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- (71) **Applicants:** **BOSCH CAR MULTIMEDIA PORTUGAL, S.A.** [PT/PT]; Rua Max Grundig, N.º 35 - Lomar, P-4705-820 Braga (PT). **UNIVERSIDADE DO MINHO** [PT/PT]; Largo do Paço, P-4704-553 Braga (PT).
- (72) **Inventors:** **DO CÉU GRAMAXO OLIVEIRA SAM-PAIO, Álvaro Miguel**; Departamento De Engenharia De Polímeros - Campus De Azurém Da Universidade Do Minho, P-4800-058 Guimarães (PT). **VILELA PONTES, António José**; Departamento De Engenharia De Polímeros - Campus De Azurém Da Universidade Do Minho, P-4800-058 Guimarães (PT). **FERREIRA PINTO, Nuno Antónino**; Bosch Car Multimédia Portugal S.a. Rua Max Grundig, N.º 35 - Lomar, Apartado 2458, P-4705-820 Braga (PT). **AZEVEDO GONÇALVES, José António**; Bosch Car Multimédia Portugal S.A., Rua Max Grundig, N.º 35 - Lomar, Apartado 2458, P-4705-820 Braga (PT). **QUEIRÓS PAIS, Vítor Manuel**; Bosch Car Multimédia

Portugal S.A., Rua Max Grundig, N.º 35 - Lomar, Apartado 2458, P-4705-820 Braga (PT).

(74) **Agent:** **SILVESTRE ALMEIDA FERREIRA, Luis Humberto**; Edifício Net, Rua de Salazares 842, P-4149-002 Porto (PT).

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(54) **Title:** HEAD-UP DISPLAY REFLECTIVE MIRROR AND SUPPORT PART, PRODUCTION METHOD THEREOF

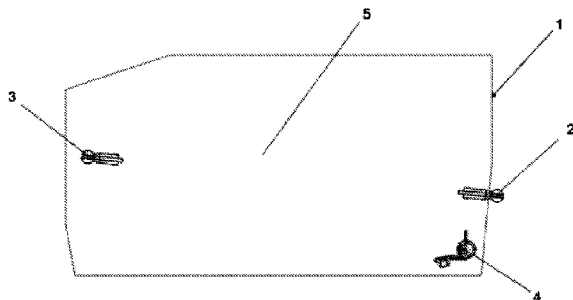


Fig. 1

(57) **Abstract:** Moulded optical part (1) having a back (5) and a front surface for a head-up display, said part comprising a rotational axis bearing or bearings (2, 3) integrally formed in the back surface for rotation of the part; and a motor and spring support or supports (4) integrally formed in the back surface for rotating the part; the front surface having a mirror coating. In particular, the mirror coating is a metalized coating, obtained by physical vapour deposition of aluminium. The optical part can be an injection-compression moulded part, in particular of a thermoplastic material, namely polyetherimide - PEI. A method of producing the moulded part comprises moulding heated material in a mould for forming said part with said bearings and supports in the back surface, and coating the front surface with the mirror coating, wherein the moulding and coating steps may be carried out in a clean room environment.



D E S C R I P T I O N

HEAD-UP DISPLAY REFLECTIVE MIRROR AND SUPPORT PART, PRODUCTION METHOD THEREOF

Technical field

[0001] The present disclosure relates to a head-up display (HUD) system and respective reflective mirror and support part, and production method thereof.

Background Art

[0001] In recent years, head-up display (HUD) systems has come into use in the automotive sector. As information requested by a driver for driving increases and is more diversified, HUD systems display critical information as a reflected image in the immediate viewing area of the driver, so that drivers do not need to take their eyes from the road to read the information since the information is deliver in a superimposed manner.

[0002] In such an HUD system, a display unit is provided inside an instrument panel of the vehicle, and at least one reflector, such as magnifying mirror, reflects the light of image-forming containing information, from the display unit onto a projection surface, such as a windshield or a combiner.

[0003] In HUD systems (i.e., Combiner HUD, augmented reality HUD, windshield HUD), reflection mirrors play a central role, since they are responsible for image projection. Projection image can be done by several types of mirrors (e.g., flat, concave, aspherical) depending on the scope for the inclusion of the mirror in the HUD. Aspherical mirrors are used to reflect and enlarge the display image.

