Bystronic, 185 Commerce Dr., Hauppauge, NY 11788.
35
40 Alternative way of reshaping the edge may include blasting the edge with abrasive particles of diamond, silicon carbide or oxides of aluminum, cerium, zirconium and iron carried by a high velocity gas stream.

5 A modified glass edge can also be produced by chemically etching the glass with a chemical solution designed to leave a frosty surface such as Superfine Glass Frosting Powder which a mixture of ammonium hydrogen fluoride and barium sulfate that is mixed with HCl available from Above Glass Corp., 18341 4th Ct., Miami, FL 33179. A modified glass edge can also be produced by coating the glass edge with a diffuse or pigmented paint such as 935 UV Series available from Ruco, Wood Dale, IL or UV
10 420 Series available from Fluorital Italy, Italy or Ultraglass UVGO Series available from Marabu, Germany or Crystal GLS Series available from Sun Chemical, Parsippany, NJ or SpecTruLite UV Series available from Ferro Corp., Cleveland, OH.

[00153] Discussion of solution to other practical problems posed by addressing the aesthetics of appearance of vehicular rearview assemblies is presented below.

15 Modifications, Auxiliary and Alternative Embodiments.

[00154] As discussed above and in Our Prior Applications, an embodiment of a rearview mirror system employing an EC-element and a source of light behind the EC-element preferably includes
20 a ring (peripheral ring) of an optical thin-film spectral filter material that is circumferentially disposed in a peripheral area, next to a corresponding perimeter-defining edge, of either the first or the second surface of the system. It is recognized that the use of the peripheral ring is partly directed to configuring an overall mirror system in such a fashion as to make the system as aesthetically appealing to the user as possible. For example, one purpose of this thin-film ring is to hide the seal, the plug material, and,
25 possibly, the electrical connectors of the EC-element from being visually discernable by the user through the first substrate. As such, this peripheral ring of material is usually opaque in at least a portion of visible spectrum of electromagnetic radiation and may be sufficiently wide, up to 6.5 mm. It has also been discussed in this application that such a peripheral ring must facilitate matching of spectral characteristics of ambient light reflected from the periphery of the mirror system that includes such a ring
30 with those of ambient light reflected from a central area inside the periphery of the mirror system where the ring is not present. The better the spectral matching, e.g., matching of reflectance and color gamut, the less discernable is the area of the peripheral ring to the viewer when the EC-element is switched "off" and the rearview assembly of the invention operates purely as a mirror. Solutions to achieving various degrees of spectral matching between the ring-portion of the mirror and the central, transfective portion
35 of the mirror have already been discussed in this application and included judicious thin-film designs of the peripheral ring with the use of such materials as chromium, nickel, stainless steel, molybdenum, silicon, platinum group metals, aluminum, silver, copper, gold or various alloys of these metals.

[00155] Also discussed was another, more tangible purpose of utilizing a peripherally deposited thin-film ring - to reduce exposure of the seal, disposed between the substrates forming an EC-
40 cavity, to UV light that causes degradation of the seal. Clearly, then, such UV-protection measure is of particular importance in an outside rearview assembly (see, e.g., Figs. 3 and 5) that is fully exposed to

5 sunlight, while requirements to UV-properties of a ring of an EC-element employed within an inside rearview assembly (see, e.g., Figs. 4 and 5) may be not as stringent.

[00156] It is recognized that the use of a peripheral ring entails certain shortcomings. For example, it must be realized that, in operation, the peripheral area of a mirror system of the assembly containing the peripheral ring does not darken, unlike the central portion of the mirror, when the voltage
10 is applied to the electrodes of the EC-element (or other electrically darkening technology) in order to reduce the light-glare blinding the user. As a result, the difference in appearances of the peripheral ring and the central portion of the mirror when the EC-element is "on" may be quite significant, in particular in inside rearview assemblies that typically employ higher reflectance levels. Consequently, not only the size of the central portion of the mirror is accordingly reduced, as compared to the overall front surface of
15 the mirror element, by a width of the peripheral ring but the peripheral ring continues producing the undesired glare even when the EC-element is "on". Another problem arises from the fact that a typical mirror system of an inside rearview assembly contains an eye-hole (such as the elements 497 and 515 of Figs. 4 and 5) behind which corresponding sensors (such as the sensor 396 of Fig. 3) may be positioned. When the eyehole is used in combination with a peripheral ring, appropriate positioning of the eye-hole
20 may not be straightforward. For example, if the eye-hole is formed by creating an opening in a coating stack of the third surface, then locating such an opening within the peripheral area of the mirror element will disrupt the visual continuity of the mirror and will be perceived as aesthetically unpleasing, particularly in an embodiment where the height of the mirror is not significant. It is appreciated that, although in description of the embodiments below mounting elements (e.g., carrier, bezel, and housing
25 elements) as well as electrical connectors are omitted, all of these elements are implied and the described alternative and modified embodiments may be used with any combination of the mounting and electrical elements discussed in this application.

Eye-hole Openings.

30 [00157] Common embodiments of automotive electrochromic mirrors generally include light sensors for measuring glare and ambient light levels. In certain embodiments the glare sensor is positioned behind the EC mirror element and views glare light levels through an aperture in the reflective coating. Prior art embodiments of eyehole openings for light sensors comprise single continuous
35 openings. These openings in the reflective layer may comprise a TCO or a transfective metal layer for conductivity. In general, these openings can be several millimeters wide and are often round or elliptical in shape. The aperture must be large enough to allow glare light entering the vehicle to adequately illuminate the glare sensor for accurate light level measurement. A single, hard edged eyehole might be considered aesthetically less than optimum by certain observers. Some prior art embodiments utilize a
40 transfective opening that is effectively stealthy and non-obvious to an observer. For certain other embodiments discussed herein, the use of a cluster of multiple, smaller openings instead one large

opening may have aesthetic and/or manufacturing advantages. Non-limiting embodiments of multi-opening eyeholes are shown in Figs. 7(A-E). These examples comprise reflective regions 6620 (reflective material present) and areas 6610 that are patterned to be essentially devoid of reflective material. As shown in Figs. 7(A-E), these patterns may be essentially circular, rectangular or line-like and may have a regular or irregular spacing. In general, an optimized pattern of reflective and essentially non-reflective regions within the geometric boundaries of an eyehole can be less noticeable and therefore less aesthetically objectionable. The size and spacing of the openings, as they contribute to percent open area in the eyehole region, determine the transmittance of light to the glare sensor. Because the eyehole is part of the EC element, it darkens when the element is energized resulting in a change of light intensity measured by the glare sensor. It is preferable that the eyehole clear as quickly as the rest of the EC mirror element so that the measured light intensity is accurately indicative of the glare observed by the driver. If the eyehole clears slower than the rest of the mirror element then it is possible that the EC mirror will not respond to changing glare situations as intended.

[00158] There can be negative impacts on EC mirror element aesthetics and function caused by essentially non-conductive regions of the electrode. In the currently described electrochromic (EC) cell embodiments, the EC fluid comprises two primary coloring compounds, an anodic material, which is bleached in its normal state and becomes oxidized at the anode when the cell is energized, and a cathodic material, which is bleached in its normal state and becomes reduced at the cathode when the cell is energized. In one embodiment the anodic material is yellow/green in its colored state and the cathodic material is violet in its colored state. Because these two EC materials are dissolved in the EC fluid, they are free to diffuse through the cell. Therefore, when the operating potential is applied between the anode and cathode, the two EC active compounds proximate to the proper electrode surface are converted to their colored states. The colored state compounds diffuse away from the electrode surfaces where they were created and are replaced by more bleached state compounds which are subsequently colored. When a molecule of oxidized (colored) anodic material diffuses proximate to a molecule of reduced (colored) cathodic material, there is some probability that a charge transfer reaction will occur, converting both molecules back into their bleached state. A second potential route to bleaching of a colored state molecule is diffusion to the opposite electrode from which it was created. A molecule of anodic material that has been oxidized at the anode has some probability of diffusing proximate to the cathode surface. Once this occurs it is likely that the anodic material will be reduced back to its bleached state. Likewise, the same effect can apply to reduced cathodic material that diffuses to the anode. In this way, some time after the initial activation of the EC cell, steady state equilibrium is reached between the creation of colored state compounds and the bleaching of colored state compounds by intermolecular charge exchange and diffusion to the opposite electrode. In the equilibrium state, colored EC molecules have the highest probability of bleaching through intermolecular charge transfer with the opposite species in a depletion zone between the two electrodes where the concentration of colored species approaches zero. As described elsewhere, in a standard EC mirror cell design, surface 2 of the EC element comprises a

transparent electrode which is commonly configured as the anode. Surface 3 of the EC element comprises a conductive, reflective layer which is commonly configured as the cathode. Considering the equilibrium described above, if one considers the EC cell in cross-section, there will be a somewhat higher concentration of colored anodic material proximate the anode surface and a somewhat higher concentration of colored cathodic material proximate the cathode surface. Nearer the center of the cell (in cross-section), the concentrations of the colored anodic and cathodic materials will be more similar until the concentrations fall to near zero in the depletion zone. To an observer viewing the reflective element from a position normal to its first surface, the stratification of the colored species is not apparent since the layered colors are blended by the path the light takes to the observer. Consequently, if there is a gap in one of the conductive layers generating a non-conductive or significantly less conductive region (for example, an area 6610), a localized imbalance can be caused in the equilibrium. The side of the cell still having a functional electrode will generate colored material as described above. The side of the cell with the compromised electrode will not generate colored material or will do so at a significantly reduced rate. Therefore if there is a gap in the cathode of the above described embodiment, yellow/green material will be produced at the anode without commensurate violet material being product at the opposing cathode location. This imbalance can lead to a net yellow/green appearance at the location of the compromised cathode. This color imbalance is here and elsewhere (US Patents 4,902,108 and 5,679,283 herein incorporated by reference in their entirety) referred to as segregation. This effect can lead to less than optimum aesthetics when the mirror element has been in the dark state for several minutes. The size or area of the compromised zone of the electrode affects the degree of segregation due to its effect on the diffusion length required to reach the other electrode. For example, in a non-compromised system with two parallel electrodes separated by 140 microns, the shortest diffusion path length at any position in the system must be less than or equal to 140 microns. If a segment of an electrode 500 microns wide is removed then the shortest diffusion path length can be as high as 287 microns in the compromised segment, describing the hypotenuse of the triangle running from the center of the compromised segment to its edge then across to the other electrode of the EC cell. Increasing the shortest path length will increase the effects of segregation. These effects are illustrated in Fig. 7F.

[00159] A common method of clearing the EC element involves removal of the driving potential and electrical shorting of the anode to the cathode. At this point no new EC molecules are being converted to their colored states and diffusion takes over. The high concentration of oxidized anodic species proximate the anode and reduced cathodic species proximate the cathode result in a chemical potential similar to a battery. Shorting the electrodes allows the species proximate to the electrode surfaces to rapidly return to their bleached state. Diffusion across the cell allows the remaining oxidized anodic molecules to bleach through charge transfer reactions with reduced cathodic molecules. Again, as described above, a non- or partially-conductive area of one of the electrodes means that the bleaching of one of the EC species cannot occur at the compromised electrode surface resulting in diffusion being the only route to bleaching. If only one electrode, cathode or anode, is compromised then one species may

5 bleach more quickly than the other resulting in a color imbalance and slower than normal clearing of that species which is herein also considered a form of segregation. The sum effect of one electrode having a non- or partially-conductive region is that in the driven (darkened) state, one colored EC species increases in concentration in the compromised zone, due to lack of depletion by the opposite EC species, until it dominates the color. This dominate color persists for some time after clearing of the EC element by the
10 method described above due to diffusion being the only route to bleaching in the compromised region. Depending on the size and shape of the compromised zone, it is possible, due to the chemical potential present during clearing, to see a small amount of the violet color, for the above described embodiment, proximate the perimeter of the compromised zone during clearing. As described above, the colored EC species persisting in the eyehole zone longer than the clearing time for the rest of the element may lead to
15 less than optimum performance of the glare sensor.

[00160] As alluded to above, one route to minimizing the segregation effects is to compromise both the anode and cathode electrodes. So if the intent is to create openings or essentially non-conductive zones in the third surface reflector layer to enhance transmission or create a conductance break, creating an essentially equivalent opening or essentially non-conductive zone in the opposing region of the second
20 surface conductive layer will have roughly equivalent, offsetting effects, resulting in less segregation effects. This is due to the effect that both electrodes are compromised meaning that neither EC material effectively dominates in the compromised zone. This may significantly reduce the color bias in the activated (dark) state as well as during clearing. This may also reduce the lag in clearing time but will not necessarily eliminate it.

25 [00161] *Examples:* EC-mirror elements were fabricated with nominal cell spacing of approximately 140 microns. The eyeholes in these devices were configured by patterning the third surface metal reflector (cathode) with vertical lines created by laser ablation in a fashion similar to that of Fig. 7C. The perimeter of the ablated area approximated an oval with a length of about 5 mm and a width of about 7 mm. The width of the remaining metal traces and the width of the ablated openings in the
30 eyehole area are shown in Table 1. Each of the samples was activated (darkened) for 10 minutes and then shorted (cleared). During the coloring and clearing phases the eyehole region was observed by transmittance spectroscopy to track the change in transmittance versus time. Examples A1-L1 represent openings in the surface 3 reflective layer without a corresponding "opening" in the surface 2 TCO. Examples A2-L2 represent openings in surface 2 plus corresponding essentially equivalent "openings" in
35 the surface 2 TCO. Fig. 7G demonstrates the change in transmittance at the eyehole during coloring and clearing for both an element showing segregation effects and an element not showing segregation. As can be seen from Fig. 7G, a non-compromised EC element shows relatively monotonic change between the bright and dark states while an EC element with a compromised electrode in the region of the eyehole shows a non-monotonic change both for coloring and clearing. The secondary, slow change identified as segregation in Fig. 7G is due to the slow diffusion of colored state EC molecules into and out of the
40 compromised zone/s of the eyehole. A time measure, t_i , was assigned for the time at which the primary

5 rapid clearing step transitioned to the slow segregation clearing step. A second time measure, t_2 , was assigned to the point at which the clearing reached essentially a steady state transmittance. The difference between t_2 and t_1 was defined as the Clearing Time Delay, Delta-t. The transmittance at time t_1 was defined as $\%T_1$. Similarly the transmittance at time t_2 was defined as $\%T_2$. The value of $\%T_2$ represents the transmittance of the eyehole in its essentially fully clear state. The attenuation of light at time t_1

10 relative to t_2 was defined as Delta-%1 which represents the loss of light intensity reaching the glare sensor at time t_1 relative to the intensity of light reaching the glare sensor in the fully clear state; in other words, the attenuation of the glare sensor response due to segregation. Table 1 lists the properties of the example surface 3 eyehole ablations including whether surface 2 was also ablated, the width of the metal traces, the width of the ablated spaces, the clear state transmittance, the dark state transmittance and the variables

15 listed above. To minimize the effects of segregation on the performance of the glare sensor it is preferable to minimize either the clearing time delay, Delta-t, or the attenuation of the glare sensor, Delta-%1. Minimizing both measures will result in a preferable embodiment however; the minimization of either measure reduces the impact of the other measure.

20 Table 1:

| Label | Surf2 Ablation | Traces (um) | Ablations (um) | %Open | % T | Darkened %T | t1 sec | t2 sec | Delta-t | %T1 | %T2 | Delta-%T | Delta-%I |
|-------|----------------|-------------|----------------|-------|------|-------------|--------|--------|---------|------|------|----------|----------|
| A1 | N | 54 | 50 | 48 | 22.1 | 4.7 | 17 | 113 | 96 | 20.7 | 22.1 | 1.4 | 6.4 |
| B1 | N | 123 | 50 | 29 | 14.1 | 2.7 | 13 | 68 | 55 | 13.6 | 14.1 | 0.5 | 3.9 |
| C1 | N | 210 | 50 | 19 | 9.2 | 1.8 | 16 | 42 | 26 | 9.1 | 9.2 | 0.1 | 0.8 |
| D1 | N | 81 | 75 | 48 | 23.6 | 7.5 | 20 | 130 | 110 | 21.2 | 23.6 | 2.4 | 10.2 |
| E1 | N | 185 | 75 | 29 | 13.8 | 4.4 | 13 | 72 | 59 | 13.1 | 13.8 | 0.7 | 5.2 |
| F1 | N | 315 | 75 | 19 | 10.1 | 3.4 | 16 | 50 | 34 | 9.8 | 10.1 | 0.3 | 2.8 |
| J1 | N | 217 | 200 | 48 | 25.4 | 16.5 | 2 | 265 | 263 | 18.8 | 25.3 | 6.5 | 25.6 |
| K1 | N | 490 | 200 | 29 | 16.1 | 10.5 | 3 | 164 | 161 | 12.2 | 16.0 | 3.8 | 23.6 |
| L1 | N | 853 | 200 | 19 | 9.4 | 6.1 | 3 | 97 | 94 | 7.1 | 9.4 | 2.3 | 24.5 |
| A2 | Y | 54 | 50 | 48 | 21.3 | 4.1 | 17 | 62 | 45 | 20.7 | 21.3 | 0.6 | 2.7 |
| B2 | Y | 123 | 50 | 29 | 13.6 | 2.4 | 20 | 42 | 22 | 13.5 | 13.6 | 0.1 | 0.9 |
| C2 | Y | 210 | 50 | 19 | 9.0 | 1.7 | 23 | 28 | 5 | 8.9 | 9.0 | 0.1 | 0.6 |
| D2 | Y | 81 | 75 | 48 | 23.8 | 6.2 | 20 | 70 | 50 | 23.3 | 23.8 | 0.5 | 2.3 |
| E2 | Y | 185 | 75 | 29 | 13.6 | 4.2 | 20 | 42 | 22 | 13.6 | 13.6 | 0.0 | 0.3 |
| F2 | Y | 315 | 75 | 19 | 9.6 | 3.1 | 18 | 22 | 4 | 9.6 | 9.6 | 0.0 | 0.4 |
| G2 | Y | 69 | 251 | 78 | 40.6 | 29.8 | 9 | 229 | 220 | 36.6 | 40.5 | 3.9 | 9.6 |
| H2 | Y | 158 | 481 | 75 | 38.9 | 25.0 | 4 | 324 | 320 | 26.6 | 38.9 | 12.3 | 31.6 |
| J2 | Y | 217 | 200 | 48 | 25.6 | 16.9 | 7 | 109 | 102 | 22.3 | 25.6 | 3.3 | 12.9 |
| K2 | Y | 490 | 200 | 29 | 15.8 | 11.2 | 9 | 109 | 100 | 14.3 | 15.7 | 1.4 | 8.9 |
| L2 | Y | 853 | 200 | 19 | 11.1 | 7.8 | 10 | 109 | 99 | 10.1 | 11.1 | 1.0 | 9.0 |

5 **[00162]** Another approach to quantifying the effects of segregation on the glare sensor response is to consider the lag between initiation of clearing the EC element and the time at which the eyehole transmittance reaches a predetermined value. For this purpose it is convenient to consider a normalized Percent Full Scale (%FS) transmittance scale for the eyehole. The actual transmittance of the eyehole at any time *t* is normalized and scaled such that the minimum transmittance of the eyehole in the fully
10 darkened state becomes 0% FS and the maximum transmittance of the eyehole in the fully cleared state becomes 100% FS. The behavior of this measure for the clearing of selected examples is given in Fig. 7H. This normalized scale is convenient because it more accurately describes the effects of the segregation on the actual response range of the glare sensor. It is preferable that the eyehole reach a %FS value of greater than 75% within 20 seconds of the initiation of clearing. It is more preferable that the eyehole
15 reach a %FS value of greater than 80% within 20 seconds of the initiation of clearing. It is most preferable that the eyehole reach a %FS value of greater than 90% within 20 seconds of the initiation of clearing. The Percent Full Scale transmittance data for the examples described above is given in Table 2. Tuning of the clearing speed and optical properties of the eyehole, as described above, is controlled by the conductivity of the surface 2 and surface 3 electrodes as well as the fraction open area in the surface 3
20 electrode within the boundaries of the eyehole zone and the selection of a metal trace (area 6620 of Figs. 7A through 7E) and open area (area 6610 of Figs. 7A through 7E) dimensions and geometry. It is therefore preferable that the fraction of open area in the eyehole zone be between 5 and 75 percent. It is more preferable that the fraction of open area in the eyehole zone be between 10 and 60 percent. It is most preferable that the fraction of open area in the eyehole zone be between 15 and 50 percent. It is
25 preferable that the minimum dimension of the metal traces be between 1 and 1000 microns. It is more preferable that the minimum dimension of the metal traces be between 10 and 500 microns. It is most preferable that the minimum dimension of the metal traces be between 20 and 250 microns. It is preferable that the maximum dimension of the openings be between 1 and 1000 microns. It is more preferable that the maximum dimension of the openings be between 10 and 500 microns. It is most
30 preferable that the maximum dimension of the openings be between 20 and 250 microns.

[00163] It is appreciated that the dimension of the remaining metal traces (areas 6620) in the eyehole zone may affect the performance of the glare sensor. If the traces are not small compared to the dimensions of the glare sensor, or its optics, then the shadowing of the sensor by the metal traces might result in the response of the glare sensor being non-uniform with respect to the angle of incidence of the
35 light. For this reason the dimension and spacing of the metal traces may require optimization beyond the requirements of the segregation effects described above. Eyeholes comprising multiple smaller apertures may be considered less obtrusive and therefore more aesthetically pleasing than larger, single aperture eyeholes. The use of laser ablation to form the above described apertures/ablations is one example of a potential manufacturing advantage over common methods used to generate conductive, single aperture
40 eyeholes in a reflective conductive layer stack.

5 Table 2: Percent of Full Scale Transmittance.

| | %Tmin | %Tmax | Time (sec) | | | | | | | | | | | | | | |
|----|-------|-------|------------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|
| | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 15 | 20 | 25 | 30 |
| A1 | 4.7 | 22.1 | 0 | 0.5 | 3.6 | 11.0 | 20.7 | 44.7 | 57.7 | 70.4 | 81.9 | 89.1 | 89.8 | 89.6 | 89.7 | 89.9 | 90.3 |
| B1 | 2.7 | 14.1 | 0 | 0.8 | 5.3 | 12.4 | 21.3 | 42.6 | 54.0 | 65.4 | 76.1 | 85.8 | 93.0 | 95.1 | 95.4 | 96.1 | 96.7 |
| C1 | 1.8 | 9.2 | 0 | 1.0 | 5.9 | 13.5 | 22.9 | 44.6 | 56.0 | 66.9 | 76.9 | 85.6 | 92.8 | 98.3 | 98.7 | 99.1 | 99.4 |
| D1 | 7.5 | 23.6 | 0 | 1.2 | 7.4 | 16.7 | 27.7 | 52.1 | 64.3 | 75.5 | 82.9 | 85.8 | 85.9 | 85.3 | 85.3 | 85.4 | 85.7 |
| E1 | 4.4 | 13.8 | 0 | 1.6 | 7.9 | 17.1 | 27.8 | 50.7 | 62.2 | 72.9 | 82.1 | 88.5 | 91.5 | 92.0 | 92.2 | 92.8 | 93.4 |
| F1 | 3.4 | 10.1 | 0 | 1.1 | 7.3 | 17.3 | 29.0 | 53.6 | 65.2 | 75.9 | 84.9 | 91.0 | 94.3 | 96.2 | 96.9 | 97.6 | 98.4 |
| J1 | 16.6 | 25.4 | 0 | 10.3 | 19.9 | 24.2 | 26.6 | 28.5 | 30.2 | 31.5 | 32.7 | 33.9 | 34.8 | 38.3 | 40.5 | 41.8 | 42.8 |
| K1 | 10.5 | 16.1 | 0 | 12.6 | 23.4 | 28.6 | 32.3 | 34.8 | 37.2 | 39.3 | 41.2 | 43.0 | 44.7 | 51.1 | 55.7 | 59.2 | 61.9 |
| L1 | 6.1 | 9.4 | 0 | 12.7 | 23.5 | 29.4 | 33.5 | 36.7 | 39.4 | 42.0 | 44.4 | 47.3 | 49.2 | 57.5 | 64.0 | 69.2 | 74.0 |
| A2 | 4.1 | 21.3 | 0 | 0.2 | 4.0 | 11.1 | 20.2 | 43.7 | 53.5 | 64.7 | 75.1 | 84.1 | 91.3 | 96.6 | 97.1 | 97.7 | 98.1 |
| B2 | 2.4 | 13.6 | 0 | 0.3 | 3.2 | 8.9 | 16.3 | 34.5 | 44.5 | 54.6 | 64.2 | 73.1 | 80.9 | 98.9 | 99.3 | 99.6 | 99.8 |
| C2 | 1.7 | 9.0 | 0 | 0.5 | 3.7 | 9.8 | 17.7 | 36.9 | 47.1 | 56.9 | 66.3 | 74.7 | 81.9 | 99.6 | 99.9 | 99.9 | 100.0 |
| D2 | 6.2 | 23.8 | 0 | 0.6 | 4.3 | 10.5 | 18.2 | 35.5 | 44.7 | 53.9 | 62.8 | 71.2 | 78.9 | 97.0 | 97.2 | 97.6 | 98.0 |
| E2 | 4.2 | 13.6 | 0 | 1.4 | 6.8 | 14.9 | 24.4 | 44.5 | 54.3 | 63.4 | 71.8 | 79.4 | 85.7 | 99.1 | 99.3 | 99.5 | 99.6 |
| F2 | 3.1 | 9.6 | 0 | 1.2 | 6.1 | 14.1 | 23.6 | 44.1 | 54.0 | 63.5 | 71.9 | 79.5 | 85.7 | 99.0 | 99.6 | 99.6 | 99.9 |
| G2 | 30.0 | 40.6 | 0 | 5.8 | 15.4 | 26.3 | 37.5 | 45.6 | 51.9 | 57.0 | 60.8 | 62.2 | 62.7 | 65.0 | 67.2 | 69.0 | 70.9 |
| H2 | 25.1 | 38.9 | 0 | 3.3 | 6.3 | 8.5 | 10.2 | 11.4 | 12.7 | 14.0 | 15.4 | 16.7 | 18.1 | 25.4 | 33.2 | 41.1 | 49.0 |
| J2 | 16.9 | 25.6 | 0 | 13.0 | 25.8 | 37.0 | 45.9 | 51.9 | 56.4 | 59.6 | 62.3 | 64.5 | 66.7 | 75.1 | 80.7 | 84.9 | 88.0 |
| K2 | 11.2 | 15.8 | 0 | 7.0 | 17.4 | 28.6 | 39.2 | 46.7 | 53.7 | 59.4 | 64.0 | 67.3 | 69.1 | 74.3 | 78.2 | 81.6 | 84.1 |
| L2 | 7.8 | 11.1 | 0 | 5.7 | 15.4 | 26.4 | 37.6 | 45.6 | 52.6 | 58.4 | 63.0 | 66.1 | 68.6 | 74.0 | 77.9 | 81.1 | 84.1 |

[00164] Another approach to making the eyehole less noticeable is to locate at least part of the light sensor behind the peripheral ring of spectral filter material and, correspondingly, the eye-hole itself within the area defined by the width of the peripheral ring. In such a configuration, the area where the reflector of the rear substrate of the EC-element is removed to form an eye-hole will be hidden from the viewer by the peripheral ring. This configuration, however, requires the peripheral ring to be sufficiently transmitting in the visible portion of the spectrum so that the light sensor could function properly. It is understood, that sufficient transmittance of a peripheral ring at a wavelength of interest may be achieved by making the ring transfective as well as by ablating a portion of the ring material or depositing the ring with the use of masking means. A transmission level of 3% to about 50% in visible light is preferred in such an application, while in the UV portion of the spectrum the peripheral ring may still be configured to remain opaque for protection of the seal and plug materials.

[00165] Similarly, mutual positioning of the light sensor and the associated eye-hole with respect to the seal is also important. For example, if the seal material is essentially opaque in visible light it should not obstruct the light that the sensor detects. On the other hand, if the seal is sufficiently translucent, the sensor can be placed behind the seal area and the associated eye-hole area may overlap

5 with the area occupied by the sealing material. The combination of the seal and the spectral filter material should have an overall visible light transmission of 3% to 50% for the same reasons as described above.

[00166] Yet another approach to configuring the eye-hole area is to simply position the light sensor behind a rear substrate with a non-patterned reflector that is sufficiently transmissive (between 3% and 50%) as is. This level of light transmittance can be obtained through the coating directly or with a
10 combination of light passing through the coating and through openings in the coating.

[00167] To eliminate the requirement for an eye-hole altogether, the light-glare sensor can be repositioned so that it is not screened from the viewer by the EC-element. This type of construction is known in the art. Often the eyehole is placed in an area just above or below the mirror or anywhere along the periphery. The placement of the light sensor could be in any number of locations including in the
15 mirror mount, in the headliner of the vehicle, near to or attached to the rear window, on the side mirror, or on the rear of the vehicle. The sensor could be a simple photo-optic sensor or a more complex camera or multiple camera system.

[00168] Some drivers of vehicles equipped with an automatically dimming mirror may not be aware that they have the dimming mirror or, in some cases, they simply don't know when the device is
20 working. To some automobile manufacturers this reduces the value of the mirror. At times indicator lights have been added to the autodimming mirror to indicate that the device is powered. Still, this indicator light does not demonstrate the function of the device. In self-dimming mirrors comprising a reflective peripheral ring, the darkening of the center of the mirror is highlighted by the contrast to the reflective peripheral ring. Alternatively, configuring the mirror to have an area that does not darken or
25 that darkens or clears at a different rate as compared to the remaining portion of the mirror may also put the user on notice about the operation of the auto-dimming mirror.

Reduction of Width of a Peripheral Ring.

[00169] Reduction of width of a peripheral ring may alleviate a problem of residual glare produced by the non-dimming peripheral area of the mirror even when the EC-element of the EC-mirror is activated. If the ring is narrowed, then the total amount of light reflected from it in the direction of the user is reduced. Preferably, the width of the peripheral ring should be less than 4 mm, more preferably less than 3 mm, and most preferably less than 2 mm.

[00170] When the peripheral ring as narrow as 2 mm, a portion of the wide seal may become visible from the front of the rearview assembly. The visibility of the seal may be reduced or eliminated if the seal is made of clear epoxy or a sealing material the color and index of refraction of which match those of the EC-medium sufficiently enough to remove the optical interface between the seal and the EC-medium upon wetting. As a result, the "exposed" to viewing portion of the seal will be effectively hidden
40 from view in the "clear" mode of the EC-element. When the EC-element operates in the "dark" mode, the

5 exposed portion of the seal just as the peripheral ring itself will not color or dim, thereby improving the appearance of the mirror element.

[00171] Alternatively, the reduction in width of the ring may require an appropriate reduction of the width of the seal, dimensions of a plug in the seal, and even dimensions of buss contacts located behind and protected by the ring from UV-exposure, especially in embodiments of an outside rearview mirror. The widths of the seal, buss can be optimized as follows:

[00172] 1) Keeping the seal width to a minimum required to pass the environmental durability tests;

2) Judiciously selecting conductive buss materials possessing such properties (of adhesion, low gas permeation, and others) that would the buss to either function as part of the seal or to simultaneously function as the buss and the seal;

3) Use electrical contacting modalities and methods that allow for incorporation of the electrical contacts within or under the seal (nanoparticle inks based on silver, nickel, copper; patterned metallic traces formed by metal deposition such as from metallo-organic systems, electroplating, or electroless plating; wire bonding of gold or aluminum wires or ribbons, as schematically shown in Fig. 8A);

4) Positioning the buss conductor primarily on the edge surface of the mirror element;

5) Optimizing or eliminating at least one of transverse offsets between the substrates of the EC-element thereby providing for extending position of the seal towards the outside edge of the peripheral ring.

[00173] The plug area can be optimized as follows:

1) Assuring that the size of the plug opening is no greater than the width of the seal, thereby enabling a controlled injection of a reduced amount of plug material;

2) Appropriately shaping a plug opening 6710b, 6710c, 6710d to assure that one dimension of the plug is greater than the width 6712b, 6712c, 6712d of the seal 6714b, 6714c, 6714d as shown in top view of a substrate 6720 of an EC-element in Figs. 8(B-D);

3) Adhering a low-gas-permeability thin metal foil, plastic foil, or glass/ceramic, or adhesive along the edge surface of the EC-element or soldering metal to the edge surface to cover the fill-port opening.

Rounded Ground Edge for Internal EC-mirrors.

[00174] European regulations of automotive design require that a non-recessed hard edge of any element have a radius of at least 2.5 mm, as a safety measure. (See, in particular, the U.N. Economic Commission for Europe Vehicle Regulation No. 46, commonly referred to as ECE Reg. 46). In response to such a requirement, a non-recessed perimeter edge of an inside automotive mirror may be covered with an appropriate bezel (and multiple embodiments of a combination of a bezel with a mirror element have

5 been discussed in this application, e.g., in reference to Figs. 42-54 and 58, 59 of U.S. 2010/0321758). To satisfy the European regulations, a front lip of a bezel extending over the perimeter edge of the mirror element is designed with an outer radius of at least 2.5 mm. For aesthetic reasons it is often desirable to either not have a perimeter bezel or have a bezel that surrounds the perimeter edge of the mirror and is substantially leveled with the front mirror element. According to an embodiment of the invention, a
10 mirror that has an about 5-mm-wide peripheral ring covering the seal from exposure to light (such as a chrome ring, for example) may be devoid of a bezel that extends out onto the first surface of the mirror. To meet the European edge design requirements and to be substantially flush with the front surface of the mirror, the bezel must be configured to have an at least 2.5 mm radius curvature, which means that the overall transverse dimensions of the rearview assembly as viewed from the front of it are at least 5 mm
15 larger than the transverse dimensions of the mirror element. Neither this rounded bezel nor a peripheral ring contributes to the auto-dimming reflective portion of the mirror and, together, the rounded bezel and the ring add an at least 7.5 mm wide non-dimmable ring around the mirror element. Moreover, the addition of a wide bezel also detracts from the sleek appearance of the mirror assembly.

[00175] One bezel-less embodiment 6800 meeting the European edge requirement and providing
20 for a durable edge of the mirror is schematically illustrated in Fig. 9. As shown, a mirror element 6701 includes a front substrate 6802 having a thickness of $t \geq 2.5$ mm and a rear substrate 6804 that are positioned in spaced-apart and parallel relationship with respect to one another, a seal 6806 disposed around the perimeter of the element 6801 so as to sealably bond the front and rear substrates 6802, 6804 and to form a cavity 6808 therebetween. A peripheral portion of the front substrate 6802 is configured by,
25 e.g., grinding to form a curvature, around the front edge of the front surface 6802a, with a radius $Rad = 2.5$ mm or bigger. The rear substrate 6804 is smaller than the front substrate 6802 and is transversely offset with respect to the front substrate 6802 along most of the perimeter of the mirror element 6801. As shown, a peripheral ring 6810 is disposed circumferentially in a peripheral area of the second surface of the element 6801 on top of a transparent TCO-electrode 6812 in such a fashion as to
30 substantially block visible and/or UV light incident onto the first surface 6802a from illuminating the seal 6804. (It is appreciated, however, that in a related embodiment the TCO-electrode can be deposited on top of the peripheral ring, instead.) A generally multi-layer thin-film stack 6814, disposed on a third surface 6816, includes at least one electrically conductive layer that is electrically extended over an edge surface 6818 of the rear substrate 6804 to the back of the element 6801 (as shown, a fourth surface 6820)
35 through a conductive section 6822. In a specific embodiment, a multi-layer thin-film stack may be a reflective electrode at least one electrically conductive layer of which is configured to be in electrically communication with the back of the mirror element. Another buss connection, 6824, provides for an electrical communication between the transparent electrode 6812 and the fourth surface 6820. This recessed back substrate design would provide for uninterrupted electrical contact from the back of the
40 embodiment to the front and/or rear electrode(s). The mirror-holding system could be designed such that

5 the mirror element 6801 is supported by a carrier 6830 having a judiciously formatted perimeter lip or wall that is flush with an edge of the front glass substrate 6802 and that covers the perimeter edge 6818 of the second glass substrate 6804 hiding it from view. A ground or frosted appearance on all visible glass edges is aesthetically preferred.

10 [00176] It would be appreciated that the use of a front substrate 6804 that is at least 2.5 mm thick will increase the overall weight of the mirror element 6801. Therefore, using glass plate that is 2.2 mm or less in thickness may be preferred. Using glass plate that is 1.6mm thick or thinner is most preferred. In such preferred cases of thinner substrates, the edge surface of the overall mirror element could be rounded to a radius of at least 2.5 mm to meet European specifications. It will be understood that a process of rounding of the edge that modifies the shape of both the front and the rear substrates of
15 the EC-element results in making either one of the electrodes or a clip, that provides for electrical communications between the electrodes and the back of the mirror element, visible from the front of the mirror element.

[00177] One solution to this unexpected "visibility" problem, in reference to Fig. 10A, is to configure the second substrate 6904 of the mirror element 6906 with a recess or indentation 6908 in
20 which an electrical buss (clip of electrically conductive section) is fit over the edge surface of the rear substrate 6904. Fig. 10B demonstrates a front view of a stack of the first substrate 6910 and the second substrate 6904. Fig. IOC schematically shows the rounded profile added to the edge surface of an assembled mirror element in the area of the recess 6908. As shown, post assembly, the recessed area 6908 of the substrate 6904 can be filled with a material 6912 that simulates the look of ground glass, such
25 as a UV-curable acrylic resin filled with glass flakes. The assembled mirror element is then shaped to a rounded profile, *Rad*, as described above, around a perimeter of the mirror element.

Rounded Carrier/ Bezel Edge.

30 [00178] Alternative solutions addressing the European requirements of safety may be based on configuring a frame of the mirror without a lip extending onto the first surface of the mirror and with a rounded edge. Aesthetic requirements currently dictating a color match between the rearview assembly and a vehicular dash board would be met if the mirror frame had a metallic appearance. Several embodiments implementing such solutions are schematically shown in Figs. 11-13.

35 [00179] As shown in a partial side view and a front view in Figs. 11(A, B), an embodiment 7000 of a multi-piece frame construction of the mirror element 7010 of the invention includes a carrier 7012 supporting the mirror element 7010 and attached to a housing 7014 and a bezel 7016 stamped of metal and attached to the carrier 7012 with adhesive. In a related embodiment, the metallic bezel 7016 may be snapped or insert-molded into the carrier 7012. As shown, the embodiment of the bezel 7016 has
40 a front lip 7018 extending over the first surface 7020 of the mirror element 7010. In a specific embodiment, the bezel 7016 may be molded out of plastic and plated with metal. It is appreciated that,

generally, no peripheral ring is required within the mirror element **7010** because a seal **7026** of the mirror element is protected from light exposure by the lip **7018**.

[00180] A partial side view and two different front views of an alternative bezel-less embodiment **7100**, **7100'** of a mirror frame are presented in Figs. 12(A-C). As shown, a decorative inlay **7102** is inserted into a front surface **7104** of a carrier **7106** having a rounded bound, $Rad \geq 2.5mm$, that levels the front surface **7104** with the first surface **7108** of the mirror element **7110**. In this configuration, the frame **7100** does not obstruct the front surface of the mirror element. The decorative inlay **7102** may be stamped of metal or extruded from plastic and plated with metal, and attached to the carrier **7106** with adhesive, by snapping, or insert molding. It is appreciated that, to be used with this embodiment of the frame, the mirror element should incorporate a peripheral ring (not shown) to protect a seal **7126** from exposure to light. The front views of Figs. 12B and 12C illustrate, respectively, that the inlay **7102** may or may not be present around the entire perimeter of the mirror element **7110**.

[00181] Figs. 13(A-C) show, in side views and in front view, two more alternative bezel-less embodiments **7200**, **7200'** satisfying the European safety and aesthetic requirements. As shown in a multi-piece embodiment **7200**, a carrier plate **7202** has a front surface **7204** rounded with a radius $Rad \geq 2.5$ mm and leveled with the front surface **7108** of the mirror element **7110**. A decorative insert **7212** of the embodiment **7200** is similar to the insert **7102** of the embodiment **7100**, but extends further towards the housing **7014** of the assembly thereby providing for an uninterrupted metallic appearance of the frame in the front view, Fig. 13C. A specific single-piece embodiment **7200'** of Fig. 13B provides for metal-plating, painting, pad-printing or hydrographic decorating **7220** of the front surface of the carrier **7202** to assure the metallic appearance in a front view of Fig. 13C.

[00182] Auxiliary embodiments of a multi-piece frame construction that include a carrier supporting a mirror element from the back and having an optically transparent bulbous peripheral part (which is adjacent at least a portion of an edge surface of the mirror element or even surrounds such portion around its entire perimeter and that is devoid of any extension onto the first surface of the mirror element), have been discussed in U.S. Provisional Patent Application No. 61/392,119, which is incorporated herein by reference.

User Interface.

[00183] As was discussed herein and in Our Prior Applications, various operator interface elements including buttons have been conventionally positioned in a housing or a mounting element that wraps around the edge surface of the mirror system (such as a bezel with a lip extending onto the first surface). To accommodate the interface modalities, the mounting element has to possess sufficient width. For example, a chin of the bezel containing buttons and switches of the user interface typically has to be wider than the remaining portion of the bezel including a lip that extends onto the first surface of the

5 mirror system. Some practical systems, e.g., employ a bezel with a chin portion that may be as wide as 20 mm. Incorporating of the user-interface components into such wide mounting element causes several problems. Firstly, the presence of a mounting element with mirror having a surface of a given size increases the overall width of the rearview assembly by the width of the mounting element, thereby blocking the front view of the road to such a degree that a driver may experience discomfort. Secondly, a
10 risk of misplacing or tilting the rearview assembly when pressing a mechanical user-interface button positioned near the edge of the assembly, in the chin of the mounting element, is increased, which causes the driver to restore the rear field of view by manually re-adjusting the assembly. Understandably, this re-adjustment may be a source of distraction to a driver. In addition, disposing movable parts such as buttons within the mounting element without additional precautions is recognized to increase the level of
15 noise such as rattling or squeaking, which may reduce the driver's comfort on the road.

[00184] The first of the abovementioned problems, related to increasing the effective area of the mirror system perceivable by the user without necessarily increasing the overall size of the rearview assembly, has been already discussed in this application. Solutions proposed herein include the use of a lip-less bezel (or a bezel with reduced width, or no bezel at all) in combination with the use of a
20 peripheral ring the visual appearance of which satisfies the auto-manufacturer's requirements (e.g., substantially matches the appearance of the central portion of the mirror, both in terms of color and irradiance of reflected light; or has a different aesthetics and/or provides a multi-band appearance). Such "reduced bezel approach", however, begs a question of how to re-configure the mirror system in order to not sacrifice any of the interface and/or indicator modalities that have been conventionally housed within
25 the wide portion of the mounting element of the mirror.

[00185] Embodiments of a user interface (UI) of a rearview assembly addressing this question and discussed below can be enabled in combination with any embodiment of the rearview assembly including that employing a prismatic element; or that employing a peripheral ring; and with any configuration of the mounting element (including mounting with a bezel; bezel-less mounting; various
30 embodiments of a carrier, housing, or casing,) discussed elsewhere in this application, in particular with those discussed in reference to Figs. 42-54 and 58, 59 of U.S. 2010/0321758 and Figs. 9-13 and 32-39 of the present application. In particular, references made specifically to EC-elements are made for convenience and illustration purposes only: the scope of invention also includes rearview assemblies employing prismatic elements or plane-parallel mirror elements even if no corresponding drawings are
35 provided.

[00186] According to embodiments discussed below, elements of the UI include various functional elements such as switches, sensors, and other actuators of the rearview assembly that may be operated with no mechanical activation. Such switching elements or sensors are activated by a user input that may include placing a driver's finger in close proximity to the switching element or sensor.
40 Alternatively, the functional element is activated when the user slightly touches on a component including the functional element in question such as, for example, a conductive pad. In response to such user input,

5 the switching element activates, triggers, or switches one of auxiliary devices that are located inside the assembly and that may exchange visual or audio information with the user. For example, an auxiliary device may be a display that forms an image to be observed by the user through the mirror element of the assembly. In another example, an auxiliary device may include a voice activated system that will await for an audio input from the user to perform a required operation.

10 [00187] In addition or alternatively, proposed implementations of the UI facilitate reduction of size or, in specific embodiments, even elimination of a rim-like portion of the mounting element (and, in particular, a bezel that structurally supports the mirror system) conventionally extending around the edge surface of the mirror system of the invention. Embodiments of the user interface of the invention include switches that are labeled, for identification purposes only, as an optical switch, a capacitive on-
15 glass switch, a capacitive through-glass switch, a capacitive in-glass switch, a capacitive glass-edge switch, a capacitive through-bezel switch, a capacitive conductive bezel switch, a conventional capacitive or a resistive touch-screen-based switch, or a waveguide-based sensor. The terms "switch" and "sensor" in the context of UI embodiments discussed herein are used interchangeably. According to the embodiments discussed below, either positioning the user's finger in proximity of a sensor or a switch of
20 an embodiment or a gentle touch on a sensing pad located adjacent to the surface of the mirror system induces the rearview assembly to activate a required function such as, e.g., illumination of a portion of a display, or dimming or clearing of an electro-optic element of the assembly. Because the operation of the user-interface embodiments of the invention may include touching an area of the first surface of the mirror element, this surface may be appropriately treated with a finger-print dissipating (smudge-
25 resistant)coating such as the Opacity film provided by Uni-Pixel Inc. (Clear View™). If an input area is configured outside of the primary reflective area of the mirror, a matte finish and/or surface treatment resulting in textured surface may be used to resist fingerprints. For example, a portion of the peripheral area of the first glass surface corresponding to a peripheral ring of the mirror may be roughened (via laser ablation, for example) to produce a region that lacks specular reflective characteristics and reflect incident
30 light in a diffusive fashion and has hazy appearance. Due to the surface structure, the visibility of a fingerprint left by the user on such surface will be reduced as compared to a glass surface characterized by specular reflection.

[00188] In describing embodiments of a non-mechanically activated UI of the invention, references are made to a legend, or indicia, corresponding to a particular sensor, or a switch, or an
35 actuator. In this context, a legend refers to a physical marking or an indication, disposed on one of the surfaces of an embodiment in such a fashion as to be perceived to correspond to a given sensor that provides identification of the given sensor and its function to the user activating this sensor. Generally, a legend or its equivalents may be configured in an opaque, transfective or translucent layer deposited on or inserted into a surface (by, e.g., masking out a portion of the layer during deposition or by pre-molding
40 an inlay that is further implanted into a component) to form a required graphical or textual identifier that is appropriately made visible to the user, from the front of the assembly. For example, as will be

discussed below, a legend may be configured in an overlay patch disposed on a first surface of the mirror system or on a mounting element; in a thin-film stack of either the second or third surfaces of the mirror system; or in a surface of the mounting element that is visually accessible by the user from the front of the assembly. According to present embodiments, the most common way of causing a legend to be visible is to highlight the legend with a source of light located behind the legend with respect to the user. It is understood that even when only a particular implementation of a legend is referred to in a description of an embodiment, other appropriate implementations are considered to be within the scope of the invention and are implied.

[00189] *Optical-switch-based embodiments* of the user interface may include at least one of a line-of-sight sensor (interrupter) and a reflective sensor. Figs. 14(A-C), e.g., illustrates an optical interrupter that is employed in an interface of an embodiment **7300** of the rearview assembly and that includes an IR photodiode and an LED pair (although multiple pairs may be present, corresponding to multiple interrupters). As shown, an emitter **7302** and a receiver (detector) **7304** form a line-of-sight sensor and are respectively disposed in opposing (as shown, top and bottom) portions of a mounting element **7310** that surrounds an edge surface **7312** of a mirror element **7314** and slightly protrudes over a first surface **7314a** toward an outside portion of the rearview assembly. In one embodiment, the mounting element **7310** may be either a bezel or a carrier of the mirror system supporting the system in the assembly. When the user interrupts an optical connection established between the emitter and detector and shown with an arrow (optical path) **7320** in Fig. 14B by placing a finger across this optical path, the detector is caused to lose the reception of optical signal, which in turn triggers the sensor's response to this user input. To increase a signal-to-noise ratio of the embodiment and to reduce or reject signal interference from ambient lighting, the operation of the emitter **7302** may be modulated at a high frequency allowing the detector **7304** to be AC-coupled.

[00190] A rearview assembly function to be initiated by the user input through activation of the line-of-sight sensor **7302**, **7304** may be indicated with a use of a graphic- or text-based legend **7322** associated with a display of the rearview assembly and located, e.g., within the boundaries of the mounting element **7310** on the first surface **7314a** of the mirror element **7314**. (It is appreciated that, in a related embodiment, when the rearview assembly contains transfective coatings such legend may be appropriately formatted in a coating disposed on either a second or a third surface, e.g., by judiciously masking a legend portion of the coating during the deposition process). In a specific embodiment, the legend **7322** may be made visible by backlighting when required. Backlighting of the legend may be provided by a simple LED, optionally with appropriate masking, or with the use of an illuminated LCD or an OLED-display from behind the element **7314**. Alternatively, the legend may be incorporated in the assembly as a permanently visible graphic.

[00191] In one embodiment, the optical communication **7320** between the emitter and detector of a line-of-sight sensor of the embodiment **7300** is established through optical windows (not shown) covering the emitter and detector. Such windows may be fabricated from IR-grade transparent or

translucent plastics that in the visible portion of the spectrum are perceived as being almost black and, therefore, may be color-matched with the dark mounting element **7310** to disguise the sensor areas. In a specific embodiment, the emitter/detector pair(s) may also be mounted in the mounting element in such a way as to provide a small gap near the glass that is covered in front by IR-light-transmitting plastic. Alternatively, as shown in Fig. 14C, the detector **7304'** may be disposed in the back of the mirror system **7314** and light pipes **7326** may be configured to deliver IR-light **7320** to the detector **7304'**. Similarly, in a related embodiment (not shown), the emitter **7302** may be disposed in the back of the mirror system, delivering light towards the front of the mirror system via another light pipe. Optionally, the hard edge of the mounting element **7310** may be rounded, preferably with a radius *Rad* of at least 2.5 mm, as illustrated in Fig. 14C and discussed in reference to Figs. 11-13.

[00192] Although only a single emitter/detector pair is shown in Fig. 14A, generally a plurality of such pairs may be employed. To this end, Fig. 15 schematically illustrates a specific embodiment including 3 line-of-sight sensors (3 pairs of emitters/detectors (**E1, D1**), (**E2, D2**), and (**E3, D3**)). In such a multi-sensor case, a process of identification of which line-of-sight among those connecting the emitters and the detector is interrupted by the user may be facilitated by operating the emitters **E1, E2, and E3** in an alternating fashion. In one embodiment, the emitters are turned "on" one at a time. Once a given emitter is switched "on", all receivers are tested for signal. Based on which light path is blocked by the user's finger, six operational modes can be identified, as shown in Table 3 corresponding to the embodiment of Fig. 15. These modes allow the electronic circuitry of the rearview assembly system to decide which light-path connecting which pair of the emitter/detector has been blocked by a user (based on, e.g., a look-up table) and, consequently, to activate a corresponding function of the rearview assembly:

| Emitter/Detector (0=blocked, 1=signal) | | | | | | | | | Zone |
|--|-------|-------|-------|-------|-------|-------|-------|-------|------|
| E1/D1 | E1/D2 | E1/D3 | E2/D1 | E2/D2 | E2/D3 | E3/D1 | E3/D2 | E3/D3 | |
| 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 2 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 3 |
| 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 4 |
| 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 5 |
| 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 6 |

Table 3.

An indicia or legend employed with this embodiment may be dynamic and configured to be perceived as located on a surface of the mirror element. For example, a legend may be formatted as an options menu that is not highlighted from behind (not visible to the user) during normal operation of the rearview assembly. However, activation of a UI by any user input triggers highlighting of the indicia. The

5 highlighting of the indicia may also be enabled automatically at vehicle ignition on. In various embodiments, the indicia is configured with a bitmapped display, or with a segmented displays or with masked backlit regions. Additionally, information contained in the legend may also be expressed through brightness of a legend-highlight or color (e.g., green or bright to indicate that a function is enabled and red or dim to indicate that a function is disabled).

10 [00193] An embodiment of user interface of the invention employing optical reflective sensors operating in, e.g., IR-light is schematically shown in Fig. 76. As shown, the emitters and detectors of the "reflective" embodiments are disposed on the same side of the mirror element, side-by-side. A group 7510 of emitters disposed in the mounting element 7310 of the assembly, while a group of detectors is positioned at a back portion of the mirror element 7314 so as to be aligned with eye-hole openings 7512.

15 The sensor system of either embodiment is then triggered when light emitted by an emitter reflects from the user's finger and is detected by a detector of the group through an eye-hole opening. The use of a visible-light reflective sensor instead of the IR-light-based sensor may provide an additional advantage of illuminating an area of interest for the user. In such an embodiment, operation of the emitter may also be modulated at a high frequency to increase a signal-to-noise ratio and reject interference due to ambient

20 light. To minimize direct coupling of light from the emitter to the detector in the absence of the triggering action by the user, an appropriate optical blocking barrier (not shown) may be disposed between the emitter and the detector. A legend (not shown) can be combined with an optical opening (e.g., overlaid upon it or be formed in one of the thin-film coatings that are internal to the EC-cell, as discussed above) to convey the information about the purpose of a switch to the user.

25 [00194] Fig. 17 illustrates an alternative embodiment 7600 operating in a reflective mode that, in addition to detecting the user input, is capable of providing positional information in a touch-type sensor application with the use in a vehicular rearview assembly. As shown, a pair of IR emitters E1, E2 is used in conjunction with a single receiver D disposed between the emitters. It is understood that lines-of-sight corresponding to the optical devices E1, E2, and D are directed along the first surface 7314a of the mirror

30 element 7314. In operation, the emitters are alternately enabled, and the user establishes optical connections between the emitters and a detector by placing a finger ("reflector") in a proximity of the detectors thereby reflecting portions of light, emanating from each of the emitters, towards the detector. Resulting optical signals are measured by the photodiode D. The ratio of the signals associated with the emitters provides the system with positional information about a location of the "reflector" (i.e., left or

35 right with respect to the detector D). The sum of the two signals provides vertical position information. As a result, a rearview assembly employing the embodiment 7600 is capable of sensing and spatially resolving multiple positions, across the surface of the mirror element, at which the user communicates with the user interface of the assembly. At these positions, virtual "touching pads" of a touch-screen sensor or switch may be deployed. A legend for such a sensor can be provided in a fashion similar to that

40 described in reference to Fig. 15. In a specific embodiment, a touch-sensor system such as that provided by the QuickSense product line of the Silicon Labs (Austin, TX; www.siliconlabs.com) can be used.

5 Because the described system can resolve both X and Y positional information, multiple user-interface options are enabled. In one embodiment, virtual touch pads are configured with the use of a programmable LCD or OLED-display located behind the mirror element. Pressing these virtual touch pads causes the activation of corresponding functions. The X/Y position information can also be used to control a cursor, similar to that of a personal computer. Tapping or pressing various regions of the display would act like a mouse click on a computer. Dragging a finger across the display surface can also act like a 'drag' function, and is useful for actions such as scrolling a map in a navigation display, or to switch between menu pages.

[00195] *Capacitive sensors* that detect finger pressure applied to a particular sensing pad are generally known. Various capacitive sensors are available from the Silicon Labs, TouchSensor (Wheaton, IL; www.touchsensor.com), AlSentis (Holland, MI; www.alsentis.com), and Microchip (Chandler, AZ; www.microchip.com). Some of capacitive sensors operate on the basis of a field effect and are structured to include a conductive sensor area surrounded with a conducting ring. Capacitive coupling between these two conductors is increased when the user places his finger in close proximity.

[00196] According to an alternative embodiment of the present invention, a capacitive sensor of the user interface of the rearview assembly is configured in an "on-glass" fashion and has a sensing area, on the first surface of the mirror element, that is in electrical communication with an electronic circuit board disposed at the back of the assembly. (If multiple sensing areas are present, these areas are electrically isolated from each other). As shown in a cross-sectional view of in Figs. 18(A, B), a layer of electrically-conductive material **7702** forming a front sensing area (or front sensing pad) is disposed on the first surface **7314a** of the mirror element **7314**. The front conductive pad **7702** is electrically extended through a connector **7708** to the back of the mirror element. In one embodiment, Fig. 18A, such electrical extension assures a direct electrical connection with control electronics on a PCB **7706**, in which case the connector **7708** may be a pin. An alternative embodiment shown in Fig. 18B employs an electrically-conductive bridge **7710**, fabricated of metal or carbon-loaded ink, between the front conductive pad **7702** and a back conductive pad **7712** positioned at the back of the mirror element **7314** (on the fourth surface of the mirror element or on a different element in the back of the mirror). The back contact area **7712** can then be further connected to the PCB **7706** by a spring contact or other well-known contacting means **7716**. In a specific embodiment, a conductive elastomer may be used instead of the spring contact. It has been unexpectedly discovered that configuring the back conductive pad **7712** to have a smaller lateral extent than that of the front conductive pad **7702** facilitates the increase of signal-to-noise ratio of operating sensor by reducing offset capacitance to the ground of the system. Therefore, in a preferred embodiment the back conductive pad has a smaller lateral extent as compared to the front conductive pad.

[00197] An alternative version of the front-to-back electrical connection of a capacitive sensor may use a conductive adhesive tape or a flex circuit leading from the first surface to the controlling PCB. The top surface of the flex circuit could also include the indicia, finger print resistant coatings, a metallic

5 or reflective cosmetic layer, and an insulating layer (such as a non-conductive layer **7704**) reducing a static spark during the operation of the embodiment and increasing the electrostatic discharge (ESD) tolerance of the system.

[00198] Suitable top conductive areas or pads may be produced by metallic coatings manufactured with electroplating, vacuum deposition, or adhesive-based conductors, metallic or carbon based conductive inks. The electrically-conductive coatings may employ copper nickel, stainless steel, or transparent coatings such as ITO. Non-transparent coatings can be patterned in a way such as to allow light form a backlight to pass through and illuminate the top cosmetic overlay **7704** or a legend (not shown) that may include information indicia for the convenience of the user. In the alternative, the conductive pad **7702** itself may be patterned and used as a legend for the corresponding switch. If desired, conductors such as carbon ink can be used as an underlayment color for a legend on the first surface of the mirror element. It is appreciated that the hard edge of the mounting element (if present) may be rounded, preferably with a radius *Rad* of at least 2.5 mm, as discussed in reference to Figs. 11-13. Alternatively, if embodiments of Figs. 18(A,B) are configured to be bezel-less, the front glass component may be appropriately rounded in a fashion similar to that discussed in reference to Fig. 9.

[00199] Embodiments of capacitive and field effect-based sensors for use with embodiments of rearview assembly of the invention can also be configured in a "through-the-glass" fashion. This requires that the sensor area be not shielded by a conductive layer, or at least that any present conductive shielding layer is small and electrically isolated from other parts of the circuit. Several alternative configurations of the invention employing a through-the-glass capacitive or field-effect based sensor **7802** are shown in Figs. 19(A-C). Fig. 19A demonstrates an embodiment in which the two substrates of an EC-element **7804** are not transversely offset with respect to one another, while Fig. 19B shows an embodiment with a transverse offset between the substrates of the EC-element. Various mounting elements and housing, electrical connectors, auxiliary thin-film coatings are not shown in Figs. 19(A-C) for simplicity of illustrations.

[00200] As shown in Figs. 19A and 19B, both a seal **7806** and electrically-conductive coatings **7808** of the EC-element **7804** are placed far enough inboard of the EC-element with respect to a seal **7806** to keep the EC-medium from shielding the front and back sensor pads **7702**, **7802** and/or providing electrical interference with its operation. (Optionally, the transfective conductive coatings of the EC-element may have external portions **7808'** as shown in a dashed line in Fig. 19A. A PCB or flex circuit is located at the back side of the element. The front sensing pad **7702** may have an insulating overlay and a legend (not shown) carried thereon, and the circuitry may optionally contain LEDs to illuminate a touch pad area (corresponding to the overlay **7704**) employed by the user to activate the sensor.

[00201] In comparison with Figs. 19A and 19B, where the seal **7806** is configured to be narrow and transversely offset with respect to the sensor pads, the embodiment of Fig. 19C illustrates a situation where the seal **7806'** is configured to be wide and placed in the area of the sensor (between the front and back conductive pads **7702**, **7802**). This embodiment may require a use of wide peripheral ring

5 configured to extend over the seal **7806'**. Here, the seal is made of material that is transparent or at least translucent at the wavelengths of light used to backlight the indicia/legend on the front of the mirror element through the mirror element. In addition, the seal material can also be adapted to optically diffuse light to provide for optically diffusive appearance of the first surface indicia. "Through-the-glass" sensing embodiments of user interface for use with rearview assembly additionally improve the ESD protection of the sensor electronics. It is appreciated that the hard edge of the mounting element (not shown) may be rounded, preferably with a radius *Rad* of at least 2.5 mm, as discussed in reference to Figs. 11-13. Alternatively, if embodiments of Figs. 19(A,B) are configured to be bezel-less, the front glass component may be appropriately rounded in a fashion similar to that discussed in reference to Fig. 9.

[00202] In embodiments of the user interface of the present invention that utilize *capacitive "in-glass"* based sensors, the electrically conductive layers and connectors positioned internally with respect to the EC-element are configured to serve as sensor areas. In one embodiment, schematically shown in Figs. 20(A, B), a transparent electrode **7912** of the EC-element **7910** (located, as discussed, on the second surface **7910b** of the element) is configured to have electrically independent portions **7912a**, **7912b**, where the portion **7912a** forms a sensing area. The reflective electrode **7914** of the third surface of the EC-element is preferably isolated into portions **7914a** and **7914b**, where the outer portion **7914a** corresponds to the sensor area **7819** and is optional (as indicated by a dashed line). When the two portions **7914a**, **7914b** are electrically connected and form a single electrically-conductive coating (not shown), it is preferred to keep the reflective electrode at or near a ground potential. As shown, the seal **7916** is appropriately positioned in-board with respect to the sensor area **7918** to prevent electrical interaction between the sensor area and the electrochromic gel (not shown). In a related embodiment (not shown), where the sealing material may be extended into the sensing area **7918**, the seal **7916** is configured to be translucent (either clear or optically diffusing) to allow for backlighting of a legend (not shown) corresponding to the sensor. (As in any of the user interface embodiments discussed in this application, a legend may be located on the first surface of the embodiment or, alternatively, in a non-transparent inner layer of the EC-element, or may be backlit by masking or programmable display.) Fig. 20B illustrates a front view of the embodiment of Fig. 20A, where the reflective electrode **7914** includes two portions - the outer portion **7914a** corresponding to the sensor area **7918** and the inner portion **7914b** corresponding to the central area of the mirror system of the rearview assembly. The portions **7914a** and **7914b** are then electrically isolated from one another with an isolation trench or area **620c** created in the reflective electrode as discussed elsewhere herein. Fig. 20B schematically illustrates, in top view, one possible way to dispose the seal **7916** around the electrical connector **7920** submerged in epoxy **7922**. In one embodiment, the epoxy may be non-conductive. Although neither a mounting element nor auxiliary electrical connectors have been shown in Figs. 20(A, B), it is appreciated that, in a specific embodiment, the mounting element including a bezel may be present. In this case, the hard edge of such mounting element is preferably rounded with a radius *Rad* of at least 2.5 mm, as illustrated in Fig. 14C and discussed in reference to Figs. 11-13. Alternatively, if embodiments of Figs. 19(A,B) are configured to

5 be bezel-less, the edge of glass component may be appropriately rounded in a fashion similar to that discussed in reference to Fig. 8.

[00203] In a *capacitive glass-edge* embodiment of the user interface (not shown), spatially isolated electrically-conductive connectors such as metallic tabs or conductive coatings are added to the edge of the glass or on the inner surface of the mounting element. In a specific embodiment, such a
 10 connector may extend inboard with respect to the edge surface of the EC-element. The conductive epoxy currently being used may be segmented, and separate segments are then electrically contacted to the PCB.

[00204] A *capacitive through-bezel* type of interface sensor embodiment, schematically shown in Figs. 20(C, D), a flex circuit or an electrical conductor **7930** is placed behind and underneath the mounting element **7932** having a front lip **7934** extending onto the first surface **7314a** of the mirror EC-
 15 element **7314** and, preferably, having a rounded profile with a radius of at least 2.5 mm. The embodiment of the sensor or switch is activated when the user touches a front pad **7940** configured on a front surface of the mounting element **7932** to carry a legend or indicia. In another embodiment, where several front pads **7940** are present that are made electrically conductive, these pads separated by corresponding non-conductive areas **7942**. (If front pads are made electrically conductive by appropriate deposition of an
 20 electrically conductive film or by use of an electrically-conductive insert as described elsewhere herein, the separating areas **7942** are made non-conductive.) The flex circuit **7930** may have several extensions behind the lip **7934**, with each extension positioned to correspond to a different front pad. Alternatively, several individual flex circuits could be used for each of the sensors corresponding to each of the front pads **7940**. Flex circuit may optionally contain the sensing electronics and LEDs. A leaf-spring contact
 25 **7946** to the main board **7948** could be used instead of a wire to establish a required electrical connection. It is appreciated that a sensor legend (not shown) may be disposed on a surface of the front lip **7914** visible to the viewer **115**, and the mounting element may be made of translucent material, in which case the legend is highlighted, e.g., by light channeled by the mounting element from a light source (such as LED, not shown) at the back of the system. In a related embodiment, the element **7930** may be a simple
 30 contacting electrically-conductive layer such as a foil, a mesh, or a thin-film layer establishing the electrical communication with the main board at the back of the system. A related alternative embodiment is schematically illustrated in Fig. 20E, where an electrical conductor **7950** is disposed on the inner surface of a lip-less mounting element **7932'** substantially surrounding the edge surface **7312** and partially extends to a front, outer surface **7952** of the mounting element. A second electrical
 35 conductor **7954** such as a leaf-spring is adapted to provide electrical connection between a conductive pad (not shown) of a main board **7948** and the front surface **7952** of the mounting element **7932'**. In this embodiment, a front pad **7940'** carrying a legend may be configured on either both the front surface **7952** of the mounting element and a peripheral portion of the first surface **7314a** of the mirror element **7314** as shown, or, alternatively, only on the front surface **7952** of the mounting element.

40 [00205] Another alternative embodiment of a component of a user-interface sensor (such as a capacitive sensor or a field sensor) of the invention operating as a switch for an auxiliary device located

5 inside the assembly is shown in cross-sectional and front views in Figs. 20F and 20G, where a plastic cap **7955**, providing a tray-like covering for a peripheral portion of the mirror element **7314**, is used to configure the component in issue. An inner surface of the removable cap **7955**, which is appropriately sized to assure a close fitting around the edge surface **7312** of the mirror element **7314** and is appropriately shaped to sufficiently extend onto and both the first surface **7314a** and over the back **7955a**
10 of the mirror element, is overlayed with an electrically-conductive covering **7955b** forming a thin-film layer, a foil, or a mesh. In one embodiment, the inner surface of the cap **7955** is in physical contact with both the first surface **7314a** and the back of the mirror element. A front portion **7956** of the covering **7955b** corresponding to a front portion of the rearview assembly acts as a front electrically-conductive pad of a sensing element. A portion of the covering **7955b** that wraps around the edge surface **7312** to
15 extend onto the back **7955a** of the mirror element establishes an electrical contact between the electrically-conductive portion **7956** and a back conductive pad **7958** (such as a thin-film layer) disposed at the back of the mirror element. The cap **7955** may be configured from a plate of translucent plastic-based material bent so as to fit around the mirror element of the rearview assembly and to allow for light channeling, within the thickness of the cap, from a light source **7960** in the back of the assembly towards
20 an indicia / legend carried on an outer surface **7962** of the cap. The legend (not shown) may be disposed within the surface **7962** (by imprinting, for example) or in a legend-layer **7964** carried on the surface **7962** so as to overlap with the pad **7956**, when viewed from the first surface **7314a**. It is appreciated that a front portion of the cap that extends over the first surface **7314a** provides the embodiment with a reliable ESD protection due to a finite thickness of the cap, which may be anywhere from several
25 hundreds of microns to a few millimeters. In an embodiment having several sensors, the electrically-conductive covering is adapted to include several sub-coverings electrically insulated from one another, along the inner surface of the cap **7950**, with non-conducting areas **7966**. In operation, the cap **7955** is removably put on over the edge surface of the mirror element.

[00206] In a "capacitive conductive bezel" type interface, an embodiment of which is
30 schematically shown in Figs. 21A and 21B, a plastic mounting element **8002** (such as a carrier extending around an edge surface of the mirror element **7314**) having metallic coating, deposited on a portion of the outer surface of the mounting element **8002** and shown with a dashed line **8002'**, is spatially segmented with electrically-isolated areas **8006** thereby forming electrically conducting pad areas **8004** that the user will touch to activate a corresponding switch. The mounting element **8002** may also be used as a
35 combination element/PCB holder. The isolation pattern **8006** may be defined by laser treatment, CNC, etching, or masking during deposition of the pattern to separate pads corresponding to different switches so as to provide for independent electrical communication between each of the front pad areas **8004** and a corresponding conductive pad (shown as **8008**) on the back of the mirror system. A rear electrical pad area **8008** can be further electrically connected to a PCB **8010** through a spring or an elastomeric contact
40 **8012**. For the convenience of the user, a legend or other graphics (not shown) identifying a particular pad and a corresponding switch can be incorporated by inscription into the metallic coating **8002'** in the area

5 **8004**. In this case, to facilitate backlighting of the legend by an optional light source **8014** such as an LED disposed in the back of the mirror system, the element **8002** may be made of transparent or translucent material. Coupling of light from the source **8014** to the translucent mounting element **8002** can be configured directly or with the use of an auxiliary optical component (not shown), and the mounting element will channel the coupled light towards the indicia at area **8004**. Alternatively,
10 indicative graphics/legends can be placed on the first surface (or formed in thin-film layers located within the EC-element) adjacent to corresponding switch areas **8004**, or backlit by LCD or masked LED graphics. In addition, the conductive coating **8002'** may be overcoated with a clear insulating coating layer to protect the finish, or may alternatively be painted to color-match the vehicle interior or some other components, as instructed by the auto-manufacturer. In a specific embodiment the front conducting
15 areas **8004** of the mounting element **8002**, a portion of which is shown in Fig. 21C, can be configured as separate inlays **8010** that are inserted within the mounting element **8002** in a fashion similar to that described in reference to Figs. 11-13.

[00207] In addition or alternatively, various already existing and commercially used (e.g., in cell phones, PDAs, navigation systems) capacitive or resistive touch screen systems may be used as part of a
20 user interface in a rearview assembly of the invention.

[00208] Various modifications of the embodiments are contemplated within the scope of the invention so as to optimize the performance of the user interface. For example, in any of the embodiments of a mirror system that includes legend/graphics on the first surface and a mounting element having a lip extending onto the first surface, the mounting element may be raised slightly above the glass
25 surface so as to reduce or prevent the wearing off of the graphics during handling (such as during loading into a shipping box and rattling or vibrating in the box during shipment). For the same reason, if a legend is placed onto a lip of a mounting element, the legend may be recessed slightly into the surface of the lip. In a different example, with any of the embodiments that use capacitive or field effect sensors, an additional optical emitter/detector pair may be used to detect that the user's finger is approaching an
30 interface. Such additional optical sensing pair can act as a 'gate' for the computer program product that enables the capacitive or field effect sensors, thereby increasing the sensitivity of the embodiment by rejecting spurious electrical noise events that may occur during the time intervals when the user is not using the interface. Increase in sensitivity of detection in this way may facilitate the use of the user interface by a driver wearing gloves, where otherwise the gloves reduce the electrical effect that a finger
35 would have on the sensor. In another embodiment, an electronic circuitry of the rearview assembly may be configured to utilize the increased sensitivity of a sensor in such a fashion as to provide for a time-period, after the sensor of the interface has been activated, during which the legend/indicia of the sensor remains lit and visible. In a related embodiment, the legend may be kept lit dimly (to minimize visual distraction of the driver), but be illuminated more intensely when the driver's hand is sensed to be
40 reaching for the legend.

5 **[00209]** In one embodiment of the invention, an area of the first surface corresponding to a virtual button of a switch (whether an optical switch or a capacitive switch) of the UI of the embodiment is appropriately adapted to enhance tactility associated with the virtual button and to facilitate a touch-based identification of the button's location. In particular, a region of the first surface within a boundary corresponding to a virtual button is structured to include a textured patch or a surface relief that can be easily identified by touch on the background of the smooth surface of glass surrounding the area of the textured patch or surface relief. In a simple case, a region of the first surface corresponding to the switch button can be simply roughened / ground (and, optionally, coated with a colored layer), or textured with abrasive blasting or laser ablation. A textured/roughened/ground area of glass corresponding to a virtual button of a switch positioned in a peripheral ring area of the mirror element (especially when the thin-film coatings of the peripheral ring include metallic layers) facilitates, on one hand, the reduction of glare experienced at night in reflection of the peripheral portion of the mirror element of the rearview assembly and, on the other hand, conceals electrical contact associated with the button. In another example, such a region can be carved out (or ground out, for example) to form a recess or indentation in the glass surface that facilitates a palpable sensation of presence of the button area. A boundary of the carved-out area may be generally chosen to be of any desired shape (such as circular, oval, rectangular, and the like). The indented / recessed surface of the relief area can be either ground, roughened or smooth. A like recess area can also be formed on a second surface of the front substrate in an embodiment where the legend of the switch button is positioned behind the second surface. In this case it may be preferred to assure that the recessed surface is smoothed or even polished: An effective lens defined by the portions of the flat first surface and the recessed (curved) second surface associated with the button area will facilitate the visual perception of the button indicia/legend located behind the curved second surface.

[00210] While direct electrical connections have been discussed in reference to Figs. 18-21, such direct connections are not always required. A flexible conductor insulated on both sides can wrap from the front surface to the back (similar to the on-glass solutions above). Having both sides insulated allows a protective cosmetic layer on the visible surface, but also allows the back side of the conductor to avoid short circuits to the exposed conductors at the edge of the element. A larger area spring contact to the electronics can compensate for an indirect connection, as this will form a capacitive coupling to the sensor.

[00211] In all optical or capacitive sensor based systems it is preferred to have a direct feedback that the sensor has been activated. Appropriate feedback can be provided for the user using optical, audible, or haptic mechanisms. An optical feedback mechanism may include a change of brightness or color of back-lit indicator(s) associated with the activated sensing area of the user interface. An audible feedback mechanism may employ a speaker or a piezoelectric device as part of the rearview assembly, or a direct connection or a network connection to an audio device already present in the vehicle. A haptic feedback mechanism can mechanically indicate (by, e.g., initiating a slight vibration of the mirror using offset weight electric motors or an electromagnetic actuator) to the user that a given function

5 / device has been activated. For example, a sensation of "friction" (tactile feedback through electrovibration, haptic response) can be created in an finger placed in a proximity of the surface, to simulate a perception "touching" the surface via electrical pulses sent to the conductive material of a switch pad. In one exemplary embodiment, the conductive pad of a switch located on the first surface is coated with an insulating material. By applying periodic voltage to the conductive pad from a specific control circuit via appropriately adapted electrical connectors, an effective electrical charge is induced in a finger proximal to the conductive pad. By changing the amplitude and/or the frequency of the applied voltage, the surface of the insulating cover of the switch pad can be made, without creating a mechanical vibration, to feel as though it is bumpy, sticky, rough, or vibrating. It is appreciated that in a related embodiment the control circuit can be adapted to supply different driving set of voltage signals to different switch pads to generate different sensations that respectively correspond to switches of different rearview assembly functions that the user can trigger.

[00212] In an embodiment employing a user interface of the invention in conjunction with a mirror element having a rounded edge (such as embodiments of Figs. 9, 10), the first surface overlay of the user interface may be wrapped around the rounded edge of the mirror element to create a continuous surface appearance. This may be done with pad printing, or adhesive overlay. Electrical isolation among the sensing areas of the embodiment discussed in reference to Figs. 14-21 should be equivalent to a resistive separation of at least 10 kOhms, and, preferably, 100 kOhms or greater. Levels of ESD, measured according to industry standards, should be on the order of at least several keV, for example 4 keV, preferably 15 keV, more preferably 20 keV.

[00213] It will be appreciated that in another alternative embodiment a sensing/switching element of the user interface of the rearview assembly may be configured with the use of waveguide optics. In particular, the first surface of the mirror element may be appropriately overcoated with a slab waveguide layer **8102**, as shown schematically in Fig. 22, guiding the light coupled from a light source **8104** through a coupling means **8106**. The coupling means **8106** may be configured as any appropriate coupling means used in waveguide optics (a diffractive element, for example). When an external object **8110** such as a user's finger makes optical contact with the surface of the waveguide layer **8102**, the waveguiding is frustrated and light leaks from the waveguide thereby scattering around the point of contact. The scattered light is further detected by an optical detector **8112** (an optical diode, CMOS or other sensor). While light in different spectral regions can be generally used for the purposes of the user interface in a rearview assembly of the invention, a narrow band light source **8104** preferred to reduce potential interference with ambient light and increase signal-to-noise ratio of the operating embodiment. Other techniques, such as pulsing of the light source to differentiate a touch response from ambient light levels through comparison of source on, to source off detected light levels can be used to actively correct for background and/or stray light and prevent false responses.

[00214] Yet another alternative implementation (not shown) a sensing/switching element may employ an acoustic wave source in optional cooperation with an information display, as part of the

5 rearview assembly. In this *acoustic-sensor* implementation, a display is positioned outside of the EC-cell of the mirror element of the assembly and behind a glass substrate (as viewed from the front of the assembly). Acoustic waves are transmitted from the acoustic wave source across the surface of the glass substrate (or through the glass substrate itself), and are absorbed by a finger of the user placed in proximity to the glass surface. An electronic controller that drives the acoustic wave source is configured to determine coordinates of the "touch" across the display by registering a change in the wave frequency at the touch location. Advantages of this embodiment include unsusceptibility of the performance of the switch to scratches and other damage of the surfaces of the embodiment.

10 [00215] Another embodiment of the switching element may use *force sensing* technology, where pressure from touching the surface of the information display is registered by strain sensors mounted at corners of a rigid piece of glass. The different strain levels recorded by the sensors are used to determine touch location. By identifying (with indicia) different virtual switch buttons at different locations across the front surface, the force-sensing switch can, therefore, be implemented with an embodiment of the rearview assembly of the invention.

15 [00216] An embodiment of a *resistive switch* may also be used with an embodiment of the invention. The resistive touch screen includes a transparent, flexible membrane layer and a transparent static layer. The flexible layer may contain polyester with a conductive coating, while the static layer can be made of rigid polyester or other rigid transparent material. When pressed (for example, with a user's finger), the conductive coating effectuates ohmic contact with a conductive coating on the static layer. Adhesives that keep the layers aligned and in close proximity to one another are located on the periphery of the transparent area. However, small insulator elements are interdispersed between the layers across the display area to control actuation force and prevent the layers from making contact when the screen is not being touched. It is appreciated that a top layer of this structure is a continuous film, which simplifies sealing of the structure against harsh environmental conditions.

20 [00217] In fabrication of the above-discussed embodiments of the user interface, a conductive capacitive or resistive switch pattern can be fabricated on or in a pattern-carrier (that may be a mounting element such as the element 7310 of Fig. 14, for example, or the surface of the mirror element) as follows:

25 [00218] - The pattern carrier can be coated with a metal or conductive metal oxide, sulfide, carbide or nitride by vacuum evaporation, sputtering or other PVD processes. The pattern carrier can be plated with metal. Metal containing or metalorganic inks can be applied to the pattern carrier. A conductive polymer such as polyaniline can be used to form the conductive pattern on or in the pattern carrier. Other techniques for applying and patterning conductive materials on substrates (such as those as described in U.S. Patent Application Publication U.S. 2007/0201 122 A1 that is incorporated herein by reference in its entirety) may also be applied. Conductive coatings can be applied in a pattern or patterned or segmented in a secondary operation using a laser, chemical etch, water jet, sand blasting or mechanical cutting, milling or scoring.

5 [00219] - Conductive metal or conductive plastic inserts can be molded or fashioned and then incorporated into the molded mounting element during the injection molding process or placed or pressed into or onto the mounting element after the molding process. A two-step injection molding process could be used with a first step involving molding of conductive portions of the mounting element from electrically-conductive plastic and another step involving molding non-conductive portions of the bezel using a non-conductive plastic. A contact point that engages the switch could also be a plastic or metal form or tape that contains the switch conductor or pattern that is adhered to the mounting element or a surface of the mirror element, preferably in a periphery of the mirror substrate.

10 [00220] - A thin metal film, or metal tape, or conductive resin could be affixed to the inside or outside surface of the mounting element or the first surface of the mirror element to form the switch contact point. Segmented conductive switch patterns could be formatted on such a film or tape prior to adhering it to the pattern carrier.

15 [00221] - A conductive paint such as a graphite, carbon nanotube, or carbon black filled resin, or a resin that is filled with a transparent or translucent conductive metal oxide particle (antimony doped tin oxide, aluminum doped zinc oxide, tin doped Indium oxide, indium oxide, zinc oxide or indium zinc oxide, for example) can be used for form conductive switch patterns on the surface of the pattern carrier. An opaque film such as a carbon-loaded paint can be applied over a translucent or transparent substrate and patterned to create an icon that could be backlit by light illuminating such a substrate. The opaque paint or film could be conductive, or, alternatively, the substrate could be coated with a transparent conductive material such as a TCO (transparent conductive oxide), a thin conductive polymer such as polyaniline. In a specific embodiment, the substrate could be filled with transparent conductive particles such as indium oxide, indium tin oxide, zinc oxide, tin oxide, or low concentration levels of carbon nanotubes or metal fibers or transparent particles or fibers coated with a transparent conductive material such as antimony doped tin oxide or indium tin oxide.

20 [00222] - In embodiment employing a capacitive type switch, it is desirable to protect the conductor and electronic circuitry from static discharge. Such protection is provided by overcoating the conductor with an insulating layer of plastic, ceramic, paint or lacquer or recessing the conductor in such a way as to avoid contact with potential static generating items (like the human hand or finger).

25 [00223] It is understood that at least one of the transparent and reflective electrodes of surfaces **II** and **III**, respectively, could be segmented or patterned with an icon/legend in an area corresponding to the area of the conductive switch or sensor. A peripheral ring could also be segmented and if desired patterned with an icon with or with out a backlight into a conductive switch contact area.

30 [00224] The icon and/or switch circuitry and/or backlight illuminator can be entirely contained in and/or behind the mirror element, in and/or behind the bezel element or a combination of the bezel and mirror area. A flush bezel could extend a minimum of **2.5** mm around the perimeter of the mirror and still meet European minimum edge radius requirements. A typical perimeter ring is about **5** mm wide. Unless the ring or the bezel is made wider in the switch area, which may be aesthetically undesirable, a

2.5 mm or 5 mm switch/icon area may not be easily discernable by the driver and a 2.5 mm or 5 mm touch landing pad area may be difficult to accurately locate and touch. Combining both the bezel area and the chrome ring area to enable an enlarged switch area for the icons, backlight and circuitry enable a more user friendly and functional switch system. The icon symbols and backlight could be positioned in the mirror area and the bezel could have a continuation of the icon, or the bezel could be a different color in the icon area and/or the bezel could be raised in the icon area to enhance switch location visibility and functionality. Since finger prints are more readily visible on a smooth glass surface than on most bezel surfaces, it may be desirable to attract direct finger contact primarily to the bezel area. It is also desirable to cover the contacted area of the bezel and/or glass area with an anti-finger print layer or coating to avoid the visually objectionable accumulation of dirt and finger oils.

User Interface: Mirror Elements With a Cut-Out Substrate Design And With a Substantially Co-Extensive Substrates Design.

[00225] Implementation of UI in some cases may potentially present problems with operation of EC-element-based rearview assemblies. One of the problems that can easily escape attention is the problem of electromagnetic interference caused by contemporaneous operation of a capacitive switch of the UI and the EC-element, which detrimentally affects the performance of the assembly as a whole. To reduce or even eliminate such interference, some embodiments of the present invention that utilize an EC-element may require the use of appropriately and non-trivially reshaped optical elements defining the EC-cavity.

[00226] One purpose of such reshaping is to spatially separate an area occupied by a conductive pad of a switch of the UI from that of the EC-portion of the EC-element such as to minimized electromagnetic coupling between the two. To this end, a mirror element may be configured such as to have the foot-print of the switch and that of the EC medium onto the first surface of the mirror element of the assembly not overlap. For example, an embodiment of the invention may include an EC element having a substrate that supports both an EC-cell and a conductive pad of a switch, which is located adjacently and peripherally with respect to the EC-cell, and another substrate cooperating with the first substrate such as to establish a ledge extending along a portion of the perimeter of the EC element. A portion of the ledge is used to configure an embodiment of the switch of the UI of the invention and to establish the associated electrical connections between the components of the switch and an electrical circuitry at the back of the EC-element.

[00227] Figs. 32(A-C) schematically illustrate the above concept. As shown in side view of Fig. 32A, a first substrate **9102** of the EC element **9104** has larger area than a second substrate **9108**, and the two substrates **9102**, **9108** in cooperation establish an EC cell **9110** and a ledge **9112** that is formed by a portion **9120** of the first substrate that extends transversely beyond the geometrical boundaries of the second substrate. As shown, the EC element **9104** has a first surface **9104a**. Figs. 32(B, C) offer two

5 exemplary sets of the first and second substrates of an EC element to illustrate the way the substrates can be reshaped to achieve the cooperation shown in Fig. 32A. The second substrate **9108'** is reshaped by carving out a portion **9124** (as compared to a fully-sized first substrate **9102**) to create a spatially-extended notch or recess. Fig. 32B, on the other hand, illustrates an embodiment where the second substrate **9108''** does not have any carved-out portion but simply has a smaller area (or transverse extent)
10 than that of the first substrate **9102**. As a result, when the first and second substrates are spaced apart parallel to each other such that their edge surfaces **9130** and **9132** are aligned, the corresponding ledge portion **9112'** (or **9112''**) is formed. However, it is understood that generally the second substrate may be smaller than the first substrate and disposed such as to have at least a portion of an edge of the second substrate be concealed by and is not observable from behind the first substrate when viewed from the
15 front of the EC element and/or the front of the rearview assembly.

[00228] Fig. 33A demonstrates, in a cross-sectional view, a portion **9200** of a vehicular rearview assembly employing an embodiment **9104** of the EC element. As shown, the first substrate **9102** of the element **9104** support the EC cell **9110**, which is generally defined by the first and second substrates and a seal **9204** disposed along the perimeter of the cell **9110**. The cell contains an EC medium **9206** in
20 physical contact with a transparent electrically conductive layer **9208** (such as a TCO) and a reflective thin-film stack **9210**.

[00229] In further reference to Figs. 32A and 33 it is appreciated that, when the TCO layer **9208** is deposited across the second surface **9104b** of the EC element **9104** and unless additional masking step is involved, the TCO layer is extended to the edge surface **9136** of the first substrate. To facilitate
25 formation of a switch element that is electromagnetically (and, in particular, capacitively) decoupled from the EC cell **9110**, as discussed below, an electrical-isolation area **9208b** is further established (e.g., by removing a strip of the layer **9208** with laser ablation, or mechanically, or via chemical etching) to electrically isolate a portion **9208c**, which is now spatially coordinated with the ledge **9112**, from a portion **9208a**. Additionally, the electrically-conductive portion **9208c** is characterized by a normal
30 projection, onto the second surface **9104b**, that is adjacent to but does not have any contact with a normal projection of the portion **9208a** onto the same surface. (In an alternative embodiment (not shown), a portion of the layer **9208** that corresponds to the areas **9208b** and **9208c** of Fig. 33A may be completely removed.) Consequently, the capacitive coupling between the switch element and the EC cell is minimized. As discussed in Our Prior Applications, the transparent conductive layer portion **9208a** is
35 further configured, by providing appropriate electrical connectors (not shown) to be operable as a transparent conductive electrode while the thin-film stack is adapted to be operable as a reflective electrode of the EC cell **9110**. The layer **9208** is shown to be disposed on top of a peripheral ring **9214** (made of chromium and/or other metals, as taught in Our Prior Application) which, in turn, is configured to substantially conceal the seal **9204** from being observable from the first surface **9104a**. An alternative
40 embodiment, not shown, may include a transparent conductive layer **9208** disposed under the peripheral ring **9214**.

5 [00230] In further reference to Fig. 33A, the EC element (such as the element **9104** of Fig. 32A) is supported, from the back, with a carrier **9230**, which is preferably made of a polymeric material and has an extended portion **9230a** positioned along a fourth surface **9232** of the EC element **9104**. The carrier **9230** is appropriately shaped to establish a step portion **9230b** and a peripheral portion **9230c**. The step portion **9230b** integrally connects the extended portion **9230a** with the peripheral portion **9230c** (in fact, it is preferred that all three portions of the carrier are co-molded or molded as a unit) and defines two surfaces: a step surface **9236**, which is generally parallel to the second surface **9104b**, and a surface **9238** that is generally transverse to the extended portion **9230a**. The carrier **9230** is appropriately dimensioned with respect to the size of the element **9112** to have the peripheral portion **9230c** (i) accommodate the first substrate on the inboard side of the peripheral portion and (ii) accommodate the second substrate **9108** on the inboard side of the surface **9238**. The peripheral portion **9230c** may be configured to be optically clear, optically diffusive (e.g., to have ground surface and, therefore, "frosted" appearance), or have a colored appearance. The peripheral portion **9230c** is additionally shaped such as to have its front surface **9230d** curved, along the outer perimeter of the peripheral portion **9230c**, with a radius of curvature *Rad* of no less than 2.5 mm. The level to which the surface **9230d** is spatially protruding with respect to the expended portion **9230a** may lie above or below the glass surface **9104a**.

 [00231] In the embodiment **9200** of Fig. 33A, the surface **9236** is shown to be a support for an electrically-conductive pad **9240** configured such as to have a normal projection, onto the second surface **9104b**, that is adjacent to but does not have any contact with a normal projection of the portion **9208a** onto the same surface. Generally, the pad **9240** may be configured as an electrically-conductive layer carried on the surface **9236**, or, alternatively, as a metallic plate, foil, or mesh juxtaposed with that surface (e.g., with the optional use of a conductive adhesive or conductive polymer as shown, in dashed line **9241**, in embodiment **9250** of Fig. 33B, or by being simply placed in proximity to the surface **9236**). The pad **9240** is electrically extended, through a passage **9242** in the step portion **9230b** and with the use of an electrical connector such as an electrical pin **9244** and a (generally optional) contact pad **9246**, to a circuitry for a capacitive switch electronics (not shown) on the PCB **9248** (at the back of the assembly) so as to define a capacitive switch of the embodiment. The capacitive switch is adapted to operate in response to a user input applied to the front of the assembly in the area of the ledge **9112**. The user input may include placing a finger in proximity to or in contact with the first surface **9104a** in the region of the ledge **9112**, which generally causes a change of electrical potential associated with the pad **9240**. The capacitive switch circuitry at the back of the assembly is thereby triggered to register a corresponding transfer of charge in response to which a particular function of the assembly is activated. In an alternative embodiment, such as an embodiment **9250** of Fig. 33B, the electrical connection operably extending the pad **9240** to the PCB **9248** may utilize a different electrically-conductive connector **9252** using, to name just a few, a specifically designed metallic spring contact, a "zebra"-strip, an electrically-conductive polymeric material or adhesive that are configured to be compressible between the conductive pad of the

switch and the PCB. In an alternative embodiment, where either a conductive epoxy or a combination of wire and solder is used, no compression is required.

[00232] To present the user with an indication of a function/device, of the assembly, that would be activated in response to a particular user input (through operation of the capacitive switch defined by the pad such as the pad **9240** or, generally, through operation of any embodiment of a switch), an at least partially opaque graphical layer **9254** that has icons or other graphical indicia contained in it may be overlayed on top of or juxtaposed with the pad **9240**. The information contained in such indicia is delivered optically, through a region **9256** and through the transparent ledge **9112** to the front of the assembly by providing a backlighting arrangement for the indicia. In a specific embodiment, the region **9256** may be at least partially filled with an optically-transparent material (not shown) such as a polymer or dielectric by depositing such a material on top of the graphical layer **9240** prior to the attachment of the EC element to the carrier. As shown schematically shown in Fig. 33A, the backlighting system may include the use of a source of light such as a single-color LED (or, if the indicia is multi-colored, a multi-color LED source) **9130** that highlights the graphical layer through an appropriate aperture created in the pad **9240**. In an alternative embodiment (not shown), the backlighting may utilize a lightpipe element configured to optically couple a source of light in the back of the assembly with the graphical layer. In yet another embodiment (not shown), the backlighting flux can be channeled to the graphical layer through the carrier itself a portion of which, co-molded with the rest of the carrier, is optically transmissive.

[00233] It is worth noting that in some embodiments a portion of the electrically-conductive layer disposed on the second surface of the EC element may be utilized as a conductive pad of the switch of the invention. In addition, in a specific embodiment, graphical information or code associated with an identified switch may be contained within a pad of the switch itself. Such an example is schematically shown in a cross-sectional view in Fig. 34A, where a TCO layer portion **9208c'** (corresponding to the layer **9208a** and electrically-isolated from that layer, as discussed in reference to Fig. 33A) may be used as a conductive pad of the capacitive switch. In this case, the visual indicia may be incorporated onto or into this layer and highlighted from the back, e.g. with light generated by a (not shown) light source that is transmitted to the layer **9208c'** directly through a channel **9310** configured in the carrier **9314** or, alternatively, through a lightpipe (not shown) that may be reaching to the indicia through such channel **9310**. When the TCO-layer portion such as the portion **9208c** of Fig. 33A or **9208c'** of Fig. 34A is used as a conductive pad of a capacitive switch of the invention, the electrical connection is preferably provided to the layer **9208c** (**9208c'**) through a channel **9312** appropriately configured in the carrier **9314**. The first substrate **9104** of the EC element of Fig. 34A is adapted to be thicker than 2.5 mm and to contain a region having a curvature with a radius *Rad* that is at least 2.5 mm or larger. This curved region is circumferential with respect to the first substrate and, therefore, presents itself as a correspondingly curved annulus defining an edge region of the front surface of the EC element **9320**. (An element or a portion of an element that has been shaped this way may be referred to herein as *Rad*-curved or *Rad*-

rounded, for simplicity.) An alternative example is provided by Fig. 35A, showing a portion **9330** of an assembly utilizing and embodiment of the EC element **9332**, where a TCO-portion **9208c'** is configured to operate as an optically-transparent conductive pad defining, in conjunction with the connecting pin **9238** and the corresponding electronic circuitry on the PCB **9248**, a capacitive switch of the invention. However, in comparison with Fig. 34A, the indicia identifying the capacitive switch is adapted in the graphical layer **9254** disposed, as discussed in reference to Figs. 33(A, B), on the step portion **9230b** of the carrier **9230**. A source of light and optical system facilitating backlighting of the graphical layer **9254** is not shown for simplicity of illustration. In operation, once the graphical layer **9254** is backlit, the indicia information is transmitted optically, through the region **9256** and the ledge **9112** towards the front of the assembly. Although not shown in the drawings, in a modification to the embodiment of Fig. 35A the graphical layer **9254** may be disposed on the exposed surface of the portion **9208c'** instead, with an electrical connector **9238** being pressed against the portion **9208c'** through an aperture in the graphical layer. To conceal at least one of the connector **9238**, the edge along which the surfaces **9236**, **9238** intersect, and the gap **9338** between the edge surface of the second substrate and the carrier from being visible from the front of the assembly, a peripheral ring layer **9214** may be deposited on top of the TCO layer **9208** such as to extend beyond the area corresponding to the seal **9204** and towards the edge surface **9136** of the first substrate **9102**, as shown in Fig. 35B. Further, the peripheral ring **9214** is judiciously ablated or etched to outline electrically isolated portions **9214a**, **9214c** along such a line as to create an elongated trench **9208b** down to the second surface **9102b** that is devoid of any conductive material and that defines a portion of ledge **9112** corresponding to the TCO-portion **9208c** (configured, in this embodiment, as a conductive pad of the capacitive switch). The use of two areas of the peripheral ring - **9214a** and **9214c** - allows to relax the positioning tolerances when affixing the EC-element to the carrier, because the outboard portion **9214c** conceals the electrical connector and the passage **9242** through which this connector is inserted, and the inboard portion **9214a** the area of the gap **9338**.

[00234] An alternative placement of the graphical layer and the conductive pad of the capacitive switch is shown in Fig. 35C. Here, an EC-element **9334** has first and second optical plates **9104**, **9336** of substantially equal dimensions. However, the EC-cell **9110** is configured to occupy only a portion of the substrates **9104**, **9336**, leaving mutually-opposing elongated parallel regions of each completely transparent, with only the TCO portion **9208c** having been formed on surface **II**. A combination **9340** of the graphical layer and the conductive pad **9240** of the switch is juxtaposed with surface **IV** (surface **9336b**) of the EC element **9334**. As shown in Fig. 35C, the combination **9340** is configured to assure that the electrically-conductive layer **9240** is electromagnetically decoupled from the EC medium of the EC-element **9334**. Specifically, the foot-print (projection) of the layer **9240** and that of the EC-medium of the EC-element **9334** onto surface **II** of the EC-element **9334** do not overlap. As a result, the electromagnetic screening of the layer **9240** by the EC-medium is minimized, as is the capacitive coupling between them. The optical system providing backlighting for the indicia in the graphical layer is not shown for simplicity of illustration. An electrical connection between the

5 conductive pad **9240** and the switch circuitry on the PCB **9238** is configured with the use of a two-sided interconnect **9342**. When inserted into a passage **9344**, the interconnect **9342** is locked in its working position, with the use of retention snaps (not shown), on either side of the extended portion **9230a** such as to have its element spring-contacts **9348** to depress firmly into the switch pad **9240** and the contact pad **9246** when the EC element is attached to the carrier (the attachment means are not shown).

10 [00235] Embodiments of electrical and optical connections that facilitate the operation of the assembly of the present invention and establish corresponding to electrical and/or optical communication(s) among its components and devices are discussed elsewhere in this application.

[00236] Returning to Figs. 33(A, B), the extended portion **9230a** of the carrier **9230** is firmly affixed to the fourth surface **9108b** of the EC element **9110** such as to mechanically hold and support the EC element during the operation of the assembly (**9200** or **9250**). The attachment between the extended portion and the fourth surface may be implemented in a number of known ways, for example with an adhesive or foam, **9258**. It is appreciated that in any embodiment of the invention, the carrier supporting the EC element is appropriately configured such as to provide for necessary apertures and openings facilitation various electrical and optical communication between the electro-optics on the back side of the carrier and the EC element and other active elements in front of the carrier. A non-limiting example of the carrier is shown in Fig. 36 that corresponds to Fig. 37D of U.S. 2010/0321758, where some structural characteristics of a carrier-embodiment have been disclosed.

[00237] An embodiment of a PCB such as the PCB **9248** of Figs. 33(A,B) generally includes circuitry for at least dimming the EC medium **9206**, driving LEDs for backlighting of graphical indicia, and controlling capacitive switches, and may include throughout openings or apertures facilitating light delivery from a light emitter positioned behind the PCB towards the FOV at the front of the assembly.

[00238] A portion of the alternative embodiment of the assembly employing an EC element with a cut-out substrate design is schematically shown in Fig. 37A to demonstrate a structure similar to that of Fig. 33B but including a differently arranged transparent electrode on surface **II** (second surface **9102b**) of the EC element. In particular, as shown, a peripheral ring **9402** is deposited on top of the transparent electrically-conducting layer **9404** on surface **II** after which both layers **9402** and **9404** are simultaneously laser ablated or etched to establish an area **9208b** devoid of these layers, thereby creating layer stacks **9402a**, **9404a**, and **9402c**, **9404c** that are electrically isolated from one another. Moreover, as shown, a peripheral ring portion **9402c** is extending onto the ledge **9112** and, therefore, at least partially overlaps with a graphical layer (as viewed from the front of the assembly) to conceal and block the edge of the graphical layer from being viewed from the front of the assembly and to relax tolerance requirements during the fabrication and component-alignment processes.

[00239] In a specific embodiment, the portion **9402c** of the peripheral ring can extend towards the edge **9136** such as to completely cover (not shown in Fig. 37A) the portion **9404c**. In such specific embodiment, at least the layer portion **9402c** and, optionally, both of the layer portions **9402c** and **9494c** are patterned (e.g., with laser ablation) to create graphical indicia therein that is backlit from the back of

the assembly to make it visually perceivable from the front of the assembly. To this end, the PCB **9410**, the extended portion **9230a** of the carrier **9230**, and the adhesive **9258** are appropriately adapted to include corresponding apertures or cut-outs that define channel(s) **9412**, through which an optical communication is established between a light source **9416** at the back of the assembly, the graphics/indicia layer(s), and the transfective portion of the EC element.

[00240] Fig. 37B illustrates a variation of the embodiment **9400**, in which the seal area is shown to include a non-conductive material **9452** disposed circumferentially, around the perimeter of the EC-cell in direct contact with the EC-medium **9206**, and a conductive material **9454** disposed outside of the conductive material **9452**. To accommodate the presence of two materials **9452**, **9454**, the peripheral ring portion **9402a** of Fig. 37A is judiciously separated into two sub-portions **9402a1**, **9402a2** that are electrically-isolated from one another by a non-conductive area **9456** (shown ablated through both the peripheral ring material and the TCO material of the layer **9404** against the area occupied by the non-conductive seal material **9452**). The conductive material **9454** electrically connects the back of the assembly (as shown, the back of the EC-element, surface **9108b**) with the electrically-conductive portion **9404a2** of the layer **9404** through the peripheral ring portion **9402a2** and a conductive member **9458**, which wraps around an edge of the substrate **9108**. The member **9458** may be an electrically-conductive clip or layer, foil, mesh or, in a specific embodiment, a thin-film continuation of a layer that is part of the thin-film stack **9210** carried on the third surface **9108a**. In a different area of the EC-element (not shown), the layer **9210** may be similarly formatted to establish an electrical connection between it and corresponding electrical circuitry at the back of the assembly. Various electrical arrangements serving this purposes were detailed in Our Prior Applications, e.g. in U.S. 2010/0321758 and U.S. 2010/0020380 and will not be discussed here.

[00241] As was mentioned above, a smoothed outer peripheral edge of the vehicular rearview assembly is dictated by considerations of safety. While embodiments of the present invention discussed above in reference to Figs. 33(A,B), 35(A-C), 37(A,B) offer such "smoothed" edge by curving the outer edge of the peripheral portion of the carrier at a radius *Rad* of no less than 2.5 mm, an alternative solution may be to curve the front perimeter edge of the front substrate of the mirror element. This solution has been already mentioned in reference to Figs. 8 and 9. The embodiment **9500** of Fig. 38 expands on this idea and illustrates a portion of the rearview assembly utilizing an EC-element **9502** with a cut-out substrate design where the first substrate **9102** has an outer edge curved, all the way along the perimeter of the substrate **9102**, at a radius *Rad* of no less than 2.5 mm. While it may be preferred to have the first substrate as thick as 2.5 mm or even thicker, in a specific embodiment a 1.6 mm thickness may suffice. In yet another specific embodiment, the front edge **9504** of the carrier **9230** may also be similarly rounded (not shown) with a radius of at least 2.5 mm. The electrical communication between the circuitry on PCB **9248** and the conductive pad **9240** of the capacitive switch is established as discussed above, while the backlighting of the indicia in the graphics layer **9254** is delivered from a source of light (not shown) at the

5 back of the assembly through a lightpipe or an optically diffusive element (not shown), whether through the carrier **9230** or along a portion of it, as schematically indicated with an arrow **9506**.

[00242] It is worth noting that in embodiments having an additional electrically-conductive layer in front of the conductive pad of the capacitive switch, the effective capacitor formed by a combination of i) the user's finger placed in the proximity of the front surface region that corresponds to the conductive pad, ii) the conductive pad itself, and iii) the additional electrically-conductive layer in between - is a serial capacitor. In such embodiments, as already mentioned in reference to Figs. 18, if the additional electrically-conductive layer intervening between the finger and the conductive pad of the switch has an area greater than that of the conductive pad, the effective sensitivity of the capacitive switch will be increased. Accordingly, embodiments described in reference to Figs. 33(A,B), 35C, 37A, 38, where the TCO portion **9208c**, **9208c'**, although optional, when present is located in front of the conductive pad **9240** of the switch, it is preferred to dimension the conductive pad **9240** to have smaller area than that of the TCO portion **9208c**, **9208c'**. In a specific embodiment (not shown), a conductive pad of the capacitive switch may be disposed on the first surface of the mirror element such as to optimize a response of the system to the user input.

[00243] Although most of the discussion in this application is presented in reference to embodiments that utilize EC-based mirror elements, a simple plane-parallel mirror element or a mirror element utilizing a prismatic element can also be used without limitation instead of the EC element in at least some of the discussed embodiments. An example is provided in Fig. 39A, wherein a mirror element **9604** (which may be configured to use either a plane-parallel or a prismatically-shaped substrate) has an outer edge region curved at a radius *Rad* of no less than 2.5 mm. Various components including a capacitive-switch conducting pad **9240**, a conductive connector **9252**, a graphics layer **9254** as well as an optical system (not shown) providing backlighting of the indicia of the graphics layer are similar to those discussed above. Another example of a non-EC mirror utilizing a capacitive switch to activate a designated function or device of the rearview assembly is shown in Figs. 39(B, C), where a conducting pad **9608** carried on the first surface of the embodiment (in order to provide for a stronger capacitance signal in response to the user input) is electrically extended onto a second surface **9604b** of the element **9604** through an electrical member **9608'** along the π -rounded edge surface of the element **9604**. The graphics layer **9254** is disposed on the surface **9604b** either adjacently or adjointly to the extension portion of the conducting pad and illuminated with light delivered from the light source **9416** at the back of the assembly. As shown in Fig. 96B, the conductive pad **9608** and its extension **9608'** include a TCO layer. In an alternative embodiment, the pad **9608** and/or the extension **9608'** may include a metallic layer. (In this case, not shown, it is preferred to incorporate the informative indicia in the pad itself, such as by patterning the now-metallic pad **9608**, and by eliminating the graphics layer **9254**). Fig. 39C offers a schematic depiction of the front of the element **9604** of Fig. 39B, and illustrates three electrically-isolated from one another pads **9608**, **9608'**, **9608''** and the isolation areas **9610**, **9612** between these pads.

5 The *Rad-curved* annulus along the edge surface of the glass element **9604** can be ground or, optionally, polished prior to deposition of the layer **9608'**.

[00244] While embodiments discussed above in general reference to Figs. 33-39 alluded to different sequences, in which a conductive pad layer of the capacitive switch and an associated graphical layer can be disposed with respect to the front of the assembly, it is appreciated that a particular
 10 orientation of these two layers provides potential advantages in manufacturing (including that of cost reduction and scalability). Specifically, a configuration in which the conductive pad of the capacitive switch is placed behind the graphical layer (see, for example, Figs. 33B, 37A, 38) simplifies formation of internal electrical connections inside the rearview assembly. In particular, establishing a connection
 15 between the conductive pad and the PCB-circuitry for this configuration does not require a formation of a passage through the graphical layer towards the conductive pad (such as a passage in the layer **9254** through which the element **9244** connect the PCB **9248** and the pad **9208c'**.

Embodiments with a Composite First Substrate.

20 [00245] In order to satisfy the requirement of the ECE Regulation 46, mentioned elsewhere in this application, a mirror assembly has to be tested with a reference ball-like test unit. Specifically, according to paragraph 6.1.1.3 of the ECE Reg. 46, any surface in "static contact with a sphere either 165 mm in diameter in the case of an interior mirror or 100 mm in diameter in the case of an exterior mirror, must have a radius of curvature 'c' of not less than 2.5 mm."

25 [00246] The use of a first substrate consisting of a single lite of glass, such as that discussed above in reference to Figs. 9, 10, 34A, 38, 39(A-C), may be an easy choice from the fabrication point of view, but it presents an unexpected challenge to optimization of operational characteristics of the related embodiments. The challenge arrives once it's appreciated that a single-lite (or single-pane) first substrate generally has to be at least 2.5 mm thick or even thicker in order to form a substantially right dihedral
 30 angle between the edge surface of the first substrate and a surface behind it (such as the second surface of the first substrate) while, at the same time, rounding the edge surface of the first substrate with *Rad*. The right dihedral angle would assure that the transition between these surfaces is fully differentiable and that the above-mentioned requirement is satisfied.

[00247] While a lite of glass thinner than 2.5 mm can also be used, some other part of the mirror
 35 assembly (like the carrier or the housing shell / casing) will need to have a curved surface extending beyond the perimeter of the glass lite, as viewed from the front, in order to prevent the outside edge of the glass with an incomplete radius from having an exposed edge. In some embodiments of the invention, a 1.6 mm thick single lite of glass is used that has its edge circumferentially ground at a 2.5 mm radius. In this case the housing shell / carrier is shaped according to provide for an overall external surface that is
 40 differentiable. Alternatively, if a glass lite thicker than 2.5 mm is used, it is possible to meet the 2.5 mm

radius requirement and have the glass proud of the carrier / housing shell when viewed directly from the front.

[00248] The glass substrate thickness of at least 2.5 mm leads to at least two shortcomings: on the one hand, the thicker the substrate the heavier it is (which is generally unwanted) and, on the other hand, a thicker first substrate reduces the sensitivity of a capacitive switch the conductive pad of which is located on surface **II**. The following exemplary embodiments are directed to solving these problems without sacrificing the safety feature provided by the *Rad-curved* peripheral edge of the first surface. The idea behind the proposed solutions stems from appreciation that configuring a composite first substrate (e.g., laminated from at least two thin lites of glass) allows to preserve the curved edge of an embodiment and, at the same time, to position a conductive pad of the capacitive switch even closer to the first surface than, e.g., in the embodiment of Fig. 38. In addition, a layer of material intermediate to individual glass components that are being laminated together facilitates keeping elements of such substrate together even when the substrate is shattered, thereby increasing the safety of the rearview assembly.

[00249] Figs. 40(A-C) illustrate portions of composite first substrates **9702, 9702', 9702''** for use in an embodiment of the rearview assembly each of which is shown as a combination of two lites, **9704a, 9704b** where the lite **9704a** is larger in size than the lite **9704b** and is preferably laminated to it such as a fashion as to define a ledge **9706** formed by a portion of the front lite **9702a** that "overhangs" the second lite **9702b**. Thickness of either lite **9702a, 9702b** is such that the composite first substrate **9702, 9702', 9702''** has a thickness of at least 2.5 mm. A conductive pad **9708** corresponding to a capacitive switch of an embodiment is disposed on a ledge surface facing away from the front of the assembly and covers at portion of the ledge **9706** (Fig. 40C) or extends all the way between edges of the lites **9702a, 9702b** (Figs. 40A, 40B). Although this conductive pad may include a metallic layer, it is preferred that it include a layer of TCO and be, therefore, optically transparent.

[00250] A peripheral portion of the ledge **9706** is shown to be augmented (e.g., through lamination) with a plate **9710** of plastic material that may additionally carry a graphics layer such as layer **9254** (Figs 97A, 97B). The thickness of the plate **9710** is chosen such as to assure that the aggregate thickness of the ledge **9706** and the plate **9710** is no less than 2.5 mm. The source of light such as the element **9416** of Fig. 37A illuminates the graphics layer **9254** from the back and transmits the indicia information towards the FOV at the front of the assembly, through the conductive pad **9708** and the ledge **9706**. In the embodiment of Fig. 40C, the inboard-located conductive pad **9708** may have the required indicia patterned therein or have an additional graphics layer (not shown) to be attached to the back surface of the pad. An electrical connection between the conductive pad **9708** and corresponding electronic circuitry at the back of the assembly is schematically indicated only in one embodiment, for simplicity of illustration with a connector **9712**. Once the first lite **9702a** has been built-up with a plastic portion **9710**, a peripheral edge of the built-up ledge is further shaped along the perimeter of the first lite **9704a**, as discussed above, to create a peripheral edge portion curved at a radius *Rad* of no less than 2.5 mm.

5 [00251] Fig. 41, for example, offers a cross-sectional view of a portion of yet another embodiment containing a composite first substrate **9802**, which includes first and second lites **9802a**, **9802b** laminated with the use of intermediate lamination material **9802c** and which serves as a front optical substrate of an EC-element **9804**. The first and second substrates, **9804**, **9806** are dimensioned so as to form a ledge **9806**. In the area of the ledge **9806** there is a front portion (as shown, a portion **9808c** of a TCO-layer that is electrically-isolated, with an area **9808b** from an adjacent TCO layer **9808a**) of the capacitive-switch's conductive pad that is laminated between the lites **9802a**, **9802b**. The composite substrate **9802** has a radius *Rad* of at least 2.5 mm around the perimeter of this substrate. Otherwise, the EC-element **9804** is structured by analogy with, e.g., the EC-element of Fig. 37A. The TCO-region **9404c**, which is electrically isolated from the TCO-portion **9810a** representing the transparent electrically-conductive layer of the EC-element **9802**, is adapted to operate as an extension of the conductive pad **9808c** connected to it with an electrically-connecting means **9812** (such as a metallic solid or patterned film, a metallic clip, conductive ink or epoxy, to name just a few) that extend along the *Rad*-rounded outer edge surface of the composite substrate **9802**. The overall conductive pad of the capacitive switch of the embodiment, therefore, is wrapped around a portion of the edge surface of the composite double-pane first substrate **9802** of the EC-element **9804** such as to electrically connect the portion **9808c** of the inter-pane transparent conductive layer with the portion **9810c** of an electrically-conductive layer on surface **II**.

 [00252] Turning to Fig. 42 and in further reference to Fig. 41, a schematic front view of the embodiment **9800** of Fig. 98 is shown with the *Rad-curved* annular edge region **9904**, corresponding to the rounded edge surface of the first substrate **9802**, and three regions **9906**, **9908**, **9910** that are defined by respective boundaries **9906'**, **9908'**, and **9910'** corresponding to respective conductive pads (such as the pad **9808c**, for example). Here, the EC-element **9804** is shown without any of the implied detail such as coatings or EC-medium. Graphical indicia or graphic layer such as the layer **9240** of Fig. 941 is shown as a star, a triangle, and a circle. Respectively-corresponding electrically-connecting means (such as the means **9812** of Fig. 41), wrapping around the *Rad-rounded* edge surface **9904** are shown as elements **9916**, **9918**, and **9920**.

 [00253] A variation of the embodiment of Figs. 41 and 42 is schematically depicted in Figs. 43 and 44, where a combination **10004** of a conductive pad and a graphic layer is laminated between the first and second lites **9802a**, **9802b**, which together form the composite first substrate **9802** of the EC-element **9804**, and is further electrically extended, **9812**, along the circumferentially *Rad-rounded* perimeter edge of the substrate **9802** to a back of a portion **10006** of the carrier of the invention. The back portion **10006**, in turn, establishes an electrical connection (not shown) between the electrical extension **9812** and the electronic circuitry triggered by the user input applied through communication with the conductive pad of the combination **10004**. A single capacitive switch is defined, in this case, by the conductive pad of the combination **10004**, the corresponding electronic circuitry, and electrical connections between the two. The front view of the embodiment, Fig. 44, illustrates three switches with corresponding conductive pads

5 extended **9812**, **9812'**, **9812''** to the back of the carrier. In yet another alternative embodiment (not shown) the electrical extension of the conductive pad of the switch may wrap around the EC-element to its back.

[00254] Modifications of the idea of a composite substrate discussed above include a substrate veneered with a lite of glass having dimensions that are substantially different from those of the substrate itself. For example, a glass veneer that is larger than the substrate can be laminated to a front surface of the substrate such as to form a ledge between the veneer and the substrate, thereby providing additional options for placing a conductive pad of the capacitive switch. A "composite" approach to formatting the first substrate of the embodiment may be advantageously used also with a non-EC-element based vehicular mirror, as well as a vehicular mirror assembly including an anisotropic polymeric film allowing to optimize performance of the assembly operating in a display mode, as discussed in details in Our Prior Applications, e.g., in Patent Applications Nos. 12/496,620, 12/629,757, and 12/774,721.

[00255] It is appreciated that in an embodiment where a sandwich-like combination of the pad and graphical layer are carried on a glass surface, such association may be formed by "dry-transferring", as known in the art, of such combination onto a pre-heated glass surface or via screen-printing onto the glass surface.

Pairs of Substrates, Peripheral Rings, and Virtual Buttons (including indicators of operation)

[00256] Figs. 45(A, B) schematically illustrate that embodiments of an EC-element having a ledge such as ledge **10220** defined by the first and second substrates of the EC-element (as discussed in reference to Figs. 32A, 33(A,B), 34A, 35(A,B), 37A, 38, 41, 43) or a similarly configured EC-elements generally utilize a pair of optical substrates such as a pair of Fig. 45A or a pair of Fig. 45B. The pair of Fig. 45A, also labeled as **10201** and referred to herein after as a "sized-down pair", includes a first substrate **10202** (whether made of a single lite substrate or a composite) and a second substrate **10204** that is formed from a lite of glass co-extensive with the substrate **10202** by removing a strip of glass **10206** thereby sizing this lite of glass down. The perimeter of the second substrate **10204** is generally shorter than that of the first substrate **10202**. A second substrate **10210** of the pair **10207** of Fig. 45B, referred to herein as a "notched pair", is formed from a lite of glass initially co-extensive with the first substrate **10202** by creating a notch (or a cut-out, or indentation) **10210**. In addition, while not shown in Figs. 45(A,B), the front edge of the first substrate or both the first and second substrates may be rounded, *Rad*. Moreover, in a specific embodiment it may be preferred to similarly round the front edge of the carrier plate supporting the EC-element, with a radius *Rad'* that is no less than 2.5 mm (see, e.g., the description of Fig. 38). This may be done in addition or alternatively to rounding an edge of a substrate of a mirror element supported by the carrier, as discussed elsewhere in this application.

[00257] A second-surface peripheral ring region(s) of the EC-element in any embodiment of the assembly has to be judiciously adapted to the choice of a pair of substrate defining the EC-element

5 and the choice of the embodiment of the conductive pad of the capacitive switch and the graphics layer corresponding to this switch to assure that its structure does facilitate the performance of all the functions of the ring. Consequently, the peripheral ring region(s) may include the ring itself (conventionally concealing the seal, plug material, and electrical connectors of the EC element, see, e.g., **9214** of Fig. 33A) and, in addition, may include region(s) outside of the EC-element such as the region **9214** of Fig. 33B or a region utilized as a conductive pad of the capacitive switch.

10 [00258] Figs. 46, 47 schematically illustrate some of the possible structure within the scope of the present invention. The front and perspective view of Figs. 46(A, B) show a combination of the sized-down pair of EC-element substrates **10202**, **10204** and a peripheral ring region **10302** disposed on the second surface of the EC element. The region **10302** includes a conventional peripheral ring **10304**
 15 shaped such as to outline the perimeter of the notched-back substrate **10204** and electrically isolated by electrically-nonconductive areas **10306**, individually and as a group, "virtual button" regions **10308a**, **10308b**, **10308c**. (The peripheral ring region **10302** is disposed, in this case, on the second surface of the EC-element.) Each of these regions is independently electrically extended (not shown) to the appropriate electronic circuitry on the PCB and is adapted to be a conductive pad of a corresponding capacitive
 20 switch. In establishing electrical connections between the conductive pads corresponding to the virtual button regions and the electronic circuitry, in one embodiment the pads are overcoated with a dielectric layer (not shown) which, when viewed from the front, visually conceals the isolation areas **10306** and prevents them from being observable. This dielectric layer is further appropriately patterned to provide for electrical passages to the conductive pads. In a specific embodiment (not shown), the peripheral edge
 25 of at least one of the first and second substrates of the sized-down pair **10202**, **10210** of Fig. 46C is *Rad*-rounded. Areas **10310** represent openings in corresponding touch-pad regions of a peripheral ring-material through which the indicia/icons corresponding to the touch-pads is observable.

[00259] A front view of an embodiment of the rearview assembly employing some of the elements of Figs. 46(A, B, C) is shown in Fig. 46D to be grouped together within a housing / casing (not
 30 shown) and a carrier the 7?ai/-rounded peripheral edge **10312** of which surrounds the EC-element (compare, e.g., with the rounded edge of the peripheral portion **9230c** of Fig. 33A). The virtual button regions **10314** are adapted to include either electrically-conductive regions **10308(a-c)** on surface **II** (in case the peripheral ring regions are adapted according to the structure **10302**) or separate layer(s) of graphical applique (such as the layer **9254** of Fig. 33A, for example) containing icons **10316**. Therefore,
 35 the surface associated with an individual pad region can be specularly reflective, optically diffusive, or colored in a particular fashion, whether opaquely or translucently.

[00260] Announcing to the user that a particular function or device of the assembly has been activated in response to the user-input applied to the virtual button, while allowing multiple implementations, is not trivial because, on one hand, such announcements should identify individual
 40 virtual buttons and/or functions / devices and, on the other hand, they should be easily observable by the

5 user. To this end, the front of the assembly may additionally configured include indicator(s) **10310** providing a preferably optical output to the user.

[00261] Generally, embodiments of the invention contemplate numerous lighting schemes (either for backlighting the applique, indicating the switch has been activated or showing that a particular switch is in use), including:

- 10 1. A *"day/night lighting" mode*, where the intensity of the highlight may vary depending on whether it is daytime or nighttime. An ambient light sensor and/or a glare light sensor of the assembly can provide an output useful for such control.
2. An *"activation" mode*, wherein, as described above, lights may be useful to show that a switch has been activated as outlined below. In this mode, arrangements include:
 - 15 i. a given icon can be caused to flash and/or to change color (especially easily if red, green and blue LEDs are combined in a backlight). In such a case the color of the backlight may change from any of these individual colors to any pre-determined color by appropriately mixing the intensities of red/green/blue backlights. Alternatively,
 - 20 ii. lit area may be separated from a virtual button and remain "on" or flash
 - through transfective coating (whether a transfective region of the peripheral ring or a transfective region of the reflector/electrode);
 - through secondary optic on the sensor, or through a transparent or translucent portion of a housing structure.
 - 25 iii. adjacent button indicate that a button is hit
 - iv. all virtual buttons can be lit or flash
 - v. while all virtual buttons flash, an active button remains "on"
 - vi. the use of a wide virtual button so lighting appears around a finger
 - vii. a center backlight to light the icon and an edge light to light the rest of the button when user input is applied.

30 [00262] In particular, in reference to Figs. 46(E-J), the indicator(s) may be disposed, e.g.:

- in the viewable area of the mirror such as above the region of the peripheral ring, Fig. 46E, or in the upper portion of the mirror such as in the area of an eye-hole corresponding to a glare sensor, Fig. 46G ;
- 35 - in the areas of isolation between neighboring virtual buttons, Fig. 46F;
- within the boundaries of a virtual button, Fig. 46H and Fig. 46J;
- within a portion of the housing structure (e.g., in a peripheral portion of the carrier, Fig. 46I).

Fig. 53 schematically additionally illustrates positioning of optical indicators for capacitive switches.

[00263] In reference to Fig. 46G, where the optical indicator such as an LED shares an eye-hole opening with the glare sensor to deliver the capacitive-switch-activation feedback signal to the user, the operation of the glare sensor and the indicator is preferably temporally coordinated. As the microprocessor controls the indicator **10310** and the glare-sensor timing, the most recent glare-sensor data is saved and its activity is suspended while the optical indicator **10310** is "on". When the indicator is disabled, however, the activity of the glare sensor is resumed to provide current, live glare sensor data.

45 Alternatively or in addition, if the operation of the glare sensor can be sampled as a fast enough rate, the optical indicator can be pulse-width modulated (e.g., be "on" 90% of the time) and readings of the glare sensor can be acquired during the "off" time of the optical indicator. In this case, care should be taken to consider rise and fall times of the optical indicator's electronic drive.

5 **[00264]** Continuing the discussion of differently dimensioned optical substrates, Fig. 47 corresponds to the assembly that utilizes the sized-down pair of substrates **10202**, **10210** and a peripheral ring **10402**, a widened portion of which extends to the ledge of the EC-element and is configured to operate as a graphics / indicia layer. A front view of a similar embodiment that utilizes a notched pair of substrates **10202**, **10210** is illustrated in Fig. 48.

10 **[00265]** Referring to Figs. 45A and 46(A-D), in one exemplary embodiment the height of the touch-pad regions **10314** may be about 10 mm to about 13 mm, with roundish icons **10316** of about 6.5 to 7 mm in diameter. The peripheral ring **10304** has a width of about 4.5 mm anywhere except in the area **10320** above the touch-pads, where it is generally wide (e.g., 5.5 mm). In another exemplary embodiment that utilizes a combination of elements of Fig. 48, the peripheral ring **10402** may have a
15 width of about 4.5 mm everywhere except in the graphics area **10504**, where it is judiciously configured to be so dimensioned as to conceal the area of the notch **10212** in the second substrate **10210**, which corresponds to the ledge of the EC-element, from being observable from the front of the assembly.

[00266] Figs. 56(A, B) provide additional description of the EC-element construction by illustrating some key components and omitting the rest of otherwise present elements for simplicity of
20 illustration. The structure of Fig. 56A generally corresponds to an embodiment employing either a sized-down pair of substrates or a notched pair of substrates and a peripheral ring layer having a single ring with a "notch" region such as the ring **10304** of Fig. 103C, with a notch region **10320**. The structure of Fig. 56B generally corresponds to an embodiment employing a notched pair of substrates and a peripheral ring layer that has either a single peripheral ring that is widened in the notch region (such as the ring
25 **10402** of Fig. 47) or a peripheral ring together with peripheral virtual button regions (such the embodiment **10302** of Figs. 46A, 46B). Here, **11302** is the first substrate of the EC-element; **10304** is its second substrate; **11308**, **11308a** and **11308'** are the corresponding peripheral ring layers; **11312** is the icon/graphics layer, while **11312'** may combine the graphics layer and the electrically-conductive layer; **11316** is the layer of opaque applique; **11320** indicate circuit traces and/or the conductive pad for a
30 capacitive switch. As discussed in reference to Fig. 35B, a portion **11308a** of the peripheral ring layer is shown to have a projection, onto the first surface **11302a** of the EC element, that overlaps with a corresponding projection of the applique layer **11316** in order to aid in alignment of EC-element components during the fabrication. While some dimensions are indicated in Figs. 56(A, B), these dimensions are exemplary and may vary in different embodiments.

35 *Specific Embodiments Facilitating Backlighting and Highlight of Indicia.*

[00267] As shown in an exploded view of Fig. 49, the integration of optical substrates in an assembly may be carried out through cooperation among the housing shell or casing **10602**, defining an
40 aperture **10604** towards the front of the assembly, and a carrier **10606**. The carrier **10606** is shown to include the extended portion **10606a**, configured to support the notched pair **10207** from behind, and a

5 peripheral portion 10606c (with an *Rad*- rounded outer edge) configured to peripherally surround the pair 10207, as discussed in reference to Fig. 37A, for example. Both the carrier 10606 and the housing shell / casing 10602 are shown to include various throughout openings and passages 10610 adapted to accommodate electrical and mechanical connectors, optical elements and other components of the rearview assembly.

10 [00268] Fig. 50A shows, at a different angle, a complementary exploded view of the carrier 10606, the notched substrate pair 10207, the peripheral ring region 10710 (such as, e.g., the ring region 10504 of Fig. 48 or the region 10302 of Figs. 46) between the substrates 10202, 10210, and a specific embodiment of a structure 10716 dedicated to facilitate delivery of light from a source of light (not shown) at the back of the assembly to the indicia layer (not shown) at the front of the assembly).

15 Generally, with respect to backlighting of indicia and indicators of the virtual buttons corresponding to capacitive switches of the invention, light sources such as LEDs can be placed directly behind an area to be lit, and may utilize optical systems including lightpipes, diffusers, lenses etc. The embodiment of the shown structure 10716 includes an array 10720 of lightpipes and a lightpipe support 10724, which are further detailed in reference to Figs. 50(B-D).

20 [00269] A front view of the carrier 10606 with the structure 10716 (including the array 10720 of lightpipes 10720a, 10720b, 10720c and the lightpipe support 10724) is illustrated in Fig. 50B. The number of lightpipes in an array of lightpipes generally corresponds to the number of the pad regions of the first substrate of the embodiment (such as regions 10314 of Figs. 46) and to the number of indicia regions (such as regions 10316 of Figs. 46) of the functional capacitive switches of a given embodiment.

25 A lightpipe such as a transparent-plastic lightpipe 10720a, for example, has an input end 10730 and an output end. An input end of any of the lightpipes 10720(a, b, c) optically communicates with a light source such as an LED, OLED, an incandescent or electroluminescent source of light at the back of the assembly. An output end is judiciously structured such as to deliver light channeled through the corresponding lightpipe to the virtual-button indicators 10310. For example, the output end 10732 is
 30 shaped as a dove-tail to mate with the optical indicator embodiment of Fig. 46H or 46J and includes an opening 10734 for transmitting light from another LED through an aperture 10736 of the lightpipe support 10724 towards the icon 10316 of the assembly. In addition, the input end 10732 includes a foot 10738 angled with respect to a body 10740 of the lightpipe 10724a, 10724b, 10724c that facilitates a snap-on removable attachment between the lightpipe support 10724 and the lightpipe 10724a, 10724b,
 35 10724c as shown in a cross-sectional view of Fig. 50C. A bridge 10742 of the support 10724 is dimensioned to fit within a cut-out opening 10610 at the bottom of the extended portion 10606a of the carrier 10606.

5 *User Interface: Embodiments Incorporating a Lock-Out Switch.*

[00270] The basic idea behind a "lock-out switch" stems from the realization that at least one of the "functional" switches (such as capacitive or optical switches) of an embodiment of a rearview assembly that are designed to respond to a user input from the front of the assembly (e.g., the one
 10 coordinated with a portion of the first surface, such as brushing or juxtaposing one's finger against it) is likely to be unintentionally triggered when the user tilts and turns the assembly affixed to the front windshield in order to adjust the viewing angle. In order to effectuate the adjustment of the mirror, the user more likely than not is bound to grasp the assembly (which is, when installed in the vehicle, is elongated in a horizontal direction, along x-axis, see, for example, Fig. 5), from the front such as to place
 15 some of his fingers on the top portion of the assembly and some of his fingers on its bottom portion, while covering a substantial portion of the front of it with the palm of his hand. In such a situation, a functional switch (such as a capacitive switch, for example, adapted to effectuate a wireless telephonic connection) that is cooperated with the front of the assembly will, more likely than not, be activated by the proximity of the palm and/or fingers of the user. It is also quite likely that more than one of such neighboring
 20 switches will be triggered simultaneously, thereby activating corresponding functions / assembly devices each and every time the user attempts to adjust the rearview mirror. Clearly, such situation is undesirable, especially when at least one of the switches activates a function requiring a participation of a third-party provider. It is preferred, therefore, to be able to mute (lock, stop temporarily, suspending the performance of) the functional switches for a period of time required to adjust the orientation of the rearview mirror.
 25 Such "muting" or "locking" can be implemented, for example, by providing a second set (of at least one) switch that locks-out the functional switches in response to an input corresponding to the angular adjustment of the rearview mirror by hand. Moreover, it is appreciated that this problem is specific to embodiments of a rearview assembly and simply does not exist in a case of, for example, networking/information/display modalities implemented in connection with and effectuated via input
 30 applied to a dash-board or any other immobile part of the vehicle. Therefore, traditional "lock-out" switch solutions that are applicable to permanently fixed devices are not likely to be befitting the vehicular rearview assembly.

[00271] In one embodiment, a dedicated pad (e.g., and electrically-conductive layer) for a lock-out capacitive switch can be added to the bottom and/or top surfaces of the assembly within such a
 35 distance behind the first surface of the mirror element as to be within the reach of a finger, for example within about an inch behind the edge 10602 defining the aperture 10604 of the housing shell/casing 10602 of Fig. 49. Alternatively, the lock-out electrically-conductive layer may be disposed on an outer or inner surface of a peripheral portion of the carrier, e.g., at the outer surface of the peripheral portion 9230c of the carrier 9230 of Fig. 33A or the carrier 10606 of Fig. 49. The conductor may be solid
 40 metallic layer or a patterned during the process of deposition such as vacuum metallization), a carbon ink coating, or conductive epoxy, to name just a few. The sensing area can also be configured by placing a

5 flex circuit along a corresponding surface in any of the abovementioned locations. A conductive pad may be electrically extended to a PCB of the embodiment via, e.g., flex-circuit connectors, conductive elastomers, metallic spring clips, or a buss bar-type connection (e.g., a bar known as "board stiffener" that forms a buss surface perpendicular to the PCB). In the latter case (not shown), a conductive pad of the switch is disposed on a surface of a buss that is located in a bottom portion of the housing or in the upper
 10 portion of the housing close to the housing shell and perpendicular to the PCB which, in turn, is substantially parallel to the mirror element of the assembly. As a result, the conductive pad is extended alongside the inner surface of the housing and is capable of sensing the presence of a finger at the side of the mirror element of the assembly.

[00272] Fig. 51 schematically shows an embodiment **10800** of a rearview assembly that
 15 includes a housing structure **10802** hosting a transfective mirror system utilizing an EC-element **10806** with a cut-out design, where the second substrate **10806b** is either notched or sized-down as compared to the first substrate **10806a**. The EC-element **10806** defines a strip-like ledge **10808** between the first and second substrates **10806a**, **1806b** extending along a bottom portion of the EC-element **10806**. The EC-element is further layered, at the first substrate **10806a**, with an additional thin lite of glass **10810**
 20 (referred to herein as veneer) that extends beyond the first substrate **10806a** such as to define a circumferential ledge **10812**. As shown, a back surface **10810b** of the veneer **10810** is overcoated with a transparent electrically-conductive layer **10814** (e.g., a TCO layer) a portion **10814c** of which is electrically isolated by a non-conductive trench **10814b** from a portion **10814a** and is adapted to operate as a conductive pad of the capacitive switch. The capacitive-switch pad **10814c** is electrically extended,
 25 through a conductor **10815** (such as, e.g. the element **9244** or **9252** of Figs. 92A, 92B) to a PCB **10815a** containing corresponding capacitive-switch electronic circuitry. An edge surface of the veneer **10810** is rounded off circumferentially, around the perimeter of the veneer with a radius *Rad* of no less than 2.5 mm. A front edge of the housing structure **10802** defines an aperture encircling the EC-element **10806** and is preferably also *Rad*-rounded around its perimeter. As shown, the veneer **18010** is adhered to the
 30 first substrate **10806a** with an optically-transparent adhesive layer **10816**.

[00273] Referring further to Fig. 51, the EC-element **10806** is configured in the above-mentioned fashion and includes an EC-cell **10818** containing, as described elsewhere in this application, a transparent electrically-conductive layer **10822** and a peripheral ring portion **10824** on the substrate **10806a**, the seal **10826**, and the transfective thin-film stack **10828** on the second substrate **10806b**. A
 35 transparent electrically-conductive portion **10830** (that is isolated from the layer **10822** and disposed on the ledge **10808**) is optional. The electrical isolation between the layers **10830** and **10822** assures that the electromagnetic coupling between the EC-cell of the embodiment and the capacitive switch is minimized. The backlighting source **10832** is disposed anywhere behind the EC-element **10806** (as shown, in front of the PCB **10815a**) and is configured to illuminate, through corresponding optical channels and/or light-
 40 guiding components (not shown) the indicia layer **10834** that is placed on a supporting surface (not shown) provided by a housing component of the assembly. A conductive layer **10840**, which is carried

5 on the inner surface of the housing structure **10802** and extends transversely to the layers **10814c**, **10822**, **10824**, **10830** and the first surface of the EC cell **10818**, is adapted to define a conductive pad of the lock-out sensor. The layer **10840** is operably communicated via known electrically-conductive means such as, for example, a flex cable, wire, electrically-conductive adhesive, electrically conductive clip, electrically-conductive thin-film member (coating or foil or mesh), or a spring member (not shown) with a responsive

10 portion of the electronic "lock-out" circuitry such as to define a lock-out capacitive switch. While the layer **10840** is shown in Fig. 51 to be a liner to an upper portion of the housing structure **10802**, it is understood that generally the layer **10840** may be disposed on an inner bottom surface or an inner side surface of the housing structure **10802**. Optionally, a layer that is functionally equivalent to the layer **10840** can be disposed on an outer surface of the housing structure **10802** or, in a related embodiment, on

15 an auxiliary PCB portion (not shown) that is electrically communicated with the PCB **10815a** and is affixed transversely to it and to the conductive pad **10814c**. (This structure is sometimes referred to as "board stiffener"). It is appreciated that, in general, any specific embodiment of the rearview assembly of the invention can be configured to contain a conductive pad of the capacitive switch and a conductive pad of the lock-out switch that are disposed transversely with respect to one another.

20 **[00274]** In one embodiment, a "lock-out" switch may be configured to include sensing pad(s) that are hidden from view and added in proximity to the sensing pads corresponding to functional capacitive switches (for example by the sides, and optionally between and above or below the sensing pads corresponding to functional capacitive switches at the front) of the assembly. When a user intends to activate a particular function or device of the assembly and extends his finger to a portion of the first

25 surface correspondingly identified by indicia area or virtual button, the "hidden" areas are configured not to perceive the presence of the small area of the finger as they are sufficiently distanced from the sensing pad of the functional switch. In contradistinction, however, when the user grabs the assembly from the front to tilt it, the area of the palm of his hand covers both a functional switch and a "lock-out" switch, the latter causing corresponding electronic circuitry to temporarily mute functional switches of the assembly.

30 Figs. 52(A, B) schematically illustrate such "hidden" positioning of the conductive pad(s) **10902**, **10902'** of a lock-out sensor with respect to conductive pad(s) **10906**, **10906'** of capacitive switch(es).

[00275] In another embodiment where a sensing area of a functional capacitive switch is disposed on surface **I** of the EC-mirror element, a transparent conductor such as a TCO (for example, ITO) is applied to surface **I** of the mirror and is configured as a capacitive sensor input. Although the

35 static offset signal of the capacitive switch may be significant due to the presence of the TCO layer (which is an effective ground) on the second surface (surface **II**) of the EC-element, the signal produced between a large-area hand of the user and the first surface capacitive pad is nevertheless measurable in comparison with the static offset and, therefore, detectable. As the cap touch circuit is tolerant of high resistance connections, higher resistance coatings may be used as a lower cost solution.

40 **[00276]** An alternative embodiment of a lock-out switch may be advantageously beneficial for the situation where more than one of functional capacitive switches is triggered simultaneously.

Specifically, the PCB-circuitry may be configured to lock out all of the functional switches in response to received data representing switch activation from more than one of standard inputs (switch pads). Fig. 52C illustrates this concept, showing electrically isolated from one another capacitive pads **10910** operably connected to the circuitry that is responsive to a multiple-pad input. Fig. 52D illustrates a disposition of the capacitive pad **10914** of a lock-out switch in a bottom portion of the peripheral portion of the carrier (such as the portion **9230c** of Fig. 32A, not shown here.)

[00277] In general, an electrically-conductive coating appropriately positioned anywhere on or in proximity with a mirror element of the assembly can be configured to operate as a pad of the capacitive lock-out switch, as long as this coating is electrically isolated from electrodes of the EC-element and does not interfere with the performance of the EC-element.

[00278] It is appreciated that coordination of operation of any functional switch (such as a capacitive switch activating an information display of a rearview mirror, for example) and that of a lock-out switch should preferably be time-coordinated to assure that no false trigger occurs. In one embodiment, for example, the controlling electronic circuitry of the assembly is adapted to delay the activation of a function or device triggered by a particular functional switch by time-delay of, for example, 100 msec (or any other time chosen depending on configuration of electronic circuitry involved). In addition, the system is configured not to activate the function/device (i.e., to nullify the triggering signal) if the controlling circuitry receives an activation signal from a lock-out switch during this time-delay. Having activation of a device delayed is typically achieved by shortening of the pulse sent to the telematics control unit by the amount of the lockout gating period. The length of the output pulse, therefore, does not represent the intended duration of the user's interaction with the functional switch (i.e., it does not represent the duration of the user input). To correct for this, the activation pulse sent to the control unit can be stretched by the amount of time by which the pulse has been delayed.

[00279] In yet another implementation, an optical detection-based lock-out switch can be implemented, which would be configured as discussed above in reference to, e.g., Figs. 14 and 15. IR wavelengths for operation of such an optical lock-out switch can be judiciously selected to minimize interference with any functional light sensor contemporaneously used in the assembly. If desired, the optical lock-out switch can operate at a wavelength detectable by the glare sensor of the assembly. In this case, the difference (delta value) in readout data respectively corresponding to readings with the IR-source "on" and "off" is calculated, with averaging multiple delta values. Here, the high level of delta values will be indicative of the attempt to grab the mirror assembly. In addition or alternatively, multiple IR-sources can be employed on either left or right side of the mirror element to improve detection capability of the embodiment. As the IR sources may interfere with the accurate measurement of glare and ambient levels of light used by the EC circuitry, the IR sources may be pulsed and time-interleaved with the EC-light-level readings.

Embodiments of Electrical Connectors

5

[00280] Existing designs and processes for configuring electrical connections of a rearview assembly involve soldering of various components to both sides of a given substrate such as a PCB with appropriate electronic circuitry and, alternatively or in addition, the use of multiple clip-like-shaped connectors the positions of which should precisely match the designated locations on corresponding opto-electronic components within the assembly. The need in formation of the electrical contacts on both sides of a given PCB increases the cost of the final assembly. Indeed, flipping the PCB after the contacts have been formatted on one of its sides and running the process again to establish the contact on the other side effectively doubles the time processing time. At the same time, the quality of soldering process has to be controlled and/or verified to assure that created electrical impedance remains within the design range.

Moreover, once soldered, a given electrical contact remains non-removable, for practical purposes, and if a positioning or soldering mistake has been made, results in a loss of a circuitry component. Furthermore, manual solder and assembly processes add labor cost and potentially create field-reliability problems. In addition, mechanical integration of various components in a housing structure of a rearview assembly usually implies that employed electrical contacts should be able to accommodate various ranges of mechanical tolerances without losing their functionality. For example, as the separation gap between the back of the EC element and the PCB with auto-dimming circuitry may vary within the prescribed range, a connector configured to provide electrical communication between the former and the latter not only should be operational as a "variable spatial range" connector but also be able to withstand different mechanical force, applied to it when the EC-element and PCB are pressed against one another, without losing its elasticity. Typically, at a high-end of force range the existing connectors may mechanically interfere with a mirror element and cause image distortions, while at a low-end of force they do not guarantee a stable electrical junction. This problem is particularly exacerbated in an embodiment where a mirror element of the rearview assembly is housed in a housing / casing structure that is devoid a portion extending over the first surface of the mirror element. In this case, controlling the pressure applied by various sources (such as electrical contacts connecting the electronic circuitry at the back of the assembly to various components of the mirror element) to the means for affixing the mirror element to a supporting element (such as an adhesive or a adhesive-treated foam tape commonly used for attachment of the carrier to the back of the mirror element, for example) becomes a non-trivial task, as the pressure-creating elements must be configured to exert a pressure within the limits not exceeding those at which the means for affixing the mirror element fails and/or those at which the performance of the mirror element itself is compromised. In particular, conventionally used plastics and adhesive means typically have an upper limit of force that these means can withstand, on a long time scale, without disassembling/detaching/deforming (corresponding to the so called "thermoplastic cold flow"). A typical EC-element-based mirror element also has an upper limit of applied pressure at which the mirror element breaks. Specific embodiments of the invention offer solutions to the above-mentioned concerns by providing electrically-conductive structures configured to establish an electrical communication between

the opposite surfaces of the PCB, and the installation of which does not require any soldering and lands itself to a fully automated process. As a result, proposed embodiments facilitate a one-step positioning process that populates both sides of the PCB with electrical contacts thereby drastically reducing the overall cost of the assembly. Connectors used in present embodiments are characterized by a spring-compression curve that allows an operation within a wide range of mechanical displacement without creating an excessive compression force. It is noted that these embodiments can be used to establish electrical communication between the electronic circuitry and the EC-cell of the EC-element of the invention as well as between the electronic circuitry and a conductive pad of the embodiments of the capacitive switch.

[00281] Figs. 54(A-D) illustrate exemplary connectors for use in embodiments of the invention. For example, as shown in Fig. 54A, a compressible pre-sized conductive polymeric "zebra-strip" connector can be used to pair electrical contacts **11104a**, **11104b**, **11104c** consolidated into a localized area with corresponding contact pads **11108a**, **11108b**, **11108c** and, through the contact pads, electrically bridge each of the regions **11104a**, **11104b**, **11104c** with corresponding electrical contacts on a PCB **11110** (compare, e.g., with elements **9240**, **9252**, **9246**, and **9248** of the embodiment **9250** of Fig. 33B, for example). In implementing the embodiment of Fig. 54A, we tested a zebra-strip Fujipoly 6127 (FujiPoly America, Carteret, NJ). Alternatively, a conductive polymeric cord (such as that used for EMI gasketing applications) can be used in place of the connector **9252**. A conductive polymer cord for use in an electrical drive circuit may include, e.g., silver; another metal overcoated with silver, non-conductive fillers like glass overcoated with silver, aluminum, nickel, copper, gold, or palladium. Conductive polymers so constructed generally have a lower initial contact resistance, as well as a lower increase in resistance after performance testing. A conductive polymer cord for use in an embodiment of a capacitive switch may include various conductive fillers as mentioned above as well as less conductive fillers such as carbon graphite. In commerce, conductive polymeric cords are offered, e.g., by Laird Technologies (Chesterfield, MO), Majr Products (Saegertown, PA), or Parker Chomerics (Woburn, MA).

[00282] In another embodiment such as the embodiment **9200** of Fig. 33A, a pogo-stick **11116** of Fig. 54B which is internally loaded with a spring (not shown) elastically adjusting the position of a head **11116a** of the stick to any point within a predetermined range **a**, can be used to implement the connector **9238**. In another embodiment, a one-sided interconnect such as an Iriso clip **11120** of Fig. 54C can be pre-attached/ soldered / welded) to provide electrical communication between the PCB **11124** and a given conductive pad (e.g., configured as the connector **9252** between the PCB **9410** and the conductive pad **9240** in the embodiment **9400** of Fig. 37A). It is appreciated, that the protruding tongue **11120a** of the clip **11120** can be broken off from the PCB during handling. It may be advantageous, therefore, to employ instead a one-sided interconnect **11126** of the type shown in Fig. 54D that has side walls **11128** protecting a compliant pin **11130** from the mechanical impact. Attachment of such interconnect to the board **11124** may be carried out from the top side through a hole **11132** in the PCB **11124** to simplify and lower the cost of manufacture.

5 [00283] As discussed in reference to Fig. 33B, 37A, 39A, the electrical connector 9252 can include a conductive polymer that is either co-molded into shape during PCB holder manufacturing process or is pre-molded (by, e.g., extrusion into a cylinder) and inserted, as a separate element, into a passage through the PCB.

10 [00284] Another embodiment may employ a two-sided interconnect described in reference to Figs. 55(A-E) and mentioned as element 9342 of Fig. 35C. Here, the embodiment 12000 of the interconnect takes a form of a slender two-sided clip having, on each side, a slender spring leaves 12004a, 12004b that preferably have rectangular cross-section and may be arced. Each of the leaves 12004a, 12004b has a width that varies from its upper value at the foundation 12008a, 12008b of the leaf to its lower value at the top 12012a, 12012b of the leaf. In one embodiment, the width of the leaf 12004a, 12004b varies linearly with distance. Each of the leaves 12004a, 12004b is attached, at a corresponding foundation 12008a, 12008b, directly to a preferably symmetrical clip-like frame 12016 having, as shown, retention snaps 12020a, 12020b formed at corresponding frame lands 12024a, 12024b. The retention snaps 12020a, 12020b are tilted inward with respect to the frame 12016. At the top 12012a, 12012b, each leaf 12004a, 12004b terminates with a corresponding contact portion. In one embodiment, the contact portions of the interconnect 12000 may include spoon end 12028a, 12028b. In a specific embodiment, the spoon ends may have corresponding concave surfaces that face the inside of the embodiment 12000. Transitions 12032a, 12032b between the contact portions 12028a, 12028b and the corresponding leaves 12004a, 12004b are appropriately curved such as to make tips 12036a, 12036b of the contact portions 12028a, 12028b protrude outwardly with respect to the corresponding leaves.

25 [00285] The embodiment 12000 may be constructed from a single metallic sheet with a formation process and have either symmetrical or asymmetrical structure. The asymmetrical structure may be advantageous in situations where the contact between a spoon end with the PCB on one side of the carrier is located in-board with respect to a contact on the other side of the carrier, between another spoon end and the EC-element's connector. In operation, the two-sided interconnector provides electrical communications between the elements located on opposite sides of the PCB drive circuitry. Figs. 55(D, E) illustrate the mating between the extended portion 10606a of the carrier such as the carrier 10606 of Fig. 49 and the embodiment 12000. As shown, the interconnect 12000 is preferably automatically lowered through an opening 12040 in the extended portion 10606a of the carrier 10606 and then translated laterally towards the land 12044 until the paired inner surfaces of the frame 12016 are in grasp with the land 12044. The retention snaps 12020a, 12020b further facilitate a firm affixation of the interconnect 12000 to the extended portion 10606a. During the assembly process, when an EC-element 12050 is being affixed to the carrier 10606, the top spoon end 12028a is brought a solderless interfacial contact with an electrical extension 12054, thereby connecting an electrode (not shown) of the EC-element 12050 with the leaf 12004a and, through the body of the interconnect 12000, to the PCB and various electrical components on the back side of the carrier 10606. An interfacial contact to the EC-element 12050 can be adapted through a bus bar, J-clip, or other conductive surface (e.g., conductive

polymer dispensed or traced onto a revealed surface; vapor deposition metal placed on glass). The interfacial contact with/to drive board can be formed with a metallic component placed onto the 'backside' of the PCB (e.g., electroless nickel immersion gold surface plating), which backside facing the back of the assembly. The interfacial contact between the contact portion **12028b** and the front side of the PCB (the side of the PCB that faces the front of the assembly) can also be made by either orienting the front side of the board to the contact and the incorporation of any metallic pad on this front side or, alternatively, by cutting/routing a hole into the PCB and soldering a metallic pad around at least a portion of the hole. A second interconnect, shown as **12064** in Fig. 55D, is configured to establish electrical communication between the conductive pad of a capacitive switch of the UI of the invention, thereby operating in place of, e.g., the electrical pin **9244** of Fig. 33A or the connector **9252** of Fig. 33B.