[0004] As the position of the projected image for a given configuration depends on the eye position of the driver, since the image will appear to be higher or lower, depending

on the drivers seating height, it is common for HUD systems to enable adjustments in, at least, one reflected mirror so that the reflected light is adjust towards the eye points of the drivers (e.g. US8885260B2, US7532175B2, US6809872B2, US5394203A). This is achieved by placing an axis of rotation on the mirror itself (US5394203A) or in the mirror support (US8885260B2, US7532175B2, US6809872B2). Motors (e.g., step motors) are used to accomplish the adjustments needed and, in addition, in order to prevent tilting forces, a spring is also used.

[0005] The inclusion of optical elements on HUD systems assumes several features and distinct configurations:

[0006] In document US539403A a panel and a mirror are assembled as a unit, being the panel and the sector gear the support for the mirror. The mirror is assembled to the panel by a ball and socket arrangement and a cam. The motor moves the sector gear (moving the mirror) and a spring between the panel and the mirror biases the mirror against the cam for preventing tilt issues.

[0007] In document US7532175B2 a mirror holder with a rotational shaft and a mounting part for the motor gear support the mirror. The holder is mounted on the housing by the rotational shaft.

[0008] In document US6809872B2 a mirror is connected to a pair of pins and is mounted in a rotational axis. A step motor provides the rotation, and a spring pressed against the mirror prevents tilting.

[0009] In document US8885260B2 a mirror, a mirror holder, a base plate and a step motor are assembled. The mirror is held by the holder, and the holder is pivotally supported by the base plate so that it pivots around a horizontal axis. The mirror assembled is fixed to the housing by screwing the base plate. The step motor pivots the holder holding the reflective mirror.

[0010] Therefore, independently of the configuration, an optical element is the assembly of several features that are implemented before being mounted in the HUD housing. A typical assembly is composed of, the reflective mirror (mirror), a mirror support (Mirror holder or panel), and by bearings (pins) for the rotational axis.

[0011] On the projection devices like, Combiner HUD, Augmented Reality HUD, the reflective mirrors are normally bounded to the support of the mirror by glue, double face adhesive or some mechanical elements, processes that contain, all of them, some problems.

[0012] The double face adhesive could not compensate the dimensional tolerances between the mirror and the mirror support. Fixing a mirror on a support that has not absolutely the same shape of the mirror results in deformations of the mirror when it is fixed with tape. Using an adhesive foam it is possible to compensate slight tolerances but, the foam has a higher thickness tolerance, which has an influence on the mirror position. The adhesive strength reduces at high temperatures, the tape never cure/hardens, so there is always a risk that the mirror could present variations in its nominal position at high temperatures due to the flowing of the adhesive tape.

[0013] The glue unlike the double faced adhesive, cures and does not flow with higher temperatures, nevertheless it is complicated to control on production and it is normally used in parts with added value, so the cost of rejection is very high.

[0014] The solution of having mechanical lockers is complex to apply on this field due to the high temperatures, since different behaviours under loads induces stress on the optical element promoting the image distortion.

[0015] Another problem, if miniaturizing HUD systems and maximizing at the same time the reflective mirror, is that features of this type of optical element (i.e., mirror holder, bearings for the rotational axis, motor and spring support) on the lateral of the element prevent the mirror size to be only constrained by the housing size, requiring additional lateral space.

General Description

[0016] Head up display systems are starting to become largely used on the automotive field. Normally this system uses two or more mirrors for projecting the information to the driver. These optical elements are very sensitive and any imperfection on the

manufacturing phase or assembly phase will cause bad functionality and consequently distortion on the image. Therefore, the present disclosure allows the possibility to obtain the optical element which fulfils all the requirements simplifying the manufacturing process and assembly process, consequently the cost of the whole systems.

[0017] The disclosure presents a mirror, in a single part, which integrates the bearings for the rotational axis, the motor and spring support, taking into account that these features are placed in the back of the mirror reflector which in particular is aspherical.

[0018] The disclosure presents an element that can be coated and used as an optical mirror to be included in head-up-displays in vehicles, that is able to incorporate all the features needed to be directly mounted in a HUD housing.

[0019] The features incorporate in the element are those needed to enable the rotation of the mirror and the motor and spring support and are placed in the back of the mirror reflector, allowing the entire front face to be metalized, in particular metalized in aluminium.

[0020] The production of the optical element is based on an injection compression moulding tool with a thermoplastic material, making the optical element as support of itself.

[0021] The process described allows the possibility to have a good quality surface (roughness) suitable for an optical element and the inclusion of mounted features, simplifying the manufacturing and assembly process.

[0022] It is disclosed a moulded optical part having a back and a front surface for a head-up display, said part comprising:

a rotational axis bearing or bearings integrally formed in the back surface for rotation of the part;

a motor and spring support or supports integrally formed in the back surface for rotating the part;

the front surface having a mirror coating.

[0023] In an embodiment, the mirror coating is a metalized coating.

[0024] In an embodiment, the metalized coating is obtained by physical vapour deposition.

[0025] In an embodiment, the metalized coating is aluminium metalized coating.

[0026] In an embodiment, the moulded part is an injection-compression moulded part.

[0027] In an embodiment, the part is of a thermoplastic material.

[0028] In an embodiment, the thermoplastic material is polyetherimide - PEI, cyclic olefin polymer - COP, or cyclic olefin copolymer - COC.

[0029] In an embodiment, the mirror surface is an aspherical mirror surface.

[0030] In an embodiment, the head-up display is an augmented reality display.

[0031] In an embodiment, the head-up display is a combiner head-up display.

[0032] In an embodiment, the head-up display is an automotive head-up display.

[0033] It is also disclosed a method for manufacturing a moulded optical part having a back and a front surface for a head-up display, said method comprising the steps of: moulding heated material in a mould for forming the part comprising:

a rotational axis protruding bearing or bearings integrally formed in the back surface for rotation of the part, and

a motor and spring protruding support or supports integrally formed in the back surface for rotating the part;

coating the front surface with a mirror coating.

[0034] In an embodiment, the moulding and coating steps are carried out in a clean room environment.

[0035] In an embodiment, the moulding heated material is thermoplastic, in particular polyetherimide - PEI, cyclic olefin polymer - COP, or cyclic olefin copolymer - COC.

[0036] Throughout the description and claims the word "comprise" and variations of the word, are not intended to exclude other technical features, additives, components, or steps. Additional objects, advantages and features of the invention will become

apparent to those skilled in the art upon examination of the description or may be learned by practice of the invention. Furthermore, the present disclosure covers all possible combinations of particular and preferred embodiments described herein.

Brief Description of the Drawings

[0037] The following figures provide preferred embodiments for illustrating the description and should not be seen as limiting the scope of invention.

[0038] **Figure 1:** Schematic representation of a first preferred embodiment of the optical element design.

[0039] **Figure 2:** Schematic representation of a first preferred embodiment of the coating area.

[0040] **Figure 3:** Schematic representation of a first preferred embodiment of a section view of the injection compression mould tool.

[0041] **Figure 4:** Schematic representation of a first preferred embodiment of the mould core.

[0042] **Figure 5:** Schematic representation of a first preferred embodiment of sequence steps of the manufacturing process.

[0043] **Figure 6:** Schematic representation of a comparison with the concepts used on the current disclosure.

Detailed Description

[0044] The present disclosure relates to an optical element suitable to be coated for optical applications on automotive field, more specifically on Augmented Reality HUD system, Combiner HUD displays or any other devices which allows the projection of information on the windshield or other projection area, and the manufacturing process of such an element.

[0045] This optical element (1) includes all the necessary features needed to promote the assembly on the HUD housing. This element, obtained in one part, includes the bearings for the rotational axis (2,3), motor and spring support (4), making the reflective mirror as support of itself, since this embodiment do not need a mirror support. The entire front of the element is the face to be metalized (Figure 2)(6). Therefore, with this invention the need to use secondary processes for bonding the different features can be excluded (e.g., gluing the different features), decreasing the assembly time, the possibility of rejected components with added value, and make it more suitable for production environment.

[0046] This optical element would be produced using an injection compression moulding (ICM) tool, with a thermoplastic material, for example Polyetherimide (PEI), Cyclic olefin polymer (COP) or Cyclic olefin copolymer (COC). The thermoplastic should present favorable processing properties for injection moulding, high long-term heat resistance, excellent dimensional stability, exceptional strength and modulus at elevated temperatures which are necessary for HUD specifications, in particular the optical components.