[00286] Generally, the leaf **12004a**, **12004b** and the contact portion **12028a**, **12028b** of the interconnect **12000** are judiciously shaped such as to ensure an interconnect deflection within a pre-determined limit that is defined by a typical assembly process. It is preferred that an embodiment of the interconnect is configured to ensure that contact force that such embodiment exerts on a portion of the assembly with which it is in electrical and mechanical connection is minimized, and, at the same time, to ensure that the established electrical connection is stable over the entire deflection range experience by the embodiment in use. The amount of force or stress induced by the deflection of the interconnect during assembly and use should not exceed the yield or tensile strength of the material used to fabricate the interconnect. This limitations facilitates the use when the maximum movement or deflection of the interconnect is smaller than that which would otherwise cause the interconnect material to yield or plastically deform. Otherwise, exceeding the yield or tensile strength of the interconnect material would result in a reduced contact force induced by the interconnect. If the stress exceeds the yield strength and subsequent deflections cause a return to a lower stress state, the resulting contact pressure will be lower than in the non-permanently deformed case. It is appreciated that, generally, given the material of choice for the interconnect, the interconnect structure can be varied to affect its yield point. Yield point, yield strength, and tensile strength are properties derived using stress-strain curve relationships. Yield strength characteristics for several materials are listed in Table 3A (standard Be-alloys, for example from Materion, Mayfield Heights, OH; remaining materials: standard, for example from Olin Brass, East Alton, IL)

| Material | Temper | Yield Strength (KSI) |
|---------------------------|--------|----------------------|
| BeCu 25 (CI 7200) | 1/2H | 75-95 |
| BeCu 190 (CI 7200) | TM02 | 95-125 |
| BeCu 290 (CI 7200) | TM02 | 95-1 15 |
| BeCu 174 (C17410) | 1/2HT | 80-100 |
| Phos Bronze 510 (B103) | TM02 | 57 |
| CuNiSi 7025 | TM02 | 85-1 10 |

(B422)

Copper 102

(B152)

TM02

37

Brass 230 (B36)

TM02

48

KSI=1000PSI; N/mm²= KSI x 6.895

5

Table 3A

[00287] Generally, the upper limit of a contact force that a spring-type contact applies at the point of contact with the board, a portion of the EC-element, or a capacitive switch portion of the assembly is defined by performance and response to such contact force of other components within the assembly, for example, by plastic flow of carrier elements **10606, 10606a**; by the amount of optical distortion exerted by a spring contact onto the EC element **12050**. It is appreciated that such contact force should be limited in order not cause the spring connector of Figs. 54(B-D) or that of the embodiment **12000** to perform outside its elastic range. Another factors defining the connector design are the strength of the solder use with the connector as well as the strength of adhesive material or other attachment means use to affix the EC element to the carrier **10606**. Embodiments of electrical connectors used herein for either the electrical drive circuit of the EC device or the capacitive switch application, should preferably exert maximum contact force of 5N, and more preferably 2N. At the same time, an embodiment of the rearview assembly is configured to assure that, regardless of the number and type of the electrical connectors used, the overall outwardly-directed force exerted, aggregately, by all electrical connectors (and that tends to push outwardly the mirror element from the aperture of the housing towards the FOV at the front of the assembly) does not exceed that corresponding to pressure of about 150 grams per square inch (or about 1.5 N per square inch) in relation to the overall area of the mirror element. For example, electrical connectors of an assembly with a mirror element having a 40 square-inch surface should be configured not to exert, aggregately, the contact force in excess of about 60 N. A mirror element with a 20 square-inch face should not be subjected to about 30 N of contact force applied by the electrical connectors. So configured assembly assures that the operation of the adhesive layer affixing the mirror element to the carrier is maintained. Other limiting factors determining the limit of contact force include the force the application of which fractures the mirror element and forces that deform the housing element or other components within the assembly. These mirror-fracturing and element-deforming forces generally vary based on the construction of the assembly as well as on the location of pressure points relative to the assembly components. Contact force applied to the mirror element directly can also induce distortion in imaging due to deformation of the mirror surface caused by the contact force.

[00288] On the other hand, the lower limit of the contact force relates to how stable and reliable is the physical contact between the connector and a responding part at the contact point. Generally, an accepted minimum contact force for tin-to-tin contacts is greater than 100 g (approximately 1 N), while that for silver-to-silver contacts is greater than 50 g (approximately 0.5N), and that for gold-to-gold contacts is greater than 25 g (approximately 0.25 N).

5 [00289] In a specific embodiment, the leaf and the spoon end were fabricated to assure the deflection on the order of 1.1 mm per side, as compared to the rest position, while exerting a mechanical stress that is linearly varied with the amount of deflection. Contacts shown in Figs. 54(B-D) are also implemented for same 1.1 mm deflection range, with a maximum force of less than 2 N at 1.1 mm of displacement. This deflection range generally depends on and can be varied as required by the specifics of designs of the PCB, the EC- element, and the interface between these components. In a specific embodiment, based on the spring rate of 0.72 N/m, the contact force applied to the embodiment **12000** during the assembly process does not exceed 2.0 N, and the rate of linearly-varying mechanical stress of the embodiment does not exceed approximately 230 MPa/mm.

10 [00290] For an interconnect used in the EC- drive circuit, a value of electrical resistance for a contact assuring optimal functionality is less than 10 Ohms, preferably less than 1 Ohm, and even more preferably less than 0.050 Ohms. A contact resistance value characterizing the electrical contact between a connector and a capacitive switch is preferably less than 5000 Ohms, more preferably 4000 Ohms, even more preferably 500 Ohms. These resistance values allow for the design and verification of any interconnect system that is chosen for either an electrochromic drive circuit interconnect or a capacitive switch interconnect.

15 [00291] The greater the difference between the minimum and maximum contact force values characterizing a stable mechanical contact between the electrical connector and a responsive element (such as an electrical pad with which this connector is in mechanical and electrical contact), the more latitude is available for connector design (e.g., features of springs, choice of metal, tempers). The range of motion or displacement provided by a given connector should also be maximized in light of limitations imposed by the minimum and maximum contact force values. The relationship between the force and displacement may be expressed in a force-vs.-displacement plot. The lower is the value of a slopes of such a force-displacement graph, the more design latitude there is for a spring-like connector. The embodiments of connectors used to provide electrical communication in EC-element based device of prior art exhibit large spring rate, modulus, or slope of the force-vs.-displacement characteristic. In contradistinction, the embodiments of Figs. 54(B-D) and **12000** have a significantly smaller spring rate. Fig. 57 shows the force-displacement relationship for the embodiment **12000** and, for comparison, a an electrical buss-bar conventionally used in an EC device. Although in this example the force range chosen for an electrical interconnect **12000** is between 0.5 N and 2.0 N, a system of Fig. 55E can be designed to operate within a wider range of contact force.

20 [00292] A related embodiment of an interconnect **12100** including, as shown in exploded view of Fig. 55F and a schematic side-views of Fig. 55G, a J-clip sub-portion **12104** and a pin or spade sub-portion **12108**, is configured to ensure the electrical communication between the electrical circuitry associated with a PCB **12112** and an electrically-conductive portion (such as, for example, an electrode of the EC-cell, not shown) of the EC-element **12116** while exerting a substantially zero contact force onto the EC-element **12116**. A J-clip sub-portion **12104** is configured to include an area **12120** of strain relief

5 affixed and suspended with respect to the land **12124** of the J-clip sub-portion **12104**. The pin or spade sub-portion **12108** having an elongated ring-like pin head **12108A** and a collar **12108B** may be integrated with the J-clip sub-portion **12104** (for example, by soldering or welding to the strain-relief area **12120**) such as to protrude transversely from the land **12124**. (It is appreciated that the interconnect **12100** can be configured as a single-piece element, where the pin sub-portion **12108** and the J-clip sub-portion **12104** are portions of the same three-dimensional J-clip configuration formed from a pliable electrically-conductive preform, such as a metallic plate, by stamping, for example). In further reference to Fig. 55G, the interconnect **12100** is appropriately attached, through its J-clip sub-portion **12104**, to a substrate of the EC-element **12116** in electrical communication with the electrically-conductive portion of the EC-element **12116**. To establish the electrical connection between the subassembly **12118** and the PCB **12112**, the former and the latter are further brought into contact (through an opening in a carrier supporting the EC-element, not shown) such as to press the pin head **12108A** through an opening **12132** that is appropriately plated with an electrically-conductive material **12132A**. The depth at which the pin head **12108A** is inserted into the opening **12132** is generally limited by the collar **12108B**. The pin-head **12108A** is appropriately configured to form mechanical and electrical contact with the electrically-conductive plating **12132A**, which is further electrically extended to the electronic circuitry (not shown) of the rearview assembly, by pushing against the plating **12132A** from inside the throughout-opening **12132** and does not create any substantial force pushing outwardly (towards the front of the rearview assembly) against the EC-element **12116**. Alternatively, a spring-like structure (not shown) mounted on the PCB **12112** could be configured to push against the pin **12108** to maintain electrical contact and causing substantially no force applied outwardly against the EC-element.

Embodiments With a Reconfigurable Switch

30 **[00293]** It is often desirable to reduce the overall weight and/or size of a rearview assembly while preserving its operability and functionality. One solution that facilitates not only the reduction of weight but also the optimization of the forward and rearview vision (by optimizing the effective size of the assembly) is the use of a reconfigurable switch, i.e. a switch that is adapted to correspond to and to activate more than one functional modality / system of the assembly.

35 **[00294]** A reconfigurable switch can be located in different portions of the assembly, for example on top of, on the bottom of, or to the side of an area corresponding to a video- or information display such as an RCD display. In one embodiment, a reconfigurable switch is operably associated with operation of the display and adapted to activate a mode of operation of the assembly that is being displayed at the display at the moment. For example, as shown schematically in Fig. 58A, a set **11502** of four
40 reconfigurable switches is associated with a low portion of the front substrate **11506** of an EC-element of the assembly and is configured to choose one or more of several modes of operation of or types of

5 information displayed by a display 11510. Once a choice is made by, for example, activating a particular switch 11502A, the visual information displayed on the display 11510 is updated. The updated information may again present an updated choice of several display modes to the user (by analogy with a "menu" arrangement, whether pictorial, or graphical, or textual), in which case the same switch 11502A is re-programmed / reconfigured, according to operation of a computer processor that is operably linked
10 to the embodiments of Figs. 58, to be associated with at least one of the modes presented on the updated display. It is appreciated that virtual button of a reconfigurable switch of the invention may be co-located or overlapped with the area occupied by a display of the assembly. For example, as shown schematically in Fig. 58B, the lower portion 11512 of the front substrate 11506 of the mirror element is associated with a display 11516, a portion of the face of which additionally displays virtual button indicia corresponding
15 to the set 11502 of reconfigurable switches. Optionally, a portion of front substrate in which a button of a reconfigurable switch is located may be protruding from the main land of the front substrate in a form of extension or a "chin" of the glass substrate (not shown).

[00295] The reconfigurable switch icons/indicia/legend may be formed using known display technologies including such technologies as LCD, VF, LED, OLED, EC, electrophoretic, and
20 electrowetting, to name just a few. Specific techniques employed in manufacture of a display with which a reconfigurable switch is associated include active matrix display, dot matrix display, segmented-numeric or alphanumeric type display, and segmented icon type display. Specific liquid crystal displays may include TN, STN, scattering (such as PDLC or dynamic scattering), dye-type, cholesteric, and/or DAP type of displays. Alternatively or in addition, the display device associated with a reconfigurable
25 switch can be configured to be transmissive (such as a TOLED or a transmissive LCD), transfective, translucent, reflective, or opaque. Many of the above-listed types of displays require the use of a sealed cell similar to a cell used in EC devices. Such a display cell can be combined with the EC-element-based mirror element using the same front substrate or be a stand-alone element. As shown in Fig. 58C, for example, a portion 11520 carrying a set 11502 of reconfigurable switches may be distinct and
30 separate/separable from (but optionally integrated with) a portion 11524 containing a mirror element of the assembly, to which such portion 11520 is geometrically mated (a gap 11526 between the portions 11520 and 11524 is reduced or even closed upon proper assembly). Fig. 58D shows in side view a portion of specific embodiment including a combination of an EC-element 11528 having a first substrate 11528A forming a ledge 11528C with respect to the second substrate 11528B and a peripheral ring 11530.
35 (Housing and other elements such as, for example, electrical connection, light source providing backlighting of the display and/or indicia of the switch are omitted for the clarity of illustration.) Behind the ledge 11528C a reconfigurable/updatable display 11532 is disposed in spatial and operable coordination with a portion 11536 of the reconfigurable switch (such as a conductive pad of a capacitive switch, for example). The display 11532 can be backlit with a lighting system (not shown) of the
40 assembly configured to deliver polychromatic / multicolored illumination (illustrated by arrows 11540) to the display 11532.

5 [00296] As shown in a related embodiment of Fig. 58E, a combination **11544** including a reconfigurable / updatable display **11544A** and a corresponding reconfigurable switch **11544B** can be integrated as a stand-alone component and coordinated with a portion of the housing element shown schematically as **11546** the outer front edge of which, in a specific embodiment, is *Rad-rowded*. The housing element **11546** is adapted to provide housing for an EC-element **11548** as well. In a specific
 10 embodiment of a rearview assembly, a portion of which is schematically shown in Fig. 58F, a portion **11552**, of the housing **11546**, corresponding to the combination **11544** can be appropriately adapted to be pliable and to move with respect to the remaining portion of the housing and to form a mechanical switch that facilitates the update of the modes of the display **11544A** when toggled with respect to the display. In, in the configuration of Fig. 58F, the reconfigurable switch **11544B** is configured as a capacitive switch
 15 (or a membrane switch, or another type of switch as discussed earlier in this application) with an electrically-conductive pad (now shown), the operation of a re-configurable/updatable combination **11544** is configured to be caused by a operably-coordinated combination of a mechanical switch formed by the pliable portion **11552** and the capacitive switch **11544B**.

 [00297] In a related embodiment of a rearview assembly (not shown) containing a reconfigurable
 20 display-switch pair in which the display is configured as a pressure-sensitive element, the optical properties of which change in response to mechanical pressure, a user input to the switch area could be recognized, by the electronic circuitry, via registration of a change in an optical characteristic in response to the finger's pressure.

25 *Embodiments With Transparent Switch Area*

 [00298] Configuring the peripheral portion of the housing or carrier (such as the portion **9230c** of Fig. 33A, as discussed above) as an optically transparent element is advantageous in that, when viewed by the driver from inside the vehicle, the transparent peripheral portion **9230c** transmits light from the
 30 scene in front of the driver thereby effectively reducing the visually perceived "weight" or "size" of the rearview assembly. Similarly adapting a "switch area" of the assembly (i.e., the area that is associated with the virtual buttons of the UI as observed by the driver) to be transparent would reduce the forward-looking visual size of the mirror even further. In this case, various icons (whether reconfigurable as discussed above or permanent) and conductive pads corresponding to switches, a reconfigurable display,
 35 and other functional elements can be coordinated with the transparent switch area. For example, a transparent capacitive switch electrode structure could be formed by disposing a layer of transparent conductor such as a TCO, a metallic thin-film (for example, silver), or a coating of carbon nanotubes or graphene on a transparent substrate (for example, glass or plastic). This transparent capacitive switch electrode structure is then further overcoated with a graphics layer containing icons / indicial for switches
 40 and disposed in the transparent switch area of the rearview assembly. On the other hand, the opaque / non-transparent components of the assembly (such as, for example, the mirror housing / casing, the

5 mounting stem of the assembly, and the PCB or other electronics) are appropriately oriented not to obstruct the view of the forward scene as viewed by the driver from inside the vehicle through the transparent switch area. This concept is illustrated schematically in Fig. 59A, showing in front view an embodiment **11600** of the rearview assembly having a transparent lower portion **11604**, through which the user can see the forward scene, and a transparent peripheral portion **11608** of the housing element. A partial cross-sectional view of the embodiment **11600** is shown in Fig. 59B. A conductive pad **11610** of the transparent capacitive switch (shown in dashed line and made of a TCO material such as, for example, ITO, ZNO, AZO and the like) is deposited on the second surface of the EC-element **11612** in the area of a ledge formed by the first substrate with respect to the second substrate. A portion of the pad **11610** is overlaid with a graphics layer **11616** (whether opaque or translucent), leaving a patch of the conductive pad electrically-connected to the circuitry at the back of the assembly (not shown). The EC-element **11612** is structurally supported by housing / carrier element **11620** at least a portion of which is transparent to light. The carrier **11620** is further mechanically affixed to the back portion of the housing of the assembly (not shown) and illuminated, from the back with a light source **11624** highlighting, in an "on" mode, the indicia **11616**. (The light from the source **11624** can be delivered to the indicia through the transparent carrier **11620** in any known fashion, for example, as free-space propagating light or light channeled towards the carrier with the use of a waveguide, not shown). Switch area **11604** could also be backlit by light **11624** when the level of illumination provided by the ambient (for example, natural light) is low. One alternative embodiment is shown schematically in Fig. 59C. Here, the first and second substrates of the EC-element **11616'** are substantially co-extensive and no ledge is formed between them. However, a carrier **11620'** has a lower transparent portion **11630** configured to protrude, as a chin extension, below the EC-element **11612'**. In this implementation, no electronics or opaque portions of the assembly are positioned behind the transparent portion **11630**, as viewed from the front of the assembly.

[00299] While not shown in the drawings, it is appreciated that, a transparent or translucent mechanical switch structure can be additionally formed in cooperation with or independently from the transparent capacitive switch. Corresponding opaque electrical contacts are moved to an edge of the mechanical switch area not to obscure the forward looking scene. In one specific embodiment, a transparent mechanical switch may include a membrane constructed with the use of transparent plastic film and transparent associated electrodes. In another specific embodiment the transparent switch could be a toggle type or a push-button switch formed primarily out of transparent plastic.

Embodiments of the Peripheral Ring.

[00300] Embodiments of peripheral rings for EC-elements of vehicular rearview assemblies discussed so far in related art and in this application have a single circumferential band **8210** disposed around a perimeter of the first or second surface of the mirror element **8220**, as shown in Fig. 23A. While

5 this "one size fits all" design has been commonly accepted, it does not address different aesthetic requirements set by different car manufacturers. We discovered that configuring an embodiment of a peripheral ring as a multi-band construct may provide a non-obvious solution to satisfying various aesthetical requirements to appearance of the mirror. Generally, in multi-band embodiments of a peripheral ring, a plurality of bands of spectral filter materials are disposed circumferentially around a perimeter of and on a surface of a mirror system of the invention. While different bands of a peripheral ring may be configured in a quasi-concentric fashion, thus sharing an origin with one inside the other, a non-concentric configuration and a segmented configuration are also contemplated to be within the scope of the present invention. An exemplary illustration of a multi-band peripheral ring concept is provided in Fig. 23B, where a top view of a substrate of an embodiment **8230** of a mirror system is shown to have two peripheral rings **8232**, **8234**. It is understood that locations within the mirror system, widths of, and materials the bands of a peripheral ring are made of will depend on a particular application and aesthetic requirements. Moreover, it is understood that different bands may be carried on different structural surfaces of a mirror system, as is described in more detail below. In a specific embodiment, therefore, a multi-band peripheral ring may include bands spatially separated along the direction of incidence of light onto the mirror system. Generally, according to the embodiment of the invention, the aggregate of widths of bands of a multi-band peripheral ring will not exceed 10 mm, and will preferably be less than 6 mm, and most preferably less than 4 mm. Relative to the aggregate width of a peripheral ring, a width of a given band can be between 5 percent and 95 percent, preferably between 10 percent and 90 percent, and most preferably between 25 percent and 75 percent.

25 **[00301]** Fig. 24A schematically shows peripheral regions **A**, **B**, **C**, and **D** of a specific embodiment **8300** of a mirror system comprising three substrates **8310**, **8312**, **8314** where a multi-band peripheral ring (in this case, a ring including up to four bands) may be configured. For simplicity of illustration, no mounting elements (such as a bezel or a carrier), or conventional optical coatings, or sealing materials are shown. Although the peripheral regions are identified on only one side of Fig. 24A, it is understood that these regions extend in a circumferential fashion around the perimeter of the embodiment **8300**. It is also understood that configuration of a multi-band peripheral ring is not limited to a single surface of a particular substrate. Rather, a multi-band peripheral ring may consist of bands generally disposed on different surfaces (in the case of embodiment **8300**, on either of surfaces **I** through **VI**). As shown, e.g., a multi-band peripheral ring **8320** includes four bands **8322**, **8324**, **8326**, **8328** disposed respectively on the first, second, third, and fourth surfaces of the embodiment. Generally, several seals can be used between the substrates forming an EO-element of the embodiment, each seal corresponding to a particular band of the peripheral ring. For example, as shown in Fig. 24B, an embodiment of a two-lite EO-element **8340** may have a peripheral ring **8344** defined by two bands (A and B, corresponding coatings not shown) and a double seal including seal components **8348**, **8346** that respectively correspond to the bands A and B.

5 **[00302]** It is also understood that, in general, some of the substrates may be transversely offset with respect to other substrates and/or be of different dimensions in order to facilitate, e.g., configuration of electrical interconnections and fabrication processes.

[00303] In reference to Fig. 24C, a peripheral region may be characterized by specular or non-specular reflectance, or a reflectance the characteristic of which spatially varies with a position in the region. The non-specular characteristic may be formed by choice of material deposited on a substrate
10 **8350**, such as a frit, or the substrate may be altered by bead (or sand or other media)-blasting, sanding, rubbing, laser treating, deposition of a transparent layer, a semi-translucent layer with small particles, or semi-transparent layer that has texture or altered from a smooth surface by other means. A peripheral region may have a color determined by various means known in the art such as thin film interference,
15 deposition of a colored thin film (absorption effects), paint, frit or other means. Alternatively, a coating or treatment may be absent in a zone and the aesthetic then determined by the seal or other components within or behind the corresponding band of a multi-band ring. It is essential that means employed to achieve desired aesthetic parameters does not hinder or frustrate electrical interconnections required for proper functioning of the embodiment. If a given treatment, coating or other aesthetic means is employed
20 that is not compatible with the necessary electrical interconnections then electrical interconnections should be appropriately modified and/or reconfigured by, e.g., employing electrically-conductive coatings instead of hard-body connectors. These reconfigured components may be hidden by the aesthetic means or may be incorporated as part of the aesthetic means whereby the reconfigured electrical interconnectors additionally contribute to the appearance of one or more regions of a band.

25 **[00304]** In one embodiment, a band of the peripheral ring (whether it belongs to a single- or multi-band peripheral ring) may be formed to include a thin-film coating deposited on a textured glass surface. For example, a glass surface of a substrate onto which a thin-film band coating is deposited (such as the second surface of the first substrate) can be textured and/or roughened (such as by laser ablation or grinding) to contain, generally in an area associated with the peripheral ring, a surface relief
30 the roughness characteristic of which is sufficient for a band of the peripheral ring to appear optically diffusive when viewed through the substrate. Surface-roughing (texturing) produces a hazy appearance of a portion of the glass surface. In addition, the "roughened" glass area of the peripheral ring region facilitates concealing the seal material and helps to reduce glare (in reflection) that may be experienced by the user at night. Figure 60 shows the relationship between transmitted haze as measured through a
35 roughened glass surface and the measured roughness of the surface. The roughness (R_a , average value, in microns, characterizing measured surface in at least one direction) depicted in Fig. 60 was measured across the glass substrate roughened / textured as discussed above, with a Taylor Hobson Form Tallysurf Aspheric Measurement System Laser 635 using a 2 micron conisphere stylus having a 40 degree cone angle, at 0.1mm per/sec, over a distance of about 30 mm. In addition, Table 4 illustrates dependence of
40 specular reflectance measured, through the glass substrate, off of the peripheral ring reflector disposed on a roughened/textured portion of the glass.

5

| Specular Reflectance (%) | Roughness (R_a , μm) |
|-----------------------------|--|
| | |
| 44.09% | 0.021 |
| 16.08% | 0.1098 |
| 7.81% | 0.272 |
| 6.69% | 0.4155 |
| 6.17% | 0.4877 |
| 5.64% | 0.5195 |
| 5.61% | 0.525 |
| 5.02% | 0.6754 |
| 5.09% | 1.4007 |
| 5.05% | 0.763 |
| 4.80% | 1.9496 |
| 4.80% | 1.017 |
| 4.60% | 1.6038 |
| 42.13% | 0.024 |
| 37.32% | 0.1116 |
| 28.75% | 0.2275 |
| 23.17% | 0.3588 |
| 20.70% | 0.3994 |
| 17.50% | 0.5156 |
| 6.69% | 1.5372 |
| 4.82% | 2.8088 |
| 4.58% | 2.7356 |
| 4.51% | 3.6906 |
| 4.50% | 4.3943 |
| 4.51% | 4.5493 |

Table 4

[00305] In a specific embodiment, when the roughened ring-like circumferential portion of the second surface in the perimeter region of the front substrate of the mirror element is overcoated with a metallic thin-film band coating, the corresponding peripheral-ring band will create a rough metallic ("brushed metal") appearance when viewed from the front of the mirror. On the other hand, when such roughened peripheral-ring area is overcoated with an appropriately designed TCO and/or dielectric thin-film stack, the peripheral-ring band viewed from the front may have a colored textured appearance. It is appreciated that the width of either thin-film band coating (whether electrically-conductive or dielectric) overlaying the roughened portion of the peripheral ring area does not, generally, equal to that of the roughened portion of the peripheral ring area. The thin-film band structure may be wider or narrower

than the textured ring-like portion of the glass surface on which it is deposited. Changing the surface-roughening pattern using a programmed laser-ablation system, for example, can produce a variety of textures and aesthetically pleasing peripheral rings (especially when the roughened area is overcoated with reflective material.)

[00306] A specific embodiment of a two-band ring where all bands are disposed on the same surface can be fabricated either in two cycles (e.g., one band per cycle) or in a single cycle if thin-film structures of the two bands are appropriately configured to contain common layers. For example, as schematically shown in Fig. 25A, two bands A and B of a peripheral ring **8410** are disposed on the same surface **8412** of a substrate **8414**. A reflectance value of a band A is higher than that of a band B. Both the thin-film stack corresponding to the band A and that corresponding to the band B include a common layer **8416** of a TCO or another dielectric material such as SiO_2 , MgO , Ta_2O_5 , ZrO_2 , MgF_2 , ITO, TiO_x , CeO_x , SnO_2 , ZnS , NiO_x , CrO_x , NbO_x , and ZrO_x , WO_3 , NiO or Ti_xSiO_y , zinc oxide, aluminum zinc oxide, titanium oxide, silicon nitride disposed on the surface **8412**. Examples of suitable TCO materials include ITO, F:SnO_2 , Sb:SnO_2 , Doped ZnO such as Al:ZnO , Ga:ZnO , B:ZnO , and/or IZO. The band A additionally includes a dielectric layer **8418** (selected from the list above for layer **8416**) and a metallic layer **8420** (such a silver-gold alloy, silver alloys as described below, chrome, ruthenium, stainless steel, silicon, titanium, nickel, molybdenum, and alloys of chromium, molybdenum and nickel, nickel chromium, nickel-based alloys, Inconel, indium, palladium, osmium, cobalt, cadmium, niobium, brass, bronze, tungsten, rhenium, iridium, aluminum and aluminum alloys as described below, scandium, yttrium, zirconium, vanadium, manganese, iron, zinc, tin, lead, bismuth, antimony, rhodium, tantalum, copper, nickel, gold, platinum, or their alloys and alloys whose constituents are primarily those aforementioned materials, any other platinum group metals, and combinations thereof. The spectral properties of light reflected from the band A are determined essentially by the material of the layer **8420** and the aggregate thickness of the layers **8416** and **8418**.

[00307] In comparison with the band A, the band B has an additional layer **8422** interdisposed between the layers **8416** and **8418**, which is used to dramatically reduce the overall reflectance of the band B. Preferably a metal used for layer **8422** should have high value of real part of a refractive index in order to meet the reflectance objectives of a given application. The real part of refractive index should be above about 1.5, preferably above 1.9, and most preferably greater than about 2.1. The value of the imaginary part of the refractive index for a metallic material **8422** for attaining very low reflectance values will vary with the real refractive index. Lower k values are needed for low real refractive indices and higher k values will work as the real index increases. Preferably, both the real and imaginary parts of the refractive indices should be relatively large. Appropriate metals or materials for the thin absorbing metal layer include nickel silicide, chrome, nickel, titanium, monel, cobalt, platinum, indium, vanadium, stainless steel, aluminum titanium alloy, niobium, ruthenium, molybdenum tantalum alloy, aluminum silicon alloys, nickel chrome molybdenum alloys, molybdenum rhenium, molybdenum, tungsten, tantalum, rhenium, alloys of these metals and other metals or materials with both the real and imaginary

refractive indices being relatively large. The thickness of the thin metal layer should be less than about 20nm, preferably less than about 15nm and most preferably less than about 10 nm. The preferred thickness will vary with the reflectance objective and refractive index of the metal selected for a given application. It is anticipated that at least one thin-film layer of the multi-band peripheral ring **8410** may extend into the viewing area while the others are localized in the area of the ring. In addition, UV shielding or blocking may be attained through a combination of material choices and the optical design of the stack. For example, the dielectric materials may be selected which display absorption properties. Specifically, TiO_2 , CeO_2 and zinc oxide are effective UV absorbers. The absorption of the UV light by these materials may be augmented through a judicious optical design of the coating by using a multilayer stack such as an H/L/H stack. It is appreciated, that coatings of a particular band of a multi-band peripheral ring that are located on surfaces preceding the sealing materials should preferably protect the sealing materials from exposure to the ambient UV light. The UV blocking means should reduce the UV transmittance below 5%, preferably below 2.5% and most preferably below 1%.

[00308] In a non-limiting example, the substrate **8414** is made of glass, and the surface **8412** is the second surface of the embodiment. The band B contains the layer **8416** is about 52 nm of ITO, the layer **8422** is 8.2 nm of Chrome, the layer **8418** is 46 nm of ITO, and the layer **8420** is 50 nm of silver-gold alloy, with gold being at about 7% of the composition. When viewed through the first glass substrate **8414**, the band B has a neutral color and a reflectance of 6.9%. The reflected value of a^* is 3.1 and that of b^* is -3.8. The band A, where the Chrome layer **8422** is not present, has a neutral reflected color and a reflectance of greater than about 86.6%. The reflected value of a^* is -2.0 and that of b^* is 0.6. The presence or absence of one layer, therefore, may result in a reflectance difference value of greater than about 70% for this coating stack. Table 5 illustrates how the value of reflectance and color of reflected light may be altered by the adjustment of the thickness of the layers. The stack may be altered to change the intensity of the reflectance and/or the color as needed for a given application. Substitution of any or all of the layers with different materials can be used to attain further degrees of freedom in designing a coating for a particular set of optical requirements. Table 6 shows how the color and transmittance vary with the thickness of the high reflectance AgAu7x layer. As a layer is thinned, the transmittance increases with only subtle changes to the color and reflectance.

| ITO | Cr | ITO | AgAu7x | R | a^* | b^* |
|-----|-----|-----|--------|------|-------|-------|
| 52 | 8.2 | 46 | 50 | 6.9 | 3.1 | -3.8 |
| 42 | 8.2 | 46 | 50 | 7.0 | 4.7 | 2.6 |
| 32 | 8.2 | 46 | 50 | 8.0 | 3.4 | 10.9 |
| 22 | 8.2 | 46 | 50 | 9.9 | 0.5 | 16.9 |
| 12 | 8.2 | 46 | 50 | 12.2 | -2.2 | 18.8 |
| 62 | 8.2 | 46 | 50 | 7.9 | -1.1 | -6.1 |
| 82 | 8.2 | 46 | 50 | 11.7 | -9.0 | -0.3 |
| 52 | 6.2 | 46 | 50 | 7.0 | 5.1 | -15.4 |

| | | | | | | |
|----|------|----|----|------|------|-------|
| 52 | 4.2 | 46 | 50 | 12.4 | 4.0 | -20.8 |
| 52 | 10.2 | 46 | 50 | 9.1 | 0.8 | 4.7 |
| 52 | 14.2 | 46 | 50 | 15.7 | -1.0 | 8.0 |
| 52 | 8.2 | 36 | 50 | 10.1 | 3.2 | -7.3 |
| 52 | 8.2 | 26 | 50 | 14.7 | 3.5 | -8.7 |
| 52 | 8.2 | 56 | 50 | 5.1 | 7.1 | -7.4 |
| 52 | 8.2 | 66 | 50 | 5.2 | 25.7 | -37.3 |

Table 5.

| ITO | Cr | ITO | AgAu7x | R | a* | b* | T |
|-----|-----|-----|--------|-----|-----|------|------|
| 52 | 8.2 | 46 | 50 | 6.9 | 3.1 | -3.8 | 0.5 |
| 52 | 8.2 | 46 | 40 | 6.8 | 2.8 | -2.6 | 1.1 |
| 52 | 8.2 | 46 | 30 | 6.5 | 2.3 | -0.1 | 2.6 |
| 52 | 8.2 | 46 | 20 | 5.9 | 1.7 | 4.0 | 6.5 |
| 52 | 8.2 | 46 | 10 | 6.1 | 2.3 | 4.1 | 16.8 |

Table 6.

[00309] The reflectance value of light reflection in the area of the "bright" band A is dominated by the reflectance of the metal positioned away from the viewer. If the silver-gold alloy from the previous example is replaced with chrome and the other layers are re-optimized (the thickness of the layer **8416** of ITO is 53nm and the thickness of the layer **8418** of ITO is 57 nm), then a neutral appearance in reflection is still attained but the reflectance of the band A is reduced to about 50%. If, instead of silver-gold alloy, Ruthenium is used in the layer **8420**, the reflectance is about 57%, Rhenium yields about 38%, Molybdenum 45%, Copper 54%, Germanium 29%, Tantalum 39%, and other metals will yield other reflectance values depending on their properties. This embodiment is not limited to this set of metals and other metals (described elsewhere in this document) with different reflectance values and hues may be used and are within the scope of this art. Moreover, multiple metals may be employed where the thickness of each layer is adjusted to attain the reflectance and hue for a given application. For example, in the case where a silver alloy is used as the second metal layer, a high reflectance is attained. If it is important to have lower reflectance and opacity one can include an additional metal or metals between the silver alloy layer and the viewer to attenuate the intensity of the reflectivity. The additional layer may provide other benefits such as adhesion, corrosion protection or any other of beneficial properties. Typically, the reflectance will decrease as the thickness of the additional layer(s) is increased, eventually reaching the reflectance of the additional metal when the thickness reaches a critical thickness. Alternatively, if only the reflectance is to be reduced, and transmittance is not needed to be low (see embodiments below) the thickness of the metal, such as silver gold alloy, can be reduced thus decreasing the reflectance and increasing the transmittance. In other embodiments where lower reflectance is desired

5 in combination with low transmittance, the additional metal or absorbing layer may be placed behind the reflector metal, relative to the viewer on the outside portion of the rearview assembly. In this manner, the thickness of the reflecting metal layer may be adjusted as needed to attain the desired reflectance value and the thickness of the additional layer behind the reflector metal can be adjusted as needed to attain the desired transmittance value. The metal above or below the silver layer may be selected to be, e.g.,
10 chromium, stainless steel, silicon, titanium, nickel, molybdenum, and alloys of chrome, and molybdenum and nickel, nickel chromium, molybdenum, and nickel-based alloys, Inconel, indium, palladium, osmium, tungsten, rhenium, iridium, molybdenum, rhodium, ruthenium, tantalum, titanium, copper, nickel, gold, platinum, and other platinum-group metals, as well as alloys the constituents of which are primarily aforementioned materials. Combinations of metal layers are selected so that the reflectance may be set
15 between about 45 and 85% with the transmittance between about 45 and 5%. Preferably the reflectance is between 55% and 80% with transmittance intensity between about 35% and 10%.

[00310] It is recognized that appropriate optimization of a thin-film stack of a particular band of the peripheral ring will affect the optical properties of the band. In a specific embodiment, it may be preferred to include a layer of a quarter wave thickness and a refractive index intermediate between the
20 first TCO or dielectric layer and the refractive index of the substrate, e.g., glass or other transparent media between the substrate and the TCO layer. Flash overcoat layers of materials mentioned in U.S. Pat. No. 6,700,692 may also be incorporated into the above described designs. Depending on the thickness and optical properties of the materials chosen for the flash layer(s), adjustments may be needed to the underlying stack to maintain a similar degree of match or mismatch between the relatively opaque region
25 and the transfective region(s).

[00311] In order to have a noticeably different appearance between the bands of a multi-band peripheral ring, when required, the corresponding brightness values should differ by at least 3 L* units. Preferably the brightness values of the bands will differ by greater than about 10 L* units, more preferably by about 20 L* units, even more preferably by more than about 50 L* units. The low
30 reflectance band of the peripheral ring should be less than about 60%, more preferably less than about 30%, even more preferably less than 20% and most preferably less than about 12%. The value of reflectance of the high-reflectance band should be greater than about 40%, preferably greater than about 50%, even more preferably greater than about 60% and most preferably greater than about 70%. The difference in reflectance values between the two bands may be a difference in magnitude of the specular
35 reflectance or it may be a difference in the specular and non-specular reflectance. In addition or alternatively, the two bands have a difference in color or hue. The corresponding difference in C* values (measured in reflectance) should be greater than about 5 units, preferably greater than about 10 units, more preferably greater than about 15 units and most preferably greater than about 25 units. The color difference may be combined with changes in either reflectance magnitude, reflectance type (specular or
40 non-specular) or some other aesthetic effect such as surface texturing.

5 **[00312]** Figs. 25B through 25D present different variants of the embodiment of Fig. 25A. The stacks A and B in Fig. 25B, for example, do not have the first TCO or dielectric layer disposed on glass as shown in Fig. 25A. (If the first TCO covered the entire surface, then its removal would result in a lower sheet resistance in the viewing area and potentially increasing the switching or darkening time.) The reflectance in the two bands and color of ambient light incident from the first surface and reflected by the bands in the +z direction are relatively unaffected by the removal of the first ITO layer. The color and reflectance may be tuned or adjusted as described above but with one less degree of freedom. The thickness of the layers, as described above, can be altered to change the color. The ease of color tuning is reduced when a layer is absent. The embodiment of Fig. 25B demonstrates a basic structure of a two-band peripheral ring having a high-reflectance band and a low-reflectance band. Fig. 84C, in comparison with Fig. 25B, has an additional TCO or dielectric layer **8416** as the layer distal to the viewer. This layer may be present in the ring area only or it may extend into the viewing area. This layer may be present to protect the metal layers or improve the adhesion to the seals or provide an altered electrical contact to the buss or electro optic material. Fig. 25D, in comparison with Fig. 84A, shows an additional TCO or dielectric layer **8426** on top of the layers **8420** in both bands A and B. The layer **8426** can add properties similar to those as described in reference to Fig. 25C. Furthermore, if the outermost layer is a TCO then it will lower the sheet resistance in the viewing area or modify the optical thickness and the resultant color in the bright and predominantly, the dark state of an EC as described in Our Prior Applications. A TCO layer used within the area of a peripheral ring serves a purpose of attaining the desired reflectance and color, and when it extends beyond the peripheral ring it also serves as a transparent electrode for the EC-cell, the conductivity of which may be modified by additional TCO layers. The thickness of a TCO layer in various positions in the stack may be optimized to coordinate the desired color in the ring positions and the viewing area in the bright and dark state. Additional TCO layers that extend beyond the ring area may be added on top of the ring layers to add additional conductivity to the electrode.

30 **[00313]** It is appreciated that when a multi-band peripheral ring is disposed on the first surface instead of the second surface, the order of the layers should be reversed (with respect to the viewer) in order to preserve the optical properties of the ring.

[00314] As demonstrated, configuring bands of a multi-band peripheral ring to have common thin-films layers makes the multi-band ring more suitable for manufacturing. One technique to facilitate a single-cycle manufacturing is to use simplified masking and registration of multiple masks. There are several masking options available for deposition of the multi-band coating depending on the type of coater used (e.g., in-line or turret). Fig. 26 shows one possible mask construction including an edge mask **8510** and the plug mask **8512**. It is understood that other masking or fabrication options are viable for making these products and the invention is not limited to this particular example. In a turret type coater the substrate **8514** to be coated is held stationary relative to the target with or without masking present. The target or other deposition means are activated and the substrate is coated in areas not masked. The

5 part then cycles to another deposition bay where the process is repeated with the same or different masking arrangement.

[00315] The number of deposition bays is selected based on a given application. In order to produce the construction described in Fig. 25A, the substrate would be arranged with only the plug mask so that both bands A and B receive the coating. Optionally, the plug mask **8512** may be absent so that the layer **8416** covers the entire surface of the substrate in addition to the regions A and B. Further, the edge mask **8510** is used to prevent the deposition of the layer **8422** in the region A and the plug mask **8512** is used to limit the deposition of layer **8422** in the region B. The layer **8418** would be disposed similarly to the layer **8416**. In the case of the layer **8420**, only the plug mask **8512** would be used. It is understood that other masks may be added or subtracted as needed to achieve the proper thickness and locations of the layers on the part and is within the capabilities of one skilled in the art.

[00316] Generally, a dark/opaque material such as an applique may be disposed at the back of the mirror element. In embodiment including two lites of glass, such applique may be disposed on or behind the fourth surface and does not need to terminate at an edge of peripheral region B. For aesthetic reasons, such as matching the color of the vehicle interior, the applique may be of a color other than black. In other embodiments it is possible that embedded light sources with means such as matte finish and / or anti-reflective coatings (to decrease the visibility when off) are incorporated within region B. If the band B has low reflectance (and, accordingly, high transmittance) and the adjacent band A has high reflectance (and low transmittance), the light from the embedded light sources will traverse the mirror element towards the viewer substantially only through the band B because the band A and the central portion of the mirror have a relatively low transmittance. Alternatively, the light can originate from the edges of the glass or from another source direction and transmit through zone B either relatively collimated or with a spread of angles. The light source(s) of the embodiment may be arranged and integrated with other functionalities for a variety of purposes. In one embodiment the light sources indicate an approaching vehicle in the blind spot of the driver by scrolling from the top middle to the top left for a vehicle on the left and from the top middle to the top right for vehicles in the right blind zone. The light sources could also be used as a compass indicator with light at the top middle and bottom of the mirror corresponding to N,S,E,W. with additional points as desired. The light source(s) could also be used as a make-up or vanity mirror that might only allow activation if the vehicle were in park. Decorative functions or themes such as a holiday theme of red and green lights could also be incorporated into the peripheral ring lighting. Additionally, layers in a particular band of a peripheral ring may have non-uniform thickness as needed to attain particular functional or aesthetic effects. This can be seen in Fig. 27, where a band in region B is divided into two portions designated as B1 and B2 and generally having different reflectance and transmittance values. The two regions in zone B can be comparable to stacks of the prior or related art and as described of the novel coatings and structures defined in this patent. The transmittance in the low reflectance and high reflectance zones, in some embodiments, is less than about 5%, preferably less than about 2%, more preferably less than about 0.5% and most preferably less than about 0.25%. This is so

5 that the seal is protected from UV light which can degrade the integrity of the seal, as described above. If, however, it is important to convey visual information through the seal area, the transmittance may be relatively high as described above.

[00317] As already mentioned, in a specific embodiments it may be beneficial to have all or part of the multi-band peripheral ring be at least partly transparent in the visible, UV or NIR spectra. For instance, a glare sensor can be positioned behind the ring when a band of region A and/or B has sufficient transmittance in the relevant part of the electromagnetic spectrum and the seal (if present in a particular band) also has the necessary transmittance. Here, teachings of U.S. Patents 7,342,707; 7,417, 717; 7,663,798 (different means for attaining a transflective coating, including a graded transition) and U.S. Patent Applications 11/682,121; 11/713,849; 11/833,701; 12/138,206; 12/154,824; 12/370,909 (transflective stacks, including means to minimize the color difference between multiple zones of a mirror element and to increase durability) can be advantageously utilized. A number of different means may be employed to produce a transflective ring. For instance, a band of a multi-band peripheral ring may comprise a thin metal layer, a semiconductor material such as silicon, or may be composed of a dielectric multilayer stack. Silver or a dielectric multi-layer is most applicable when both relatively high transmittance and reflectance is desired. The semiconductor layer may comprise Silicon or doped silicon. Small amounts of dopants may be added to alter the physical or optical properties of the Silicon to facilitate its use in different embodiments. The benefit of a semiconductor layer is that it enhances the reflectivity with less absorption compared to a metal. Another benefit of many semiconductor materials is that they have a relatively low band gap. This equates to an appreciable amount of absorption at the UV and blue-to-green wavelengths and high transmittance in the amber/red parts of the spectrum is needed for sensors and the like. The preferential absorption of one or more bands of light lends the coating to have relatively pure transmitted color. The high transmitted color purity equates to having certain portions of the visible or near infrared spectra with transmittance values greater than 1.5 times the transmittance of the lower transmitting regions. More preferably the transmittance in the high transmitting region of a multi-band transflective peripheral ring will be more than 2 times the transmittance in the low transmitting region of a multi-band transflective peripheral ring and most preferably more than 4 times the transmittance in the low transmitting region. Alternately or in addition, the transmitted color of a transflective band of a multi-band peripheral ring should have a C* value greater than about 8, preferably greater than about 12 and most preferably greater than about 16. Other semiconductor materials that result in transflective coatings with relatively high purity transmitted color include SiGe, InSb, InP, InGa, InAlAs, InAl, InGaAs, HgTe, Ge, GaSb, AlSb, GaAs and AlGaAs. Other semiconductor materials that would be viable would be those that have a band gap energy at or below about 3.5 eV. In an application where stealthy characteristics are desired and a red signal is used then a material such as Ge or an SiGe mixture may be preferred. Ge has a smaller band gap compared to Si and this resulting in relatively low transmittance levels within greater wavelength range, which facilitates the "hiding" of any features

5 behind the mirror. If a uniform transmittance is needed then it would be advantageous to select a semiconductor material that has a relatively high band gap.

[00318] Fig. 28A shows an example where a portion C of a two-band peripheral ring is transfective, while another portion includes the above-described bands A and B. Optionally, the portion of the ring outside of portion C may consist of a single band A, produced with the desired aesthetics for a given application. The transfective portion C may cover a part or the entire peripheral ring as needed for a given application. In Fig. 28B, the transfective portion C is relatively small and a sensor 8710 is placed behind it. The sealing element (not shown) may be positioned in the portion C such that it does not block the light from reaching the sensor or, optionally, the seal may be formed by using a clear seal. The transitions between the opaque zone A and the transfective zone C may be formed using means taught in "multi-zone mirror" so that there is no discernable line or interface between the two zones. Some examples of transfective thin-film stacks for use with corresponding opaque zone are listed in Table 7. Examples A through I in Table 7 all include a specific embodiment of a transfective surface II perimeter ring stack. Examples A, B, C and G also include an opaque equivalent. In each case, the stack is identified as being on surface II with the glass substrate listed as the first entry. Each subsequent entry represents a layer applied to surface 2 subsequent to the layer listed above it. The opaque versions are designed to match the color and reflectance of the transfective perimeter ring stack as closely as is reasonable for embodiments where it is desirable for only a portion of the perimeter ring to be transfective with the remainder being essentially opaque. The thickness of each layer is shown in nanometers. The transmittance (%), reflectance (%) and color (a*, b*) are also given for each example. In each case other than A, the transition between the transfective stack and the opaque stack can be abrupt, which will yield a reasonably stealthy transition, or the transition can be graded to yield a very stealthy transition. Example A would likely require a graded transition in order to appear stealthy. Both approaches are taught in detail in U.S. 2009/0207513. Fig. 28C shows the reflectance and transmittance of example H. The spectra show low transmittance in the UV portion of the solar spectrum and a relatively high transmittance in the visible spectrum. Preferably the UV transmittance is less than about 15% of the visible transmittance, preferably less than about 10% of the visible transmittance and most preferably less than about 5% of the visible transmittance.

Table 7: Examples of surface 2 transfective thin film stacks, some with matching opaque equivalents.

| Transfective: | | | | | | | Opaque: | | | | | |
|---------------|-----------------------|-------|-----|------|------|------|-----------------------|-------|-----|------|------|------|
| Example | Layer | nm | %T | %R | a* | b* | Layer | nm | %T | %R | a* | b* |
| A | Glass | | 5.1 | 64.9 | 0.4 | 4.8 | Glass | | 0.8 | 73.2 | -0.4 | 1.8 |
| | A190/SiO ₂ | 23.5 | | | | | A190/SiO ₂ | 40.0 | | | | |
| | ITO | 145.0 | | | | | ITO | 145.0 | | | | |
| B | Glass | | 6.5 | 46.2 | -1.8 | -3.8 | Glass | | 0.7 | 57.1 | -1.3 | -2.5 |

| | | | |
|-----|-------|-----|-------|
| Cr | 14.0 | Cr | 35.0 |
| ITO | 145.0 | ITO | 145.0 |

| | | | | | | | | | | |
|----------|-------|-------|------|------|-----|-------|-------|------|------|-----|
| C | Glass | 5.5 | 52.8 | -1.1 | 0.3 | Glass | 0.5 | 63.7 | -1.0 | 2.7 |
| | Brass | 10.0 | | | | Brass | 10.0 | | | |
| | Cr | 13.0 | | | | Cr | 35.0 | | | |
| | ITO | 145.0 | | | | ITO | 145.0 | | | |

| | | | | | |
|----------|-------|-------|------|-----|------|
| D | Glass | 10.1 | 34.0 | 4.5 | -4.6 |
| | Ti | 35.0 | | | |
| | ITO | 145.0 | | | |

| | | | | | |
|----------|-------|-------|------|-----|-----|
| E | Glass | 8.2 | 40.9 | 4.2 | 0.2 |
| | Brass | 5.0 | | | |
| | Ti | 35.0 | | | |
| | ITO | 145.0 | | | |

| | | | | | |
|----------|-------|-------|------|-----|-----|
| F | Glass | 8.8 | 64.9 | 2.2 | 2.5 |
| | 7X | 25.0 | | | |
| | Ru | 5.0 | | | |
| | ITO | 145.0 | | | |

| | | | | | | <u>Layer</u> | <u>nm</u> | <u>%T</u> | <u>%R</u> | <u>a*</u> | <u>b*</u> |
|----------|-------|------|------|-----|-----|--------------|-----------|-----------|-----------|-----------|-----------|
| G | Glass | 21.5 | 65.4 | 0.4 | 3.1 | Glass | | 2.0 | 65.7 | 0.7 | 0.0 |
| | ITO | 72.7 | | | | ITO | 72.7 | | | | |
| | 7X | 14.0 | | | | 7X | 14.0 | | | | |
| | Ni | 0.0 | | | | Ni | 30.0 | | | | |
| | 7X | 9.3 | | | | 7X | 9.3 | | | | |

| | | | | | |
|----------|-------|------|------|------|------|
| H | Glass | 12.9 | 56.2 | -5.7 | -0.1 |
| | ITO | 115 | | | |
| | Cr | 5 | | | |
| | Ru | 5 | | | |
| | Si | 115 | | | |

| | | | | | |
|----------|-------|------|------|------|-----|
| I | Glass | 31.4 | 66.2 | -1.7 | 0.6 |
| | TiO2 | 54.5 | | | |
| | SiO2 | 91.4 | | | |
| | TiO2 | 54.5 | | | |
| | SiO2 | 91.4 | | | |
| | TiO2 | 54.5 | | | |
| | ITO | 72.1 | | | |

5

[00319] In another embodiment of a peripheral ring, as shown in Fig. 29A, a transfective portion C of a two-band (A and C) peripheral ring may include indicia or icons **8810**. The indicia may be invisible under normal conditions and only become observable when needed. In other embodiments it

5 may be preferable to have the indicia visible under normal conditions. In yet another embodiment, the indicia may become observable via voice activation, proximity sensors or other sensing means. In the embodiment where the ring is transfective (see Figs. 29B and 29C, for example), the openings **8812** for indicia or icons **8810** may be formed in a relatively opaque coating **8814** located behind a transfective coating **8816** on one of the surfaces of a corresponding substrate **8820**. Alternatively, see Fig. 29D, the
10 openings **8812** for indicia or icons may be present on a separate masking element **8824** located behind the transfective coating **8816** of the peripheral ring and only become visible when the light unit **8830** of the rearview assembly is activated.

Optimization of Thin-Film Stacks for Low-Reflectance (Dark) Peripheral Ring.

15 [00320] The basic block of a thin-film structure (Glass / relatively thick metallic layer 1 / dielectric or TCO layer / thin metallic layer 2) for constructing a band of a peripheral ring with desired color/reflectance properties has been discussed above. Reduction of the reflectance figure for a thin-film stack of a peripheral ring can be achieved by adding a TCO or dielectric layer under the
20 metallic layer 1, thereby creating a four-layer stack. In the following Tables 8, 9, 10, the additional TCO layer is denoted as "base ITO", the metallic layer 1 is denoted as "#1 Cr", the following dielectric or TCO layer - as "middle ITO", and the upper metallic layer 2 - as "top chrome". While the following examples present embodiments of a low-reflectance peripheral ring that employ particular materials (ITO and Chrome), it is understood that these are non-limiting examples and that the use of TCO materials and
25 metals in general for configuring a band of such peripheral ring is within the scope of the present application.

[00321] The goal in creating samples 1 through 3 was to form peripheral-ring thin-film coatings having a different low-reflectance values while maintaining a neutral color in reflection. The goal in creating the remaining samples 4 through 7 was to maintain a low level (of about 10 percent) reflectance
30 while varying the reflected color. Since the optical constants of a thin metallic film often deviate from those of a bulk metal, the transmittance value of the metallic layer 1 is provided for reference. Designs of samples 8-15 demonstrate that a low-level reflectance of the peripheral ring (about 7.5 percent) can be attained while varying the color of light reflected off the ring to the FOV in front of the rearview assembly. Maintaining the thickness of the top metallic layer 2 (for example, as shown, at 66%)
35 facilitates minimization of transmittance of the peripheral ring, thereby preserving its operation as a ring concealing the seal/plug of the EC element from exposure to incident ambient light. Reduction of the thickness of the metallic layer 2 ("top chrome") increases the transmittance of the thin-film stack 9 from essentially zero up to 1.8%), as shown in Table 10.

| Sample # | Base ITO | #1 Cr | Middle ITO | Top Chrome | Model Results | | | | Experimental Results | | |
|----------|----------|-------|------------|------------|-------------------------|-------------|------|-------|----------------------|------|-------|
| | | | | | #1 chrome transmittance | Reflectance | a* | b* | Reflectance | a* | b* |
| 1 | 67 | 5.4 | 59 | 66 | 30.0 | 4.7 | -0.3 | -0.1 | 4.2 | 0.5 | -2.6 |
| 2 | 56 | 11.5 | 50 | 66 | 13.4 | 10.2 | 2.3 | 0.0 | 13 | 0.4 | 2.1 |
| 3 | 155 | 7.6 | 71 | 66 | 22.0 | 15.0 | 0.0 | 0.0 | 15.1 | -4.5 | 2.4 |
| 4 | 102 | 7.2 | 60 | 66 | 22.9 | 10.0 | 0.0 | -15.0 | 10.3 | -3.8 | -14.5 |
| 5 | 138 | 6.6 | 51 | 66 | 25.0 | 11.2 | 0.6 | 15.0 | 9.5 | -3.6 | 9.4 |
| 6 | 81 | 3.0 | 69 | 66 | 45.6 | 10.0 | 15.0 | -15.0 | 12.6 | 11.7 | -7.9 |
| 7 | 140 | 4.0 | 37 | 66 | 38.0 | 10.6 | 14.0 | 14.0 | 9.3 | 20.3 | -1.9 |

Table 8

| Sample # | Base ITO | #1 Cr | Middle ITO | Top Chrome | #1 chrome transmittance | Reflectance | a* | b* |
|----------|----------|-------|------------|------------|-------------------------|-------------|------|------|
| 8 | 82 | 3.7 | 62 | 66 | 40.0 | 7.5 | 7.5 | 0.0 |
| 9 | 91 | 3.9 | 56 | 66 | 38.5 | 7.5 | 6.1 | 6.0 |
| 10 | 88 | 4.6 | 53 | 66 | 34.1 | 7.5 | 0.0 | 7.5 |
| 11 | 74 | 4.4 | 51 | 66 | 35.1 | 7.5 | -4.4 | 6.9 |
| 12 | 76 | 5.4 | 47 | 66 | 29.9 | 7.5 | -4.8 | 0.1 |
| 13 | 77 | 6.9 | 47 | 66 | 23.9 | 7.5 | -4.1 | -6.7 |
| 14 | 64 | 9.5 | 47 | 66 | 16.9 | 7.5 | 0.8 | -7.8 |
| 15 | 56 | 9.3 | 66 | 66 | 17.4 | 7.5 | 6.6 | -7.7 |

Table 9

| Sample # | Base ITO | #1 Cr | Middle ITO | Top Chrome | Transmittance | Reflectance | a* | b* |
|----------|----------|-------|------------|------------|---------------|-------------|------|------|
| 25 | 166 | 19.6 | 142 | 66 | 0.02 | 40.0 | 14.7 | 14.9 |
| 26 | 166 | 19.6 | 142 | 40 | 0.19 | 40.2 | 15.0 | 14.9 |
| 27 | 166 | 19.6 | 142 | 25 | 0.73 | 40.6 | 14.3 | 14.9 |
| 28 | 166 | 19.6 | 142 | 15 | 1.8 | 40.0 | 12.2 | 13.7 |

Table 10

| Sample # | Base ITO | #1 Cr | Middle ITO | Top Chrome | Reflectance | a* | b* |
|----------|----------|-------|------------|------------|-------------|-------|-------|
| 16 | 149 | 13.5 | 10 | 66 | 40.0 | 1.1 | 15.8 |
| 17 | 166 | 19.6 | 142 | 66 | 40.0 | 14.7 | 14.9 |
| 18 | 174 | 27.4 | 139 | 66 | 40.0 | 15.0 | 0.0 |
| 19 | 186 | 38.0 | 123.8 | 66 | 40.0 | 10.7 | -10.0 |
| 20 | 200 | 47.6 | 117.2 | 66 | 40.0 | 0.0 | -13.2 |
| 21 | 120 | 14 | 95 | 66 | 40.0 | -15 | -15.4 |
| 22 | 157.9 | 11.4 | 102.7 | 66 | 40.0 | -15.3 | 0.8 |
| 23 | 123 | 19.0 | 50 | 66 | 40.0 | -9.9 | 14.5 |
| 24 | 40 | 36.0 | 87 | 66 | 40.0 | -1.4 | 1.3 |

5 Table 10A.

[00322] Table 10A summarizes thin-film stacks for use in an embodiment of the peripheral ring that ensures reflection of ambient incident daylight light with efficiency of 40% (corresponding the common mirror standards employed in automotive industry) but with different colors. Here, the thickness of the first chrome layer was increased over the preferred ranges established for the low-reflectance peripheral ring examples discussed above.

[00323] In another embodiment, a low-reflectance band of a peripheral ring (which will appear dark to the observe during normal exploitation of the rearview assembly). In a specific implementation, a layer of Chromium employed in the peripheral ring can be doped with oxygen and nitrogen, for example during reactive sputtering of Cr with air. For better stoichiometry of the resulting deposited layer, both O_2 and N_2 can be introduced as reactive gases under independent control to enable ratios other than the native O_2/N_2 ratio of air (-78% N_2 , -21 % O_2). Experimentally-derived data showing a portion of the range of reflectance and colors (glass side) available by reactively sputtering Cr with air is shown in Table 11. Experimentally derived data showing a portion of the range of reflectance and colors (glass side) available reactively sputtering Cr with O_2 and N_2 is shown in Table 12. The sputtered Cr data in Tables 11 and 12 were obtained from a 5 x 22 in² Cr target sputtered at 3 kW (DC) at a standoff distance of - 3in and 3 passes at a substrate velocity of 24 inches per minute.

[00324] In another embodiment, a thin layer of Cr (base layer) was deposited onto the glass substrate, followed by a layer of air-doped Cr (referred to as "black Cr") was deposited onto the base layer (50/40 gas ratio, 3 kW, 2 Passes @ 24 ipm). A bulk layer of Cr (-630 Å) was then deposited onto the black Cr layer. The glass side reflectance and color of these black Cr stacks are given in Table 13. The base layer and bulk layer materials might be substituted with materials other than Cr to yield the same dark ring effect. Also, the doping of metals other than Cr may also yield similar dark rings.

30 Table 11: Cr reactively sputtered with air.

| Ar/Air (sccm) | Pressure (mTorr) | %Reflectance (glass side) | a* | b* |
|------------------|---------------------|------------------------------|------|------|
| 50/0 | 2.60 | 54.5 | -1.2 | -0.2 |
| 50/10 | 2.65 | 49.3 | -0.6 | 3.0 |
| 50/20 | 2.70 | 41.1 | 0.2 | 4.9 |
| 50/30 | 2.85 | 32.2 | 0.6 | 6.3 |
| 50/40 | 2.90 | 23.4 | 0.3 | 5.1 |

Table 12: Cr reactively sputtered with N_2/O_2 mixtures.

| Ar (sccm) | N_2 (sccm) | O_2 (sccm) | Pressure (mTorr) | %Reflectance (glass side) | a* | b* |
|--------------|-----------------|-----------------|---------------------|------------------------------|------|-----|
| 50 | 32 | 8 | 2.90 | 26.9 | 0 | 3.6 |
| 50 | 32 | 11 | 2.92 | 17.0 | -1.1 | 0.7 |

5 Table 13: Multilayer "black Cr" coatings.

| Ar (sccm) | Air (sccm) | Cr Base Layer (Å) | Pressure (mTorr) | %Reflectance (glass side) | a* | b* |
|--------------|---------------|----------------------|---------------------|------------------------------|------|-----|
| 50 | 40 | 25 | 2.90 | 25.2 | -0.5 | 2.8 |
| 50 | 40 | 12 | 2.90 | 21.7 | -0.2 | 4.3 |
| 50 | 40 | 8 | 2.90 | 21.5 | -0.4 | 4.0 |

[00325] Yet in another embodiment, Cr layer may be doped with carbon. The doping can be obtained through reactive sputtering in a similar manner to that described above. Cr can be sputtered with argon and a carbon source such as acetylene can be introduced as a reactive gas. The doping of the Cr layer can also be accomplished through ion-assisted deposition in which case the carbon will be provided via the ion source. In yet another method, a thin layer of Cr might be deposited and then implanted with carbon from an ion source. The thickness of the Cr layer would be limited by the energy of the implanting ion source due to the relationship between ion energy and implantation depth. Bulk Cr might then be deposited onto the carbon implanted Cr layer to make it opaque. As was described for the O_2/N_2 doped Cr, a thin base layer of Cr, or another adhesion or optical layer, might be deposited prior to the carbon doped layer and then that bilayer coating might be over-coated with an optically dense layer, such as Cr.

20 *Shaping the Peripheral Ring.*

[00326] When physical masking is employed during physical vapor deposition step of EC-element fabrication (such as, for example, sputtering of a peripheral ring), the deposited material layer is often caused to be non-uniform and have thickness that decreases towards the edge of mask, as schematically shown in Fig. 61A due to shadowing effects of the mask edge. In some peripheral rings this effect can lead to an observable artifact such as a dark or fuzzy edge or even a color shift at the edge of the coating attributed to the thickness change. To remove this unwanted artifact, embodiments of the present invention employ the combination of physical masking with laser ablation. Physical masking can have the advantage of speed and simplicity for patterning larger features of an EC-element. Laser ablation generally uses a laser beam focused into a very small spot and scanned (rastered) across an element being ablated. The time required for ablating large features can negatively impact the cycle time of a fabrication process. Nevertheless, combining these two methods can be synergistic. Physically masking off a portion of the area of interest during deposition can greatly reduce the area that must be later laser ablated thereby improving cycle time.

[00327] In one embodiment, a band of a peripheral ring of an EC-element can be fabricated by first employing a physical mask to create a crudely shaped open area (Fig. 61B) in the central portion of the substrate element, and then refining the crude shape of the formed peripheral ring with laser ablation

5 to yield the peripheral ring shaped according to the design and having sharp edges (Fig. 61C, 61D). One advantage of this approach is that the roughly-shaped thin-film pattern (Fig. 61B) formed by physical masking can be designed in such a way that several different finely-shaped patterns (similar to that shown in Fig. 61D) can be obtained by laser ablation of the rough shape. This allows to reduce the number of physical masks that have to be machined in order produce several different final peripheral ring shapes.

10 Another advantage of the combined manufacturing approach is that the visual edge quality of the chrome ring may be improved by the laser ablation finishing of the edges. In a specific embodiment, the outer circumference of the peripheral ring of Fig. 61D can be formed by laser ablation or by cutting of the substrate. In another embodiment, the rough mask might be an under-sized copy of the intended final shape so that the laser ablation step of manufacturing process serves only to remove a small amount of

15 material in order to clean the edge of the ring and improve its appearance.

[00328] The approach of laser ablation of the unwanted portion of the thin-film coating to yield the intended shape is easily applied to an EC-element a peripheral ring of which includes a "metal under TCO" combination. Here, the TCO is deposited onto the substrate before the metallic layer of the peripheral ring. Laser ablation of the metallic layer of the peripheral ring with the use of a typical

20 marking laser is likely to partially remove or damage the TCO layer. Such damage may adversely impact the performance of the EC-element. In this instance, the use of a specialized, pico-second pulsed laser is preferable. It was shown that a Trumpf sourced, green, pico-second laser is capable of removing the metallic layer of the peripheral ring without damaging the underlying TCO layer. The pulsed laser beam was directed through the glass and through the TCO layer prior to impinging upon the metallic layer. The

25 laser beam does not interact with the glass or TCO since either is transparent in the green (~500 nm) portion of the optical spectrum. In addition, energy pulses are delivered to the metallic coating on a short enough time scale, and there is not enough time for significant energy to propagate into the layers adjacent to the layer being ablated before the pulse is over. This enables the removal of the metallic layer of the peripheral ring from the surface of the TCO without significant damage to the TCO.

30 [00329] Fig. 62 shows an SEM image of the edge of a multilayer metal coating that was removed from the surface of an ITO layer without damaging the ITO. The ITO in the ablated area was analyzed by spectroscopic ellipsometry and compared to a control ITO layer that has not been overcoated with a metallic layer and not subjected to laser ablation. The refractive index of a TCO material (such as ITO) relates to the electrical conductivity of the TCO. The ellipsometry analysis showed the two ITO

35 layers to be equivalent. Sheet resistance measurements of the two ITO layers were also equivalent.

[00330] In carrying out the ablation of a metallic coating on a glass substrate, it was observed that the results were dependent on whether the laser beam was delivered to the coating directly or through the glass substrate. In the former case, there usually remained metal residue on the glass which, in the case of an actual EC-element, can lead to optical absorption and/or scattering. In the latter case, however, the

40 ablated surface was significantly cleaner with no visible residue by optical microscopy. (Under these conditions, however, some damage to the surface of the glass could be produced on a size scale

5 observable under optical microscopy and visible to the eye as subtle haze. Optimization of the laser power, frequency and motion velocity enabled minimization of the surface damage to the glass.)

Adaptability of the Perimeter Portion of the EC-based Mirror Element to Glare Reduction

10 **[00331]** The problem of glare, arising when driving at night, is well recognized in the field of vehicular rearview assemblies. This problem has been substantially addressed with respect to the portion of the assembly, the optical properties of which are controllable and where an EC-element is caused to reduce its effective reflectance value, perceivable from the front, in response to a signal from the glare sensor. However, a peripheral region of the EC-element-based mirror that is associated with a peripheral
15 ring of the EC element is passive and, therefore, not operable to change its optical characteristics. As a result, industry and related art give no credence to and are practically silent about attempting to use the passive peripheral (perimeter) portion of the EC-element-based mirror element in addressing the problem of glare. We have discovered, however, that optimization of response of the EC-element-based rearview mirror assembly to lighting conditions over the whole clear aperture of the EC-element can be achieved
20 by specifically configuring the peripheral ring of the EC-element. According to embodiments of the invention, the glare caused by light reflection from the perimeter portion of the EC-element-based vehicular mirror is optimized by configuring the thin-film stack of the peripheral ring such as to achieve a compromise in optical characteristics of the peripheral ring under both the photopic and scotopic lighting conditions.

25 **[00332]** Photopic vision is generally understood as human vision in daylight, well-lit conditions (luminance levels of about 1 to about 10^6 cd/m²), that is defined primarily by on the function of the retinal cone receptor cells. In comparison, scotopic vision is vision in low illumination occurring at luminance levels of about 10^{-2} to about 10^{-6} cd/m² and defined primarily by the function of the retinal rod receptor cells. The photopic visual response curve has a peak at about 55 nm or so, while the scotopic visual
30 response curve is spectrally shifted, with respect to the photopic curve, towards the shorter wavelengths by about 50 nm. Human vision in transitional, intermediate lighting conditions is known as mesopic vision and is effectively a combination of scotopic and photopic vision. Visual acuity and color discrimination of the human vision under mesopic illumination conditions is known to be rather inaccurate. Typical scotopic and photopic spectral responses of a human eye are well known and are not
35 discussed in this application.

[00333] Owing, in part, to temporal asymmetry of the rate of accommodation of the eye to changing illumination conditions, a glare-reduction benefit that a particular passive reflector is thought to provide under low-illumination conditions can be substantially nullified by the change of illumination when the headlights of the following car strike the rearview mirror. While counterintuitive and surprising,
40 this effect is rather straightforward to rationalize. Indeed, accommodation of the eye to change of lighting conditions is asymmetric: it takes minutes to transition from high to low levels of illumination, while

accommodation in reverse takes significantly shorter time. If a passive reflector (such as, for example, the annular peripheral ring corresponding to the perimeter portion of the EC-element) is designed to assure low levels of reflectance (i.e., a reduced glare) under low illumination conditions (i.e., as perceived by an eye that has adapted to scotopic vision), the abrupt change of the eye's vision from scotopic to photopic may result in perceiving the levels of light reflectance from the passive reflector as being excessively high, thus actually worsening the perceived glare in comparison with that for which the reflector has been designed. In other words, the passive reflector designed to ensure low reflectance levels as perceived by the scotopically-adjusted eye, may produce prohibitively excessive reflectance as perceived by an eye in a photopic mode. It is appreciated that such effect also depends, in part, on the spectral content of incident light and, therefore, depends on the type of the light source used in the headlights of a vehicle producing the glare in the rearview mirror at hand.

[00334] Table 13A summarizes the integrated reflectance values (Y) describing the optical performance of the thin-film coating samples listed in Table 10A for the two modes of vision, photopic and scotopic, and under illumination produced by different light sources. The design of every listed coating sample was optimized to achieve a 40% reflectance value under illumination typical for daylight conditions (D65 standard illuminant) as perceived by a 10-degree observer. The plurality of light sources considered includes, in addition to the D65 standard illuminant, the standard illuminant A (corresponding to incandescent headlights), the HID light source (standard high-intensity discharge headlights), and standard LED headlights. Because spectral contents of light produced by these light sources differ, the corresponding integrated reflectance values vary as well. The presented averaged, over the types of light sources, reflectance values attend to the fact that under actual driving conditions the driver is likely to be exposed to light from every type of the headlights. Figs. 64A and 64B show how the averaged reflectance levels vary as a function of color of the reflected light (expressed in CIELAB terms of L*, a*, and b*) and, in reference to Figs. 64A, 64B, conclusions about the optimal structure of the EC-element based vehicular rearview reflector can be made.

| Sample # | Headlight Effects | | | | | | | | | |
|--|--------------------|------|------|------|----------|------|------|------|----------|----------|
| | Photopic 10 Degree | | | | Scotopic | | | | Photopic | Scotopic |
| | D65 | A | HID | LED | D65 | A | HID | LED | Average* | Average* |
| 16 | 40.0 | 41.7 | 41.6 | 41.1 | 34.5 | 36.6 | 36.2 | 34.9 | 41.5 | 35.9 |
| 17 | 40.0 | 43.7 | 42.5 | 41.4 | 31.1 | 32.9 | 33.0 | 32.5 | 42.5 | 32.8 |
| 18 | 40.0 | 42.3 | 41.1 | 40.5 | 36.0 | 36.0 | 36.4 | 37.1 | 41.3 | 36.5 |
| 19 | 40.0 | 40.6 | 39.7 | 39.6 | 41.6 | 39.9 | 40.5 | 41.7 | 40.0 | 40.7 |
| 20 | 40.0 | 38.5 | 38.0 | 38.5 | 46.2 | 43.9 | 49.0 | 45.4 | 38.3 | 46.1 |
| 21 | 40.0 | 35.5 | 36.4 | 37.5 | 51.0 | 48.0 | 48.0 | 49.0 | 36.5 | 48.3 |
| 22 | 40.0 | 37.5 | 38.3 | 38.9 | 44.5 | 44.3 | 43.9 | 43.0 | 38.2 | 43.7 |
| 23 | 40.0 | 39.7 | 40.1 | 40.0 | 38.3 | 39.8 | 39.0 | 37.8 | 39.9 | 38.9 |
| 24 | 40 | 39.9 | 39.9 | 39.9 | 40.2 | 40.2 | 40.1 | 40 | 39.9 | 40.1 |
| * No Daylight (D65) Conditions factored into Average | | | | | | | | | | |

Table 13A.

5

[00335] For example, during the scotopic illumination conditions (after the dusk and during night-time), the EC-part of the rearview mirror quickly reduces its reflectance in response to the bright headlights and prevents the driver's eye from shifting its sensitivity to the photopic mode. The low levels of reflectance (between approximately 35% and 60%, preferably between 35% and 55%, and more preferably between 35% and 50%) that are required to result from the operation of the rearview mirror as a whole (i.e., a combination of the scotopically-optimized peripheral ring and the EC-element) in low illumination conditions dictate, in reference to Fig. 64B, such a structure of the the scotopically-optimized peripheral ring that ensures the color of reflected light to have $a^* > 0$ and $b^* > 0$. In a specific embodiment, the scotopically-optimized peripheral ring should be configured to ensure that reflected light has a^* and b^* value that lie above the line $a^* = -b^*$ on the color-map of Fig. 64B.

[00336] On the other hand, and in further reference to Figs. 64A and 64B, during the operation under high-level illumination (bright day light), the peripheral ring the structure of which is optimized for scotopic vision will produce higher levels of reflection than the peripheral ring the structure of which is optimized for photopic vision. In a photopic-vision environment, therefore, it is preferred to configure the rearview assembly such as to equip the EC-element with a peripheral ring reflecting the incident light at the specific levels of reflectance listed above and with the spectral content described by the negative values of a^* and b^* . In a specific embodiment, the EC-element-based rearview assembly optimized for operation under daylight conditions should have a peripheral ring that, in reflection, produces light the spectral characteristics of which correspond to the portion of the color-map of Fig. 64A that lies below the line $a^* = -b^*$.

[00337] A practical design of the peripheral ring thin-film coating, from the glare reduction point of view, should ensure, therefore, that the reflectance of the peripheral ring portion of the EC-element-based mirror perceived by either the scotopically- or photopically-adapted eyes remains within the specified limits. Fig. 65 shows preferred color characteristics of light reflected by such practical thin-film structure. It is preferred that the thin-film structure of the peripheral ring is configured to reflect light with efficiencies of (between approximately 35% and 60%, preferably between 35% and 55%, and more preferably between 35% and 50%) and color described by a^* and b^* values corresponding to the portion of the color-map of Fig. 65 defined between the limits $a^* = -b^* + 15$ and $a^* = -b^* - 15$.

Optimization of Choice of Materials for Reflectance Enhancement.

[00338] Earlier in this application described was a means of increasing the reflectance of a portion of the peripheral ring with the use of high reflectance (HR) metallic layers by disposing them directly on a TCO, dielectric or another other layer, directly on glass substrate, or an optional adhesion-enhancement layer that may be present on the glass surface. The high reflectance metals appropriate for such a purpose are defined based on their bulk reflectance properties and, to a large extent, their intrinsic color.

- 5 Preferably the high reflectance metal should have a neutral color so that ambient light reflected from the resulting peripheral ring substantially matches in color the light reflected from the central portion of the mirror element. Table 14 below illustrates the reflectance values characterizing various metallic 3 nm-thick layers deposited on and viewed through the glass substrate and comparisons of these reflectance values and color of reflected ambient light with that of the glass substrate itself.