[0047] Also, thermoplastic material, as PEI, is well suitable for using on the coating process (i.e., metallization in aluminum), since it can be a specifically good fit in a heat dominated area like automotive lighting, and allows a design and processing flexibility.

[0048] Applying a thermoplastic material with the ICM it is possible to eliminate all the problems described and makes the process of manufacturing more 'lean' and cost effective. Since ICM, compensates shrinkage by compressing the melt through the clamping movement, eliminates sink marks with thicker wall sections and improves long-time dimensional stability, it is a remarkable tool to achieve the mandatory specifications of the mirror part (1).

[0049] Figure 3 shows a section view of the ICM tool (6) responsible for the production of the mirror part (1), the tool has two parts: the ejector side part (7) with the mould core (10) and, the injection side part (8) with the mould cavity (11). 10 and 11 are responsible to give shape to the mirror part (1). After a determinate amount of time of

the cavity (12) filling, a stamping plug (9) is actuated making the compression on the material to ensure the right filling of the moulded part.

[0050] From figure 4 it is possible to see the mould core (10), with film/flash gate (13), ejector pin marks (14) and stamping plug mark area (15). This area should preferably be the largest possible inside of what the back of the design part enables. Since the part has some undercuts it is necessary to use a side core movement (17) for the supports and lifters (16) for the bearings.

[0051] This method of producing the mirror part, with the use of thermoplastic material, enables a production of a high quality optical element with advantage of having the optical piece as support of itself.

[0052] The chart in fig. 5 represents the different steps of the manufacturing process, starting with the reception of the material, which is evaluated in terms of chemical properties, after this process the material receive the approbation to be loaded on the injection machine, in this particular situation, the injection compressing technique is preferred in order to obtain the best results, but other techniques can be used, after the process of injection the optical element is removed of the mould by a robot and proceed to the metallization process, the steps of injection and metallization should preferably be done on clean room (outline square in figure 5), avoiding the contamination of the mirror surface. After the process of metallization the optical element is carefully packed and transported to the assembly line.

[0053] Figure 6 describes the clear advantage of this invention in terms of production process when compared to the actual concepts used on head up displays.

[0054] With minor changes the process of manufacturing this optical element can be adapted for any competitor product allowing the incorporation in any device of Augmented Reality HUD, Combiner-HUD or any other projection device.

[0055] The term "comprising" whenever used in this document is intended to indicate the presence of stated features, integers, steps, components, but not to preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

[0056] Flow diagrams of particular embodiments of the presently disclosed methods are depicted in figures. The flow diagrams do not depict any particular means, rather the flow diagrams illustrate the functional information one of ordinary skill in the art requires to perform said methods required in accordance with the present disclosure.

[0057] It will be appreciated by those of ordinary skill in the art that unless otherwise indicated herein, the particular sequence of steps described is illustrative only and can be varied without departing from the disclosure. Thus, unless otherwise stated the steps described are so unordered meaning that, when possible, the steps can be performed in any convenient or desirable order.

[0058] The disclosure should not be seen in any way restricted to the embodiments described and a person with ordinary skill in the art will foresee many possibilities to modifications thereof.

[0059] The above described embodiments are combinable.

[0060] The following claims further set out particular embodiments of the disclosure.

C L A I M S

1. Moulded optical part having a back and a front surface for a head-up display, said part comprising:
a rotational axis bearing or bearings integrally formed in the back surface for rotation of the part;
a motor and spring support or supports integrally formed in the back surface for rotating the part;
the front surface having a mirror coating.
2. Part according to the previous claim wherein the mirror coating is a metalized coating.
3. Part according to the previous claim wherein the metalized coating is obtained by physical vapour deposition.
4. Part according to any one of claims 2 - 3 wherein the metalized coating is aluminium metalized coating.
5. Part according to any one of the previous claims wherein the moulded part is an injection-compression moulded part.
6. Part according to any one of the previous claims wherein the part is of a thermoplastic material.
7. Part according to the previous claim wherein the thermoplastic material is based on polyetherimide - PEI, cyclic olefin polymer – COP, or cyclic olefin copolymer - COC.
8. Part according to any one of the previous claims wherein the mirror surface is an aspherical mirror surface.
9. Head-up display comprising the part according to any one of the previous claims.
10. Head-up display according to the previous claim wherein the head-up display is an automotive head-up display.
11. Augmented reality head-up display or combiner head-up display comprising the part according to any one of the claims 1 - 8.

12. Method for manufacturing a moulded optical part having a back and a front surface for a head-up display, said method comprising the steps of:
moulding heated material in a mould for forming the part comprising:
 - a rotational axis protruding bearing or bearings integrally formed in the back surface for rotation of the part, and
 - a motor and spring protruding support or supports integrally formed in the back surface for rotating the part;coating the front surface with a mirror coating.
13. Method according to claim 12 wherein the mirror coating step is a coating by physical vapour deposition of a metal.
14. Method according to the previous claim wherein the moulding and coating steps are carried out in a clean room environment.
15. Method according to any one of claims 13 - 14 wherein the metal coating is of aluminium.
16. Method according to any one of the claims 12 – 15 wherein the part is of a thermoplastic material.
17. Method according to the previous claim wherein the thermoplastic material is polyetherimide - PEI, cyclic olefin polymer – COP, or cyclic olefin copolymer - COC.
18. Method according to any one of the claims 12 – 17 wherein the mirror surface is an aspherical mirror surface.
19. Method according to any one of the claims 12 – 18 wherein the moulding step is an injection-compression moulding.
20. Method according to the previous claim comprising for moulding the heated material by injection-compression moulding comprising the steps of:
 - injecting the heated material into the mould cavity;
 - after a determined amount of time, actuating a stamping plug for compressing the heated material;
 - extracting the moulded part using one or more ejector pins;
 - wherein the mould comprises a side core movement and two lifters.