10

| Material | Reflectance | a* | b* | Delta R | Delta a* | Delta b* |
|--------------------|-------------|------|------|---------|----------|----------|
| glass | 7.9 | -0.2 | -0.6 | | | |
| 3nm cobalt | 5.8 | -0.1 | 0.0 | -2.2 | 0.1 | 0.6 |
| 3 nm chrome | 6.3 | -2.0 | -2.3 | -1.7 | -1.8 | -1.7 |
| 3 nm iridium | 6.7 | -0.9 | 0.7 | -1.3 | -0.8 | 1.2 |
| 3 nm Mo | 5.4 | -2.9 | -1.2 | -2.6 | -2.7 | -0.7 |
| 3 nm Ag with 7% Au | 11.0 | 1.3 | 4.1 | 3.1 | 1.5 | 4.6 |
| 3nm Au | 7.8 | 0.8 | 9.2 | -0.2 | 0.9 | 9.8 |
| 3nm Cd | 8.5 | -0.5 | -0.4 | 0.5 | -0.3 | 0.2 |
| Cu 3nm | 6.9 | 5.1 | 3.7 | -1.1 | 5.3 | 4.3 |
| 3n 5050 SnCu | 6.7 | -0.1 | 0.6 | -1.2 | 0.0 | 1.2 |
| 3nm 5050 CuZn | 7.5 | 1.0 | 4.7 | -0.4 | 1.2 | 5.3 |
| 3nm Nb | 4.2 | -0.1 | -1.3 | -3.7 | 0.1 | -0.7 |
| 3nm Pd | 6.5 | 0.3 | 0.6 | -1.4 | 0.5 | 1.1 |
| 3nm Ru | 10.5 | 0.4 | -0.1 | 2.5 | 0.6 | 0.4 |
| 3nm Pt | 5.5 | 0.2 | 0.5 | -2.4 | 0.3 | 1.0 |
| 3 nm Rhenium | 5.8 | -1.5 | -4.7 | -2.2 | -1.3 | -4.1 |
| 3 nm Rh | 7.7 | 0.7 | 0.3 | -0.3 | 0.9 | 0.9 |
| 3 nm Ta | 5.1 | -0.2 | -0.2 | -2.9 | 0.0 | 0.4 |
| 3 nm Ag | 10.3 | 1.2 | 3.7 | 2.4 | 1.4 | 4.3 |
| 3nm Al | 19.9 | 0.2 | 3.5 | 11.9 | 0.4 | 4.0 |

Table 14.

- 15 [00339] Table 15 illustrates values of real and imaginary parts of the refractive indices at 550 nm for various metals.

| Metal | n @550 nm | K @550 nm |
|-------------|-----------|-----------|
| Ag | 0.136 | 3.485 |
| AgAu7x | 0.141 | 3.714 |
| Al | 0.833 | 6.033 |
| Al:Si 60:40 | 3.134 | 4.485 |
| Al:Si 90:10 | 1.244 | 4.938 |
| Al:Ti 50:50 | 2.542 | 2.957 |
| Al:ti 70:30 | 2.885 | 3.392 |
| Au | 0.359 | 2.691 |
| Cd | 1.041 | 4.062 |
| Co | 2.053 | 3.826 |

| | | |
|------|-------|-------|
| Cr | 2.956 | 4.281 |
| Cu | 0.958 | 2.577 |
| CuSn | 1.871 | 4.133 |
| CuZn | 0.587 | 2.854 |
| Ge | 3.950 | 1.975 |
| Ir | 2.229 | 4.314 |
| Mo | 3.777 | 3.521 |
| Nb | 2.929 | 2.871 |
| Ne | 1.772 | 3.252 |
| Pd | 1.650 | 3.847 |
| Pt | 2.131 | 3.715 |
| Re | 4.253 | 3.057 |
| Rh | 2.079 | 4.542 |
| Ru | 3.288 | 5.458 |
| Ta | 3.544 | 3.487 |
| Ti | 1.887 | 2.608 |
| V | 3.680 | 3.019 |
| w | 3.654 | 3.711 |
| Zn | 1.117 | 4.311 |
| Zr | 1.820 | 0.953 |

Table 15.

[00340] It is known by one skilled in the art that refractive index of a given metal and dispersion of refractive index are dependent on the process and deposition parameters used to produce the coating and that a deposition processes can be optimized to slightly modify optical constants of a particular metal.

The difference between material properties of thin metallic films as compared to bulk (or thick film) metals has limited the use of metals, at least in applications related to automotive rearview mirror assemblies, to substantially thick metallic layers where the optical properties are more predictable and consistent with the "bulk"-metal behavior. The data of Table 14 suggest that, generally, metals would not be optimal materials for increasing the reflectance of other metals or, if such a possibility exists, then at least the increase in reflectance may not be accompanied with a neutrality of color. As a result, the use of thin metallic film for reflectance-enhancement of multi-layer stacks has been substantially limited.

[00341] The following describes an attempt to formulate a generalized approach of determining which metals can be reliably used for enhancing the reflectance of a simple structure comprising a chosen metallic material (referred to hereinafter as a base metal) carried by a thick glass superstrate that acts as incident medium. In particular, such reflectance-enhancing (RE) metallic layers are considered to be disposed on a second surface of the thick glass superstrate and the base metal. The change in reflectance is being considered in light incident onto the metallic layers through the glass superstrate and reflected back to the first surface. The generalized approach is determined based on considering the relationships, between the real and imaginary parts of refractive indices for several base metals and several 3 nm thick

- 5 RE-metallic layers, that allow for increase in reflectance at issue. The D65 Illuminant and 10 degree observer color standards were used for all calculations.

[00342] *Example 1:* Environmentally stable and low-cost Chromium is used as the base metal. A thin film program was used to calculate the resultant color and reflectance of light for the different 3 nm-thick RE-metallic layers. The results are summarized in Table 16.

10

| Structure | Reflectance | a* | b* |
|--|-------------|------|------|
| Reference (Glass + chrome base layer) | 52.3 | -1.9 | -0.7 |
| Reference + RE-layer made of... | | | |
| cobalt | 54.3 | -1.6 | 0.5 |
| chrome | 52.3 | -1.9 | -0.7 |
| iridium | 54.8 | -1.8 | 0.6 |
| Mo | 50.1 | -1.4 | 1.5 |
| Ag with 7% Au | 57.4 | -1.7 | -0.3 |
| Au | 54.7 | -2.1 | 2.1 |
| Cd | 56.7 | -1.7 | -0.6 |
| Cu | 54.4 | -1.3 | 0.3 |
| SnCu 5050 | 55.2 | -1.7 | 0.2 |
| CuZn 5050 | 55.0 | -1.7 | 0.9 |
| Nb | 50.9 | -1.4 | 1.4 |
| Pd | 55.2 | -1.6 | 0.3 |
| Ru | 54.9 | -1.6 | 0.2 |
| Pt | 53.9 | -1.6 | 0.8 |
| Rhenium | 47.6 | -1.2 | 4.3 |
| Rh | 55.7 | -1.4 | 0.4 |
| Ta | 50.2 | -1.6 | 2.1 |
| Ag | 56.9 | -1.7 | -0.2 |
| Al | 62.2 | -1.5 | -0.9 |
| Al:Si 60:40 | 53.2 | -1.6 | 0.3 |
| Al:Si 90:10 | 58.3 | -1.7 | -0.3 |
| Al:Ti 50:50 | 51.8 | -1.7 | 0.9 |
| Al:Ti 70:30 | 51.7 | -1.6 | 1.3 |
| Ge | 47.4 | -1.9 | -1.1 |
| Ni | 53.8 | -1.7 | 0.8 |
| Ti | 52.7 | -1.8 | 0.4 |
| W | 49.2 | -1.7 | 3.1 |
| V | 49.4 | -0.7 | 0.8 |
| Zn | 56.7 | -3.1 | -1.1 |
| Zr | 51.7 | -1.9 | -0.7 |

Table 16.

[00343] Fig. 30A graphically shows a corresponding change in reflectance of the considered structures of Table 16 with n (real part of the index of the RE-metal, x-axis) and k (imaginary part of the index of RE-metal, y-axis). The dots on the graph represent the reflectance values for the different RE-metals. The contour lines represent contours of iso-reflectance. The dashed line represents a contour approximately describing the reference structure of Table 16. The use of metals having n and k values falling to the right of the dashed reference line as RE-metals leads to decrease of the reflectance value of the structure, while the use of metals with n and k values falling to the left of the dashed reference line leads to the overall increase in reflectance. Based on the dashed reference iso-contour, the condition on RE-metals assuring the increase in reflectance of the reference structure of Table 16 is $k-1.33n>0.33$.

It is understood that when a metal satisfying the above equation is used as a RE-layer added to the reference structure, the increase of the RE-layer thickness above 3 nm will only further increase the overall reflectance. Generally, therefore, the thickness of the RE-metallic layer should be greater than about 1 nm, preferably greater than about 3 nm, more preferably greater than about 5 nm and most preferably greater than about 10 nm. As noted above there may be other layers between the reflectance enhancement layer and the substrate.

[00344] Similarly, two additional examples have been considered: Example 2 with CuSn alloy (50:50) as the base metal, and Example 3 with Ta as the base metal. Table 17 and Fig. 30B present results for Example 3, while Table 18 and Fig. 30C summarize the results for Example 4.

| Structure | n | k | R | a^* | b^* |
|-------------------------------------|-------|-------|------|-------|-------|
| Reference (Glass + CuSn base layer) | 1.871 | 4.133 | 60.0 | -0.4 | 3.2 |
| Reference + RE-layer made of... | | | | | |
| AgAu7x | 0.141 | 3.714 | 65.4 | -0.4 | 3.3 |
| Al:Si 90:10 | 1.244 | 4.938 | 64.1 | -0.5 | 2.7 |
| Cr | 2.956 | 4.281 | 56.2 | -0.2 | 1.5 |
| Ge | 3.950 | 1.975 | 50.3 | 0.1 | 2.3 |
| Ru | 3.288 | 5.458 | 56.7 | -0.6 | 2.3 |
| Ta | 3.544 | 3.487 | 52.4 | 0.2 | 5.4 |
| Ti | 1.887 | 2.608 | 58.1 | -0.3 | 4.0 |
| V | 3.680 | 3.019 | 57.3 | 0.4 | 2.5 |
| Zr | 1.820 | 0.953 | 58.4 | -0.4 | 3.0 |

Table 17

| Structure | n | k | R | a* | b* |
|--------------------------------------|-------|-------|------|------|-----|
| Reference (Glass + Ta base metal) | 3.544 | 3.487 | 46.6 | 0.2 | 3.7 |
| Reference + RE-layer made of ... | | | | | |
| AgAu7x | 0.141 | 3.714 | 51.9 | 0.1 | 4.0 |
| Al:Si 90: 10 | 1.244 | 4.938 | 53.6 | -0.1 | 3.1 |
| Cr | 2.956 | 4.281 | 49.2 | -0.3 | 1.9 |
| CuSn | 1.871 | 4.133 | 50.6 | 0.0 | 3.4 |
| Ge | 3.950 | 1.975 | 42.9 | 0.1 | 1.0 |
| Ru | 3.288 | 5.458 | 51.3 | -0.2 | 2.1 |
| Ti | 1.887 | 2.608 | 47.7 | 0.2 | 3.6 |
| V | 3.680 | 3.019 | 47.6 | 0.4 | 2.2 |
| Zr | 1.820 | 0.953 | 46.3 | 0.1 | 3.2 |

Table 18

[00345] The reflectance iso-contour for Example 2 in Fig. 30B is at 60% reflectance and is described by the equation $k=3.919*n-3.6129$. The higher reflectance is attained when the following condition is met: $k-3.919*n \geq -3.6129$. The reflectance iso-contour for Example 3 in Fig. 30C is at 46.6%. The equation for this contour is estimated to be $k=0.8452*n+0.1176$. The condition for enhanced reflectance is $k-0.8453*n \geq 0.1176$.

[00346] Further, values of slopes of the above three linear dependences and values of k corresponding to $n=0$ (the intercept of the y-axis) were plotted against values of n to obtain Figs. 90A and 90B, where discrete results are fitted linearly (Figs. 31A and 31B) and quadratically (Fig. 31B). The obtained fits are as follows: slope = $7.362-1.911*n$; linearly fit intercept = $2.413*n-7.784$ and the quadratically fit intercept = $-23.7+15.23*n-2.401*n^2$. Based on these generalized fits, the estimate of the coefficients of the equation necessary to define the optical constants for the RE- metals can be performed.

[00347] The appropriate materials for reflectance enhancement taught above are defined for systems with a relatively high refractive index superstrate. Float glass or plastic, for instance, have a relatively high refractive index relative to air. That is why the thin metals, as taught above, act as anti-reflection layers when in contact with, and viewed through, a high index superstrate. A similar behavior occurs with other superstrate materials such as Electrochromic fluid or gel. The EC fluid or gel has a high refractive index relative to air and that is why the reflectance of an EC element is substantially lower than the reflectance of the mirror metalized glass. A mirror system described herein, comprising a first lite of glass with a first and second surface, a transparent electrode arranged on the second surface such as ITO, a second lite of glass with a third and fourth surface, a reflective metal system comprising a first layer of chrome on the third surface and a second layer of ruthenium on the chrome layer with a perimeter seal that forms a chamber between the two lites of glass. The chrome/ruthenium coated glass has a reflectance of about 70% when measured with air as a superstrate and about 57% in the EC configuration.

5 Much of the reflectance drop is due to the high refractive index of the EC fluid being in contact with the ruthenium layer.

[00348] Various metals have been taught in the art that exhibit high reflectance and are electrochemically stable in an Electrochromic device. For instance, silver alloys, such as silver gold, or other noble metals such as platinum or palladium have been described in the Electrochromic art. There have been a limited number of viable metals taught in the art due to the combined requirement of high reflectance and electrochemical stability. For instance, as taught in U.S. 6,700,692, the metals must have a sufficient electrochemical potential to function satisfactorily as an anode or cathode in a fluid based electrochemical device. Only noble metals, Au, Pt, Rh, Ru, Pd have demonstrated sufficient reflectivity and electrochemical stability. The prior art references that alloys may be viable but no methods are described that can be used determine which alloys may be viable from a reflectance perspective. The formula described above can be used to target the viable noble metals alloys that will increase the reflectance of a base metal in an electrochromic device. The structure of the coatings on the 2nd lite of glass would be glass/base metal/reflectance enhancement noble metal alloy/ viewer. The formula taught above demonstrates a way to select improved metal alloys that include noble metals that are suitable for Electrochromic devices.

[00349] The previous teaching around the use of noble metals in Electrochromic devices relies on the combination of electrochemical stability and high reflectivity that the noble metals possess. Other metals, other than aluminum, haven't been proposed because they do not have sufficient reflectivity and electrochemical stability. Aluminum has been proposed, but has not been realized practically as a third surface electrode because it does not have sufficient electrochemical stability in a fluid based EC device. Other metals or alloys have not been employed in Electrochromic devices because it is believed that they do not have the necessary reflectivity and electrochemical stability. The discovery described above, where a metal with a newly defined refractive index characteristic can increase the reflectance of a base metal, enables a new class of metals, alloys and materials to be considered for use in Electrochromic mirrors and devices. The REM should increase the reflectance of the base metal by at least 2 percentage points, i.e., 50 to 52%, preferably increase the reflectance by about 5%, more preferably by about 7.5% and most preferably by greater than about 10%.

[00350] The refractive index characteristic is insufficient because there is no correlation between this characteristic and the electrochemical potential characteristics. If the REM is doped or alloyed with a noble metal it would fall within the improvements for the noble metal alloys defined above. The REM may be employed in a thin film stack in an intermediate location by the application of a capping layer with sufficient electrochemical properties. The capping layer may be a noble metal, or alloy of a noble metal or may be a transparent conduction oxide such as ITO, IZO or the like described elsewhere in this application. The capping layer, if it does not have a refractive index as defined with our new equation will reduce the reflectance of the REM. This has obvious disadvantages and therefore the capping layer must be relatively thin otherwise there will be no reflectance increase attained from the REM. The

5 capping layer, if it does not meet the criteria for reflectance enhancement, will decrease the reflectance to a greater degree in an opposite manner to which the refractive index will increase the reflectance. Therefore, layers with large real parts of the refractive index and low parts of the imaginary refractive index will decrease the reflectance the greatest. Obviously, as taught above the relative change in the reflectance is a function of the relative refractive indices between the two metals. The amount of change
10 for a given thickness of film (such as 3 nm, for example) can be estimated from the newly developed formulae. Preferably, a capping layer with noble characteristics should reduce the reflectance by less than 5%, more preferably less than 2.5% and most preferably less than 1.5%. The thickness of the capping metal layer with noble characteristics necessary to maintain these reflectance changes will vary with the refractive index properties of the REM but should be less than about 4 nm, preferably less than about 3
15 nm and most preferably less than about 2 nm. A TCO-based capping layer may meet the reflectance requirements at up to a 30 nm thickness.

Silver Alloys for Corrosion Resistance

20 [00351] High reflectivity of silver makes this material particularly useful for mirrors and EC-mirrors. Specifically, in applications where a central portion of the mirror inside the peripheral ring has reflectance values greater than 60%, more preferably greater than 70% and most preferably greater than about 80%, and where matching of the ring's reflectance value to that of the central portion of the mirror is required, it is advantageous to use high-reflectance Ag-based materials for in a thin-film stack of the
25 peripheral ring instead of Chrome and noble metals. Generally, the quality requirements for a peripheral ring are more stringent than those for a 3rd surface reflector because all portions of the peripheral ring are visible to the user while portions of the 3rd surface reflector next to electrical buss connections are hidden from the view and, therefore, allow for minor metal degradation and corrosion. Therefore, not only must the seal and electrical connections adjoining the peripheral ring be maintained in environmental tests but
30 the visual appearance of the peripheral-ring coating must be maintained. Silver has limited corrosion resistance and electrochemical stability that in the past limited its use as a 3rd surface reflector electrode in EC-mirror systems. Later, dopants and stabilizing layers have been proposed and commercialized that were claimed to increase both the resistance of silver to CASS testing (from a chemical durability perspective) and its electrochemical stability (from a device electrical cycling perspective). For example,
35 a commonly-assigned U.S. 6,700,692 generally taught that platinum-group metals (such as, for example, Pt and Pd along with Au) were the preferred dopants for Ag, and that noble metals (such as, for example, Ru, Rh and Mo) were preferred materials for stabilization layers. No specific examples were offered by the related art, however, that pertain specifically to the dopants alone and their effect on chemical or environmental durability of Ag. Prior art simply implied that addition of the platinum-group metals to the
40 silver layer provides the electrochemical stability while the use of stabilization layers below (and/or above) the silver provide the CASS resistance.

5 **[00352]** We discovered non-obvious solutions that allow for substantial improvement of the durability of Ag and Ag-alloys through the use of alternate dopants and without the use of stabilization layers. The basic structure of an underlying embodiment included Glass / ITO (125 nm) / silver or silver alloy (50 nm) / ITO (15 nm). Fully assembled EC-elements were run through the CASS testing and steam testing, while epoxy-sealed EC-cells without EC-medium were subjected to blow tests. Testing
10 conditions were as follows: CASS testing was performed according to recognized industrial standards. In the steam tests the parts are held in an autoclave at approximately 13 psi and 120 C in a steam environment and checked once a day until failure. In the case of CASS two failure modes are noted - coating degradation and seal integrity. In the case of the steam tests, only seal failure is reported. In the blow test, a hole is drilled in a part, the part is gradually pressurized until failure occurs, and the pressure
15 at failure is noted. A number of failure modes are possible in the Blow test but in this example, adhesion of the coating materials to the glass, adhesion of the coating materials to each other and adhesion of the coating materials to the epoxy are the failure modes of most interest.

[00353] Table 19 shows the CASS, Steam and Blow results, obtained with multiple samples, for pure silver and different silver alloys. The average values are presented for the Steam and Blow tests,
20 while results of the CASS tests are expressed in days to failure. It is believed that ability of a material to survive approximately 2 days without coating damage (in CASS test) is sufficient for most vehicle interior applications. All CASS tests were stopped at 17 days or 400 hours, which corresponds to a relatively long exterior vehicle test. Depending on the application the CASS requirement may vary between these two extrema. The pure silver has the worst performance in the steam test, relatively poor
25 CASS results, and relatively poor adhesion in the blow tests that demonstrated substantial intra-coating delamination. Samples made with the traditional dopants, Pd, Pt and Au, are also shown in Table 19. Improvements are demonstrated for the steam and blow tests relative to the pure silver but the CASS results are still not adequate. Similarly, the Agin alloy has improved properties in Steam and Blow but the CASS results are improved but not adequate for all applications.

30 **[00354]** Silver alloys known as Optisil™ (supplied by APM Inc.) were also evaluated. Three versions, 592, 595 and 598 were tested. The compositions are shown below in Table 20. Each version demonstrates substantial improvement relative to the pure silver with the Optisil 598 showing the best performance. The Optisil 598 has some coating lift in the blow tests but percentage of coating lift was very small and this also corresponded with the highest average blow value. Therefore, even though some
35 lift is present, the results do not show significant failure mode for this material. The Optisil materials are viable for interior vehicle applications and some are viable for external applications also. A number of sterling silver alloys were tested. The specific compositions, based on analysis of the sputtering targets, are shown in Table 16. These particular alloys show substantial improvement over the pure silver. The Sterling "88" and 51140 alloys had the best performance of the group with the 51308 and Argentium
40 having lesser performance. In the Optisil family, the lower levels of Cu and Zn provide better CASS resistance. For the Argentium, the copper and germanium additions help improve the CASS resistance.

- 5 The "Sterling" samples benefited from the addition of copper (all), zinc and Si (88 and 51308) and Sn (51308).

| Material | Days to Failure (Results are for all parts in test unless noted) | | | | Blow PSI |
|-----------------------|---|--|----------------------|-------------------------|-------------------|
| | CASS Coating | CASS Seal | Steam Day-To-Fail | Steam % Coating lift | |
| Ag99.99% | 1 (1 part ok to day 12) | 1 (1 part ok to day 12) | 4.3 | 30 | 31.2 [#] |
| Optisil 592 | 5.5 (2 part average) (2 parts ok to day 17) | 15 | 20.5 | 0.8 | 32.4 |
| Opti 595 | 17 | 17 | 20.2 | 15.8 | 30.1 |
| Optisil 598 | 17 | 17 | 24.3 | 0.83 | 41.5 [#] |
| 83Ag/17In | 1 | 6.25 | 19.7 | 0 | 37.0 |
| Ag94/Pt6 | 1 | 1 | 18.7 | 4.2 | 35.2 [#] |
| Ag96/Pd3 | 1 | 1 | 12.2 | 86.7 | 39.4 [#] |
| Argentium sterling | 1 (2 part average) (2 parts ok to day 17) | 5.5 (2 part average) (2 parts ok to day 17) | 27.3 | 0 | 38.1 [#] |
| Sterling "88" | 17 | 9 (2 part average) (2 parts ok to day 17) | 21.3 | 0 | 28.5 |
| Sterling 51140* | 7 (1 part) (3 parts ok to day 17) | 7 (1 part) (3 parts ok to day 17) | 23.7 | 0 | 32.1 |
| Sterling 51308 | 8 | 8 | 20.7 | 8.3 | 34.6 |
| Ag93/Au7 | 1 | 1.33 | 13.3 | 25.8 | 29.2 [#] |
| Ag16Au | 2 | 2 | 18.3 | 22.5 | 30.2 |
| Ag76/Au24 | 1 | 1.33 | 11.3 | 95.8 | 40.5 |

10

* These parts had some suspended data in steam tests, therefore actual average is higher than reported values

*These part had some intra-coating adhesion failures

Table 19

Silver Alloy Compositions

| Name | Ag | Cu | Ge | Zn | Sn | Si | Au | In |
|----------------|-------|-------|-------|-------|--------|--------|--------|----|
| Argentium | 91.73 | 6.879 | 1.329 | | | | | |
| Sterling 51308 | 92.76 | 2.775 | | 4.194 | 0.1097 | 0.0894 | 0.0153 | |
| Sterling 51140 | 92.18 | 7.779 | | | | | | |

| | | | | | | | | |
|--------------------|-------|--------|--|--------|--------|--------|---------|--------|
| Sterling 88 | 92.49 | 5.5403 | | 1.8833 | | 0.0422 | | |
| Optisil 598 | 98.24 | 1.134 | | 0.4805 | | 0.088 | | |
| Optisil 595 | 95.04 | 2.761 | | 1.892 | 0.0573 | 0.2066 | | |
| Optisil 592 | 92.95 | 4.767 | | 2.064 | 0.1183 | 0.0577 | | |
| Ag/In | 82.82 | 0.0124 | | 0.0056 | | | 0.01 14 | 17. 13 |

Table 20

[00355] Degradation of a material usually occurs in multiple ways, and there are often multiple possible protection pathways and the different elements doped into or alloyed with the silver can act to stabilize the metal thus improving its performance. The different silver alloys may contain one or more elements that act on one or more of the protection pathways to stabilize the silver. Silver often degrades by migration into a lower energy state. The silver atoms are 100 times more mobile along the boundary of an Ag-grain than within the bulk of the grain. Therefore, addition of an element migrating to the Ag-grain boundary and inhibiting the mobility of the silver is expected act to improve the durability of Ag. Metals such as Ti and Al are often corrosion resistant because they oxidize and the surface oxide seals the metal preventing further reactions. In the case of silver, elements may be added to the metal that act to protect the silver from the corrosive or degradation of environmental stressors. In other cases an element may be added that forms an alloy with the silver that alters the chemical or environmental activity of the silver. The Sterling silver alloys described above may, in part, contribute to this stabilization method. Still other methods to stabilize the silver include the use of an interface treatment as taught in Our Prior Applications, where sulfur or other element is embedded into the surface of a coating or substrate prior to the deposition of the silver or silver alloy. Our Prior Applications also taught the deposition of silver or a silver alloy onto a ZnO or other surface that puts the deposited material into a low energy state, thereby improving its environmental durability. The silver layer may also be protected by the application of metal or non-metal (oxide, nitrides, etc) either above or below the silver layer. Additionally, the silver or silver alloy may be protected by being overcoated with a relatively thick oxide layer such as ITO. It is recognized that variation of deposition conditions such as target shielding angles, target to substrate distance, composition of residual background gasses, speed of layer growth, e.g., may produce somewhat varying results. Nonetheless, the trend of improvement of various characteristics for noted materials noted is expected to hold over a range of parameters, particularly those typical for magnetron sputtering.

[00356] Specific materials that may be added to the silver that enable one or more of the stabilization mechanisms described above include: Al, Zn, Cu, Sn, Si, Ge, Mn, Mg, W, Sb, B, Cr, Th, Ta, Li, and In. These can be used either alone or in combination to enable good CASS performance, adequate Steam lifetime and good adhesion of the silver layer. Preferably, the CASS resistance should be greater than about 2 days, preferably greater than 5 days, more preferably greater than 10 days and most preferably greater than 17 days. The steam lifetime should be greater than 10 days, preferably greater

than 15 days, and more preferably greater than 20 days. The coating stack should maintain adherence to glass, epoxy and within itself during adhesion tests. The blow test described above demonstrates relative performance among a set of samples but the test is dependent on mirror shape, pressure ramp rate, edge treatment and epoxy type as well as coating performance.

Galvanic Corrosion

[00357] While the problem of galvanic corrosion of thin-films of the EC element in a rearview assembly arises due to exposure of an edge of the EC-element to electrolytes (such as salt laden solutions from road-spray, for example, or CASS solution), related art does not seem to address or even acknowledge this problem. For example, an exemplary thin-film stack such as a stack of the third-surface transfective electrode, deposited on a glass substrate and comprising Cr, Ru, Ag, and TCO layers may form a galvanic series, thereby facilitating degradation of the electrode from the edge of the EC-element inwards and causing not only the change in appearance of the EC-element based mirror but also a breach of EC-cell. In an embodiment of the present invention, protection of the EC-element thin-film stack against corrosion includes the use of a so-called "sacrificial anode" co-located with (either adjacently or adjoining) with the thin-film stack at the edge of the EC-element. Experiments were conducted to determine the extent of protection provided by the sacrificial anode element to a third-surface thin-film stack including a 35 nm thick Cr layer, a 3 nm thick Ru layer, a silver-gold alloy (7% Au) of about 25 nm, and an ITO of about 15 nm. A portion of a bus clip (containing either a single section or "tooth" or multiple sections/"teeth", thus having various lengths as described in Table 21) constructed of a copper-cobalt-beryllium alloy (alloy C17410, Be 0.15-0.5; Co 0.35-0.6; Cu balance) was used as a sacrificial anode element at attached to the edge of the EC element in contact with the thin-films stack. In reference to Fig. 63 and Table 21, the lower portion of the EC-element was exposed to an electrolyte (CASS solution), while a chosen sacrificial anode element(s) were placed at location(s) labeled with numerals (1 through 9) along the lower edge of the element (for samples in Group 1) or along the upper edge of the element (for samples in Group 2). The zones of the lower portion of the EC-element, in which effects of galvanic corrosion of the lack thereof were subsequently observed, are labeled with letters (A through J).

[00358] Samples of Group 1 were held in the CASS chamber for only 24 hours. The parts were inspected after the 24 hour period was complete. Samples 1 to 3 had no bus clips present and had extensive corrosion damage within the 24 exposure. There were failures in most of the zones A to J. Samples 4 to 6 had full continuous clips present between positions 1 to 9. One part had a failure in Zone A while the other two samples did not fail during the 24 hour exposure. Samples 7 to 9 had individual bus clips present at positions 1 to 9. These parts only had failures in zones A and J. The zones between the individual clips were protected by the proximity of the individual clips. This implies that at the 0.5" distance away from the clips the coating is protected. The failures in Zones A and J show that at up to a distance of 1.25" the clips provide galvanic corrosion protection.

5 [00359] Group 2 had two groups, those that had failures within 24 hours and those kept in the chamber for another 24 hours for a total exposure of 48 hours. Various locations for the clips were tried in this series of experiments. In each case the coating was protected between individual clips spaced at 1" separations. For the other variants the protection distance varied from between 1/2" up to 4". In practice, the necessary distance between the sacrificial anode and the coating to be protected will vary with the specific geometry of the full mirror assembly but as this test shows additional protection is attained when the distance between them is relatively small.

| Group 1 | | | |
|--|--|-----------------------------------|--|
| 24 Hour inspection | | | |
| Sample ID | Configuration | Result by zone | Distance of Degradation to Sacrificial Anode |
| 1 | No buss bar or individual teeth | failure in most zones | N/A no clips |
| 2 | No buss bar or individual teeth | failure in most zones | N/A no clips |
| 3 | No buss bar or individual teeth | failure in most zones | N/A no clips |
| 4 | Continuous serrated buss bar points 1-9 | Failure in zone A. | 7/8" |
| 5 | Continuous serrated buss bar points 1-9 | No Failure | |
| 6 | Continuous serrated buss bar points 1-9 | No Failure | |
| 7 | Individual clips at points 1-9 | Failure in zone J | 1 1/4" |
| 8 | Individual clips at points 1-9 | Failure in zone J | 1" |
| 9 | Individual clips at points 1-9 | Failure in zone A | 3/4" |
| Group 2 | | | |
| 24 hour inspection (parts listed under 48 hour inspection had no breach at 24 hours) | | | |
| 10 | Continuous serrated buss bar from points 5-9 | Failure in zones D and E | 5/8" |
| 11 | Individual clips at points 4-9 | Failure in zones C and D | 7/8" |
| 12 | Individual clips at points 1-6 | Failure in zone J | 4" |
| 13 | Continuous serrated buss bar from mid 3 and 4 to mid 6 and 7 | Failure in zones A, B and J | 2 1/2" |
| 14 | Individual clips at points 4-9 | Failure in zone A | 3 3/4" |
| 15 | Individual clips at points 1-7 | Failure in zone J | 2 5/8" |
| 16 | Individual clips at points 1-7 | Failure in zone J | 2 1/2" |
| 17 | Continuous serrated buss bar from points 1-5 | Failure in zones G and H | 1 3/4" |
| 18 | Individual clips at points 2-9 | Failure in zone A | 1 5/8" |
| 19 | Individual clips at points 1-3 and 7-9 | Failure in zones A, D, E, F | 1/2" |
| 20 | Continuous serrated buss bar from mid 3 and 4 to 6 | Failure in zones A, B, C, D and J | 1 1/2" |
| 21 | Individual clips at points 1-6 | Failure in zone J | 3 3/4" |
| 48 hour inspection | | | |
| 22 | Individual clips at points 2-9 | None | N/A |
| 23 | Individual clips at points 1-8 | None | N/A |
| 24 | Individual clips at points 1-3 and 7-9 | D, E, F, G | 1 1/8" |
| 25 | Individual clips at points 3-9 | Failure in zones A, J | 1 1/2" |
| 26 | Individual clips at points 3-9 | Failure in zones A, B, C, J | 1" |
| 27 | Continuous serrated buss bar from points 5-9 | Failure in zones D, E | 7/8" |
| 28 | Continuous serrated buss bar from points 1-5 | Failure in zones F, G, J | 1/2" |
| 29 | Individual clips at points 1-8 | Failure in Zone A | 5/8" |

Table 2 1

5 *Aluminum Alloys for Corrosion Resistance*

[00360] As noted in other parts of this specification, aluminum has a high reflectance and, for that reason, is also of interest for fabrication of a peripheral ring. Though the use of this material in peripheral rings is known, no means of improving its chemical and environmental durability has been proposed. We discovered a variety of alloys of aluminum and dopants that improve the stability of aluminum in EC-element environment. Elements such as magnesium, manganese, silicon, copper, ruthenium, titanium, copper, iron, oxygen, nitrogen or palladium either alone or in combination with other elements in this group will improve the stability of the aluminum. Other elements may be present in the aluminum without deviating from the spirit of this invention. The amounts of these elements required for improvement of aluminum qualities may be between 50 and 0.1 weight-%, preferably between 40 and 0.5 weight-%, more preferably between about 25 and 0.5 weight-%, and most preferably between about 10 and 0.5 weight-%.

[00361] Table 22 shows the performance of different Al-based materials in the CASS test either as single layers or in stacks. The stack consists of 120nm ITO / 5nm chrome/ Al-based material / 35 nm chrome / 5 nm ruthenium. This stack is particularly well suited for a perimeter ring. The ITO provides the electrical conductivity for the EC-cell, the 5 nm chrome layer provided adhesion of different metals to the ITO, the Al-based material provides relatively high reflectance for the system, the 35nm chrome provides opacity, and the 5nm ruthenium provides good electrical conductivity and stability to a Ag-paste type electrical buss of the EC-element. The aluminum-based materials may be spatially uniform in composition or the composition may be graded across a part. A graded part is one in which the composition gradually changes from one composition to another composition across the part. The graded parts are produced in a combinatorial fashion using two three-inch sputter cathodes angled toward each other. The angle of the cathodes, the relative power and the composition of the targets mounted to each cathode can be varied to alter the composition across the substrate. The relative composition of the coating at different locations can be estimated using analytical techniques or from calibration experiments.

[00362] As shown in Table 22, the pure aluminum coating is degraded in less than a day in CASS testing. We discovered that stability of aluminum coatings varies with the thickness of the aluminum layer. In particular, the lifetime in CASS decreases as the thickness of the layer increases. A very thin layer, approximately 50 angstroms, has significantly superior stability lasting up to 17 days in CASS. We also unexpectedly discovered that Al deposited at high grazing angles in the combinatorial deposition system also had unexpectedly high stability, which can possibly be explained by the fact that a thin metallic layer incorporates more of the background gas into its matrix during deposition and the trace oxygen or water present during deposition is partially oxidizes the aluminum, thereby leading to the improved CASS stability. For improved stability, the oxygen content in the aluminum film should be below about 20%, preferably below about 10%, more preferably less than about 5%, and most preferably less than about 2.5%. The lower oxygen content has the added benefit of having a lesser impact on the

optical properties of the aluminum. Alternatively, the crystal structure of the aluminum may vary with thickness. In this case the physical thickness of the layers themselves, rather than oxygen content is the mechanism leading to improved stability. The aluminum layer should be less than about 70 angstroms, preferably less than about 55 angstroms and most preferably less than about 40 angstroms. The reflectance of a stack may be tailored to a specific level by depositing a breaker layer in between multiple silver layers such as Al/SiCVAI/SiCVAI. The breaker layer should be relatively thin to avoid thin film interference colors, i.e., less than about 500 angstroms, preferably less than 250 angstroms and most preferably less than about 100 angstroms.

[00363] We also discovered that Al:Si compound, where the Si-content varies from about 40% to 10%, performs substantially better than the pure aluminum. The higher Si level of about 40% has CASS performance that is independent of thickness, while the lower Si content material (at about 10% level) demonstrates the CASS stability versus thickness of the layer similar to that of the pure aluminum.

[00364] Aluminum-titanium compounds were also evaluated. Titanium contents between about 50% and 25% show substantially improved CASS stability. Ruthenium added to AlTi or other aluminum compounds also substantially improved the performance even at very small levels. This additive, along with Pd, is expected to lead to improved CASS results in various aluminum-based materials.

Table 22

| Stack | Metal Details | Metal Thickness (angstroms) | CASS Performance |
|--------------------|---------------|-----------------------------|---------------------------------|
| ITO/Cr/Metal/Cr/Ru | Al | 140 | < 1 day |
| ITO/Cr/Metal/Cr/Ru | AlTi 70:30 | ~150-200 | 14 days |
| ITO/Cr/Metal/Cr/Ru | AlTi 50:50 | ~150-200 | 14 days |
| ITO/Cr/Metal/Cr/Ru | AlTi 75:25 | ~150-200 | 14 days |
| ITO/Cr/Metal/Cr/Ru | Al | 94 | < 1 day |
| ITO/Cr/Metal/Cr/Ru | Al | 70 | < 1 day |
| ITO/Cr/Metal/Cr/Ru | Al | 56 | 2 days |
| ITO/Cr/Metal/Cr/Ru | Al | 47 | very light damage up to 21 days |
| ITO/Cr/Metal/Cr/Ru | Al | 40 | very light damage up to 21 days |
| ITO/Cr/Metal/Cr/Ru | Al:Si 60:40 | 140 | >21 days |
| ITO/Cr/Metal/Cr/Ru | Al:Si 60:41 | 105 | >21 days |
| ITO/Cr/Metal/Cr/Ru | Al:Si 60:42 | 84 | >21 days |
| ITO/Cr/Metal/Cr/Ru | Al:Si 60:43 | 70 | >21 days |
| ITO/Cr/Metal/Cr/Ru | Al:Si 60:44 | 60 | >21 days |
| ITO/Cr/Metal/Cr/Ru | AlTiRu | ~150-200 | >17 |
| ITO/Cr/Metal/Cr/Ru | AlTiRu 90:8:2 | ~150-200 | >17 |

[00365] Optical properties of aluminum may be affected by added elements. Table 23 shows the refractive index of some of the aluminum-based materials. These values may be used in conjunction with the reflectance-enhancement-metal (REM) formula described above to determine the arrangements wherein these materials can be used to increase the reflectance of Al-based film.

Table 23

| Material | N | K |
|-----------|------|------|
| Al60/Si40 | 3.13 | 4.49 |
| Al90/Si10 | 1.24 | 4.94 |
| Ti50/Al50 | 2.54 | 2.96 |
| Ti30/Al70 | 2.88 | 3.39 |

Other Materials Viable as REM with CASS resistance

[00366] Copper alloys of Zinc and tin, known as brass and bronze, respectively, have good optical properties and function well as REM layers for a wide range of base metals and, depending on the composition, can have good CASS resistance. Naval brass, with a 60:40 Cu:Zn ratio and other trace elements, lasted up to 7 days in CASS while Cu:Sn at a 50:50 ratio also survived up to 7 days in CASS (both in a ITO/Cr/Metal/Cr/Ru stack described above for Al. It is expected that select alloys and compound of copper, alloyed with other elements will be suitable for use as REM layers. The homogeneous peripheral ring embodiments described herein are often preferred to match the reflectivity and color of the main mirror reflector. The color tolerancing described elsewhere in this document may be preferred in some applications. Additives to make brass more corrosion resistant include iron, aluminium, silicon nickel, tin and manganese. In certain applications, where a single phase is present in the brass, phosphorus, arsenic or antimony in levels of less than 0.1% can provide further stability. In some embodiments, having a zinc content of less than 15% may also provide benefits. Brasses known commonly as "Admiralty" or "Naval" brass may be particularly stable in corrosive environments. Bismuth bronze, a copper/zinc alloy with a composition of 52 parts copper, 30 part nickel, 12 parts zinc, 5 parts lead, and 1 part bismuth is quite stable. It is able to hold a good polish and so is sometimes used in light reflectors and mirrors. Additives to make copper-tin bronzes more corrosion resistant include phosphorus, zinc, aluminum, iron, lead, and nickel.

[00367] The homogeneous ring embodiments described herein are often preferred to match the reflectivity and color of the main mirror reflector. The color tolerancing described elsewhere in this document may be preferred in some applications.

5 *Universal thinfilm stacks.*

[00368] The durable silver- and aluminum-based alloys are particularly useful as so-called universal materials. Depending on the requirements of a particular application, the reflectivity and color of the peripheral ring may vary. As more reflectivity levels of the ring are requested by the users, manufacturing of peripheral rings becomes challenging if multiple metals are needed to attain the desired reflectivity properties. If, for instance, different embodiments or applications require 35%, 45%, 55%, 65%, 75% or 85% reflectance, then up to 6 different materials could be used to attain the desired color match. It is often easier to lower the reflectance of a high reflectance metal rather than raise the reflectance of a lower reflectance metal. Therefore, in certain manufacturing scenarios a range of reflectance values can be obtained with a high reflectance metal by either reducing the thickness of the metal and optionally backing the layer with a low transmittance metal when opacity is needed. The REM formula described above can be used to assist selecting appropriate metal combinations. Another way to lower the reflectance of a high reflectance metal is to put a lower reflectance metal in front of it (relative to the viewer). The thickness of the lower reflectance metal can be increased to decrease the reflectance of the high reflectance metal. The silver and aluminum alloys described herein are particularly good in that they have excellent environmental durability, adhesion and high reflectance. Therefore, in a production environment, a number of commercial products may be produced simply by adjusting the thickness of a single layer. This leads to a particularly simple process for manufacturing thus reducing capital cost, development time and product durability.

[00369] For example, silver and silver alloys and aluminum alloys are particularly reflective. A stack consisting of these material maybe quite reflective. Table 24 shows the calculated reflectance of stacks using a silver gold alloy with 7% gold as the principle reflector layer while Table 25 shows the calculated reflectance of stacks using an aluminum silicon alloy with 10% silicon. The stack have additional layers present. A thin ITO layer is present next to the glass based on the assumption that an adhesion layer may be needed while a layer of ruthenium and chrome are added on top of the reflected layer to guarantee an opaque coating. These layers may be present or not depending on the needs of a given application. Examples 1 to 7 show the impact of altering the silver alloy on reflectance. By changing the thickness the reflectance may be altered without sacrificing transmittance properties. In examples 8 to 13 a thin layer of ruthenium is placed between the ITO and the silver alloy wherein the ruthenium acts to minimize the reflectance. In either of these ways a single stack can be used for a variety of applications by simply adjusting the thickness of one layer.

[00370] A similar behavior is shown with aluminum as the principle reflector metal in Table 25. In examples 14 to 19 the thickness of the aluminum alloy is altered to modify the reflectance. Examples 20 to 24 show the effect of adding a thin ruthenium layer between the viewer and the aluminum alloy. In this embodiment, as in the embodiment above with silver, the reflectance may be attenuated with the adjustment of only a single layer.

5 **[00371]** The novelty of these designs is their ability to adjust the appearance with a simple one layer adjustment. In practice, one or more layers may be adjusted as needed to attain the desired optical effects. The table shows a particular effect for a specific stack. In practice alternate metals may be used as defined elsewhere in this document.

10

| Sample # | ITO | Ru | AgAu7x | Ru | Cr | Y | a* | b* |
|----------|-----|-----|--------|-----|----|------|------|-----|
| 1 | 10 | 0 | 60 | 4.5 | 50 | 92.3 | -0.6 | 2.4 |
| 2 | 10 | 0 | 40 | 4.5 | 50 | 90.4 | -0.6 | 2.6 |
| 3 | 10 | 0 | 20 | 4.5 | 50 | 81.0 | -0.8 | 2.9 |
| 4 | 10 | 0 | 15 | 4.5 | 50 | 75.9 | -0.9 | 2.9 |
| 5 | 10 | 0 | 10 | 4.5 | 50 | 69.2 | -1.1 | 2.7 |
| 6 | 10 | 0 | 5 | 4.5 | 50 | 61.5 | -1.3 | 2.2 |
| 7 | 10 | 0 | 0 | 4.5 | 50 | 53.6 | -1.6 | 1.5 |
| 8 | 10 | 1 | 60 | 4.5 | 50 | 79.5 | -0.5 | 5.1 |
| 9 | 10 | 2 | 60 | 4.5 | 50 | 70.4 | -0.4 | 6.2 |
| 10 | 10 | 2.5 | 60 | 4.5 | 50 | 67.0 | -0.5 | 6.4 |
| 11 | 10 | 3 | 60 | 4.5 | 50 | 64.1 | -0.5 | 6.4 |
| 12 | 10 | 4 | 60 | 4.5 | 50 | 59.8 | -0.6 | 6.1 |
| 13 | 10 | 5 | 60 | 4.5 | 50 | 56.9 | -0.7 | 5.5 |

Table 24

| Sample # | ITO | Ru | AlSi (90:10) | Ru | Cr | Y | a* | b* |
|----------|-----|----|--------------|-----|----|-------|-------|------|
| 14 | 10 | 0 | 60 | 4.5 | 50 | 73.43 | -0.77 | 2.64 |
| 15 | 10 | 0 | 40 | 4.5 | 50 | 73.46 | -0.77 | 2.63 |
| 16 | 10 | 0 | 20 | 4.5 | 50 | 72.01 | -0.89 | 2.41 |
| 17 | 10 | 0 | 15 | 4.5 | 50 | 70.32 | -0.98 | 2.24 |
| 18 | 10 | 0 | 10 | 4.5 | 50 | 67.19 | -1.11 | 2.02 |
| 19 | 10 | 0 | 5 | 4.5 | 50 | 61.84 | -1.29 | 1.75 |
| 20 | 10 | 1 | 60 | 4.5 | 50 | 69.41 | -0.77 | 2.95 |
| 21 | 10 | 2 | 60 | 4.5 | 50 | 66.24 | -0.79 | 3.03 |
| 22 | 10 | 3 | 60 | 4.5 | 50 | 63.76 | -0.82 | 2.97 |
| 23 | 10 | 4 | 60 | 4.5 | 50 | 61.84 | -0.85 | 2.84 |
| 24 | 10 | 5 | 60 | 4.5 | 50 | 60.39 | -0.88 | 2.66 |

15

Table 25

Electrochromic medium.

20 **[00372]** Preferably the chamber contains an electrochromic medium. Electrochromic medium is preferably capable of selectively attenuating light traveling therethrough and preferably has at least one solution-phase electrochromic material and preferably at least one additional electroactive material that may be solution-phase, surface-confined, or one that plates out onto a surface. However, the presently

5 preferred media are solution-phase redox electrochromics, such as those disclosed in commonly assigned U.S. Patents. 4,902,108, 5,128,799, 5,278,693, 5,280,380, 5,282,077, 5,294,376, 5,336,448, 5,808,778 and 6,020,987; the entire disclosures of which are incorporated herein in their entireties by reference. If a solution-phase electrochromic medium is utilized, it may be inserted into the chamber through a sealable fill port through well-known techniques, such as vacuum backfilling and the like.

10 **[00373]** Electrochromic medium preferably includes electrochromic anodic and cathodic materials that can be grouped into the following categories:

[00374] (i) Single layer - the electrochromic medium is a single layer of material which may include small inhomogeneous regions and includes solution-phase devices where a material is contained in solution in the ionically conducting electrolyte and remains in solution in the electrolyte when
15 electrochemically oxidized or reduced. U.S. Patents 6,193,912; 6,188,505; 6,262,832; 6,129,507; 6,392,783; and 6,249,369 disclose anodic and cathodic materials that may be used in a single layer electrochromic medium, the entire disclosures of which are incorporated herein by reference. Solution-phase electroactive materials may be contained in the continuous solution phase of a cross-linked polymer matrix in accordance with the teachings of U.S. Patent No. 5,928,572 or International Patent Application
20 No. PO7US98/05570 entitled "ELECTROCHROMIC POLYMERIC SOLID FILMS, MANUFACTURING ELECTROCHROMIC DEVICES USING SUCH SOLID FILMS, AND PROCESSES FOR MAKING SUCH SOLID FILMS AND DEVICES," the entire disclosures of which are incorporated herein by reference.

[00375] At least three electroactive materials, at least two of which are electrochromic, can be
25 combined to give a pre-selected color as described in U.S. Patent No. 6,020,987 the entire disclosure of which is incorporated herein by reference. This ability to select the color of the electrochromic medium is particularly advantageous when designing information displays with associated elements.

[00376] The anodic and cathodic materials can be combined or linked by a bridging unit as described in International Application No. PCT/W097/EP498 entitled "ELECTROCHROMIC
30 SYSTEM," the entire disclosure of which is incorporated herein by reference. It is also possible to link anodic materials or cathodic materials by similar methods. The concepts described in these applications can further be combined to yield a variety of electrochromic materials that are linked.

[00377] Additionally, a single layer medium includes the medium where the anodic and cathodic materials can be incorporated into the polymer matrix as described in International Application
35 No. PCT/W098/EP3862 entitled "ELECTROCHROMIC POLYMER SYSTEM," U.S. Patent No. 6,002,511, or International Patent Application No. PCT/US98/05570 entitled "ELECTROCHROMIC POLYMERIC SOLID FILMS, MANUFACTURING ELECTROCHROMIC DEVICES USING SUCH SOLID FILMS, AND PROCESSES FOR MAKING SUCH SOLID FILMS AND DEVICES," the entire disclosures of which are incorporated herein by reference.

40 **[00378]** Also included is a medium where one or more materials in the medium undergoes a change in phase during the operation of the device, for example, a deposition system where a material

5 contained in solution in the ionically conducting electrolyte which forms a layer, or partial layer on the electronically conducting electrode when electrochemically oxidized or reduced.

[00379] Multilayer - the medium is made up in layers and includes at least one material attached directly to an electronically conducting electrode or confined in close proximity thereto which remains attached or confined when electrochemically oxidized or reduced. Examples of this type of

10 electrochromic medium are the metal oxide films, such as tungsten oxide, iridium oxide, nickel oxide, and vanadium oxide. A medium, which contains one or more organic electrochromic layers, such as polythiophene, polyaniline, or polypyrrole attached to the electrode, would also be considered a multilayer medium.

[00380] In addition, the electrochromic medium may also contain other materials, such as light
15 absorbers, light stabilizers, thermal stabilizers, antioxidants, thickeners, or viscosity modifiers.

[00381] It may be desirable to incorporate a gel into the electrochromic device as disclosed in commonly assigned U.S. Patent No. 5,940,201, the entire disclosure of which is incorporated herein by reference.

[00382] In at least one embodiment, a rearview mirror assembly is provided with an electro-optic
20 element having a substantially transparent seal. Examples of substantially transparent seals and methods of forming substantially transparent seals are provided in U.S. Patent No. 5,790,298, the entire disclosure of which is included herein by reference.

[00383] In at least one embodiment, the rearview mirror assembly is provided with a bezel 6580
for protecting the associated seal from damaging light rays and to provide an aesthetically pleasing
25 appearance. Examples of various bezels are disclosed in U.S. Patents, 5,448,397, 6,102,546, 6,195,194, 5,923,457, 6,238,898, 6,170,956 and 6,471,362, the disclosures of which are incorporated herein in their entireties by reference.

[00384] It should be understood that the above description and the accompanying figures are for
illustrative purposes and should in no way be construed as limiting the invention to the particular
30 embodiments shown and described. The embodiments described herein can employ, without limitation, any additional features and elements taught in Our Prior Applications, including thin-film coating configurations and multi-zone embodiments pertaining to transfective arrangements of the EC-element based or prismatic element based mirror system such as those taught in U.S. Patent Application S/N 12/370,909; and including mirror systems and rearview assemblies with anisotropic polymer laminates
35 such as those taught in U. S Patent Applications S/Ns 12/496,620, 12/629,757, and 12/774,721. The appending claims shall be construed to include all equivalents within the scope of the doctrine of equivalents and applicable patent laws and rules.

5

CLAIMS

What is claimed is:

1. A vehicular rearview assembly having a front and a front peripheral portion, the assembly comprising:
 - an electrochromic (EC) element including
 - a first glass substrate having first and second surfaces, the first surface configured as an outer surface of the EC element and corresponding to the front of the assembly, the second surface carrying a transparent electrically-conductive layer thereon;
 - a second glass substrate having third and fourth surfaces, the third surface carrying a reflective electrically-conductive thin-film stack thereon,
 - wherein the first and second substrates are disposed in a spaced-apart and parallel relationship with the second and third surfaces facing each other and an EC medium disposed therebetween and bounded by a perimeter seal;
 - a mounting element adapted to support the EC element, the mounting element having an extended portion that is positioned behind and along the EC element;
 - a housing shell configured to mechanically engage the mounting element;
 - an electronic circuitry disposed behind the mounting element inside the housing shell; and
 - a user interface (UI) at the front, the user interface including
 - a first electrically-conductive layer in first electrical coupling with the electronic circuitry, and
 - a second electrically-conductive layer that is extended transversely with respect to the first electrically-conductive layer and proximately to the front peripheral portion of the assembly in second electrical coupling with the electronic circuitry,
 - wherein a surface of the first substrate that is internal to the EC element carries a peripheral ring established around a perimeter thereof and configured to conceal the perimeter seal;
 - wherein the first electrically-conductive layer and the EC medium are substantially electromagnetically decoupled;
 - wherein the first and second electrically-conductive layers are electrically isolated from one another;
 - wherein the electronic circuitry is operable to register changes in first and second electrical couplings and is adapted to trigger, in response to an input applied to the front of the assembly, at least one auxiliary device associated with the rearview assembly if the second electrical coupling does not change during a predetermined time-delay; and

5 wherein the front peripheral portion of the assembly has an annular region with a radius of curvature of at least 2.5 mm, the annular region defined around the circumference of the front peripheral portion and observable from the front of the assembly.

2. An assembly according to claim 1,

10 wherein the mounting element further includes a side portion cooperating with the extended portion along a periphery thereof and protruding from behind the second substrate towards the first substrate when the EC element is supported by the mounting element,

 wherein said side portion is configured to define a step surface extending parallel to the first substrate, the step surface located behind the first substrate;

15 wherein the first electrically-conductive layer is juxtaposed with the step surface and is electrically connected with the electronic circuitry through an electrical connector that is extended through an opening in the mounting element, said electrical connector being elastically-deformable in response to pressure applied thereto; and

 wherein the UI further includes at least partially opaque graphical layer associated with the first electrically-conductive layer, the at least partially opaque graphical layer having graphical indicia therein and disposed on top of the first electrically-conductive layer.

3. An assembly according to claim 2, wherein said elastically-deformable electrical connector is configured to generate, in response to a deflection of said elastically-deformable electrical connector, a
25 mechanical stress that is below the yield point of a material of said elastically-deformable electrical connector.

4. An assembly according to claim 3,

30 wherein said elastically-deformable electrical connector includes a two-sided cantilever having spring leaves terminating with respective contact portions and configured to establish opposite contact force vectors when deflected, and

 wherein the width of spring leaves linearly varies between upper and lower values.

5. An assembly according to claim 1,

35 wherein the first substrate forms a ledge with respect to the second substrate, and

 wherein the first electrically-conductive layer and the at least partially translucent layer are observable through the ledge.

6. An assembly according to claim 1,

40 wherein an edge of the second glass substrate is concealed behind the first glass substrate, and

5 wherein said annular region of the front peripheral portion includes one of a peripheral region of the first glass substrate and a peripheral portion of the mounting element.

7. An assembly according to claim 1, wherein the first substrate includes a laminate of two lites of glass, wherein the first substrate includes an annular peripheral region having a radius of at least 2.5 mm,
10 and wherein a thickness of the first substrate is at least 2.5 mm.

8. An assembly according to claim 1, wherein an auxiliary device includes at least one of an interior illumination assembly, a digital voice processing system, a power supply, a global positioning system, an exterior light control, a moisture sensor, an information display, a light sensor, a blind spot indicator, a
15 turning signal indicator, an approach warning, an operator interface, a compass, a temperature indicator, a voice actuated device, a microphone, a dimming circuitry, a GPS device, a telecommunication system, a navigation aid, a lane departure warning system, an adaptive cruise control, a vision system, a rear vision system and a tunnel detection system of the assembly.

20 9. A vehicular rearview assembly having a front and a front peripheral portion, the assembly comprising:

a mirror device having a glass substrate, a first surface of which corresponds to the front, the first surface being unobstructingly observable from the front;

a mounting element having an opening therethrough and adapted to support the mirror element
25 via a cooperation defined by an adhesive element;

a housing shell defining an inner volume and an aperture corresponding to the front of the assembly, the housing shell being configured to mechanically engage the mounting element;

an electronic circuitry disposed behind the mounting element inside the housing shell;

a first electrically-conductive layer disposed within the assembly parallel to the glass substrate of
30 the mirror device;

a second electrically-conductive layer disposed transversely to the first electrically-conductive layer and in proximity to the front peripheral portion of the assembly;

an electrical-connection means configured to establish electrical communication between the electronic circuitry and at least one electrical contact pad of a component of the mirror device, said

35 electrical-connection means being configured to create a compound pressure, on the adhesive element, that does not exceed 150 N per square inch; and

an auxiliary device in operational communication with the assembly,

wherein the front peripheral portion of the assembly includes an annular perimeter region having a radius of at least 2.5 mm,

40 wherein each of said first and second electrically-conductive layers is electrically coupled with the electronic circuitry,

5 wherein the electronic circuitry is operable to trigger the auxiliary device in response to the user input applied to the front and configured to change a degree of electrical coupling between any of the first and second electrically-conductive layers and the electronic circuitry,

 wherein said electrical-connection means includes an elastically-deformable contact.

10 10. An assembly according to claim 9,

 wherein said electrical-connections means includes a two-sided cantilever having spring leaves terminating with corresponding contact portions, and

 wherein the width of the spring leaves varies linearly between upper and lower values.

15 11. An assembly according to claim 9,

 wherein the mirror device includes an electrochromic (EC) element having first and second substrates and an EC medium disposed therebetween and bound by a perimeter seal,

 wherein a perimeter of the second substrate is concealed behind the first substrate, and

20 wherein the first and second electrically-conductive layers are electromagnetically decoupled from the EC medium.

 12. An assembly according to claim 10,

 wherein the first electrically-conductive layer is disposed on a step formed by the mounting element outside the perimeter of the second substrate,

25 wherein the rearview assembly further comprises at least partially opaque graphical layer having graphical indicia therein, and

 wherein the EC element has a peripheral ring that includes an electrically-isolated portion concealing an edge of said graphical layer from being viewable from the front of the assembly.

30 13. An assembly according to claim 9,

 wherein the annular region of the front peripheral portion of the assembly includes one of a glass surface of the mirror device and a perimeter portion of the mounting element.

 14. An assembly according to claim 9,

35 wherein the electronic circuitry is operable to nullify triggering of the auxiliary device in response to said user input when said user input is configured to change a degree of electrical coupling between the first electrically-conductive layer and the electronic-circuitry and when the change of a degree of electrical coupling between the second electrically-conductive layer and the electronic circuitry occurs within a pre-determined time-delay.

5 15. An assembly according to claim 9, further comprising
a transfective element disposed behind the first surface with respect to the front, and
an illumination assembly positioned behind said transfective element,
wherein a portion of said illumination assembly is adapted to transmit light through said
transfective element, said aperture, and said surface to a field-of-view (FOV) a the front of the assembly.

10

16. An assembly according to claim 15, further comprising a graphical layer having graphical indicia
therein adjacent to or adjoining a top of the first electrically-conductive layer, wherein a portion of the
illumination assembly is adapted to highlight said graphical layer and transmit light through said
graphical indicia towards the FOV.

15

17. An assembly according to claim 9, further comprising a reflective optical polarizer disposed
across a surface of said transfective element and including an optically-anisotropic plastic layer.

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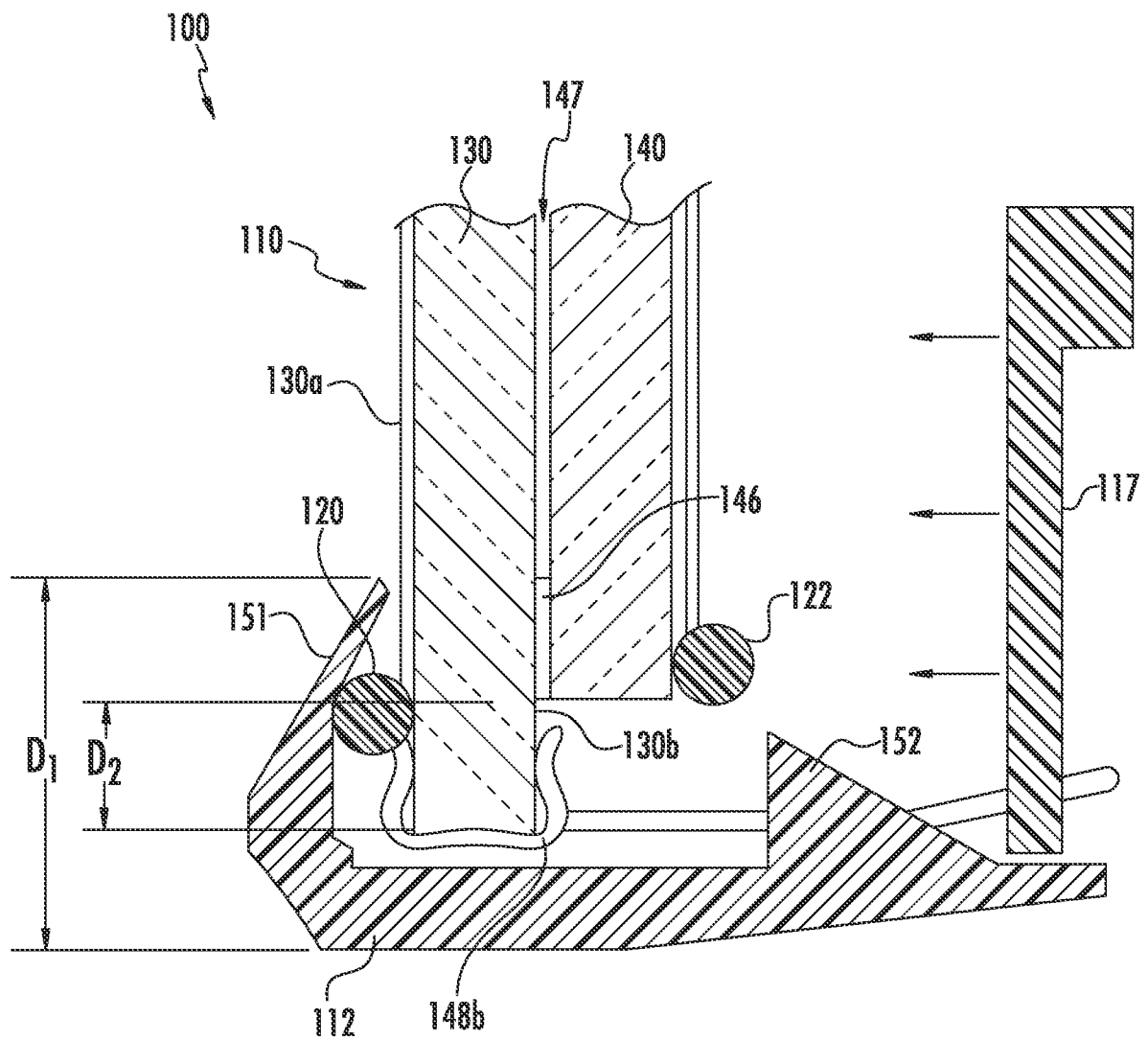


FIG. 1
(PRIOR ART)

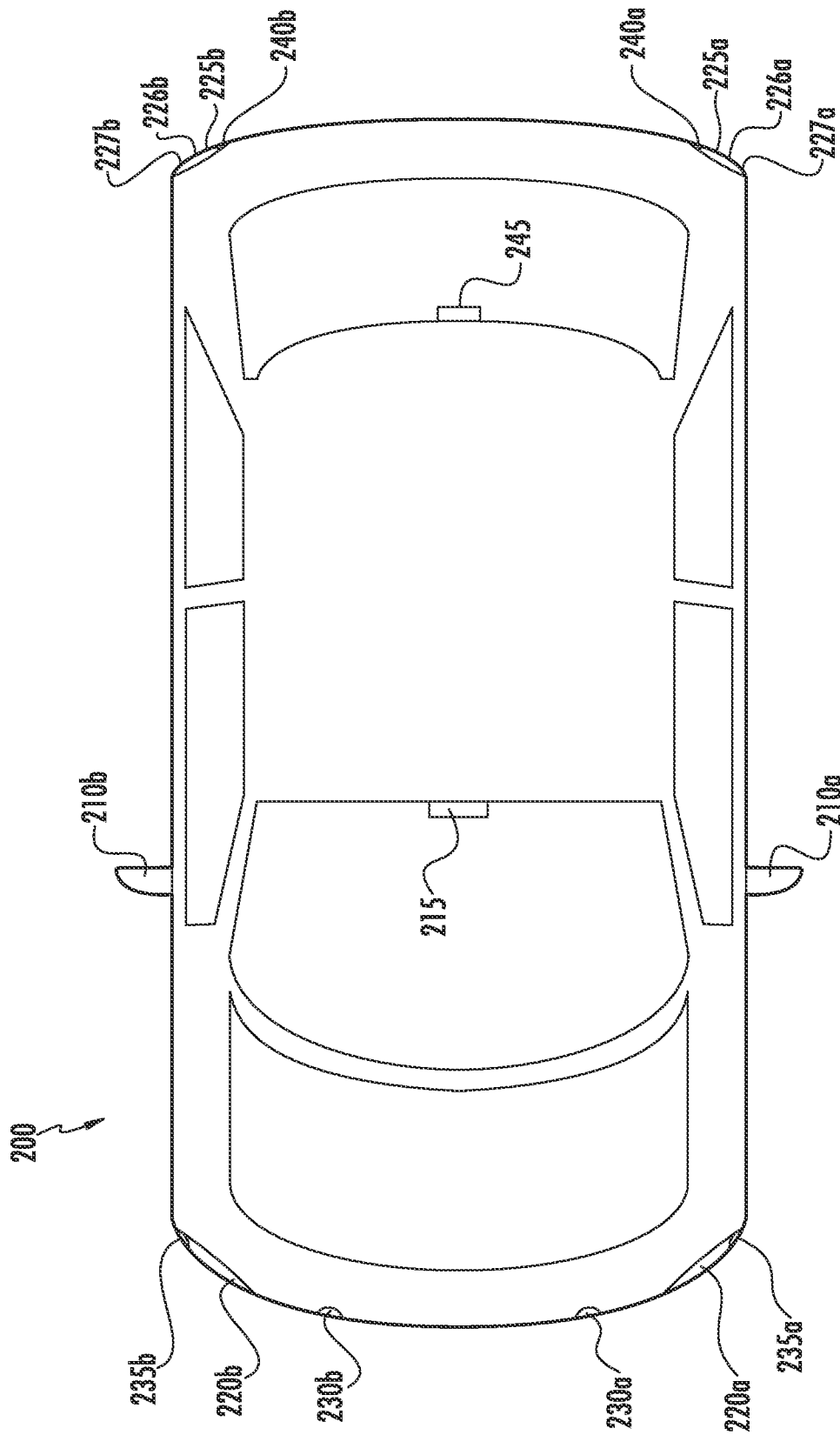
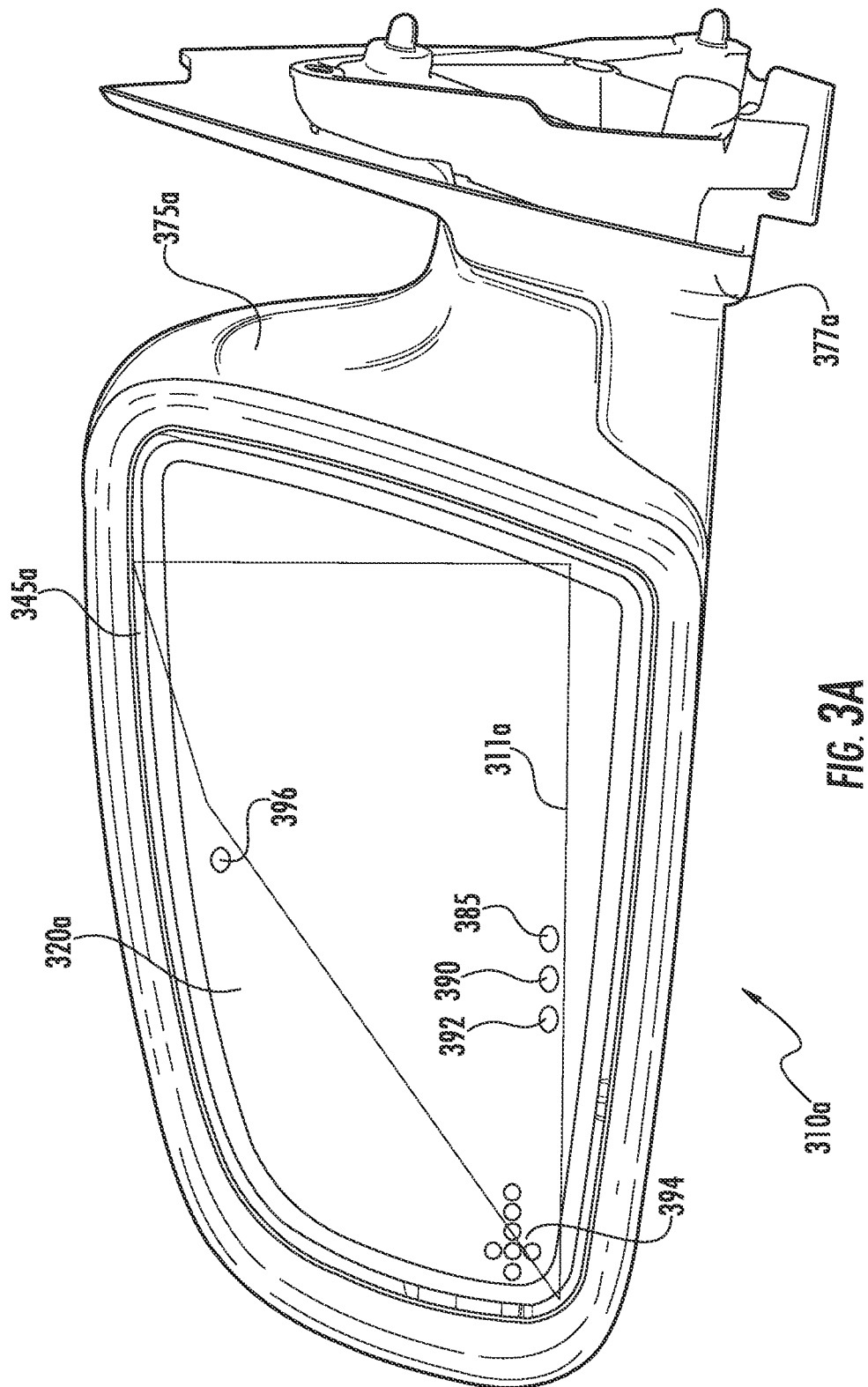


FIG. 2



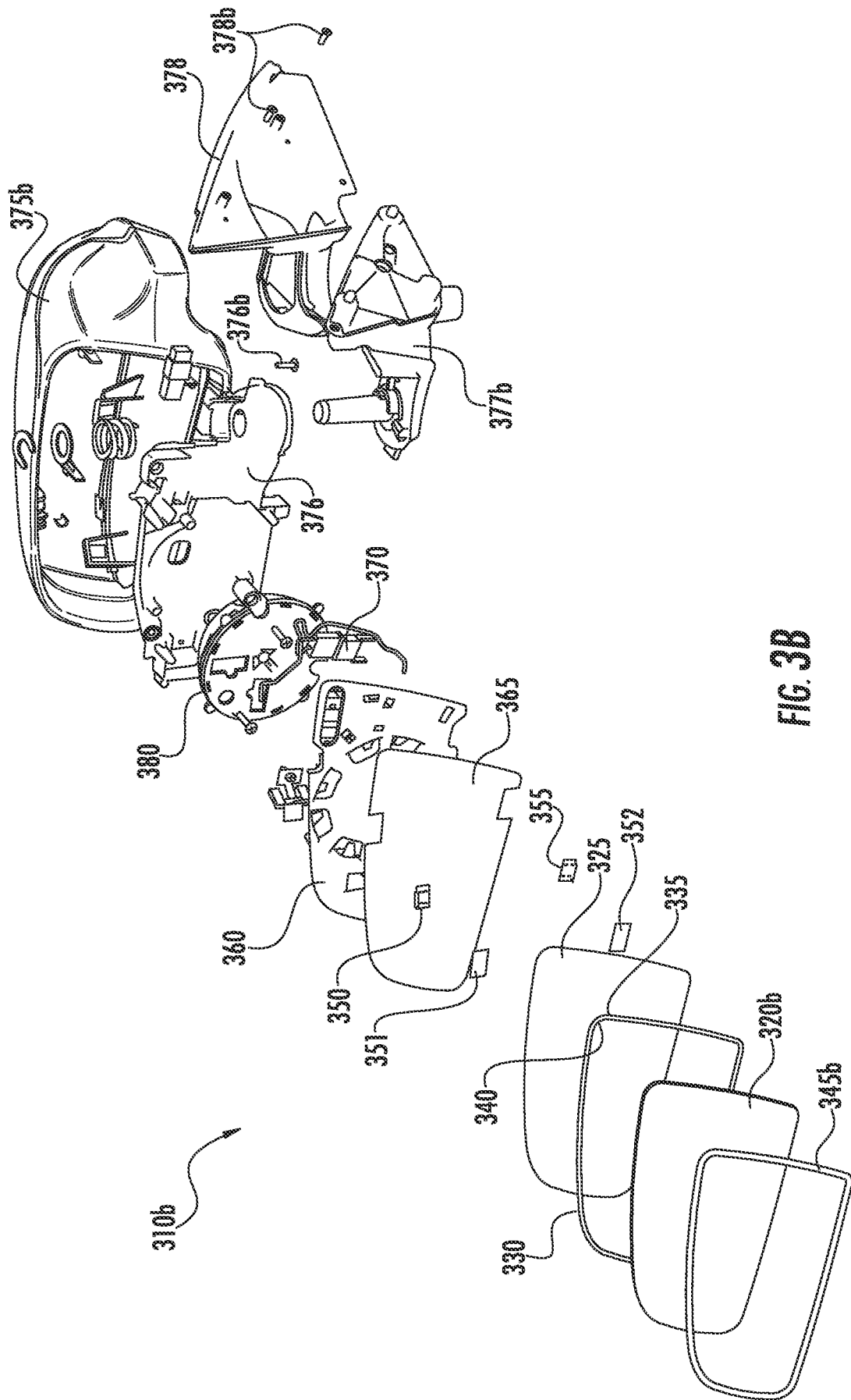
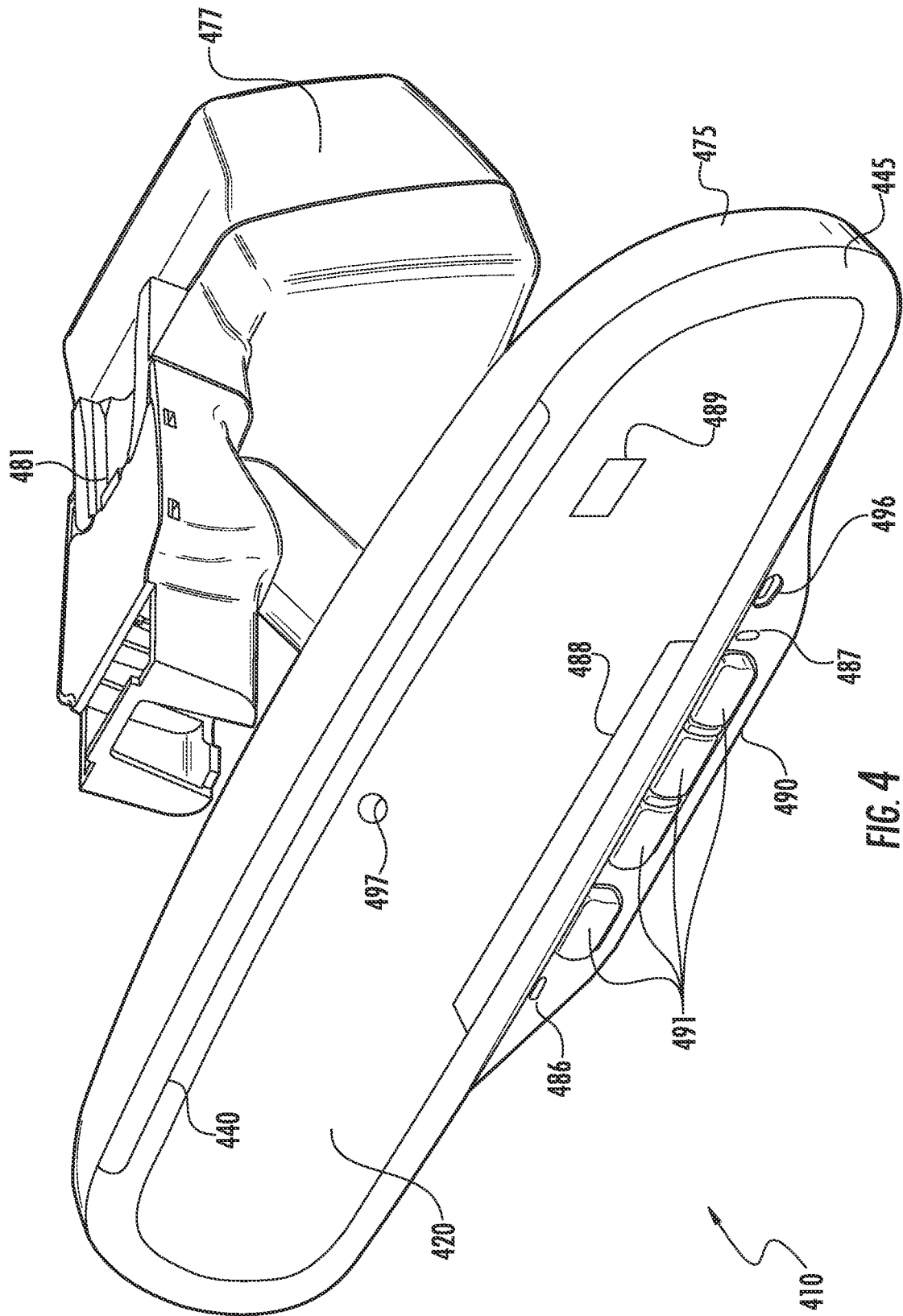


FIG. 3B



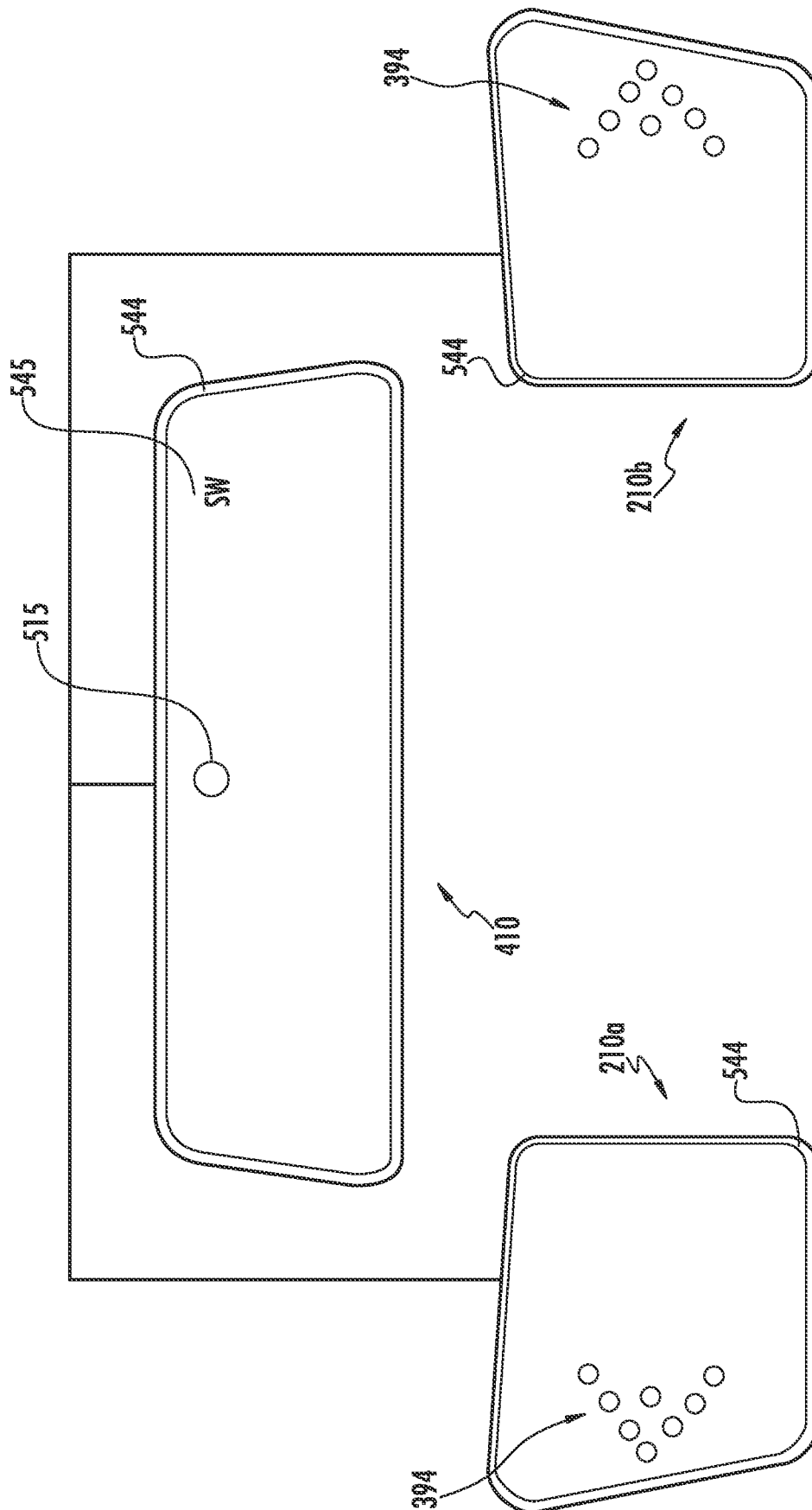


FIG. 5

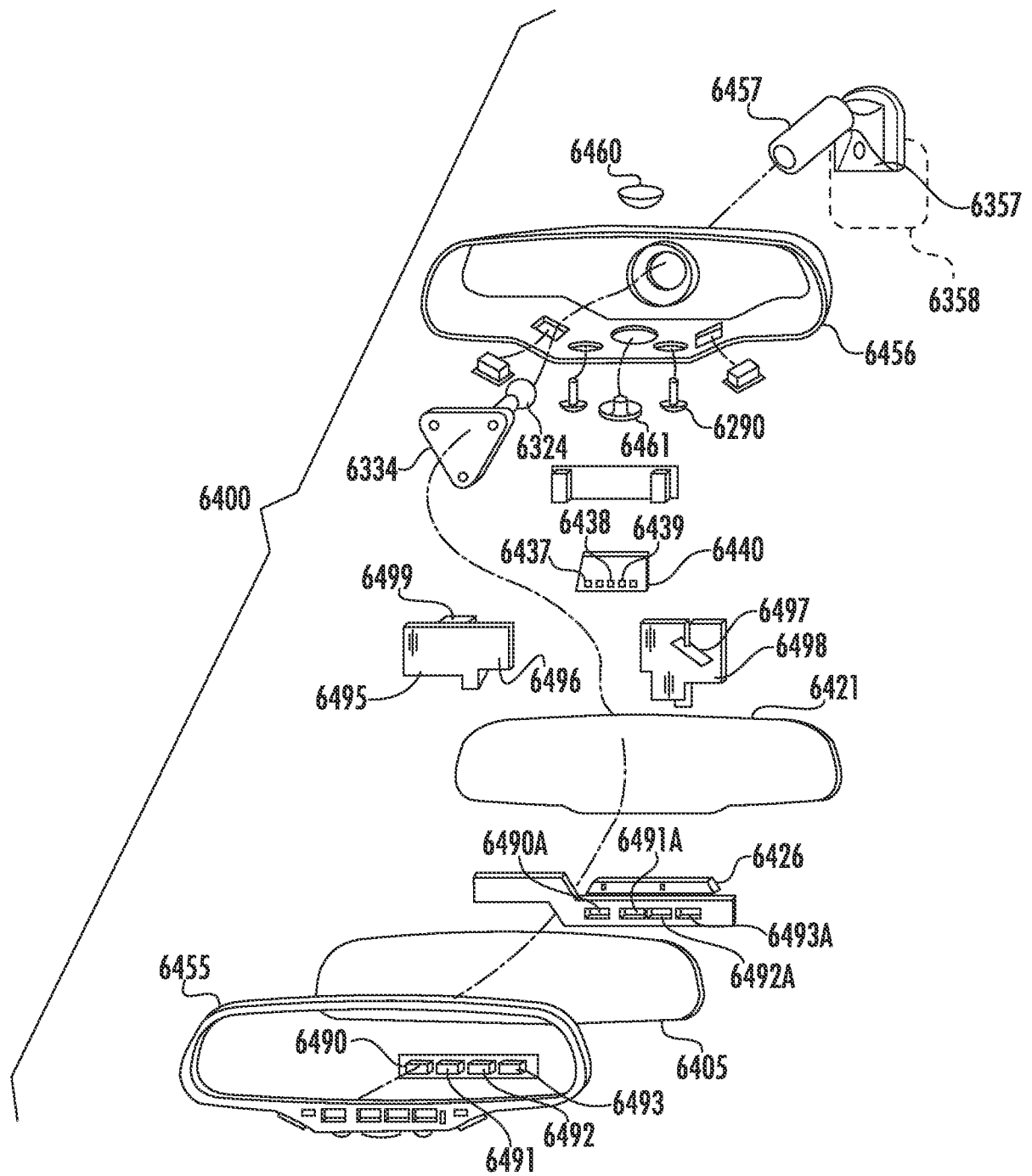


FIG. 6

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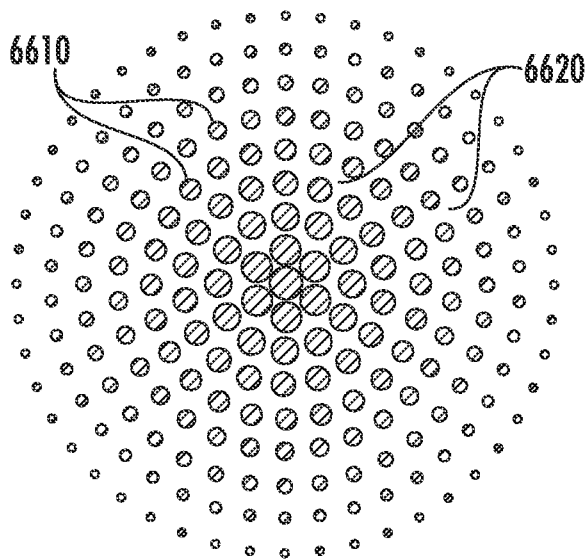


FIG. 7A

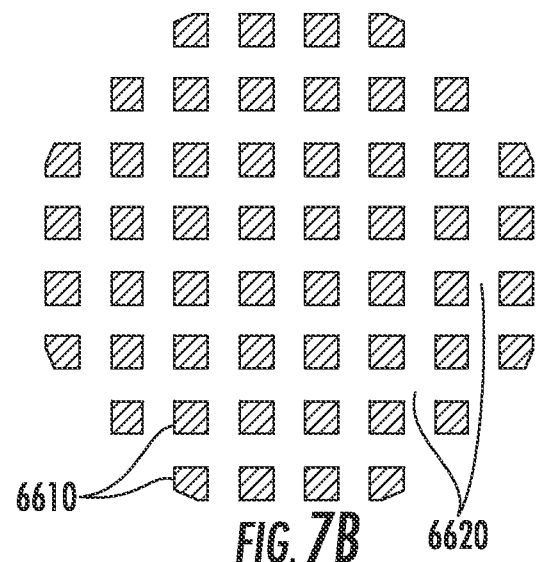


FIG. 7B

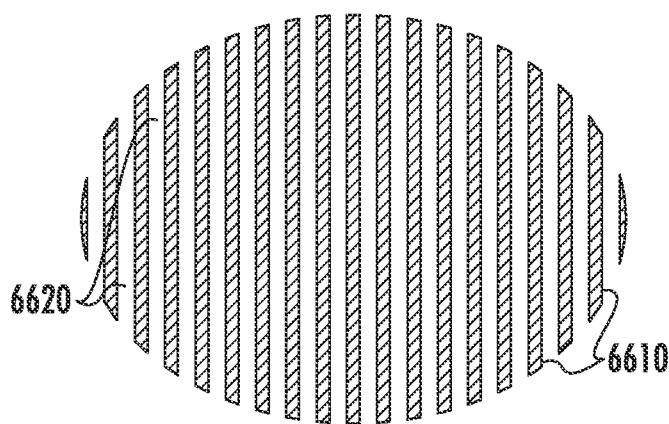


FIG. 7C

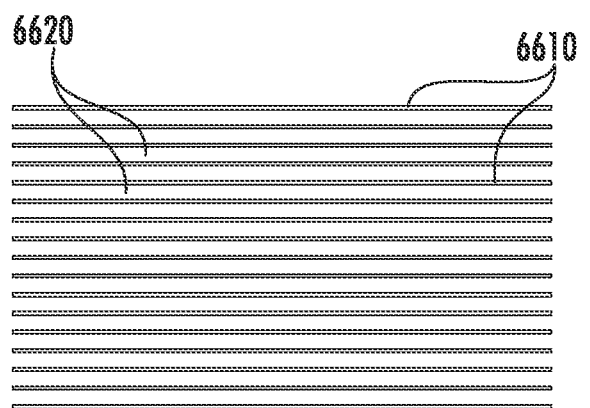


FIG. 7D

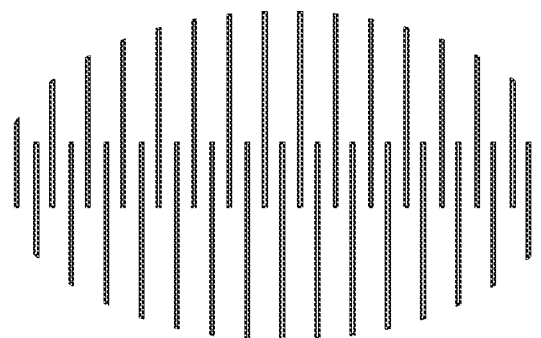
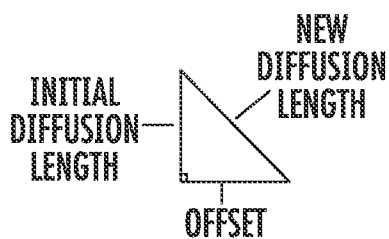
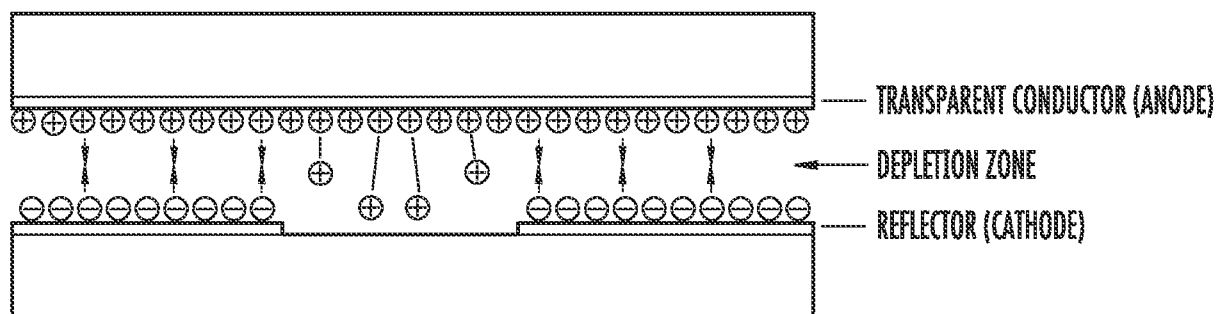


FIG. 7E

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⊕ COLORED ANODIC EC MOLECULE

⊖ COLORED CATHODIC EC MOLECULE

FIG. 7F

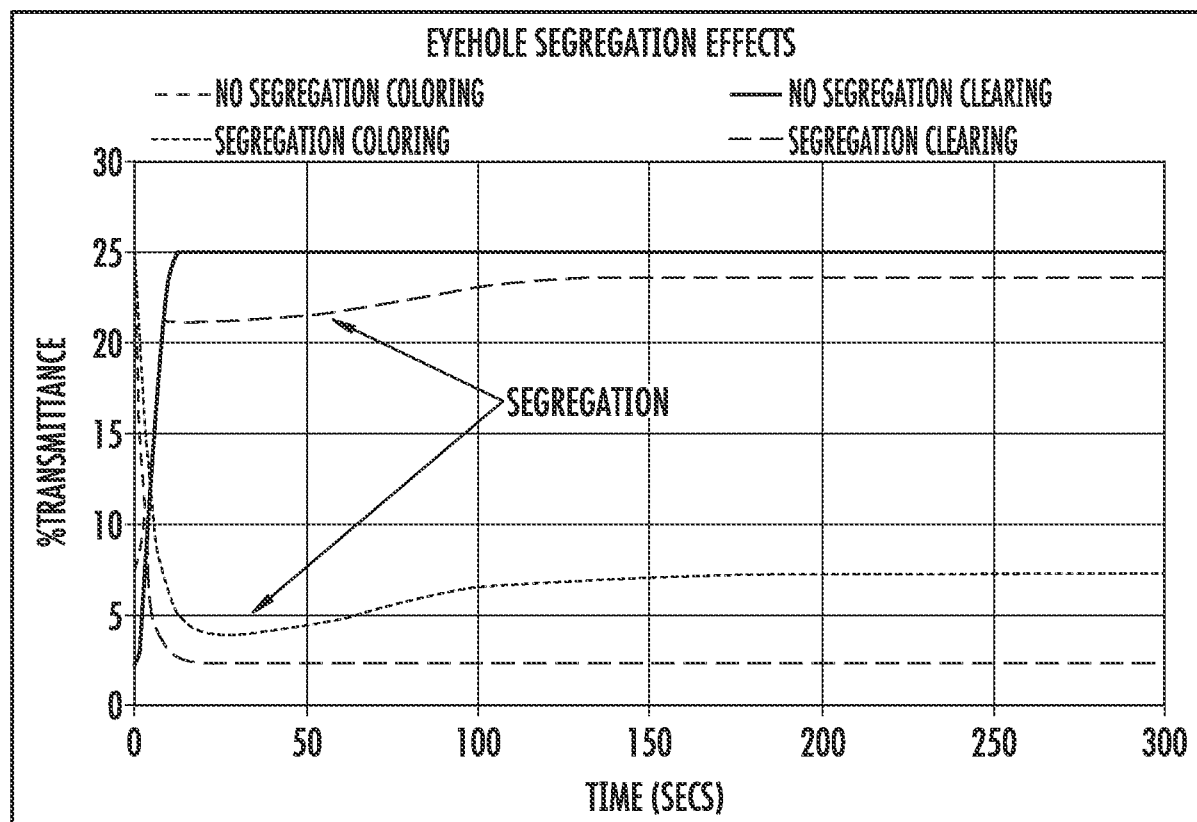


FIG. 7G

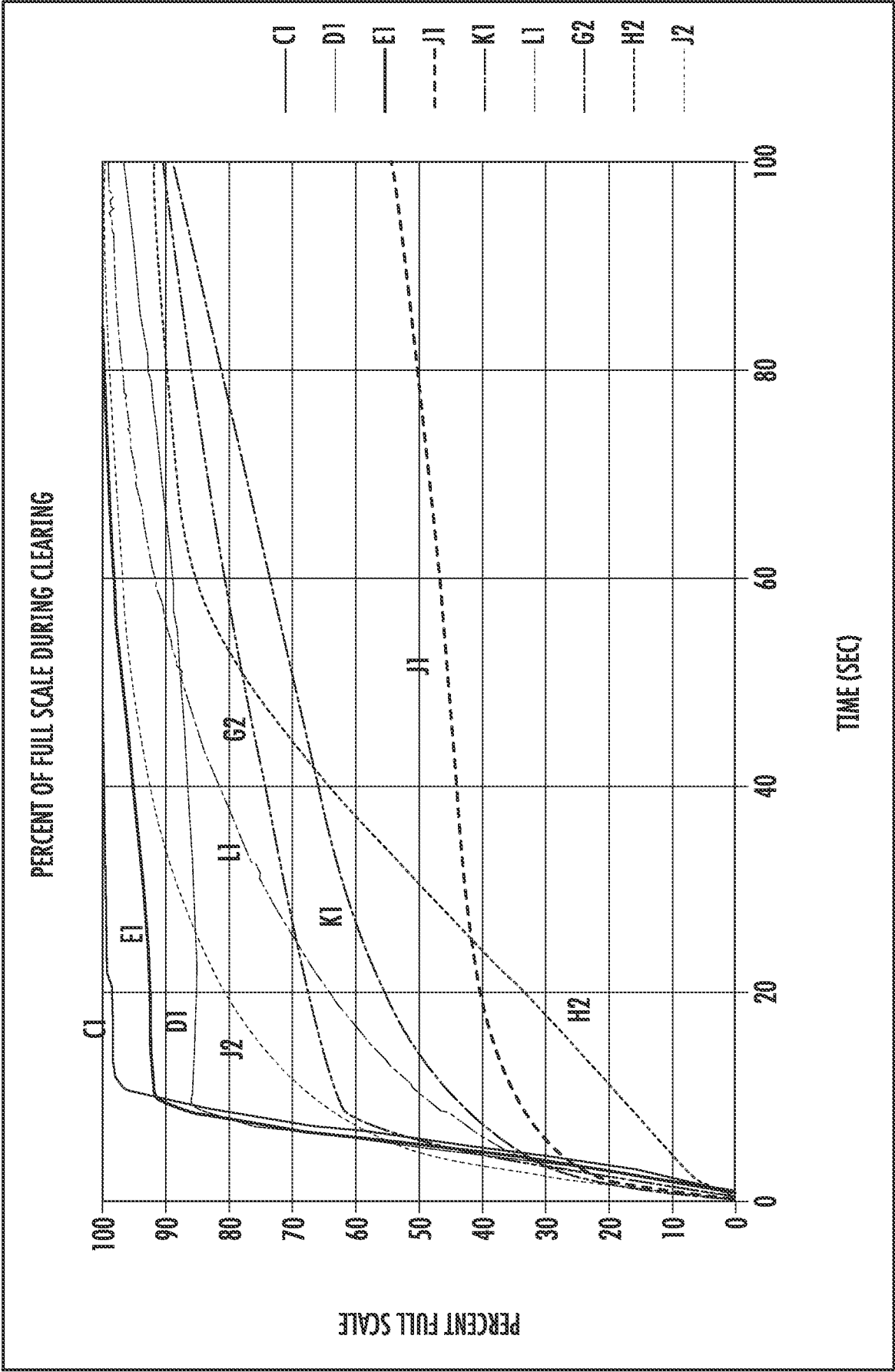


FIG. 7H

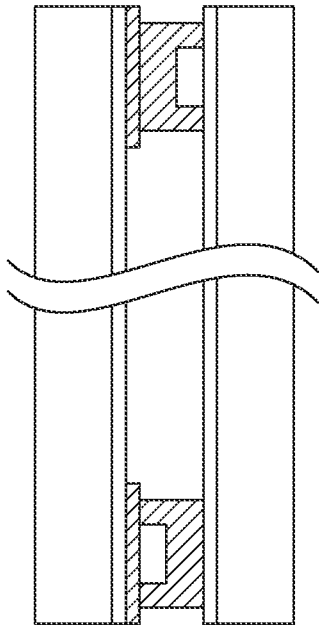


FIG. 8A

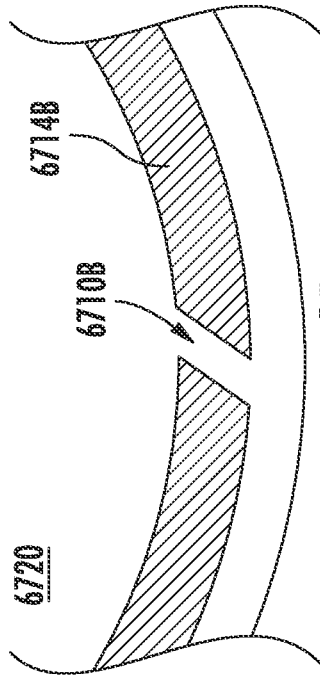


FIG. 8B

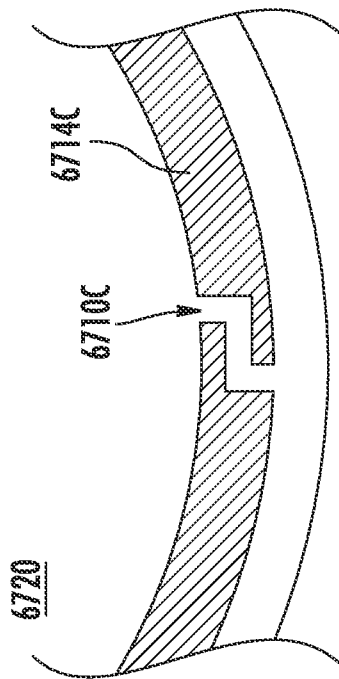


FIG. 8C

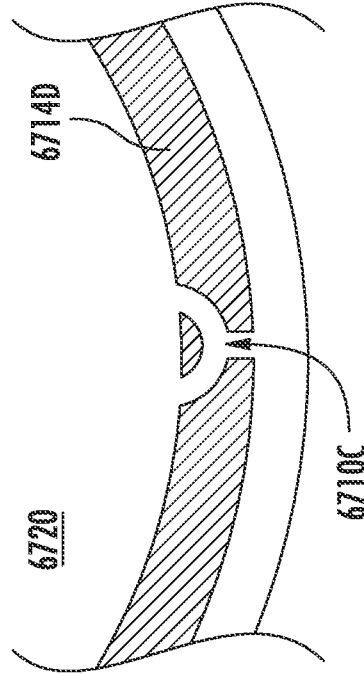


FIG. 8D

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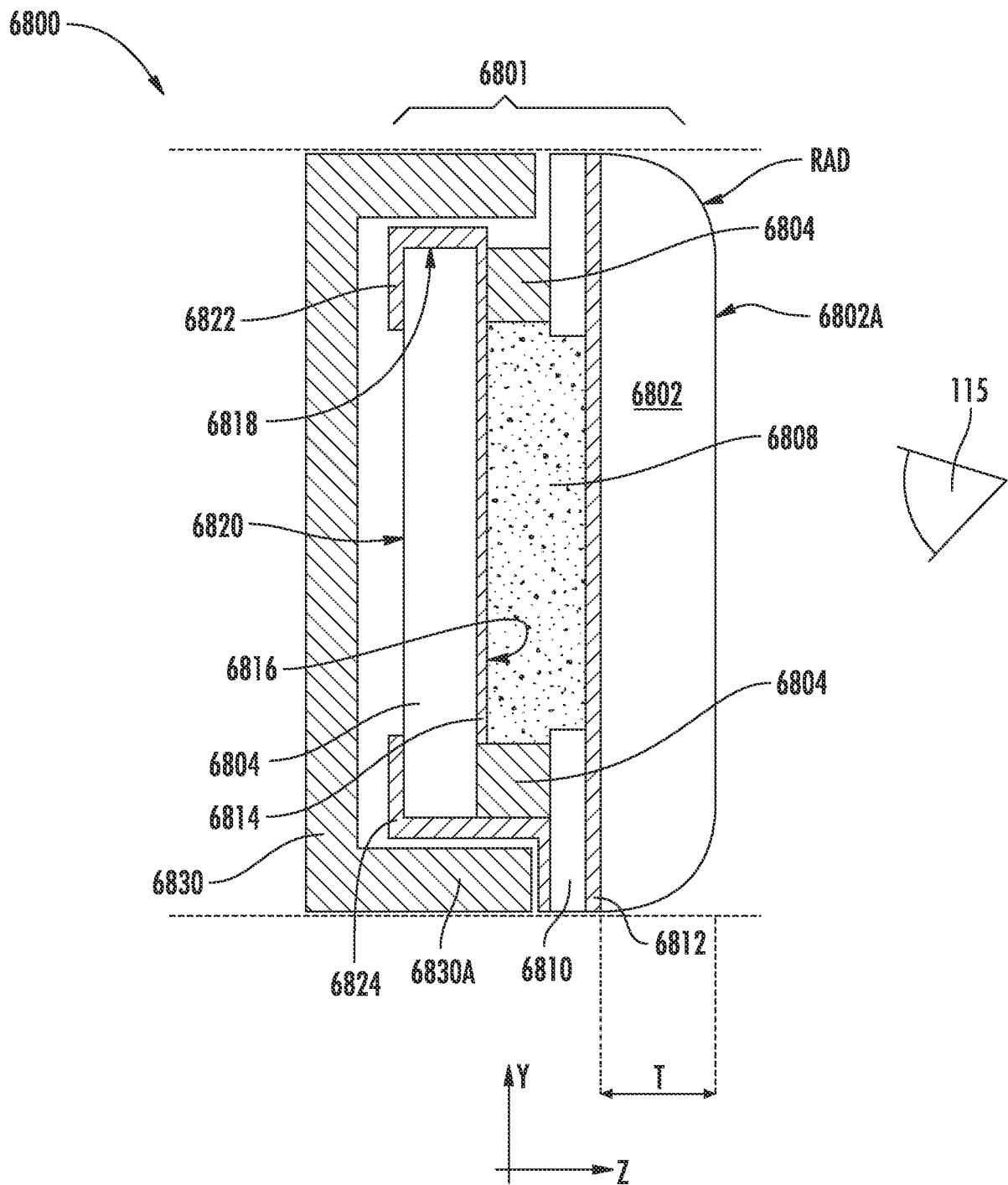
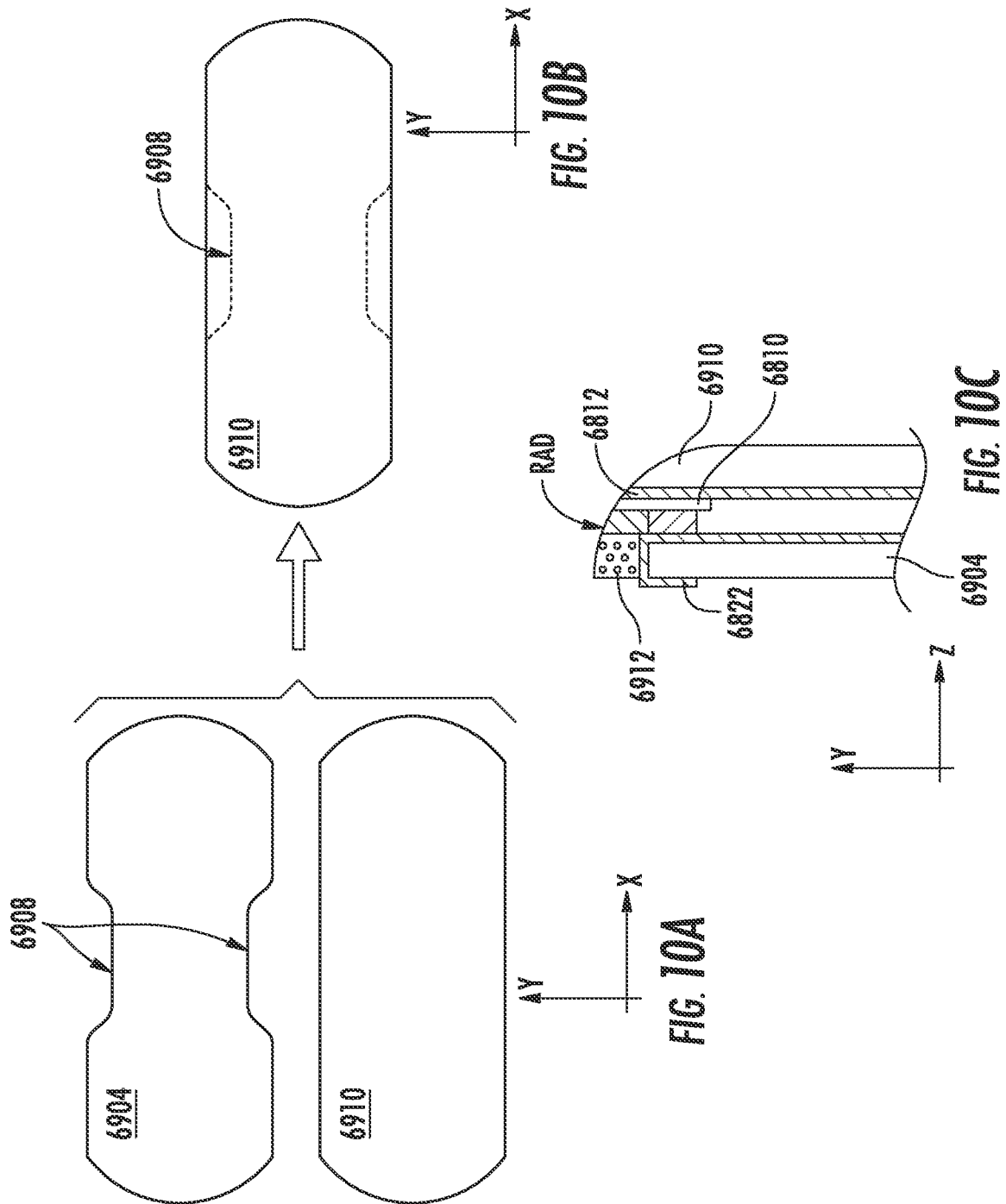
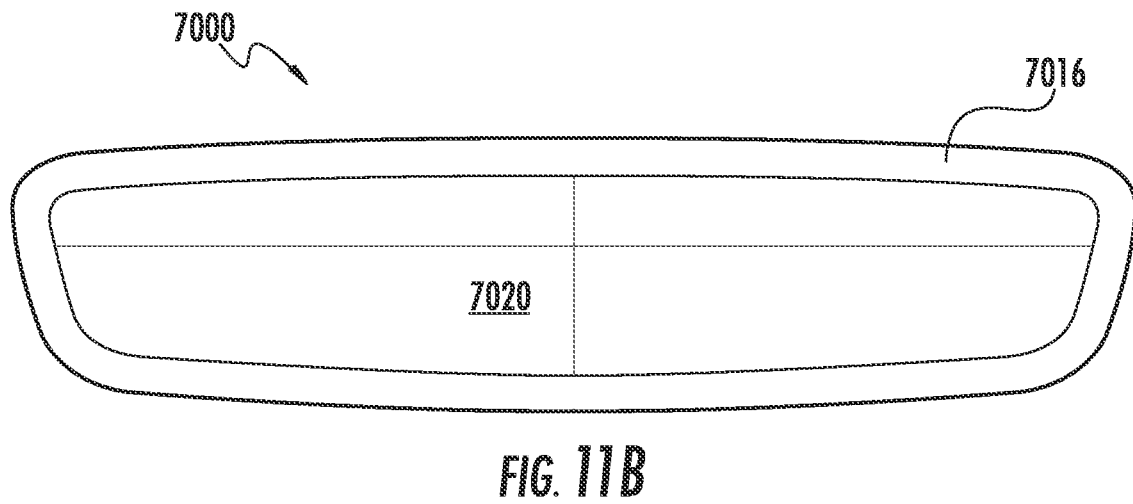
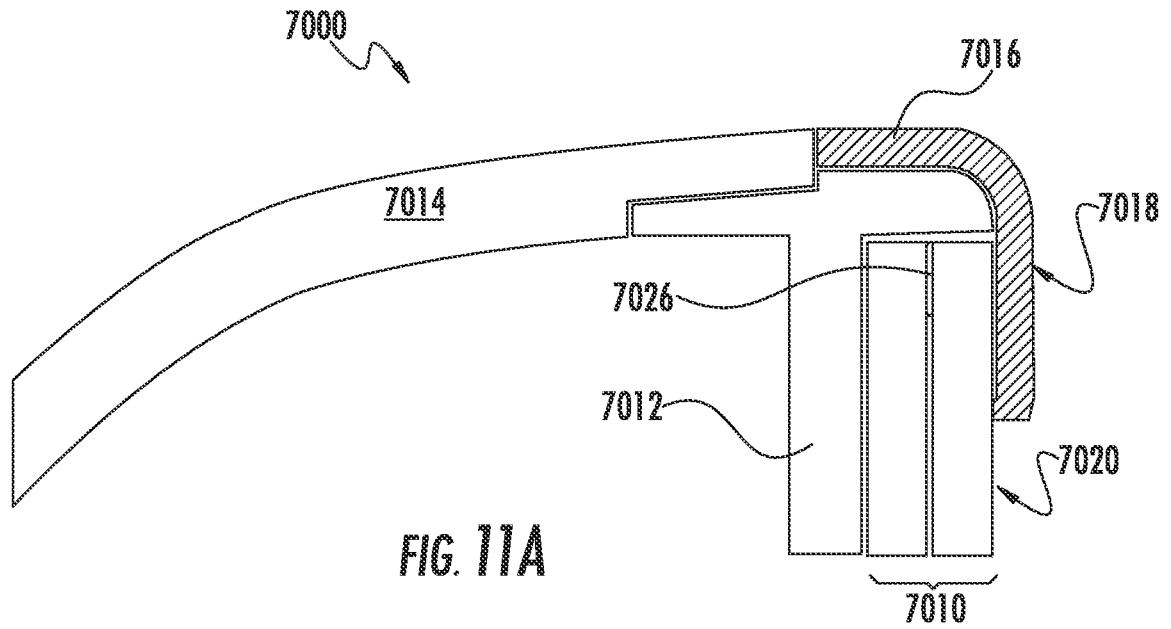
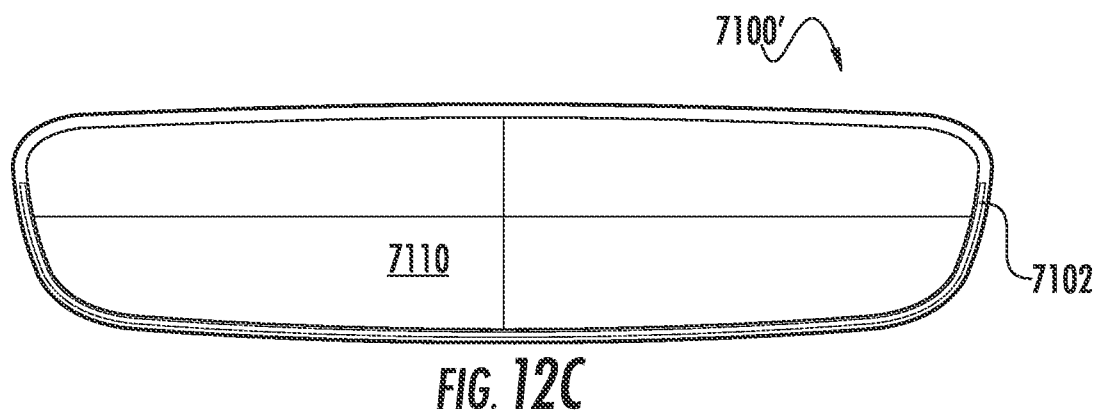
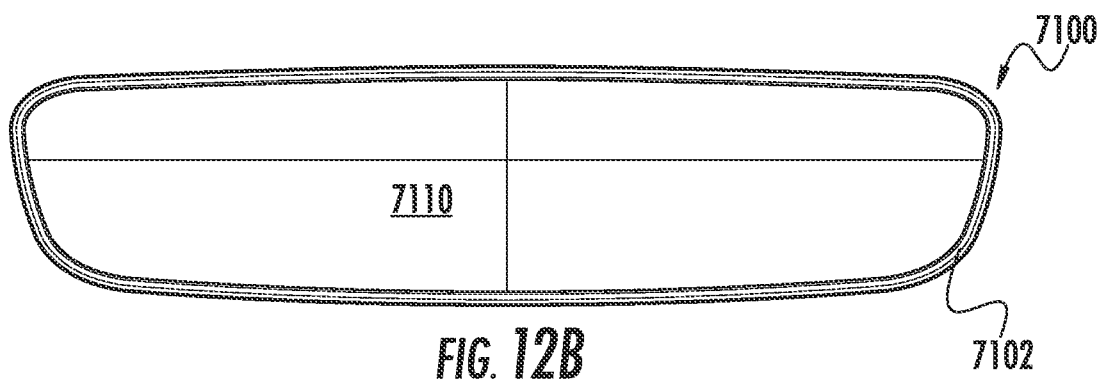
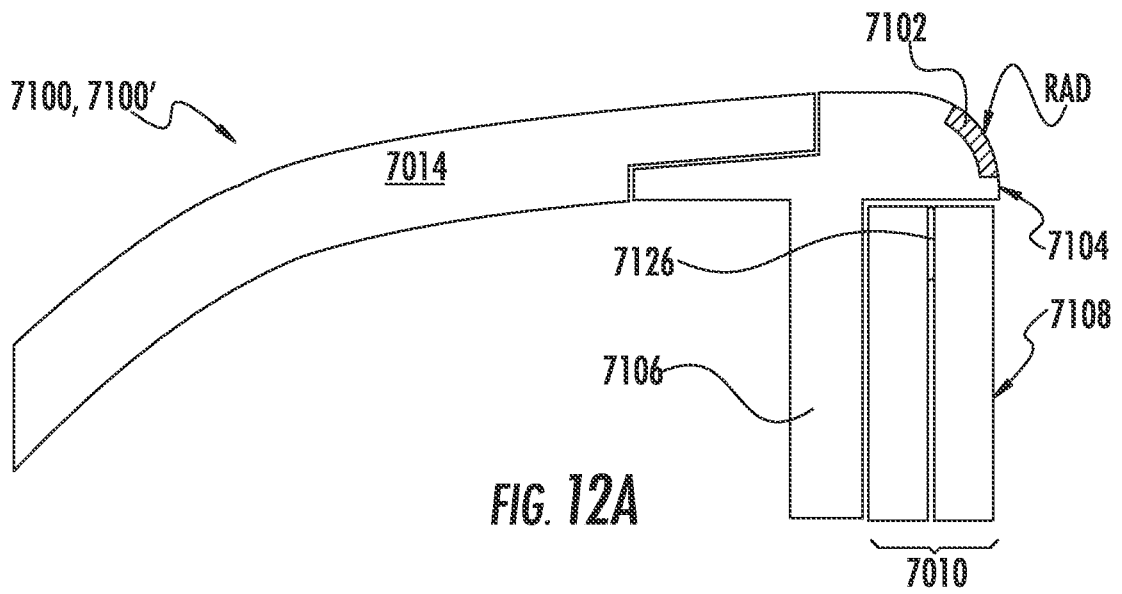


FIG. 9

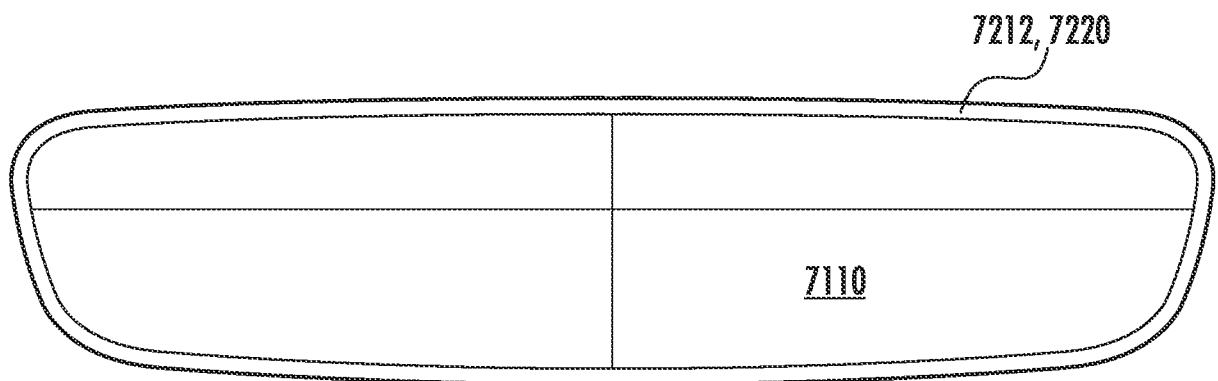
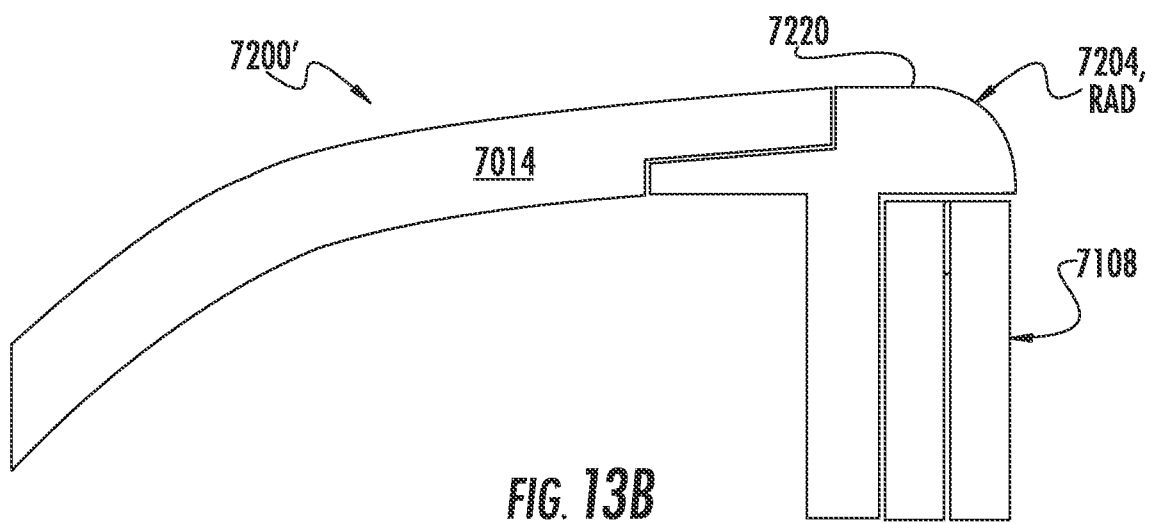
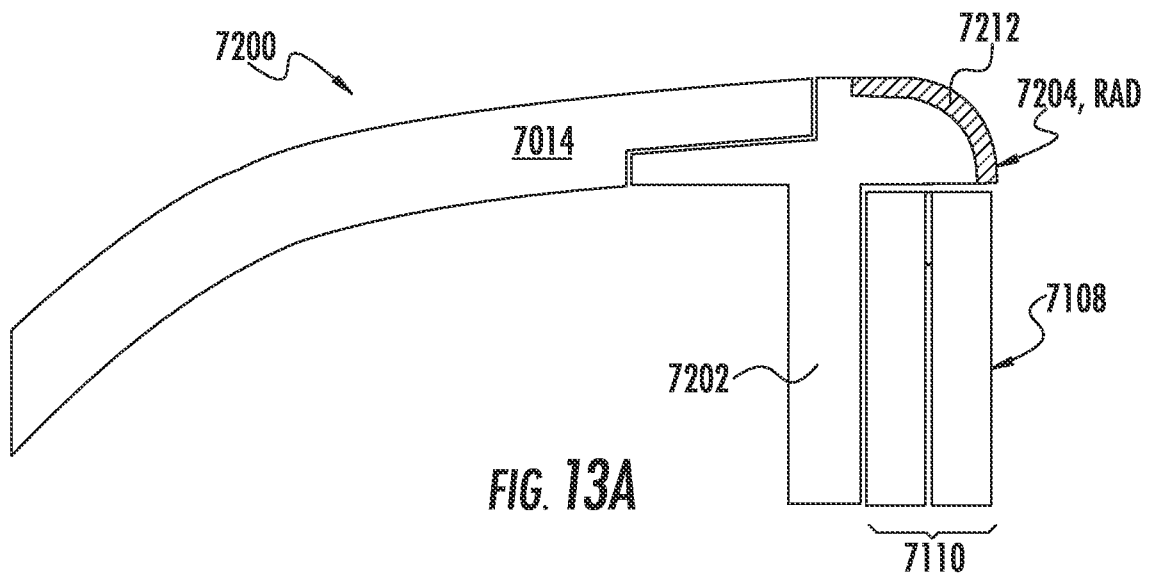




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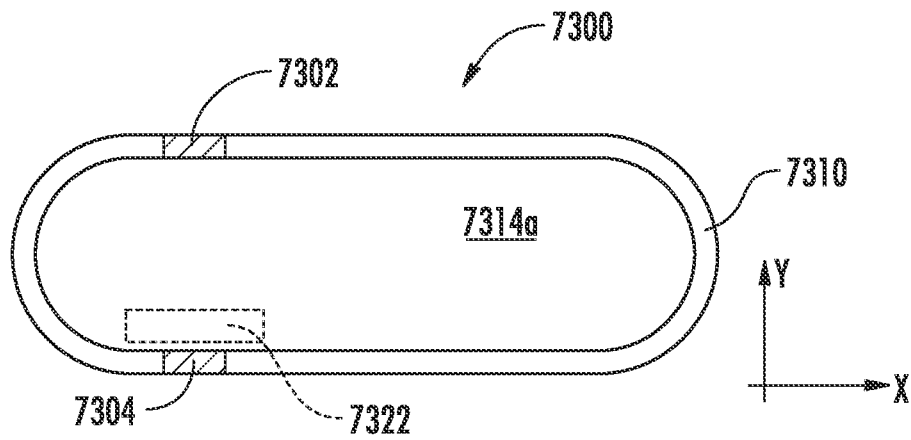


FIG. 14A

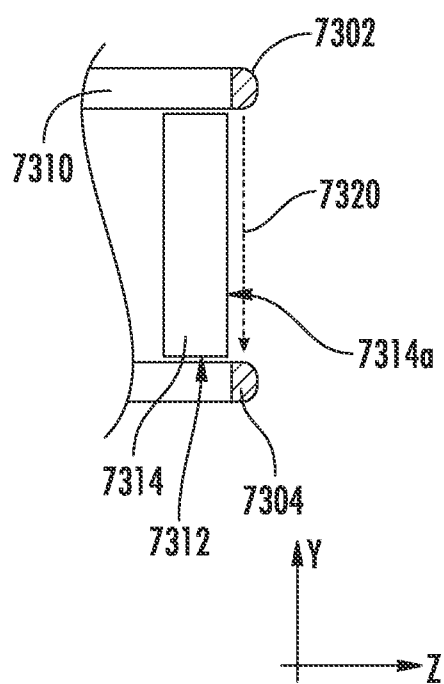


FIG. 14B

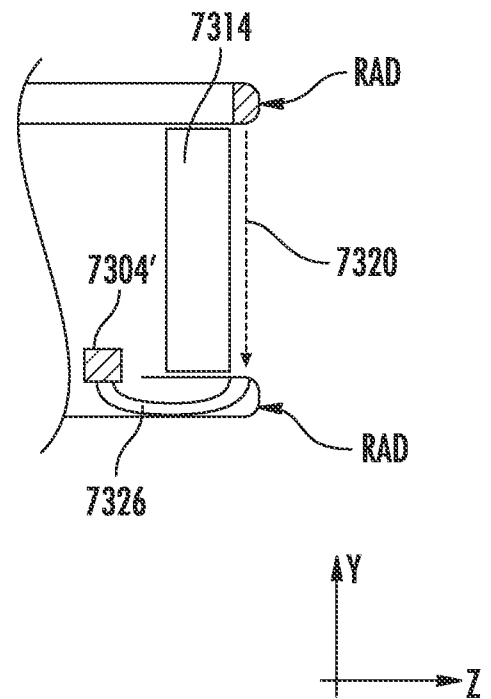
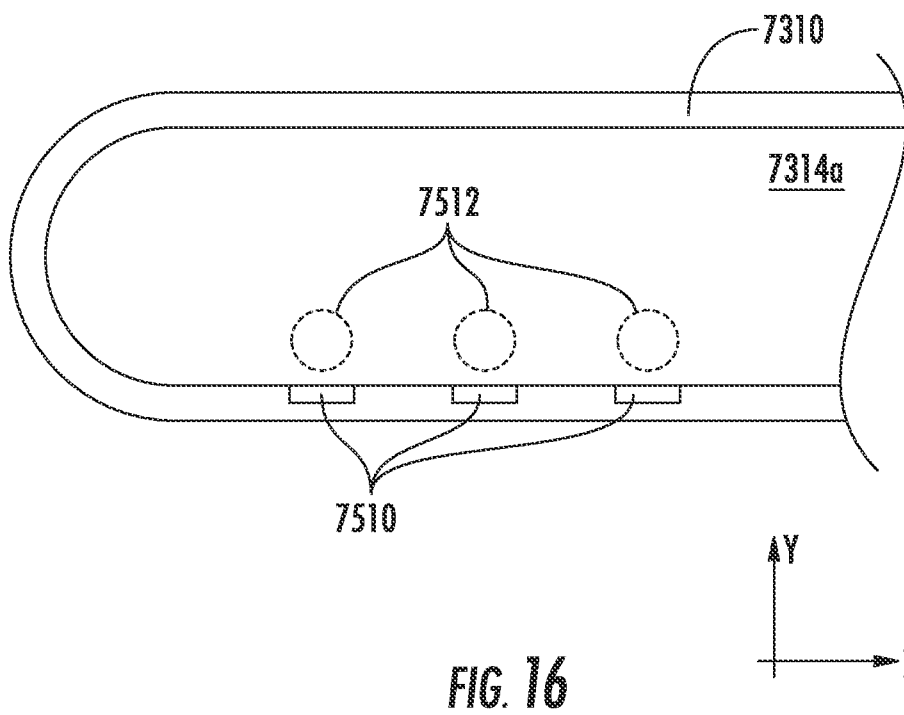
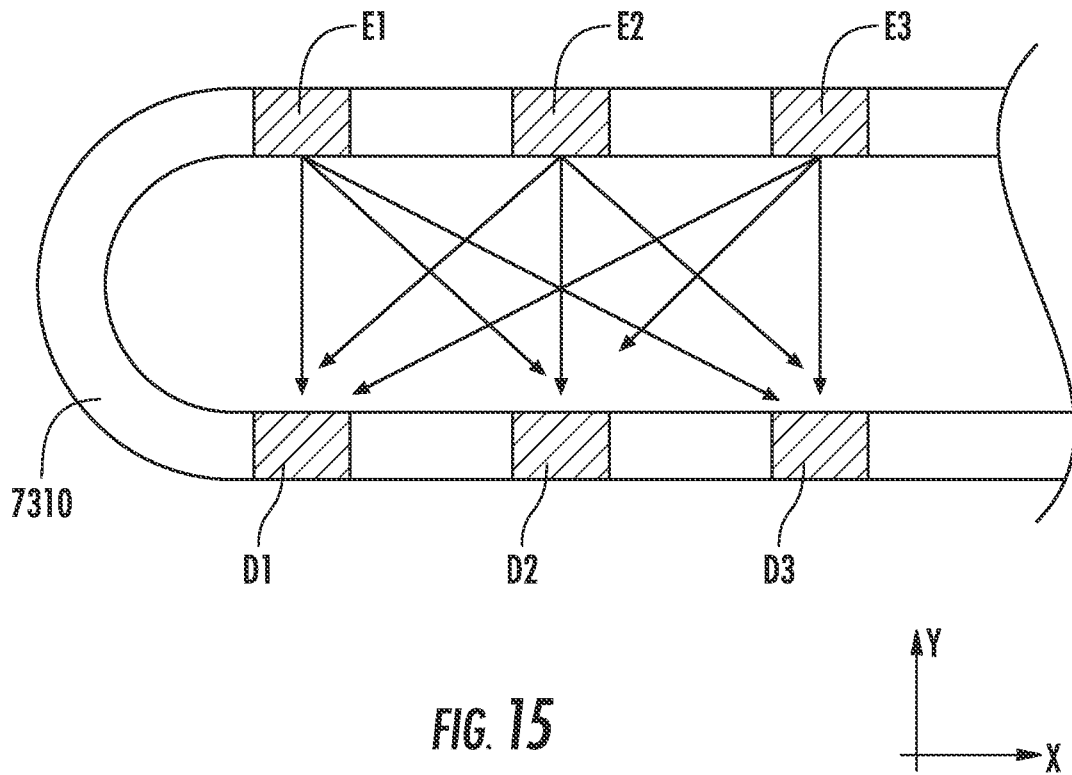
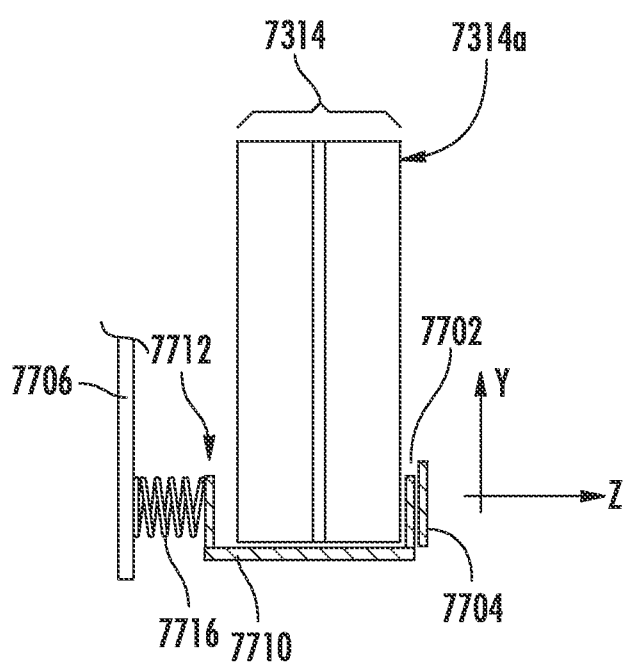
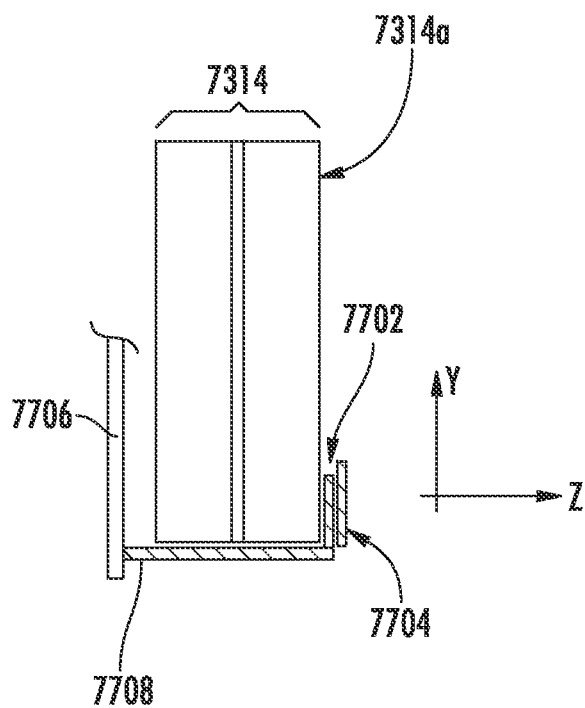
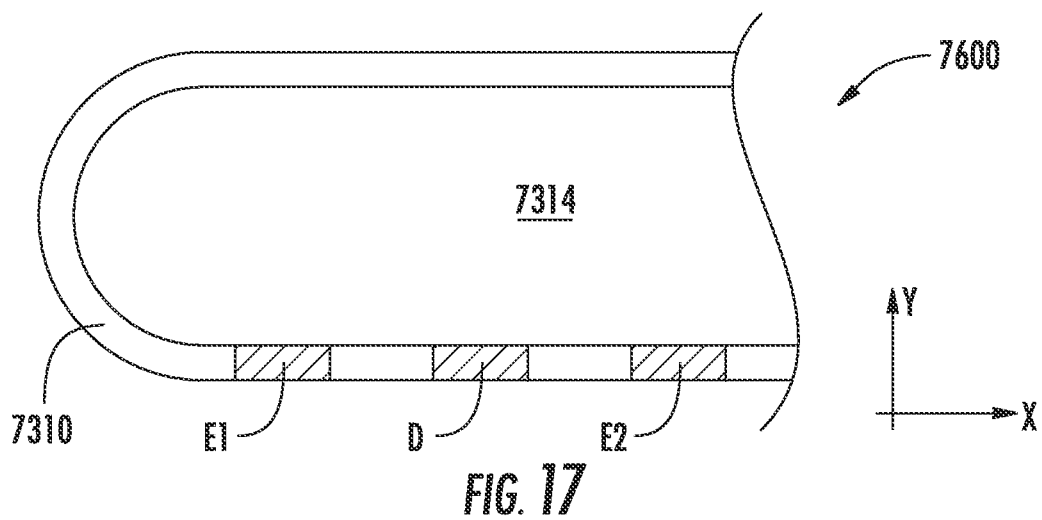


FIG. 14C



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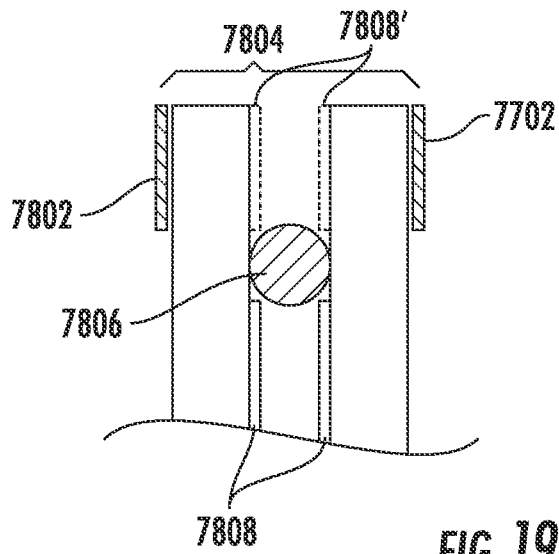


FIG. 19A

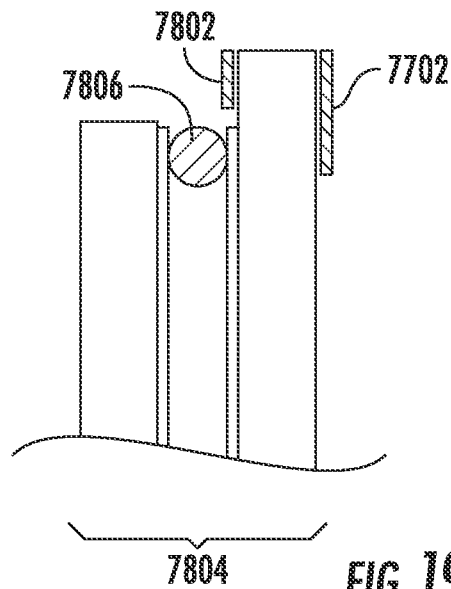


FIG. 19B

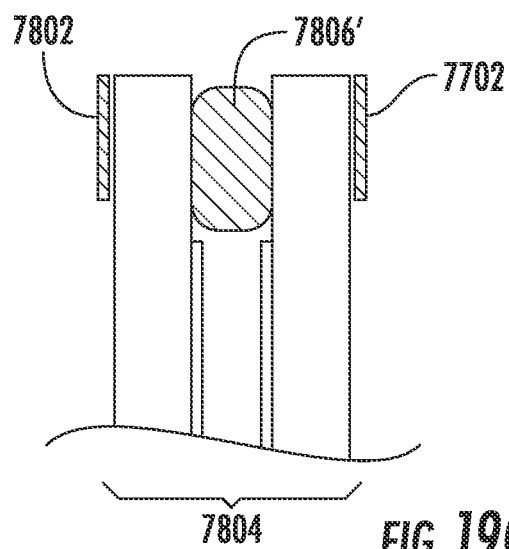
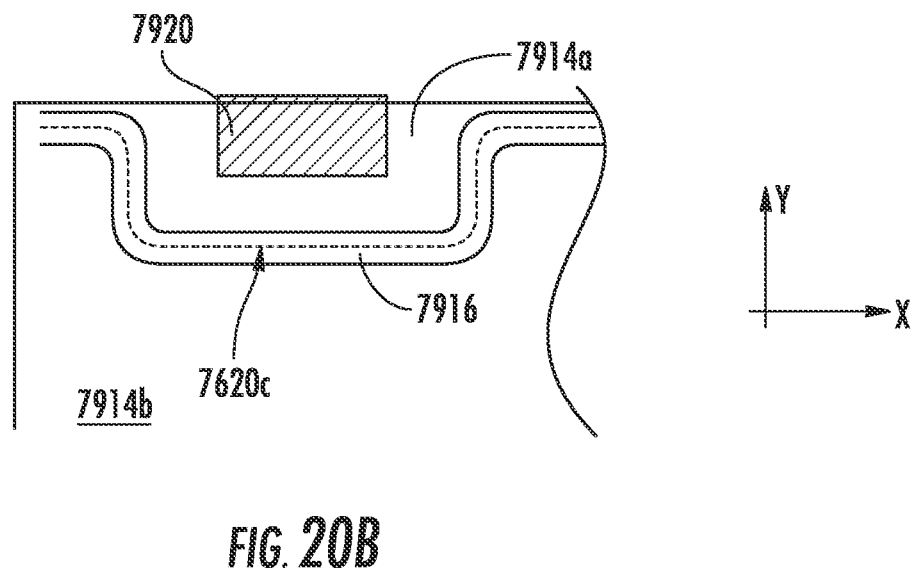
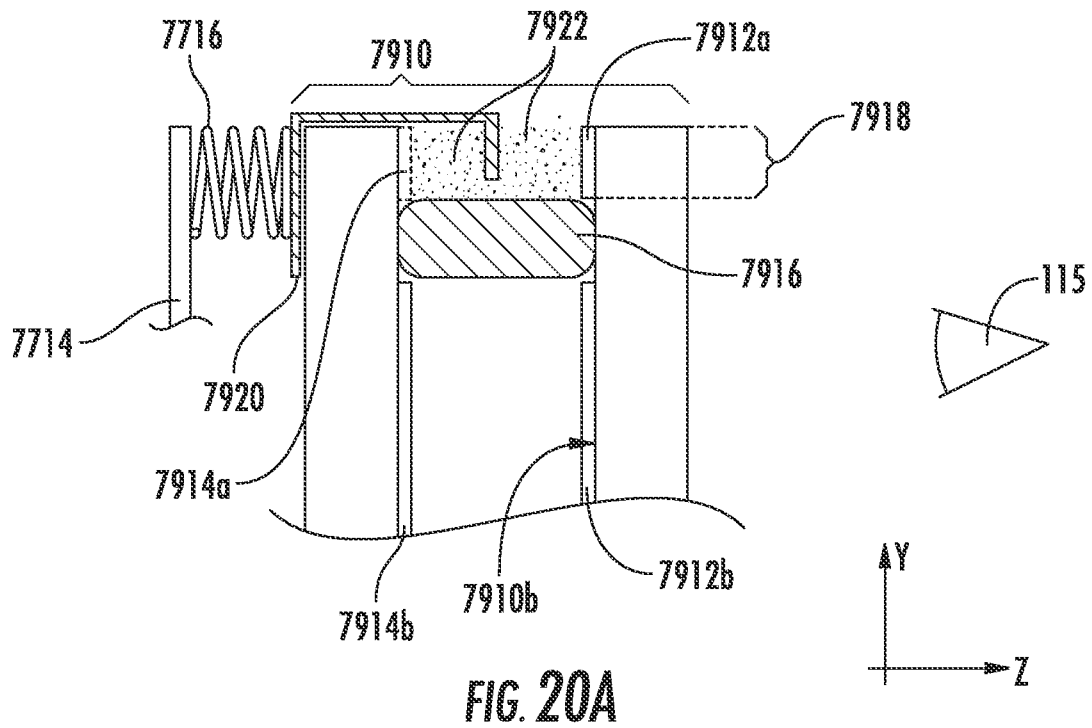
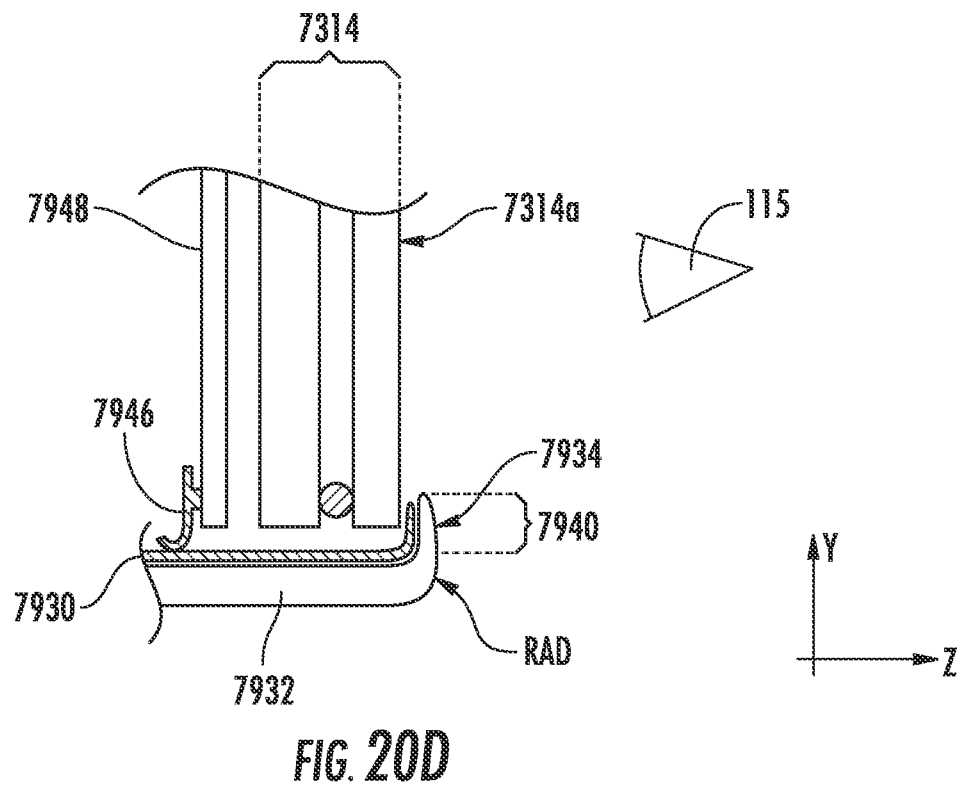
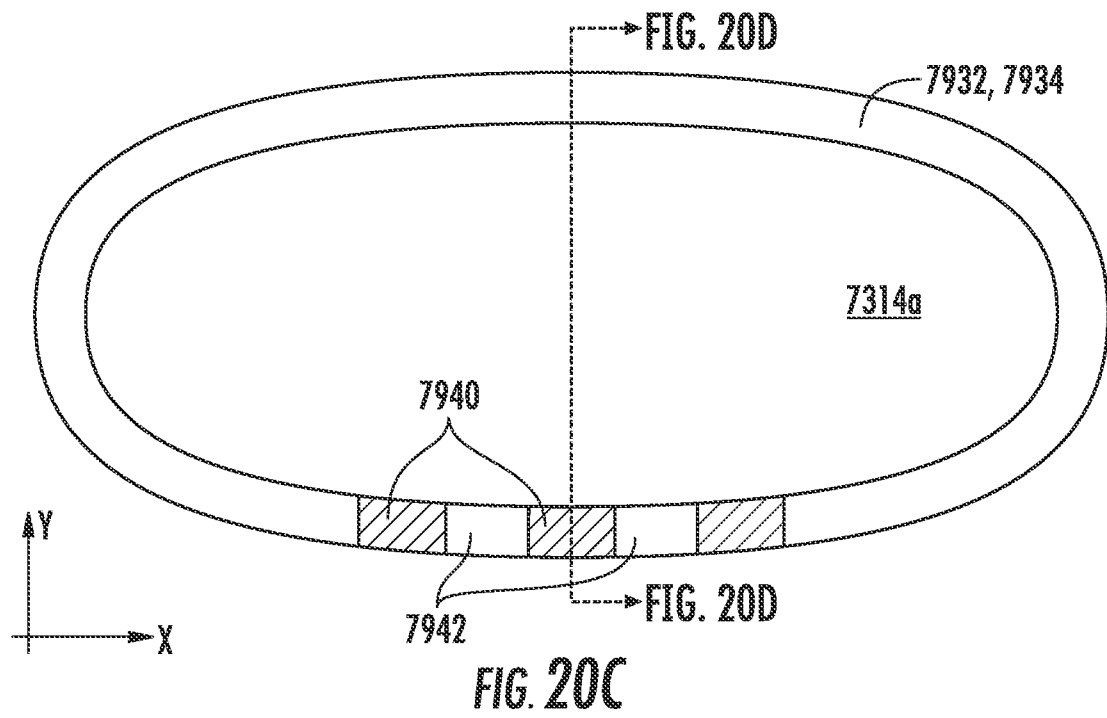


FIG. 19C



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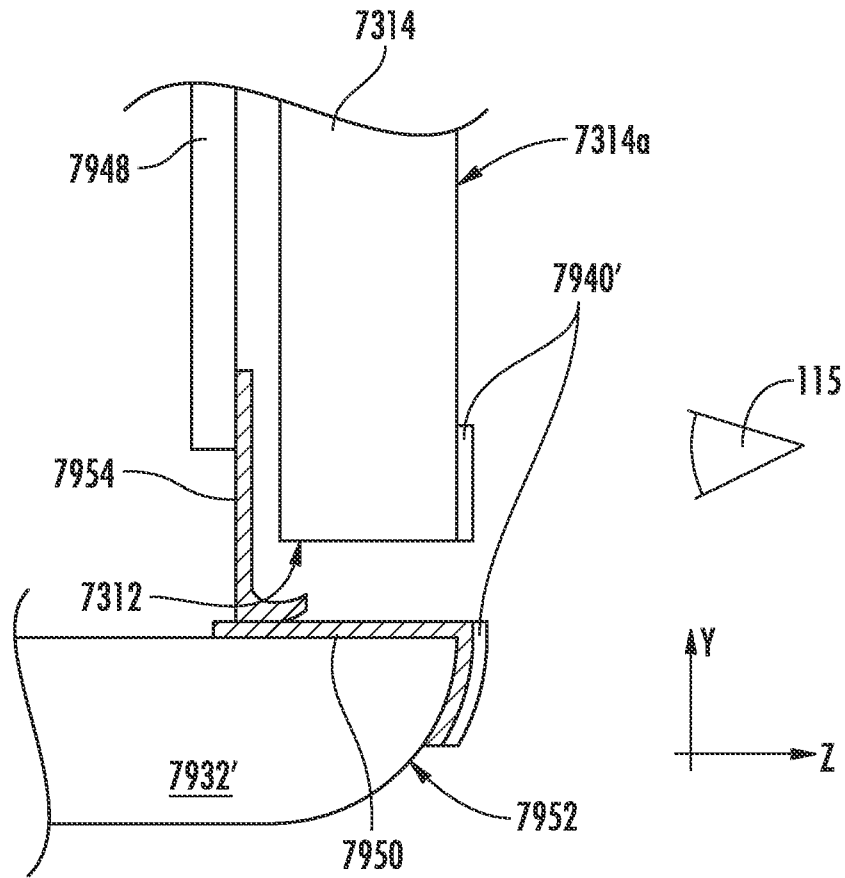