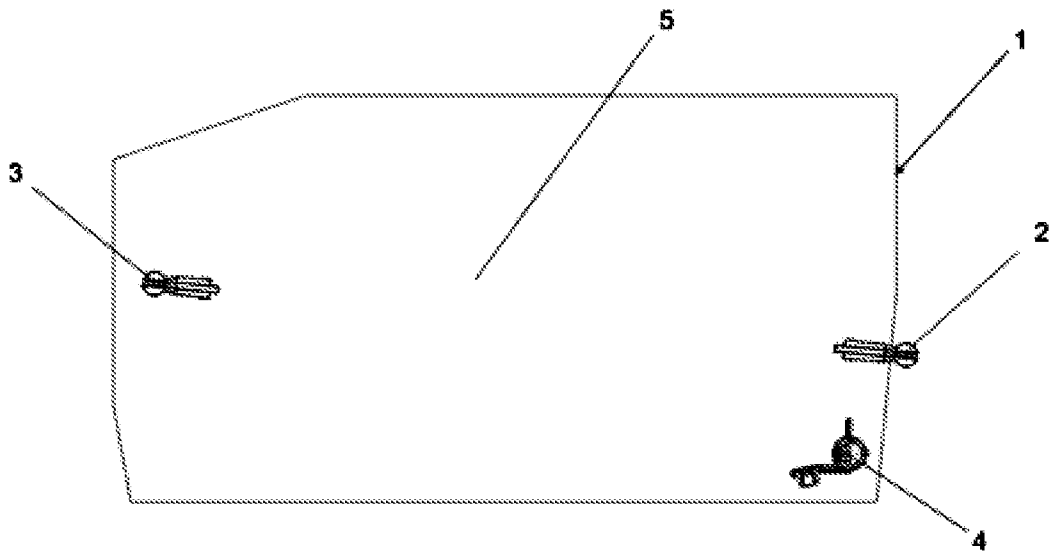


Fig. 1

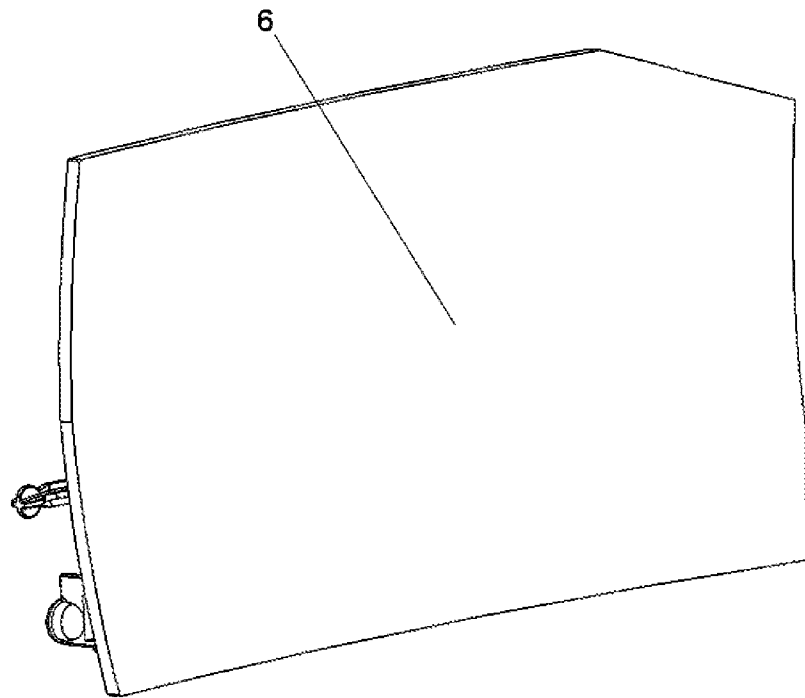


Fig. 2

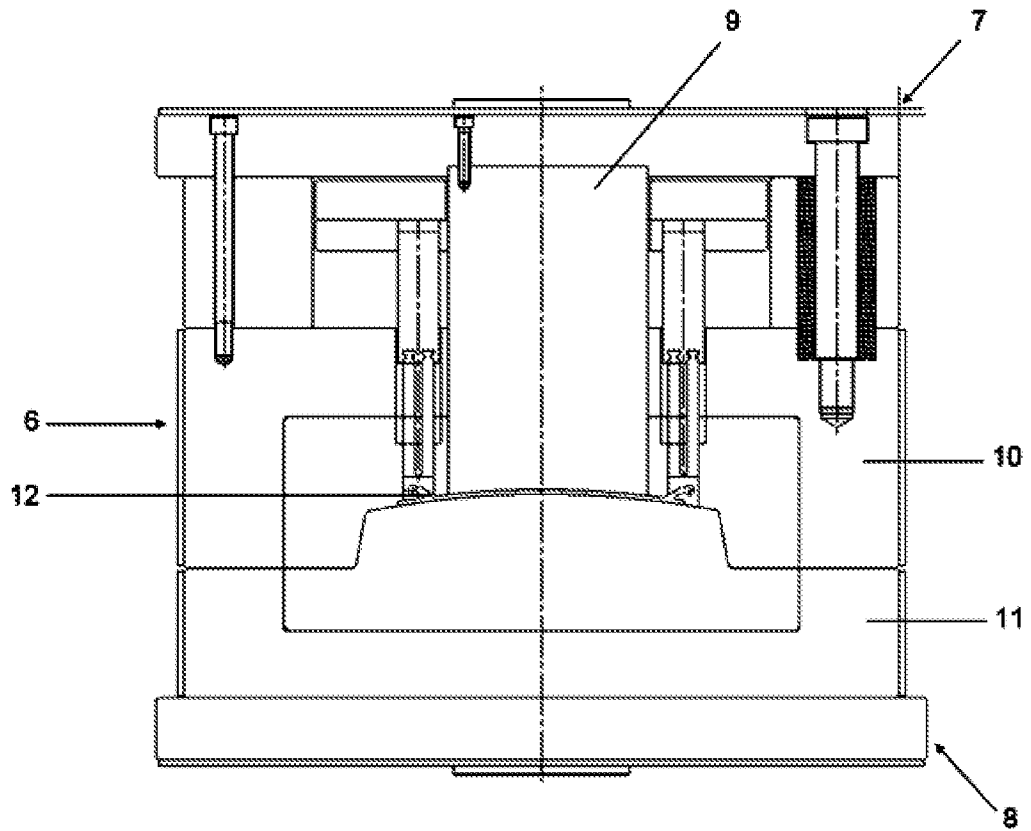


Fig. 3

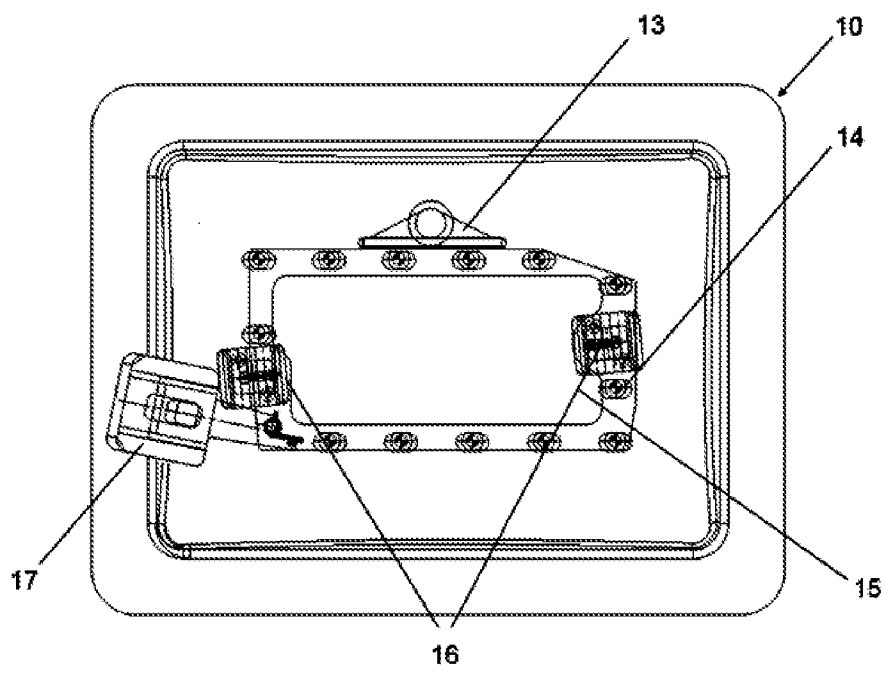


Fig. 4

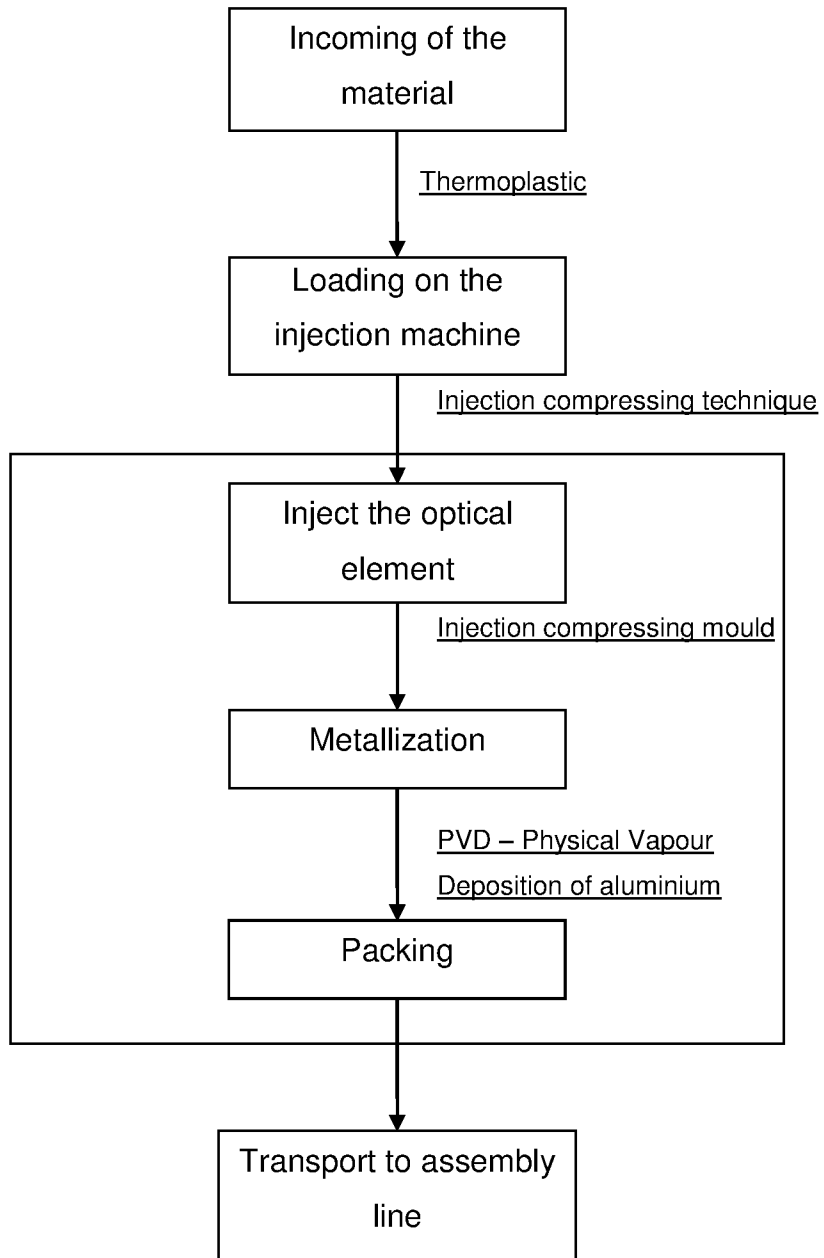


Fig. 5

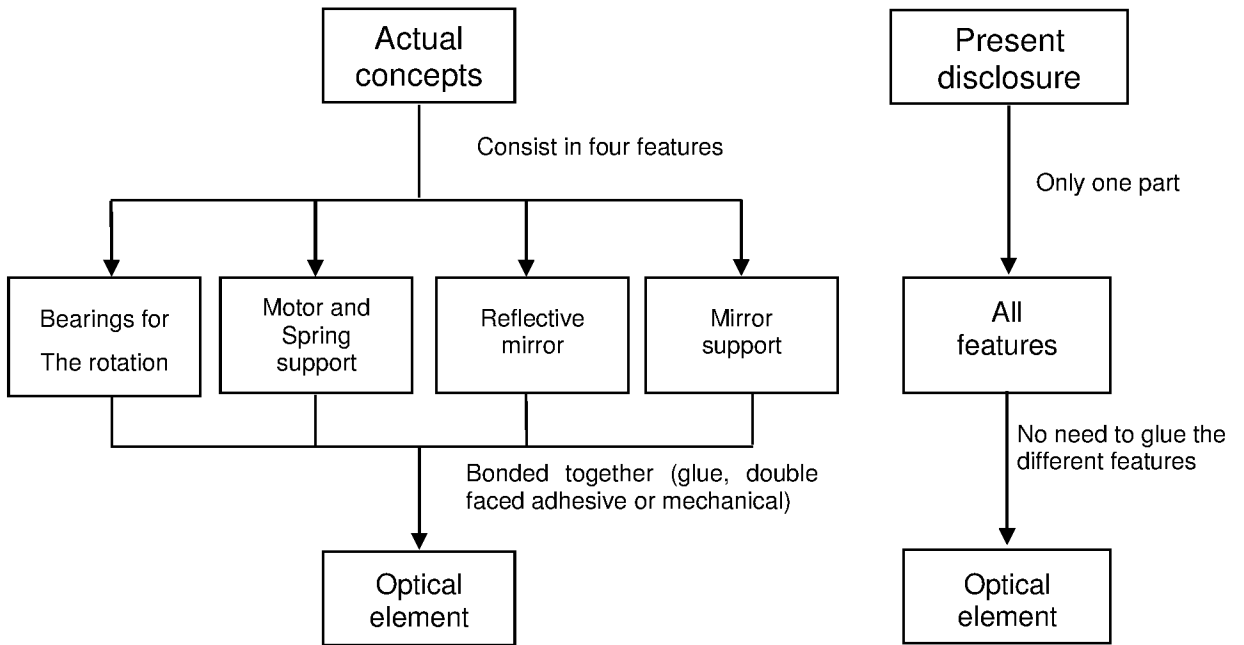


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B27/01 G02B7/182
ADD.
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)
G02B
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	EP 2 434 312 A1 (SICK AG [DE]) 28 March 2012 (2012-03-28) paragraph [0016]; figures 1-3 -----	1-20
X	US 2006/017993 A1 (HIROSE KAZUYA [JP] ET AL) 26 January 2006 (2006-01-26) paragraph [0032]; figures 1-12 -----	1-20
X	EP 2 484 507 A1 (KONICA MINOLTA OPTO INC [JP]) 8 August 2012 (2012-08-08) figures 1-4b -----	1-20

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

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance	"T" 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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 11 January 2016	Date of mailing of the international search report 20/01/2016
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Daffner, Michael
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2015/054627

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