FIG. 20E

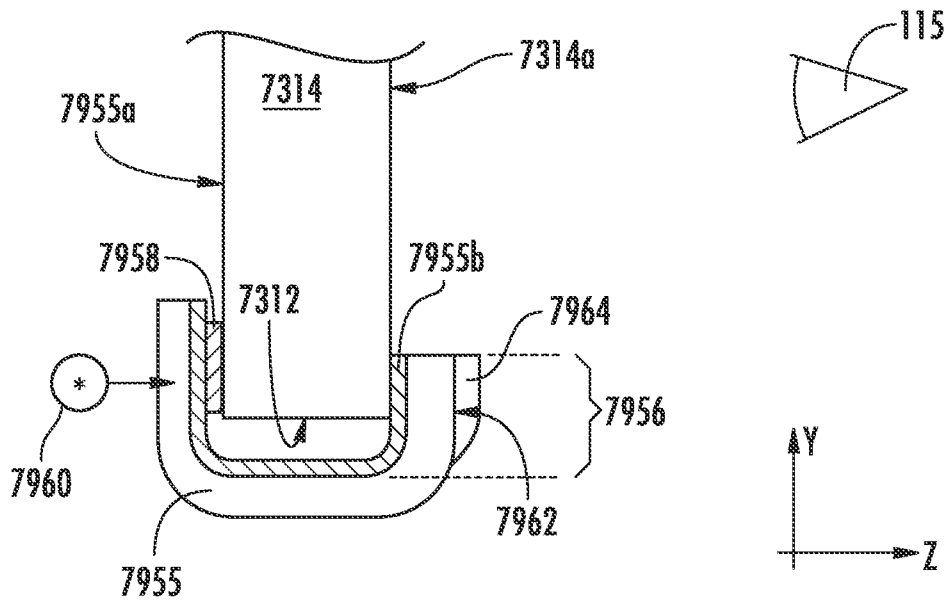


FIG. 20F

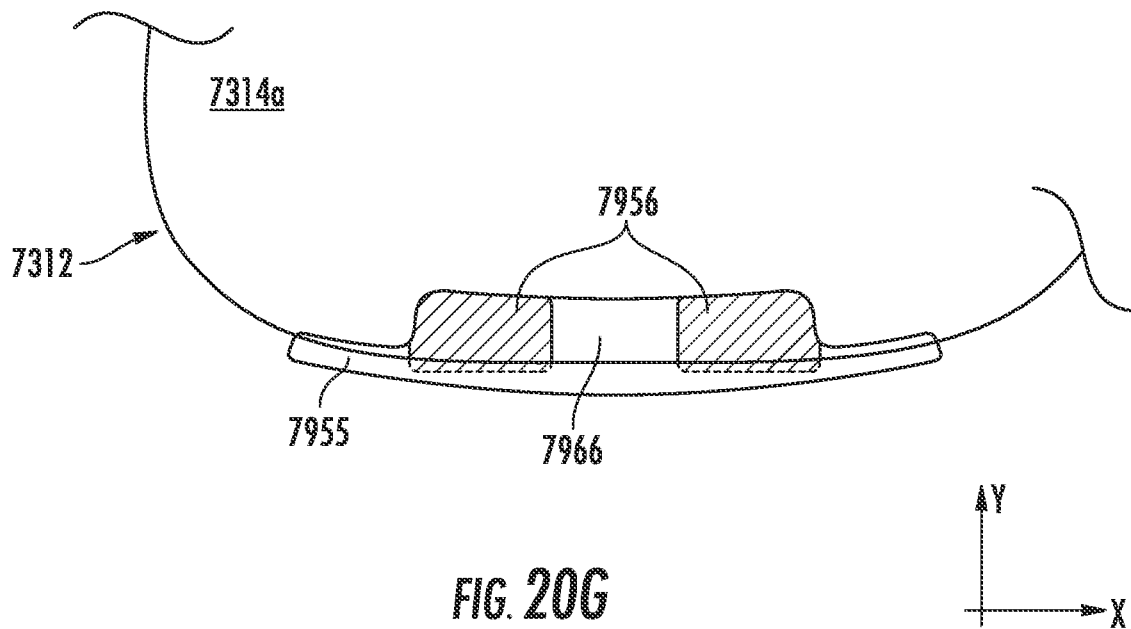
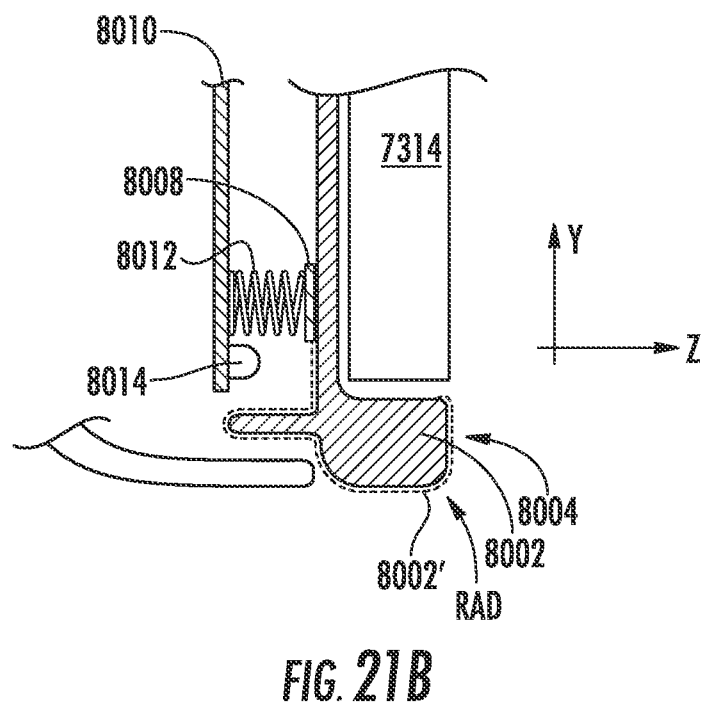
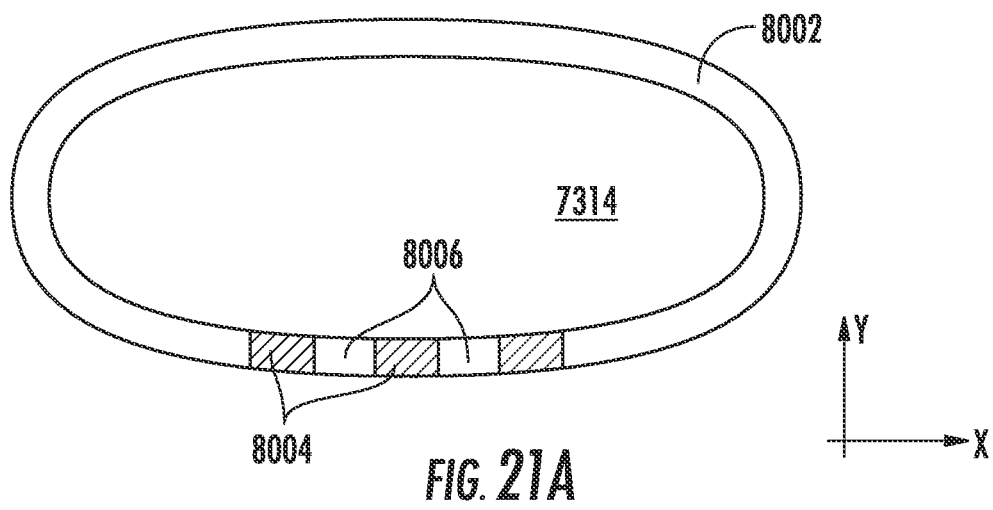


FIG. 20G

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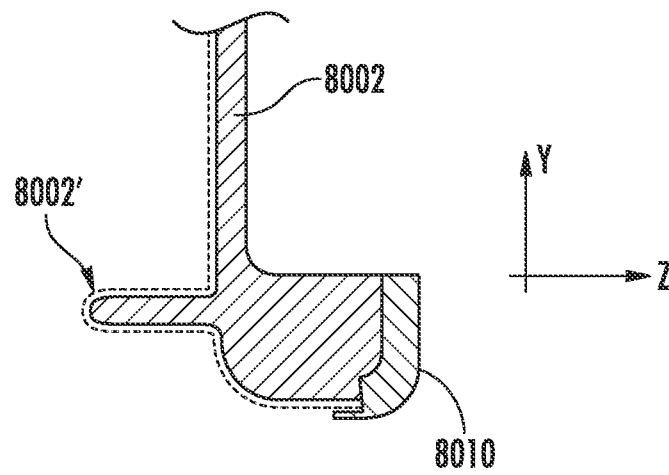


FIG. 21C

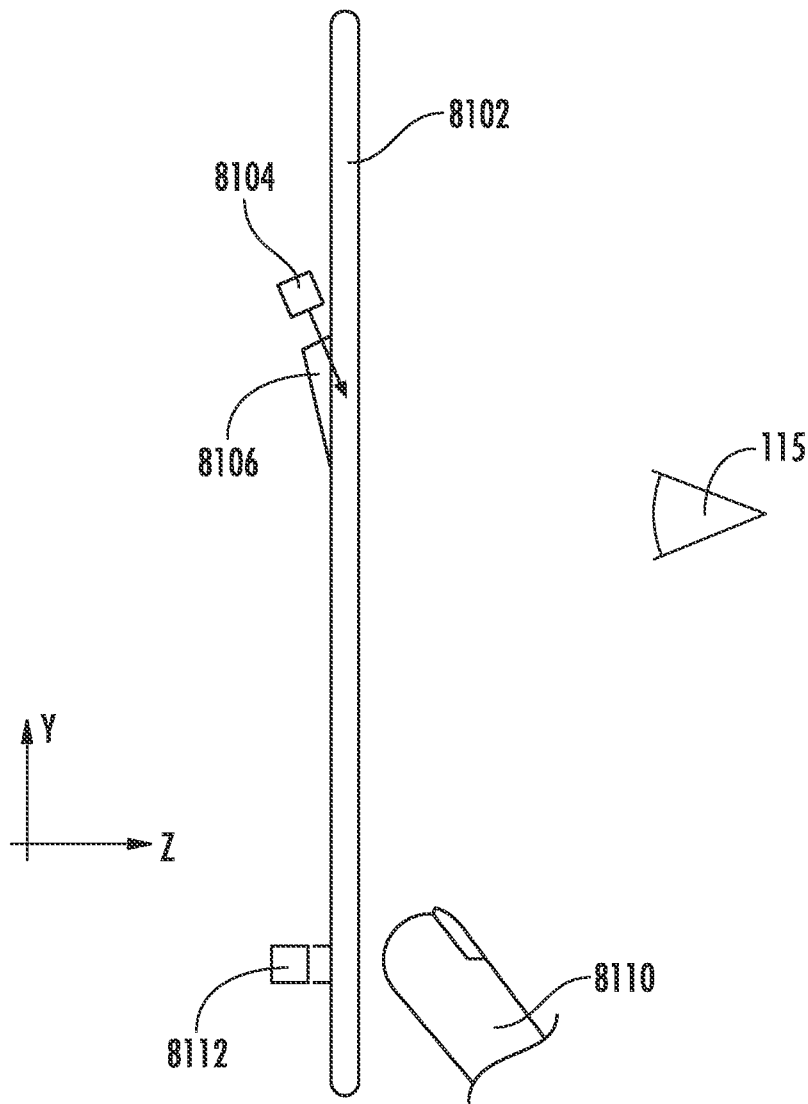
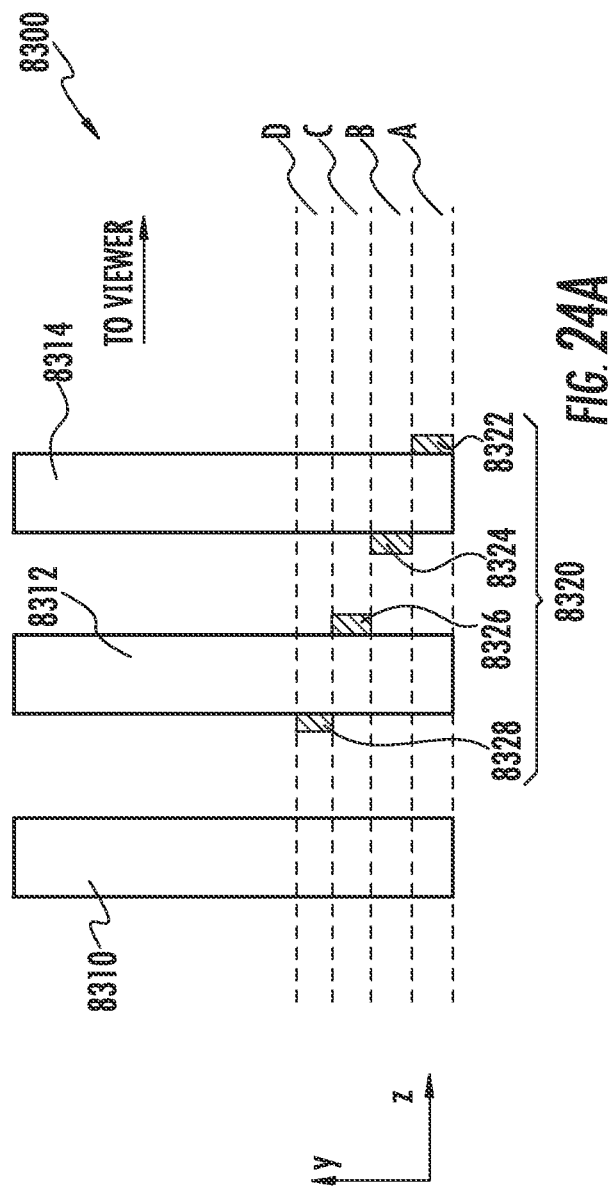
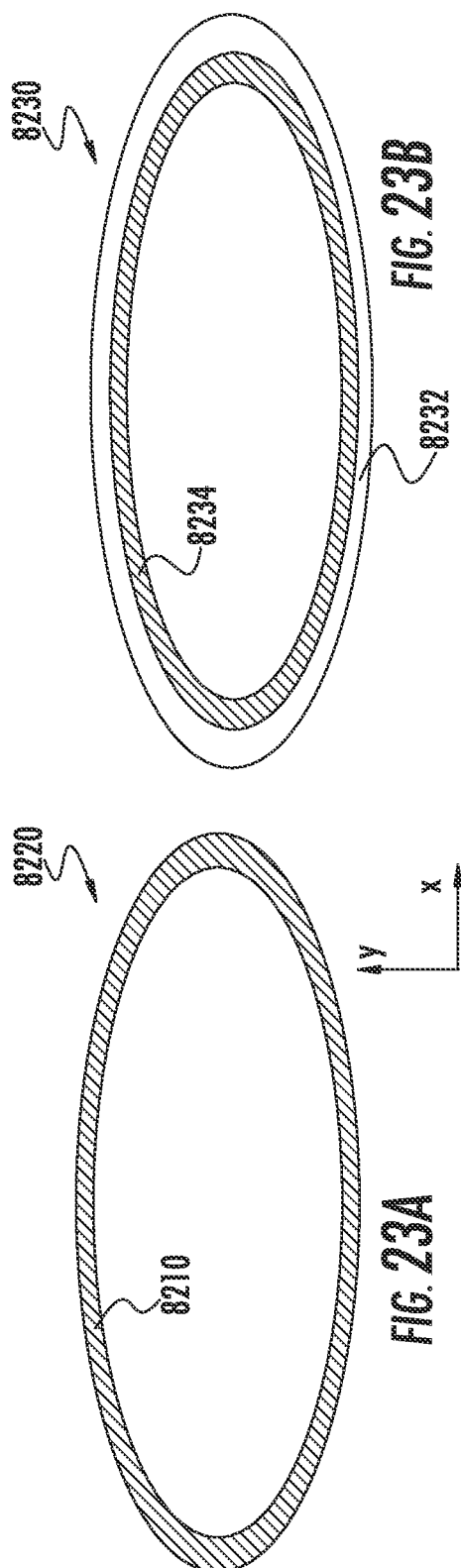


FIG. 22



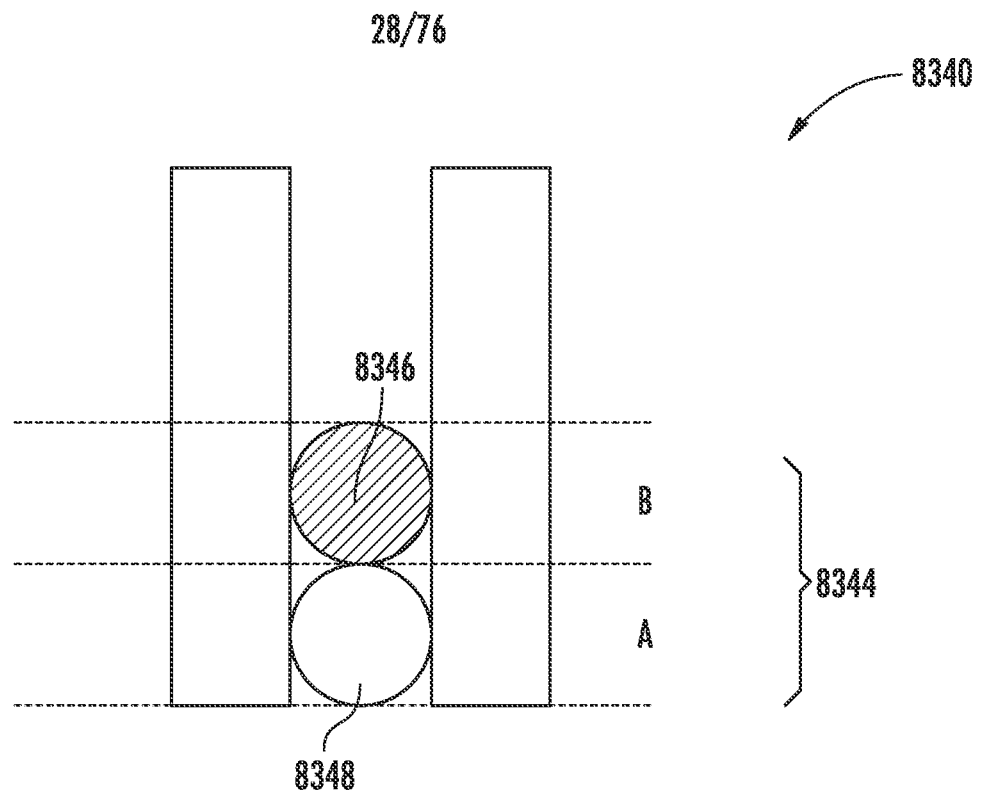


FIG. 24B

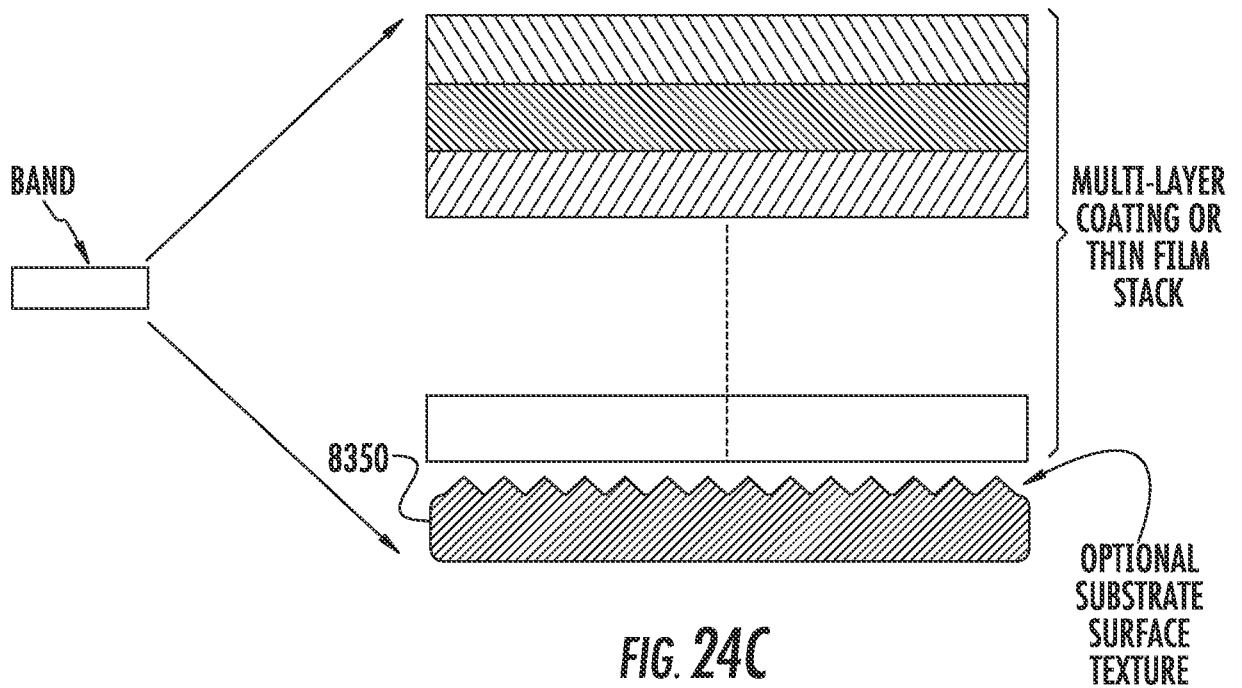
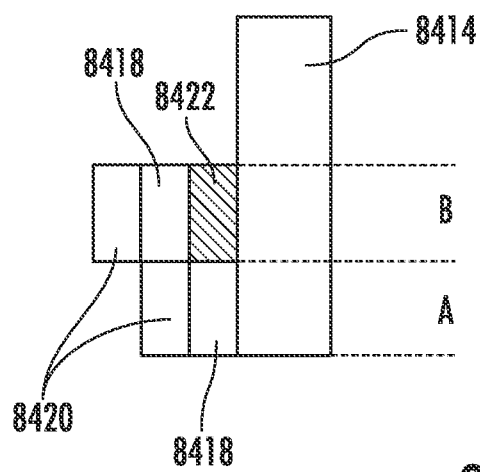
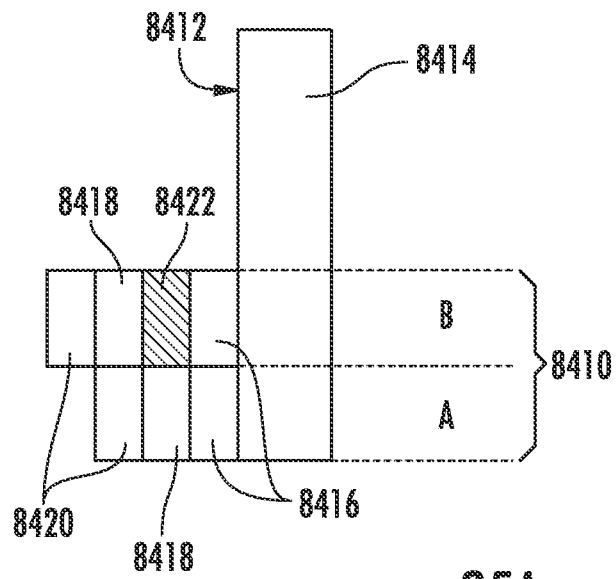


FIG. 24C



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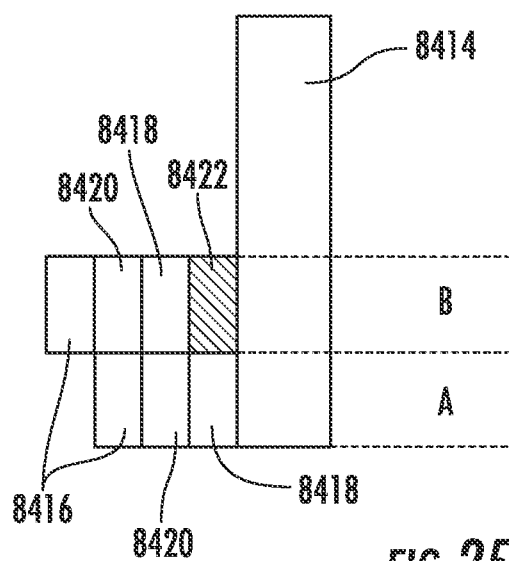


FIG. 25C

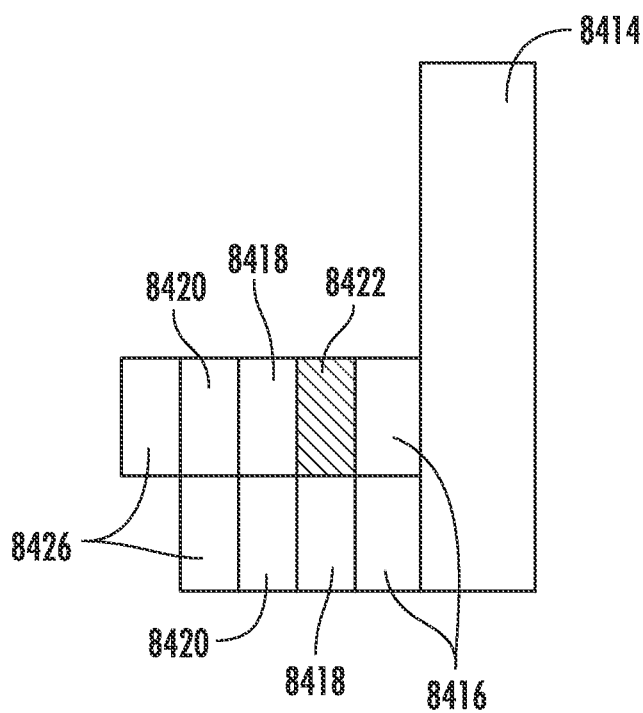
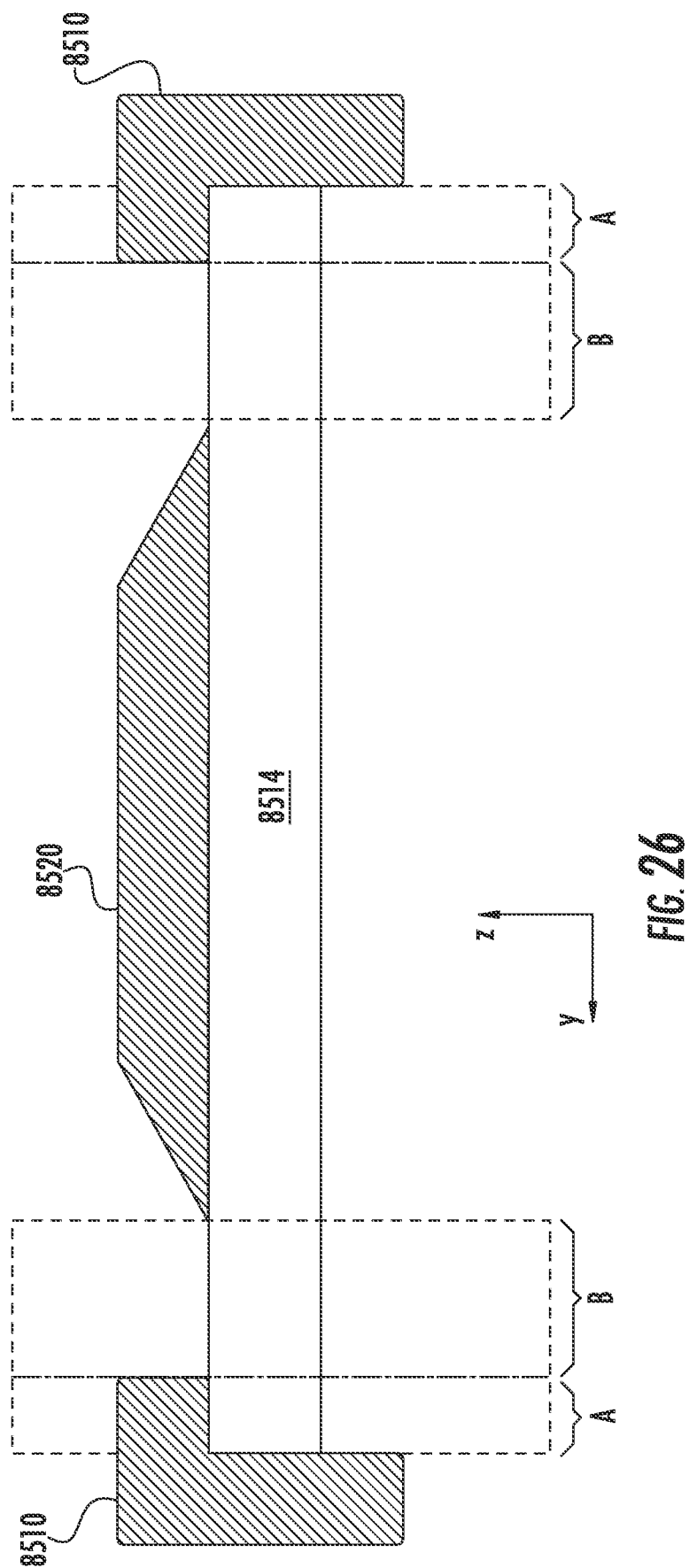
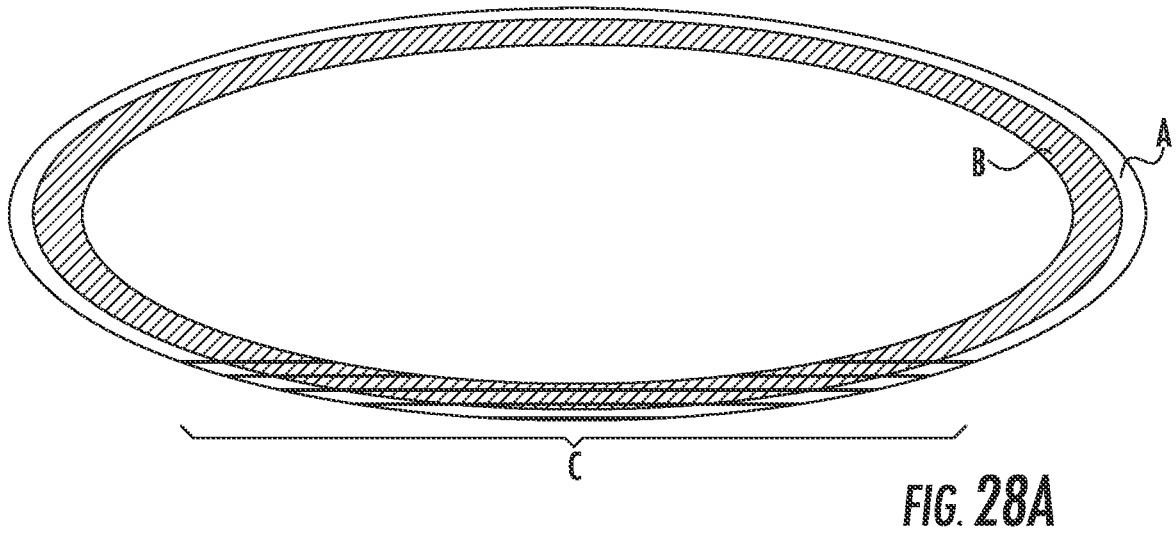
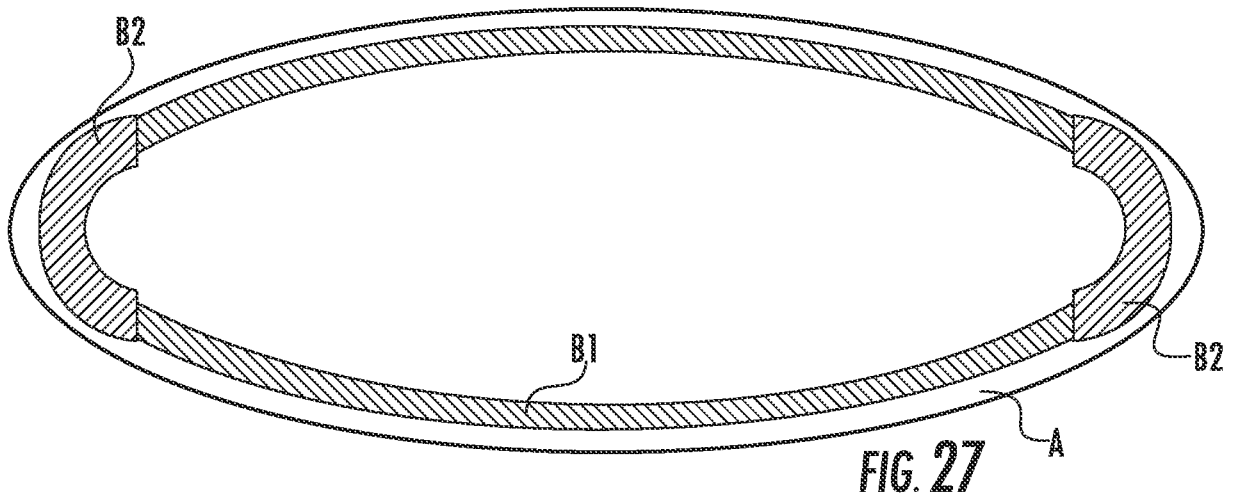


FIG. 25D





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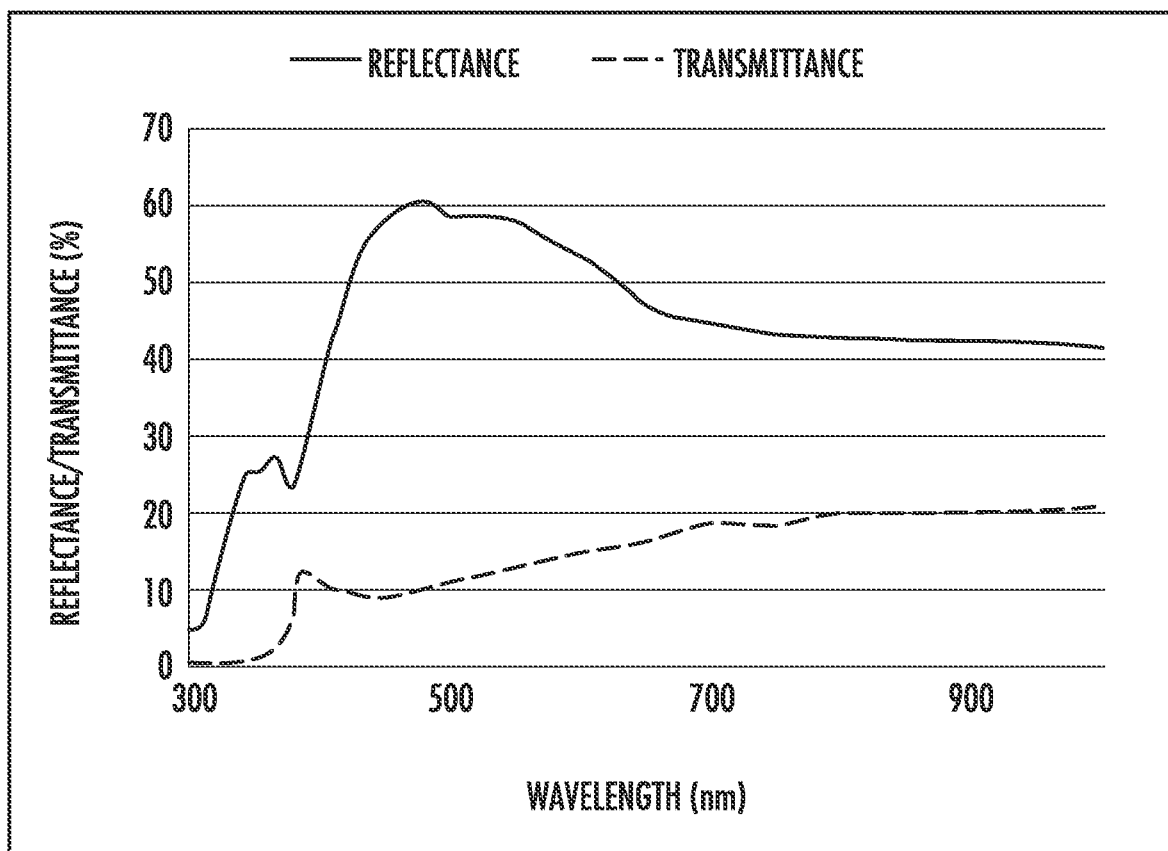
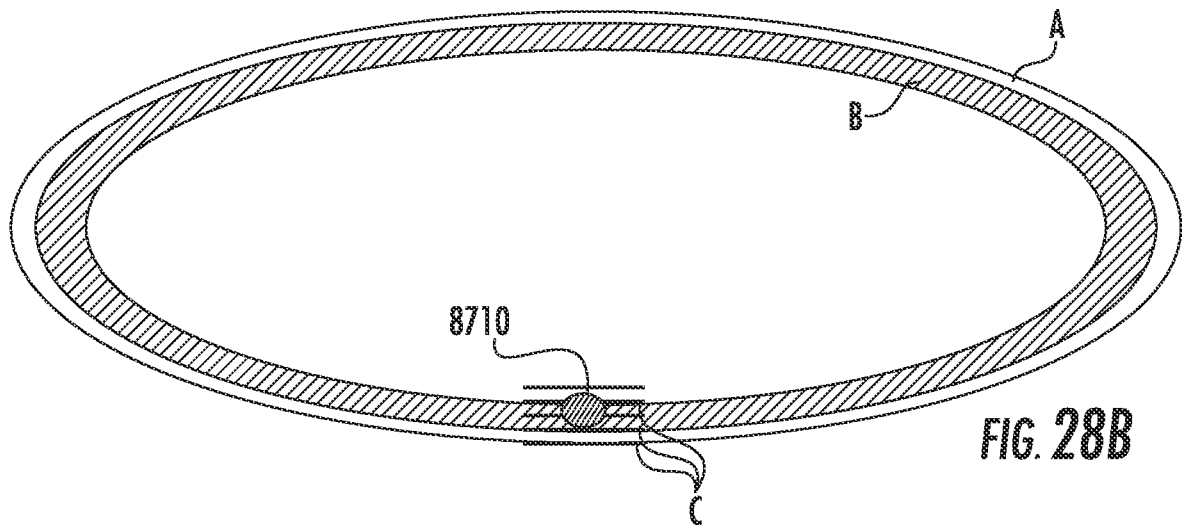


FIG. 28C

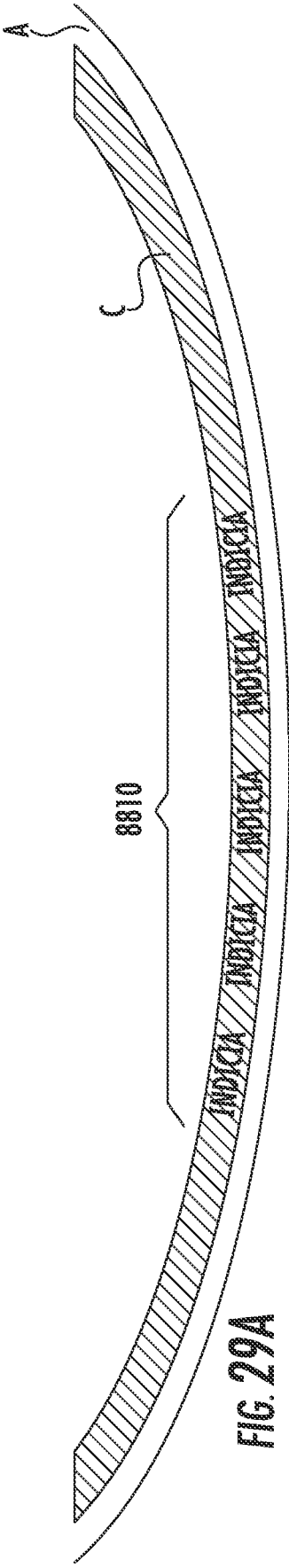


FIG. 29A

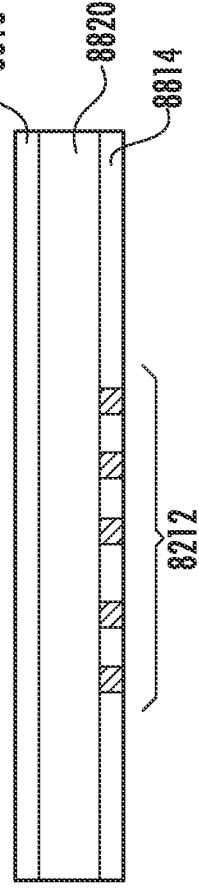


FIG. 29B

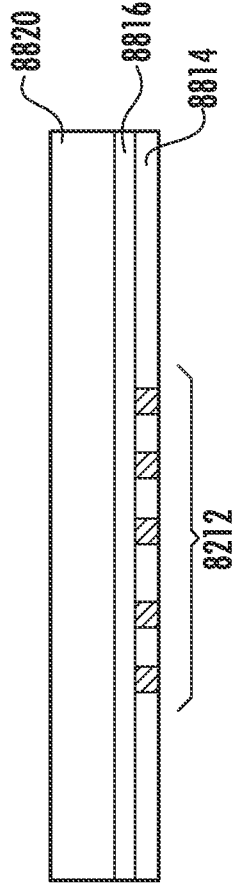


FIG. 29C

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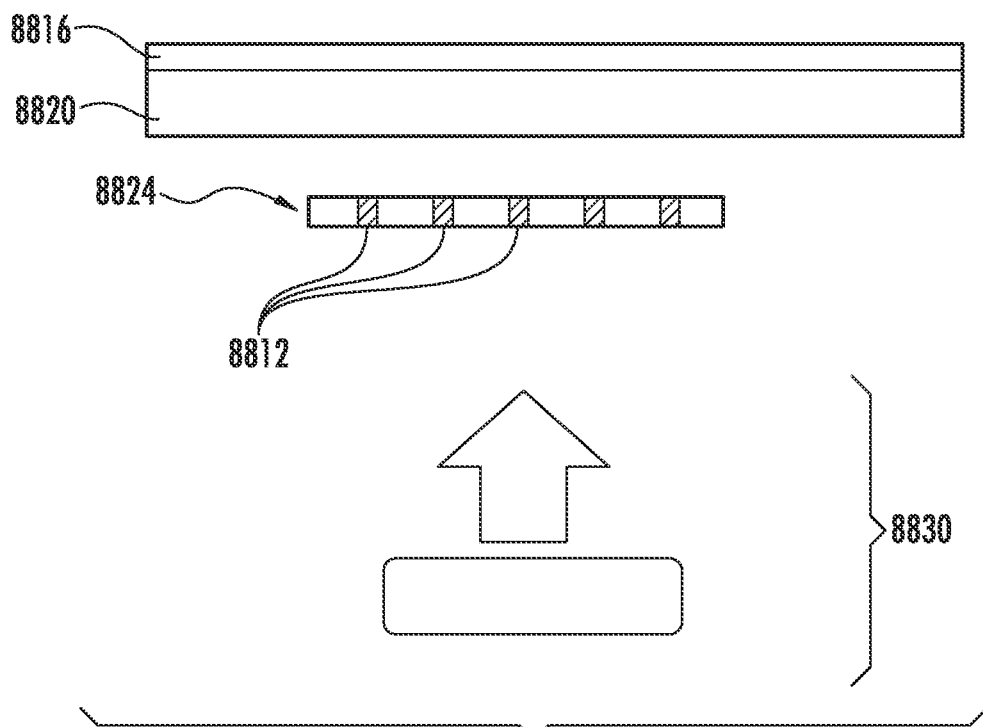


FIG. 29D

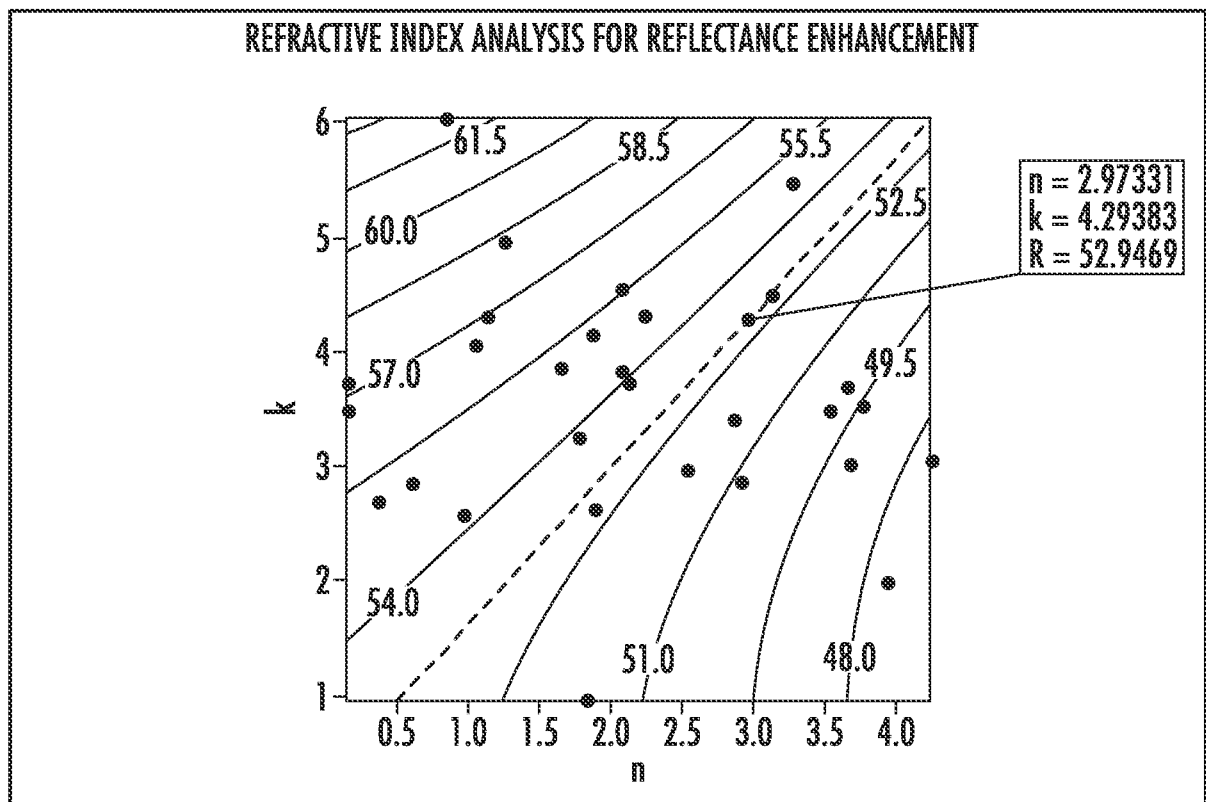


FIG. 30A

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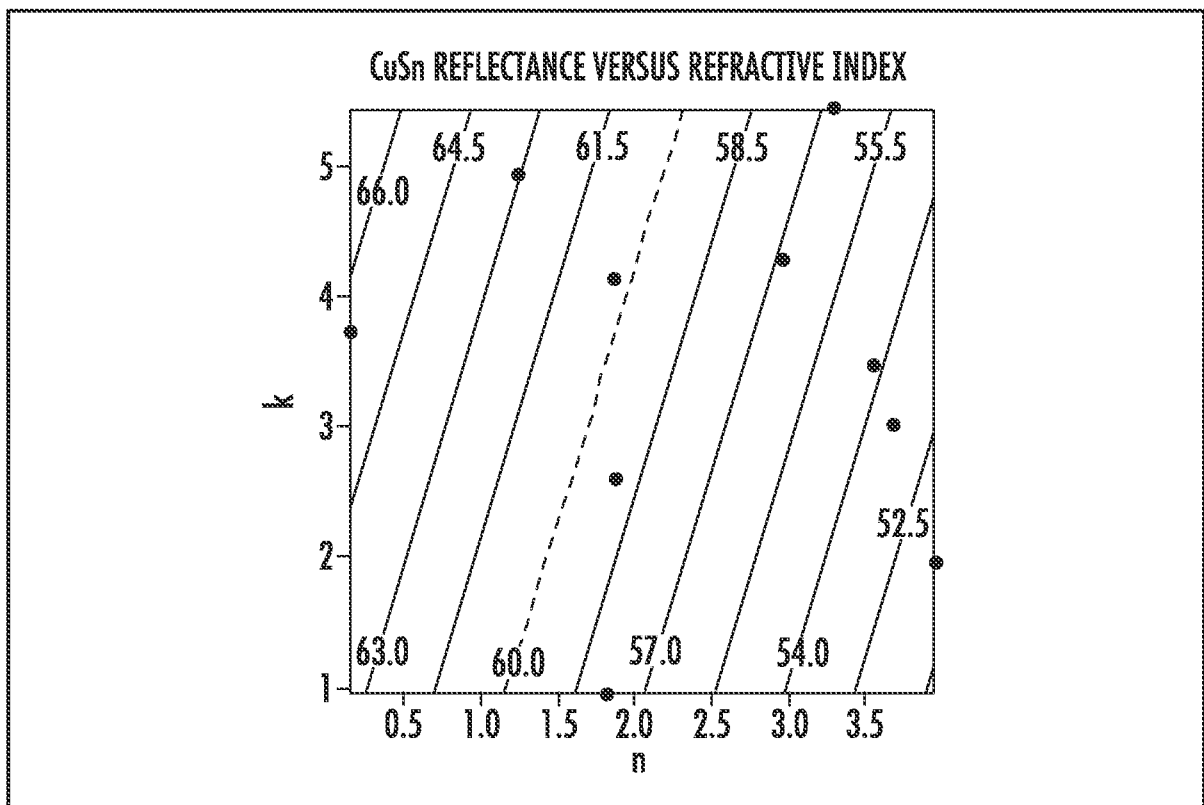


FIG. 30B

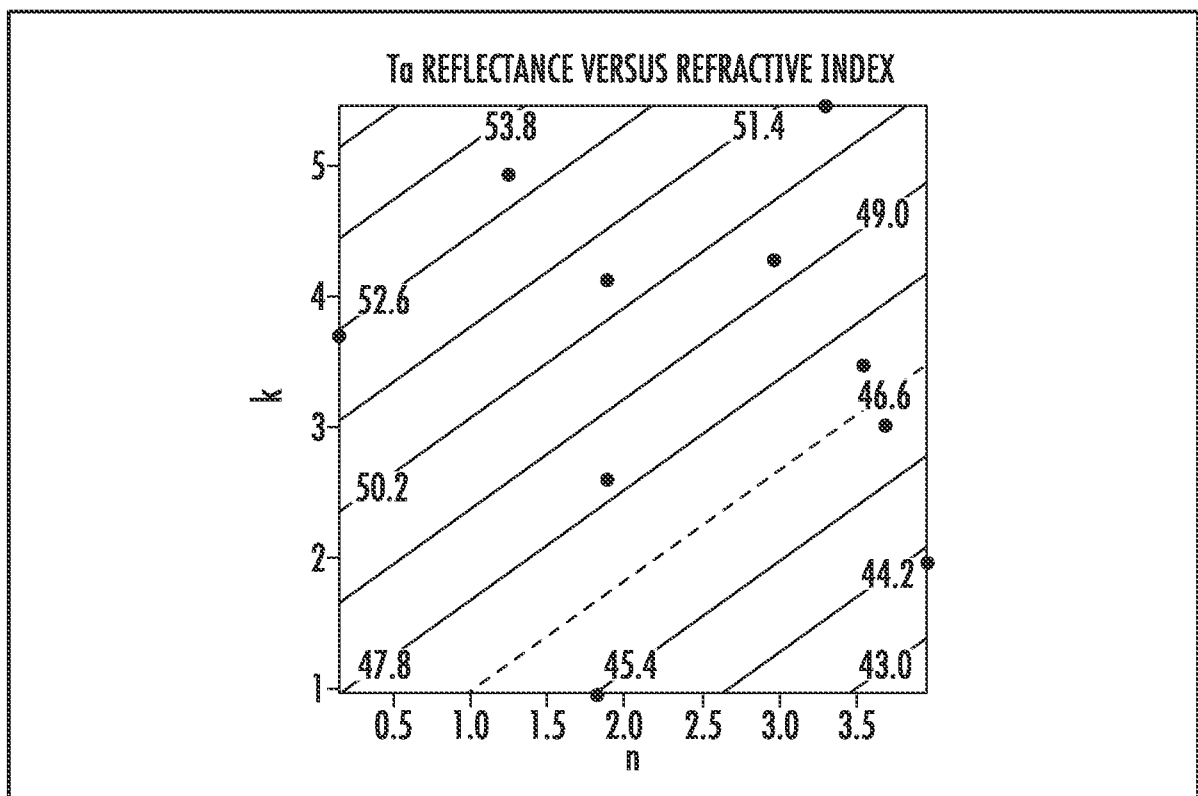


FIG. 30C

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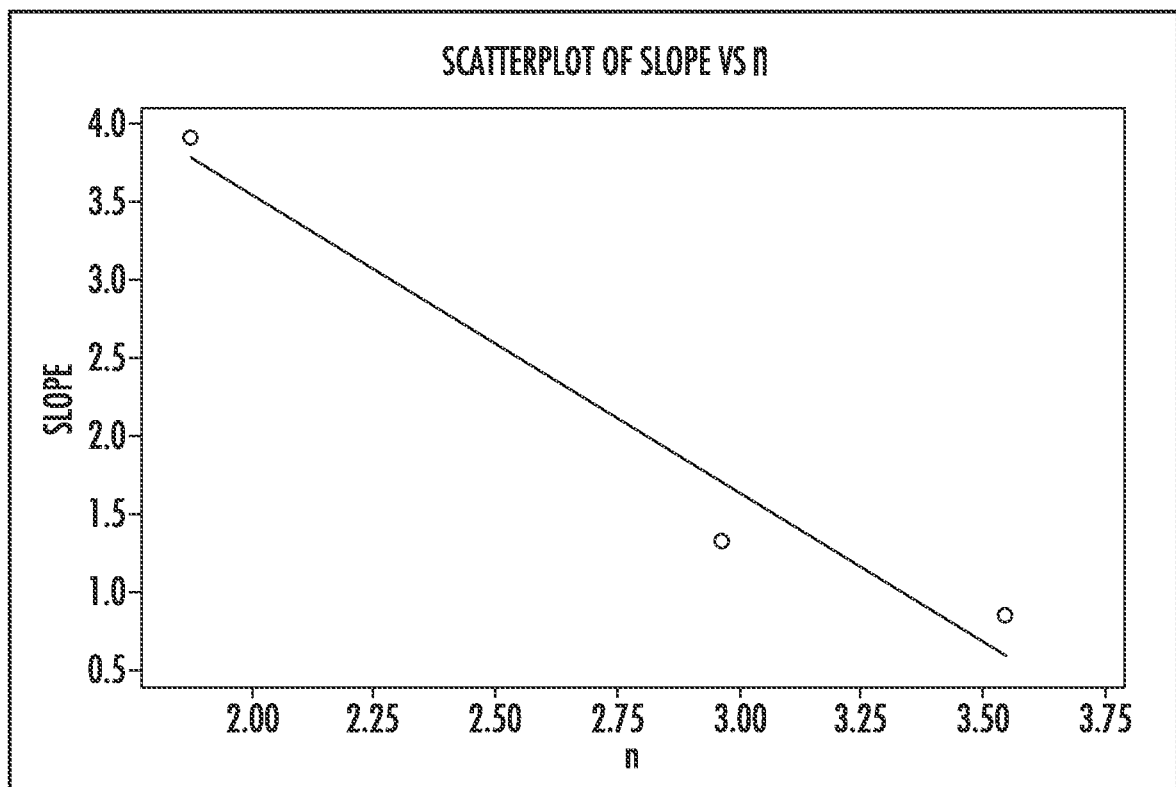


FIG. 31A

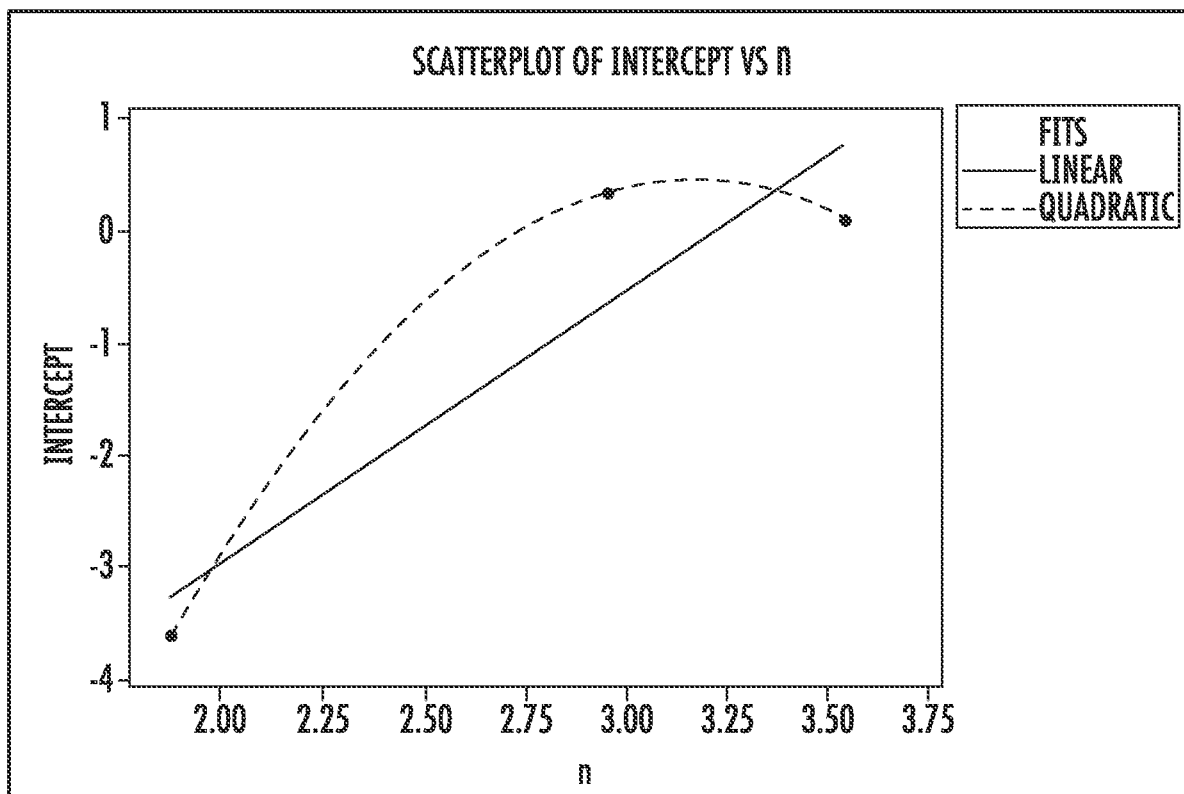
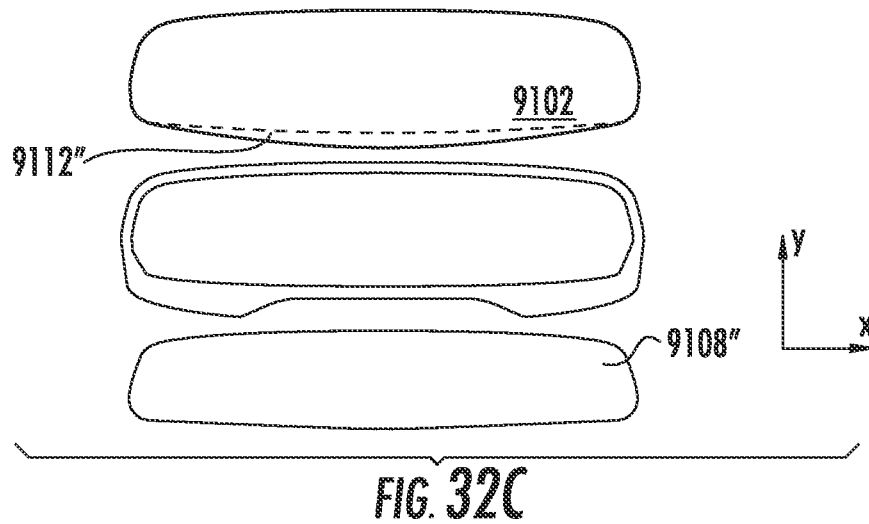
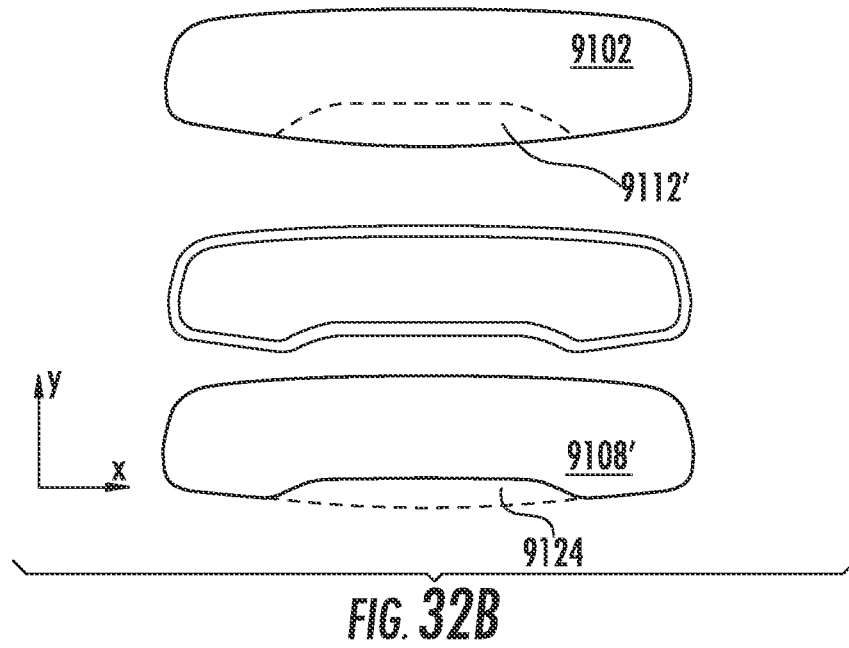
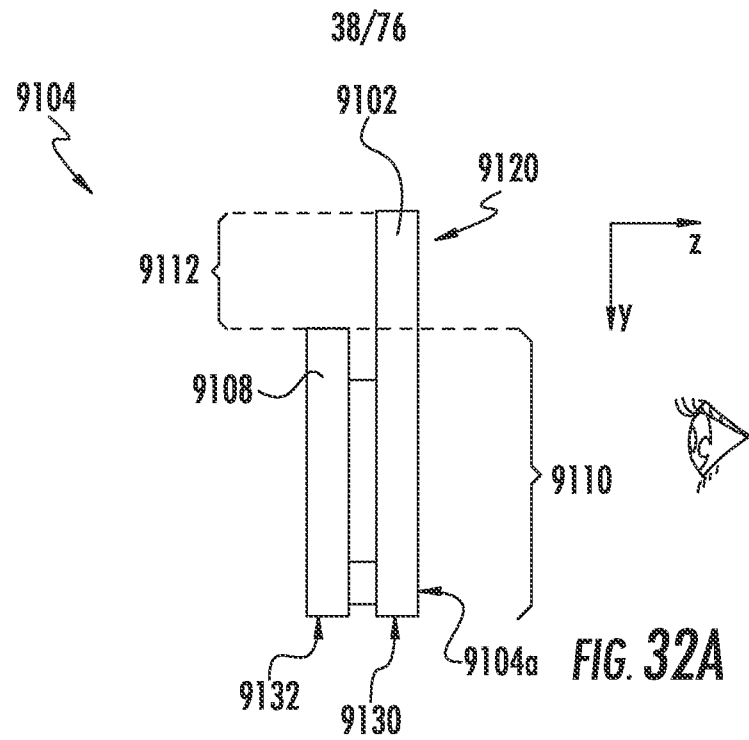


FIG. 31B



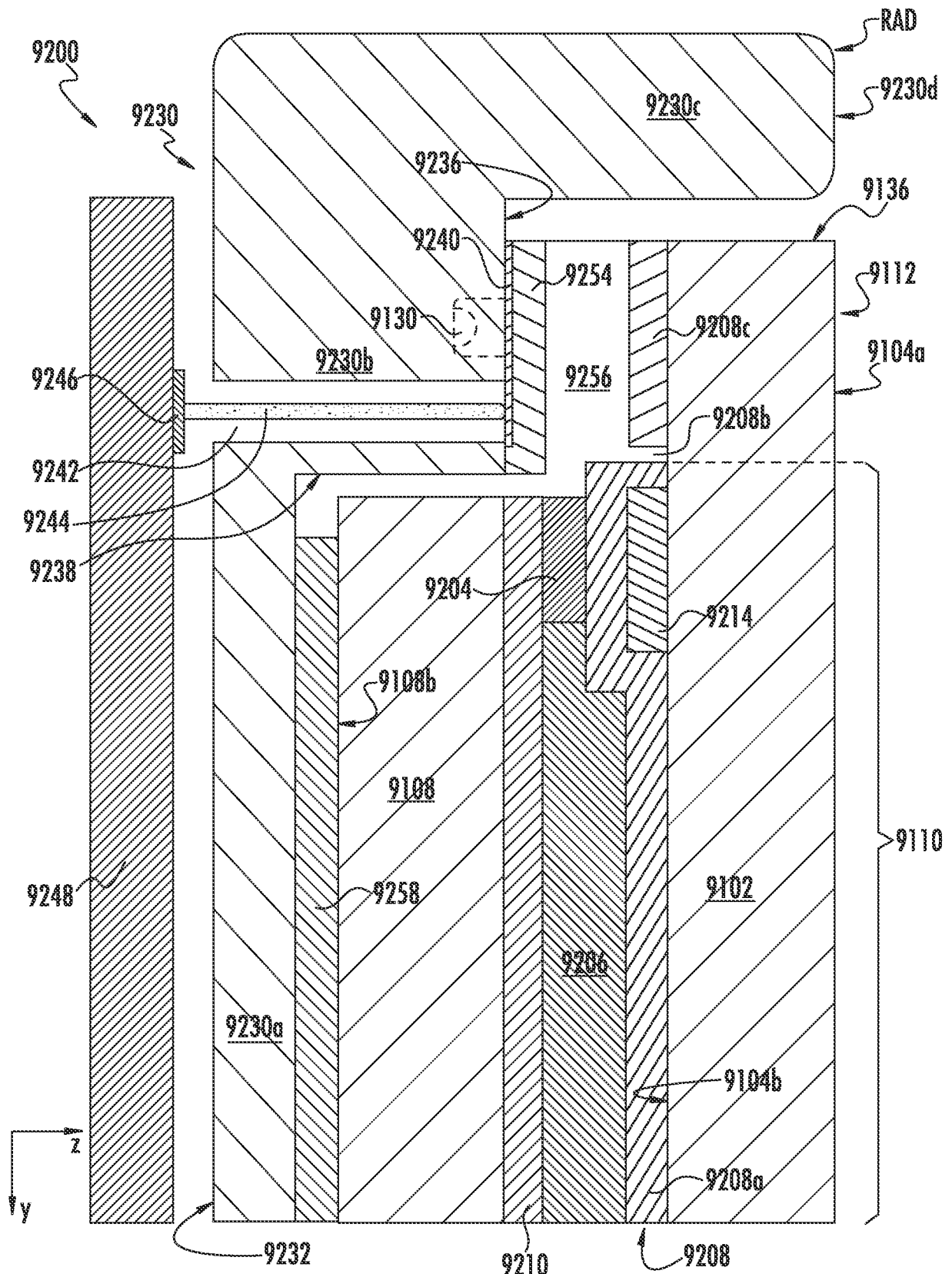


FIG. 33A

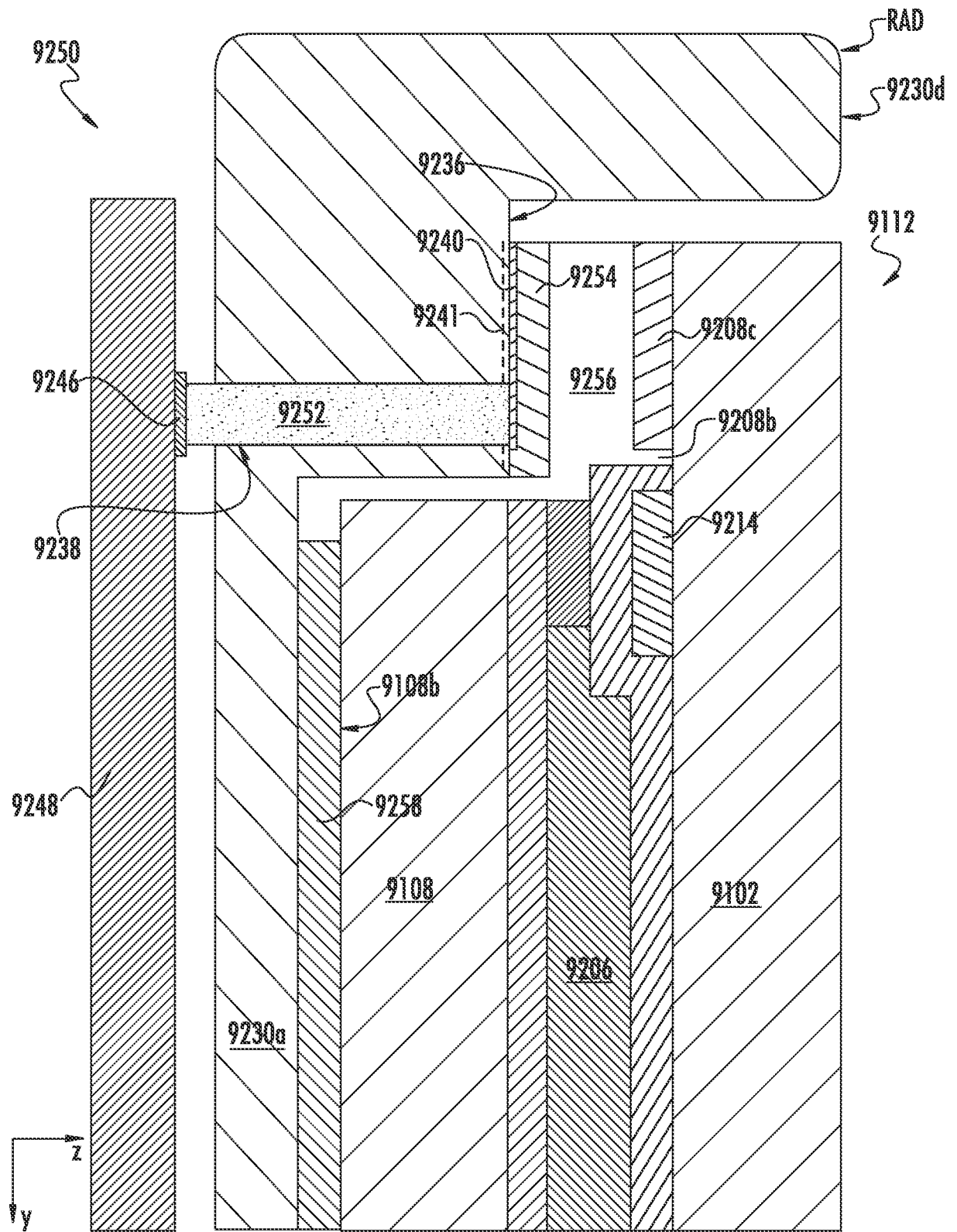
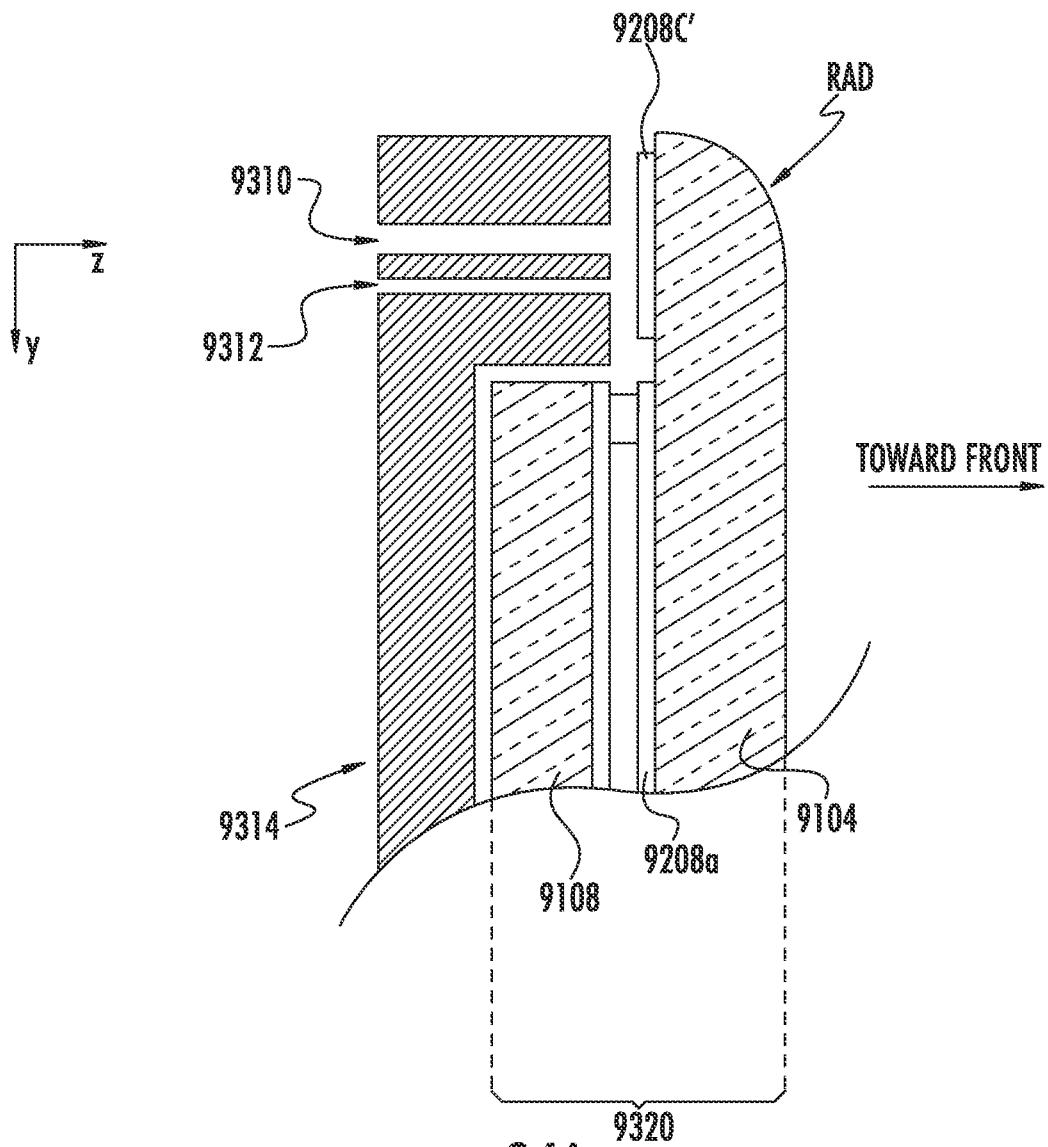


FIG. 33B



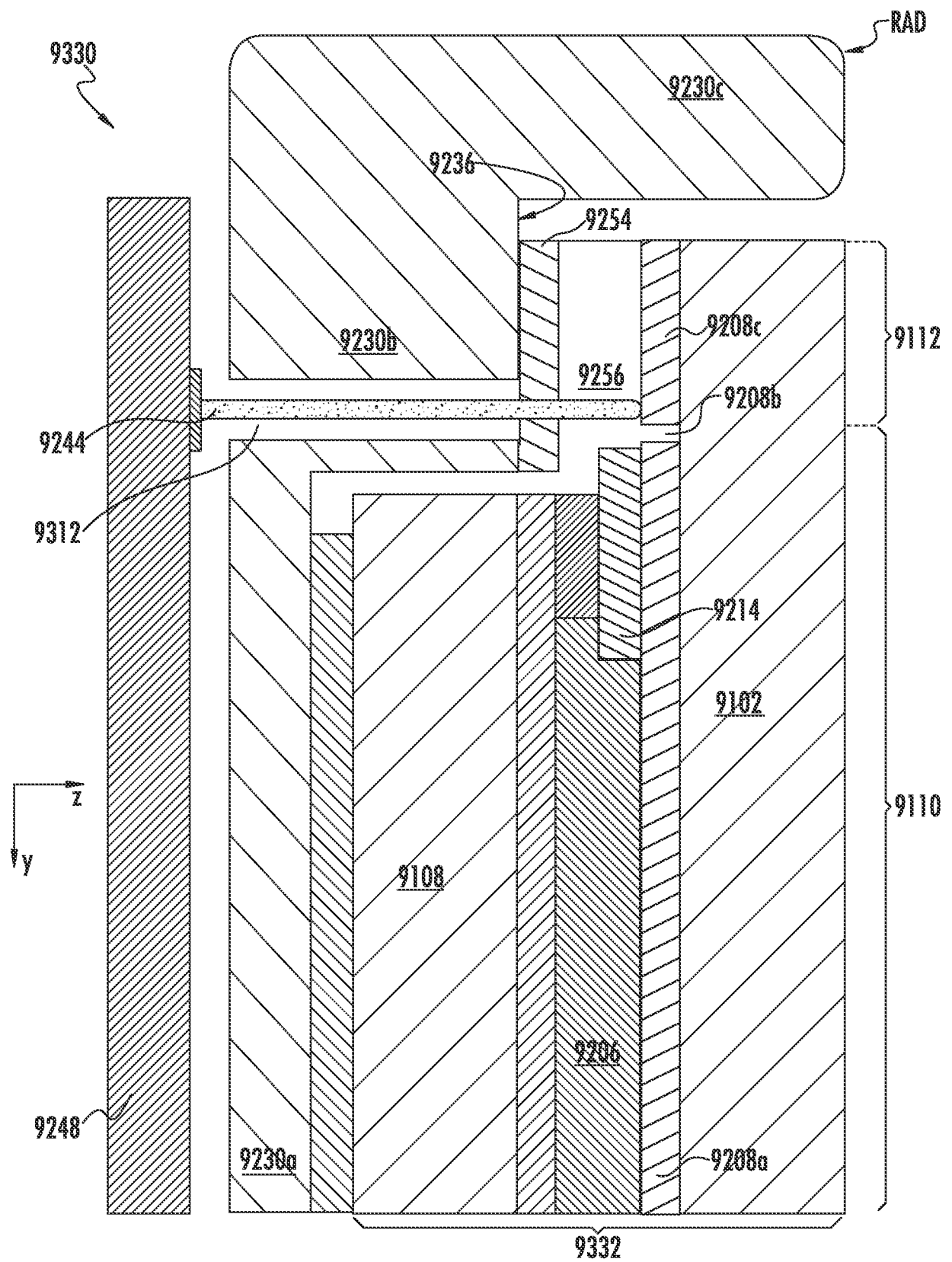


FIG. 35A

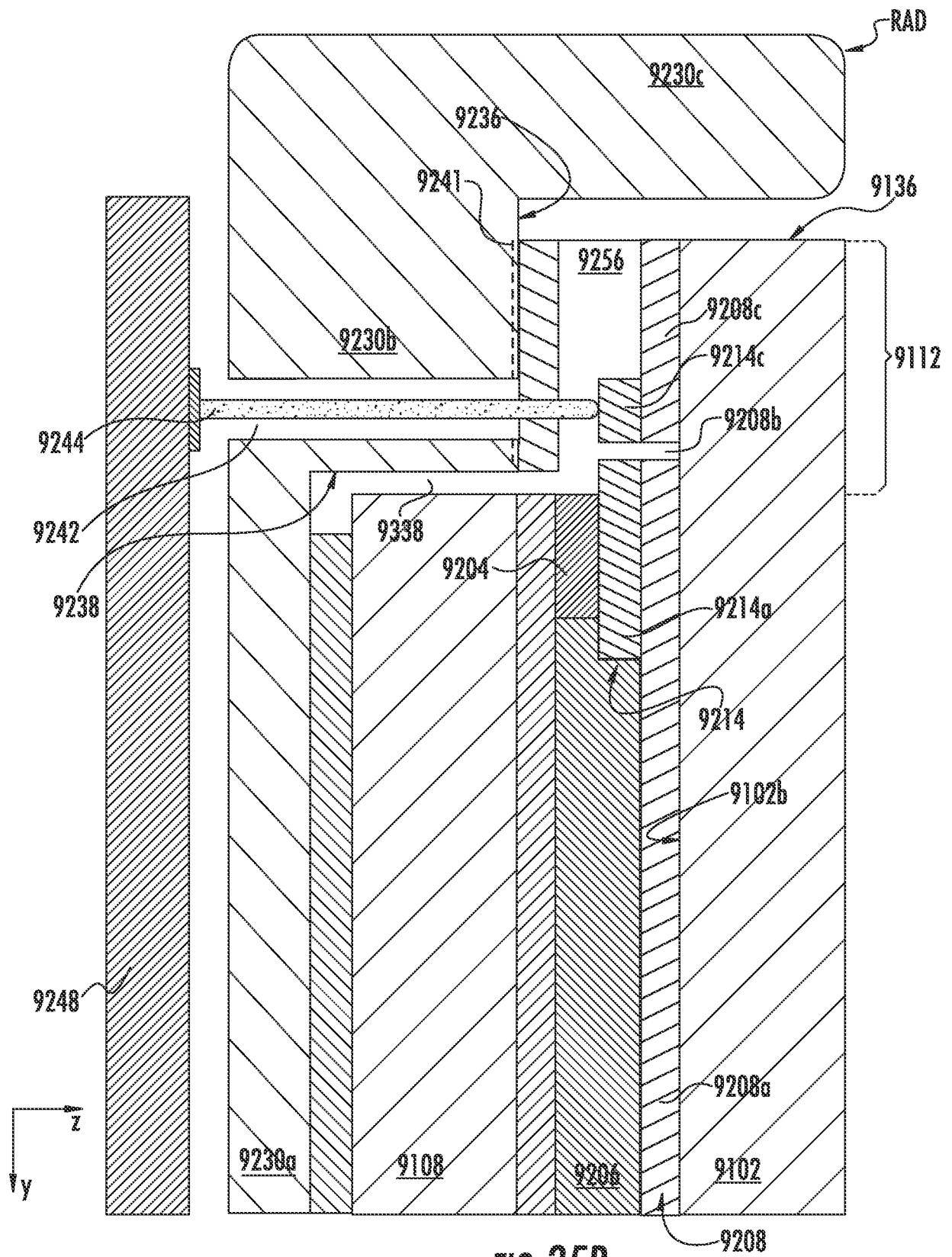


FIG. 35B

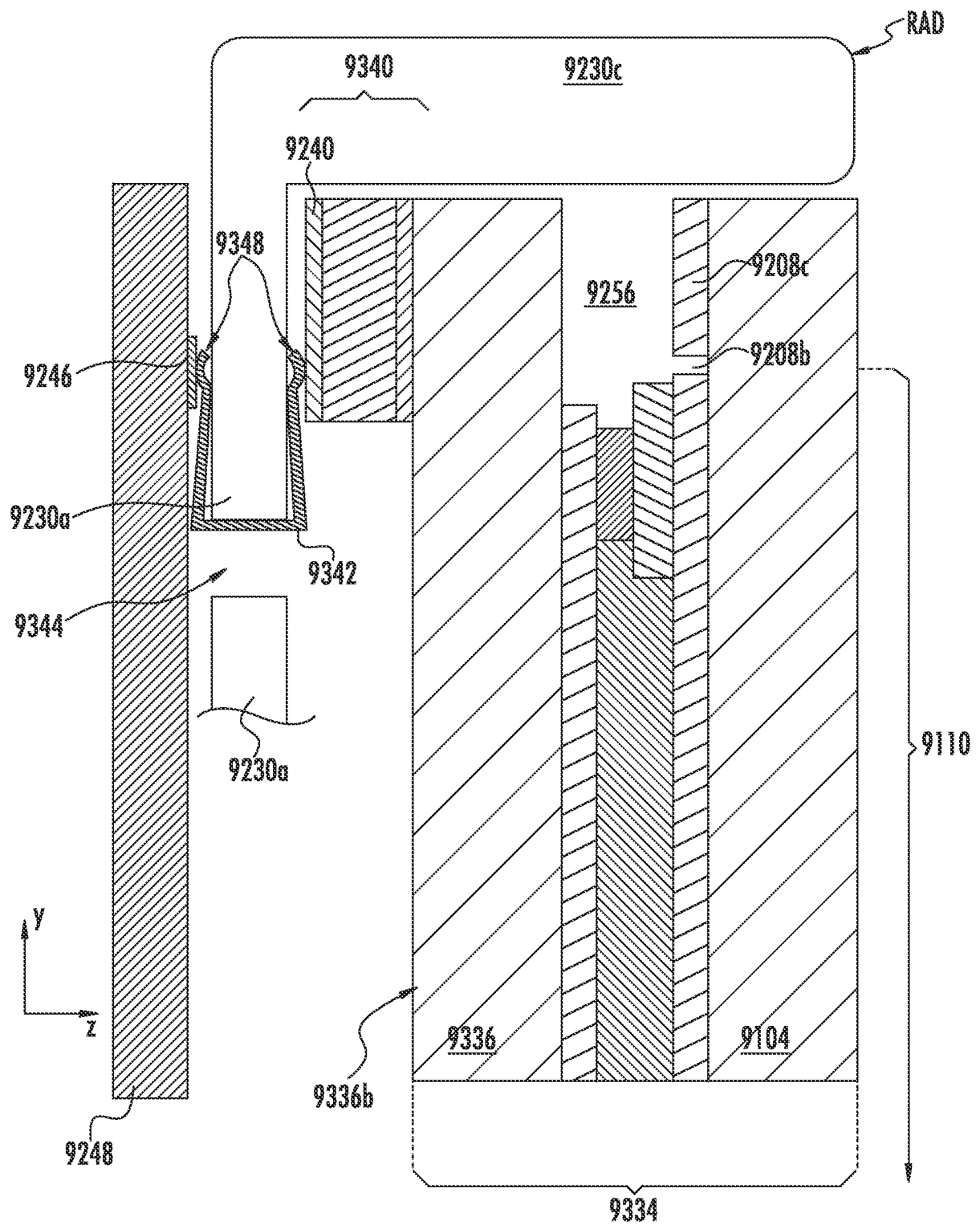


FIG. 35C



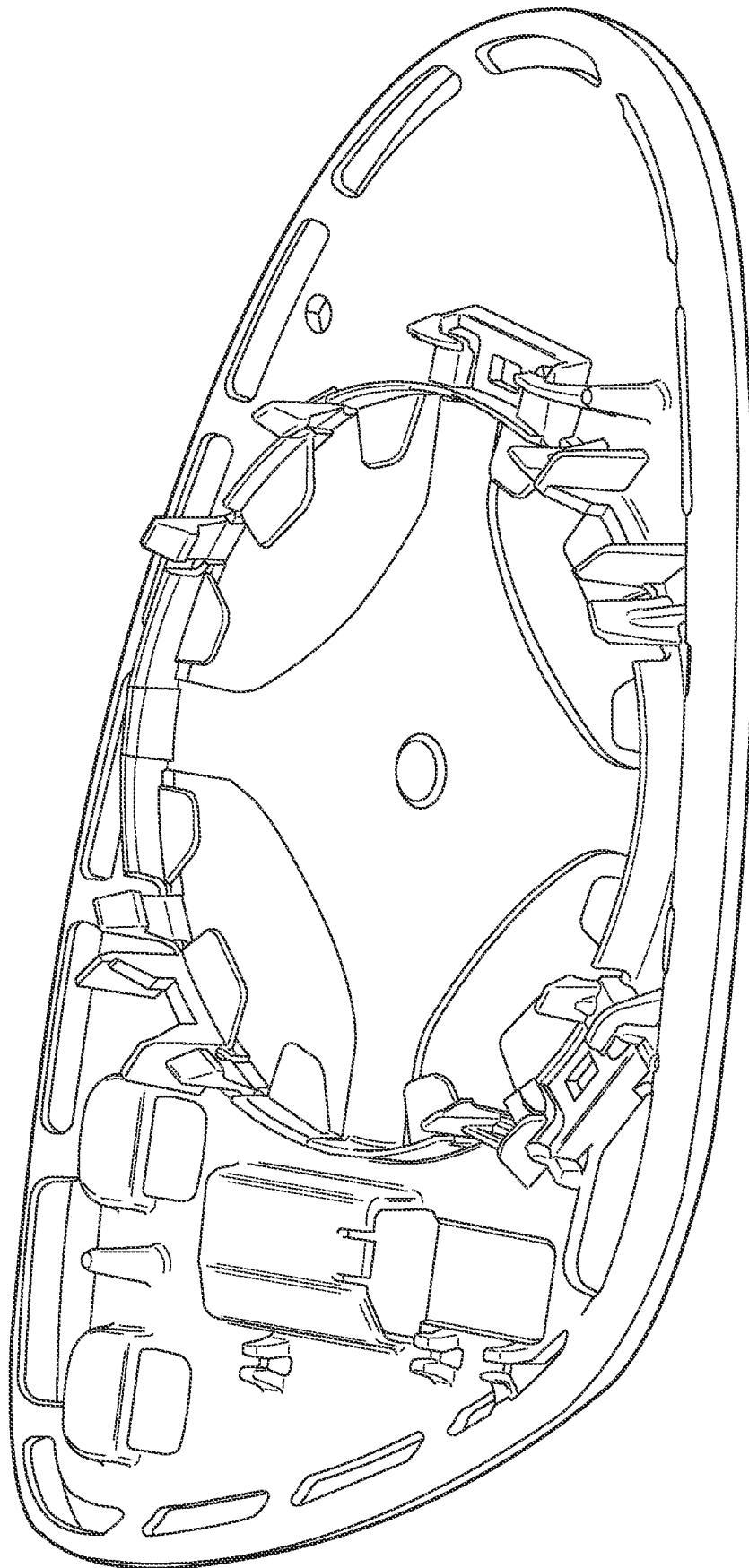
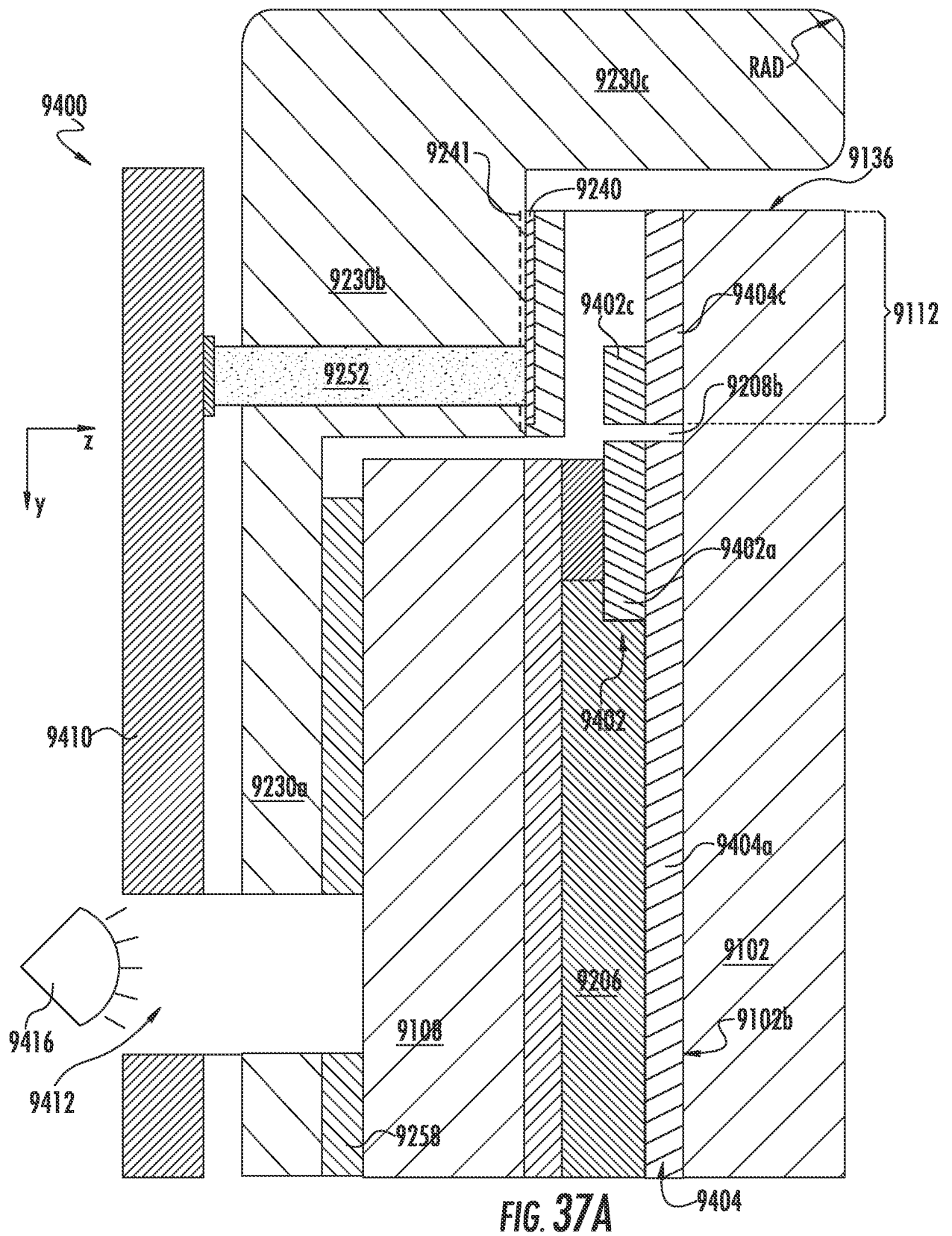


FIG. 36



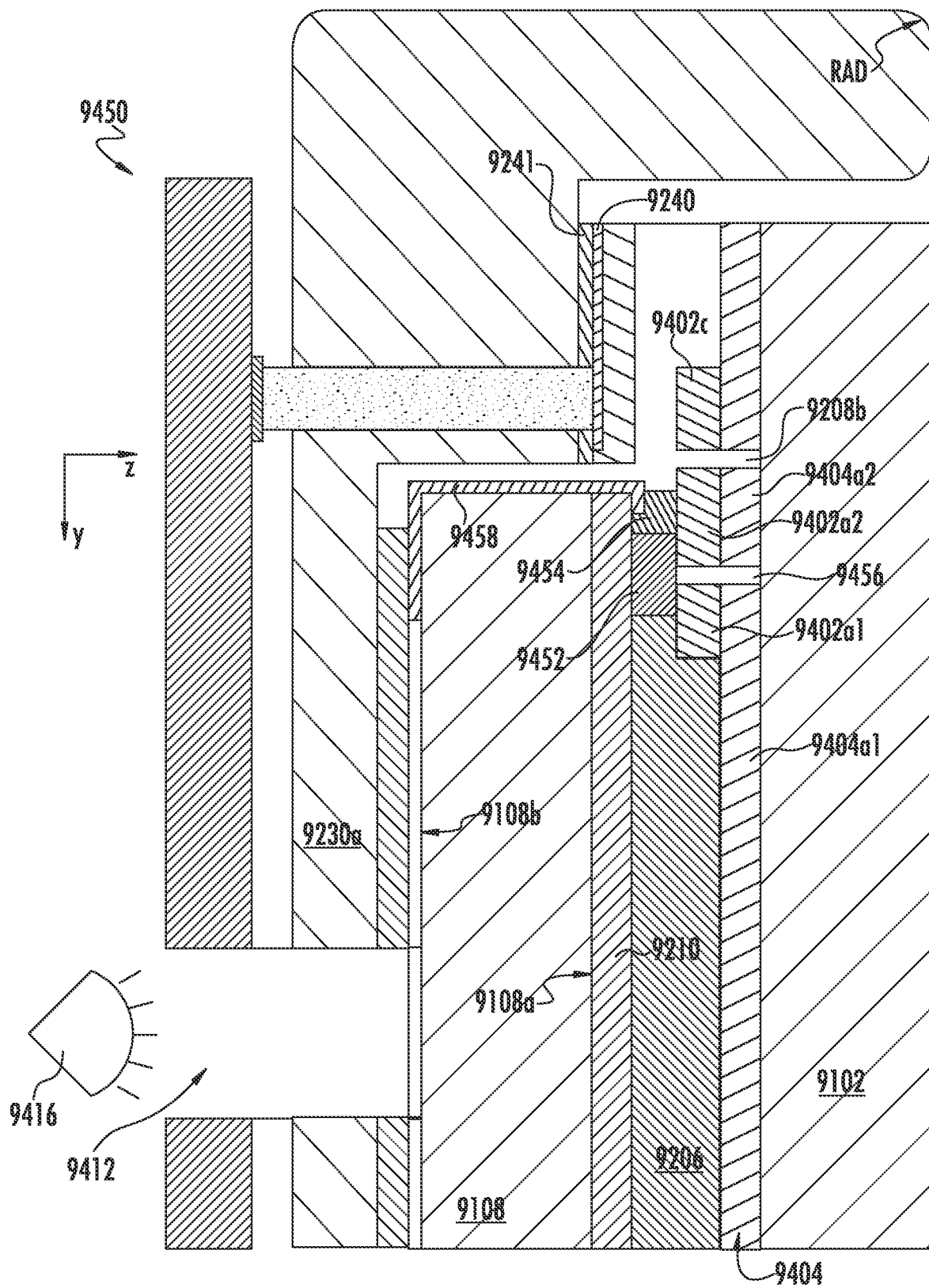


FIG. 37B

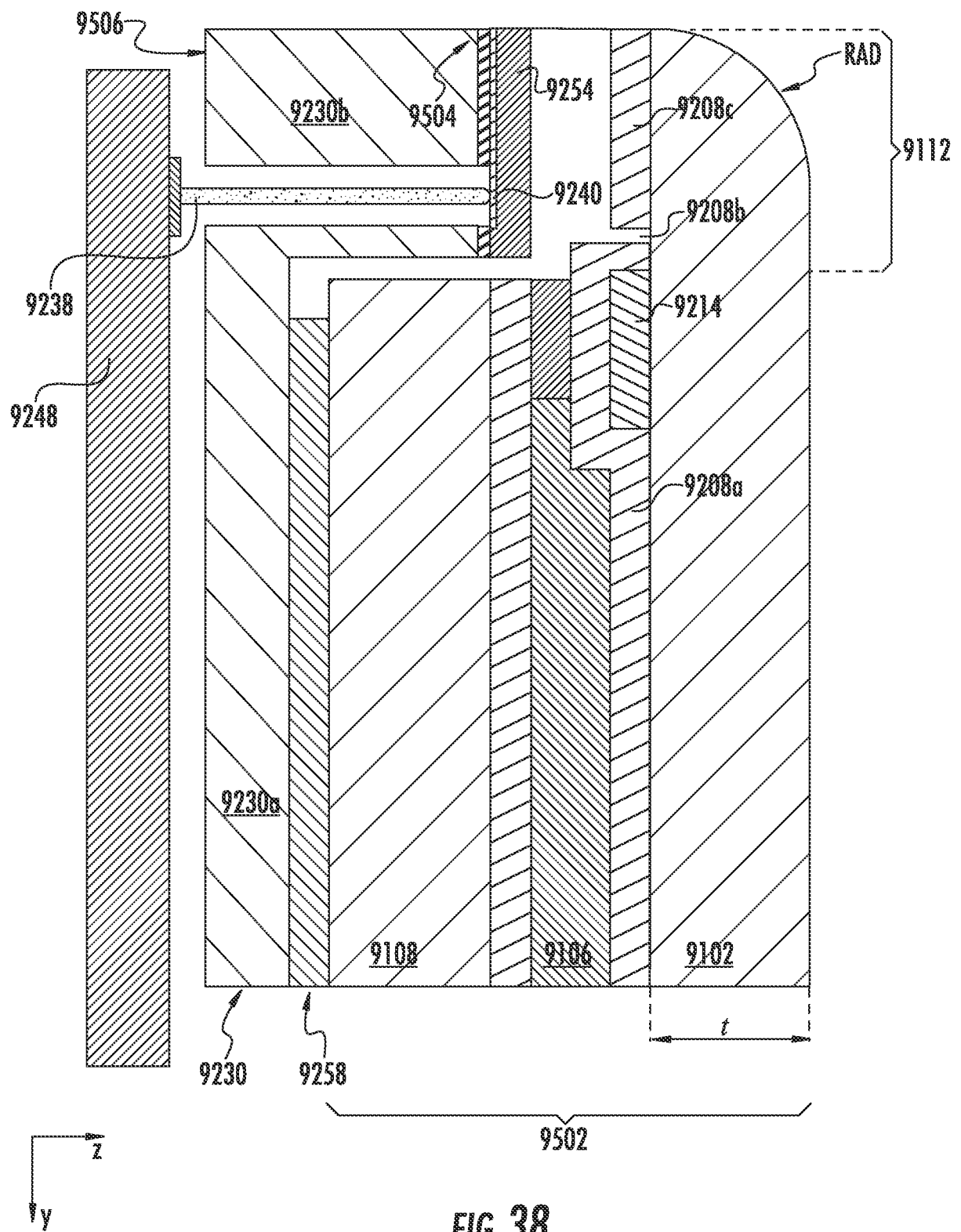


FIG. 38

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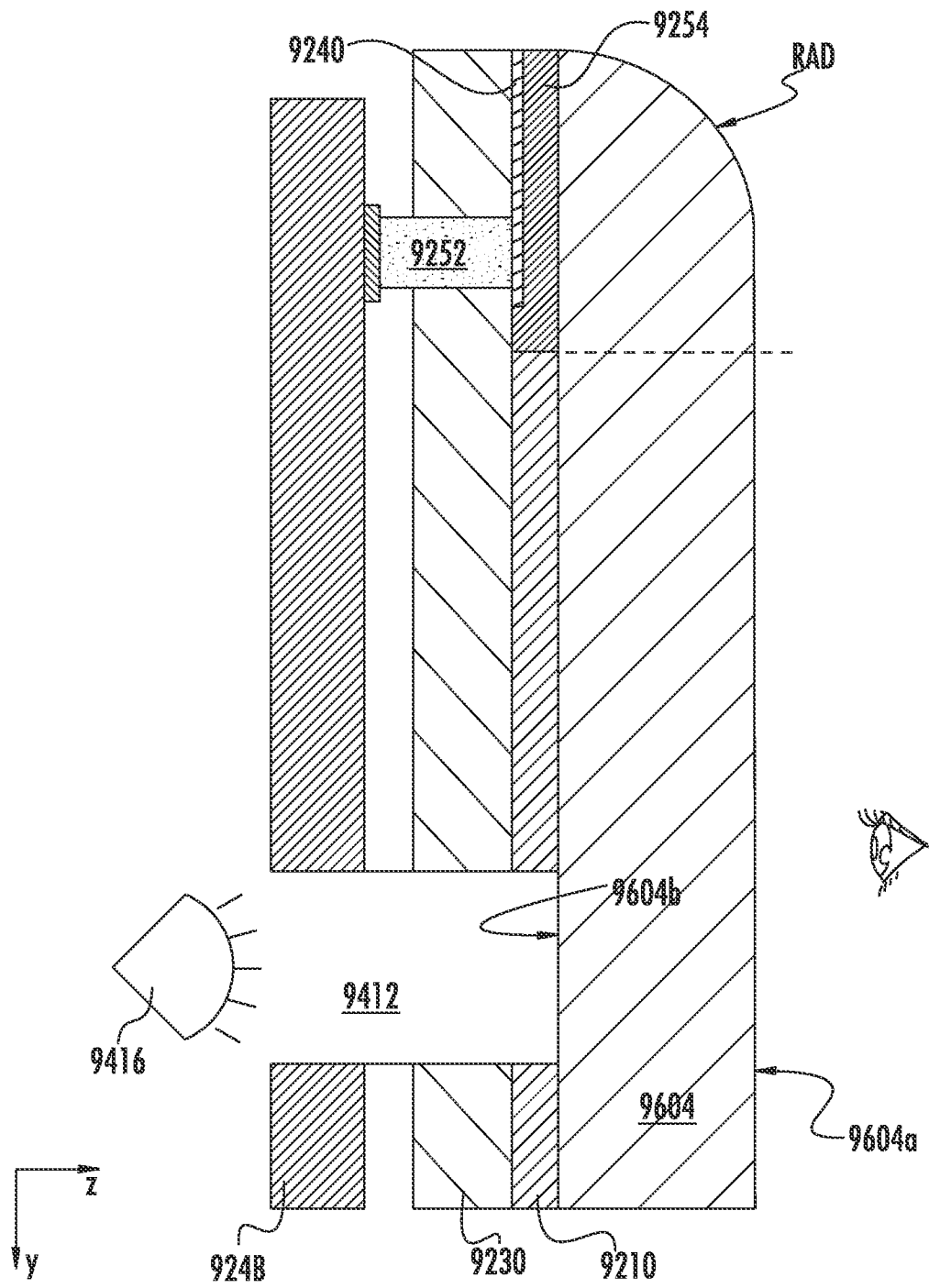
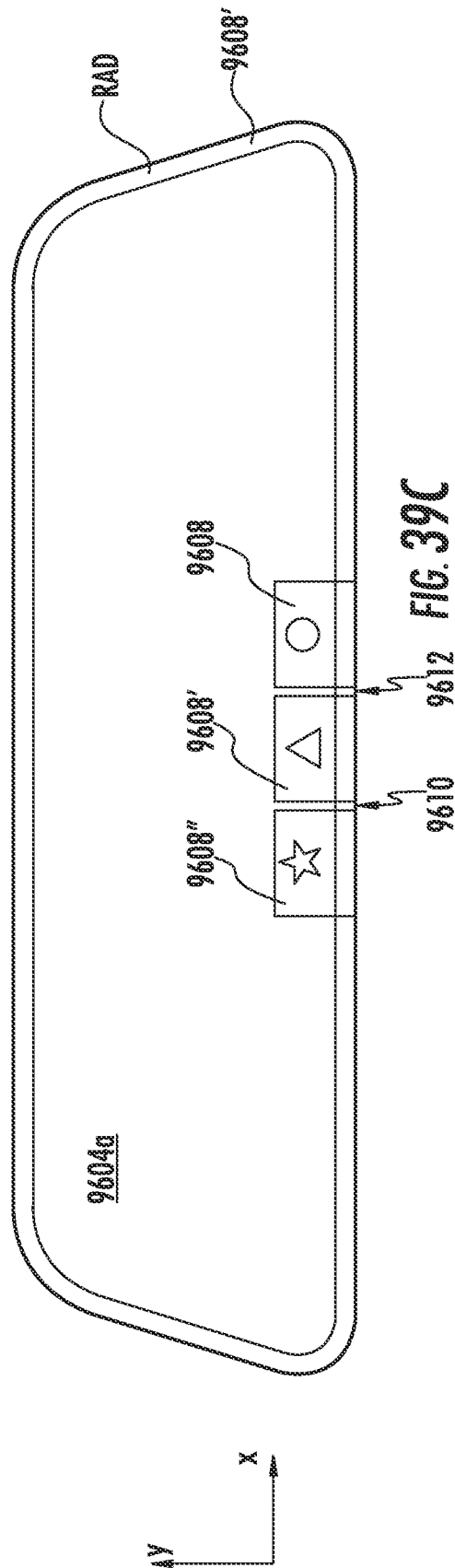
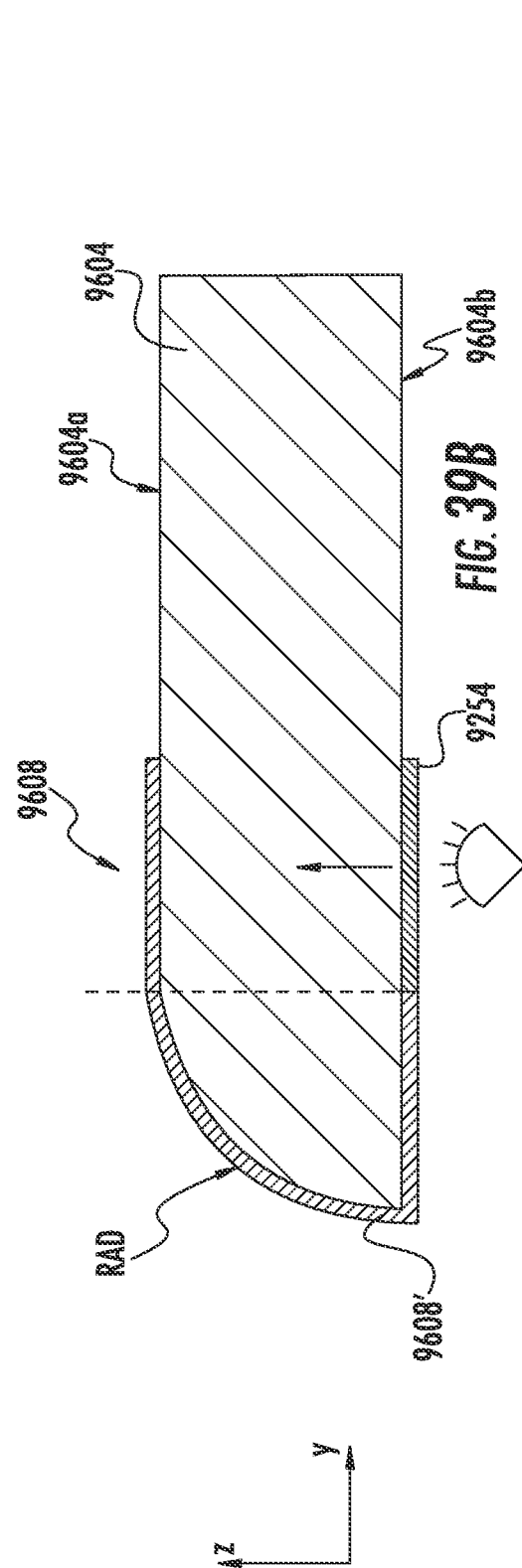
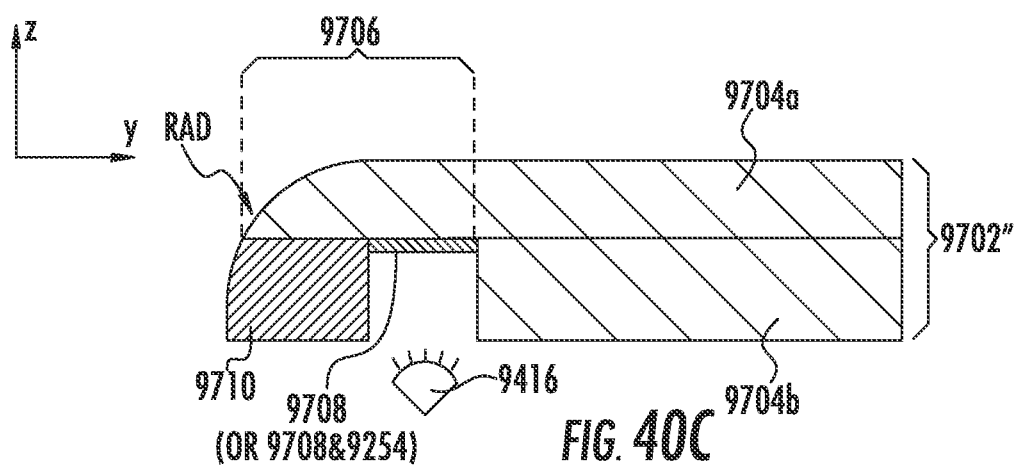
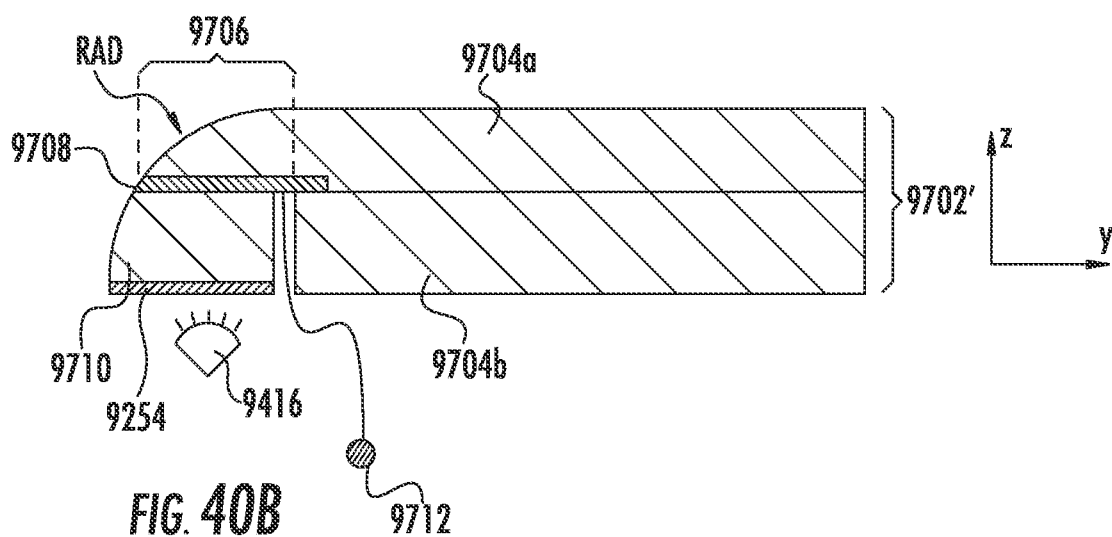
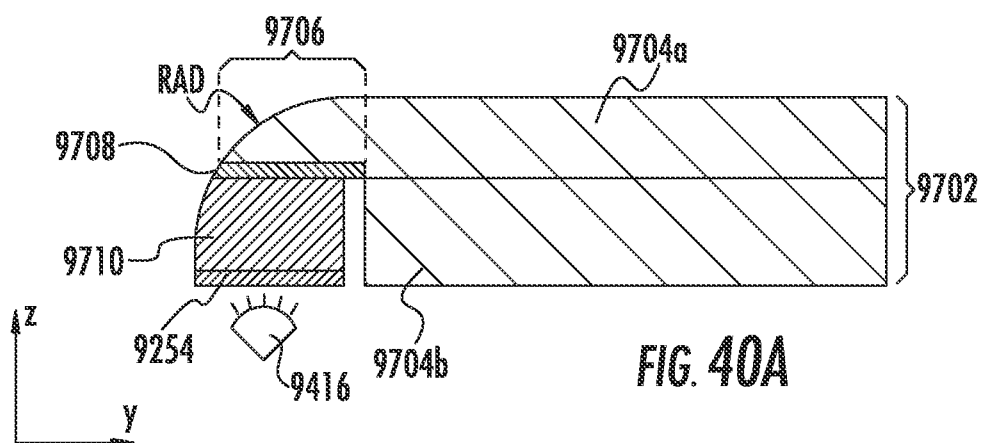
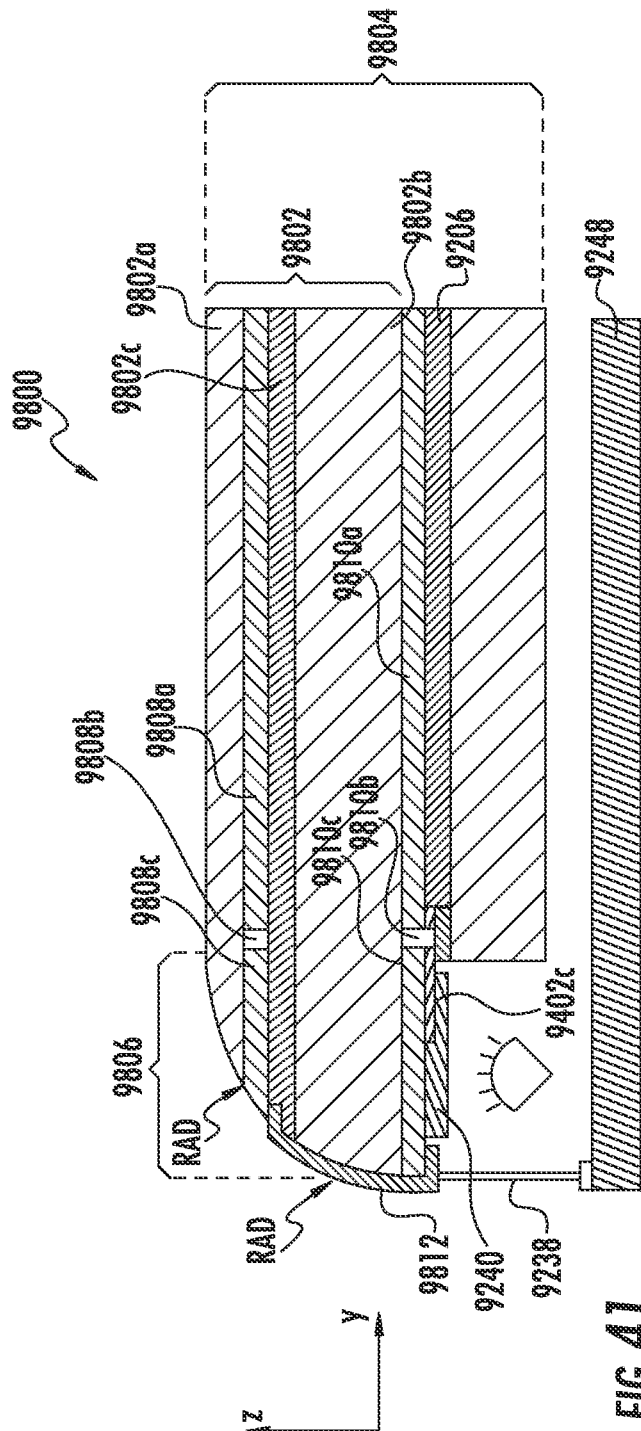


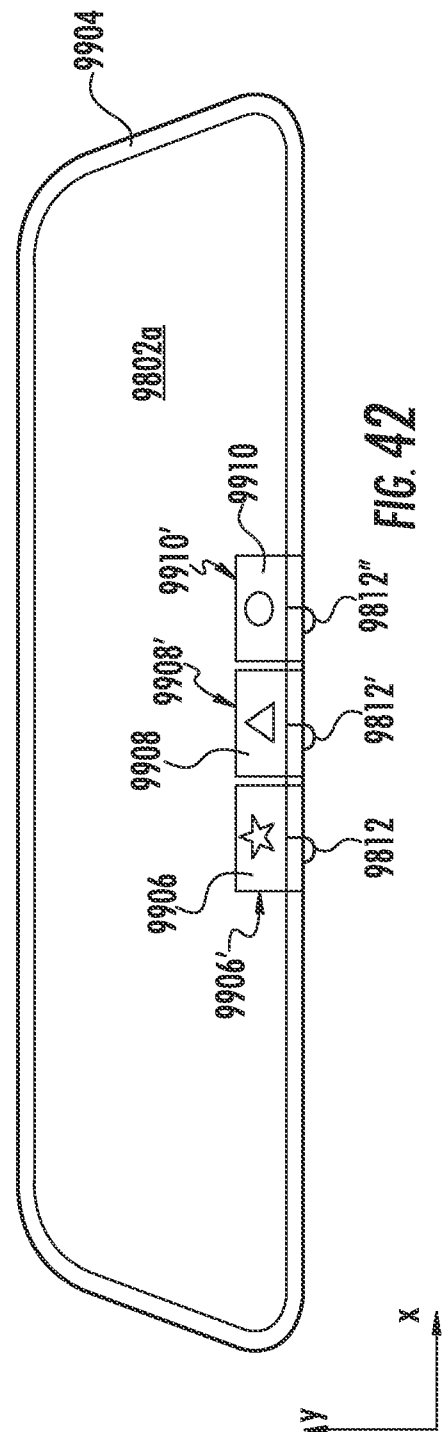
FIG. 39A

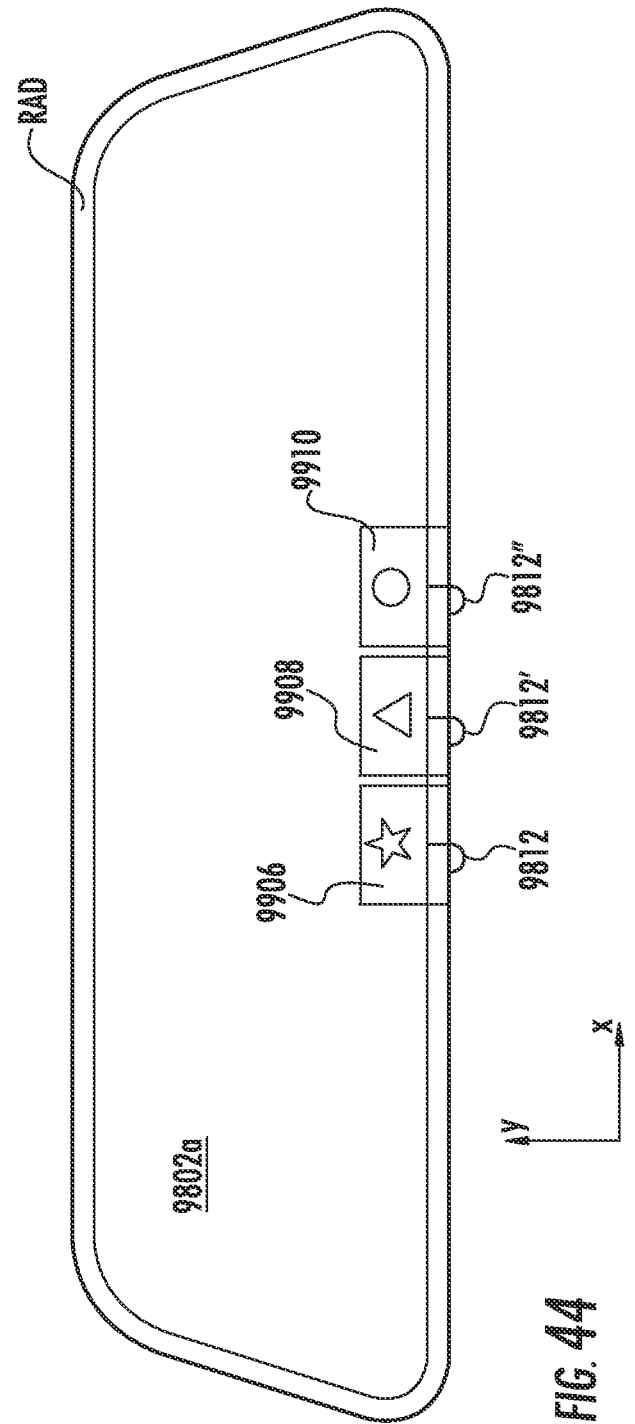
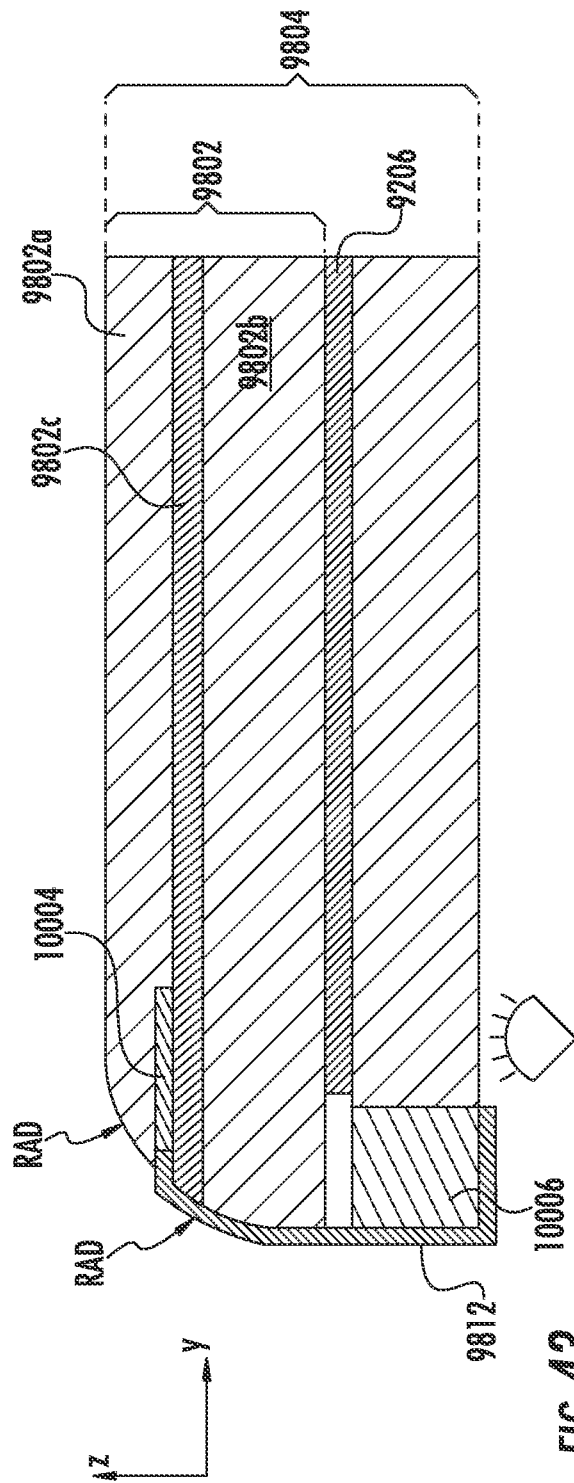


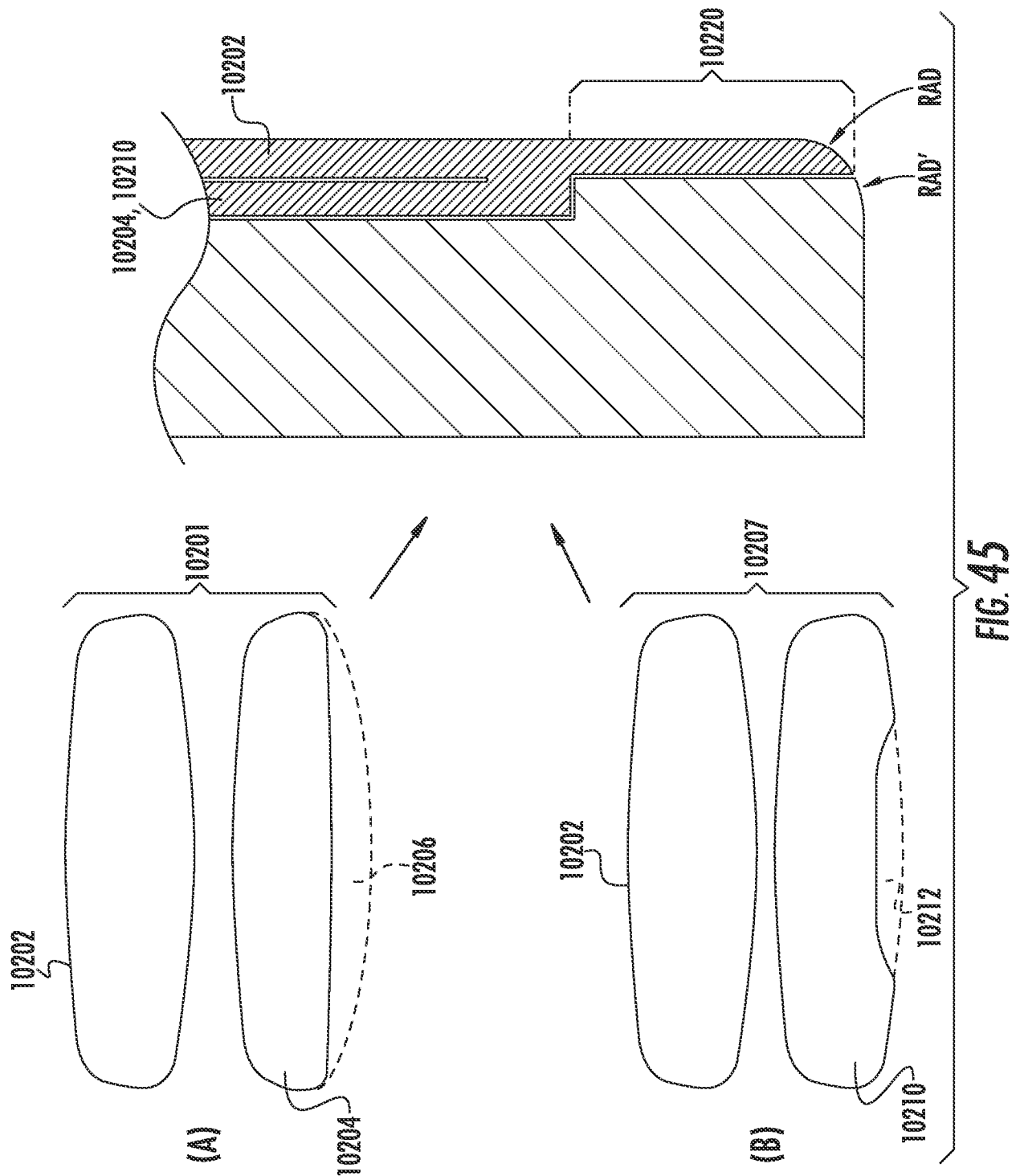




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F. G.





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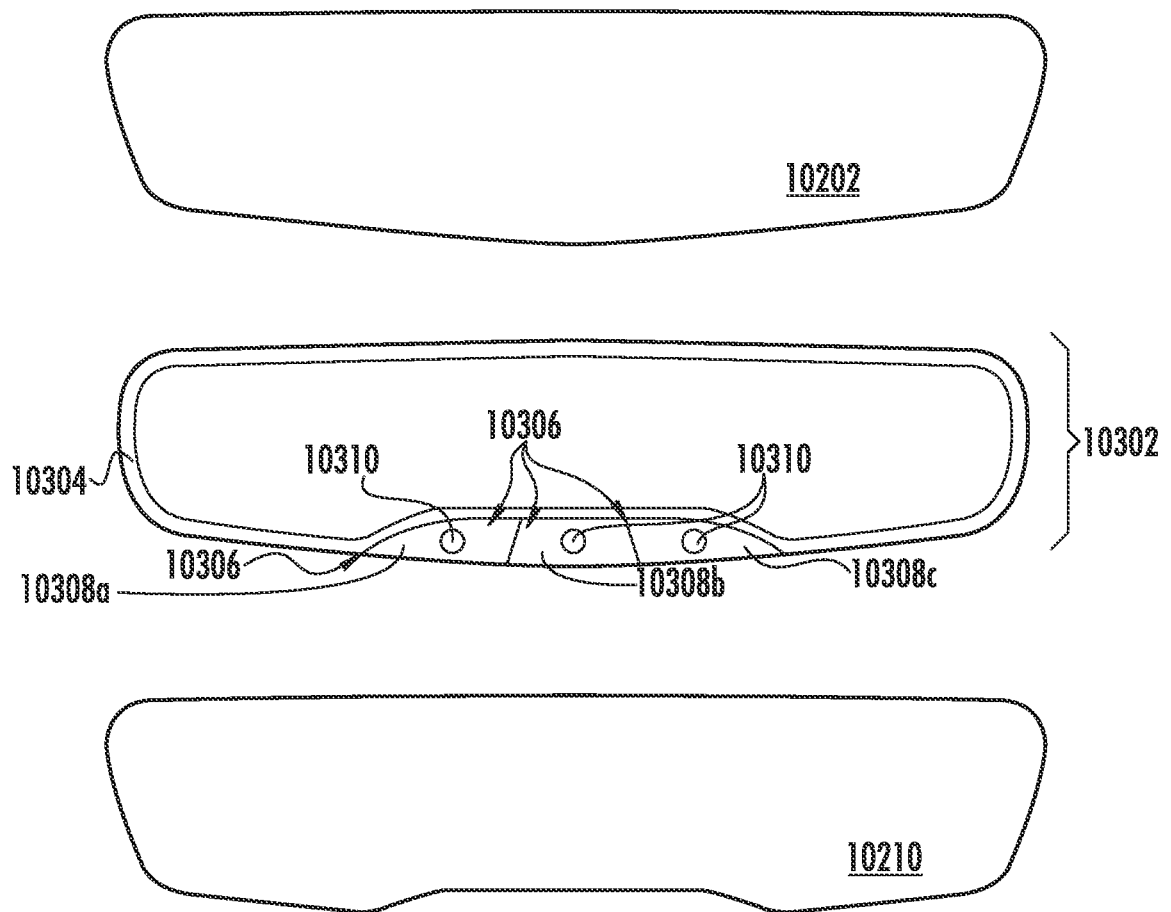


FIG. 46A

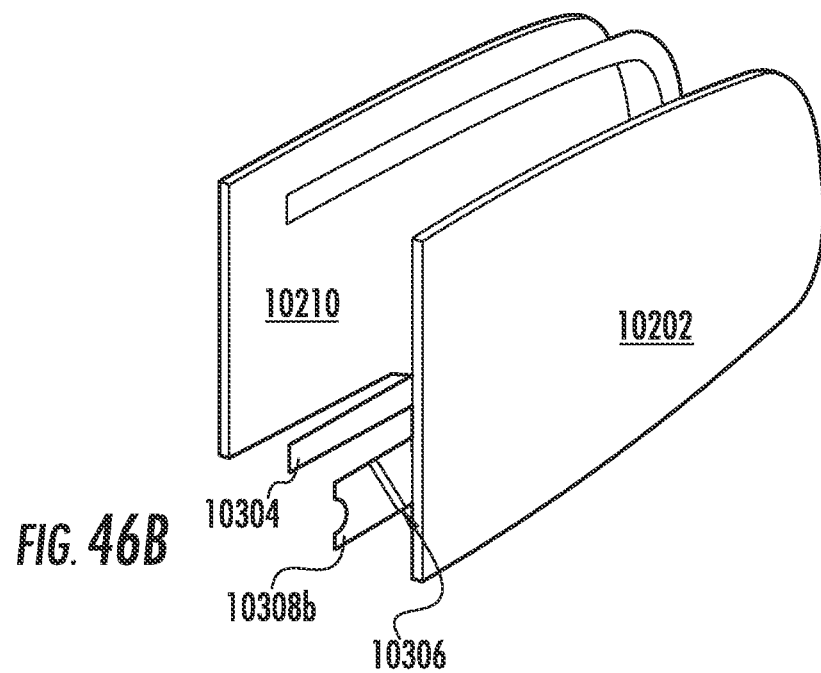


FIG. 46B

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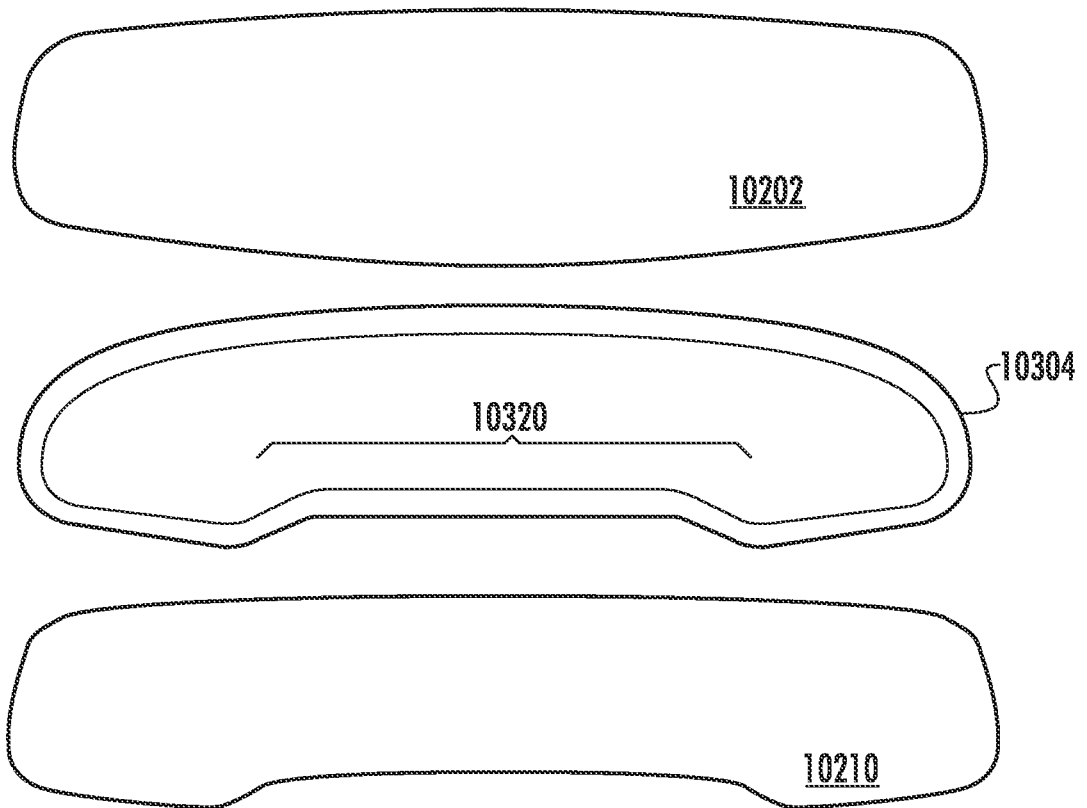


FIG. 46C

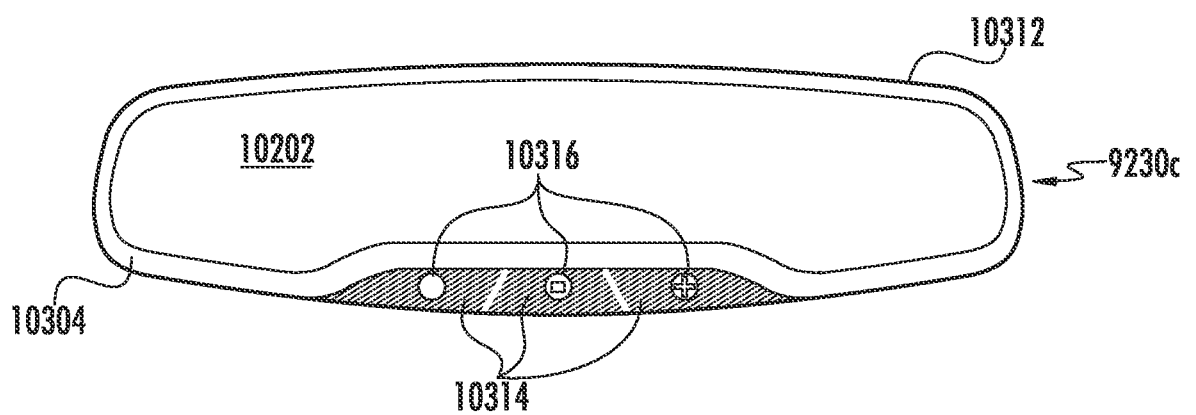


FIG. 46D

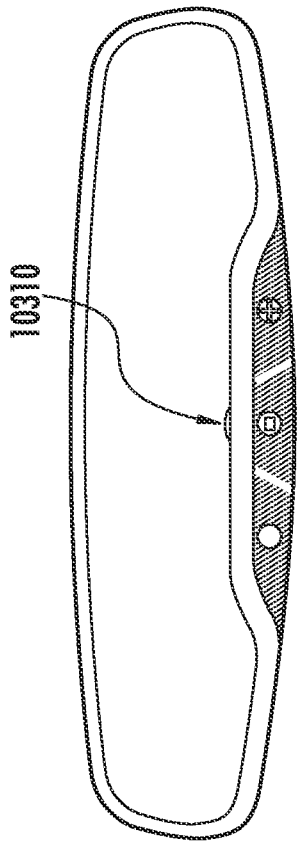


FIG. 46E

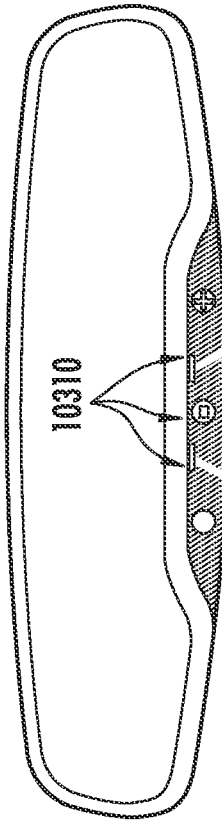


FIG. 46H

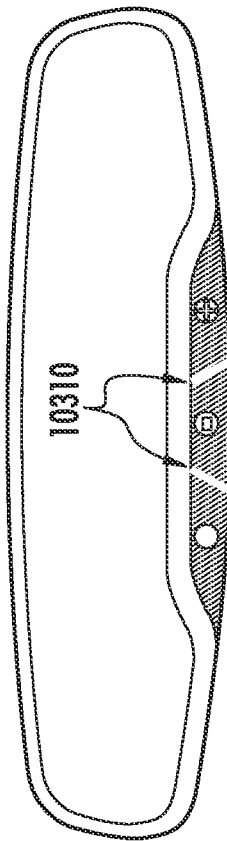


FIG. 46F

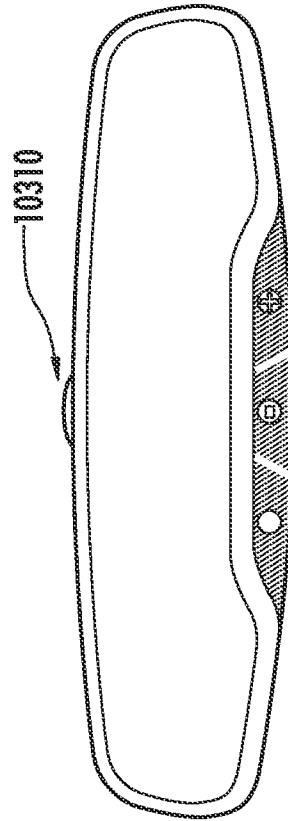


FIG. 46I

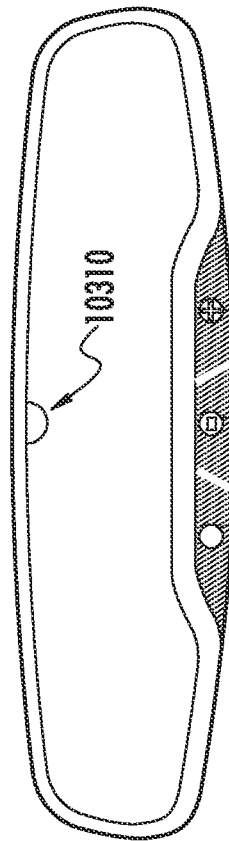


FIG. 46G

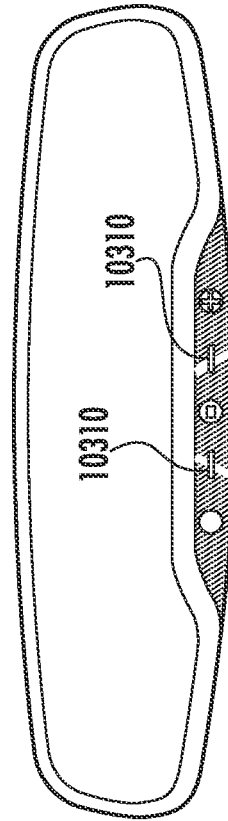
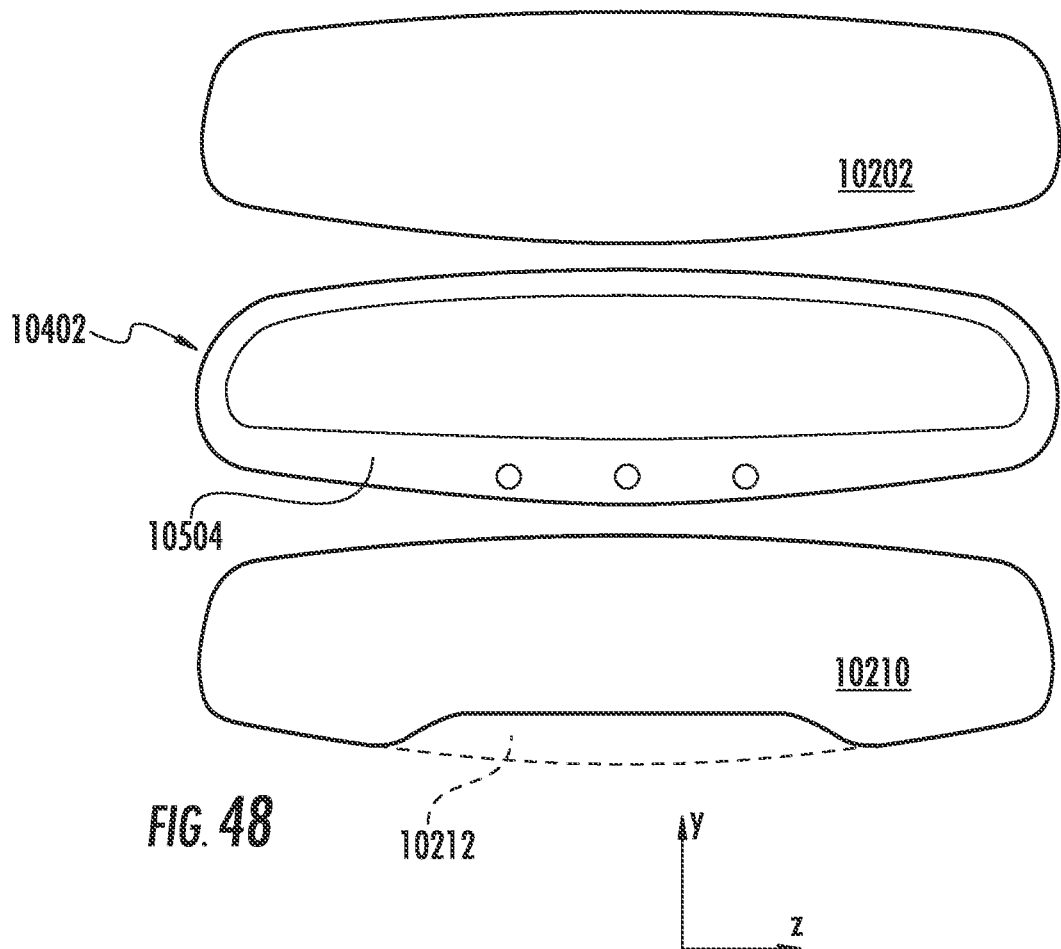
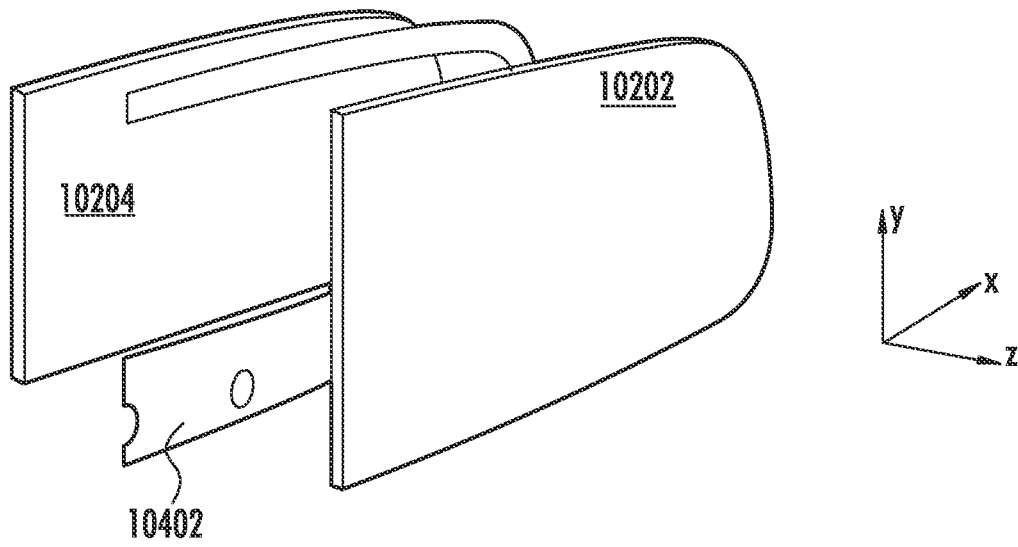
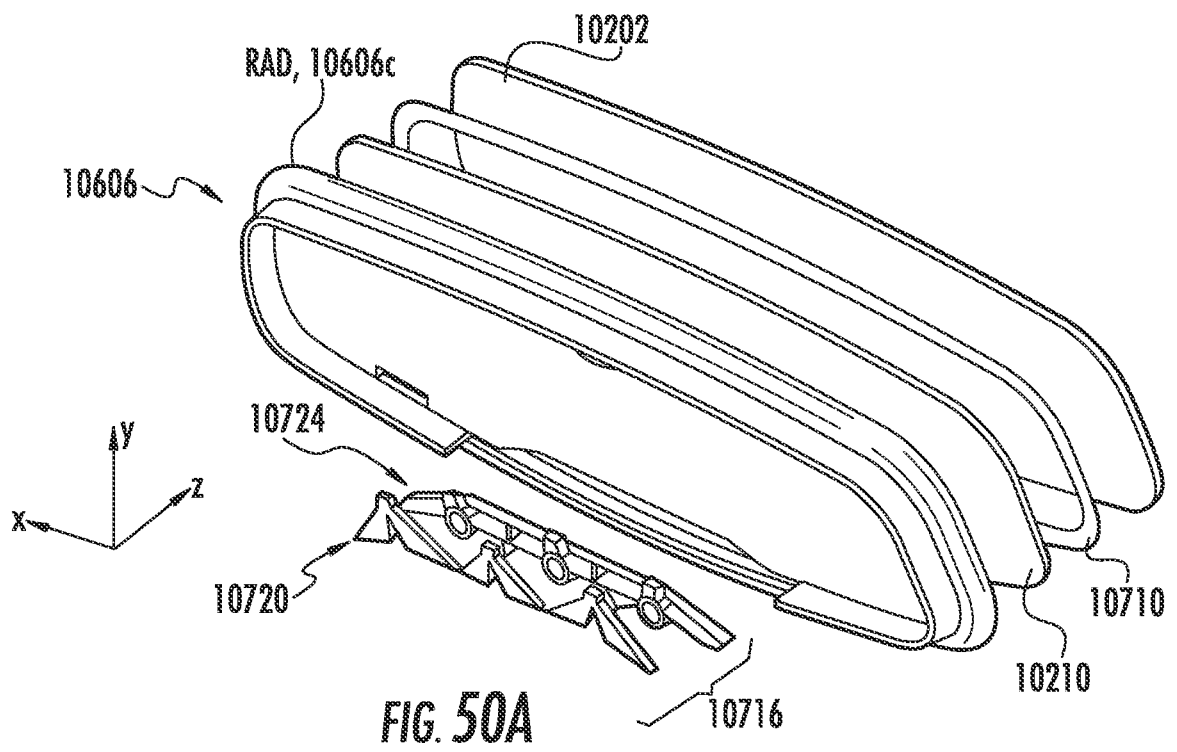
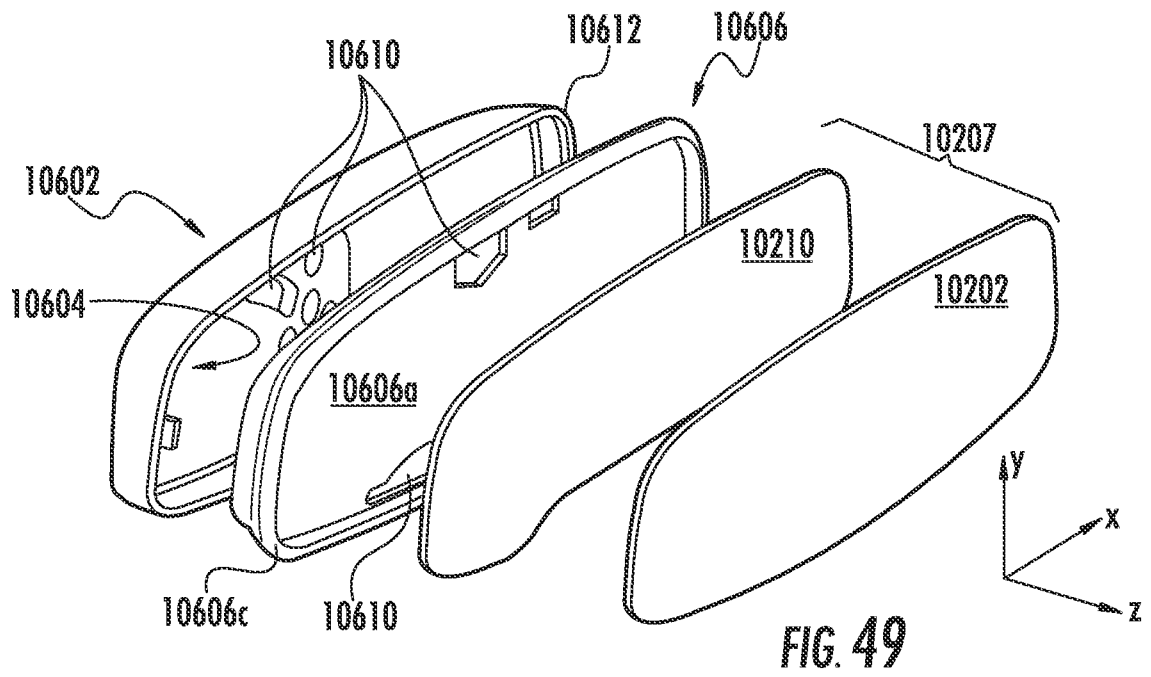
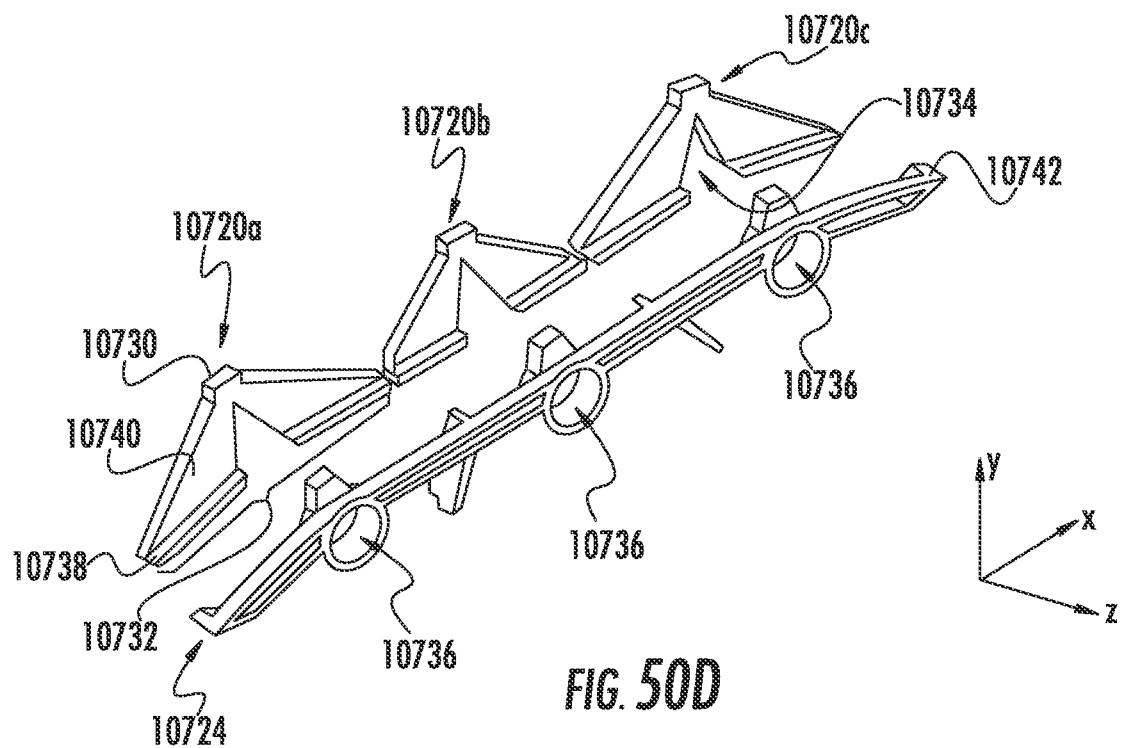
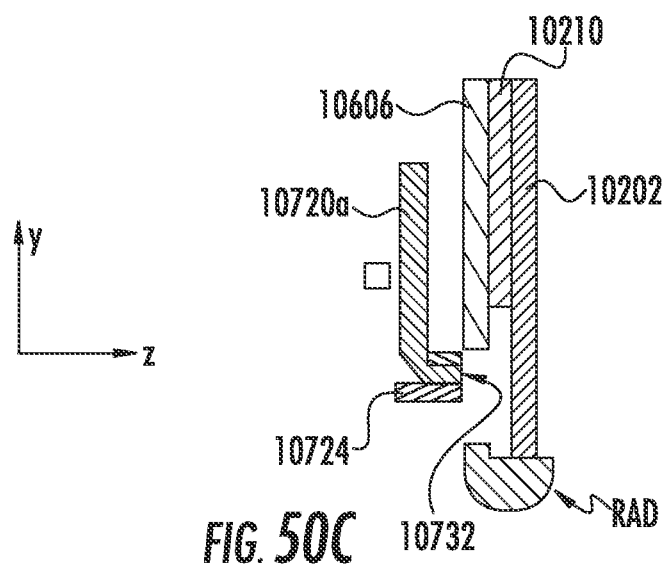
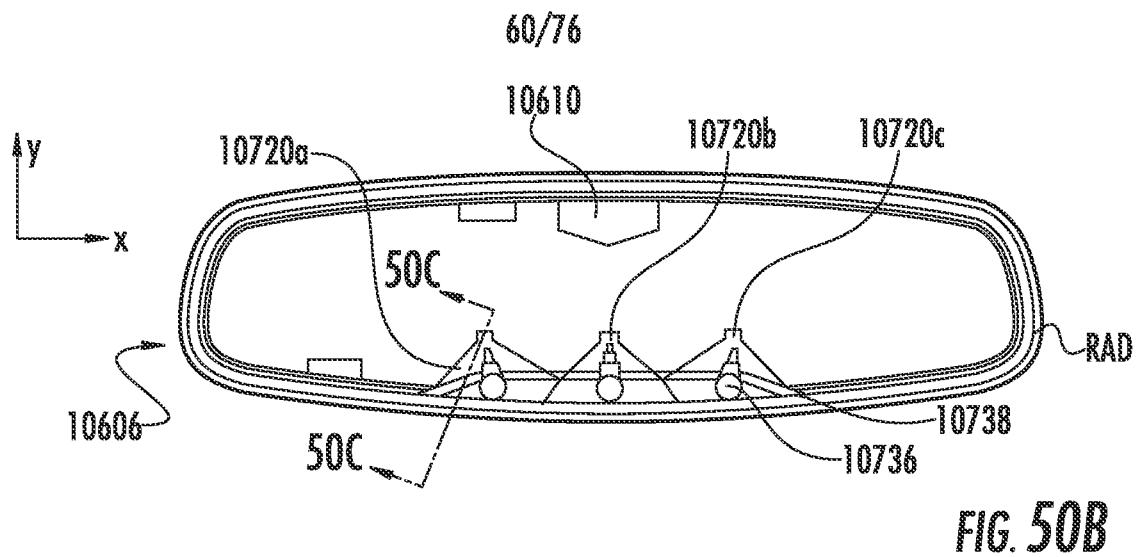


FIG. 46J



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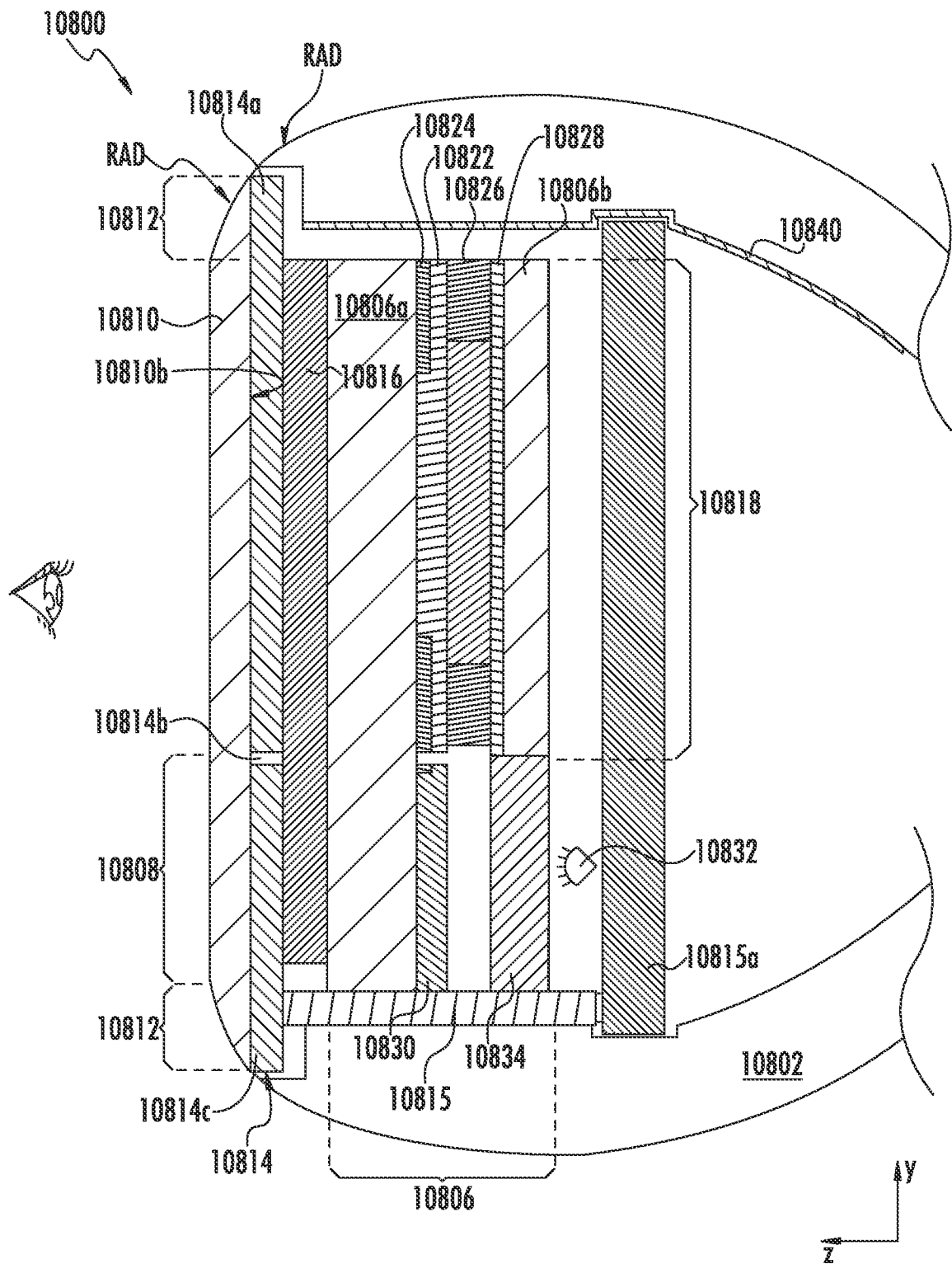
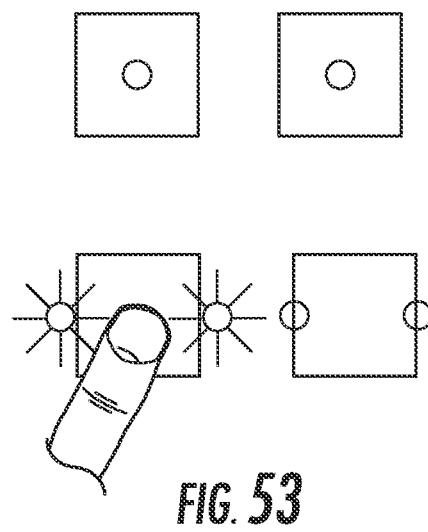
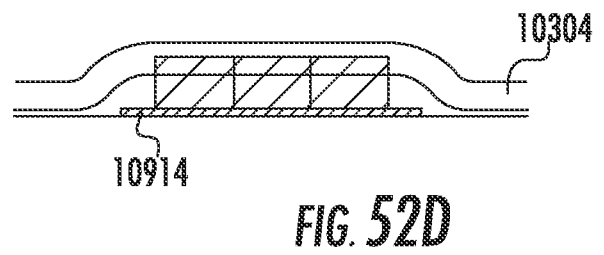
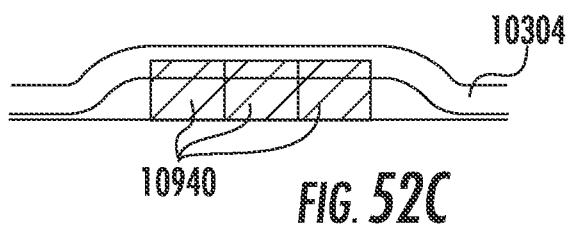
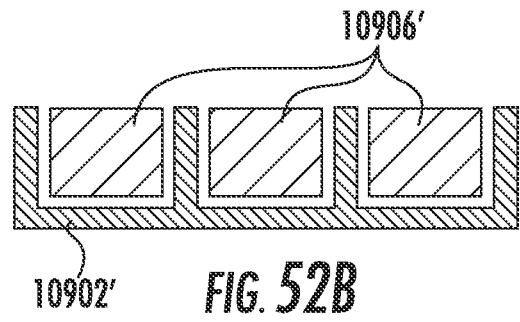
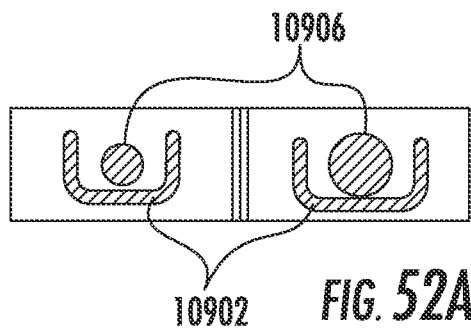
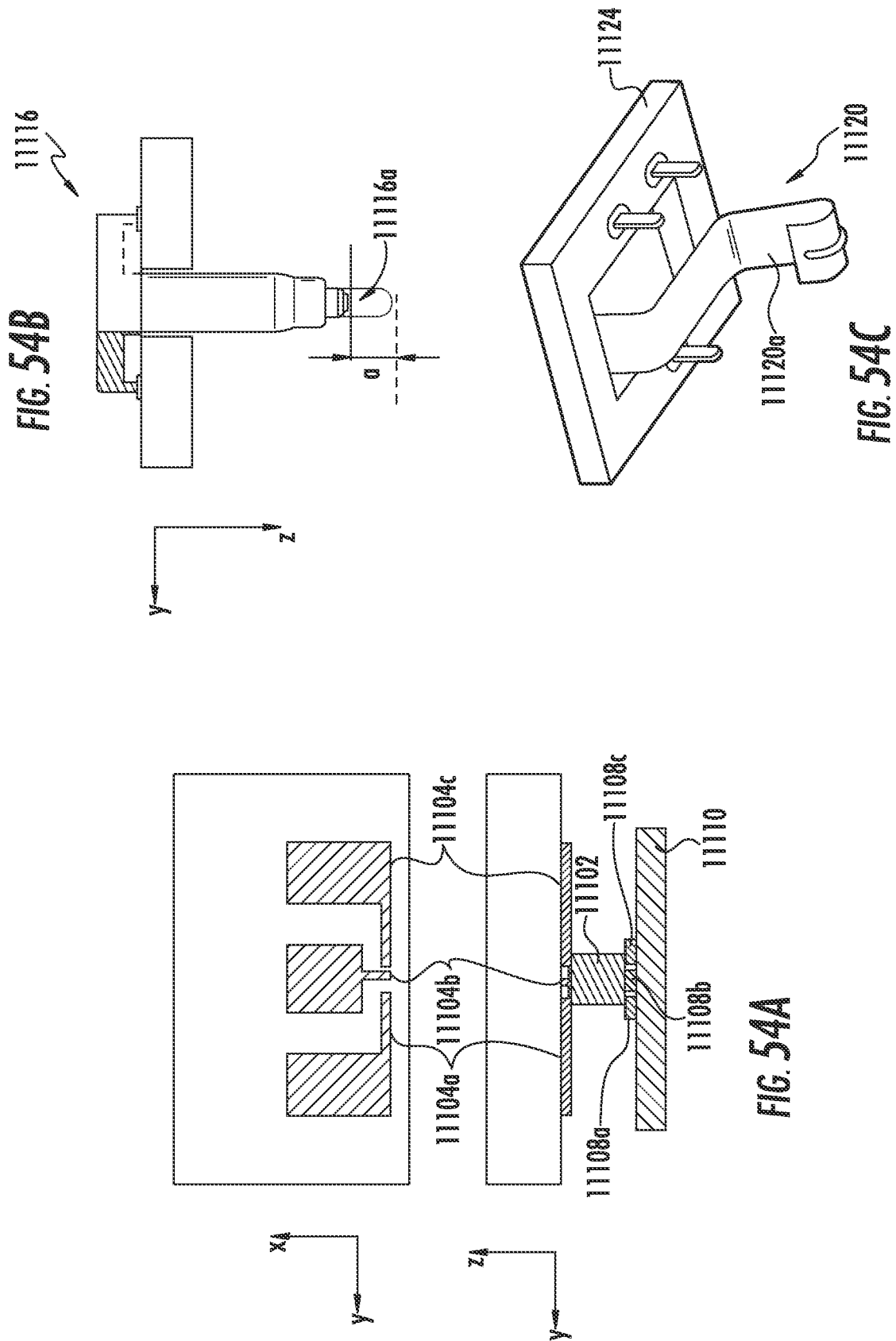
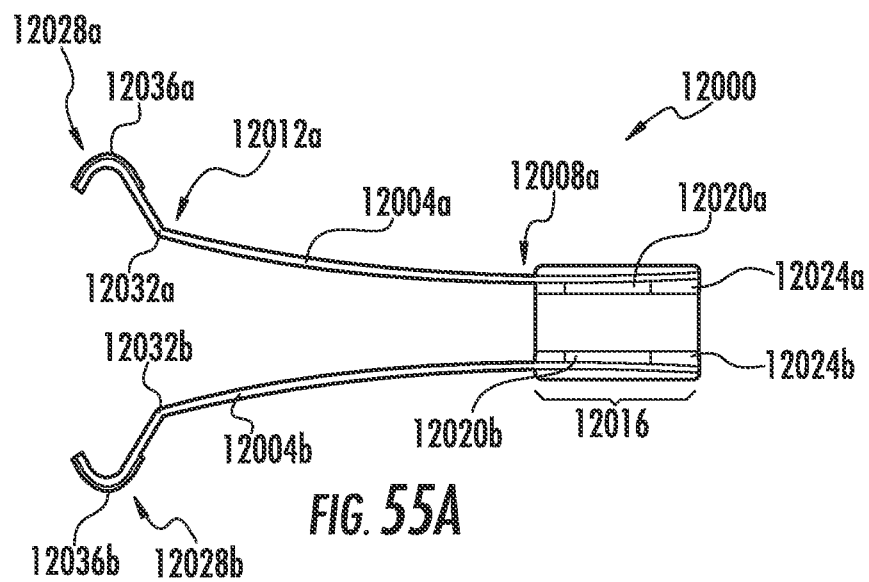
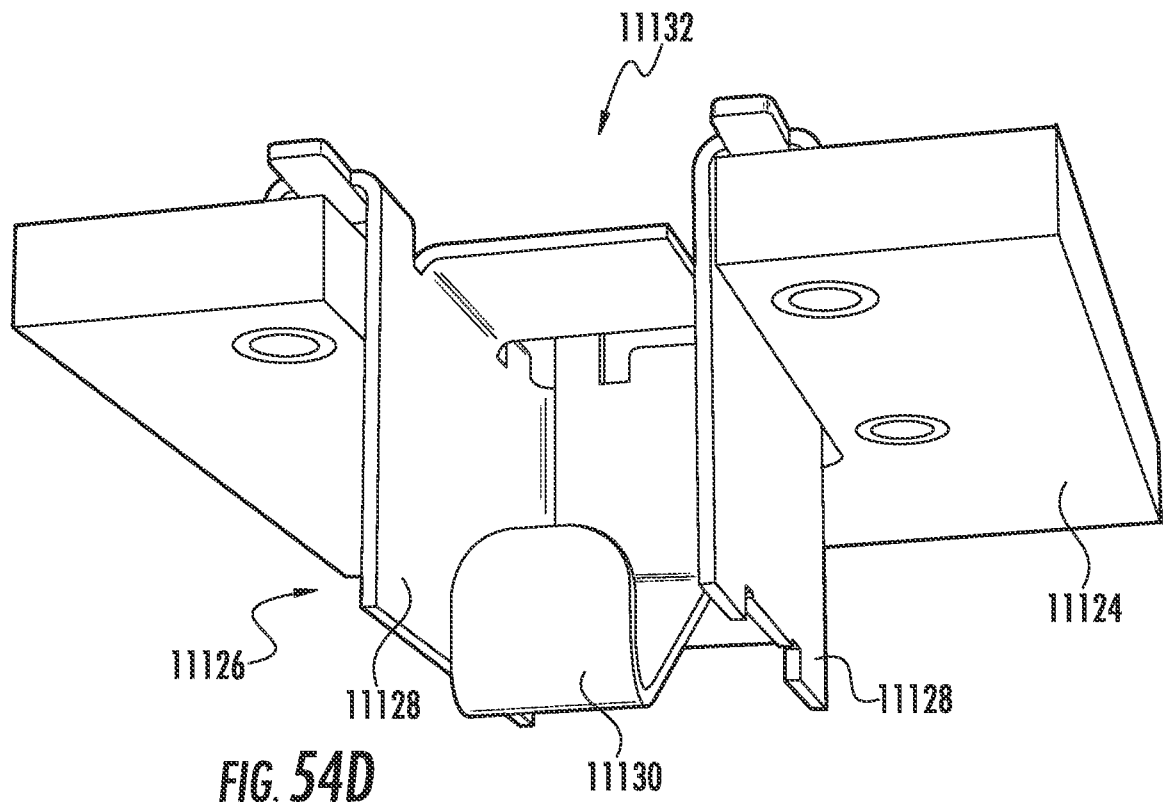


FIG. 51

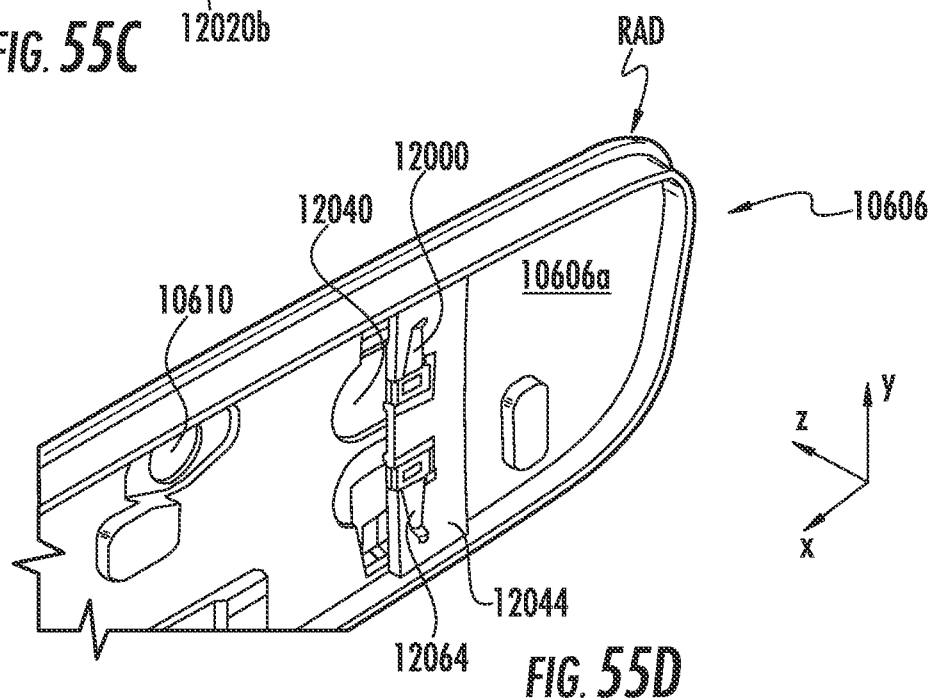
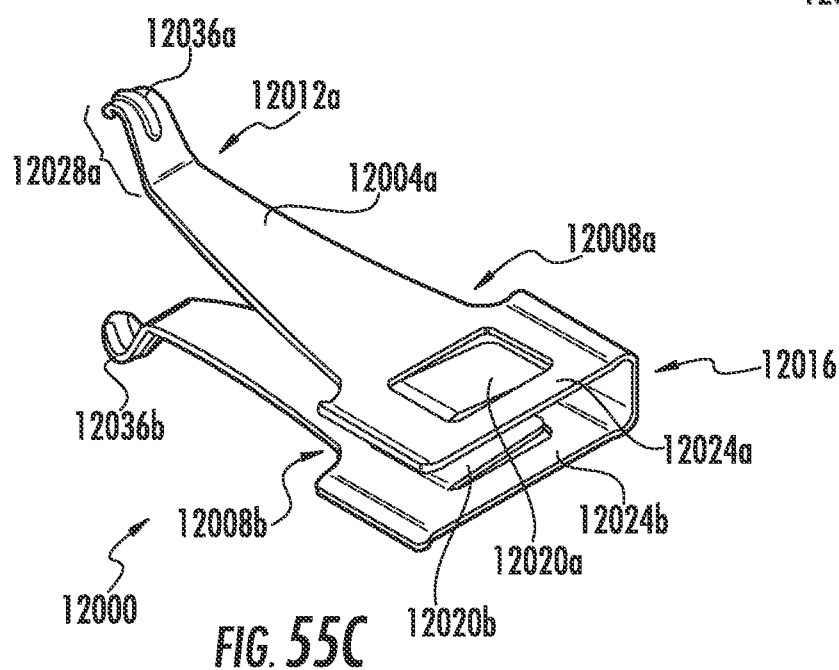
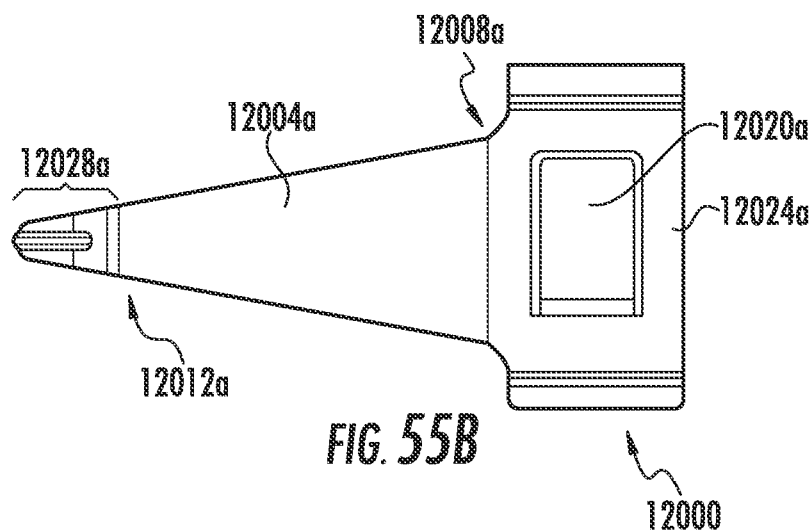


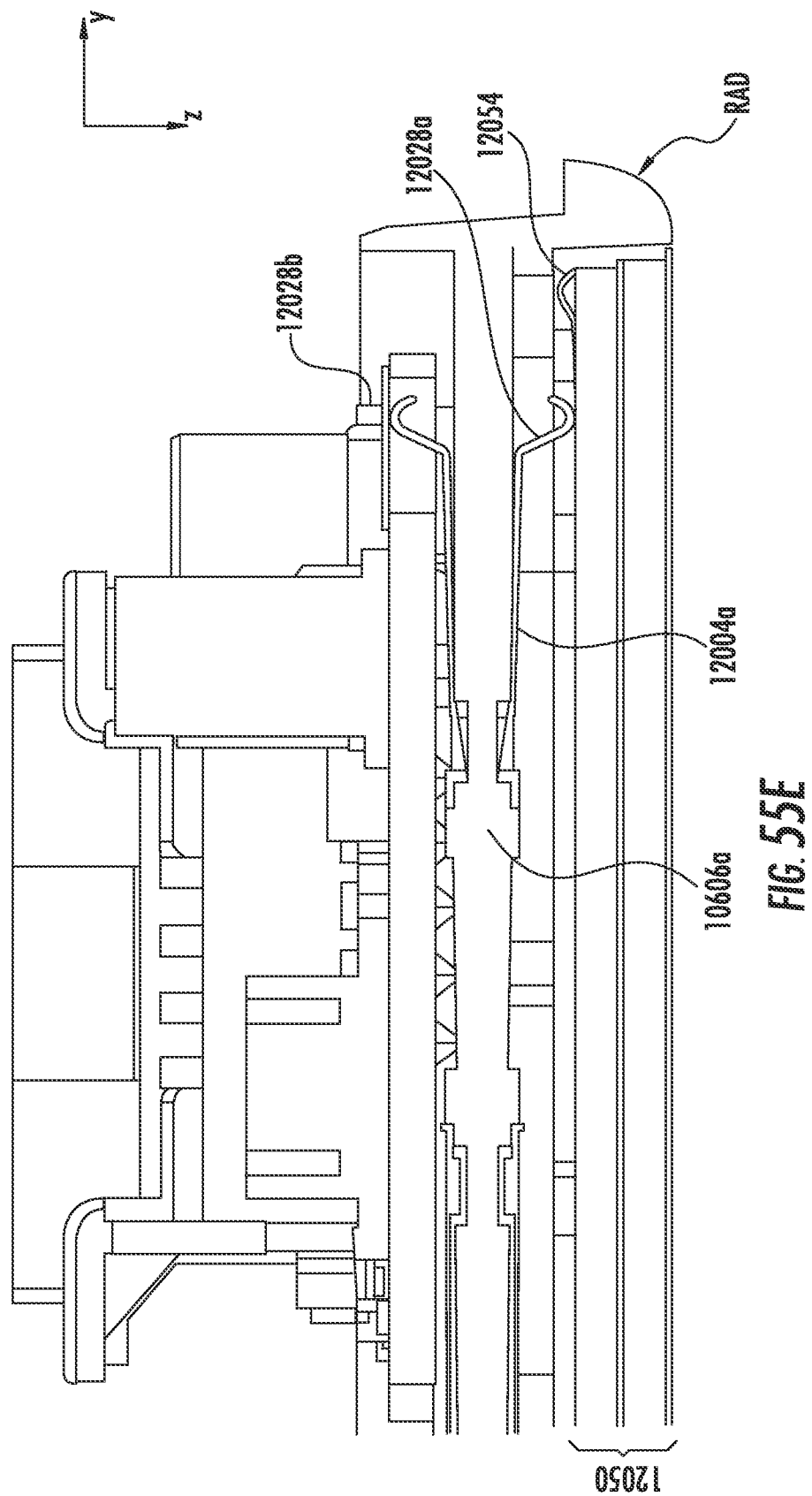


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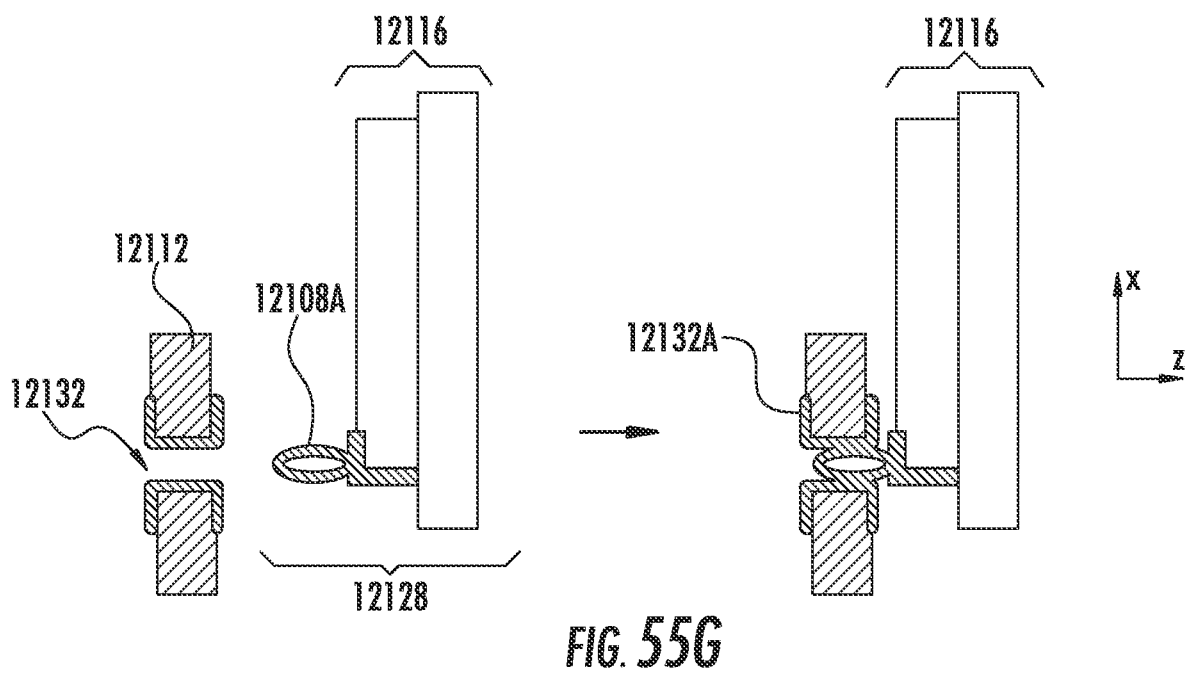
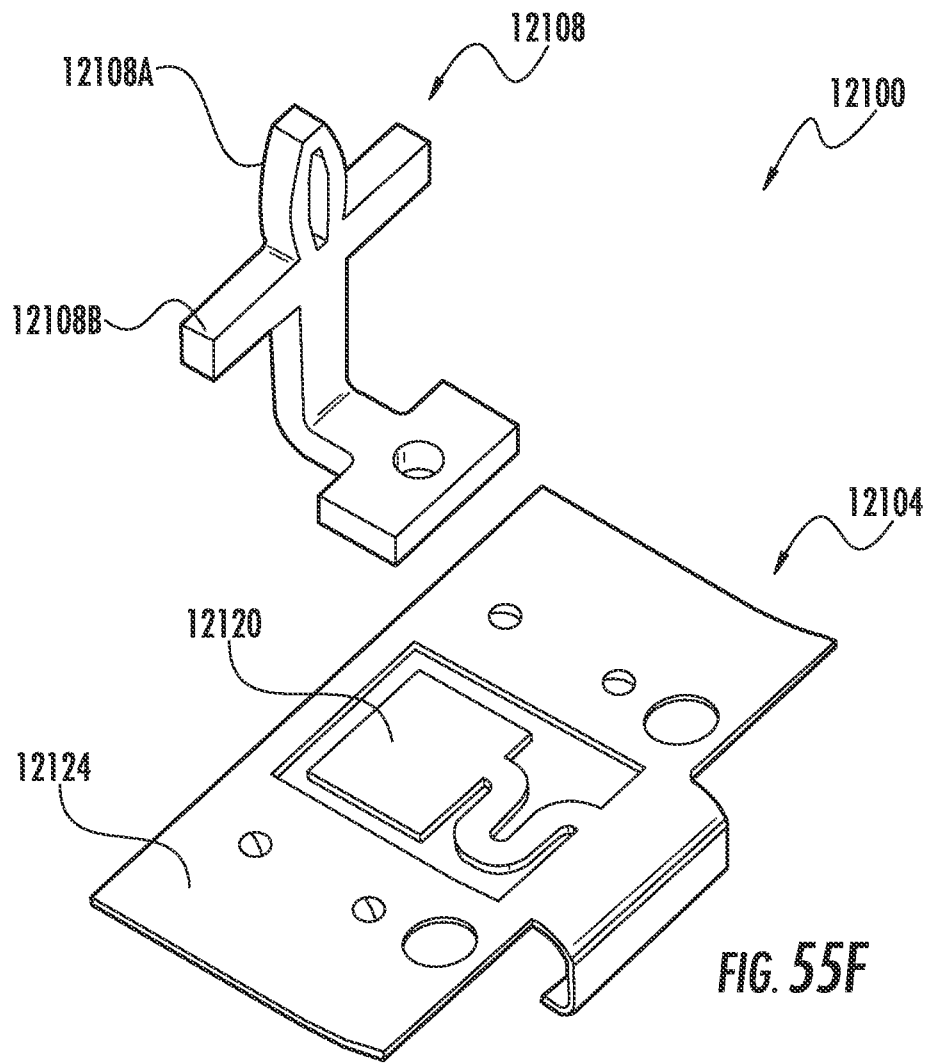


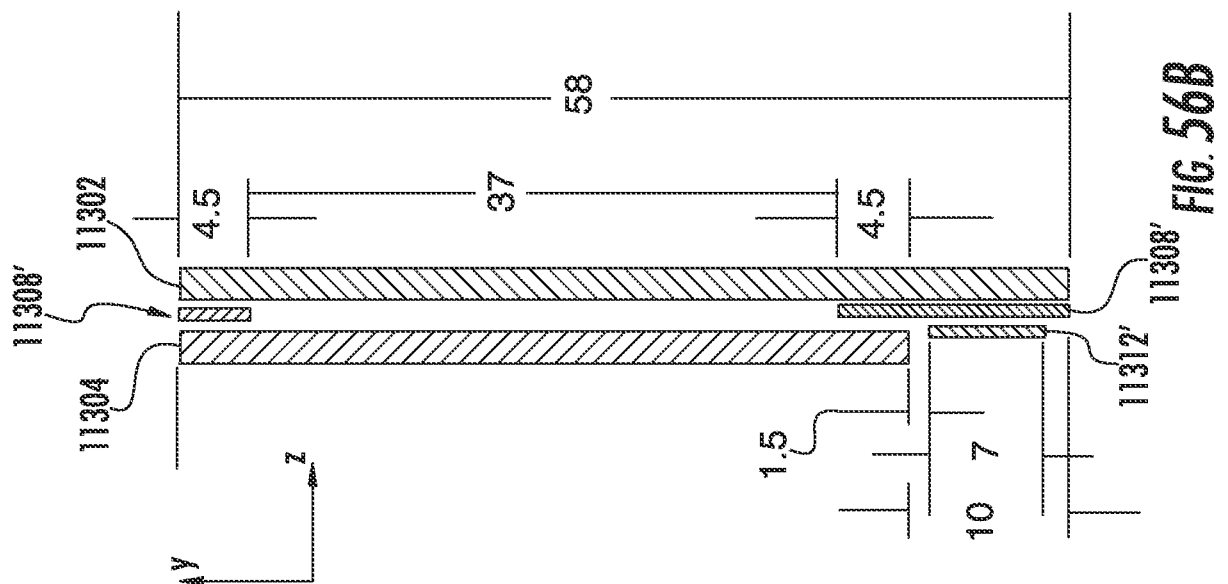
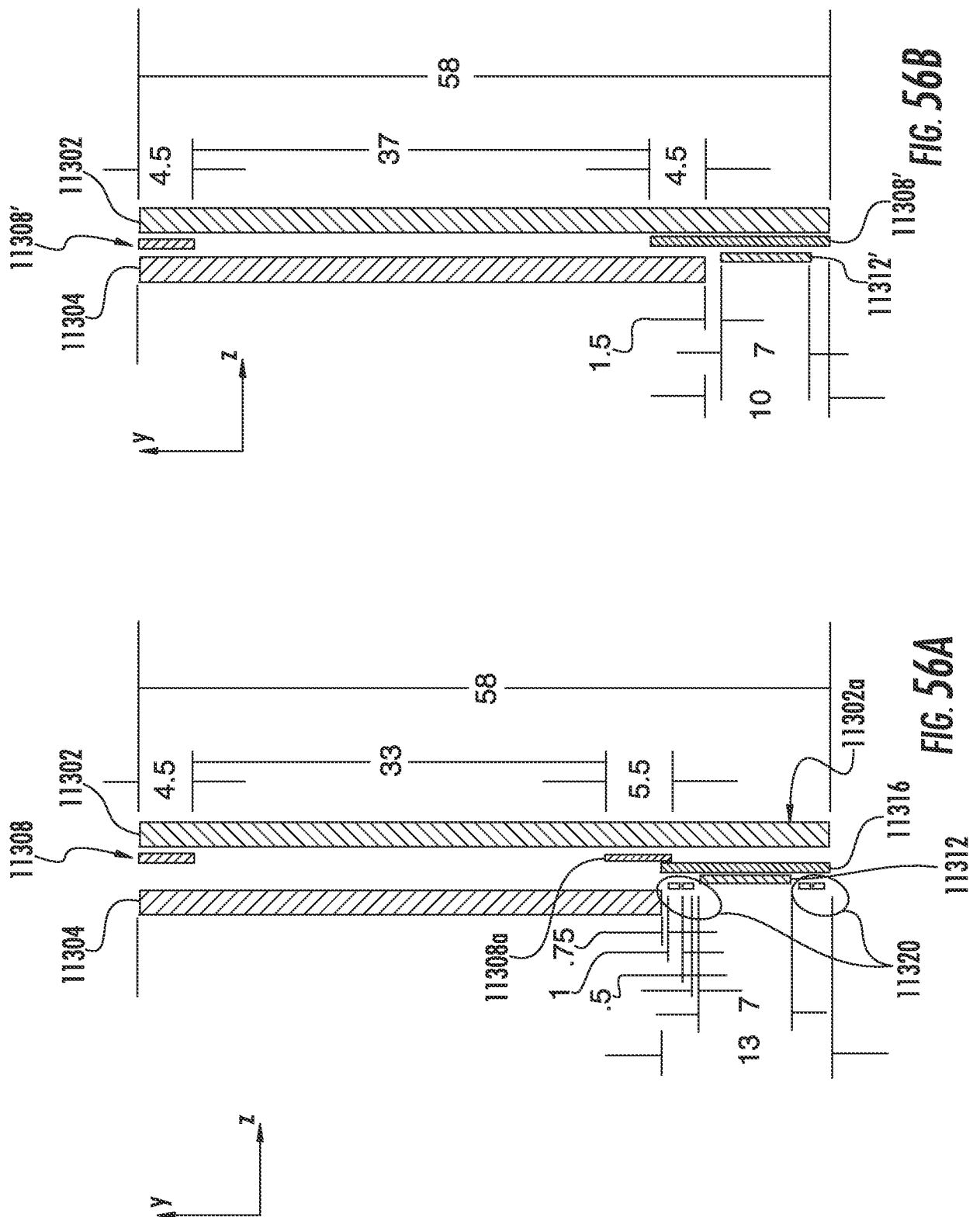
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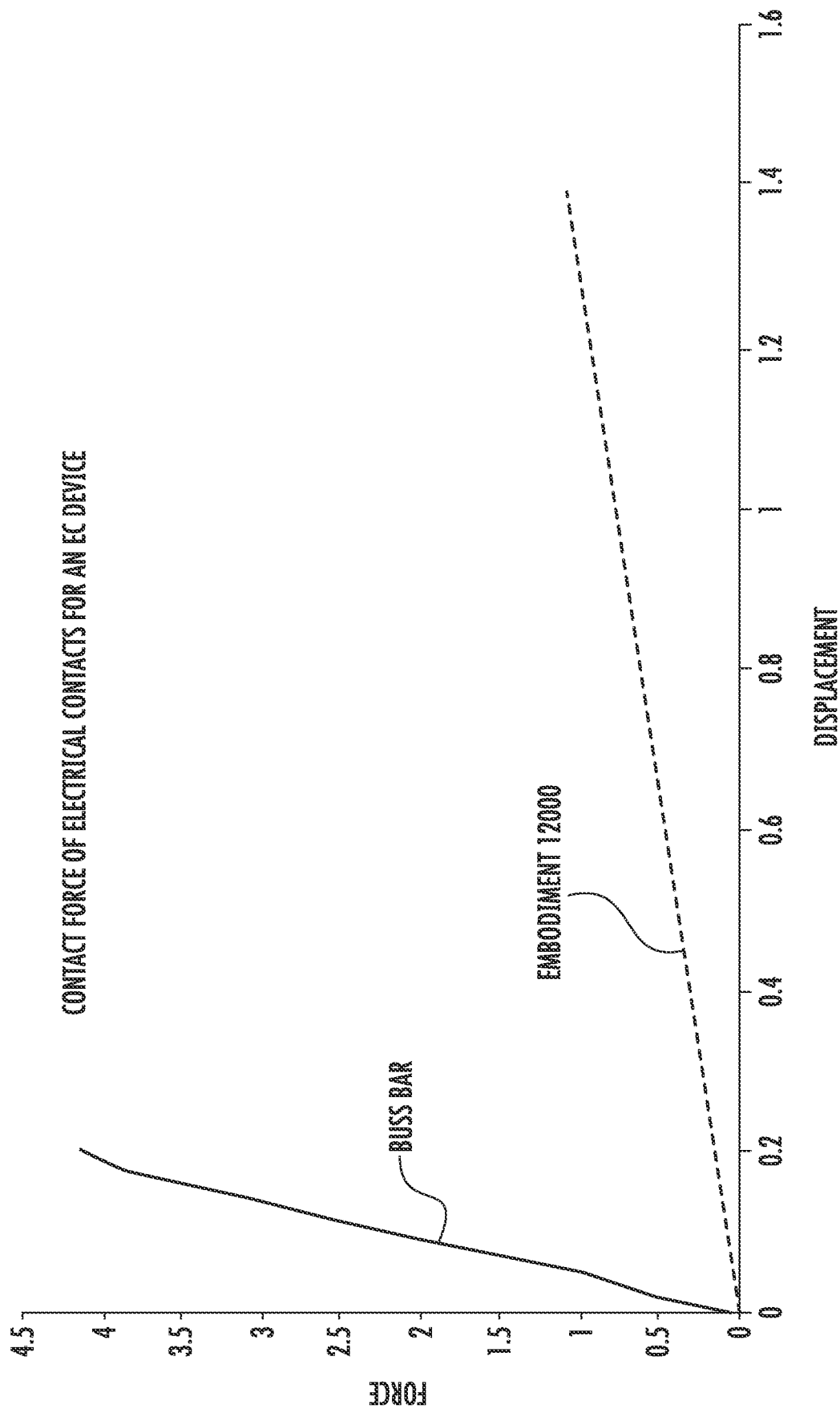
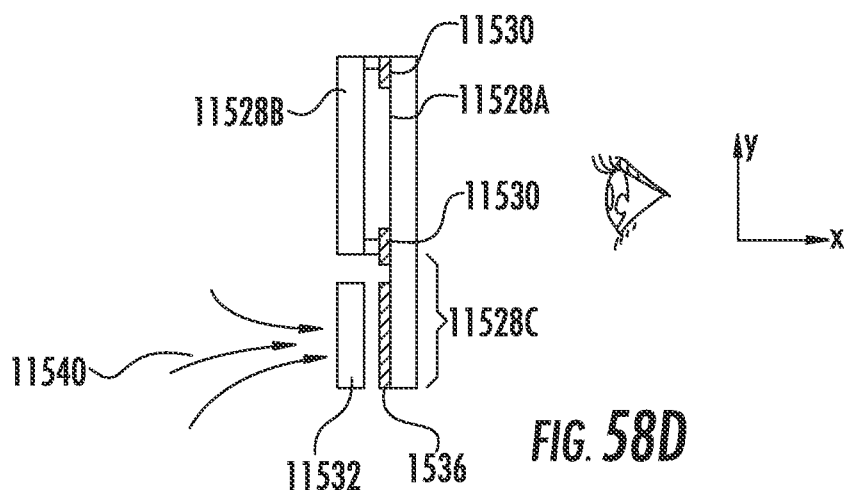
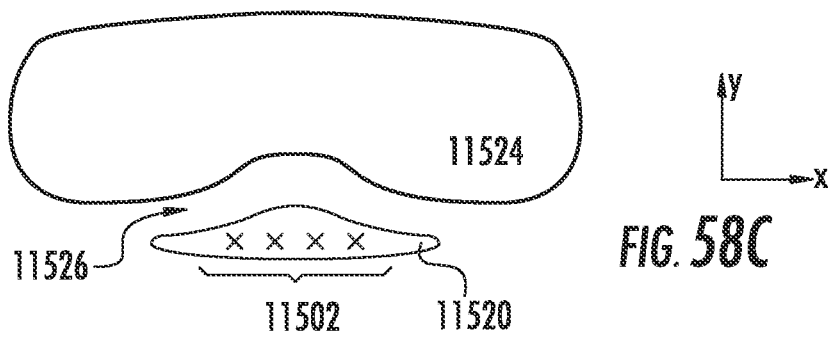
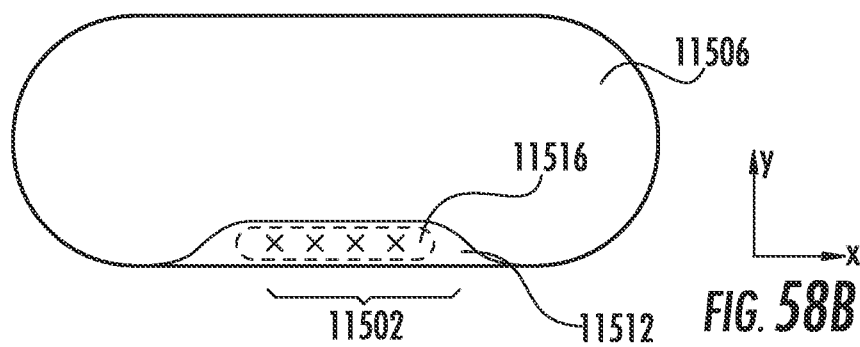
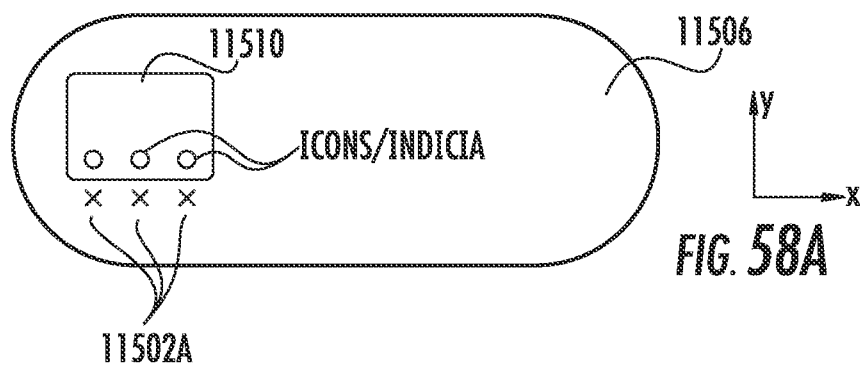
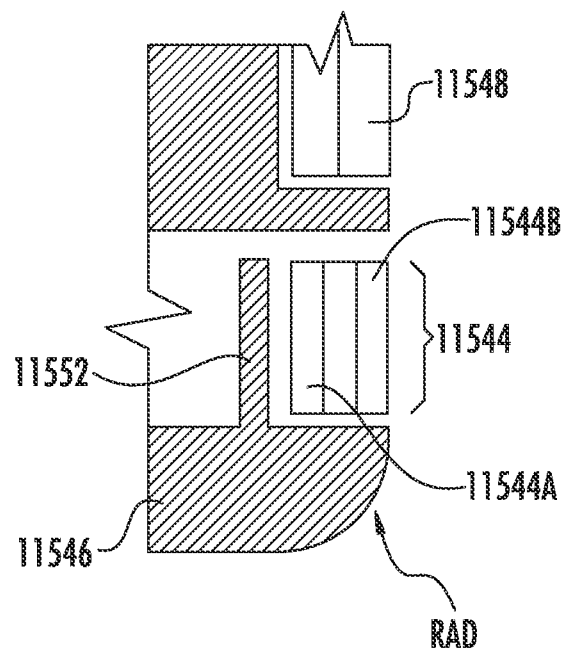
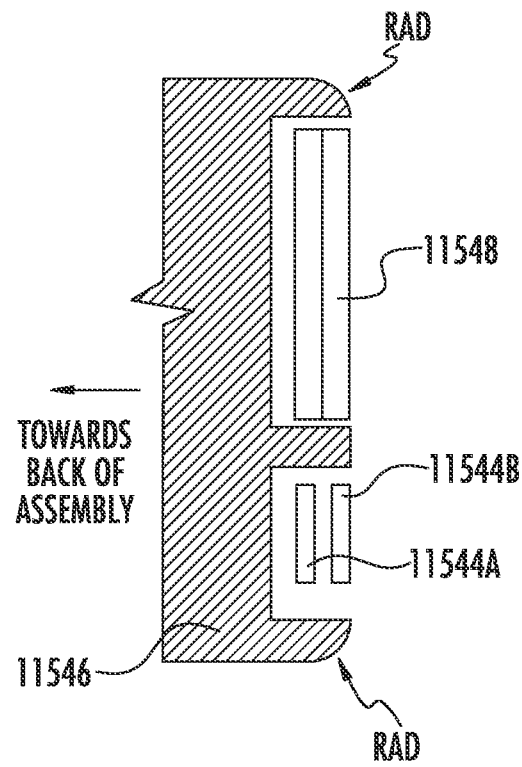


FIG. 57

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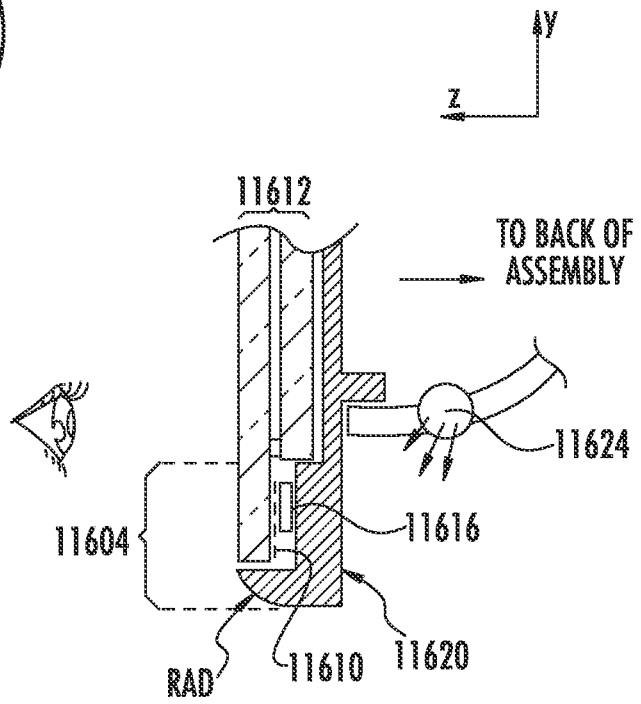
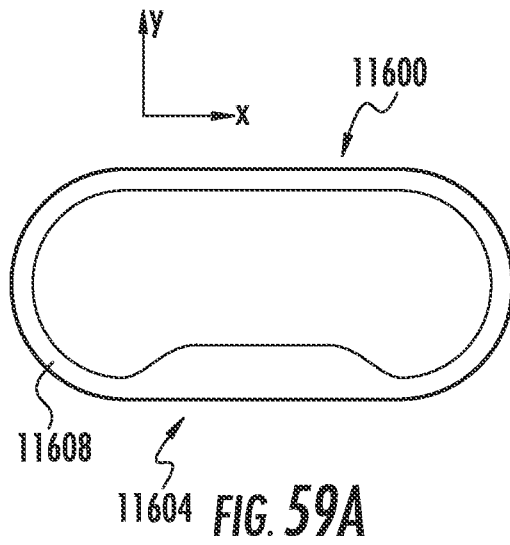


FIG. 59B

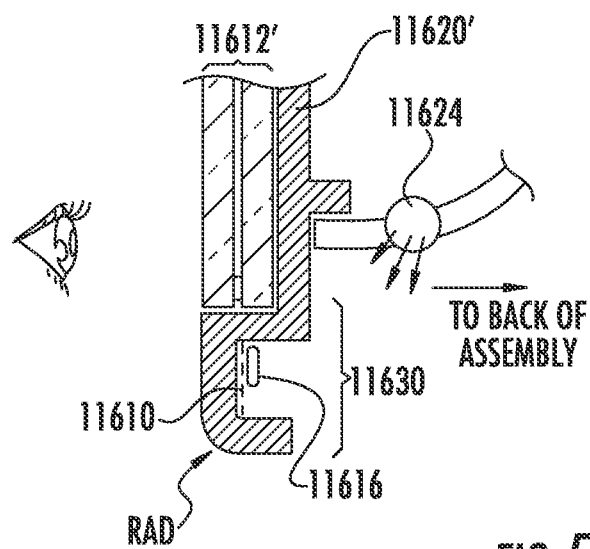


FIG. 59C

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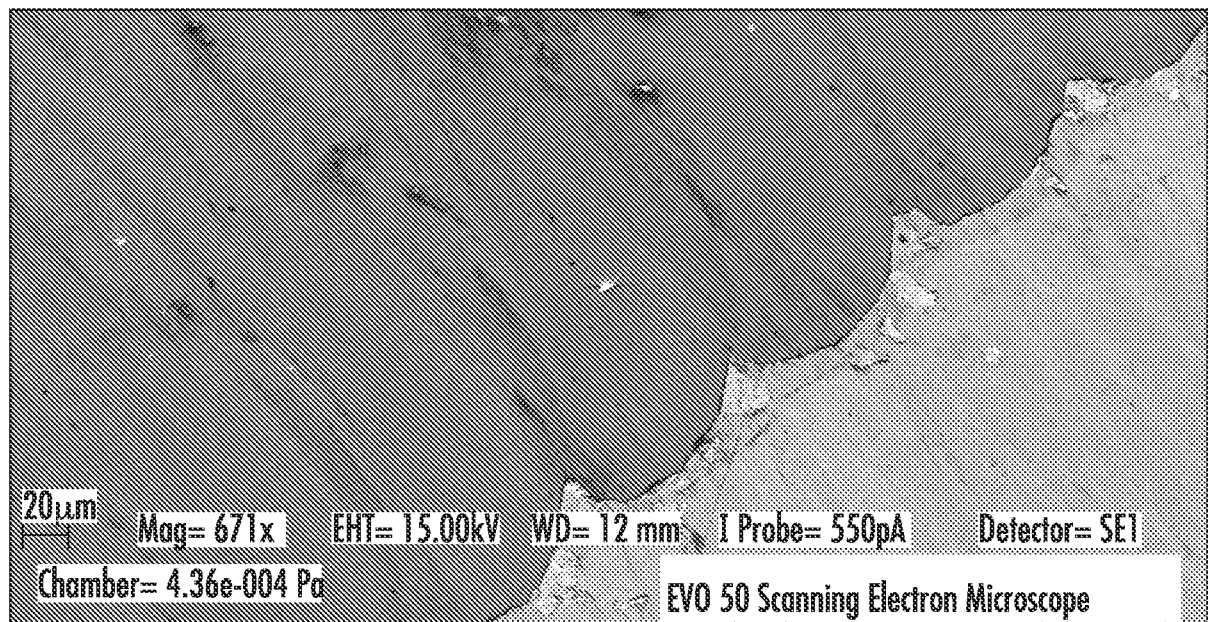
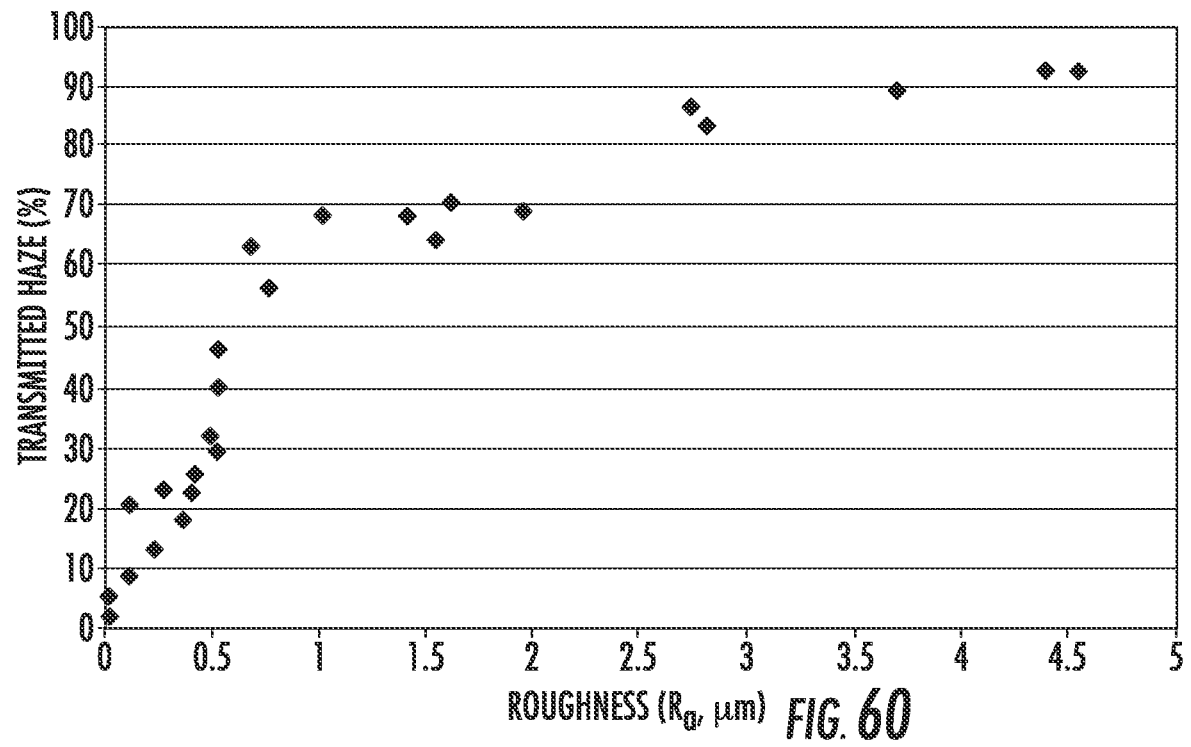
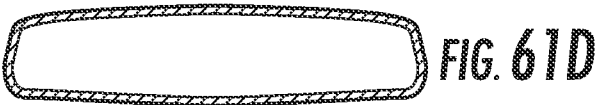
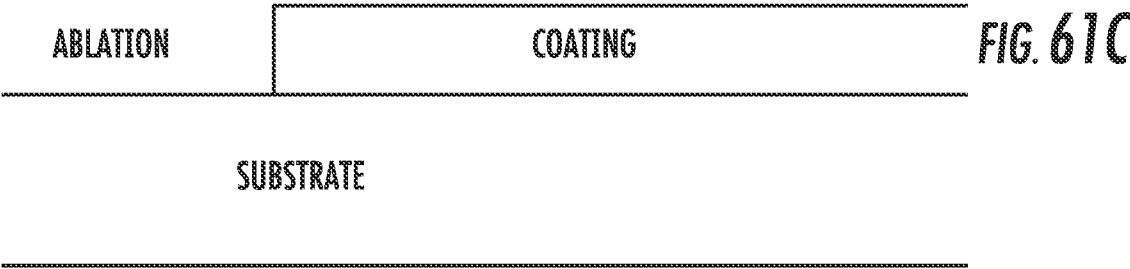
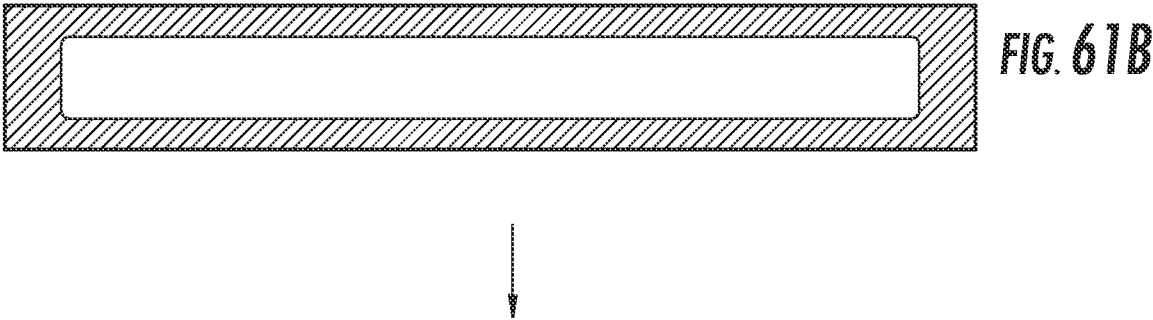
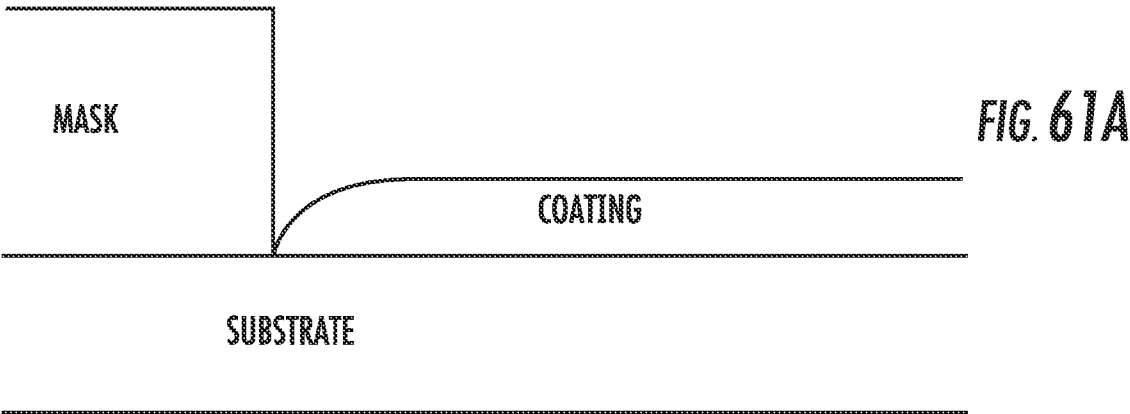


FIG. 62



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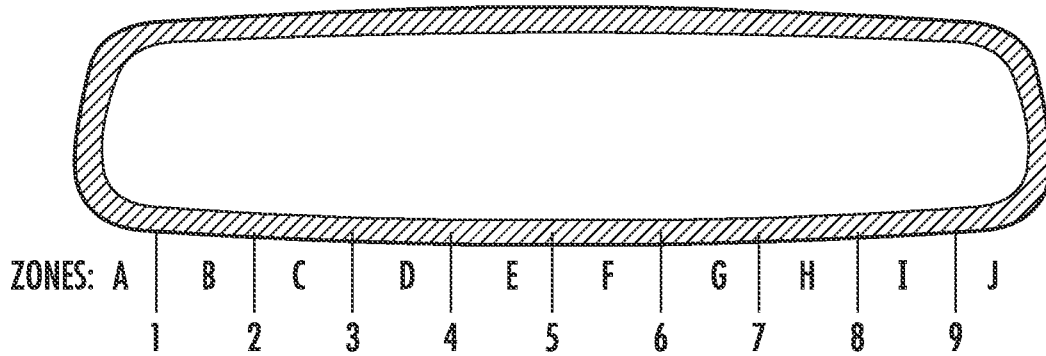


FIG. 63

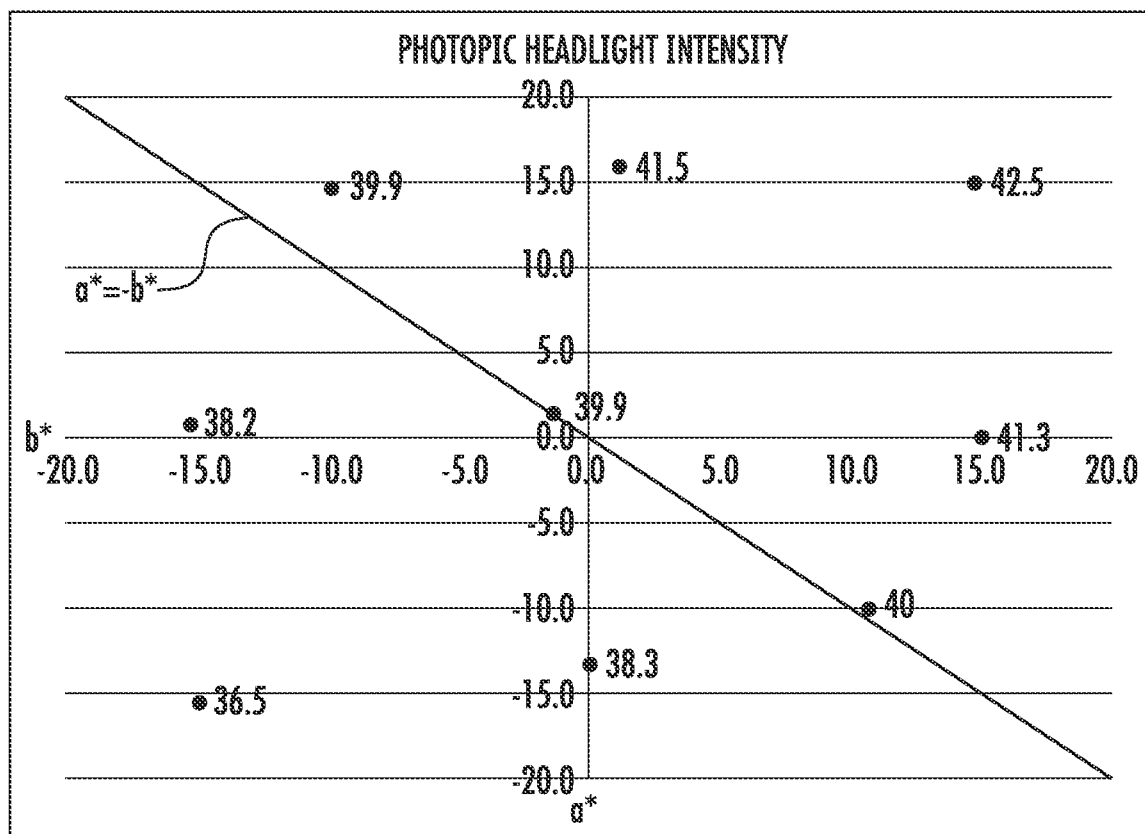


FIG. 64A

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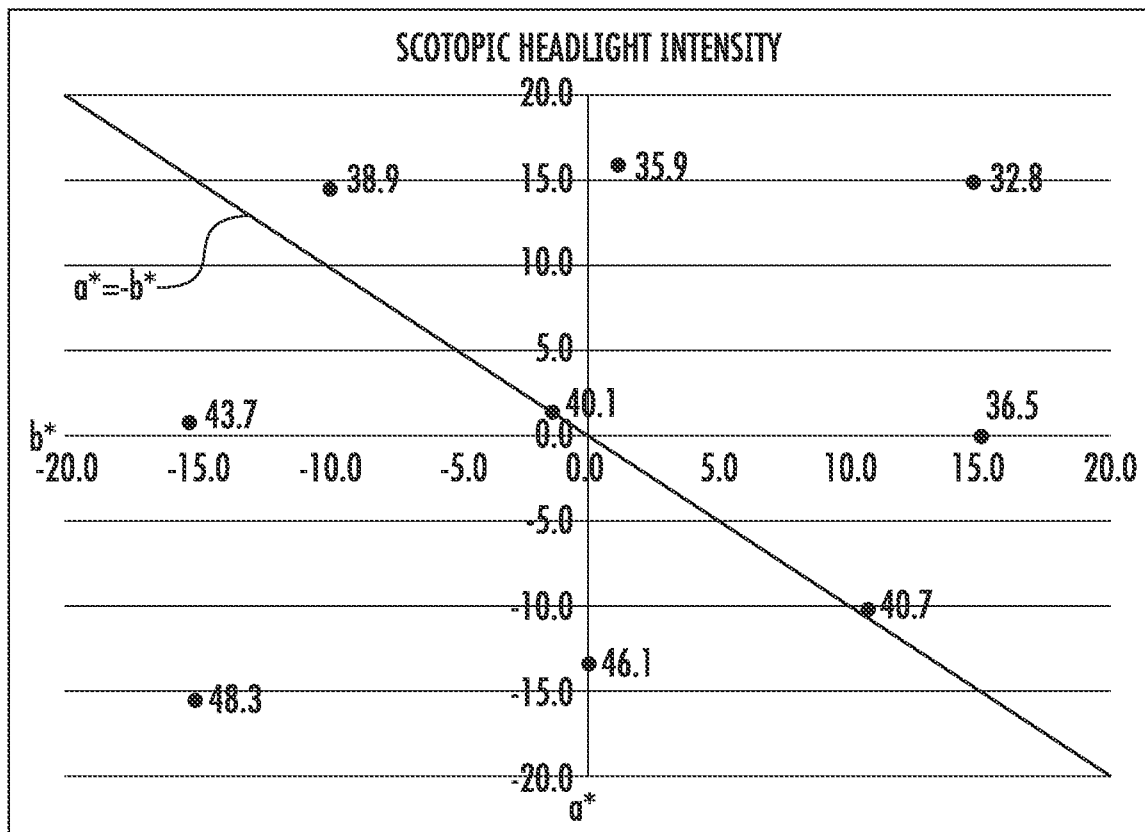


FIG. 64B

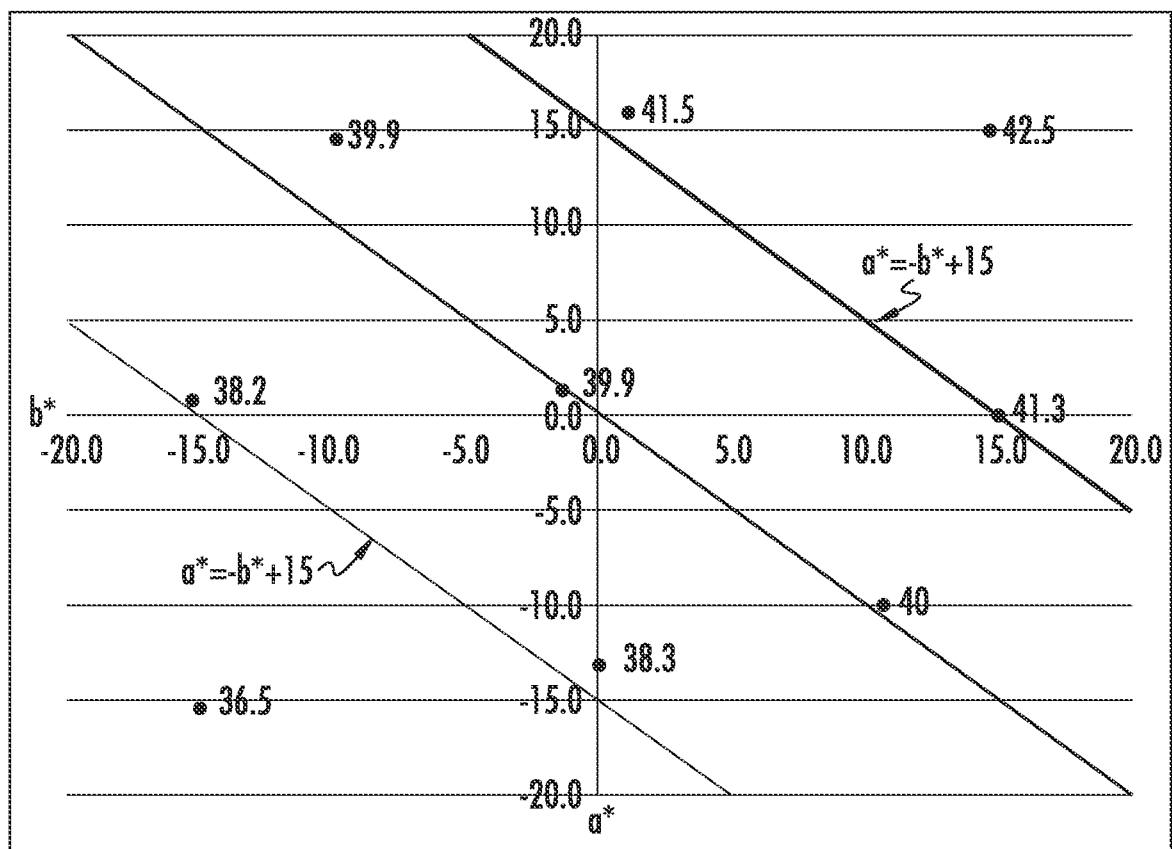


FIG. 65

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/43191

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G02F 1/15 (201 1.01)**USPC - 359/265**

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)

USPC: 359/265

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

IPC(8): G02F1/15 (201 1.01); USPC: 359/237,265,267,871

(keyword limited; terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWEST(USPT,PGPB,EPAB,JPAB); Google Scholar

Search Terms: ec, electrochromic, rear-view mirror, reflector, automobile, vehicle, car, truck, seal, gasket, user, interface, touch, capacitive, spring, lites, thin film, electric, conductor, lyaer, glare, polarization.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|---|-----------------------|
| Y | US 7,612,929 B2 (TONAR et al.) 03 November 2009 (03.11.2009), entire document, especially; FIG 3A, 3C, 49, 56, col 2, ln 55-64, col 8, ln 23-49, col 9, ln 38-67, col 15, ln 47-54, col 16, ln 63 to col 17, ln 9, col 17, ln 23-53, col 18, ln 48 to col 19, ln 20, col 20, ln 8 to col 21, ln 40, col 35, ln 14-23, col 37, ln 11-57, col 38, ln 53 to col 39, ln 20, col 40, ln 60 to col 41, ln 31. | 1-17 |
| Y | US 2005/0270620 A1 (Bauer et al.) 08 December 2005 (08.12.2005), entire document, especially; para [0001], [0104], [0105]. | 1-17 |
| Y | US 2008/0225396 A1 (MCCABE et al.) 18 September 2008 (18.09.2008), entire document, especially; para [0279], [0286]. | 17 |
| A | US 2009/0243824 A1 (Peterson et al.) 01 October 2009 (01.10.2009) entire document. | 1-17 |

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

"E" earlier application or patent but 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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"I"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search

31 October 2011 (31.10.2011)

Date of mailing of the international search report

15 NOV 2011

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
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